Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Northern Region Publication No. R1-22-03a January 2022

Final Environmental Impact Statement for the Land Management Plan

Custer Gallatin National Forest

Volume 1: Chapters 1, 2, and 3 (part 1)

Custer Gallatin National Forest Title Page: Photo Credit Top left to right – Custer Gallatin National Forest Title Page: Photo Credit – Mariah Leuschen-Lonergan. Top left, going clockwise – Coneflower, Echinacea, native wildflowers, Sioux Ranger District; American Flag and U.S. Forest Service Flag displayed in winter on the Hebgen Lake Ranger District; Packing trip in the Absaroka-Beartooth Wilderness, Yellowstone, Gardiner and Beartooth Ranger Districts, photo by Terry Jones; Elk grazing on the Gardiner Ranger District with sagebrush in background, foreground; Bison grazing in the Greater Yellowstone Ecosystem with Arrowleaf Balsamroot in background, Gardiner and Hebgen Lake Ranger Districts; Center - Close up of Indian Paintbrush, Bozeman Ranger District; View looking into the Rock Creek drainage and Absaroka-Beartooth Wilderness atop Beartooth Pass, Beartooth Ranger District; Rafting on the Gallatin Wild and Scenic River, Gallatin Canyon, Bozeman Ranger District, Calf nursing from Mother (Cow), Multiple use grazing allotments are a critical economic and social fabric of the Ashland and Sioux Ranger Districts; Holiday Christmas Tree gathering is a long-standing tradition for many Montana families, passed down from generation to generation, Bozeman Ranger District, Custer Gallatin National Forest.

Note: We make every effort to create documents that are accessible to individuals of all abilities; however, limitations with our word processing programs may prevent some parts of this document from being readable by computer-assisted reading devices. If you need assistance with this document, please contact the Custer Gallatin National Forest at (406) 587-6701.

Final Environmental Impact Statement for the Land Management Plan

Custer Gallatin National Forest

Lead Agency: United States Department of Agriculture (USDA) Forest Service

Cooperating Agencies:
Park County, Montana
Sweet Grass County, Montana
South Dakota Department of Game, Fish and Parks
State of South Dakota

Responsible Official:
Mary Erickson, Forest Supervisor
10 East Babcock
Bozeman, MT 59715
406-587-6701

For Information Contact:
Virginia Kelly, Plan Revision Team Leader
10 East Babcock
Bozeman, MT 59715
406-587-6701

Abstract: This final environmental impact statement discloses the effects of revising the Custer and Gallatin Plans, which were developed in the 1980s. The proposed action is to provide revised management direction in one land management plan now that the two national forests are administratively managed as one unit (the Custer Gallatin National Forest). This document contains analysis of the preferred alternative, four other action alternatives, as well as a no-action alternative (the current plans) for the programmatic management of approximately 3,046,000 acres administered by the Custer Gallatin National Forest. The Forest Service has identified alternative F as the preferred alternative.

Contents of Volume 1

List of Tables

List of Figures

Contents of Volume 2

Contents of Volume 3

Contents of Volume 4

Chapter 1. Purpose and Need for Action

1.1 Introduction

The National Forest Management Act of 1976 (Public Law 94-588) requires the preparation of an integrated land management plan by an interdisciplinary team for each unit of the National Forest System. The Forest Service began using new planning regulations (2012 Planning Rule) to guide collaborative and science-based revision of land management plans that promote the ecological integrity of national forests while contributing to social and economic sustainability. Public involvement must be provided in preparing and revising land management plans. Land management plans must provide for multiple use and sustained yield of products and services, and include coordination of outdoor recreation, range, timber, watershed, fish, wildlife, and designated areas such as wilderness. The land management plan does not authorize site-specific projects or activities; rather, it establishes overarching direction to guide future project and activity decision making.

The Custer National Forest and the Gallatin National Forest were consolidated in 2014 into the Custer Gallatin National Forest. Prior to the official combination, each national forest had its own land management plan.

The forest plan revision process began with preparation of an assessment that summarized the current status and management of various resources on the Custer Gallatin National Forest. The Final Assessment of Existing Conditions was published in February 2017. This assessment evaluated existing information about relevant ecological, economic, and social conditions, trends, and sustainability, as well as their relationship to the land management plan within the context of the broader landscape. This information was used to identify any need for change in forest resources or in the management of those resources, and as a basis for preparing a proposed plan (proposed action) that was released for public review and comment (scoping) in early 2018. The scoping comments were used to make changes to the proposed plan and to develop alternatives that were analyzed in a draft environmental impact statement released for public review and comment in March 2019. In response to public comments and internal Forest Service review, the national forest staff refined the plan direction and the analysis in the final environmental impact statement.

This final environmental impact statement documents a programmatic National Environmental Policy Act review. It discloses the broad environmental impacts and benefits of the proposed alternatives, in contrast to analyses conducted for site-specific projects. This document describes, in general terms, the expected effects of management during the plan period, but does not predict the site-specific effects of future speculative actions each time the standards and guidelines are implemented at the project level. Those site-specific effects would be disclosed in subsequent National Environmental Policy Act reviews during the implementation of individual projects.

1.2 Proposed Action

The Forest Service proposes to revise the 1986 Custer Land and Resources Management Plan (approved in June 1987) and the 1987 Gallatin Forest Plan in compliance with the National Forest System land management planning rule (36 Code of Federal Regulations (CFR) 219).

The purpose and need for the proposed action is to: create one, unified land management plan (hereinafter referred to as the "plan," "forest plan," "revised forest plan," or "land management plan") for the Custer Gallatin National Forest; address gaps in current plan direction; address changes in ecological, social, and economic conditions; and comply with the 2012 Planning Rule as well other laws, policies, regulations, and Forest Service direction adopted since 1986.

On January 3, 2018, the Custer Gallatin National Forest released a proposed plan (the proposed action) with a notice of intent to prepare an environmental impact statement in the Federal Register. The notice of intent initiated the scoping process, which guides the development of the environmental impact statement. The Custer Gallatin National Forest received over 10,000 public comments on the proposed action during the 60-day comment period. Based upon the issues identified during the scoping process on the proposed action, the Custer Gallatin prepared and published a draft revised plan and draft environmental impact statement, with a notice of availability in the Federal Register on March 8, 2019. This publication of the notice of availability of the draft documents in the Federal Register began the public comment period on the draft forest plan and draft environmental impact statement. Over 21,000 comments were received during the 90-day comment period. The public comments and responses by the Custer Gallatin staff improved the analysis in the final environmental impact statement by refining the plan direction, refining the analysis, and aiding the forest supervisor in developing the draft record of decision.

Additional documentation, including more detailed analysis of project area resources, public involvement information and background information for the resource analyses may be found at the Custer Gallatin National Forest Supervisor's Office.

1.3 Document Organization

The Custer Gallatin National Forest Final Environmental Impact Statement is organized into five documents:

- Volume 1
    - Chapter 1: Purpose and Need, Proposed Action, and Decision Framework
    - Chapter 2: Public Involvement, Issues and Alternatives
    - Chapter 3: Affected Environment and Environmental Consequences (part 1)
- Volume 2
    - Chapter 3: Affected Environment and Environmental Consequences (part 2)
    - Chapter 4: Other Disclosures, Preparers, and Distribution of the Environmental Impact Statement
    - Glossary of Terms Used in the Analysis
    - Literature Cited in the Affected Environment and Environmental Consequences
- Volume 3
    - Appendix A Maps
    - Appendix B Vegetation and Timber Analysis Process
    - Appendix C Species of Conservation Concern Plan Components, Sensitive Species Lists and Plan Components
    - Appendix D Recommended Wilderness Analysis
    - Appendix E Compatibility of the Plan with Relevant Plans of Other Public Agencies
    - Appendix F. Climate Change Vulnerabilities and Adaptation Strategies

- Volume 4: Appendix G Responses to Public Comments on the Draft Environmental Impact Statement and Revised Forest Plan

1.4 The Planning Area

The Custer Gallatin National Forest (the planning area) encompasses over 3 million acres in southern Montana and the northwestern corner of South Dakota. Stretching over 400 miles from its westernmost to its easternmost boundaries, the Custer Gallatin is highly diverse ecologically, socially, economically, and culturally.

The Custer Gallatin National Forest consists of two individual proclaimed national forests: the Custer National Forest and the Gallatin National Forest. In 2014, the two national forests were combined to be administratively managed as one national forest. For ease of discussion throughout this document, the Custer Gallatin National Forest will also be referred to as the Custer Gallatin or the national forest when referencing the single administrative unit, the staff that administers the unit, or the National Forest System lands within the unit. The consolidated Custer Gallatin continues to operate with the forest plans developed for each national forest in the 1980s, as amended.

The national forest includes portions of 11 counties (Carbon, Carter, Gallatin, Madison, Meagher, Park, Powder River, Rosebud, Stillwater, and Sweet Grass Counties in Montana and Harding County in South Dakota). The Custer Gallatin is administered in seven ranger districts, with offices located in Camp Crook, South Dakota, and in Ashland, Red Lodge, Livingston, Gardiner, Bozeman, and West Yellowstone, Montana. The supervisor's office is in Bozeman, and an office is in Billings, Montana.

The Custer Gallatin National Forest includes lands on the northern end of the Greater Yellowstone Area, and several island mountain ranges. Individual places across the Custer Gallatin National Forest have unique characteristics and conditions; referred to as "geographic areas," these places define a landscape people associate with the national forest. The Custer Gallatin determined geographic areas using distinct land masses of the national forest, coupled with a sense of place with meaning to the public. While Ashland and the Pryor Mountains are separate geographic areas, the eight individual land units of the Sioux District are grouped into one geographic area. Because the Bridger, Bangtail, and Crazy Mountains are in close proximity, they are grouped into one geographic area. The Greater Yellowstone Area lands south of Interstate 90 are divided into two geographic areas at the Yellowstone River, because one geographic area would be such a large area it begins to lose a distinctive sense of place. Figure 1 displays the six geographic areas, and table 1 displays the acres of the national forest by geographic area.

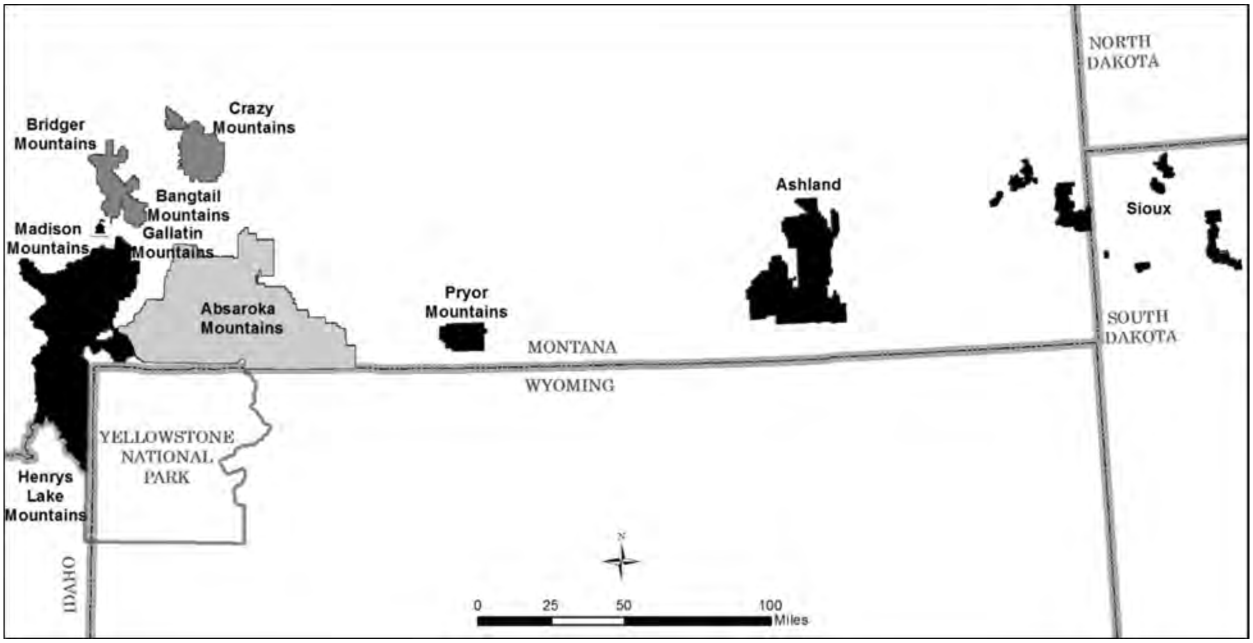

Figure 1. Location of the Custer Gallatin National Forest and geographic areas

Table 1. Acres within the six geographic areas on the Custer Gallatin National Forest

Geographic Area (GA)	Total Acres (All Ownerships)	National Forest System Acres within GA	Percentage of GA in National Forest System Lands
Sioux	176,973	164,460	93
Ashland	501,797	436,134	87
Pryor Mountains	77,944	75,067	96
Absaroka Beartooth Mountains	1,387,707	1,358,541	98
Bridger, Bangtail, and Crazy Mountains	314,598	205,148	65
Madison, Henrys Lake, and Gallatin Mountains	953,001	806,615	85

1.5 Purpose and Need for Action

The purpose of the proposed action is to revise the 1986 Custer and 1987 Gallatin Forest Plans and to provide an integrated set of plan direction for social, economic, and ecological sustainability, and multiple uses of the Custer Gallatin lands and resources.

Changes in the current plans are needed to address requirements of the 2012 Planning Rule, findings from the assessment, changes in conditions and demands since the 1986 and 1987 forest plans, and public concerns. The revised forest plan is an outcome of collaboration with Tribes, State and local governments, other Federal agencies, and public involvement.

In the 30 plus years since the current forest plans were developed: (1) the two national forests have been combined administratively to be managed as a single national forest, (2) demographics have shifted, (3) new threats have emerged, (4) new Forest Service planning regulations have been adopted, and (5) new laws and policies have been adopted. Four broad categories described below relate to the need to change. Taken together, the changes related to these four categories will result in substantial changes to the current plans. The Preliminary Need to Change the Existing Custer and Gallatin Forest Plans (February 2017) describes each category, with examples, in more detail:

1. Address gaps in current plan direction, shifting demographics, and new threats that have emerged.
    - Population growth near the national forest has increased demands for additional recreation opportunity and access to the national forest
    - Plan direction reflecting the Custer Gallatin National Forest's role in supporting local economies through both commodity production, including timber, permitted grazing, mining and other multiple-uses, and the service-based economy that includes recreation and tourism
    - Plan direction reflecting the Custer Gallatin National Forest's role in meeting the range of public recreation demands considering the social, environmental, fiscal, and regional context
    - Plan direction to prevent aquatic invasive species; neither current plan has direction related to this threat
    - Plan direction to mitigate disease (for example, white-nose syndrome in bats and white pine blister rust); current plans have no direction related to disease
    - The Forest Service acquired roughly 73,000 acres since the current plans were adopted, and there is a need to provide management direction for these lands
2. Create one, unified forest plan for the Custer Gallatin National Forest.
    - Depending on the resource or land use, either the Gallatin or the Custer Forest Plan may have flexible or prescriptive management direction. Each plan has unique delineations and descriptions of management areas. The number, arrangement, boundaries, and plan direction for the existing management areas in the current plans are challenging to apply to project-level activities. A unified plan replacing tactical, prescriptive language with strategic language is needed to provide more efficient project planning
    - Unified plan direction is needed for topics such as wildland fire management, watershed management, scenery management, and the recreation opportunity spectrum
3. Comply with the 2012 Planning Rule and associated directives.
    - Direction is needed to address social, economic, and ecological sustainability and multiple uses
    - Direction guided by new information and science is needed to address impacts reasonably expected to occur as a result of climate change
    - Identify areas to be managed under plan land allocations including recommended wilderness and eligible wild and scenic rivers
4. Reflect new laws, policies, regulations, and Forest Service direction adopted since 1986.

Revision is also needed because the current plans are beyond the 10- to 15-year duration provided by the National Forest Management Act (16 United States Code (U.S.C.) 1606(e) (5) (A)).

1.6 Decision Framework

The 2012 Planning Rule specifies nine primary decisions to be made in forest plans:

- Forestwide components to provide for integrated social, economic, and ecological sustainability, and ecosystem integrity and diversity, while providing for ecosystem services and multiple uses. Components must be within Forest Service authority and consistent with the inherent capability of the national forest (36 CFR 219.7 and 219.8–219.10)
- Recommendations to Congress (if any) for lands suitable for inclusion in the National Wilderness Preservation System and rivers eligible for inclusion in the National Wild and Scenic Rivers System (36 CFR 219.7(c)(2)(v) and (vi))
- The plan area's distinctive role and contributions within the broader landscape
- Identification or recommendation (if any) of other designated areas (36 CFR 219.7(c)(2)(vii)
- Identification of suitability of areas for the appropriate integration of resource management and uses, including lands suited and not suited for timber production (36 CFR 219.7(c)(2)(vii) and 219.11)
- Identification of the maximum quantity of timber that may be removed from the national forest (36 CFR 219.7(c)(2)(ix) and 219.11 (d)(6))
- Identification of geographic area- and management area-specific components (36 CFR 219.7(d)).
- Identification of watersheds that are a priority for maintenance or restoration (36 CFR 219.7(f)(i))
- Plan monitoring program (36 CFR 219.7 (c)(2)(x) and 219.12

The forest supervisor is the responsible official for the revised forest plan. After reviewing the results of the analysis evaluated in the final environmental impact statement, the responsible official will issue a record of decision, in accordance with agency decision-making procedures (40 CFR 1505.2) that will:

- disclose the decision (identifying the selected alternative) and reasons for the decision,
- discuss how public comments and issues were considered in the decision, and
- discuss how all alternatives were considered in reaching the decision, specifying which one is the environmentally preferable alternative (defined in 36 CFR 220.3)

The forest plan includes recommendations for areas that can only be designated by statute, such as wilderness. The forest plan provides integrated plan direction for managing the national forest for approximately the next 15 years. However, even after approval of the plan, project-level environmental analysis will still need to be completed for specific proposals to implement the direction in the forest plan. Forest plans do not make budget decisions. Should Congress emphasize specific programs by appropriation, a redistribution of priorities would follow, regardless of the alternative implemented.

1.7 Relationship to Other Entities

The 2012 Planning Rule (36 CFR 219.4(b)) requires the review of the planning and land use policies of other Federal agencies, State and local governments, and American Indian Tribes. The Custer Gallatin staff consults with 19 American Indian Tribes to gauge interest and issues for the forest plan revision. The national forest established an "Intergovernmental Working Group" for city, county, State, Federal, and Tribal representatives with webinars several times a year that focus on current planning topics. District rangers periodically brief county commissioners at county commission meetings. Forest planners brief the Custer Gallatin Working Group at its monthly meetings and have met as requested with individuals and interest groups.

The national forest notified all members of the Intergovernmental Working Group of the opportunity to participate as a cooperating agency in forest plan revision, and the topic was the subject of an Intergovernmental Working Group webinar in January 2018. Four agencies requested cooperating agency status, and formal agreements have been executed for these four agencies:

- Park County, Montana
- Sweet Grass County, Montana
- South Dakota Department of Game, Fish and Parks
- The State of South Dakota, represented by the South Dakota Department of Agriculture

The Forest Service reviewed the relevant planning and land use policies of other public agencies to understand and consider those agencies' objectives. The Forest Service is not required to ensure that a Forest Service land management plan is in accord with Tribal, State, or local resource and land management plans. In the course of considering those agencies' objectives, however, the Forest Service considers ways the land management plan could contribute to common objectives, address impacts, resolve or reduce conflicts, and contribute to compatibility between Forest Service and other agencies' plans.

Appendix E of this environmental impact statement displays the compatibility review of 11 county growth policies and county comprehensive plans, the City of West Yellowstone Growth Policy, City of Bozeman plans, State forest action plans, State wildlife action plans, statewide fisheries plans, statewide comprehensive outdoor recreation plans, Bureau of Land Management (BLM) resource management plans, the Yellowstone National Park Foundation Document, and land management plans of adjacent national forests. Cooperating agencies contributed the review of plans within their jurisdictions. Individual sections of the final environmental impact statement may evaluate additional plans.

1.8 Forest Service Planning

Forest Service planning takes place at different organizational levels and geographic scales. Planning occurs at three levels—national strategic planning, National Forest System unit planning, and project or activity planning. The Chief of the Forest Service is responsible for national planning, such as preparation of the Forest Service strategic plan that establishes goals, objectives, performance measures, and strategies for managing the national forests. National forest unit planning results in the development, amendment, or revision of a land management plan, such as the Custer Gallatin Plan. The supervisor of the national forest is the responsible official for developing and approving a plan, plan amendment, or plan revision for lands under the responsibility of the supervisor. The forest supervisor or district ranger is the responsible official for project and activity planning (36 CFR 219.2).

1.8.1 National Strategic Planning

The U.S. Department of Agriculture (USDA) Forest Service Strategic Plan: Fiscal Years 2015–2020 contains four outcome-oriented goals for the Forest Service, each with strategic objectives. The strategic plan can be accessed online (www.fs.fed.us/strategicplan). The first two goals and related objectives are directly related to the current planning effort:

- Sustain our Nation's forests and grasslands
- Foster resilient, adaptive ecosystems to mitigate climate change

- Mitigate wildfire risk
- Conserve open space
- Deliver benefits to the public
- Provide abundant clean water
- Strengthen communities
- Connect people to the outdoors.

The Forest Service continues to use the results of the 2010 Resources Planning Act Assessment, a report on the status and projected future trends of the Nation's renewable resources on all forests and rangelands, as required by the 1974 Forest and Rangeland Renewable Resources Planning Act. The assessment includes analyses of forests, rangelands, wildlife and fish, biodiversity, water, outdoor recreation, wilderness, urban forests, and the effects of climate change on these resources. The assessment provides a snapshot of current United States forest and rangeland conditions (all ownerships), identifies drivers of change for natural resource conditions, and projects the effects of those drivers on resource conditions 50 years into the future. This assessment uses a set of future scenarios that influence the resource projections, allowing the exploration of a range of possible futures for renewable natural resources. Alternative future scenarios were used to analyze the effects of human and environmental influences on forests and rangelands, including population growth, domestic and global economic growth, land use change, and climate change.

In addition, the USDA strategic plan for fiscal years 2018 through 2022 has specific goals that also align with the 2012 Planning Rule, including (1) facilitate rural prosperity and economic development, and (2) ensure productive and sustainable use of National Forest System lands. The USDA strategic plan can be accessed on the USDA's website (www.usda.gov).

1.8.2 National Forest System Unit Planning

The National Forest Management Act of 1976 (Pub. L. 94-588) amended the Forest and Rangeland Renewable Resources Planning Act of 1974. The National Forest Management Act requires the preparation of an integrated land management plan by an interdisciplinary team for each unit of the National Forest System (national forests and grasslands). The public must be involved in preparing and revising land management plans, also called forest plans. Forest plans must provide for multiple use and sustained yield of products and services and include coordination of outdoor recreation, range, timber, watershed, fish, wildlife, and designated areas such as wilderness. The forest plan does not authorize site-specific prohibitions or activities; rather, it establishes overarching direction to guide future project and activity decision making.

The 2012 Planning Rule for Land Management Planning for the National Forest System sets forth process and content requirements to guide the development, amendment, and revision of land management plans to maintain and restore National Forest System land and water ecosystems while providing for ecosystem services (the benefits people obtain from the National Forest System planning area) and multiple uses. The final planning directives, effective January 30, 2015, are the key agency guidance documents that direct implementation of the 2012 Planning Rule.

1.8.3 Project and Activity Planning Consistency and Transition to the Revised Plan

As required by National Forest Management Act and the Planning Rule, subject to valid existing or statutory rights, all projects and activities authorized by the Forest Service after approval of this plan must be consistent with the applicable plan components (16 U.S.C. 1604(i)) as described at 36 CFR 219.15. Projects and activities approved before the revised plan's approval are not required to meet the direction of the revised plan and will remain consistent with the direction in the 1986 and 1987 forest plans, as amended.

All project or activity approval documents, made after the effective date of the plan, will describe how the project or activity is consistent with the applicable components of the forest plan. When a proposed project or activity would not be consistent with the applicable plan components, the responsible official shall take one of the following steps, subject to valid existing rights:

1. Modify the proposed project or activity to make it consistent with the applicable plan components
2. Reject the proposal or terminate the project or activity
3. Amend the plan so that the project or activity will be consistent with the plan as amended
4. Amend the plan contemporaneously with the approval of the project or activity so that the project or activity will be consistent with the plan as amended. This amendment may be limited to apply only to the project or activity.

Resource plans (for example, travel management plans) developed by the national forest that apply to the resources or land areas within the planning area must be consistent with the plan components. Resource plans developed before this plan decision will be evaluated for consistency with the plan and updated, if necessary, through site-specific National Environmental Policy Act decision making.

Authorizations for occupancy and use made before this plan approval may proceed unchanged until time of reauthorization. At time of reauthorization, all permits, contracts, and other authorizing instruments must be made consistent with the land management plan, subject to valid existing or statutory rights, as provided at 36 CFR 219.15(d).

Chapter 2. Alternatives

2.1 Introduction

This chapter describes and compares the alternatives the responsible official considered for the revised plan. It includes a discussion of how the alternatives were developed, issues raised, descriptions and comparisons of the alternatives, and alternatives that were not considered in detail. Numbers such as acres, miles, and volumes are approximate due to the use of geographic information systems (GIS) data and rounding. Small discrepancies may result from rounding.

Chapter 2 presents the alternatives in comparative form, providing a clear basis for choice among options by the decision maker. Chapter 3, "Affected Environment and Environmental Consequences," summarizes the information used to compare alternatives and contains the detailed basis used to measure the potential environmental consequences of each of the alternatives.

2.2 Alternative Development

As discussed in chapter 1, this forest plan revision effort is based on the requirements of the 2012 Planning Rule, findings of the forest assessment, changes in conditions and demands since the 1986 and 1987 forest plans, and public concerns. A list of significant issues was identified from the public involvement period, and some of these issues drove the development of alternatives. Some additional items, such as the Wild and Scenic River eligibility study and the wilderness inventory and evaluation, are addressed in the revision because they are required by planning regulations (such as, 36 CFR 219.17(3)(b)(1)).

The Council on Environmental Quality regulations, with respect to the National Environmental Policy Act procedures and specifically the aspect related to alternative development (36 CFR 40 1502.14), are fundamental to the process. This section of the Code of Federal Regulations reads as follows:

> This section is the heart of the environmental impact statement. Based on the information and analysis presented in the sections on the affected environment (1502.15) and the environmental consequences (1502.16), it should present the environmental impacts of the proposal and the alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice among options by the decision maker and the public. In this section agencies shall:
>
> a. Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives that were eliminated from detailed study, briefly discuss the reasons for elimination
> b. Devote substantial treatment to each alternative considered in detail, including the proposed action, so that reviewers may evaluate their comparative merits
> c. Include reasonable alternatives not within the jurisdiction of the lead agency
> d. Include the alternative of no action (which represents the current plans)
> e. Identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference
> f. Include appropriate mitigation measures not already included in the proposed action or alternatives.

All reasonable alternatives to the proposed action must meet the purpose and need for change and address one or more of the significant issues. Not all possible alternatives were carried into detailed study, because the list of options would have been prohibitively large. Instead, the responsible official identified those alternatives that met the criteria and created a reasonable range of outputs, direction, costs, management requirements, and effects from which to choose.

Revised plan alternatives represent a range of possible management options. Information presented here and in chapter 3 provides the basis from which to evaluate the comparative merits of the alternatives. Each alternative emphasizes specific land and resource uses and deemphasizes other uses in response to the significant issues.

Alternative A (often referred to as the current plans in this document) is the no-action alternative, which reflects the 1986 and 1987 forest plans as amended to date, and accounts for current laws, regulations, and terms and conditions from biological opinions. Alternative B was released for public review and comment as the proposed action, and was subsequently updated in response to public comment and internal Forest Service review. Development of alternatives C, D, and E was driven by issues identified during scoping. Alternative F was developed after consideration of comments on the draft plan and draft environmental impact statement, and represents the preferred alternative.

2.3 Public Involvement

The Custer Gallatin Forest Plan revision process was publicly launched in January 2016, with email announcements, a press release, social media, and website information. A Federal Register notice of initiation for the Assessment of the Custer Gallatin National Forest was published February 4, 2016. The forest plan revision team held 15 public meetings in February and March 2016, to explain forest plan revision; to describe the scope and scale of the national forest; and to gather local knowledge and information, current trends, conditions, perceptions, and concerns.

A second set of meetings during the summer of 2016 shared information about results to date on the assessment process and early ideas of the need to change the existing forest plans. These meetings also provided a forum for people to share what they care about and what they want to see from the Custer Gallatin National Forest. A Draft Assessment Report and 25 draft, in-depth topical (specialist) reports were released for public review on November 30, 2016, and feedback was requested by January 6, 2017. The national forest received about 150 submissions from the public, plus approximately 600 letters asking that bison be identified as a species of conservation concern and a focal species. The plan revision team examined all feedback, and updated the assessment report and individual specialist reports as appropriate.

As planning moved into development of a proposed action, a third set of public meetings was held in early 2017, focusing on the distinctive roles and contributions of the Custer Gallatin and on developing desired conditions. In summer 2017, public feedback was requested on the draft eligible Wild and Scenic Rivers and the Wilderness Inventory. Webinars provided an overview of both of these processes. A fourth set of meetings during the fall of 2017 gathered the public’s ideas on early plan components.

The notice of intent for the proposed action to prepare an environmental impact statement was published in the Federal Register on January 3, 2018. The notice of intent asked for public comment on the proposal for a 60-day period. The agency held 16 public meetings and 8 webinars to provide opportunities to better understand the proposed action, so that meaningful public comments could be provided by the end of the scoping period. The national forest received about 10,500 comments, of which about 1,000 were considered unique comments. Using the comments from the Tribes, public, other agencies, and organizations, the Custer Gallatin's interdisciplinary team developed a list of issues to address through changes to the proposed action, development of alternatives, or in analysis of impacts of the alternatives.

In April 2018, the Custer Gallatin shared a range of preliminary alternatives focused on recommended wilderness and other land management plan allocations. Many commenters were interested in land management plan land allocations. The maps were available online and the national forest hosted two public meetings for the public to review and provide feedback on the range of preliminary alternatives. The preliminary alternatives were revised in response to public feedback and further internal review.

A notice of availability for the draft revised plan and draft environmental impact statement was published in the Federal Register on March 8, 2019, for a 90-day comment period ending June 6, 2019. Information was widely available on various multimedia platforms including social media, the Custer Gallatin National Forest planning website, a forest planning series of 20-minute podcasts, hardcopy documents, and articles in numerous local and regional newspapers. The agency held 10 public meetings and 8 live webinars to help interested parties provide meaningful input.

The Custer Gallatin received over 21,000 comments, of which about 2,750 were unique. Comments were organized and aggregated into concern statements. The responses to the comments are in appendix F of the final environmental impact statement. The public comments and the interdisciplinary team's responses were essential in improving the final environmental impact statement and the plan.

A notice of availability for the draft record of decision, 2020 land management plan, and final environmental impact statement for the 2020 plan was published in the Federal Register on July 10, 2020, initiating a 60-day objection filing period. Eligible objectors filed 677 timely objections. Following an internal objection review, the Northern Regional Forester hosted objection resolution meetings on November 17, 18, and 19, 2020. The Northern Regional Forester's response to the objections was released on April 15, 2021.

2.4 Issues

Issues highlight effects or unintended consequences that may occur from the proposed action or alternatives, giving opportunities during the analysis to reduce adverse effects and compare trade-offs for the decision maker and public to understand. Issues were identified through scoping. Significant issues were defined as those that are directly or indirectly caused by implementing the proposed action, involve potentially significant effects, and could be meaningfully and reasonably evaluated and addressed within the programmatic scope of a land management plan. Some issues are best resolved at finer scales (subsequent environmental analysis) where the site-specific details of a specific action and resources it affects can be meaningfully evaluated and weighed. Conversely, some issues have already been considered through broader programmatic environmental analysis (such as the Northern Rockies Lynx Management Direction Final Environmental Impact Statement). In these cases, the issues focus on evaluating the effects unique to and commensurate with the decisions being considered here.

In many cases, plan direction was revised in response to comments, and the revised direction is included in all of the revised plan alternatives.

Revised plan alternatives were developed around significant issues that involved unresolved conflicts concerning alternative uses of available resources (40 CFR 1500.2(e)). The Custer Gallatin National Forest identified the following significant issues during scoping that drove alternative development.

2.4.1 Issues that Drove Alternatives

Forest Plan Land Allocations and Allowed Uses

The allocation of recommended wilderness areas was a primary issue for many of the public commenters. Public comments regarding recommended wilderness areas ranged from commenters asking the national forest to consider all existing inventoried roadless areas for recommended wilderness areas, or to include all possible lands from the wilderness inventory. At the other end of the spectrum, commenters desired no recommended wilderness areas. Many commenters recommended considering additions, boundary modifications, or deletions to specific areas that were identified in the proposed action. Commenters also suggested types of uses they wished to be allowed or not allowed in recommended wilderness areas.

The proposed action included seven backcountry areas, with direction to maintain the generally undeveloped or lightly developed character of these areas. Public comments proposed additional backcountry areas, different boundaries, and different allowed uses in backcountry areas.

The proposed action included eight recreation emphasis areas; these areas offer a variety of quality recreation opportunities for a wide range of recreationists and challenges to a wide range of skills. Public comments proposed additional recreation emphasis areas, different boundaries, and different allowed uses in recreation emphasis areas.

In addition to the issue of the amount and location of recommended wilderness areas and backcountry areas, a primary concern of many public comments was whether to allow motorized and mechanized transport (such as bicycles) within these areas. Comments included those in favor of prohibiting motorized and mechanized transport within recommended wilderness areas or certain backcountry areas, as well as those that desire to continue these uses unless the recommended wilderness areas are formally designated by Congress. Some motorized recreationists do not want to see further restrictions on motorized transport. The mountain bike community was concerned about the potential loss of access to areas that they currently use, or requested additional areas be available for mountain biking use. To address these public concerns, alternatives vary in whether motorized or mechanized transport is suitable in recommended wilderness area, and alternatives vary in the configuration of recommended wilderness area boundaries to include or exclude certain trails that allow motorized or mechanized transport. Alternatives vary in whether motorized or mechanized transport is suitable in the Pryor Mountain Backcountry Areas, and whether mechanized transport is suitable in the Bad Canyon Backcountry Area.

Some commenters requested more motorized transport opportunities. The recreation opportunity spectrum is a classification tool Forest Service managers use to provide visitors with varying challenges and outdoor experiences. The recreation opportunity spectrum classifies National Forest System lands into six management class categories defined by setting and the probable recreation experiences and activities it affords including: urban, rural, roaded natural, semi-primitive motorized, semi-primitive non-motorized, and primitive. The classification varies by alternative in concert with the varying land management plan allocations; with alternatives varying in the amount of motorized recreation opportunity spectrum acreage.

While not a topic of high public interest, inclusion of the Stillwater Complex as a plan land allocation varies by alternative as needed to be consistent with the overall theme of an alternative.

Measurement indicators:

- number of recommended wilderness areas, acres of recommended wilderness areas, uses suitable or not suitable in recommended wilderness areas, miles of motorized and mechanized trails no longer suitable in recommended wilderness areas, and acres of winter motorized recreation opportunity no longer suitable in recommended wilderness areas
- number of backcountry areas, acres of backcountry areas, uses suitable in backcountry areas, miles of motorized and mechanized trails no longer suitable in backcountry areas and acres of winter motorized recreation opportunity no longer suitable in backcountry areas
- number of recreation emphasis areas and acres of recreation emphasis areas
- inclusion of the Stillwater Complex allocation
- acres in each recreation opportunity spectrum class.

Wildlife: Bison, Bighorn Sheep, and Connectivity

Many commenters desired that bison and bighorn sheep be designated as species of conservation concern or focal species. Commenters also provided feedback on plan direction for bison and bighorn sheep. While the designation of any species as a species of conservation concern cannot vary by alternative, bison plan direction varies by alternative to reflect tradeoffs between management for wildlife or livestock.

Commenters identified substantial declines in bighorn sheep populations and distribution, including extirpation from parts of the national forest. Commenters were concerned about potential disease transmission from domestic sheep and goats to bighorn sheep. To address these concerns, alternatives vary in their approach to permitted domestic sheep and goat grazing, to recreational goat packing, and to agency use of domestic sheep and goats for weed control.

The 2012 Planning Rule requires the revised plan to address connectivity; this topic was also a subject of public comments. All revised plan alternatives have forestwide plan components to address connectivity, and they vary by including “key linkage areas.”

Measurement indicators:

- level of proactive Forest Service management related to bison
- areas where permitted domestic sheep and goat grazing would be an allowed use
- areas where permitted recreational goat packing would be an allowed use
- areas where public recreational goat packing would be a suitable use
- areas where agency use of domestic sheep and goats for weed control would be an allowed use
- inclusion of key linkage areas.

Timber Harvest and Timber Production

Public commenters raised timber harvest and production as an issue. This topic includes identifying lands suitable for timber production, estimated volume outputs of timber, and timber harvest conducted both for timber production and for other purposes. The comments included requests to increase the amount of lands suitable for timber production, increase timber volume offered from National Forest System lands, and increase the number of acres treated with harvest. Conversely, other commenters requested that few or no lands be suitable for timber production, and that less timber harvest occurs on National Forest System lands.

Measurement indicators:

- acres suitable for timber production
- acres unsuitable for timber production where vegetation management, including timber harvest, is suitable for other purposes
- volume for projected timber sale quantity (PTSQ)
- volume for projected wood sale quantity (PWSQ)
- acres of projected vegetation management (both fuels and timber harvest).

Objectives

Commenters requested that objectives for many resources be increased, such as weed treatment or trail maintenance. An objective is a concise, measurable, and time-specific statement of a desired rate of progress toward a desired condition or conditions. More objectives, or a higher objective for a particular resource would mean a faster rate of progress to a desired condition, while fewer objectives or a lower objective would mean a slower rate of progress toward a desired condition. Objectives should be based on reasonably foreseeable budgets, and they are determined through a trend analysis of the past 3 to 5 years of national forest budgets. Therefore, if objectives for some resource desired conditions increase, objectives for other resource desired conditions would need to decrease. Alternatives vary objectives, consistent with the theme of that alternative, while maintaining constant budget assumptions across all alternatives. Objectives are expected minimum achievements and could be exceeded with additional funding, additional authorities, or partnership opportunities.

Measurement indicators:

- numerical objectives described in table 10, objectives by alternative.

Airfields

Many commenters desired that public recreational airfields be acknowledged as an allowed use of the national forest. Other commenters requested the use not be allowed. Alternatives vary on the locations where public recreational airfields are allowed.

Measurement indicators:

- acres suitable for airfields.

2.4.2 Issues that Did Not Drive Alternatives

Other issues were raised both internally and externally. In many cases, plan direction was revised in response to internal and external comments, and the revised direction is included in all the revised alternatives. While these issues did not drive the development of alternatives (other than aspects of issues described above), they are important elements of the analysis in this document.

These issues include but are not limited to:

- air quality
- soils
- water supply and quality
- riparian areas
- fisheries
- spread and control of invasive species (weeds and aquatic invasive species)
- role of fire management, including fire suppression, the identification of high-value resources, fire suppression, and wildland-urban interface considerations
- natural range of variation of vegetation conditions
- specific vegetation components (such as old growth, snags, and large trees)
- condition of specific plant species or types (whitebark pine, aspen, sagebrush, non-forested plant communities, spruce, and fir)
- carbon storage
- at-risk (federally listed threatened, endangered, proposed and candidate species and species of conservation concern) plant and animal species
- wildlife species diversity and persistence of species
- availability of certain wildlife species for hunting, trapping, viewing and other human uses
- areas of Tribal interest
- cultural and historical resources
- livestock grazing
- infrastructure (such as roads, trails, facilities, and dams)
- recreation special uses, outfitter guides, permitted recreation facilities and uses (such as ski areas, organizational camps, events, group use), developed and dispersed recreation
- scenic integrity objectives
- congressionally or administratively designated areas
- access and land status.

2.5 Alternatives

The range of alternatives developed and presented is based on an evaluation of the information gathered from public and internal comments and the purpose and need. While all alternatives provide a wide range of ecosystem services and multiple uses, some give greater emphasis to selected resources based on the theme of the alternative and response to revision topics.

The revised plan alternatives were developed based on the Custer Gallatin National Forest's assessment (2016); the need for change; desired conditions; implementation and monitoring of the current forest plans; public, agency, and Tribal input; comments received during the public scoping period; and comments on the draft revised plan and draft environmental impact statement. The alternatives represent a range of possible management options from which to choose. Each alternative emphasizes specific land and resource uses and de-emphasizes other uses in response to the revision topics. Some components may vary between alternatives to address the issues identified during scoping or the draft plan and draft environmental impact statement comment period (the description of the alternatives provides specific details). Plan direction for desired conditions, goals, standards, and guidelines typically remains constant for all revised plan alternatives, with the exceptions noted.

In addition to the no-action alternative (A) (often referred to as the current plans in this document) and the proposed action (B), which was modified based on public and internal comments, three additional alternatives (C, D, and E) were developed based on the identified scoping issues. A sixth alternative (alternative F) was developed in response to comments on the draft revised plan and draft environmental impact statement. The alternatives span the range of forest management practices and uses of available resources. The general theme and intent of each alternative is summarized below, in relationship to the issues that drove alternatives.

2.5.1 Changes Between Draft and Final

Changes between the draft and final EIS were incorporated to provide additional analysis or explanation in response to public and internal comments, analysis of alternative F, and technical corrections. The changes are qualitatively within the spectrum of alternatives and effects discussed in the draft EIS. In the beginning of each section of the final environmental impact statement, notable changes between the draft and final EIS and plan for that resource are indicated.

Maps and acreages were updated to reflect a new ownership layer that was available in July 2019. The new ownership layer incorporated recent land exchanges, the allocation of unpartitioned riparian acres, and needed corrections. The most recent data available were used in the 2020 final EIS, for instance, an updated trails layer. The same data sets were largely used for the final EIS and the final EIS. GIS acres were used for all analysis. Small mapping corrections apply to all applicable revised plan alternatives (for example, removing the Sheep Creek trailhead and access road from the Lionhead Backcountry Area in both alternatives E and F).

Changes in the wording of plan components occurred between the draft plan (March 2019) and the 2020 Plan (July 2020) for various reasons, including to improve clarity, and to respond to public and internal comments. Added plan direction for the OTO Ranch applies to alternatives B through F. Comparison of the draft plan with the 2020 Plan is necessary to fully understand all modifications.

The descriptions of the revised plan alternatives include alternative specific changes. In addition, in the draft plan, some plan components varied by alternative. Plan components that vary by alternative may be referred to as "draft plan" components in the analysis. The descriptions of the revised plan alternatives have been augmented to display plan component variations that no longer appear in the plan. The variation in objectives by alternative is displayed in table 10 (objectives by alternative).

2.5.1.1 Changes in Response to Objections

Following the 60-day objection period and subsequent objection response, additional changes and clarifications were made to the land management plan and final EIS. Changes in the wording of plan components between the 2020 Plan (July 2020) and the land management plan occurred for various reasons, including to respond to the regional forester's instructions, to respond to objections and agency review, and to improve clarity or consistency in plan component wording. Comparison of the 2020 forest plan with the land management plan is necessary to fully understand all modifications

Changes between the 2020 final EIS and final EIS were incorporated to provide additional analysis or explanation in response to the regional forester's instructions, to respond to objections and agency review, including changes made to alternative F, and technical corrections. The description of alternative F includes specific changes made in response to objections and mapping adjustments to provide more manageable boundaries.

The changes are qualitatively within the spectrum of alternatives and effects discussed in the draft and 2020 final EIS. Additional notable changes between the 2020 final EIS and the final EIS or in the plan are indicated in the beginning of applicable sections of final EIS Chapter 3.

2.5.2 Elements Common to All Alternatives

All alternatives adhere to the principles of multiple use and the sustained yield of goods and services required by the Code of Federal Regulations (36 CFR 219.1 (b)). All alternatives are designed to:

- meet laws, regulations, and policies
- contribute to ecological, social, and economic sustainability
- provide sustainable levels of products and services
- provide integrated direction as included in the plan components
- allow reasonable access and mineral development for private mineral rights (locatable mining claims, reserved and outstanding rights) and existing oil and gas leases on the national forest and consistent with subject laws and regulations
- retain the existing decisions for the Northern Rockies Lynx Management direction and Grizzly Bear Conservation Strategy direction
- manage the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area consistent with the Montana Wilderness Study Act of 1977 (unless released by Congress) and the 2001 Roadless Area Conservation Rule (Roadless Rule)
- retain all existing permitted activities and facilities
- do not make oil and gas leasing decisions
- do not make minerals withdrawal decisions

2.5.3 Elements Common to All Revised Plan Alternatives

In addition, under the revised plan alternatives:

- Plan direction would be consistent with the 2012 Planning Rule and associated directives, and emphasize adaptive management, and consider the best available scientific information.
- Plan direction would meet the purpose and need for change and address one or more significant issues.
- Plan direction would provide direction that is consistent with the travel planning rule and the existing travel plans, except where suitability for motorized recreation and mechanized recreation varies by revised plan alternatives. Site-specific travel decisions needed to bring travel plans into compliance with the revised forest plan would occur through site specific NEPA decision making subsequent to the revised forest plan decision.
- Designations and plan components would remain constant for designated wilderness; the designated East Rosebud Wild and Scenic River; Pryor Mountain Wild Horse Territory; research natural areas; special areas; national natural landmarks; the Earthquake Lake Geologic Area; national scenic, historic, and recreation trails; and the Beartooth Highway.
- Thirty eligible wild and scenic rivers and their plan components would remain constant.
- A range of options would be provided if Congress were to release the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area. Inventoried roadless area direction would continue to apply in this area.
- Plan components that provide the ecological conditions to support the persistence of species of conservation concern remain constant for all revised plan alternatives. Regional forester sensitive species and management indicator species would no longer be in place under the revised plan alternatives.

2.5.4 Alternative A – No Action (the Current Plans)

Alternative A, the no-action alternative, is also referred to as the current plans throughout this document. Alternative A reflects current direction under the 1986 and 1987 forest plans, as amended, and provides the basis for comparing alternatives to current management and levels of output. Alternative A does not address some of the elements associated with the 2012 Planning Rule, such as the natural range of variation of vegetation conditions, habitat connectivity or the conservation watershed network. The Council on Environmental Quality regulations (40 CFR 1502.14d) requires that a "no action" alternative be analyzed in every environmental impact statement. This does not mean that nothing would occur under alternative A. The current conditions as described by each resource in chapter 3 would continue. Under this alternative, current management plans would continue to guide management of the national forest, and ongoing work or work previously planned and approved would occur under that guidance. Laws and regulations that have been adopted since the 1986 and 1987 plans will be analyzed as part of the no-action alternative (for example, the designation of inventoried roadless areas). With respect to the identified issues, the alternative is described as follows:

- There are seven recommended wilderness areas (Lost Water Canyon, Line Creek Plateau, Red Lodge Creek/Hellroaring, Mystic Lake, Burnt Mountain, Republic Mountain, and Lionhead).

- There are three “low development areas” in the Ashland Geographic Area (King Mountain, Cook Mountain, and the Tongue River Breaks), similar to the backcountry areas proposed in the revised plan alternatives.
- There are plan land allocations for travel corridors with heavy recreation use (portions of the Gallatin Canyon, Boulder River, Yankee Jim Canyon of the Yellowstone River, highway U.S. 212 in the Cooke City vicinity, highways U.S. 191 and U.S. 287 in the West Yellowstone vicinity, and areas adjacent to Hebgen Lake and Hyalite Reservoir, as well as most access corridors to developed recreation sites on the former Custer National Forest).
- The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area would continue to be managed consistent with the Montana Wilderness Study Act of 1977 and the 2001 Roadless Rule. In alternative A, the current Gallatin Forest Plan, Gallatin Travel Plan, and inventoried roadless area direction would apply if Congress were to release the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area.
- There are plan land allocations for minerals activity.
- Existing motorized and mechanized transport is suitable in all areas currently suitable. Mechanized transport is suitable in the Lionhead Recommended Wilderness Area.
- Eleven eligible wild and scenic rivers are managed to continue their protection of identified outstandingly remarkable values, tentative classifications, and free-flowing nature.
- No specific bison management direction is stated in the current forest plans, although the national forest would continue bison management in conjunction with partners under the Interagency Bison Management Plan.
- While no specific management direction is stated related to disease transmission to bighorn sheep from domestic sheep and goats, the Forest Service would follow current policies to only allow this use if a risk assessment indicates risk of disease transmission to bighorn sheep can be minimized.
- Lands suitable for timber production are based on the 1986 and 1987 plans as amended, with current regulations and policies. When consistent with other plan components, harvest for purposes other than timber production could occur on a subset of unsuitable lands.
- Plan objectives are based on national forest accomplishments from 2014 through 2017, and reflect a mix of resource enhancement, timber and wood products volume, hazardous fuel treatment, road, trail and facility maintenance, and new recreation facilities.
- Airfields are allowed in certain areas, subject to Forest Service permitting.

2.5.5 Alternative B

Alternative B was the proposed action in the draft environmental impact statement. It is the result of public engagement efforts since 2016, and represents a mix of recommended wilderness areas, backcountry areas, recreation emphasis areas, and lands identified as suitable for timber production. With respect to the identified issues, the alternative is described as follows:

- There would be nine recommended wilderness areas (Lost Water Canyon, Line Creek Plateau, Timberline (formerly termed Red Lodge/Hellroaring), Mystic Lake, Republic Mountain, Gallatin Crest, Sawtooth, Taylor Hilgard, and Lionhead).

- There would be nine backcountry areas (King Mountain, Cook Mountain, the Tongue River Breaks, Punch Bowl, Big Pryor, Bear Creek, Bad Canyon, Buffalo Horn, and Cowboy Heaven).
- There would be eight recreation emphasis areas (Main Fork Rock Creek, Boulder River, Cooke City Winter, Yellowstone River, Hyalite, Gallatin Canyon, Hebgen Lakeshore, and Hebgen Winter).
- The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area would continue to be managed consistent with the Montana Wilderness Study Act of 1977 and the 2001 Roadless Rule. If Congress were to release the wilderness study area, portions of the wilderness study area would have plan land allocations of recommended wilderness area, backcountry area, and recreation emphasis areas; a portion would be managed under inventoried roadless area direction without an additional land management plan allocation.
- There would be a Stillwater Complex allocation for minerals.
- Existing motorized and mechanized transport and continued use of existing commercial communication facilities would be suitable in recommended wilderness areas.
- Other uses would not be allowed in recommended wilderness areas, such as new use of cabins as recreation rentals, new recreation events such as races, and new commercial communication facilities; continued rental use of the Windy Pass cabin would not be allowable.
- Mechanized transport and existing motorized transport would continue to be suitable in backcountry areas where currently suitable. New recreation events would not be authorized in the Buffalo Horn Backcountry Area (also included in alternatives C and F).
- Mechanized transport (such as bicycles) would be suitable only on designated routes and areas in semi-primitive non-motorized recreation opportunity spectrum settings (also included in alternatives C, D, and E).
- New trails would not be prohibited in the Cook Mountain, King Mountain, and Tongue River Breaks Backcountry Areas (also included in alternatives C, D, and E).
- Plan components would support management of bison on the Custer Gallatin National Forest. In alternative B, the bison-related plan components that vary by alternative would be:
    - Guideline: To promote bison expansion within management zones, vegetation treatment projects and management actions taken to resolve bison-livestock conflicts should favor bison within these zones (also included in alternatives C, D, and F).
    - Guideline: To facilitate bison expansion into unoccupied, suitable habitat, management actions should not impede bison movement unless needed to achieve interagency bison population and distribution (also included in alternatives C and E).
- New permitted domestic sheep and goat grazing, and permitted and non-permitted recreational goat packing would not be allowed in the Madison, Henrys Lake, and Gallatin Mountains, the Absaroka Beartooth Mountains, and the Pryor Mountains Geographic Areas. Elsewhere on the national forest, permitted domestic sheep and goat grazing, and permitted recreational goat packing would be allowed only if a risk assessment indicated risk of disease transmission to bighorn sheep can be minimized. Forestwide, use of domestic sheep and goats for weed control would be allowed only if a risk assessment indicated that mitigation can effectively minimize disease transmission

between domestic sheep and goats and bighorn sheep. Additional conditions would apply inside grizzly recovery zone.

- In addition to forestwide plan components that address connectivity, key linkage areas with associated plan components would be included in the northern end of the Gallatin Mountains and the western and southern Bridger Mountains.
- Grizzly bear developed site guidance inside the recovery zone/primary conservation area would require the number and capacity of developed sites to be maintained at or below 1998 baseline levels.
- All lands not withdrawn from timber suitability due to legal or technical factors (for example, designated wilderness) would be suitable for timber production except for research natural areas, special areas, the Pryor Mountain Wild Horse Territory, the Continental Divide National Scenic Trail, recommended wilderness areas, backcountry areas, designated and eligible wild and scenic rivers, national natural landmarks, and riparian management zones. When consistent with other plan components, harvest for purposes other than timber production could occur on other lands not suitable for production.
- Plan objectives reflect a mix of resource enhancement, moving toward forested vegetation desired conditions, timber and wood products volume, hazardous fuel treatment, road, trail and facility maintenance, and new recreation facilities.
- Airfields would be suitable in certain areas, subject to Forest Service permitting.

Modifications to Alternative B

Alternative B (as published in the draft revised plan, March 2019) was modified so that the Bad Canyon Backcountry Area would be suitable for mechanized transport. In response to public comments, this change was made to more closely align the themes of alternatives B and C, with respect to suitability of mechanized transport.

2.5.6 Alternative C

Alternative C also represents a mix of recommended wilderness areas, backcountry areas, recreation emphasis areas, and lands identified as suitable for timber production. The alternative reflects the Gallatin Forest Partnership proposal for the Gallatin and Madison Mountains. The alternative reflects public input requesting backcountry areas for the Crazy Mountains, West Bridgers, and Blacktail Peak and public input for the uses in the Pryor Mountains Backcountry Areas. It omits most mountain biking trails from boundaries of the Lionhead Recommended Wilderness Area in response to public interest. With respect to the identified issues, the alternative is described as follows:

- There would be nine recommended wilderness areas (Lost Water Canyon, Line Creek Plateau, Timberline (formerly termed Red Lodge/Hellroaring), Mystic Lake, Republic Mountain, Gallatin, Cowboy Heaven, Taylor Hilgard, and Lionhead).
- There would be thirteen backcountry areas (King Mountain, Cook Mountain, the Tongue River Breaks, Punch Bowl, Big Pryor, Bear Creek, Bad Canyon, Hyalite, Buffalo Horn, West Pine, Crazy Mountains, West Bridgers, and Blacktail Peak). Suitable uses in some backcountry areas vary from alternative B.

- There would be eight recreation emphasis areas as listed for alternative B. The Hyalite Recreation Emphasis Area would be smaller in alternative C than alternative B.
- The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area would continue to be managed consistent with the Montana Wilderness Study Act of 1977 and the 2001 Roadless Rule. If Congress were to release the wilderness study area, the entire wilderness study area would continue to be managed as an inventoried roadless area. In alternative C, plan land allocations for nearly all of the wilderness study area would include recommended wilderness area, backcountry area, and recreation emphasis area; a portion would be managed under inventoried roadless area direction without an additional land management plan allocation.
- There would be a Stillwater Complex allocation for minerals.
- Motorized and mechanized transport and continued use of existing commercial communication facilities would not be suitable in recommended wilderness areas.
- Other uses would not be allowed in recommended wilderness areas, such as new recreation events and new commercial communication facilities. Continued rental use of the Windy Pass cabin would be suitable.
- Mechanized transport and existing motorized transport would continue to be suitable in backcountry areas where currently suitable, except motorized or mechanized transport would not be suitable in the Punch Bowl, Big Pryor, Bear Creek and Bad Canyon Backcountry Areas. The Punch Bowl, Big Pryor, and Bear Creek Backcountry Areas would not be suitable for vegetation management, including timber harvest, for purposes such as fuels reduction, restoration, or wildlife habitat enhancement.
- Mechanized transport (such as bicycles) would be suitable only on designated routes and areas in semi-primitive non-motorized recreation opportunity spectrum settings (also included in alternatives B, D, and E).
- New trails would not be prohibited in the Cook Mountain, King Mountain, and Tongue River Breaks Backcountry Areas (also included in alternatives B, D, and E).
- Plan components would support management of bison on the Custer Gallatin National Forest. In alternative C, the bison-related plan components that vary by alternative would be:
    - Guideline: To promote bison expansion within management zones, vegetation treatment projects and management actions taken to resolve bison-livestock conflicts should favor bison within these zones (also included in alternatives B, D, and F).
    - Guideline: To facilitate bison expansion into unoccupied, suitable habitat, management actions should not impede bison movement unless needed to achieve interagency bison population and distribution (also included in alternatives B and E).
- Plan components for new permitted domestic sheep and goat grazing, permitted and non-permitted recreational goat packing, and use of domestic sheep and goats for weed control would be the same as described in alternative B.
- In addition to forestwide plan components that address connectivity, key linkage areas with associated plan components would be included in the northern end of the Gallatin Mountains and the western and southern Bridger Mountains.

- Grizzly bear developed site guidance inside the recovery zone/primary conservation area would require the number and capacity of developed sites to be maintained at or below 1998 baseline levels.
- The criteria used for the timber suitability and availability determinations would be the same as described for alternative B; except the Buffalo Horn, Punch Bowl, Big Pryor, and Bear Creek Backcountry Areas would not be suitable for timber harvest.
- Plan objectives reflect a similar mix of activities as described in alternative B.
- Airfields would be suitable in certain areas, subject to Forest Service permitting.

Modifications to Alternative C

Alternative C was modified so that the Bad Canyon Backcountry Area would not be suitable for mechanized transport. In response to public comments, this change was made to more closely align the themes of alternatives B and C with respect to suitability of mechanized transport. In response to public comments, changes and additions were made to plan components and boundaries of several alternative C plan land allocations. To present a complete picture of the plan direction for these allocations, all unique plan components for these allocations in alternative C are displayed below, whether originally displayed in the draft revised plan or added to the final environmental impact statement alternative descriptions.

The draft plan's Hyalite Recreation Emphasis Area has been divided into a Hyalite Backcountry Area and a Hyalite Recreation Emphasis Area.

Unique plan components for the Hyalite Recreation Emphasis Area in alternative C would include:

- Objective: Per decade, one additional shoreline access day use area will be developed or converted from other developed recreation sites, such as campsites on the lakeshore (also included in alternatives B and F).
- Objective: Over the life of the plan, create two loop trail opportunities by developing additional trail connections and converting non-system trails (also included in alternative F).
- Standard: Construction and designation of new motorized trails shall not be allowed.
- Standard: Extraction of saleable mineral materials shall not be allowed.

Plan components for the Hyalite Backcountry Area would include:

- Desired Condition: The area provides for less developed, semi-primitive recreation opportunities, both motorized and nonmotorized, in both summer and winter.
- Desired Condition: Loop trail opportunities are available outside of the Hyalite Creek watershed.
- Standard: New permanent or temporary roads shall not be allowed.
- Standard: No new motorized trails shall be designated or constructed.
- Standard: No new motorized oversnow use areas shall be designated.
- Standard: In the Hyalite Creek watershed, no new trails shall be constructed to ensure the high peaks (Flanders, Mt. Bole, Divide Peak, Maid of the Mist) stay without system trails.

- Suitability: The Hyalite Backcountry Area is suitable for motorized transport on existing motorized trails and in existing motorized oversnow use areas. Mountain biking is suitable only on approved system routes.
- Suitability: The portion of the Hyalite Backcountry Area within the Wilderness Study Area boundary is not suitable for timber production or timber harvest.

Unique plan components for the Buffalo Horn Backcountry Area in alternative C would include:

- Standard: New permanent or temporary roads shall not be allowed (also included in alternative F).
- Standard: New recreation events shall not be authorized (also included in alternatives B and F).
- Standard: New motorized trails shall not be constructed or designated (also included in alternative F).
- Suitability: The backcountry area is not suitable for timber production or timber harvest.
- Suitability: The Buffalo Horn Backcountry Area is suitable for motorized recreation use on existing motorized trails and in existing motorized oversnow use areas. Mountain biking is suitable only on approved system routes. (Similar wording in alternatives B and F.)

Plan components for the West Pine Backcountry Area would include (components also included in alternative F):

- Desired Condition: Quiet, nonmotorized recreation opportunities predominate.
- Objective: Over the life of the plan, create at least one opportunity to enhance non-motorized trail connectivity by connecting existing trails to create loop rides or to connect to other parts of the trail network.
- Standard: New permanent or temporary roads shall not be allowed.
- Standard: New recreation events shall not be authorized.
- Suitability: The backcountry area is not suitable for motorized transport. The backcountry area is suitable for mechanized transport. Mountain biking is suitable only on approved biking routes.

An added plan component for the Taylor Hilgard, Cowboy Heaven, and Gallatin Recommended Wilderness Areas in alternative C:

- Guideline: To maintain areas of undeveloped wilderness characteristics, there should be no net increase in miles of system trails within recommended wilderness. However, trail re-routes for resource protection or after natural occurrences such as fire, floods, windstorms, and avalanches should utilize the best long-term sustainable routes with minimal trail infrastructure.

In alternative C, the key linkage area in the northern Gallatin Mountains omits Sections 28, 33; Township 3S 7E.

2.5.7 Alternative D

Alternative D was developed to address comments and themes of emphasizing natural processes and restoration. This alternative would be responsive to commenters who desire more undeveloped recreation opportunities, and a more prominent role for natural ecological processes. This alternative includes the greatest amount of recommended wilderness areas, higher objectives for restoration, and less land suitable for timber production. With respect to the identified issues, the alternative is described as follows:

- There would be 39 recommended wilderness areas (listed from the eastern geographic areas to the western geographic areas): Cook Mountain, King Mountain, Tongue River Breaks, Bear Canyon, Big Pryor, Crooked Creek-Lost Water Canyon, Punch Bowl, Chico Peak, Deckard Flats, Deer Creek, Dome Mountain, East Rosebud to Stillwater, Emigrant Peak, Knowles Peak, Line Creek Plateau, Mount Rae, Mystic, North Fork, Phelps Creek, Red Lodge Creek, Republic, Sheep Creek, Strawberry Creek, Tie Creek, West Fork Rock Creek, West Woodbine, Crazy Mountains, Blacktail Peak, West Bridger, Buck Creek, Cabin Creek North, Cabin Creek South, Cowboy Heaven, Gallatin, Lionhead, Spanish Peaks East, Spanish Peaks South, Taylor Hilgard, and Yankee Jim Lake.
- There would be one backcountry area (Chalk Buttes).
- There would be four recreation emphasis areas (Main Fork Rock Creek, Yellowstone River, Hyalite, and Gallatin Canyon). The Yellowstone River, Hyalite, and Gallatin Canyon recreation emphasis areas would be smaller in alternative D than in other alternatives.
- The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area would continue to be managed consistent with the Montana Wilderness Study Act of 1977 and the 2001 Roadless Rule. If Congress were to release the wilderness study area, the entire wilderness study area would continue to be designated as an inventoried roadless area. In alternative D, nearly the entire wilderness study area is proposed as recommended wilderness area.
- There would be no Stillwater Complex allocation for minerals, yet mining would continue in the area.
- Motorized and mechanized transport would not be suitable in recommended wilderness areas.
- Other uses would not be suitable in recommended wilderness areas, such as use of cabins as recreation rentals, new recreation events, and commercial communication facilities.
- Mechanized transport and existing motorized transport would continue to be suitable in the backcountry area.
- Mechanized transport (such as bicycles) would be suitable only on designated routes and areas in semi-primitive non-motorized recreation opportunity spectrum settings (also included in alternatives B, C, and E).
- New trails would not be prohibited in the Cook Mountain, King Mountain, and Tongue River Breaks Backcountry Areas (also included in alternatives B, C, and E).
- Plan components would support management of bison on the Custer Gallatin National Forest, including a year-round self-sustaining bison population on the national forest. In alternative D, the bison-related plan components that vary by alternative would be:
    - Desired Condition: Bison are present year-round with sufficient numbers and adequate distribution to provide a self-sustaining population on the Custer Gallatin National Forest.
    - Guideline: To promote bison expansion within management zones, vegetation treatment projects and management actions taken to resolve bison-livestock conflicts should favor bison within these zones (also included in alternatives B, C, and F).
    - Guideline: To facilitate bison expansion into unoccupied, suitable habitat, management actions should not impede bison movement.

- New permitted domestic sheep and goat grazing; permitted and public recreational goat packing; and use of domestic sheep and goats for weed control would not be allowed.
- Grizzly bear developed site guidance inside the recovery zone/primary conservation area would require the number and capacity of developed sites to be maintained at or below 1998 baseline levels.
- The criteria used for the timber suitability and availability determinations would be the same as described for alternative B.
- In addition to forestwide plan components that address connectivity, key linkage areas with associated plan components would be included in the northern end of the Gallatin Mountains and the western and southern Bridger Mountains.
- Plan objectives would emphasize resource enhancement, moving toward forested vegetation desired conditions, hazardous fuel treatment, and moving toward wilderness characteristics. Objectives would deemphasize road and trail maintenance, and new recreation facilities. This alternative proposes a lower timber and wood products volume.
- Airfields would not be suitable on the national forest.
- Plan components specific to alternative D that are not described above include:
    - Permitted Livestock Grazing Goal: When evaluating vacant livestock allotments, the Forest Service may emphasize allotment closure for accelerated ecological enhancement in areas of greatest conservation concern This includes, but not limited to proposed or established research natural areas or special areas, at-risk species habitat, under-represented reference areas, native species restoration areas, key linkage areas, conservation watershed networks, areas with opportunities for reduced risk of disease transmission between domestic and wild animals, or retention for forage reserves (grassbanks) or opportunities to enhance management or improve resources through combination with adjacent allotment(s). The Forest Service may de-emphasize use demand as a consideration in these types of conservation areas.
    - Continental Divide National Scenic Trail Suitability: The Continental Divide National Scenic Trail is not suitable for mountain biking where the trail is within recommend wilderness area.

2.5.8 Alternative E

Alternative E was developed to address comments and themes of higher human presence and use of the national forest, additional recreation emphasis areas, increasing timber production from National Forest System lands, additional motorized and mechanized transport opportunities, and not including any recommended wilderness areas. With respect to the identified issues, the alternative is described as follows:

- There would be no recommended wilderness areas.
- There would be two backcountry areas (Buffalo Horn and Lionhead).
- There would be twelve recreation emphasis areas (Main Fork Rock Creek, West Fork Rock Creek/Red Lodge Mountain, Boulder River, Cooke City Winter, Yellowstone River, Hyalite, the M, Bridger Winter, Storm Castle, Gallatin Canyon, Hebgen Lakeshore, and Hebgen Winter).

- The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area would continue to be managed consistent with the Montana Wilderness Study Act of 1977 and the 2001 Roadless Rule. If the wilderness study area were released by Congress, the entire wilderness study area would continue to be managed as an inventoried roadless area. In alternative E, the entire wilderness study area would become a backcountry area.
- There would be a Stillwater Complex allocation for minerals.
- Mechanized transport and existing motorized transport would continue to be suitable in backcountry areas where currently suitable. Additional opportunity for motorized and mechanized transport would be provided in the Buffalo Horn Backcountry Area. New recreation events could be authorized in the Buffalo Horn Backcountry Area.
- Mechanized transport (such as bicycles) would be suitable only on designated routes and areas in semi-primitive non-motorized recreation opportunity spectrum settings (also included in alternatives B, C, and D).
- New trails would not be prohibited in the Cook Mountain, King Mountain, and Tongue River Breaks Backcountry Areas (also included in alternatives B, C, and D).
- Plan components would support management of bison on the Custer Gallatin National Forest, but in a less proactive manner than other revised plan alternatives. In alternative E, the bison-related plan components that vary by alternative would be:
    - Guideline: To minimize impacts to livestock operations, vegetation treatment projects and management actions taken to resolve bison-livestock conflicts should favor livestock.
    - Guideline: To facilitate bison expansion into unoccupied, suitable habitat, management actions should not impede bison movement unless needed to achieve interagency bison population and distribution (also included in alternatives B and C).
- New permitted domestic sheep and goat grazing, permitted recreational goat packing, and use of domestic sheep and goats for weed control would be allowed only if a risk assessment indicated risk of disease transmission to bighorn sheep can be minimized. The use of public recreational goat packing would be suitable. Additional conditions would apply inside grizzly recovery zone.
- Forestwide plan components address connectivity; this alternative would not include key linkage areas.
- Grizzly bear developed site guidance inside the recovery zone/primary conservation area would require the number and capacity of developed sites to be maintained at or below 1998 baseline levels.
- The criteria used for the timber suitability and availability determinations would be the same as described for alternative B, except no recommended wilderness areas are included in alternative E.
- Plan objectives would emphasize timber and wood products volume. The additional Forest Service funding needed to accomplish the higher timber volume would result in lower objectives for resource enhancement, hazardous fuel treatment, moving toward wilderness characteristics, and road and trail maintenance.
- Airfields would be suitable in certain areas, subject to Forest Service permitting.

2.5.9 Alternative F

Alternative F is a new alternative that was not in the March 2019 draft revised plan. Alternative F is the preferred alternative and draws from alternatives B through E. It represents a mix of recommended wilderness areas, backcountry areas, recreation emphasis areas, and lands identified as suitable for timber production. With respect to the identified issues, the alternative is described as follows:

- There would be eight recommended wilderness areas (Lost Water Canyon, Bear Canyon, Timberline (formerly termed Red Lodge/Hellroaring), South Crazy Mountains, Cowboy Heaven, Gallatin Crest, Sawtooth, and Taylor Hilgard).
- There would be thirteen backcountry areas (Chalk Buttes, King Mountain, Cook Mountain, Tongue River Breaks, Punch Bowl, Big Pryor, Bad Canyon, Crazy Mountains, Blacktail Peak, West Pine, Buffalo Horn, South Cottonwood, and Lionhead).
- There would be ten recreation emphasis areas (Main Fork Rock Creek, Boulder River, Cooke City Winter, Yellowstone River, Bridger, Hyalite, Gallatin Canyon, Storm Castle, Hebgen Lakeshore, and Hebgen Winter).
- The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area would continue to be managed consistent with the Montana Wilderness Study Act of 1977 and the 2001 Roadless Rule. If Congress were to release the wilderness study area, portions of the wilderness study area would have plan land allocations of recommended wilderness area, backcountry area, and recreation emphasis area; a portion would be managed under inventoried roadless area direction without an additional plan land allocation. A small portion of the wilderness study area would be managed as a key linkage area.
- There would be a Stillwater Complex allocation for minerals.
- Motorized and mechanized transport would not be suitable in recommended wilderness areas. Continued use of existing commercial communication facilities would not be suitable in recommended wilderness areas, except for continued use of the existing Sheep Mountain and Twin Peaks passive reflector sites within their current footprints and with existing types of equipment.
- Other uses would not be allowed in recommended wilderness areas, such as new use of cabins as recreation rentals, new recreation events such as races, and new commercial communication facilities. Continued rental use of the Windy Pass cabin would not be suitable.
- Mechanized transport and existing motorized transport would continue to be suitable in backcountry areas where currently suitable, except mechanized transport other than game carts would no longer be suitable in the Bad Canyon, Crazy Mountains, and Punch Bowl Backcountry Areas and summer motorized transport would not be suitable in the Punch Bowl Backcountry Area. In all backcountry areas where mountain biking is suitable, mountain biking would be suitable only on approved system routes. In backcountry areas that are not suitable for mechanized transport, game carts would be suitable. New recreation events would not be authorized in the Buffalo Horn Backcountry Area (also included in alternatives B and C). New mountain bike trails could not be constructed in the Chalk Buttes Backcountry Area, or constructed or designated in the Big Pryor or Lionhead Backcountry Areas.
- No new trails would be allowed in the Cook Mountain, King Mountain, and Tongue River Breaks Backcountry Areas.

- West Pine Backcountry Area would have an objective to create at least one opportunity to enhance non-motorized trail connectivity by connecting existing trails to create loop rides or to connect to other parts of the trail network (also included in alternative C).
- Hyalite Recreation Emphasis Area would have an objective to create two loop trail opportunities by developing additional trail connections and/or converting non-system trails (also included in alternative C), and a standard that no new trail construction would be allowed that would provide access to Flanders, Mt. Bole, Divide Peak, and Maid of the Mist peaks.
- Plan components would support proactive management of bison on the Custer Gallatin National Forest. In alternative F, the bison-related plan components that vary by alternative would be:
    - Desired Condition: Bison are present year-round with enough numbers and adequate distribution to support a self-sustaining population on the Custer Gallatin National Forest in conjunction with bison herds in Yellowstone National Park.
    - Guideline: To promote bison expansion within management zones, vegetation treatment projects and management actions taken to resolve bison-livestock conflicts should favor bison within these zones (also included in alternatives B, C and D).
    - Guideline: To facilitate bison expansion into unoccupied, suitable habitat in the area that coincides with the grizzly bear primary conservation area, management actions should not create a barrier to bison movement unless needed to achieve interagency targets for bison population size and distribution.
- New permitted domestic sheep and goat grazing would not be allowed in the Madison, Henrys Lake, and Gallatin Mountains, the Bridger, Bangtail, and Crazy Mountains, the Absaroka Beartooth Mountains, and the Pryor Mountains Geographic Areas. Stocking of permitted grazing allotments with domestic sheep or goats for livestock production may be permitted in the Ashland and Sioux Geographic Areas only if a risk assessment indicates that spatial or temporal separation, or other mitigation can effectively minimize risk of disease transmission between domestic sheep and goats and bighorn sheep. Forestwide, use of targeted grazing by domestic sheep or goats for weed control may occur only if a risk assessment indicates that mitigation can effectively minimize disease transmission between domestic sheep and goats and bighorn sheep. Additional conditions would apply inside grizzly recovery zone.
- Permitted and non-permitted recreational goat packing would be suitable in the Bridger, Bangtail, and Crazy Mountains; Ashland; and Sioux Geographic Areas. Permitted recreational goat packing in these geographic areas would be allowed only if a risk assessment indicates that spatial or temporal separation, or other mitigation can effectively minimize risk of disease transmission between domestic sheep and goats and bighorn sheep. Once occupied by bighorn sheep, recreational use of pack goats in these geographic areas would be subject to the conditions outlined in the following bullet.
- Permitted and non-permitted recreational goat packing would be allowed in the Madison, Henrys Lake, and Gallatin Mountains, the Absaroka Beartooth Mountains, and the Pryor Mountains Geographic Areas, subject to the following conditions:
    - Pack goat packers and permittees will take reasonable measures to avoid contact between pack goats and bighorn sheep when encountered on the trail or in camp. Any observed

contact between pack goats and bighorn sheep will be reported within 24 hours to Montana Fish Wildlife and Parks or the Forest Service.

    - Pack goats are individually identifiable (such as collar or tag with owner information, micro-chips, or tattoos).
    - Pack goats shall always be under direct human supervision; on leads or with leads attached:
        - In camp and at night, pack goats shall be in direct sight or tethered or picketed with bells on.
        - Packers and permittees will make every effort to find lost pack goats; if unsuccessful, the packer shall contact Montana Fish Wildlife and Parks or the Forest Service within 24 hours.
        - Pack goats will only be allowed between June 20 and October 31 each year.
        - Packers and permittees must carry a certificate of health for all pack goats.
        - Pack goats are limited to no more than 6 goats per person or 12 goats per party.

- In addition to forestwide plan components that address connectivity, key linkage areas with associated plan components would be included in the northern end of the Gallatin Mountains and in the western and southern Bridger Mountains. In key linkage areas, mountain biking would be suitable only on approved system routes.
- Grizzly bear developed site guidance inside the recovery zone/primary conservation area would require new infrastructure designed to accommodate additional human capacity for administrative or public use to be restricted to the area within the authorized footprint of a site that existed in 1998, or the area within 300 meters of a primary road that existed in 1998.
- The criteria used for the timber suitability and availability determinations would be the same as described for alternative B.
- Plan objectives reflect a mix of resource enhancement, moving toward forested vegetation desired conditions; timber and wood products volume; hazardous fuel treatment; road, trail, and facility maintenance; and new recreation facilities.
- Airfields would be suitable in certain areas, subject to Forest Service permitting.

Modifications to Alternative F in response to objections

The following changes were made in plan land allocations:

- Cowboy Heaven has been changed to a recommended wilderness area with modified boundaries from the previous backcountry area.
- The Gallatin Crest Recommended Wilderness Area has been enlarged to connect to the Sawtooth Recommended Wilderness Area near Sheep Mountain, although the two recommended wilderness areas remain separately named.
- South Cottonwood has been added as a backcountry area.

The following changes were made in plan land allocation boundaries:

- Boundaries were adjusted for the South Crazy Mountains, Bear Canyon and Lost Water Canyon Recommended Wilderness Areas, the Crazy Mountain and West Pine Backcountry Area, the Hyalite and Storm Castle Recreation Emphasis Areas and the Gallatin Key Linkage Area.
  - The South Crazy Mountain Recommended Wilderness Area has been reduced by one section (638 acres), and the Crazy Mountain Backcountry Area has been enlarged by about 2,500 acres.
  - The Bear Canyon and Lost Water Canyon Recommended Wilderness Areas boundaries have been adjusted to provide more consistent distance from adjacent roads, resulting in larger recommended wilderness areas.
  - The boundaries of the Hyalite Recreation Emphasis Area and the Gallatin Key Linkage Area were adjusted, to allow heavily recreated areas south and west of Bozeman Creek to be managed in the Recreation Emphasis Area.
  - The boundaries of the Storm Castle Recreation Emphasis Area were adjusted to provide a more manageable boundary.

The following changes were made in recreation opportunity spectrum:

- The recreation opportunity spectrum was changed to semi-primitive non-motorized near Hyalite Lake (Summer), Republic Mountain (summer and winter) and near the Line Creek RNA (winter).
  - The summer recreation opportunity spectrum near Hyalite Lake was changed from semi-primitive motorized to semi-primitive non-motorized.
  - The summer and winter recreation opportunity spectrum at Republic Mountain were changed from semi-primitive motorized to semi-primitive non-motorized.
  - The winter recreation opportunity spectrum near the Line Creek RNA was changed from semi-primitive motorized to semi-primitive non-motorized.

The following changes were made in plan components and monitoring questions:

- The Punch Bowl and Crazy Mountain Backcountry Areas would not be suitable for mechanized transport, except use of game carts. The Punch Bowl Backcountry Area would not be suitable for summer motorized transport.
- New mountain bike trails could not be constructed in the Chalk Buttes, or constructed or designated in the Big Pryor, and Lionhead Backcountry Areas, other than reroutes of existing trails.
- In the Madison, Henrys Lake, and Gallatin Mountains, the Absaroka Beartooth Mountains, and the Pryor Mountains Geographic Areas, pack goats would be limited to no more than 6 goats per person or 12 goats per party.
- A monitoring questions was added to monitor the aggregate trend in mountain bike and motorized recreation use in the wilderness study area.

2.5.10 Alternatives Considered, but not Given Detailed Study

The Council on Environmental Quality requires Federal agencies to briefly discuss the reasons for eliminating any alternatives that were not developed in detail (40 CFR 1502.14(a)). Public comments received during scoping provided suggestions for alternative methods for achieving the purpose and need for action. Some of these alternatives were outside the scope of the purpose and need for action, duplicative of the alternatives considered in detail, or determined to be components that would cause unnecessary harm. The alternatives provided by the public (in bold) and the subsequent agency rationale as to why they were not given further detailed study are described below.

All inventoried roadless areas should be recommended wilderness: Not all the lands designated as inventoried roadless area were contained in the wilderness inventory, and only lands in the wilderness inventory can be considered for recommended wilderness. Some of the lands designated as inventoried roadless area have roading or other developments that made portions of inventoried roadless areas ineligible for the wilderness inventory. Of the lands designated inventoried roadless area that were contained in the wilderness inventory, some inventoried roadless areas or portions of inventoried roadless areas were not recommended as wilderness in any alternative because of unmanageable boundaries or small size. Detailed rationale of the wilderness inventory is documented in appendix D of the 2018 Proposed Action (https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd567792.pdf) and detailed rationale for areas excluded from recommended wilderness in any of the alternatives considered in detail is documented in appendix D of this document. This proposed alternative contains elements of the Northern Rockies Ecosystem Protection Act (NREPA), which would designate all roadless areas in the Custer Gallatin National Forest as wilderness.

All areas in the wilderness inventory should be recommended wilderness: Not all the lands in the wilderness inventory are included as recommended wilderness in any of the alternatives considered in detail for the following reasons. Detailed rationale is documented in appendix D of this document.

- Each area recommended as wilderness in any alternative considered in detail must have a clearly defined boundary that supports management of the area for wilderness and other adjacent uses (Forest Service Handbook (FSH) 1909.12 Chapter 70). Boundaries should be easy to identify and locate on the ground and may use locatable natural features (for example, ridges and perennial streams), locatable human features and setbacks from locatable human features (for example, roads, trails, and powerlines), boundary lines, section lines, lines between locatable points, or a metes and bounds survey. Once manageable boundaries were established, some areas larger than 5,000 acres in the wilderness inventory were smaller than 5,000 acres; too small to be recommended wilderness area.
- Many areas less than 5,000 acres were included in the wilderness inventory because they are attached to existing designated wilderness or lands managed as wilderness by other Federal agencies. Small areas attached to other Federal lands tend to be surrounded by non-wilderness use and difficult to manage for wilderness characteristics.
- Small additions to existing designated wilderness areas would result in less manageable boundaries than the boundaries in existence for the past 30 years, unless small additions were well-defined blocks of land.
- In the Sioux, Ashland, and Pryor Mountains Geographic Areas, the wilderness characteristics of wilderness inventory areas are affected by the density of all motor vehicle trails, which may be under permit for motorized access for grazing infrastructure, and some routes are through-routes used for access beyond the forest boundary.

The Cabin Creek Recreation and Wildlife Area should be recommended wilderness. Because Congress has already decided the designation of this area, the Forest Service is not to proposing a different plan land allocation.

Recommended wilderness should be at least 2 miles from state and private land. A 2-mile distance from State and private land can be calculated for the recommended wilderness in any detailed alternative, therefore, the proposed configuration of recommended wilderness is included in the detailed alternatives as a smaller area of recommended wilderness than displayed.

The area around Big Sky should be a recreation emphasis area. The National Forest System land near Big Sky is either wilderness or small, disjointed areas of rural recreation opportunity spectrum that do not comprise a cohesive manageable recreation emphasis area. Therefore, this alternative was not considered in a detailed analysis.

The West Bridgers should be a recreation emphasis area. The area does not meet intent for recreation emphasis areas, which are areas with high use and a variety of uses. Therefore, this alternative was not considered in a detailed analysis. However, other allocations for the West Bridgers vary in the detailed alternatives.

Several additional rivers should be identified as eligible wild and scenic rivers. To be eligible as a wild and scenic river in the land management plan, a river or stream must have one or more outstandingly remarkable value in the region of comparison. Comments requesting additional rivers did not:

- include a description of the region of comparison
- define every category of outstandingly remarkable value
- state the criteria used to determine that a river should be found eligible
- list the outstandingly remarkable value that would be used to qualify the river
- explain why the river was unique or exemplary within the region of comparison
- list an outstandingly remarkable value meeting the definition used by the Forest Service. For example, a comment might state that bison use a river corridor, which was not part of the Forest Service outstandingly remarkable value definition for wildlife.

The proposed additional streams and rivers were not rare, unique, or exemplary when considered based on the regions of comparison, nor with the definitions of the outstandingly remarkable values. Since the finding of an “eligible river” does not change by alternative, other rivers found not to meet the criteria were dropped from further study. Public comments did lead to a change in the tentative classification of one river.

No rivers, or fewer rivers, should be identified as eligible wild and scenic rivers. Comments did not provide rationale related to outstandingly remarkable values in the region of comparison that would lead to different determination of eligibility. Some comments raised issues appropriate for a suitability study, such as potential trade-offs related to a potential wild and scenic river designation. A suitability study is not being undertaken with this plan revision process. Since the finding of an “eligible river” does not change by alternative, none of the rivers listed as eligible in the 2018 Proposed Action were dropped from the revised plan.

The Pryor Mountain Wild Horse Territory should be expanded. Expansion of the Pryor Mountain Wild Horse Territory is beyond the scope of the forest plan revision. Wild horses can only be managed on areas of public lands where they were known to exist in 1971, at the time of the passage of the Wild Free-Roaming Horses and Burros Act (Forest Service territories and BLM herd areas). Under section 1339 “Limitation of Authority,” the Wild Free-Roaming Horses and Burros Act of 1971 states “Nothing in this

Act shall be construed to authorize the Secretary to relocate wild free-roaming horses or burros to areas of the public lands where they do not presently exist." Until a change in the law allows for expansion of the Pryor Mountain Wild Horse Range onto additional lands managed by the Forest Service and BLM that are outside of the territory and herd area, the agencies have a legal obligation to follow the law. Horses were in the Pryor Mountains historically, but by 1968, they were largely limited to the 1968 designated range because of the Forest Service and BLM boundary fence. Though there is some supposition as to the extent of wild horses in 1971, comprehensive agency inventories in 1971 and 1972, Forest Service and BLM assessments, and public involvement in 1972 and 1973 provided the basis for territory and herd area boundaries per the 1971 Act. Subsequent land use planning efforts in 1984 (BLM) and 1987 (Forest Service) validated the same areas as being wild horse herd management area and territory, respectively. Therefore, expansion of the Pryor Mountain Wild Horse Territory was not considered in a detailed analysis.

There should be more minerals special emphasis areas like the Stillwater Complex. The Stillwater Complex is unique in the critical minerals available and level of ongoing mineral development, and is where most future minerals proposals are expected. Other areas of the national forest do not have the same level of unique available minerals or expected level of development. Therefore, additional mineral plan land allocations were not delineated in a detailed alternative.

The Emigrant and Crevice Mountain Potential Mineral Withdrawal area (about 30,370 acres) should have a special emphasis plan land allocation with direction for the scenic integrity, important wildlife corridors, and high recreation values of the area. Forestwide plan direction addresses scenic integrity, wildlife, and recreation. Therefore, commenter's concerns are included in the detailed alternatives.

Lionhead should be designated as a national recreation area. A national recreation area designation is beyond the authority of the Forest Service. The public proposed several plan land allocations for Lionhead, with the underlying issue being whether mountain biking is allowed in the area. The alternatives considered in detail, including no action, provide a range of options for addressing mountain bike use in Lionhead.

The Crazy Mountains and the Pryor Mountains should be allocated as Tribal special emphasis areas. A Tribal special emphasis area land allocation may or may not be sought by Tribes. No Tribe has requested that any area of the national forest be identified as a Tribal special emphasis area. Plan direction in all detailed alternatives addresses Tribal uses and protection of cultural and historical resources on the Custer Gallatin.

Wildland-urban interface areas should be allocated as special emphasis areas. The wildland-urban interface areas are not suitable for a specific wildland-urban interface plan land allocation because wildland-urban interface locations could change over time due to new development near the national forest boundary, new methods of mapping wildland-urban interface, the evolving science of predicting fire impacts to community values, and county updates to wildland-urban interface maps (counties are responsible for wildland-urban interface maps, and updating the maps every 5 to 10 years). Although a detailed alternative that delineates a specific plan land allocation is not considered, plan components would apply in locations that meet the wildland-urban interface criteria.

The Ashland District should be allocated as a grazing special emphasis area. The Distinct Roles and Contributions section for the Ashland Geographic Area acknowledges that the district manages one of the largest national forest livestock grazing programs. Other areas of the national forest have the same level of expected administrative needs and issues with permitted grazing. Other multiple uses are legitimate uses of the Ashland unit and to single out livestock grazing as an emphasis area for the entire district would not meet the principles of multiple use, sustained yield. Therefore, this alternative was not considered in a detailed analysis.

An alternative should make all lands suitable for motorized and mechanized transport that were suitable prior to 2006, when travel planning was initiated. This alternative was not considered in a detailed analysis because the Custer Gallatin has completed travel management, broad changes in motorized transport suitability was not part of the need for change.

An alternative should include no permitted livestock grazing. Adjustments to livestock use have been incorporated into the alternatives considered in detail, as appropriate, to address identified issues with livestock management. Since the national forest has considerable discretion, through its livestock grazing regulations, to determine and adjust stocking levels, seasons-of-use, and livestock grazing management activities, as well as to allocate forage, the detailed analysis of an alternative to eliminate livestock grazing is not needed. A detailed alternative that proposes closing the entire national forest to livestock grazing would also be inconsistent with the intent of the Granger-Thye Act of 1950, Multiple Use Sustained Yield Act of 1960, Forest and Rangeland Renewable Resources Planning Act of 1974, the Wilderness Act of 1964, National Forest Management Act of 1976, Public Rangelands Improvement Act of 1978, and the Rescission Act of 1995, which directs the Forest Service to provide for livestock use of National Forest System lands; to provide for the orderly use, improvement, and development of the range; and to stabilize the livestock industry dependent upon the public range. The multiple-use mandate does not require that all lands be used for livestock grazing; however, complete removal of livestock grazing on the entire national forest would not meet the principles of multiple-use and sustained-yield management. Livestock grazing is and has been an important use of the public lands in the planning area for many years and is a continuing government program. For these reasons, an alternative of no livestock grazing for the entire national forest was not considered in a detailed analysis.

An alternative should include a reduction in permitted livestock grazing. It is not appropriate at the 3-million-acre programmatic forest planning scale to determine the number of animal unit months that any individual allotment can support due to the need for site-specific inventory, monitoring, and condition information. In addition, this alternative would be counter to FSH 1909.12, sections 22.13 and 22.14, which direct that plan components should not direct or compel processes such as analysis, assessment, inventory, or monitoring. Objectives for forestwide animal unit months vary by alternative, based on potential disposition of vacant allotment animal unit months. Therefore, this alternative was not considered in a detailed analysis.

An alternative should allow very limited management. An alternative of very limited management would not meet the laws, regulations, and policies that guide the multiple-use management of national forests.

An alternative should manage half of each watershed for wildlife and natural conditions, and conduct management activities on the other half of each watershed. It would not be appropriate to bisect all watersheds in this manner, because it would not provide for ecological and economic sustainability or be consistent with the laws, regulations, and policies that guide forest plan revision. For example, the opportunities to manage some watersheds are limited or precluded by land designations beyond the scope of forest planning, such as designated wilderness areas—in these watersheds, no lands would be appropriate for many management activities. Further, providing a mosaic of areas designated for wildlife habitats tied to half of each watershed would not necessarily be sufficient to provide for the ecosystem components and linkages required by all species.

An alternative should maintain half of all watersheds across the forest for wildlife conservation, with no type of management activity, including habitat improvement projects such as prescribed burning. In the objection phase, proponents of the alternative described above to manage half of each watershed for wildlife and natural conditions, and to conduct management activities in the other half of each watershed, clarified that they meant to propose an alternative to maintain half of all watersheds across the forest for wildlife conservation. In response, all watersheds on the forest provide for wildlife conservation because forestwide plan components for wildlife and other natural resources apply to all lands forestwide. In addition, about 1,050,000 acres are designated wilderness and another 844,000 acres are within inventoried roadless areas, where many management activities are limited. These two designations alone account for over 60 percent of the forest. Additional allocations such as recommended wilderness, backcountry area, research natural area, or the Pryor Mountain Wildhorse Territory also limit many management activities. Therefore, this alternative was not considered in detail because many elements of this suggested alternative are included in the plan and range of alternatives.

An ecocentric/biocentric alternative should be considered. Many elements of this suggested alternative are included in the plan and range of alternatives. For example, the desired conditions were developed with an emphasis on the natural processes that influence the vegetation on the Custer Gallatin, as well as appropriate consideration of the impacts of climate change. The plan components also recognize and support the important natural roles of wildfire, insects, and diseases on the landscape, and strives to conserve key ecosystem components such as old growth, snags, and downed woody material as well as connectivity for wildlife species. Further, the plan protects soils and aquatic resources, protects the values of eligible wild and scenic rivers, and is consistent with the Inventoried Roadless Area Conservation Rule. Certain elements of this alternative are not addressed to the degree suggested by the commenters, such as protecting all roadless areas as recommended wilderness (although alternative D does reflect these interests to a large degree). Not all inventoried roadless areas qualified to be included in the wilderness inventory. Not all suggested elements would meet the laws, regulations, and policies that guide the management of National Forest System lands. For example, a standard requiring evaluation of unroaded areas contiguous with inventoried roadless areas and wilderness for their wilderness characteristics and eligibility for wilderness designation during site-specific project National Environmental Policy Act analyses is not necessary since the forest plan revision process inventoried and evaluated these unroaded areas for their wilderness characteristics and eligibility for wilderness designation. In summary, this alternative was not analyzed in additional detail because most elements are addressed as appropriate, although not necessarily with the same guiding scientific information or specific methods (such as standards) as suggested by the commenters. This alternative contains elements of the Northern Rockies Ecosystem Protection Act (NREPA), which would designate all roadless areas in the Custer Gallatin National Forest as wilderness.

All lands that would be designated wilderness in the Northern Rockies Ecosystem Protect (Act) be designated as Wilderness Study Areas. Elements of this alternative are addressed in other alternatives not considered in detail (*All inventoried roadless areas should be recommended wilderness, an ecocentric/biocentric alternative should be considered),* which address recommended wilderness allocation for inventoried roadless areas and unroaded areas. Further, neither a forest plan nor the Forest Service can designate a wilderness study area, only the U.S. Congress can designate a wilderness study area.

The Forest Service should manage wildlife instead of the States of Montana and South Dakota. Based upon Forest Service Manual (FSM) 2643.1, hunting, fishing, and trapping of fish and wildlife and associated practices on National Forest System lands are subject to State fish and wildlife laws and regulations unless they conflict with Federal laws or would permit activities that conflict with the land and resource management responsibilities of the Forest Service. Although the national forest has the authority to restrict hunting and trapping on National Forest System lands, Custer Gallatin staff is unaware of any scientific evidence indicating that impacts from hunting and trapping would warrant this restriction. The range of alternatives considered is responsive to 2012 Planning Rule requirements for ecological, social, and economic sustainability and the multiple-use requirements of the Forest Service.

The Forest Service does not have the capacity to manage the functions that the States now manage such as hunting, fishing, trapping, poaching enforcement, aquatic invasive species watercraft inspections. Through partnership with the States, the Forest Service can extend the reach of resource enhancement, such as native fish and wildlife reintroduction. Therefore, this alternative was not considered in a detailed analysis.

2.6 Comparison of Alternatives

Table 2 through table 8 compare alternatives by issue, first at the forestwide scale and then for each geographic area. Issues that are not applicable to a given geographic area are omitted from the table (for example, if no recommended wilderness areas are identified under any alternative, or if no trail suitability is affected under any alternative, those indicators are not listed for that geographic area). Some issues are not relevant to display at the geographic area scale, such as bison management and objectives. Acreages and mileages are rounded to the nearest whole number. Alternative A represents the current plans.

.

Table 2. Forestwide comparison of issues by alternative

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended wilderness area number	7	9	9	39	0	8
Recommended wilderness area acres	33,741	113,382	145,777	711,425	0	139,425
Backcountry area number	3	9	13	1	2	13
Backcountry area acres	38,414	124,980	299,522	5,937	171,326	207,677
Recreation emphasis area number	0	8	8	4	12	10
Recreation emphasis area acres	0	176,958	160,665	33,408	212,689	229,482
Stillwater complex acres	0	101,832	101,832	0	101,832	101,832
Miles summer motorized trail no longer suitable	0	0	4	172	0	0
Miles mechanized trail no longer suitable	0	0	34	264	0	31
Acres winter motorized transport no longer suitable	0	0	24,885	234,431	0	10,900
Forested acres suitable for timber production; percent Custer Gallatin National Forest	664,628 (22%)	573,275 (19%)	549,115 (18%)	545,274 (18%)	593,735 (19%)	560,071 (18%)
Forested acres unsuitable for timber production but where timber harvest is suitable for other purposes; percent Custer Gallatin National Forest	517,195 (17%)	595,964 (20%)	577,591 (19%)	249,141 (8%)	610,629 (20%)	602,696 (20%)
Bison	No plan direction	Proactive bison support	Proactive bison support	Most proactive bison support	Less proactive bison support	Most proactive bison support
<u>Bighorn sheep disease prevention:</u> Permitted grazing of domestic sheep or goats.	No plan direction; risk assessment per policy.	No in Pryor, AB, or MHG GAs. Yes, with risk assessment elsewhere.	No in Pryor, AB, or MHG GAs. Yes, with risk assessment elsewhere.	No forestwide	Yes, forestwide with risk assessment	No in Pryor, AB, BBC, or MHG GAs. Yes, with risk assessment elsewhere.

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Bighorn sheep disease prevention: Public and outfitter use of recreational pack goats	No plan direction	No in Pryor, AB, or MGH GAs. Yes, with risk assessment elsewhere.	No in Pryor, AB, or MGH GAs. Yes, with risk assessment elsewhere.	No forestwide	Yes, forestwide with risk assessment	Yes, with conditions in Pryor, AB, and MGH, GAs. Yes, with risk assessment elsewhere. With conditions, once occupied by bighorn sheep
Bighorn sheep disease prevention: Agency use of domestic sheep or goats for weed control	No plan direction; risk assessment per policy.	Yes, forestwide with risk assessment	Yes, forestwide with risk assessment	No forestwide	Yes, forestwide with risk assessment	Yes, forestwide with risk assessment
Connectivity	No plan direction	Plan components and key linkage areas	Plan components and key linkage areas	Plan components and key linkage areas	Plan components	Plan components and key linkage areas
Key linkage area acres	0	60,834	59,528	60,834	0	60,523
Airfield acres	1,022,282	900,261	871,614	0	924,574	896,908

GA = geographic area; AB=Absaroka Beartooth Mountains Geographic Area; BBC=Bridger, Bangtail, Crazy Mountains Geographic Area; MHG=Madison, Henrys Lake, and Gallatin Mountains Geographic Area

Table 3. Sioux Geographic Area (GA) comparison of issues by alternative

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Backcountry area number	0	0	0	1	0	1
Backcountry area acres	0	0	0	5,937	0	5,937
Bighorn sheep disease prevention: Permitted grazing of domestic sheep or goats	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Bighorn sheep disease prevention: Public and outfitter use of recreational pack goats	No plan direction	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment. With conditions, once occupied by bighorn sheep.

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Bighorn sheep disease prevention: Agency use of domestic sheep or goats for weed control	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Forested acres suitable for timber production; percent of GA	65,959 (40%)	59,061 (36%)	59,860 (36%)	56,779 (35%)	59,061 (36%)	56,779 (35%)
Forested acres unsuitable for timber production but where timber harvest is suitable for other purposes; percent of GA	1,090 (1%)	7,811 (5%)	7,811 (5%)	10,015 (6%)	7,811 (5%)	10,015 (6%)
Airfield acres	163,269	143,627	143,627	0	143,627	143,627

Table 4. Ashland Geographic Area (GA) comparison of issues by alternative

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended wilderness area number	0	0	0	3	0	0
Recommended wilderness area acres	0	0	0	37,180	0	0
Backcountry area number	3	3	3	0	0	3
Backcountry area acres	38,414	38,348	38,348	0	0	38,882
Bighorn sheep disease prevention: Permitted grazing of domestic sheep or goats	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Bighorn sheep disease prevention: Public and outfitter use of recreational pack goats	No plan direction	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment. With conditions, once occupied by bighorn sheep.
Bighorn sheep disease prevention: Agency use of domestic sheep or goats for weed control	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Forested acres suitable for timber production; percent of GA	196,127 (45%)	186,299 (43%)	186,299 (43%)	186,305 (43%)	186,449 (43%)	186,299 (43%)
Forested acres unsuitable for timber production but where timber harvest is suitable for other purposes; percent of GA	21,043 (5%)	30,500 (7%)	30,500 (7%)	11,567 (3%)	30,352 (7%)	30,500 (7%)
Airfield acres	402,555	379,804	367,177	0	379,804	379,806

Table 5. Pryor Mountains Geographic Area (GA) comparison of issues by alternative

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended wilderness area number	1	1	1	4	0	2
Recommended wilderness area acres	6,804	6,797	6,797	43,861	0	18,830
Backcountry area number	0	3	3	0	0	2
Backcountry area acres	0	29,389	29,389	0	0	18,707
Miles motorized trail no longer suitable	0	0	4	5	0	0
Miles mechanized trail no longer suitable	0	0	6	6	0	0
Acres winter motorized recreation use no longer suitable	0	0	16,001	23,314	0	5,596
Bighorn sheep disease prevention: Permitted grazing of domestic sheep or goats	No plan direction; risk assessment per policy.	No	No	No	Yes, with risk assessment	No
Bighorn sheep disease prevention: Public and outfitter use of recreational pack goats	No plan direction	No	No	No	Yes, with risk assessment	Yes, with conditions
Bighorn sheep disease prevention: Agency use of domestic sheep or goats for weed control	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Forested acres suitable for timber production; percent of GA	32,888 (44%)	12,628 (17%)	12,628 (17%)	11,349 (15%)	27,371 (36%)	12,522 (17%)
Forested acres unsuitable for timber production but where timber harvest is suitable for other purposes; percent of GA	6,267 (8%)	26,432 (35%)	8,218 (11%)	3,754 (5%)	15,178 (20%)	20,961 (28%)
Airfield acres	49,489	42,704	29,071	0	42,898	38,293

Table 6. Absaroka Beartooth Mountains Geographic Area (GA) comparison of issues by alternative

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended wilderness area number	5	4	4	19	0	1
Recommended wilderness area acres	6,163	2,238	2,238	214,247	0	802
Backcountry area number	0	1	1	0	0	1
Backcountry area acres	0	18,712	18,712	0	0	18,712
Recreation emphasis area number*	0	4	4	2	5	4
Recreation emphasis area acres+	0	38,754	38,754	7,464	48,813	41,195
Stillwater Complex acres	0	101,832	101,832	0	101,832	101,832
Miles motorized trail no longer suitable	0	0	0	55	0	0
Miles mechanized trail no longer suitable	0	0	14	98	0	14
Acres winter motorized recreation use no longer suitable	0	0	0	98,999	0	0
Bighorn sheep disease prevention: Permitted grazing of domestic sheep or goats	No plan direction; risk assessment per policy.	No	No	No	Yes, with risk assessment	No
Bighorn sheep disease prevention: Public and outfitter use of recreational pack goats	No plan direction	No	No	No	Yes, with risk assessment	Yes, with conditions
Bighorn sheep disease prevention: Agency use of domestic sheep or goats for weed control	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Forested acres suitable for timber production; percent of GA	98,637 (7%)	80,108 (6%)	80,108 (6%)	71,558 (5%)	85,962 (6%)	80,111 (6%)
Forested acres unsuitable for timber production but where timber harvest is suitable for other purposes; percent of GA	226,056 (17%)	247,340 (18%)	247,340 (18%)	95,975 (7%)	242,823 (18%)	247,958 (18%)
Airfield acres	172,316	153,575	153,575	0	153,974	153,969

*The Yellowstone River Recreation Emphasis Area is counted in both this geographic area and the Madison, Henrys Lake, and Gallatin Mountains Geographic Area; acreage in this geographic area is reported.

Table 7. Bridger, Bangtail, Crazy Mountains Geographic Area (GA) comparison of issues by alternative

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended wilderness area number	0	0	0	3	0	1
Recommended wilderness area	0	0	0	91,889	0	9,619
Backcountry area number	0	0	3	0	0	2
Backcountry area acres	0	0	115,622	0	0	35,282
Recreation emphasis area number	0	0	0	0	2	1
Recreation emphasis area acres	0	0	0	0	5,502	12,969
Miles motorized trail no longer suitable	0	0	0	27	0	0
Miles mechanized trail no longer suitable	0	0	0	36	0	4
Acres winter motorized recreation use no longer suitable	0	0	0	38,836	0	0
Bighorn sheep disease prevention: Permitted grazing of domestic sheep or goats	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	No
Bighorn sheep disease prevention: Public and outfitter use of recreational pack goats	No plan direction	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment. With conditions, once occupied by bighorn sheep
Bighorn sheep disease prevention: Agency use of domestic sheep or goats for weed control	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Connectivity	No plan direction	Plan components and key linkage areas	Plan components and key linkage areas	Plan components and key linkage areas	Plan components	Plan components and key linkage areas
Key linkage area acres	0	38,661	38,661	38,661	0	38,459
Forested acres suitable for timber production; percent of GA	59,203 (29%)	51,355 (25%)	43,780 (21%)	50,528 (25%)	51,355 (25%)	50,947 (25%)
Forested acres unsuitable for timber production but where timber harvest is suitable for other purposes; percent of GA	87,674 (43%)	95,448 (47%)	102,973 (50%)	40,489 (20%)	95,448 (47%)	92,768 (45%)
Airfield acres	98,131	72,763	72,763	0	86,242	72,811

Table 8. Madison, Henrys Lake, and Gallatin Mountains Geographic Area (GA) comparison of issues by alternative

Issue	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended wilderness number	1	4	4	10	0	4
Recommended wilderness acres	20,774	104,346	136,741	324,248	0	110,174
Backcountry area number	0	2	3	0	2	4
Backcountry area acres	0	38,531	97,449	0	171,326	90,157
Recreation emphasis area number*	0	5	5	3	6	6
Recreation emphasis area acres*	0	138,205	121,912	25,994	158,373	175,318
Miles motorized trail no longer suitable a	0	0	0	85	0	0
Miles mechanized trail no longer suitable	0	0	14	124	0	13
Acres winter motorized recreation use no longer suitable	0	0	8,884	73,282	0	5,304
Bighorn sheep disease prevention: Permitted grazing of domestic sheep or goats	No plan direction; risk assessment per policy.	No	No	No	Yes, with risk assessment	No
Bighorn sheep disease prevention: Public and outfitter use of recreational pack goats	No plan direction	No	No	No	Yes, with risk assessment	Yes, with conditions
Bighorn sheep disease prevention: Agency use of domestic sheep or goats for weed control	No plan direction; risk assessment per policy.	Yes, with risk assessment	Yes, with risk assessment	No	Yes, with risk assessment	Yes, with risk assessment
Connectivity	No plan direction	Plan components and key linkage areas	Plan components and key linkage areas	Plan components and key linkage areas	Plan components	Plan components and key linkage areas
Key linkage area acres	0	22,173	20,867	22,173	0	22,064
Forested acres suitable for timber production; percent of GA	211,814 (26%)	183,823 (23%)	167,239 (21%)	168,755 (21%)	183,538 (23%)	173,412 (22%)
Forested acres unsuitable for timber production but where timber harvest is suitable for other purposes; percent of GA	175,065 (22%)	188,432 (23%)	180,749 (22%)	87,341 (11%)	219,016 (27%)	200,494 (25%)
Airfield acres	136,523	107,785	105,398	0	118,028	108,402

*The Yellowstone River Recreation Emphasis Area is counted in both this geographic area and the Absaroka Beartooth Mountains Geographic Area; acreage in this geographic area is reported.

Table 9 portrays the relative contributions to social and economic sustainability by alternative. When relative contributions are expected to be similar, alternatives are listed in parenthesis in alphabetical order.

Table 9. Relative contributions to social and economic sustainability by alternative

Key Social Benefit from the National Forest	Relative Contributions Greatest to Smallest (left to right)
Clean air	E, (A/B/C/D/F)
Clean water, aquatic ecosystems, and flood control	D, (B/C/F), E, *A
Conservation of wildlife and rare plants, including species for fishing, hunting, and wildlife viewing)	D, (B/C/F), E, A
Designated areas	(A/B/C/D/E/F)
Plan Land allocations (e.g., RWA, BCA)	(B/C/D/E/F), A
Educational and volunteer programs	(B/C/D/E/F), A
Fire suppression and fuels management	D, (A/B/C/F), E
Forest products (including timber, firewood, Christmas trees, berries, mushrooms)	E, (B/C/F), D, A
Permitted livestock grazing	(A/B/C), F, (D/E)
Income (payments in lieu of taxes, secure rural schools, labor income in various industries: recreation, timber, grazing, etc.)	E, (B/C/F), D, A
Infrastructure	(A/B/C/F), E, D
Inspiration (including spiritual inspiration)	(B/C/D/E/F), A
Jobs (and induced jobs, including recreation, timber, grazing, etc.)	E, (B/C/F), D, A
Mineral and energy resources	A, E B, F, C, D
Preservation of historic, cultural, Tribal, or archeological sites	D, C, F, B, A, E
Sustainable recreation	(B/C/D/E/F), A
Scenery	D, C, F, B, A, E

*Alternative A represents the current plans in this table.
Alternatives are ordered left to right, from greatest to smallest contribution to social sustainability.
Alternatives in parentheses and separated by a slash denote similar contributions.

Table 10 displays a range of objectives by alternative. The objectives for alternatives A, B, and C are based on the budget and accomplishments from 2014 through 2017. Alternatives D and E vary the objectives based on the theme of the alterative. In alternative E, the higher costs to accomplish the timber volume drive other objectives lower. The cumulative totals of all objectives in any alternative would be within the budgets from 2014 through 2017. Except where noted, partnership and external funds are not accounted for in the objectives.

Table 10. Objectives by alternative

Topic	Measure	Alternatives A, B, C	Alternative D	Alternative E	Alternative F
Streams	Miles restoration per decade	600	800	200	600
Lakes, Ponds, Wetlands	Acres restoration per decade	50	100	10	50
Aquatic Passage; Conservation Watershed Network priority	Number of projects installed per decade	5 to 7	7 to 10	1 to 3	5 to 7
Conservation Watershed Network roadway drainage erosion control enhancement	Road miles per year	5 to 8	5 to 8	5 to 8	5 to 8
At-risk Aquatic Species	Number of enhancement projects per decade	5 to 7	8 to 10	1 to 3	5 to 7
At-risk Plants	Number of enhancement projects per decade	2	3	1	2
At-risk Plants Whitebark Pine	Acres restored or sustained per decade	1,000	1,200	500	1,000
At-risk Wildlife	Number of enhancement projects per decade	3 to 7	8 to 10	1 to 2	3 to 7
Terrestrial Wildlife	Number of enhancement projects per decade	10	12	5	10
Bison	Number of enhancement projects every 3 years	1	3	0	3
Grizzly Bears	Number of potential relocation sites by 2022	5	7	3	5
Noxious weeds	Acres treated per year	2,500 to 4,500	4,500 to 7,000	500 to 2,500	2,500 to 4,500
Cultural Resources	Number of public outreach projects per year	10	5	5	10
Cultural Resources	Percent priority assets managed per year	20	25	20	20

Topic	Measure	Alternatives A, B, C	Alternative D	Alternative E	Alternative F
Permitted Grazing	Animal Units Months (AUMs) per year	219,293	213,652	213,652	217,221
Projected Timber Sale Quantity (PTSQ) PTSQ does not include salvage harvest	Million board feet per year (mmbf) Million cubic feet per year (mmcf)	10 1.96	6 1.26	15 2.94	10 1.96
Projected Wood Sale Quantity (PWSQ)	Million board feet per year (mmbf) Million cubic feet per year (mmcf)	18 3.53	13 2.61	25 4.8	18 3.53
Projected Vegetation Treatment (fuels and timber)	Acres per year	6,000 to 7,500	8,000	5,000	6,000 to 7,500
Hazardous fuels	Acres treated per year	6,000	7,000	4,000	6,000
Natural unplanned wildfire	Acres per decade	375,000	375,000	375,000	375,000
Hardwoods, grasslands, shrublands, woodlands	Projects to sustain or restore per decade Acres sustained or restored per decade	6 to 8 600 to 750	8 to 10 800	2 500	6 to 8 600 to 750
Roads - high clearance	Percent maintained per year	20	5	10 Priority timber access	20
Roads - passenger	Percent maintained per year	75	75	75	75
Trails	Percent maintained to standard per year	30	30	30 Priority front country	30
Trails	Percent maintained per year	80	30	30	80
Facilities (admin)	Percent maintained per year	60	40	40	60
Recreation sites or facilities in riparian management zone	Number removed per decade	5	7	2	5
Wilderness and recommended wilderness boundaries near adjacent motorized settings	Number boundary areas signed per decade	5	20	2	5
Identified travel incursions in P ROS	Number incursions eliminated per decade	5	5	2	5
Identified unauthorized motorized travel incursions in SPNM ROS	Number incursions eliminated per decade	5	0	5	5
Recreation site accessible design in RN ROS	Number sites accessibility improved per decade	3	1	3	3

Topic	Measure	Alternatives A, B, C	Alternative D	Alternative E	Alternative F
Designated wilderness. Unneeded existing improvements, facilities or uses	Number removed per decade	3	3	3	3
West Pine BCA (alternatives C, F)	Number new trail connections	(C only) 1	0	0	1
Hyalite REA day use access sites	Number added per decade*	1	0	2	1
Hyalite REA new trail connections	Number new trail connections	(C only) 2	0	0	2
Hebgen Lakeshore REA dispersed sites	Number converted to larger campgrounds per decade*	1	0	2	1
Main Fork Rock Creek REA dispersed sites	Number converted to larger campgrounds per decade*	1	0	2	1
Road or trail right-of-way	Number acquired per decade	1 to 5	1 to 5	1 to 5 Priority timber access	1 to 5

*Recreation emphasis area additional facilities depend on competitive capital improvement project funds and external funds

Chapter 3. Affected Environment and Environmental Consequences

3.1 Introduction

This chapter presents the existing environment of the Custer Gallatin National Forest plan revision area and the potential consequences to that environment that may be caused by implementing the alternatives described in chapter 2. Within each resource section, the boundaries of the area used for the resource analysis are disclosed. The discussions of resources and potential effects use existing information included in the Assessment of Existing Conditions, other planning documents, resource reports and related information, and other sources as indicated. Where things have changed since the assessment was published, updates have been included.

Numbers such as acres, miles, and volumes are approximate due to the use of geographic information system (GIS) data and rounding.

This is a programmatic document, disclosing affected environments and environmental consequences at a planning level scale; not at the site-specific project-level scale. Therefore, this document does not predict what would happen each time the proposed plan components are implemented. Land management plans do not have direct effects. They do not authorize or mandate any site-specific projects or activities (including ground-disturbing actions). However, there may be implications, or longer-term environmental consequences, of managing the national forests under this programmatic framework. As a result, all effects discussed in this section are considered indirect effects, unless otherwise noted. The environmental effects of those site-specific projects depend on the environmental conditions of each project site, the plan components applied, and implementation.

The affected environment is based in large part upon the Assessment of Existing Conditions, but includes updates and new information that have become available since its printing. The environmental consequences discussions in this chapter allow a reasonable prediction of consequences on the Custer Gallatin National Forest. However, this document does not describe every environmental process nor condition.

The 2012 Planning Rule requires the responsible official to use the best available scientific information to inform the development of the proposed plan, including plan components, the monitoring program, and plan decisions. The foundation from which the plan components were developed for the proposed action was provided by the Assessment of Existing Conditions, the best available scientific information, and analyses therein. From this foundation, specialists used a number of resources that included peer-reviewed and technical literature, databases and data management systems, modeling tools and approaches, local information, workshops and collaborations, and information received during public participation periods for related planning activities. Resource specialists considered what is most accurate, reliable, and relevant in their use of the best available scientific information. Best available scientific information includes literature referenced in the Assessment of Existing Conditions and this final environmental impact statement.

3.2 Air Quality

3.2.1 Introduction

The Forest Service is required to monitor and protect several resources on public lands, including air quality. Air quality is dependent on the type and amount of pollutants emitted into the atmosphere, the location and topography of an airshed, and the prevailing meteorological and weather conditions. Sources of air pollution within the Custer Gallatin National Forest include particulates and chemicals generated from timber and mining operations, wildland fire, road dust, transportation, and other combustion engines sources. Air pollution sources outside of the Custer Gallatin affecting the national forest include agricultural sources such as crop burning, municipal emissions, and other sources including long distance source emissions transmitted via continental airflow patterns.

The focus of this discussion is on smoke and how the various Custer Gallatin Plan alternatives could affect smoke production through the use of wildland fire, natural (but unplanned) ignitions to meet resource objectives, and emissions from wildfires. Smoke from all activities is the greatest contributor to air quality and visibility. Of all potential sources of air pollution from management activities that occur on the Custer Gallatin (such as, road dust, mining operations, emissions from logging equipment and recreational vehicles), smoke is the most substantial contributor to air quality and visibility. Smoke can exacerbate public health issues as well as obscure visibility. However, there is a need to use fire to maintain and restore the fire-adapted ecosystems on the national forest and to reduce hazardous fuels in the wildland-urban interface.

Regulatory Framework

Federal Clean Air Act: The 1970 Clean Air Act, as amended in 1977 and 1990 (42 U.S.C. 7401 et seq.) provides the foundation for protections of clean air on Federal lands. The 1977 Clean Air Act amendments direct Federal land managers to “preserve, protect, and enhance the air quality” in 156 mandatory class I national parks and wilderness areas (42 U.S.C. 7470 et seq.). Class I areas are wilderness areas that were designated before August 7, 1977, and larger than 5,000 acres and national parks greater than 6,000 acres. All other land managed by Federal land managers are designated class II. Under the Clean Air Act, Federal agencies (including the Forest Service) are held responsible to protect air quality related values in class I areas.

Prevention of Significant Deterioration: The Clean Air Act requires Federal land managers, “… to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, … and other areas of special national or regional natural, recreational, scenic, or historic value.” Prevention of significant deterioration addresses resource protection through the establishment of ceilings on additional amounts of air pollution over base-line levels in “clean” air areas, the protection of the air quality-related values of certain special areas, and additional protection for the visibility values of certain special areas.

National Ambient Air Quality Standards (40 CFR part 50): Under the Clean Air Act, national ambient air quality standards were established (40 CFR part 50). National ambient air quality standards identified six criteria pollutants and established standards for each that must be met by state and Federal agencies and private industry (table 11). Criteria pollutants include carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter (PM2.5 and PM10), and sulfur dioxide. Primary standards are designed to provide protection to public health. Secondary standards are intended to protect against damage to animals, crops, vegetation, and buildings and to limit reductions in visibility. The National Ambient Air Quality Standards, which apply to Montana and South Dakota, directly regulate criteria pollutants. These standards are set at the federal level and states can set standards at or below federal levels. The Environmental Protection Agency has developed regulations for large industrial sources of greenhouse gasses but currently no standards or regulatory tools have been developed for agricultural (included prescribed burning) sources of greenhouse gas emissions.

Conformity Determinations: The general conformity provisions of the Clean Air Act (section 176(c)) prohibits Federal agencies from acting within a non-attainment area which causes or contributes to a new or existing violation of the standards or delays the attainment of a standard.

Regional Haze Rule (40 CFR Part 51): Haze is created when sunlight is either absorbed or scattered by air pollution particles. Environmental Protection Agency's 1980 visibility rules (40 CFR 51.301-307) were developed to protect mandatory class I areas from human caused damages attributable to a single or small group of sources. In 1988, Environmental Protection Agency and other agencies began monitoring visibility in class I areas.

The 1999 Regional Haze Rule (40 CFR 51.308-309) called for states to establish goals to improve visibility in 156 national parks and wilderness class I areas and to develop strategies for the long term to reduce the emissions of air pollutants that cause visibility impairment. The regional haze regulations apply to all states, and require states to demonstrate reasonable progress for improving visibility in each class I area over a 60-year period (to 2064), during which visibility should be returned to natural conditions.

The Interim Air Quality Policy on Wildland and Prescribed Fires (U.S. EPA 1998): On May 15, 1998, the Environmental Protection Agency issued the Interim Air Quality Policy of Wildland and Prescribed Fire to address impacts to public health and welfare (U.S. Environmental Protection Agency 1998). The goal of the policy is to allow fire to function in an ecological role in order to help maintain healthy ecosystems. In doing so, it must also while balance the need to protect public health and welfare from the impacts of fire-related air pollution emissions. The policy is interim because it does not yet address agricultural burning or regional haze (U.S. Environmental Protection Agency 1998).

The Interim Air Quality Policy of Wildland and Prescribed Fire suggests air quality and visibility impact evaluations of fire activities on Federal lands should consider several different items during planning (U.S. Environmental Protection Agency 1998). In a project-level environmental analysis document it is appropriate to consider and address, to an extent practical, a description of applicable regulations, plans, or policies, identification of sensitive areas (receptors), and the potential for smoke intrusions in those sensitive areas. Other important disclosure items include applicable smoke management techniques, participation in a basic smoke management program, and potential for emission reductions.

Ambient air quality and visibility monitoring (for class I areas) are typically done collaboratively with the states. Impacts to regional and sub-regional air are addressed operationally through coordinated smoke management programs. The Environmental Protection Agency urges states to develop, implement, and certify smoke management programs that meet the recommended requirements of the Interim Air Quality Policy of Wildland and Prescribed Fire. In accordance with the policy, Montana has implemented a certified smoke management program. This program is administered through the Montana or Idaho Airshed Group (Montana/Idaho Airshed Group Operating Guide 2010). Member burners of the Montana or Idaho Airshed Group (including the Forest Service) submit burn requests to the Smoke Monitoring Unit, which coordinates with the state regulatory agencies to issue daily burn recommendations.

The Wilderness Act (16 U.S.C. 1131-1136): The Wilderness Act of 1964 mandates that wilderness areas be preserved for wilderness character and manage, preserve, and protect natural wilderness conditions (16 U.S.C. 1131-1136).

The Wilderness Act requires wilderness areas (class I and II) to be administered "for the use of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness." While class II wilderness areas are protected by the Wilderness Act, class I areas have additional protections under the Clean Air Act. The Wilderness Act does not protect wilderness study areas or research natural areas.

National Forest Management Act (16 U.S.C. 1600-1614): Under the National Forest Management Act of 1976, national forests and grasslands must create land management plans. The law states "National forests are ecosystems and their management… requires awareness and consideration of the interrelationships among plants, animals, soil, water, air, and other environmental factors within such ecosystems" (16 U.S.C. 1600-1614).

National Environmental Policy Act (NEPA) (42 U.S.C. 4321-4346): The National Environmental Policy Act requires national forests and grasslands to examine the environmental consequences of major proposed Federal actions. The decision-making process must incorporate public input (42 U.S.C. 4321-4346).

State Implementation Plans: Each state is required under the Clean Air Act to have an Environmental Protection Agency approved state implementation plan (section 110(a)(2)) which identifies a strategy to maintain or attain national ambient air quality standards (section 110(h)(1)). The Montana State Implementation Plan was approved by the Environmental Protection Agency and promulgated through the Montana Clean Air Act, and implementing regulations to provide specific guidance on maintenance of air quality, including restrictions on open burning (ARM 16.8.1300). Montana and South Dakota State Implementation Plans can be found at: Approved Air Quality Implementation Plans in Region 8. The Montana Department of Environmental Quality and the South Dakota Department of Environment and Natural Resources have the regulatory authority to implement and enforce air quality in Montana and South Dakota respectively, at a standard equal to or stricter than Environmental Protection Agency standards. Montana uses Federal and Montana Ambient Air Quality Standards. South Dakota's uses national ambient air quality standards as their ambient air quality standards.

Montana Code Annotated (Title 75. Environmental Protection): The Clean Air Act of Montana, chapter 2 "Air Quality" provides state regulatory requirements and outlines intent, limitations, and powers associated to the regulatory agency within Montana.

Administrative Rules of Montana (ARM) (Title 17, Chapter 8, Subchapter 6): This rule covers the general provisions of open burning including definitions, restrictions on non-burnable material, and major/minor burner requirements.

Smoke Management: Smoke management plans have been developed for many states with the purpose to manage and control smoke from wildfires and prescribed burns. The goal is to minimize smoke in populated areas, prevent public safety hazards, avoid violations of the national ambient air quality standards, and to avoid visibility impacts in class I areas.

In Montana, the Forest Service is considered a major open burner (any entity that emits more than 500 tons of carbon monoxide or 50 tons of any other regulated pollutant per calendar year), and conducts prescribed burning under the provisions of an annual open burning permit issued by Montana Department of Environmental Quality.

The Custer Gallatin National Forest is a member of the Montana/Idaho Airshed Group. Any prescribed burning in Montana must follow the guidelines established in the Montana/Idaho Airshed Group's Operating Guide (Montana/Idaho Airshed Group Operating Guide 2010). Planned permitted burns are submitted to the smoke monitoring unit in Missoula, Montana. For each burn planned, the type of burn, the number of acres to burn, location, and elevation of each site are provided to the smoke monitoring unit. The Montana or Idaho Airshed Group Smoke Program Coordinator uses the burn information, along with meteorological forecasts, to recommend burn restrictions for airsheds with planned burning. The smoke monitoring unit issues daily burn recommendations for airsheds, elevations, or impact zones on the Montana/Idaho Airshed Group Website. The Smoke Monitoring Unit coordinates with the state regulatory agencies to issue daily burn recommendations.

The Custer Gallatin National Forest will also comply with open burning guidelines of South Dakota's Department of Environment and Natural Resources (34A-1-18).

Key Indicators and Measures

Key indicators are ambient air quality and visibility, measured by projected acres of prescribed fire. On the Custer Gallatin, smoke provides much greater air quality impacts that other management related actions such as recreation, grazing, agricultural burning, industrial emissions, mining and oil and gas development, residential sources, construction equipment, vehicles, road dust, gravel pit dust, and campground wood fires (Story et al. 2005).

Methodology and Analysis Process

A qualitative assessment of smoke emissions from prescribed burning and wildfire was used in lieu of quantifying smoke emissions since the locations and timing of emission sources are not defined specifically in the plan alternatives. Wildfire emissions depend on site-specific vegetation and fuels conditions, ignitions, weather, and suppression resources and are much too variable to predict quantitatively. Therefore, the acres of prescribed burns and average estimated wildfires acres on the Custer Gallatin Forest were used to compare the air quality effect of alternatives. Modeling techniques (SIMPPLLE and PRISM) and estimated prescribed burn and wildfire acreage by plan alternatives are described in the terrestrial vegetation, fire and fuels, and appendix b sections of the revised plan.

Information Sources

This analysis is based on the best available scientific information including peer-reviewed journal articles, Forest Service publications, state (Montana and South Dakota) and Federal statutes, laws, and regulations, and personal communication with air quality specialists. Best available scientific information includes literature referenced in the Assessment of Existing Conditions and in this final environmental impact statement.

Journal articles cited have undergone a peer-review process from the scientific community as well as scrutiny from air quality specialists. The U.S. Forest Service is not a regulatory agency and must abide by the laws and regulations set forth by Federal (U.S. Environmental Protection Agency) and State (Montana Department of Environmental Quality and South Dakota Department of Environment and Natural Resources) governments. Forest Service publications include direction on smoke management.

Analysis Area

Air quality is affected by emissions sources and pollutants, as well as weather patterns, terrain, and prevailing winds. All of these factors develop an area or region of consequential air quality. Primary pollutants are emitted directly. Secondary pollutants are formed through chemical reactions in the atmosphere from precursor pollutants. The region of influence for a primary pollutant depends on the rate of emissions from a source, the elevation of the source, the type of pollutant, and the meteorological conditions that determine dispersion and dilution during transport from the emissions source. The region of influence for primary pollutants (an area potentially subject to measurable air quality impacts under unfavorable dispersion conditions) is generally a relatively small area, ranging from 1 mile to less than a few miles from the source. The region of influence for a secondary pollutant, such as ozone, is much larger because secondary pollutants can impact air quality for well over 100 miles.

The analysis area for the evaluation of effects to air quality from the revised plan alternatives includes the airsheds in which the Custer Gallatin National Forest is located. An airshed is a geographical area with similar atmospheric characteristics, such as wind patterns. Airshed boundary descriptions are detailed in the Montana/Idaho Airshed Group Operations Guide (Montana Department of Environmental Quality 2010). The Custer Gallatin National Forest is within airsheds 8A, 8B (primarily Gallatin), and 10 (primarily Custer) (figure 2). The Montana Department of Environmental Quality and the Montana/Idaho Airshed Group Operations Guide established the Big Sky Smoke Impact Zone within airshed 8A due to potential inversions during prescribed burning projects. Proximity to the impact zone must be considered when burn plans are submitted for review and approval. The state of South Dakota does not have guidelines specific to burning on National Forest System land and the state has not designated airsheds.

Because air flows freely across jurisdictional boundaries and pollutant sources include local and long-distance sources covering vast landscapes, the analysis discusses air quality across the entire Custer Gallatin National Forest. The temporal scope of the analysis is the anticipated life of the plan.

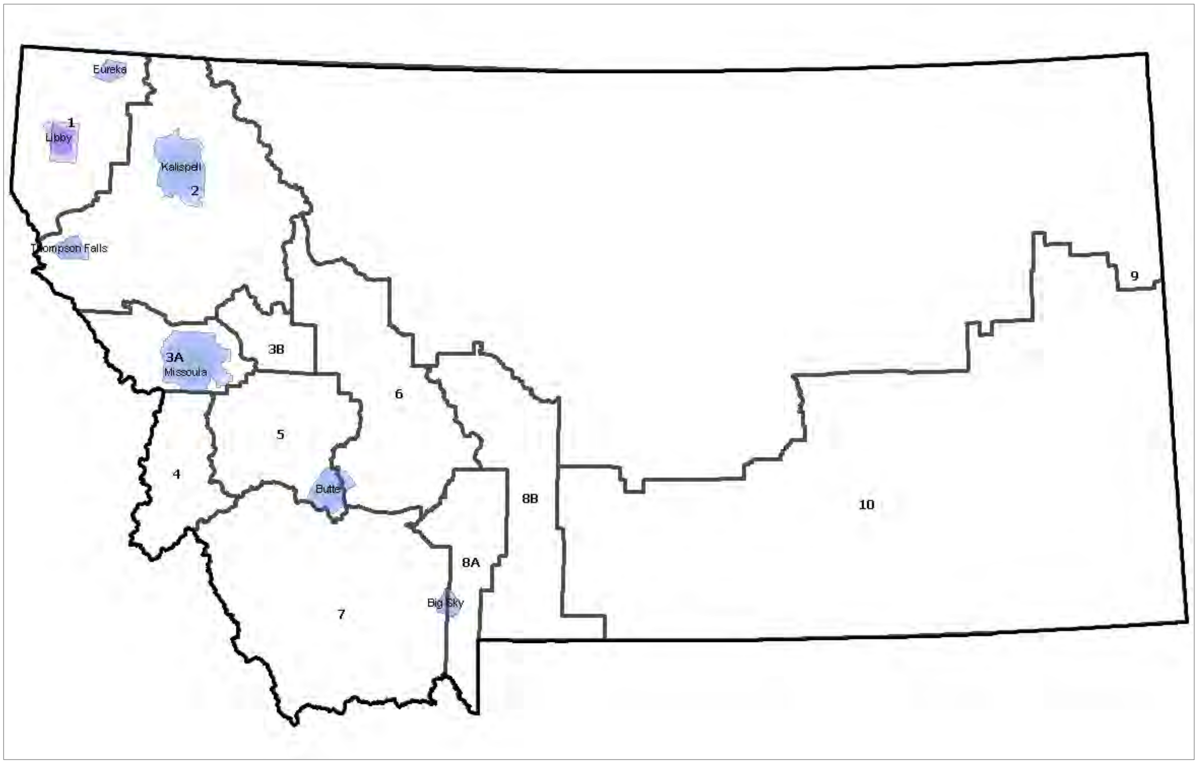

Figure 2. Montana airsheds

Notable Changes between the Draft and Final Environmental Impact Statement

The final environmental impact statement has been supplemented with clarifying language, minor edits, and analysis of alternative F.

3.2.2 Affected Environment (Existing Condition)

Emission Inventories

The Environmental Protection Agency requires each state to report emissions of criteria pollutants and their precursors to the National Emission Inventory database. The National Emission Inventory is prepared and released online every 3 years. The data for table 11 was for 2014 U.S. Environmental Protection Agency National Emission Inventory 2014 data. These numbers represent the inventory of all criteria pollution sources located in counties in and surrounding the Custer Gallatin National Forest and include emissions from man-made sources of pollution. The primary source of emissions on the national forest is PM 10 and 2.5 due to fires, both wildland and prescribed.

Table 11. National Emission Inventory for criteria pollutants by counties in Montana and South Dakota that contain part of the Custer Gallatin National Forest, 2014

County	PM_{10}	$PM_{2.5}$	SO_2	CO	NO_x
Carbon	7,818.53	1,170.80	33.17	6,891.65	1,279.64
Carter	8,167.27	1,739.87	17.23	7,580.73	1,198.37
Gallatin	26,140.57	3,773.88	479.59	25,249.91	4,871.40
Madison	7,250.96	1,165.49	23.12	8,090.87	1,350.21
Meagher	2,471.93	640.37	32.31	7,276.20	757.17
Park	6,496.83	1,028.13	61.10	8,618.64	1,834.14
Powder River	4,006.48	1,293.06	62.63	15,053.71	1,317.45
Rosebud	18,934.39	5,743.65	11,439.30	31,120.25	20,204.63
Stillwater	7,777.00	1,184.97	103.60	6,552.46	2,062.28
Sweet Grass	3,089.40	491.90	20.14	4,933.25	1,649.50
Harding (South Dakota)	6,547.46	1,302.87	12.97	4,034.79	1,557.80

[Emissions reported in tons per year*]

* National Emission Inventory (NEI) emissions are subject to change—these emissions reflect NEI estimates accessed online January 29, 2017

PM10 = particulate matter of 10 microns; PM2.5 = particulate matter of 2.5 microns; SO2 = sulfur dioxide; CO = carbon monoxide; NO2 = nitrogen dioxide

In general, the predominant winds in south central Montana come from the west and southwest. The Custer Gallatin National Forest has complex mountainous and valley terrain, which can affect local wind patterns. In general, the Custer Gallatin National Forest has robust wind dispersion with consistent up valley daytime breezes and down valley night drainage. Some valley inversions can reduce emission dispersion, particularly in the west fork of the Gallatin River including the Big Sky area. Regional air pressure patterns substantially affect air quality with robust dispersion during frontal storms. Wind patterns and climate in South Dakota is summarized by the National Oceanic and Atmospheric Administration (Frankson et al. 2017).

Sensitive Air Quality Areas

Class I wilderness areas are managed in accordance with the Clean Air Act and Wilderness Act. Non-wilderness Class II areas are managed consistent with the Clean Air Act. Federal land managers, however, still have an obligation to protect air quality in Class II wilderness areas. Non-wilderness class II areas are managed according to multiple use objectives (such as habitat protection, recreation, and forest products) in accordance with forest management plans.

No class I areas are managed by the Custer Gallatin National Forest. Yellowstone National Park and the Northern Cheyenne Reservation are both class I areas in close proximity to the Custer Gallatin National Forest. The Lee Metcalf Wilderness and the Absaroka-Beartooth Wilderness are both class II wilderness areas and sensitive air quality areas, but do not have additional specific air quality regulatory protection by the Wilderness Act. The Hyalite-Porcupine-Buffalo Horn Wilderness Study Area is also considered a sensitive air quality area.

The Montana/Idaho Airshed Group designated the Big Sky Smoke Impact Zone on the Custer Gallatin, which is in airshed 8A. Proximity to the impact zone and potential emission effects are considered by the airshed group before issuing burn permits.

Nonattainment Areas

National Forest land that falls within nonattainment areas are subject to Conformity Determinations of the Clean Air Act (section 176(c)); meaning every Forest Service action that produces non-mobile air pollutants must be evaluated for its effect on the nonattainment area.

The entire state of South Dakota is in attainment. No portion of the Custer Gallatin National Forest lies within a nonattainment area; however, there are a few nonattainment areas in close proximity as of October 31, 2019 (U.S. Environmental Protection Agency Air Quality Greenbook). Lame Deer in Rosebud County is in marginal nonattainment for PM10. Billings and the greater Laurel area in Yellowstone County are both in Maintenance Area for sulfur dioxide.

Monitoring Programs

Air quality monitoring in and around the Custer Gallatin National Forest is conducted by national, state, and local programs that inform the Custer Gallatin of trends and changes in air quality around the national forest. The two primary national monitoring programs are Interagency Monitoring of Protected Visual Environments (IMPROVE) and National Atmospheric Deposition Program (NADP). The Environmental Protection Agency mandates each state to establish a network of monitors that measure ambient air concentrations of criteria pollutants (40 CFR Part 58). This monitoring network is known as State and Local Air Monitoring Stations. States also have special purpose monitors that are not part of the State and Local Air Monitoring Stations network. The Custer Gallatin National Forest uses IMPROVE and NADP data to assess air quality conditions on National Forest System lands. Visibility measured by IMPROVE and precipitation chemistry measured by NADP are part of the Air Quality Related Values monitored across the Custer Gallatin to keep track of overall air quality (table 12). Other Air Quality-Related Values measured directly by the Forest Service are lichens and lake water chemistry. The Custer Gallatin National Forest works as a cooperator with the U.S. Geological Survey to help sample snowpack chemistry each year at selected sites. The Custer Gallatin National Forest intermittently partners with universities and researchers to gain and expand knowledge about air pollution.

Table 12. Wilderness areas, class rating, air quality-related values that are monitored, and laws

Wilderness	Air Quality-Related Values	Laws
Absaroka-Beartooth (Class II)	Long-term lake water chemistry, lichens, visibility, snowpack chemistry	Wilderness Act
Lee Metcalf (Class II)	Lichens, snowpack chemistry, synoptic lake sampling	Wilderness Act
Porcupine-Buffalo Horn Wilderness Study Area (Class II)	Lichens	National Forest Management Act
Yellowstone National Park (Class I)	Visibility, National Atmospheric Deposition Program precipitation chemistry, snowpack chemistry, climate	Clean Air Act National Park Service 1916 Organic Act
Northern Cheyenne Reservations (Class I)	Visibility	Clean Air Act

The Interagency Monitoring of Protected Visual Environments (IMPROVE) Program

The Interagency Monitoring of Protected Visual Environments (IMPROVE) is a national program that started in 1985 to establish baseline conditions and monitor visibility in 156 class I areas as mandated from the 1977 amendments to the Clean Air Act. Interagency Monitoring of Protected Visual

Environments monitoring also serves as a marker to assess progress toward the national visibility goal of no manmade impairment in support of the Regional Haze Rule. IMPROVE monitors sample ambient air with samples collected every Tuesday throughout the calendar year.

The Interagency Monitoring of Protected Visual Environments network includes two monitors in the vicinity of the Custer Gallatin National Forest; in Yellowstone National Park (YELL2) (near Yellowstone Lake) and the North Absaroka (NOAB1) (at Dead Indian Pass). Grenon et al. (2010) found an increase in visibility (visual range) from 1988 to 2007 at YELL2 Interagency Monitoring of Protected Visual Environments site due to annual decreasing trends in elemental carbon, fine soil, and coarse mass. No annual or seasonal trends were found with ammonium sulfate and ammonium nitrate (Grenon et al. 2010). Plotting the 20 percent most impaired) days with anthropogenic visibility impairment indicates an increase (improvement) in visibility at both the NOAB1 and YELL 2 IMPROVE sites between 2004 and 2014.

National Atmospheric Deposition Program

The National Atmospheric Deposition Program (NADP) started in 1978 with the primary purpose to monitor acidity levels in precipitation. The program measures precipitation chemistry (both rain and snow) and total precipitation at numerous sites across the country. Samples are collected every Tuesday throughout the calendar year. Data and sampling protocols can be found at http://nadp.slh.wisc.edu/.

Two National Atmospheric Deposition Program sites relevant to the Custer Gallatin National Forest; Tower Falls (WY08) in Yellowstone National Park and Little Bighorn (MT00) at the Little Bighorn Battlefield National MonumentWY08 was started in 1980 and MT00 was started in 1984. Analyzed NADP data between start dates and 2006 found annual ammonium concentrations in precipitation had increased significantly while sulfate concentrations had decreased significantly at both the MT00 and WY08 sites. Nitrate concentrations have increased at the WY08 site (Grenon and Story 2009) of increasing ammonium and decreasing sulfate concentrations have been widely documented over much of the western United States.

State Monitoring

The Montana Department of Environmental Quality has four air quality monitors within the Custer Gallatin National Forest. These monitors are located in Billings, Broadus, Birney, and West Yellowstone. The monitors measure ambient emissions of ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and particulate matter of 10 microns (PM10) and 2.5 microns (PM2.5) (table 11). In South Dakota, no state air quality monitors are located in Harding County or near the Custer Gallatin National Forest.

Additional information about Montana's and South Dakota's monitoring programs can be found in the Montana Ambient Air Monitoring Program Network Plan (Montana Department of Environmental Quality 2018) and the South Dakota's Ambient Air Monitoring Annual Plan (South Dakota Department of Environment and Natural Resources 2019).

Long-term Lake Chemistry

The Forest Service Northern Region Air Monitoring Program has annually sampled lake chemistry since 1993 in the Absaroka-Beartooth Wilderness (Story 2007).

In 2009, chemistry in both lakes was analyzed for trends (1993 to 2007) in acid neutralizing capacity, ammonium, nitrate, sulfate, calcium, chloride, and pH. No trends have been detected in acid neutralizing capacity (McMurray 2017).

U.S. Geological Survey Snowpack Surveys

In 1993, the U.S. Geological Survey (USGS) initiated snow sampling across the Rocky Mountains to measure winter atmospheric pollution. Fourteen sites are located in the Greater Yellowstone Area, including 3 sites on the Custer Gallatin. At each site, a bulk sample of the entire snowpack is collected once per year and the snow sample is then analyzed for pollutants (nitrogen, sulfur, mercury) and major ions (U.S. Department of the Interior 2017c).

Three snowpack sites are located on the Custer Gallatin National Forest in Montana: Lion's Head near West Yellowstone, Big Sky Ski Resort, and Daisy Pass near Cooke City.

Snowpack sites in the Greater Yellowstone Area have trends similar to much of the western United States, with a trend of increasing ammonium. The highest concentrations were on the west side of the Greater Yellowstone Area. Snowpack sites had decreasing trends in nitrate and sulfate with mean concentrations lower than the regional median.

Critical Loads

In order to protect sensitive ecosystem components, critical loads have and are being developed (Pardo et al. 2011). A critical load quantifies atmospheric deposition loading (usually in kg ha-1 year-1), attaching a number to different ecosystem components, below which no harmful effect will occur (Spranger et al. 2004). Exceedance of critical loads for nitrogen deposition has been linked to ecosystem eutrophication (excess nutrients) or acidification.

Nearly all the work done on critical loads in the northern Rocky Mountains has focused on nitrogen deposition. Critical loads range from 1.4 kg wet nitrogen ha-1 year-1 for diatoms in sensitive high alpine lakes (Saros et al. 2011) while wet + dry nitrogen deposition above 4.0 kg ha-1 year-1 has been associated with episodic freshwater acidification, lichen degradation, and changes in mineralization, nitrification, and soil chemistry of subalpine forests (Baron et al. 1994, Williams and Tonnessen 2000, Rueth and Baron 2002, Fenn et al. 2003, Baron et al. 2011, Saros et al. 2011).

Background (pre-industrial) nitrogen deposition in the northern Rocky Mountains forested ecosystems is estimated at less than 1 Kg N ha-1 year-1 (Holland et al. 1999, Sverdrup et al. 2012). Current total nitrogen (wet + dry) deposition levels in this area are estimated to be between 0.5 to 8 kg nitrogen ha-1 year-1 (Burns 2003, Grenon et al. 2010, U.S. Department of the Interior 2011b, Nanus et al. 2017), meaning some areas in the northern Rocky Mountains are exceeding critical loads for nitrogen deposition.

Epiphytic Lichens

Lichens have been collected on the Custer Gallatin National Forest to assess trends, hotspots of deposition, and to help inform critical load estimates.

Lichens have been sampled from established plots every 5 to 8 years. Lichen collection and laboratory protocols follow (Geiser 2004). There are no lichen plots east of the Beartooth Mountain Range on the Custer Gallatin National Forest.

Lichen analysis has estimated that nitrogen deposition on parts of the Custer Gallatin National Forest are twice the estimated background amounts (less than 1 Kg nitrogen ha-1 year-1) (Holland et al. 1999, Sverdrup et al. 2012), but lower than maximum critical loads for lichens (less than 4.0 Kg nitrogen ha-1 year-1) (McMurray et al. 2013). These hotspots occur at lower elevations around Bozeman, Montana, and may be due in part to localized sources and inversions. No critical loads for sulfur deposition have been identified for lichens in the northern Rocky Mountains.

Atmospheric Deposition of Nitrogen and Sulfur in the Greater Yellowstone Area

(Nanus et al. 2017) developed annual deposition maps and critical loads estimates in the Greater Yellowstone Area for nitrate, ammonium, and dissolved inorganic nitrogen wet deposition (at 400-meter scale).

Hot spots for ammonium and total nitrogen deposition have been identified at high elevations areas on the Custer Gallatin around West Yellowstone and the Beartooth Plateau. Critical total nitrogen load estimates for surface waters on the Custer Gallatin National Forest ranged from less than 1.5 to more than 10.0 kg ha-1 year-1. The variation in range reflects differences in elevation, precipitation, and vegetation. High alpine zones have little buffering capacity due to sparse vegetation and shallow soils. Lakes on the Beartooth Plateau that are fed by glacier melt water maybe at even more risk to nitrogen critical load exceedances as glacier melt water has been found to influence nitrate concentration in streams (Saros et al. 2010, Vandeberg and VanLooy 2016). However, no trends in nitrogen chemistry have been documented in the two long-term lakes monitored by the Northern Region Air Program (Grenon and Story 2009).

3.2.3 Environmental Consequences

All Alternatives

Management Direction under the Current Plans

Gallatin Forest Plan forestwide standard 9 requires that the Custer Gallatin will cooperate with the Montana Department of Environmental Quality in the state implementation plan and smoke management plan. The Custer Forest Plan goal of air resource management is to meet or exceed State air quality standards and ensure protection of Air Quality Related Values. Custer Forest Plan standards require cooperation and coordination with states, other agencies, and organizations in identifying, evaluating, proposing solutions, reducing impacts, and monitoring air quality problems associated with activities permitted on national forests and grasslands.

Custer Forest Plan fuels standards require that a combination of treatments will be used that will most efficiently meet the fuels management direction of each management area; this includes, the use of wildland fire (using both planned and unplanned ignition) as a management tool. A forestwide Gallatin Forest Plan standard provides that one or more fire management strategies may be considered and implemented for any unplanned wildland fire to achieve a variety of resource management objectives, while minimizing negative effects to life, investments, and valuable resources.

Management Direction under all Revised Plan Alternatives

Similar to the current plans, a goal of the revised plan alternatives would be cooperation with Tribal, Federal, and State Agencies to meet air quality regulations, and to coordinate prescribed burns with appropriate partners to minimize smoke impacts. Further, the revised plan Desired Condition FW-DC-AQ-

01 envisions positive air quality contributions to human and ecosystem health, visibility, and recreation, multiple-uses, and wilderness values while acknowledging that short term smoke impacts from local, regional, or national fire may occur. As stated in Goal FW-GO-AQ-01, the Forest Service cooperates with Tribal, Federal, and State agencies to meet air quality regulations as necessary. Prescribed burns are coordinated with appropriate partners (such as the Montana Idaho Airshed Group) to minimize smoke impacts.

Effects Common to All Alternatives

The Custer Gallatin National Forest and adjacent communities generally have good air quality as detailed in the affected environment section of this plan. Municipalities in winter, December, and January, can have elevated PM2.5 concentrations due to localized inversions, which can reduce atmospheric mixing of pollution sources. July, August, and September are likely to register increases the highest overall PM2.5 concentrations due to wildland fires, agricultural burning, and agriculture dust. Much of the Custer Gallatin National Forest is sparsely populated and subject to transport winds that disperse pollutant emissions. However, calm high-pressure systems common in the summer can reduce dispersion. Smoke from agricultural, personal debris burning, prescribed burning, or wildfires can settle for days, concentrating pollutants in valley bottoms. The primary pollutant of concern from prescribed fire or wildfires is particulates (including smoke, road dust, and engine emissions) which can cause adverse health effects. Other pollutants include carbon dioxide, carbon monoxide, water vapor, hydrocarbons and other organic chemicals, nitrogen oxides, and trace minerals (U.S. Environmental Protection Agency 2021) Fine particulates associated with smoke from wildland fires can be especially problematic for ongoing health problems and for the elderly and children (Montana Department of Environmental Quality 2010). The Montana Department of Environmental Quality and counties regulate open burning throughout the year while working with the Montana/Idaho Airshed Group to coordinate projects and potential air quality impacts from each prescribed burn.

Air quality impacts from wildfires may intensify in the future with greater frequency and larger amounts of burned acres. Climate projection scenarios anticipate increased temperatures on the Custer Gallatin (Halofsky et al. 2018b;a), which would likely lengthen wildfire seasons. The window for available burning by wildfires may broaden which would affect fire frequency in mid to upper elevation areas where fuel moisture and burning conditions during summer months currently inhibit fire spread. indicate that increases in emissions from wildfires may increase organic carbon concentrations by 40 percent and elemental carbon concentrations by 20 percent over the western United States by 2050. Large fires are expected to continue to occur on the Custer Gallatin Forest, driven by climate, weather, and fuel conditions, including the influence of the Pacific and Atlantic climate cycles which affect winds and sea surface temperatures. These cycles include the Decadal Oscillation, El Niño Southern Oscillation, and the Atlantic Multidecadal Oscillation (Kitzberger et al. 2007). An increase in fire emissions would be accompanied by a corresponding increase in adverse health effects, primarily respiratory illness.

National direction for Forest Service management actions would continue to affect how wildfires and fuels are managed across the Custer Gallatin. Variable fire budgets would affect suppression efforts, hazardous fuels planning, and prescribed fire implementation. National direction will also continue to provide forests with guidance in the management of wildland fires and fuels on the landscape. National direction would likely continue to focus on increasing the occurrence of fires managed for restoration, resiliency, and resource benefit objectives; hazardous fuels reduction; and accelerated restoration and resiliency objectives.

Climate change would likely increase smoke emissions for each alternative. Higher temperatures are anticipated to result in decreased snowpack, earlier springtime snow melt, and longer fire seasons would increase the frequency and area burned by wildfires.

Effects of the Current Plans

Current plan direction is to coordinate all Forest Service management activities to meet the requirements of the State implementation plans and State smoke management plan (Montana/Idaho Airshed Group (Montana Department of Environmental Quality 2010), South Dakota Department of Environment and Natural Resources requirements, and Federal and State air quality standards.

Projected vegetative treatments include primarily prescribed burning and thinning. The acres per decade of prescribed fire were estimated to be 27,645 acres for the current plans. Prescribed fire must operate under constraints established by the Montana/Idaho Airshed Group and South Dakota Department of Environment and Natural Resources. Air quality is to be maintained at adequate levels as described by State, county, and Federal direction, and all prescribed burns conducted on the Custer Gallatin will be governed by this direction and meet this intention.

Under the current plans, short and long-term effects to air quality would continue under current management of prescribed fire. Continued use of prescribed fire has the potential to influence air quality and visibility in local areas in the short term. The current management direction requires meeting air quality standards established by Federal and State agencies through requirements of state implementation plans and smoke management plans. The Custer Gallatin must meet air quality standards established by the Environmental Protection Agency and Montana Department of Environmental Quality through requirements of state implementation plans (concerning National Ambient Air Quality Standards) and the State smoke management plan. Use of prescribed fire under all alternatives would be restricted by how much vegetation, (for example, fuel loading/acre, acres that can be burned per day), when and where burns can occur, and budget constraints. These constraints limit the use of prescribed fire and affect the rate of emissions and volume of smoke and particulates, which in turn limits impacts to human health and visibility.

Effects Common to the Revised Plan Alternatives

The primary air quality emission variable from the plan revision alternatives is smoke from wildland fires. Wildfire smoke, and to a lesser degree, prescribed burning smoke, is anticipated to be the primary source of emissions and associated impacts to air quality on the Custer Gallatin National Forest, as it has been historically. The Greater Yellowstone Area air quality assessment in 2005 modeled historical prescribed fire and wildfire emissions and acreages and found that per acre PM 2.5 (particulate) emissions were 4.4 times as high for wildfires compared to prescribed fires (Story et al. 2005). Prescribed fire projects can reduce future risk of large wildfires which produce large amounts of emissions. Wildfires also generally produce more per acre carbon emissions than prescribed fire (and greater amounts of carbon emissions than prescribed fires (Wiedinmyer and Hurteau 2010). The Forest Service has limited ability to alter or control the location or extent of wildfires due to their unpredictable nature. Wildfires from local and long-range sources have potential to influence short-term air quality and visibility, but the SIMPPLLE and PRISM model results indicate that wildfire acreage potential does not vary between alternatives.

Table 13 displays estimated acres of wildland fire for all revised plan alternatives based on modeled future projections using the PRISM model. These estimates are derived from a modeling analysis explained in the terrestrial vegetation and fire and fuels sections, and appendix B. The SIMPPLLE and PRISM model analysis shows that the potential differences in estimated wildfire acres per decade (averaged over five decades) in forested areas between alternatives are too small between alternatives to show a difference. Estimated 10-year wildfire acreages for each alternative are 250,000 forested acres.

Table 13. Projected SIMPPLLE and PRISM model average acres per decade of wildfire and prescribed fire by each alternative (averaged over five decades)

Component and Indicator	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Wildfire (NFS lands): forested acres burned	250,000	250,000	250,000	250,000	250,000	250,000
Forested Areas Prescribed Fire (NFS lands): acres burned[1]	27,460	27,560	27,660	29,820	27,320	27,440

1. Acres are from the SIMPPLLE and PRISM models and only include forested areas. Non-forested area is not included in these figures, but do include areas both inside and outside the wildland-urban interface.

Note: Alternative A represents the current plans' future projections if kept. NFS = National Forest System.

The Custer Gallatin will continue to adhere to the current state smoke management plans, the Montana/Idaho Airshed Group and open burning guidelines of South Dakota's Department of Environment and Natural Resources (34A-1-18). The Custer Gallatin staff will obtain required permits and approval from the Montana Department of Environmental Quality and South Dakota Department of Environment and Natural Resources to conduct prescribed burning operations and implementation of wildfires used for resource benefit. These controls are managed to provide for protection of public health and welfare by mitigating the impacts of air pollution, while still allowing fire to be used in maintaining healthy ecosystems, reducing catastrophic wildfire, and protecting property. Controls which can be used to reduce smoke emissions and impacts are described by the National Wildfire Coordinating Group (National Wildfire Coordinating Group 2018). These include burning fewer acres per day, burning when fuels have higher moisture content, mechanical fuel removal in lieu of burning, constructing fire lines around fuel bed components to be left unburned, aerial ignition/mass ignition, air curtain incineration, using natural barriers such as rock outcrops and residual snow to reduce the size of a prescribed burn, concentrating fuels to burn piles, mopping up prescribed fires quickly after burning to reduce smoldering emissions. Controls for a specific prescribed fire depend on the size of an area to be burned, proximity to human exposure, smoke dispersion conditions, and numerous variables and logistical considerations.

Effects of Alternatives B, C, and F

Alternatives B, C, and F objectives reflect a mix of resource enhancement with timber production on suitable lands. Projected timber harvest and prescribed fire acres for alternatives B (27,569 acres), C (27,660 acres) and F (27,440 acres), are similar to the current plans. Estimated emissions and cumulative effects for alternatives B, C, and F are similar to the current plans.

Effects of Alternative D

Alternative D emphasizes resource enhancement, moving towards forested vegetative desired conditions and wilderness characteristics. This alternative maximizes recommended wilderness areas, but deemphasizes timber and wood products volume, road and trail maintenance, and new recreation facilities. Projected vegetative treatments include primarily prescribed burning and thinning. The acres per decade of prescribed fire were estimated to be 29,810 acres. This would likely result in higher prescribed fire emissions than the current plans and alternatives B, C, E, and F associated with more acres of prescribed fire in alternative D.

Effects of Alternative E

Alternative E emphasizes higher human presence and use of the Custer Gallatin National Forest with greater timber and wood products volume. Alternative E has lower objectives for hazardous fuels treatment, with less emphasis on moving toward wilderness characteristics, resource enhancement, and road maintenance. Alternative E would offer more motorized and mechanized recreation opportunities and not include any recommended wilderness areas. Projected vegetative treatments include primarily prescribed burning and thinning. The acres per decade of prescribed fire were estimated to be 27,320 acres for alternative E, which is the lowest amount of prescribed fire of all alternatives since more of the timber volume would be included in wood sales. Overall, prescribed fire emissions would likely be slightly lower than the current plans and alternatives B, C, D, and F due to fewer acres of prescribed burning.

Consequences to Air Quality from Plan Components Associated with other Resource Programs or Management Activities

Other management activities, such as dust from roads, mining, pollution from recreational and administrative vehicles, recreation activities, methane emissions from grazing, timber harvesting, and additional wilderness areas are not expected to substantially affect air quality compared to the much larger smoke emissions from wildfire and prescribed burning smoke as discussed in the affected environment section.

Cumulative Effects

Most impacts to air and visual quality in the Custer Gallatin National Forest are related to the contribution of smoke from areas south and west of the national forest which can result in decreases in air quality and visibility. Smoke from Canadian wildfires, as occurred from British Columbia and Alberta in 2017, can also contribute to decreased air quality on the national forest.

Portions of the Custer Gallatin adjoin other national forests, each having its own forest plan. Management of vegetation is generally similar across all national forests due to law, regulation, and policy. In addition, the Custer Gallatin is intermixed with lands of other ownerships, including private lands, other Federal lands, and State lands.

In addition to emissions from wildfire and prescribed burning on the Custer Gallatin National Forest, air quality would be affected by other emissions on the national forest, surrounding and upwind regional area sources including, but not limited to wildfire and prescribed burning, agricultural burning, industrial emissions, mining and oil and gas development sources, residential and municipal sources, construction equipment, vehicles, road dust, gravel pit dust, and campground wood fires, and smoke from non-national forest wildland fires. Long distance regional sources can occur from the western United States and even Canada and Asia.

Conclusion

The air quality in and around the Custer Gallatin is generally good with limited amounts of industrial, residential, agricultural, and transportation source emissions. The primary alternative variable that affects air quality in the Custer Gallatin National Forest is smoke and particulate matter from wildfires with most of the wildfire smoke impacts occurring in the July through September period. The revised plan alternatives vary slightly in smoke production due to the amounts of prescribed fire. Variability in wildfire smoke on the Custer Gallatin is largely a function of weather and location of fire ignition sites and beyond the direct control of management plan alternatives. In general, for the Custer Gallatin, wildfire smoke particle emissions on a per acre basis are about four times the smoke emissions from prescribed fire since wildfires usually occur in warmer and drier conditions than prescribed fire. However, due to the non-site-specific nature of the revised plan alternatives, smoke/particulate quantification poses too many variables to be credibly quantified. In all alternatives, climate change is anticipated to increase the frequency of large wildfires and increased smoke impacts.

The revised plan alternatives incorporate legal and policy direction designed to enhance and maintain ecosystem resiliency and sustainability, and protect values at risk of damage from wildfires. The Custer Gallatin would continue to adhere to the Montana smoke management plan, and obtain required permits and approval in order to conduct prescribed burning operations and implementation of wildfires used for resource benefit purposes.

The revised plan alternatives would meet the purpose and need because the use of wildland fires used for management for resource benefit would improve ecosystem sustainability and resiliency, and protect values at risk from damaging wildfires, while meeting air quality requirements mandated by the Clean Air Act. Adverse effects of increased smoke emissions would be mitigated by the Custer Gallatin’s compliance with the legal frameworks that regulate air pollution sources in the states of Montana and South Dakota.

3.3 Soils

3.3.1 Introduction

In natural systems, soil resources, along with local climate and topography, are primary determinants of the land’s inherent ability to grow specific types and amounts of native vegetation. As a result, nearly all goods and services provided to the public on national forest lands are in one way or another dependent on soil productivity. Maintaining that productivity is essential to preserving the Custer Gallatin’s ability to provide resource benefits to the public. These benefits include, but are not limited to, clean water, wildlife habitat, fisheries, timber and grazing resources, recreation opportunities, and pristine landscapes.

The people of the United States benefit from all the above listed amenities as well as others not listed. Without soil resource, there would be little or no terrestrial vegetation present on the landscape, nor would most of the benefits currently enjoyed by the public on Forest Service lands exist (or would exist in a degraded state). The reasons why national forest lands were set aside would no longer exist if not for a healthy, productive, soil resource.

Regulatory Framework

The Multiple-Use, Sustained-Yield Act of 1960 (P.L. 86-517, 74 Stat. 215: 16 U.S.C. 528-531): indicates that a high-level of annual or regular periodic output of renewable resources will be produced on national forest lands while also specifying that "coordinated management of resources will be utilized without impairment of the productivity of the land."

National Forest Management Act (NFMA) of 1976 (16 USC 1604) stipulates to:

- "ensure…evaluation of the effects of each management system to the end that it will not produce substantial and permanent impairment of the productivity of the land" 16 USC 1600, Section 6 (g)(3)(C).
- "ensure that timber will be harvested from National Forest System lands only where- (i) soil, slope, or other watershed conditions will not be irreversibly damaged…" 16 USC 1604 (g)(3)(E).
- "ensure that clearcutting, seed tree cutting, shelterwood cutting, and other cuts designed to regenerate and even-aged stand of timber will be used as a cutting method on National Forest System lands only where…. (v) such cuts are carried out in a manner consistent with the protection of soil, watershed, fish, wildlife, recreation, and esthetic resources" 16 USC 1604 (g)(3)(F).

Forest Service Manual, Chapter 2550 for Soil Management: directs land managers to "coordinate validation studies of soil quality criteria and indicators with Forest Service Research and Development staff to ensure soil quality measurements are appropriate to protect soil productivity." Six different soil functions are described: soil biology, soil hydrology, nutrient cycling, carbon storage, soil stability and support, and the capacity to filter and buffer environmental contaminants.

Forest Service Manual Northern Region Supplement 2550-2014-1: directs land managers to "design new activities that do not create detrimental soil conditions on more than 15 percent of an activity area" and that "research guidelines such as those contained in (Graham et al. 1994) for coarse woody debris should be used if more specific local guidelines are not available."

Key Indicators and Measures

The key indicators for assessing soil resource affects among alternatives are:

- maintaining soil productivity, based on acres of timber suitability by alternative, objectives for vegetation management by alternative, and qualitative assessment of plan components
- restoring soils, based on objectives for restoration by alternative, and qualitative assessment of plan components

Methodology and Analysis Process

Methods and Assumptions

This analysis takes a programmatic look at the outcomes that may result from implementing the proposed management direction for each alternative over the life of the plan. For estimating the effects at the programmatic forest plan level, it is assumed that the types of resource management activities allowed under the action alternatives are reasonably foreseeable future actions to achieve the Forest Service mission. Since future activities locations are not known at the programmatic land management plan level, specific spatial and temporal effects to soil productivity cannot be determined. Therefore, impacts of potential management actions are considered as indirect impacts to soil productivity.

Cumulative effects from adjacent management of other Forest Service units and state and private entities would not measurably impact soil productivity for this programmatic analysis.

Past, Present, and Future Activities used in the Analysis

Management and public use activities that have affected the soil resource include timber harvest and associated skid trails; landings and temporary roads; fuels reduction activities; landscape prescribed burning; livestock grazing; mining; road and trail construction; wildfire suppression operations; dispersed camping; introduction of invasive plant species; invasive plant treatment; and off-road motor vehicle use.

Information Sources

This analysis draws upon the best available scientific information that were found to be relevant to the Custer Gallatin National Forest. Literature sources that were the most relevant, most recent, peer-reviewed, and local in scope or directly applicable to the local ecosystem were selected. In addition, local studies and anecdotal information that is not peer-reviewed is included where appropriate to provide context.

Analysis Area

This programmatic land management plan analysis focuses on broad scale estimated effects related to soil productivity on National Forest System lands. The spatial analysis area for soils includes all the lands within the boundary of the Custer Gallatin National Forest. This area represents where changes may occur as a result of Forest Service management actions. The temporal scope of the soils analysis assumes a time period of roughly 15 years, the life of the plan.

Notable Changes between the Draft and Final Environmental Impact Statement

The final environmental impact statement was updated with new information, citations, clarifying language, minor edits, and analysis of alternative F. Notable changes to the plan include:

- Desired conditions were tailored to reduce redundancy, while providing coarse woody debris ranges for future monitoring. Coarse woody debris ranges were derived using Custer Gallatin National Forest, Forest Inventory and Analysis data.
- Standard FW-STD-SOIL-01 was reworded to match the regional soil standards (U.S. Department of Agriculture 2014b). Standard 2 was removed due to redundancy with existing riparian protections. Potential application and monitoring techniques are provided in appendix A of the plan (Management Approaches).
- Soil guidelines were clarified, and additional information is provided in appendix A of the plan (Management Approaches).
- The ground-based equipment slope restriction was raised from 35 to 40 percent (FW-GDL-SOIL-01) due to 1) advances in ground-based equipment design and construction that both reduce ground pressures and the likelihood of tires spinning which are the primary causes of ground disturbance associated with using ground-based harvesting equipment on sloping ground; 2) the majority of soils on the forest are not especially prone to either soil compaction or rutting; and 3) soil monitoring has found that the use of ground-based, harvesting equipment off skid trails accounts for a minor amount of the overall ground disturbance associated with either pre-existing or current activity caused detrimental soil disturbance.

- Guideline FW-GDL-SOIL-07 (coarse woody debris) was modified to define optimum ranges of coarse woody debris for broad potential vegetation types based on a synthesis of best available scientific information (Brown et al. 2003). Analysis was updated to reflect changes to FW-GDL-SOIL-07.

3.3.2 Affected Environment (Existing Condition)

The description of soils existing conditions on the Custer Gallatin National Forest is divided between montane and pine savanna portions of the national forest. Montane ecosystems of the Custer Gallatin include the Madison, Henrys Lake, and Gallatin Mountains; the Absaroka Beartooth Mountains; the Bridger, Bangtail, and Crazy Mountain; and the Pryor Mountain Geographic Areas. The pine savanna ecosystem includes the Ashland and the Sioux Geographic Areas.

Much of the soil on the Custer Gallatin National Forest is in a relatively undisturbed, natural condition. Overall soils in most areas are in good condition. Improved management practices result in less soil disturbance than that created for past management activities. In certain locations, however, human activities such as timber harvesting, mining, grazing, and recreational use have left their mark. Most of this disturbance occurred prior to 1994, with many of the worst impacts being “legacy” soil disturbances on lands that the Forest Service acquired relatively recently after soil disturbance already existed. Overall, soils in many of these areas appear to have mostly recovered from past harvest activities, except along major log skidding pathways and at log landings. From an area wide perspective, limited access, whether due to jurisdictional or physical constraints, has kept overall average of detrimental soil disturbance levels for montane portions of the Custer Gallatin National Forest low. Those same factors, however, have concentrated most ground-disturbing activities onto a relatively small portion of the Custer Gallatin National Forest land base. Because of this, many of the current timber management projects and some proposed projects are re-entering lands previously harvested.

Montane Areas

Much of the Custer Gallatin National Forest consists of multiple mountain ranges that are part of the larger Northern Rocky Mountain Geographic Area with a prevalence of hard bedrock highly resistant to weathering. The active tectonics and extremely erosion resistant bedrock results in rugged topography that has exposed bedrock ridgelines and narrow canyons indicative of wild and scenic natural settings. Due to the rugged topography, much of the Custer Gallatin remains inaccessible to management activities such as road building, timber harvesting, and even cattle grazing. Approximately two-thirds of the montane portion of the Custer Gallatin is protected from selected management activities through wilderness, wilderness study, or inventoried roadless area designations.

The shallow soils, steep terrain, and the resulting abundance of hard rock fragment in most soils of montane areas, which along with cold temperatures in the spring and dry soil conditions during the late summer and early fall of most years reduces the growth potential for conifers. These soil factors also influence potential soil disturbance from management activities. Soils containing abundant rock fragments within surface and near surface soil horizons limit soil compaction from ground-based equipment operation during timber harvest. On the other hand, the abundance of steep to extremely steep mountain slopes and long slope lengths in montane areas, increases risk for soil erosion or landslides events (both naturally and in response to ground disturbance), regardless of the rock fragments in soil.

Pine Savanna Areas

Pine savanna areas on the Ashland and Sioux Geographic Areas have primarily been managed for cattle grazing with more limited amount of timber harvesting. This is primarily due to the limited growth potential of the predominantly ponderosa pine forests growing in semi-arid areas of southeast Montana and northwest South Dakota. Lack of locally available timber mills within a reasonable haul distance also contributes to the limited amount of timber harvesting on the Sioux District of the Custer Gallatin National Forest (Hansen 2014 personal communication).

Stands that support the growth of conifers in sufficient quantity and with reasonable growth potential in on the pine savanna portions of the Forest occur primarily in sandstone areas on north tending aspects. Ponderosa pine can also be found growing on shale landscapes in some areas, but growth rates in shale areas are often reduced. Soils formed in sandstone areas are fairly resistant to certain types of detrimental soil disturbance such impacts from soil compaction, severe burning, or rutting. These areas in general are well suited for timber harvesting or other management activities so long as those activities do not occur on steep to very steep (greater than 35 percent) slopes. The same cannot be said about areas of shale. Other local parent materials of limited extent include porcelanite (locally known as scoria), quartzite, and floodplain deposits along rivers. Porcelanite parent materials do not tend to support ponderosa pine. Although soil salinity issues are common throughout much of this geographic area, in general, they are restricted to lower elevations outside the national forest boundary.

Only a limited amount of soil monitoring has been conducted in pine savanna areas of the Custer Gallatin using updated protocol in 2012 (Keck 2012). These data, summarized by (Robinson 2011), indicate low levels of detrimental soil disturbance found in those past timber harvest areas sampled. The limited evidence available would indicate cattle grazing on the pine savanna districts has not created substantial soil impacts in terms of high detrimental soil disturbance levels except in sensitive areas such as highly erodible, wet, or clayey soils, or concentrated use areas such around watering troughs, feeding areas and along frequently used trailing routes and potentially in transitional wetland areas.

3.3.3 Environmental Consequences

Current Plans

Management Direction under the Current Plans

Management direction in the current 1986 Custer Forest Plan and 1987 Gallatin Forest Plan, as amended, is limited for the management of soil resources. Between the two forest plans, this direction can be paraphrased as follows: maintain soil resources and watersheds in a desirable condition, maintain or improve soil productivity, best management practices will be applied, and forest soil survey be incorporated into resource analysis. The current direction with regard to the use of existing soil surveys will in many instances provide inaccurate information.

Effects of the Current Plans

The environmental consequences analysis for the soils resource focuses on timber harvest, restoration, and noxious weed treatment associated activities that have measurable impacts to soils over the next planning cycle on the Custer Gallatin National Forest. Other management activities, such as livestock grazing, dispersed camping, invasive plant treatment, prescribed fire, fuels treatments, and fire suppression operations, can also cause ground disturbance and detrimentally impact soils. The scale of the disturbance is small enough and distributed such that comparisons between the alternatives are slight.

Maintaining Soil Productivity

Timber harvest and associated actions would continue to produce the highest amount of ground disturbance. Under the current plans, the Region 1 Soil Manual (FSM 2550-2014-1) applies to all vegetation activity areas and treatment units. Protocol in the Region 1 Soil Technical Guide (U.S. Department of Agriculture 2011b) will be followed for all timber harvesting projects. Technical guidance at the national forest level supplements the Region 1 Soil Manual with field indicators of detrimental soil disturbance based on measurable field criteria, the use of appropriate field sampling procedures, and effective soil mitigation measures based on both the type and severity soil disturbance to be mitigated and properties of the local soil resource.

Management of soil organic matter and coarse woody debris is recognized as vital for soil function (Graham et al. 1994, Jurgensen et al. 1997, Page-Dumroese et al. 2010). The Custer Gallatin National Forest has managed for organic matter using new available science without management plan direction. There remains a need for the national forest to update direction and tailor coarse woody debris levels according to the Custer Gallatin National Forest potential vegetation types. Trade-offs often exist where balancing needs for fire risk while managing for soil productivity. Though guidance exists in general (Brown et al. 2003), forest projects must balance soil productivity needs without forest specific information.

The intensity of disturbance would not vary appreciably across any of the alternatives. About 22 percent of the national forest would be suitable for timber production under the current plans; slightly higher than other alternatives. The current plans estimate 6,000 to 7,500 acres of vegetation treatment per year. The current plans would have a range of impacts to soils from dedicated administrative purpose. This occurs when areas are no longer dedicated to growing vegetation are used for administrative use such as system roads, airfields, facilities, and mining operations. The amount of future development cannot be predicted.

Restoring Soils

The Custer Gallatin National Forest continues to perform rehabilitation efforts to improve and restore soil and vegetation. Restoration would continue on a site-by-site basis without defined management plan direction. Treatments and mitigations rely on resource expertise and proven best practices.

Revised Plan Alternatives

Management Direction under the Revised Plan Alternatives

Revised plan direction for soils does not vary by revised plan alternative. Overall, soils plan components in the revised plan alternatives would protect soil productivity while allowing management flexibility with respect to mitigating soil disturbance. The revised plan adds soil standards and guidelines to strengthen the management direction for soil management. Their inclusion in the revised plan would move the Custer Gallatin National Forest towards more of an ecological land management approach with specifics on organic matter and reclamation emphasis.

The revised plan adds desired conditions to emphasize the value of organic matter for soil processes. Organic matter provides the substrate needed for soil microbial function, adds protection against soil erosion and holds nutrients for plant and soil nutrient cycling. Soil organic carbon forms the carbon sink for ecosystem processes; soils can account for over 50 percent of overall site level carbon (Heath et al. 2011).

The revised plan also strengthens the sideboards to ensure the Custer Gallatin National Forest meets desired conditions. Though similar to the current plans, the revised plan incorporates the current Region 1 Soil Manual (U.S. Department of Agriculture 2014b) that uses the 15 percent maximum allowable detrimental soil disturbance standard (FW-STD-SOIL-01). FW-STD-SOIL-01 would apply to all vegetation management activity areas and treatment units under all revised plan alternatives with exception to areas designated for administrative use such as infrastructure. These standards rely on the adequate use of activity area, as defined in the manual, to detect effects of management activities. The management approaches outlined in appendix A of the revised plan detail potential additional project level monitoring indicators that supplements the Soil Manual.

Soil guidelines in the revised plan use a combination of avoidance measures and reclamation to maintain soil productivity. Avoidance measures restrict ground-based timber harvest systems to slopes less than 40 percent (FW-GDL-SOIL-01) and operation on high-risk landslides areas (FW-GDL-SOIL-05), conserve surface soil when conducting management (FW-GDL-SOIL-03 and FW-GDL-SOIL-06), and reduce displacement during site preparation for reforestation (FW-GDL-SOIL-04). Reclamation efforts focus on burn piles after forestry activities (FW-GDL-SOIL-02) in addition to temporary roads, skid trails and landings (FW-GDL-SOIL-04). The guidelines also set bottom line targets for maintaining coarse woody due to the importance for microsites and overall soil productivity (FW-GDL-SOIL-07).

Effects Common to the Revised Plan Alternatives

The environmental consequences analysis for the soils resource focuses on timber harvest, restoration and noxious weed treatment associated activities that have measurable impacts to soils over the next planning cycle on the Custer Gallatin National Forest. Other management activities, such as livestock grazing, dispersed camping, invasive plant treatment, prescribed fire, fuels treatments, and fire suppression operations, can also cause ground disturbance and detrimentally impact soils. The scale of the disturbance is small enough and distributed such that comparisons between the alternatives are slight.

Maintaining Soil Productivity

The revised plan would maintain soil productivity with stronger direction by providing desired conditions that include organic matter with coarse woody debris a key factor, along with the broader implication of ecological functions. This direction gives more vision for managing trade-offs for projects. Forest Service actions typically control removal of vegetation and control the impacts from those activities and how much and what type of vegetation is left behind. The emphasis on organic matter ensures sufficient soil organic matter and cover is provided to maintain soils within the natural range of variability or for reclamation purposes.

The intensity of disturbance would not vary appreciably across the revised plan alternatives. The scale of forest treatments would be similar for all revised plan alternatives except a slightly higher restoration emphasis in alternative D. Alternative E emphasizes timber production and projects vegetation treatments on 5,000 acres per year compared to 6,000–7,500 acres for alternatives B, C, and F, and 8,000 acres for alternative D. Lands suitable for timber production range from 18 to 20 percent in the revised plan alternatives.

The revised plan components would help ameliorate the effects of timber harvest above the current plans by providing more direction on avoiding circumstances that impair soils. Timber harvest affects soil productivity by compacting and displacing soils when yarding logs and slash to central locations. Ground based methods have the highest impact due to the prevalence of machine traffic. The skidding also displaces surface soil where organic matter, soil organisms and nutrient base highest.

The revised plan would carry on best practices, but incorporate slope restrictions and the Region 1 Soil Manual that restricts the disturbance intensity of management actions which includes timber harvest. Projects may deviate from the 40 percent restriction on untethered, ground based mechanical equipment (FW-GDL-SOIL-01) so long as the intent of the guideline is met. For example, tethered equipment may operate on slopes over 40 percent, while in areas of shale, untethered, ground based mechanical equipment may need to be limited to slopes less than the guideline. The revised plan further emphasizes the importance of conserving surface soil for forestry operations when blading temporary roads or preparing sites for reforestation. Ground based timber operations would avoid high risk landslide areas. The management approaches in appendix A of the revised plan outline the complex evaluations and approaches needed to address landslide risk.

Coarse Woody Debris

The management of coarse woody debris would be improved with the revised plan due to additional guidance and according to habitat types. This guidance would help retain sufficient coarse woody debris to benefit soil productivity. The presence of adequate amounts of coarse woody debris in the soil and on the ground, in contact with the soil surface, provides a range of benefits to conifers to help tip the competitive balance in their favor, especially on low fertility sites or during prolonged drought conditions. The greatest benefit to coniferous forests likely comes from an indirect effect as coarse woody material provides important habitat for ectomycorrhizal fungi. These fungi, in turn, enable the conifers to obtain adequate nutrient and water resources on low fertility sites and during prolonged drought conditions contributing to their competitive advantage over other vegetation types on such sites.

Coarse woody debris provides numerous other benefits to the local environment. These include moderating surface and near-surface soil temperature and moisture conditions; protecting the surface from soil erosion; providing a supplemental water during prolonged dry periods; as well as providing an additional source of plant nutrients. Coarse woody debris also offer many benefits to numerous wildlife species. Thus, maintaining adequate levels of coarse woody debris in managed conifer stands is an essential component for maintaining the long-term productivity and the resiliency of conifer trees while also preserving the ecological integrity of such sites. Coarse woody debris increases soil moisture while also adding fuel load. The added soil moisture supplements conifer demand for water through the mycorrhizal network especially in stressed environments (Wiensczyk et al. 2002, Bingham and Simard 2012).

Ensuring that adequate levels of coarse woody debris are retained either partially buried in the soil or in contact with the ground surface in conifer stands after timber harvesting plays an important role in maintaining soil fertility specific to conifers and some ecotonal plant community types. A range of coarse woody debris levels is provided in the revised plan (FW-DC-SOIL-03) by Northern Region broad potential vegetation group. A primary assumption used in the development of desired conditions for coarse woody debris is that the best indication of the natural range of variability is the abundance of coarse woody debris found in wilderness and roadless areas, where natural processes have by and large been allowed to occur (Bollenbacher et al. 2008). Notably, while the desired condition is based on local FIA data, these ranges are also consistent with the optimum ranges of coarse woody debris for providing acceptable risks of fire hazard and fire severity while providing desirable quantities for soil productivity, soil protection and wildlife needs presented by Brown et al. (2003). MON-VEGF-01 will be used to monitor forestwide levels of coarse woody debris.

While variable conditions exist both spatially and temporally in forested stands, an overall pattern exists with lower amounts of coarse woody debris in warm, dry potential vegetation types, developed recreation areas, and high values at risk areas and higher amounts of coarse woody debris in the cold and cool, moist potential vegetation types as well as riparian areas. The revised plan sets minimum amounts of coarse woody debris after vegetation management projects based on potential vegetation types (FW-GDL-SOIL-07). The minimum amounts of coarse woody debris set forth by this guideline are based on a synthesis of best available scientific information indicating optimum ranges of coarse woody debris for these broad potential vegetation types (Brown et al. 2003). The Custer Gallatin National Forest recognizes that in some locations such as the pine savanna sufficient coarse woody debris may not exist. The intent of the guideline is to retain the largest diameter and most decomposed coarse woody debris since this material has the highest water retention. Also, the intent is to manage available coarse woody debris on the ground, with some consideration to recruitment from naturally occurring snags. The guideline applies as an average across each vegetation treatment unit. The distribution of coarse woody debris may be clumped naturally from snagfall or management may intentionally irregularly distribute coarse woody debris to break up the fuel bed. Ultimately, coarse woody debris loads would be managed to balance soil productivity and fire hazard depending on project purposes (Brown et al. 2003).

Noxious Weed Control

Of all the resource areas considered relative to soil disturbance effects, the relationship between noxious weeds or other, non-native, undesirable plant species, such as cheatgrass and smooth brome, and soils is most intertwined. Soil disturbance, especially if it exposes poor quality subsoil, restrictive soil layers, or unsuitable substrate materials, often provides a preferred very suitable substrate for many invasive weed species. In general, the less fertile the soil, the more likely is it to become a target for the establishment of new weed infestations, especially when a ready source of weed seed is present locally or vegetative propagules, such as rhizomes or corms, exists in the surrounding soil.

The presence of weed seed and weeds themselves above some minimum threshold level becomes a biological property of the soil and begins to alter management options and requires even greater expenditures of limited resources to be controlled in the future. Alternative D proposes the highest objective for noxious weed treatment and alternative E the lowest. The revised plan would increase the effectiveness of noxious weed treatment by providing control measures for site disturbance. Either through disturbance avoidance or restoration, the balanced proposals outlined in the management approaches in appendix A of the revised plan can increase restoration effectiveness that would decrease the establishment of invasive plants on rehabilitated temporary roads, landings and burn piles.

Wildfire and Prescribed Fire

Wildfires are not predictable, but the revised plan would give more guidance for soil stabilization and recovery when they occur. Effects from wildfire and prescribed fire can have positive and negative effects on soil productivity depending on the severity of fire, site recovery potential, and erosion effects afterward. The revised plan components provide desired conditions to help promote the positive aspects of fire—increased nutrient availability and charcoal that can ameliorate soils (Hart et al. 2005, DeLuca and Aplet 2008). On the other hand, the plan components bolster the sidelines to consider when rehabilitating burned landscapes and fire suppression features. Appendix A of the plan proposes management approaches as working examples for fire suppression rehabilitation.

The increase in burn scars from wildfire create a higher need for reforestation. The revised plan addresses potential need for site preparation associated with reforestation needs. Guideline FW-GDL-SOIL-04 limits disturbance to balance scarification needs for conifer planting while preventing soil damage that can limit site productivity.

Permanent Losses of Soil

The revised plan under any alternative would have a range of impacts to soils from dedicated administrative purposes. This occurs when areas are no longer dedicated to growing vegetation and are used for administrative use such as system roads, airfields, facilities, and mining operations. The amount of future development cannot be predicted.

Restoring soils

Timber harvest may require temporary road access by machinery to cut and yard trees that excavates and compacts soils. In addition, fuel reduction activities can conduct mastication, and pile slash and brush using ground-based machines such as excavators that disturb soils. The most traveled areas by these machines can have the severest impacts on soils. Whole tree yarding, one of the dominant timber harvest techniques, tends to create very large burn piles at log landings. These landings would have additional impacts from severe burning. The impact may be severe since these large burn piles may smolder such that the deep heating affects the recolonization of soil and plant communities. These conditions may create lasting burn scars prone to invasive weeds (Korb et al. 2004, Rhoades and Fornwalt 2015).

The Custer Gallatin National Forest manages these impacts by reclaiming elements of soil productivity along temporary roads and skid trails. Traditionally, soil reclamation addresses erosion and Best Management Activities focus on stabilization and erosion control to meet the Clean Water Act (Binkley 1991). Over the years, the Forest Service has expanded mitigation to integrate more soil specific actions such as decompacting, subsoiling, scarification, transplanting, and seeding. These restoration techniques have been demonstrated effective associated with decommissioning roads (Switalski et al. 2004, Lloyd et al. 2013) and adopted for soils mitigation (Archuleta and Baxter 2008).

There is no one size fits all mitigation strategy given the large amount of spatial variability in soil resources throughout much of the Custer Gallatin National Forest. While ripping and re-contouring the road prism may be the best approach in one area, it can actually create additional detrimental soil disturbance in very rocky soils due to the sorting of material that was cast downslope. Other strategies such as windrowing, ripping without re-contouring, or simply breaking up the continuity of a temporary road left intact may be preferred strategies in certain instances, depending on soil and site conditions.

The revised plan would improve the effectiveness of these mitigations by adding direction for soil restoration to address temporary roads, skid trails, landings and burn piles (FW-GDL-SOIL-04), and underscores balancing the technique according to site, level of disturbance and soil type (see the management approaches in appendix A of the revised plan).

Restoring the burn pile scars that forestry operations produce is addressed in the revised plan because of the lasting effects. Burning of extremely large slash piles at landings can create major disruption of soil processes needed to restore vegetation on the landing burn pile footprint. The primary adverse effects in this case are likely complex but appear to relate in large part to the deep wood ash layer that is left behind after burning. The revised plan would improve the effectiveness of restoring these burn piles, and help focus where needed most. More explanation of effective mitigation actions to be used after burning very large size slash piles are outlined the management approaches in appendix A of the revised plan.

Native Vegetation Restoration

The revised plan includes objectives for vegetation management treatments that benefit wildlife, at-risk species habitat, pollinator habitat, and rare and unique habitats (FW-OBJ-VEGF-01, FW-OBJ-VEGNF-01), and objectives for restoration of lake, pond, or wetland areas (FW-OBJ-WTR-01). Associated with many such restoration projects would be some level of soil restoration work needed to promote the propagation and survival of the target plant species or mitigate degraded conditions of the local environment. Objectives are highest in alternative D and lowest in alternative E. The overall acreages of soil restoration associated with these projects would be low, especially in comparison to combined total size of the forest. Inclusion of these objectives in the revised plan demonstrates commitment to ecological management that benefits native vegetation and soil resources.

Consequences to Soils from Plan Components Associated with other Resource Programs or Management Activities

Overall plan components associated with most of the other resource programs or management activities are complimentary to forestwide soil resource direction in the revised plan. The plan components for other resources support management direction that protects soil resources, while at the same time efforts to protect soil productivity provide tangible benefits to many of the other resource disciplines, such as riparian management zones, wildlife, forested environment, commercial timber harvesting, watershed, fire, terrestrial vegetation, livestock grazing, and many others.

Cumulative Effects

Past actions and foreseeable future actions primarily affect soils at the site location. Influence from adjacent management on private, state, or federally managed areas would have undetectable effects on site-specific soil conditions. Legacy disturbance from past and present management actions could affect the soil condition where future management activities are planned.

Conclusion

The revised plan alternatives would strengthen the Custer Gallatin National Forest ability to maintain and improve soil productivity by providing desired conditions and additional sideboards that the current plans lack. The desired conditions incorporate the need to manage for soil organic matter, including coarse woody debris, and the Region 1 Soil Manual. The revised plan provides for more effective soil restoration with several specific plan components and management approaches.

Alternative D could have the lowest level of potential detrimental soil disturbance overall than any other alternative considered because this alternative proposes the lowest level vegetation treatment intensity that results in soil disturbance, while emphasizing the most restoration with noxious weed treatments.

Alternative E would have the greatest potential to negatively impact soil resources of the revised plan alternatives due to the projected reduction in management activities such as noxious weed control and treatments and concentration of forestry treatments. While alternative E has the highest level of timber harvesting activities with the potential to create soil disturbance in concentrated areas, the revised soil plan components would provide for increased soil restoration over the current plans.

In conclusion, the revised plan alternatives plan components would protect soil productivity of vegetation treatment unit areas. Alternative D would provide the greatest level of soils benefit, followed by alternatives B, C, and F, and the least benefit would be provided by alternative E.

3.4 Watershed, Aquatic Species and Habitat, and Riparian Ecosystems

3.4.1 Introduction

This section considers the physical, chemical, and biological resources in aquatic and riparian ecosystems and watersheds on the Custer Gallatin National Forest. Managing for high quality water, intact and productive aquatic species habitat, native and non-native desirable species, and high-quality riparian areas is integral to maintaining and enhancing watershed health.

For planning purposes, the revised plan arranges the Custer Gallatin National Forest into six distinct geographic areas ranging from roughly 78,000 acres to 1.4 million acres. Ecologically, the Custer Gallatin has termed its mountainous area as “montane” and the eastern districts as “pine savanna.” Montane ecosystems of the Custer Gallatin include the Madison, Henrys Lake, and Gallatin Mountains Geographic Area; the Absaroka Beartooth Mountains Geographic Area; the Bridger, Bangtail, and Crazy Mountain Geographic Area; and the Pryor Mountain Geographic Area. The pine savanna ecosystem includes the Ashland Geographic Area and the Sioux Geographic Area.

These two ecosystem areas are nested within the broader ecoregions (Environmental Protection Agency Level III Ecoregions). An ecoregion provides a larger scale for planning and analysis that distinguishes common climatic and vegetation characteristics. Approximately 81 percent of the Custer Gallatin is in the middle Rocky Mountains, consisting of coniferous forest, alpine meadow, and shrubland-grassland steppe. Approximately 19 percent of the Custer Gallatin National Forest is in the Northwest Great Plains Province, consisting of ponderosa pine and shrubland-grassland steppe. A small amount of the national forest (less than 1 percent) is in the Wyoming Basin Province around the Pryor Mountains, consisting of semi desert shrubland-grassland.

Across this enormous landscape resides the broadest diversity of aquatic and riparian ecosystems and species in the Northern Region of the Forest Service, ranging from glacial meltwaters to intermittent prairie streams. In addition to the ecosystem services they provide, these aquatic and riparian ecosystems offer a variety of social and economic benefits to local, national, and international communities.

The montane landscape is drained by five major rivers, the Yellowstone, Boulder, Shields, Gallatin, and Madison Rivers. The Yellowstone River flows northeast from Yellowstone National Park. It follows a large, gently sloping valley between the Absaroka and Gallatin Mountain Ranges. The Boulder River flows northward from the Absaroka and Beartooth Mountain ranges. The Shields River originates in the western part of the Crazy Mountains and flows south into the Yellowstone River, near the town of Livingston. The Gallatin River, which originates in Yellowstone National Park and flows northward, divides the Gallatin and Madison Mountain Ranges. The Madison River originates in Yellowstone National Park and flows west through Henrys Lake Mountains, near the town of West Yellowstone.

The pine savanna landscape has nine distinct and isolated Forest Service land parcels amongst the Ashland and Sioux Geographic Areas. Though these units are geographically isolated, they contain ecologically important headwater streams, springs, and wetlands that eventually flow into five major drainages of the Missouri River Basin. The Tongue River flows north starting in Wyoming in the Big Horn Mountains, flows through northern Wyoming and southeastern Montana and empties into the Yellowstone River at Miles City, Montana. The Powder River flows north starting in Wyoming, in the Big Horn Mountains, and flows through northern Wyoming and southeastern Montana and empties into the Yellowstone River 50 miles downstream of Miles City, Montana. The Little Missouri River flows northeast from Wyoming near Devils Tower across a corner of southeastern Montana, into South Dakota and then into North Dakota, and eventually joining the main channel of the Missouri River about 25 miles northeast of Killdeer. The Grand River flows east starting in northwestern South Dakota, joins the Missouri in Lake Oahe, approximately 2 miles northwest of Mobridge. The Moreau River flows east starting in northwestern South Dakota and joins the Missouri in Lake Oahe, with the lower 25 miles of the river forming an arm of the reservoir.

Across elevations in the montane units, watershed hydrology is strongly dependent on timing and magnitude of seasonal snowmelt (generally occurring in April and May). For example, in the Beartooth District, an average of about 31 inches of precipitation falls at the Cole Creek SNOTEL site (site with a weather station that measures precipitation and snowpack) (elevation 7,850 feet), whereas about 29.5 inches of annual precipitation are received at the Burnt Mountain SNOTEL site (elevation 5,880 feet). The elevation difference between these two sites translates to a significant difference in the ratio of precipitation falling as rain versus snow. Over 50 percent of Cole Creek's precipitation occurs as snow, whereas only approximately 13 percent of the precipitation falling at Burnt Mountain occurs as snow. While the above-mentioned SNOTEL sites exemplify the elevation control on precipitation in the area, these stations are not representative of average annual precipitation across the entire montane units of the Custer Gallatin.

The pine savanna units occur in southeastern Montana and into western South Dakota and as such, the physical and hydrologic characteristics are much different from the montane units. Surface flow regimes throughout the Ashland and Sioux Geographic Areas are largely ephemeral and intermittent. Average annual precipitation is approximately 13 to 17 inches, with precipitation increasing to the east and at higher elevations (High Plains Regional Climate Center[1]). While minor peak flows resulting from snowmelt are common, short duration high-intensity precipitation events (often from summer thunderstorms) can produce substantial peak flow events in small watersheds around the Ashland and Sioux Geographic Areas. Such events have been documented in post-wildfire settings and in absence of wildfire (Parrett and Johnson 2004, Efta 2014a;b). This suggests that storm characteristics may have an overriding influence in some cases. While not well understood, sediment transport processes likely follow these sporadic flashy events; sediment delivery to and conveyance through draws and channels appears to be largely periodic and tends to occur in large pulses such as during debris flow events. Head cut initiation (a form of erosion) has been observed in numerous locations across the Ashland and Sioux Districts where between one and two-tenths of a square mile drainage area are contributing upstream.

[1] High Plains Regional Climate Center

Below these head cuts, a transition to riparian or wetland vegetation is commonly encountered, generally signaling a decrease in water table depth relative to surface elevation.

Regulatory Framework

Organic Administration Act of 1897: states that one aspect of the mission of the national forests is to "provide favorable conditions of water flow."

Clean Water Act of 1948, as amended: the principal law concerned with polluting activity in the nation's streams, lakes, and estuaries. Originally enacted in 1948, it has been revised by amendments in 1972 (Pub. L. 92-500) that gave the act its current form and spelled out ambitious programs for water quality improvements that are now being put in place by industries and cities. Congress refined these amendments in 1977 (Pub. L. 95-217) and 1981 (Pub. L. 97-117). The 1987 amendments added:

- Section 319, under which states are required to develop and implement programs to control non-point sources of pollution, or rainfall runoff from farm and urban areas as well as construction, forestry, and mining sites.
- Section 303(d), which requires states to identify pollutant-impaired water segments and develop total maximum daily loads that set the maximum amount of pollution that a waterbody can receive without violating water quality standards; develop a water-quality classification of streams and lakes to show support of beneficial uses; and establish anti-degradation policies that protect water quality and stream conditions in systems where existing conditions exceed standards.

Federal Water Pollution Control Act, as amended: provides direction intended to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Sections 303, 319, and 404 apply to forest management activities. Section 208 of the 1972 amendments specifically mandates identification and control of non-point source pollution resulting from silvicultural activities. There are five required elements:

- Compliance with state and other Federal pollution control rules.
- No degradation of instream water quality needed to support designated uses.
- Control of non-point source water pollution using conservation or "best management practices."
- Federal agency leadership in controlling non-point source pollution from managed lands.
- Rigorous criteria for controlling the discharge of pollutants into the nation's waters.

Multiple-Use Sustained-Yield Act of 1960: Congress has affirmed the application of sustainability to the broad range of resources over which the Forest Service has responsibility. The Multiple-Use Sustained-Yield Act confirms the Forest Service's authority to manage the national forests and grasslands "for outdoor recreation, range, timber, watershed, and wildlife and fish purposes" (16 U.S.C. 528) and does so without limiting the Forest Service's broad discretion in determining the appropriate resource emphasis or levels of use of the lands of each national forest and grassland.

Sikes Act of 1960 (16 U.S.C. 670a): provides for carrying out wildlife and fish conservation programs on Federal lands, including authority for cooperative state and Federal plans and authority to enter into agreements with states to collect fees to fund the programs identified in those plans.

National Environmental Policy Act (NEPA) of 1969: requires the analysis of projects to ensure that the anticipated effects upon all resources within the project area are considered prior to project implementation (40 CFR 1502.16).

Endangered Species Act of 1973, as amended: Section 7(a)(1) supports biotic sustainability by requiring that "all… Federal agencies shall… utilize their authorities in furtherance of the purposes of this act by carrying out programs for the conservation of endangered species and threatened species." Section 7(a)(2) of the Endangered Species Act includes direction that Federal agencies, in consultation with the USFWS, will not authorize, fund, or conduct actions that are likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of their critical habitat.

National Forest Management Act of 1976: directs the Forest Service to manage for a diversity of habitat to support viable populations (36 CFR 219.19). Regulations further state that the effects on these species and the reason for their choice as management indicator species need to be documented (36 CFR 219.19(a)(1)).

Safe Drinking Water Act of 1977 and amendments (1996): In 1996, the Safe Drinking Water Act was amended with requirements to identify "Source water protection areas" and to assess their susceptibility of contamination. This provides states with more resources and authority to enact the Safe Drinking Water Act. This amendment directs the state to identify source water protection areas for public water supplies that serve at least 25 people or 15 connections at least 60 days a year. In terms of relative size and scope, while an individual national forest unit may have 4 designated municipal watersheds, there may be over 100 source water protection areas that intersect with that National Forest System lands managed by that unit.

Source water protection areas have been established to protect public water systems from contamination. Public water systems are defined as entities that provide "water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year." The term "public" in "public water system" refers to the people drinking the water, not to the ownership of the system (www.epa.gov/sourcewaterprotection). These systems can be dependent on any type of water source, including streams, lakes, reservoirs, springs, wells, or infiltration galleries, and include systems used either year-round or only seasonally.

State governments were given the option to accept primacy or responsibility for delineating and developing assessments for these source water protection areas. Montana and South Dakota have accepted this responsibility and should be contacted for the most up-to-date information regarding the source water protection delineations, assessments, and management requirements or goals.

Municipal Watersheds – 36 CFR 251.9: authorizes the chief of the Forest Service to enter into agreements with municipalities to restrict the use of National Forest System lands from which water is derived to protect the municipal water supplies (Forest Service Manual 2542).

Executive Order 11988 (May 24, 1977): directs Federal agencies on taking action on Federal lands to avoid, to the extent possible, the adverse impacts, in the short and long term, associated with the occupancy and modification of floodplains. Agencies are required to avoid the direct or indirect support of development on floodplains whenever there are reasonable alternatives and to evaluate the potential effects of any proposed action on floodplains.

Executive Order 11990 (May 24, 1977), as amended: requires Federal agencies exercising statutory authority and leadership over Federal lands to avoid, to the extent possible, the adverse impacts, in the short and long term, associated with the destruction or modification of wetlands. Where practicable, direct or indirect support of new construction in wetlands must be avoided. Federal agencies are required to preserve and enhance the natural and beneficial values of wetlands.

Executive Order 12962 (June 7, 1995): acknowledges the recreational value of aquatic biota by stating the objectives “to improve the quantity, function, sustainable productivity, and distribution of United States aquatic resources for increased recreational fishing opportunities” by “(h) evaluating the effects of federally funded, permitted, or authorized actions on aquatic systems and recreational fisheries and document those effects relative to the purpose of this order.”

Executive Order 13112 (Feb. 3, 1999): directs Federal agencies whose actions may affect the status of invasive species to prevent the introduction of invasive species and to detect and respond rapidly to and control populations of such species in a cost-effective and environmentally sound manner, as appropriations allow.

Section 8405 of the Agricultural Improvement Act of 2018 (a.k.a. the 2018 Farm Bill): permanently authorizes the Forest Service to develop and maintain the Watershed Condition Framework, using the agency's existing processes and criteria.

Administrative Rules of the State of Montana 16.20.603: states that best management practices are the foundation of water-quality standards for the state of Montana. The Forest Service has agreed to follow best management practices in a memorandum of understanding with the state. Many best management practices are applied directly as mitigation at the project level. Implementation and effectiveness monitoring of best management practices are routinely conducted by contract administrators and during other implementation and annual monitoring events.

Administrative Rules of the State of Montana 17.30, subchapter 6: details water-quality standards for the state of Montana. The Forest Service has primary responsibility to maintain these standards on lands under their jurisdiction in the state.

Montana Natural Streambed and Land Preservation Act of 1975, also known as the 310 law: requires any person planning on working in or near a perennial stream on public or private lands to first obtain a permit from the state.

Administrative Rules of the State of South Dakota 74:51:03: developed a beneficial uses classification system and associated water quality standards for ensuring that beneficial uses are protected.

Administrative Rules of the State of South Dakota 74:51:01:11: indicates wetlands are waters of the state and are allowed provisions under South Dakota water quality law. Multiple protection provisions apply to wetlands within state regulatory authority, including prohibition of pollutant discharge, aquatic nuisance species proliferation, and protection of biological integrity.

Administrative Rules of the State of South Dakota 74:51:01:02: states a person may not discharge or cause to be discharged into surface waters of the state pollutants that cause the receiving water to fail to meet the criteria for its existing or designated beneficial use or uses.

Administrative Rules of the State of South Dakota 74:51:01:34: outlines the anti-degradation policy for the state. Existing designated beneficial uses must be maintained and protected. No further reduction of water quality is allowed for surface waters of the state that do not meet water quality levels assigned to their designated beneficial uses. Item 6 of the policy notes that “the secretary shall assure that regulatory requirements are achieved for all new and existing point sources and that nonpoint sources are controlled through cost effective and reasonable best management practices.”

Forest Service Manual 2520: provides direction for watershed protection and management.

Key Indicators and Measures

The differences between alternatives will be qualitatively evaluated by considering effects of plan direction and how well it supports and protects watershed, aquatic, and riparian values. Additionally, ecosystem integrity will qualitatively be evaluated to understand potential impacts to watershed and riparian resources.

Varying level of plan objectives will be evaluated, including number of aquatic organism passage devices installed, number of acres or miles of stream of stream habitat improved, number of recreation facilities removed from the riparian management zones, timber suitability, and road conditions improved.

Methodology and Analysis Process

This analysis takes a programmatic look at the outcomes that might result from implementing the proposed management direction in each alternative over the life of the plan. The three watershed scales most relevant to the implementation of the revised plan are subbasin (8-digit hydrologic unit), watershed (10-digit hydrologic unit), and subwatershed (12-digit hydrologic unit). A subwatershed may range from 10,000 to 40,000 acres in size. For estimating the effects at the programmatic management plan level, the assumption has been made that the kinds of resource management activities allowed under the alternatives are reasonably foreseeable future actions to achieve the desired conditions and objectives. However, the specific location, design, and extent of such activities are generally not known because these activities are made at the project level based on a site-specific analysis. Therefore, the discussions here refer to the potential for the effects to occur and are in many cases only estimates. The effects analyses are useful when comparing and evaluating alternatives, but are not intended to be applied directly to specific locations on the Custer Gallatin National Forest.

Since the site specificity of future activities are not known at the programmatic plan level, the potential spatial and temporal effects to water quality cannot be attributed to any specific watershed, nor can quantitative estimates of potential effects to aquatic resources be determined (such as changes in water quantity). Broad scale estimated effects and trends related to hydrologic function and watershed processes for National Forest System lands within the project area have been qualitatively estimated. Cumulative effects to water quality are described in terms of their potential to generally affect trends on the subwatershed to basin scale.

Information Sources

This analysis draws upon the best available literature citations that were found to be relevant to the ecosystems on the Custer Gallatin National Forest. Literature sources that were the most relevant, most recent, peer-reviewed, and local in scope or directly applicable to the local ecosystem were selected. Uncertainty and conflicting literature have been acknowledged and interpreted when applicable.

Key information on population trends, life history, and status of aquatic species in the plan area was obtained from the Montana Field Guide (http://fieldguide.mt.gov), state wildlife management agencies for Montana and South Dakota, Forest Service databases, natural heritage programs, Nature Serve, and the U.S. Fish and Wildlife Service, and peer reviewed literature.

Analysis Area

The analysis area for watersheds, riparian management zones, and aquatic species includes all lands within the boundary of the national forest. The temporal scope of the analysis is the anticipated life of the plan. The cumulative effects analysis area includes Custer Gallatin lands and adjacent jurisdictions and landowners.

Notable Changes between the Draft and Final Environmental Impact Statement

In addition to supplementing the final environmental impact statement with new information and citations, clarifying language, minor edits, and analysis of alternative F, notable changes include:

- An outer riparian management zone of 50 feet was added to Category 2 streams in the Riparian Management Zone section.
- Draft plan standard FW-STD-WTR-02 was removed because it was duplicated in FW-STD-RT-05.
- Draft plan guideline FW-GDL-WTR-04 was removed because compliance with total maximum daily loads is already law and policy that must be followed.
- The riparian management zones are now standard FW-STD-RMZ-01.
- Draft plan guideline FW-GDL-RMZ-01 was removed because it was duplicated in FW-GDL-EMIN-02.
- Other plan components were revised to add clarity and/or to provide exceptions to manage infrastructure.

3.4.2 Affected Environment (Existing Condition)

Watersheds

Watershed Condition Framework

Watersheds and their ecological condition have been an increasingly important focus of public land managers in the last two decades (Thomas et al. 2006, Esselman et al. 2011, Reeves et al. 2016). Congress has also had increasing interest in watershed condition, especially when it comes to investment in watershed restoration. Nationally, in 2011 the Forest Service introduced two general technical reports responding to congressional interest. These reports are the Watershed Condition Framework (FS-977) (U.S. Department of Agriculture 2011d) and the Watershed Condition Classification Technical Guide (FS-978) (Potyondy and Geier 2011). These reports were developed in tandem to provide a consistent method for categorizing how the Forest Service identifies the condition of sub-watersheds as well as to provide broad guidance to help national forests select priority watersheds.

The watershed condition framework establishes a nationally consistent reconnaissance level approach for classifying watershed condition. It does so by using a comprehensive set of 12 indicators that are surrogate variables representing the underlying ecological, hydrological, and geomorphic functions and processes that affect watershed condition. The primary emphasis is on aquatic and terrestrial processes and conditions that Forest Service management activities can influence. The indicators use data when available and professional opinion when data is not available. The approach is designed to foster integrated ecosystem-based watershed assessments, provide guidance to programs of work in watersheds that have been identified for restoration, enhance communication and coordination with external agencies and partners, and improve national-scale reporting and monitoring of program accomplishments. The watershed condition framework provides the Forest Service with an outcome-based performance measure for documenting improvements to watershed condition at forest, regional, and national scales (U.S. Department of Agriculture 2011d).

Watershed condition classification ultimately ranks watersheds in one of three discrete categories (or classes) that reflect the level of watershed health or integrity. Watershed health and integrity are considered conceptually the same (Regier 1993). Watersheds with high integrity are in an unimpaired condition in which the ecosystems show little or no influence from human actions (Lackey 2001).

The Forest Service Manual 2520 (Watershed Protection and Management) defines watershed condition in terms of "geomorphic, hydrologic and biotic integrity" relative to "potential natural condition." In this context, integrity relates directly to functionality. In this analysis, geomorphic functionality or integrity is defined in terms of attributes such as slope stability, soil erosion, channel morphology, and other upslope, riparian, and aquatic habitat characteristics. Hydrologic functionality or integrity relates primarily to flow, sediment, and water quality attributes. Biological functionality or integrity is defined by the characteristics that influence the diversity and abundance of aquatic species, terrestrial vegetation, and soil productivity. In each case, integrity is evaluated in the context of the natural disturbance regime, geoclimatic setting, and other important factors within the context of a watershed. The definition encompasses both aquatic and terrestrial components because water quality and aquatic habitat are inseparably related to the integrity and, therefore, the functionality of upland and riparian areas within a watershed.

Within this context, the three watershed condition classes are directly related to the degree or level of watershed functionality or integrity:

- Class 1: functioning properly
- Class 2: functioning at risk
- Class 3: impaired function.

In this framework, a watershed is considered in good condition if it is functioning in a manner similar to one found in natural wildland conditions. This characterization would not be interpreted to mean that managed watersheds cannot be in good condition. A watershed is considered to be functioning properly if the physical attributes are appropriate to maintain or improve biological integrity. This consideration implies that a class 1 watershed in properly functioning condition has minimal undesirable human impact on natural, physical, or biological processes and is resilient and able to recover to the desired condition when or if disturbed by large natural disturbances or land management activities. By contrast, a class 3 watershed has impaired function because some physical, hydrological, or biological attributes indicate a degraded state. Substantial changes to the factors that caused the degraded state are commonly needed to set them on a trend or trajectory of improving conditions that sustain physical, hydrological, and biological integrity.

Watershed Conditions on the Custer Gallatin National Forest

The primary hydrologic unit upon which watershed condition has been assessed is the 6th-level hydrologic unit, or sub-watershed, which is a watershed of about 10,000 to 40,000 acres. To evaluate baseline watershed conditions across the analysis area, a watershed condition rating was determined for each sub-watershed. This characterization estimated the existing condition based on physical characteristics (for example, hydrologic, geomorphic, landscape, topographic, vegetative cover, and aquatic habitat) and human-caused disturbances (such as road construction and vegetative treatments).

The Custer Gallatin National Forest is in 271 sub-watersheds. Eighty-one of these are in pine savanna geographic areas, while 190 are in montane geographic areas. Following the watershed condition class protocol in 2016, 224 watersheds were rated as functioning properly, 47 watersheds were rated as functioning at risk, and none were rated as impaired. Of the functioning at risk watersheds 15 (18.5 percent of pine savanna) were in pine savanna geographic areas, while 32 (17 percent of montane) were in montane geographic areas. Table 14 is a summary of watershed condition classes across the Custer Gallatin by geographic area.

Table 14. Sixth-level watersheds rated in each condition class using the watershed condition framework

Geographic Area	Class 1	Class 2	Class 3	Total	Percentage Watersheds in Class 2
Sioux	40	2	0	42	5
Ashland	26	13	0	39	33
Pryor Mountains	10	0	0	10	0
Absaroka Beartooth Mountains	72	12	0	84	14
Bridger, Bangtail, and Crazy Mountains	25	11	0	36	30.5
Madison, Henrys Lake, and Gallatin Mountains	51	9	0	60	15
Total	224	47	0	271	17.5

Some characteristics of channels commonly measured to help identify changes caused by management include the frequency and depth of large pools, the width-depth ratio of stream channels, and the percentage of fine sediment contained in the substrate (Al-Chokhachy et al. 2010). Low-gradient stream channels show the most response to land management activities. Lower pool frequencies and higher fine sediment concentrations are most obvious in watersheds with higher road densities. These findings are consistent with observations that indicate that past road construction and maintenance, grazing, and timber harvest practices alter sediment delivery and routing (and potentially other habitat components). This in turn, led to fewer pools, higher fine sediment content, and stream aggradation.

Water Quality

The states of Montana and South Dakota non-degradation policies states that existing and anticipated uses and the water quality, necessary to protect those uses, must be maintained, and protected. Many, but not all, land management activities on National Forest System lands are considered nonsignificant activities under state laws so long as reasonable land, soil, and water conservation practices are applied and existing and anticipated beneficial uses will be fully protected.

Water quality is regulated under the authority of the Clean Water Act. States assess waters within their jurisdiction and identify stream segments and other waterbodies whose water quality is “impaired” or generally do not meet water quality standards for beneficial uses.

Individual stream segments, lakes, and other waterbodies have been listed as “water quality limited segments” (for example, “impaired”) by the states of Montana (Montana Department of Environmental Quality 2010) and South Dakota and are described in subsection 305(b) and 303(d) of the Clean Water Act as waters that do not meet State standards. This broad term includes water quality criteria, designated uses, and anti-degradation policies. These impaired waterbodies are identified in a biennial integrated report that lists the status of water quality for waterbodies under state jurisdiction, which includes all National Forest System lands in their respective states.

The Montana Department of Environmental Quality and South Dakota Department of Environment and Natural Resources develop total maximum daily loads and submits them to the U.S. Environmental Protection Agency for approval. A total maximum daily load is the maximum amount of a pollutant a waterbody can receive and still meet water quality standards. Section 303(d) of the Clean Water Act requires advises the development of total maximum daily loads for streams and lakes that do not meet, or are not expected to meet, State water quality standards. Total maximum daily loads provide an approach to improving water quality so that streams and lakes can support and maintain their state designated beneficial uses.

According to the Montana Department of Environmental Quality list, published in 2018, 23 stream segments on the Custer Gallatin National Forest in Montana are on the 303d list and not meeting water quality standards. There are no streams on the Sioux District in South Dakota (on Forest Service lands) that are listed with South Dakota Department of Environment and Natural Resources. This list is typically updated every 2 years by the Montana Department of Environmental Quality in Montana and every 2 years by the South Dakota Department of Environment and Natural Resources.

Groundwater

Groundwater-dependent ecosystems are communities of plants, animals, and other organisms that rely on access to or discharge of groundwater such as springs, fens, seeps, areas of shallow groundwater, cave and karst systems, hyporheic and hypolentic zones, and groundwater-fed lakes, streams, and wetlands.

Groundwater is an important resource in Montana and South Dakota, and it will likely become more important in the future as the states’ population and industries grow. More than half of Montanans depend on groundwater for their primary water supply. According to the Montana Natural Resource Information Service, groundwater provides 94 percent of Montana’s rural domestic water supply and 39 percent of the public water supply. Montana uses over 188 million gallons of groundwater per day for domestic use, public water supplies, irrigation, livestock, and industry (Hutson et al. 2005). Water generated in the mountains of the Custer Gallatin is an important source of recharge for valley aquifers and is therefore an important forest product.

The Custer Gallatin National Forest is also a source of groundwater whereby runoff, especially from snowmelt, will infiltrate soils and stream substrates to recharge downstream aquifers. Montana’s mountains may receive two to three times the amount of precipitation as nearby lowland areas. Currently there is not enough data to numerically differentiate these snowmelt recharge events from the national forest versus deeper groundwater resources and which of those two has a larger impact on aquifers. However, hydrogeologic assessments (Marvin 2000, Schmechel 2015); indicate that in close proximity to surface water some springs and wells may be under direct influence of surface water recharge driven by snowpack accumulation and precipitation. Groundwater recharge to shallow aquifer systems (for example, hyporheic zones) has substantial importance to stream and river flow during base-flow in some cases being critically important for surface water quantity, water quality, and thermal buffering for aquatic biota.

Across the Custer Gallatin National Forest, it is currently assumed (due to relatively sparse populations, large amount of wilderness and remote terrain, and lack of industry currently using that resource on the Custer Gallatin) that groundwater extraction is not significantly drawing down aquifers. Monitoring in areas of high residential and commercial development and areas where industry needs to withdraw groundwater would determine the extent of potential impacts from those activities. There are very few natural sources of ground-water contamination. However, on the Custer Gallatin many streams and rivers of the Yellowstone Gallatin, and Madison River systems drain from Yellowstone National Park where surface water flow from geothermal areas can naturally discharge compounds that are hazardous to humans and potentially fish and wildlife as well. For example, wells in the Madison River drainage have arsenic and fluoride concentrations that exceed U.S. Environmental Protection Agency human health limits for arsenic and fluoride (Thompson 1979). Further, Schmechel (2015) found geothermal features within the south Hebgen Basin confined aquifer are releasing arsenic and fluoride in quantities above the Environmental Protection Agency human health standard.

Despite little known human-caused effects to the groundwater resource at the plan level, there are some localized examples of effects on or near the Custer Gallatin. Adjacent to the Ashland District, in the Powder River Basin, there was a substantial increase in drilling and developing wells for coal bed methane production in the 2000s. This activity has dropped substantially, with 90 Montana wells producing methane and water in 2015 down from a peak of approximately 700 in 2008. Twenty-foot drawdown contours were found to extend a maximum of approximately 1.5 miles from the edge of producing coal bed methane fields, much less than the projected four miles. To date, monitoring data indicates that coal bed methane production has and had not affected groundwater table depth or groundwater quality on the southern end of the Ashland District (Kuzara et al. 2015). If this development activity, likely coinciding with changes in natural gas economy and industry, were to again increase and well(s) were being pumped on or adjacent to forest lands' groundwater resources may be impacted. Coal bed methane development requires withdrawing large volumes of groundwater to release the methane gas. Myers (2009) found that drawdown of groundwater from coal bed methane fields could exceed 6m in depth and extend many kilometers beyond the well(s) or gas field affecting groundwater resources, wells, springs, and pumps. Additionally, replenishing of groundwater resources could take on the order of up to 50 years depending on various parameters such as geologic porosity.

The Sibanye Stillwater Mining Company's extensive palladium and platinum mine operations in the East Boulder and Main Stillwater drainages have rerouted groundwater pathways and altered groundwater quality and quantity. Montana Department of Environmental Quality and the Custer Gallatin National Forest cooperatively regulate and manage water resource impacts associated with mine infrastructure, and as such, surface water quality is maintained within state water quality standards. While much of the mine infrastructure is on private land adjacent to National Forest System lands, the ongoing Benbow Exploration Portal development is on National Forest System lands. Water from this development will be rerouted to the mine for treatment. Over approximately a five-year time span, produced water will be treated then injected into the regional Madison aquifer.

The Sioux Ranger District has three oil and gas wells, two in the North Cave Hills, and one in the South Cave Hills. One of the two wells in the North Cave Hills is a saltwater disposal well. No local surface water or groundwater effects have been observed (Hansen, 2021 personal communication).

Lotic Waterbodies: Streams and Rivers

Streams and rivers (hereafter referred to as streams) are inherently tied to their valley (Hynes 1975), carrying water, sediment, dissolved minerals, and organic material derived from hillsides and the riparian areas adjacent to the stream channel. Thus, streams have developed in more than the longitudinal (upstream-downstream) dimension and instead are active in four dimensions: longitudinal, lateral, vertical, and temporal (Ward 1989). Longitudinal refers to the simple movement of water, nutrients, and materials in the stream channel itself; lateral refers to the exchange of materials with riparian areas and uplands areas; vertical refers to the exchange of surface water and shallow groundwater, or hyporheic water; and finally, temporal is highly variable, but refers to the time continuum constantly shaping and changing ecosystems ranging from evolutionary responses to succession after a disturbance event. Further, moving from headwaters downstream biological organization adapts structurally and functionally to how energy is dissipated along the physical stream template (Vannote et al. 1980).

The shape and character of stream channels constantly adjusts to the flow of water and material by adopting distinctive patterns such as pools, riffles, runs, meanders, and step pools. The vast array of physical channel characteristics, combined with energy and material flow, provide diverse habitats for a wide array of aquatic organisms. Varied topography coupled with irregular occurrences of channel-affecting processes and disturbance events such as fire, debris flows, landslides, drought, and floods result in a mosaic of river and stream conditions that are dynamic in space and time under natural conditions. The primary consequence of most disturbances is to directly or indirectly provide pulses of or to rearrange sediment, gravels and cobbles, and organic matter and wood into stream systems. As a result, most streams and rivers undergo cycles of channel change on timescales ranging from inter-annual to hundreds of years in response to episodic inputs of wood and sediment. The types of disturbances that affect the morphology of a particular channel depend on ecoregion climate (for example, the Rocky Mountains vs the Northern Great Plains), watershed characteristics, size, and position of the stream within the watershed. Many aquatic and riparian plant and animal species have evolved in concert with stream channels. They develop traits, life-history adaptations, and propagation strategies that allow persistence and success within these dynamic landscapes.

Unique within the Northern Region are the pine savanna, as known in the scientific literature, prairie streams that occur in the Ashland and Sioux Geographic Areas. Prairie streams in reference condition are almost nonexistent in some areas yet are a valuable resource in the Northern Great Plains Ecoregion (Sampson and Knopf 1994, Dodds et al. 2004). Previous studies on prairie streams in the Northern Great Plains have shown prairie stream systems are very unpredictable, constantly changing from drying to flooding stages between seasons, sometimes even in a matter of days (Matthews 1988, Ostovar 2007). These systems have shown the need for multiple spatial and temporal sampling to occur along each stream for an adequate understanding of prairie stream assemblages (Ostovar 2007). In-stream habitats are constantly changing in prairie systems (Matthews 1988) and prairie fishes and other aquatic biota have adapted to the drying and flooding landscape of the prairie (Dodds et al. 2004).

Beavers, historically, were an integral part of stream ecosystems in North America, acting as ecosystem engineers where they modify the structure, function, and composition of streams. Their dam building can strongly modify habitats, make lentic habitats altering nutrient cycling dynamics (Naiman et al.

1994), alter fluxes of organic matter, sediment, and heat (Rosell et al. 2005), and increase overall bio-complexity (Wright et al. 2002, Malison and Baxter 2010b). Beaver populations have declined across much of the Custer Gallatin due to trapping and reductions in woody forage species from livestock grazing impacts, road construction, and access-related activities (Pollock et al. 2015). Fire suppression is also a factor as riparian areas can convert from the cottonwood, aspen, green ash, and willow species preferred by beavers towards coniferous tree species under the prolonged absence of fire. This reduction in beaver populations in ecosystems adapted to their presence results in reduced and less resilient riparian and aquatic habitats (Bouwes et al. 2016). An estimated 50 percent of pine savanna stream miles have potentially suitable conditions to provide beaver habitat, whereas 30 percent of montane streams have these ratings (Great West Engineering 2016). Although beaver are currently present in many of the stream reaches, identified by the model as being highly suitable habitat across the Custer Gallatin, occupied habitat is much less than the model projects. For example, on the pine savanna portion of the national forest, many of the stream reaches indicated as highly suitable have intermittent flow regimes, despite wetter than average conditions in the past five years, thereby violating the model assumption of reliable water supply (Efta and Layhee 2016). These reaches are roughly split between watersheds with fully functioning watershed condition framework ratings and those with functioning at risk ratings), indicating that although land management activities such as grazing may play a key role, particularly in modifying riparian vegetation and streambanks, underlying landscape variables (headwater prairie stream hydrology and geomorphology) also drive patterns. Therefore, the model is a useful starting point, but additional analysis and ground truthing is required to refine the model to understand where and how beaver might be managed to restore aquatic habitat composition. Nonetheless, beaver do appear to inhabit less of the Custer Gallatin landscape than they did historically (Pollock et al. 2015). Scrafford (2018b) demonstrated that beaver reintroduction, in the Absaroka Beartooth Geographic Area, can be successful even when historical ungulate pressure had degraded riparian areas and is linked to improved willow condition. Given the many benefits to ecosystems an increase in beaver modified habitat on the Custer Gallatin could ameliorate, in part, the effects of climate change on the landscape.

Human uses have altered some stream channels in the last two centuries. Stream channels have changed as a result of channelization; dam building; wood removal; road, trail, bridge building; logging practices; water diversions for uses such as agriculture; fire suppression; and livestock grazing. Some characteristics of channels commonly measured to help identify changes caused by management include the frequency and depth of large pools, the width-depth ratio of stream channels, and the percentage of fine sediment contained in the substrate (Al-Chokhachy et al. 2010). Low-gradient alluvial stream channels show the most response to land management activities. Past road construction and maintenance, livestock grazing, and timber harvest practices can alter sediment delivery and routing, and potentially other habitat components, which in turn may lead to fewer pools, higher fine sediment content, and stream aggradation.

There are a total of 5,653 mapped stream miles on the Custer Gallatin National Forest (table 15). This is a coarse scale estimate and will change as geospatial datasets, along with ground-truthing data, increase the accuracy of this data over the life of this plan. The pine savanna ecosystem has 1,243 miles while the montane has 4,410 miles, which is roughly proportional to 600,584 acres of pine savanna and 249,226 acres of montane. At this scale most of those stream miles are intermittent and perennial and thus expected to express riparian vegetation. The pine savanna ecosystem has 178 miles of fish bearing streams while the montane has 2,252 miles of fish bearing streams (data comes from nhd – national hydrography dataset) that was analyzed at the 1:100,000 scale. at this scale not all stream types are well represented, particularly ephemeral streams (table 16). At this scale, then, 14 percent of pine savanna streams are fish bearing while 51 percent are fish bearing in the montane streams. Some of that difference could be the fact that montane streams, to date, have had extensive inventory and research on fisheries as compared to streams in the Northern Great Plains ecoregion including the Custer Gallatin pine savanna units.

Table 15. Ephemeral, intermittent, and perennial stream miles in each of the geographic areas

Stream Type	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger, Bangtail, and Crazy Mountains	Madison, Henrys Lake, and Gallatin Mountains	Total
Ephemeral	66	165	0	0	0	0	231
Intermittent	152	498	214	265	130	245	1,504
Perennial	58	304	32	1,695	429	1,400	3,918
Total	276	967	246	1,960	559	1,645	5,653

Data comes from NHD (National Hydrography dataset) that was analyzed at the 1:100,000 scale. At this scale not all stream types are well represented, particularly ephemeral streams.

Table 16. Miles of fish-bearing and non-fish-bearing perennial and intermittent streams in each of the geographic areas

Stream Type	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger, Bangtail, and Crazy Mountains	Madison, Henrys Lake, and Gallatin Mountains	Total
Non-Fish bearing	179	655	225	1,243	360	330	2,992
Fish Bearing	31	147	21	717	199	1,315	2,430
Ephemeral	66	165	0	0	0	0	231
Total	276	967	246	1,960	559	1,645	5,653

Fish bearing data comes from internal Custer Gallatin records while stream data is derived from NHD (National Hydrography dataset) that was analyzed at the 1:100,000 scale.

The most comprehensive and consistent data set on stream channel conditions is provided by the PacFish Infish Biological Opinion monitoring program, which is a highly organized monitoring effort that collects data systematically across National Forest System and Bureau of Land Management lands. This program allows the evaluation of status and trends and comparison of reference and managed conditions at the stream reach scale. A draft analysis of stream habitat conditions on the Custer Gallatin National Forest using the PacFish Infish Biological Opinion data was completed in 2016 (Archer and Ojala 2016a;b). Monitoring began on the Custer Gallatin in 2005 and includes 43 managed sites and 22 reference sites in montane watersheds as well as 22 managed sites in the pine savanna units. The pine savanna units do not have reference sites because nearly all acres on the Custer Gallatin have an ongoing history of land-use, particularly livestock grazing. Additionally, the PacFish Infish Biological Opinion protocol was developed specially for salmonid streams, not warm-water prairie streams that occur in the two eastern units of the Custer Gallatin. Trend data at these pine savanna sites are being analyzed to determine best indicators of trend for pine savanna systems. The goal will be for the PacFish Infish Biological Opinion team and Custer Gallatin National Forest watershed staff to continue to work together to develop a robust monitoring program built on the PacFish Infish Biological Opinion principle that addresses the unique stream systems of the pine savanna units.

PacFish Infish Biological Opinion data for Custer Gallatin National Forest montane streams shows the overall index of habitat condition (a composite of measured habitat values) for montane stream reaches shows that managed watersheds (watersheds exposed to disturbance from various management actions) have habitat conditions about 15 percent lower than reference sites (relatively pristine watersheds that are used as a benchmark of expected condition). The distribution of biological integrity scores is skewed to a lesser extent, about 5 percent, with a similar range of biological integrity scores between managed and reference sites. Overall, about 60 percent of managed watersheds had a biological integrity such as “pristine” conditions, whereas about 80 percent of reference watersheds met that criterion. Taken together, these patterns confirm that land management activities do imprint on Custer Gallatin aquatic habitat conditions, but also that disturbance is a natural occurrence (hence the range of habitat and biotic conditions at reference sites). Indeed, disturbance is often the agent that replenishes critical habitat elements, such as large woody debris and streambed substrates (Kreutzweiser et al. 2012). Further, pristine (for example, unmanaged) systems may actually exhibit a wider range of conditions than more heavily managed systems (Lisle 2002).

Lentic Waterbodies: Lakes, Wetlands, and Reservoirs

Lentic waterbodies, which include natural lakes, wetlands, and constructed reservoirs, are prominent features on the Custer Gallatin National Forest landscape. The Custer Gallatin National Forest has a diversity of these habitats ranging from large montane lakes such as Hebgen Lake just outside the town of West Yellowstone to the hundreds of alpine lakes on the Beartooth Plateau to ponds with warm-water fish on the eastern units.

Lentic habitats on Custer Gallatin pine savanna landscapes are largely the result of constructed reservoirs (such as Mud Turtle and Rabbit Creek Reservoirs, Black’s and Brown’s Ponds). Since the early 1900s, and in particular post WWII, hundreds of thousands of reservoirs have been built across the northern great plains, largely for livestock watering demands, but also for sport-fishing ponds and other uses. Many were also built for concerns over potential floods. These reservoirs often block stream channels. Whether that flow is perennial, intermittent, or even less regular, these structures change the landscape. Overall, the large number of reservoirs across eastern Montana and western South Dakota, including on the Custer Gallatin National Forest, has had a dramatic influence on natural hydrologic processes. The Custer Gallatin pine savanna units have 195 constructed dams and reservoirs that block stream channels of varying size and flow characteristics. Additionally, there are 25 recorded dugouts (areas often in depression or swales of stream channels that will catch water for livestock use). As reservoirs fill with sediment or the dams are breached (as these earthen structures are not permanent) some agencies or landowners are deciding to discontinue the use of these reservoirs and breach dams or reclaim and restore stream channels. During the life of the revised plan, the Custer Gallatin National Forest will have to make decisions and weigh cost verses benefits, at the project scale, as some of these dams will begin to fail. While many amphibians, reptiles (for example, snapping turtle), and fish are known to use these reservoirs, it is unknown how exactly the presence of these habitats changed the hydrology and prairie stream network, but likely that the constructed ponds have bolstered lentic habitat at the sacrifice of lotic habitat.

Springs, a groundwater-dependent ecosystem, in the pine savanna units are a prominent ecological feature on the landscape in that, like streams, they are green lush and diverse areas in an otherwise arid landscape. There are 1,288 stock tanks, which are springs that have been developed for the purpose of watering livestock where the spring water is diverted to a tank. The tanks are often immediately adjacent to the spring. Those spring areas without fencing, can lead to resource damage from trampling and associated soil compaction.

Glaciers

Alpine and rock glaciers are found in several high elevation locations across the greater Yellowstone area of the Custer Gallatin National Forest. Glaciers provide an important source of meltwater in the late summer months when typically, most of the annual winter snowfall has melted. Late summer melt from glaciers provides important habitat for trout and other wildlife as well as a water source for drinking and recreation for the surrounding towns and people in the region. Glacial meltwater is an important habitat component for cold-water aquatic species such as cutthroat trout and various macroinvertebrates.

Glaciers are large flowing masses of ice formed by the compaction and recrystallization of snow. For purposes of this analysis, glaciers, and perennial snowfields are not differentiated, as this would require site-specific field evaluation of each location. In the Absaroka Beartooth Mountains, there are 401 glaciers and perennial snowfields, about 35 percent of the total number in Montana, totaling 20 square kilometers (Fountain 2011). The Crazy Mountains contain 57 glaciers and perennial snowfields, representing 5 percent of the population in Montana, and totaling 1.9 square kilometers (Fountain 2011). Glaciers can be connected to or transition into debris-covered rock glaciers.

Rock glaciers are tongue-shaped flowing masses of ice, rock, and debris often found just downslope of glaciers. Rock glaciers contain significant amounts of water stored as ice and also provides late summer meltwater sources (Price et al. 2013, Rangecroft et al. 2015). Surface debris atop rock glaciers serves as an insulator that makes rock glaciers less sensitive to climatic fluctuations when compared to ice glaciers (Price et al. 2013, Sorg et al. 2015). In a scenario of warming climate, rock glaciers may persist and provide hydrologic input longer than ice glaciers.

In the northern Absaroka and Beartooth Mountain ranges, there are approximately 660 rock glaciers with a total 73 km2 area (Seligman 2009). Approximately 15 rock glaciers have been mapped in the Spanish Peaks area (Vuke 2013). Mapping and assessment of rock glaciers in other portions of the Custer Gallatin have not been completed, but it is likely that additional areas of rock glaciers are present across higher elevation portions of the national forest.

Riparian Ecosystems

Riparian ecosystems are comprised of riparian areas and adjacent corridors. Riparian areas are lands at the interface between uplands and waterbodies saturated with water all year or for varying periods of time during the year. They encompass unique and diverse vegetation types that are closely associated with streams and rivers, lakes, ponds, marshes, swamps, bogs, fens, and other areas of high or fluctuating water tables. Riparian corridors provide important inputs into the overall ecosystem such as shade for aquatic habitats, and organic matter (for example, leaves) and large woody debris that is critical for aquatic organisms. Although riparian areas and corridors may occupy a small percentage of the landscape, they provide important habitat for many terrestrial and aquatic species, including connectivity of habitat from headwaters to downstream areas.

About 77,540 National Forest System acres of riparian areas and corridors associated with these aquatic features comprise about 4 percent of the montane units and 1 percent of the pine savanna units. Table

17 displays the acres of riparian areas and corridors by vegetation dominance types, by geographic area. Of that, nearly 30,000 acres contain riparian and wetland obligate vegetation types: riparian graminoid (grass and grass-like; about 19,700 acres), riparian deciduous tree (cottonwood, aspen, green ash; about 7,900 acres), and riparian shrub types (about 2,400 acres). The remaining 92,850-plus acres are dominated by non-riparian vegetation types, such as Douglas-fir, Engelmann spruce, and grasses. This is likely a slight underrepresentation of montane riparian vegetation as there are some data gaps in the central portion of the Madison, Gallatin, Henrys Lake Geographic Area and the Absaroka Beartooth Mountain Geographic Area. At long-term monitoring sites, within grazing allotments, 484 plant species have been documented.

Natural disturbances that historically influenced the forests within riparian areas are floods, fire, insects, disease, and weather events such as windstorms and blowdown. These effects cause varying amounts and extents of tree mortality, from nearly all trees killed (such as in a mountain pine beetle epidemic in a lodgepole pine-dominated stand) to only scattered trees killed. Forest structure is affected, including changes to and decreases in forest density and canopy closure and increased amounts of dead wood. Reduced canopy closure may stimulate growth of understory grasses, forbs, and shrubs as well as improve growth on remaining live trees. Tree species compositions may change.

Table 17. Riparian vegetation dominance types and National Forest System acreage by geographic area

Geographic Area (GA)	Aspen (acres)	Cotton-wood Green Ash[1] (acres)	Graminoid[2] (acres)	Shrub (acres)	Riparian Vegetation (acres)	Riparian Corridor (acres)[3]	Total Riparian Ecosystem (acres)	Percentage Riparian by GA
Madison, Henrys Lake, and Gallatin	4,932	318	18,393	1,823	25,466	24,297	49,763	6
Absaroka Beartooth Mtns	3,717	227	6,160	672	10,776	24,571	35,347	3
Bridger, Bangtail, and Crazy Mtns	924	7	767	338	2,036	3,429	5,465	3
Pryor Mountains	40	2	11	109	163	2115	2,278	3
Montane	5,896	544	25,331	2,942	38,441	54,412	92,853	4
Sioux	Trace[1]	744	458	56	1,259	NA	1,259	1
Ashland	Trace[1]	38	732	73	843	NA	843	<1
Pine Savanna	Trace	782	1,190	129	2,102	NA	2,102	<1
Total	NA[4]	NA	NA	NA	29,767	NA	77,540	3

1. Aspen and cottonwood are present on the pine savanna units, usually within green ash dominant riparian, but are not the dominant species; green ash is only present on pine savanna units.
2. Moist site grass and grass-like vegetation (for example, sedges).
3. Non-riparian vegetation dominates but riparian processes still at play (such as, conifers dominate, but within recruitment zone of stream channel). Typical vegetation types: Douglas-fir, Engelmann spruce, lodgepole pine, dry site grasses.

NA = not applicable

Riparian Management Zones

Riparian management zones are areas where riparian-dependent resources receive primary emphasis and management activities are subject to specific standards and guidelines. These areas consist of riparian and upland vegetation adjacent to streams, wetlands, and other bodies of water and help maintain the integrity of aquatic ecosystems by influencing the delivery of coarse sediment, organic matter, and woody debris to streams; providing root strength for channel stability; shading the stream;

and protecting water quality (Naiman et al. 1992). Fish, other aquatic life, and wildlife benefit greatly from riparian area protection due to these functions.

Upland vegetation within riparian management zones in combination with the riparian vegetation create zones that provide important wildlife habitat and connectivity. Most wildlife use riparian management zones and aquatic habitats for at least some of their daily or seasonal needs. Due to their widespread distribution and linear or clustered pattern, riparian management zones provide extensive and important habitat connectivity areas for numerous species of wildlife. Refer to wildlife section for information on riparian-associated wildlife species and connectivity of habitat

During the past few decades, land managers have recognized the importance of riparian ecosystems in maintaining water quality, terrestrial habitat, and aquatic habitat. As a result, riparian conservation measures have been developed for Federal, State, and private lands—helping to preserve and protect the integrity of the riparian and wetland habitats as well as the water quality of associated waterbodies. On National Forest System lands, site-specific standards and guidelines are applied to riparian management zones, helping to provide connectivity and maintain composition, structure, and function. Riparian area protections were included in the 1986 and 1987 forest plans.

The Custer Gallatin National Forest is more arid than units west of the Continental Divide, a fact that strongly influences vegetative productivity overall (Pfister et al. 1977). This same dynamic is foremost in relevance to riparian management, because it results in generally smaller site potential trees (verified by Custer Gallatin, unpublished data) within and adjacent to riparian areas, likely smaller channel and floodplain widths, and reduced riparian vegetation expression. When site potential trees are used as an indicator to define riparian zone widths, the smaller site potential trees of the Custer Gallatin would result in a narrower riparian management zone width than forests west of the Continental Divide.

Aquatic Species and Habitat

Thirty-six species of fish (21 native; table 18) are known (or suspected, in some cases) to occupy approximately 2,880 miles of stream, and 565 lakes (includes lakes, ponds, and reservoirs). The montane units have cold water species such as trout, while the pine savanna units have warm water fish species. Occupied stream miles are likely much higher because fish distribution hasn't been verified for many streams, particularly alpine and pine savanna streams. As fish distribution is verified, species composition is also likely to change, particularly in pine savanna and lower elevation montane streams, where fewer surveys have been conducted, but where species diversity is higher. Across the Custer Gallatin, aquatic macroinvertebrates occur in great abundance and diversity and are important indicators of bio-integrity. Currently there are 349 species of aquatic invertebrates known to occur on the Custer Gallatin. As inventories continue, that composition is also likely to change. Amphibians and reptiles are also present in waterbodies and riparian areas across the Custer Gallatin National Forest increasing the overall biodiversity. Amphibians are often associated with or even dependent on water and riparian areas while most reptiles, save for snapping and painted turtles, are not water or riparian obligates yet many are often present in and benefit from aquatic and riparian resources.

Aquatic invasive species are a substantial threat to aquatic species and include any non-native plant or animal species and disease that threatens the diversity or abundance of native species, the ecological stability of infested waters, or the commercial, agricultural, or recreational activities dependent on such waters. The Montana Aquatic Nuisance Technical Committee (2002) has identified over 70 nuisance species while South Dakota Department of Game, Fish and Parks has identified 24 nuisance species

(Adams et al. 2016). Some that are well known include the New Zealand mud-snail, curly-leaf pondweed, whirling disease, rusty crayfish, and various non-native fish. Although non-native fish such as brook trout and rainbow trout are desirable in many locations, there are places where they are not due to their ability to outcompete or hybridize with native cutthroat. An environmental assessment by the Montana Fish, Wildlife and Parks is now required before fish introductions can legally occur.

Table 18 displays fish species of the Custer Gallatin National Forest. Stream miles indicated estimate occupied habitat on the national forest. An "incomplete survey" comment indicates distribution is likely more extensive than indicated, given knowledge of available habitat types.

Table 18. Fish species of the Custer Gallatin National Forest

Fish Species	Montane (stream miles)	Pine Savanna (stream miles)	Total (stream miles)	Status	Comments
Arctic grayling	28	0	28	SGCN-MT	Stream miles linked to occupied Montane lakes
Black bullhead	0	26	26	Introduced	Also, in some Pine Savanna impoundments
Black crappie	0	0	0	Introduced	Pine Savanna impoundments
Brassy minnow	0	92	92	Native	None
Brook stickleback	0	1	1	Native	Incomplete survey
Brook trout	717	1	718	Introduced	None
Brown trout	384	0	384	Introduced	None
Creek chub	0	1	1	Native	Estimated based on adjacent records
Fathead minnow	0	63	63	Native	None
Flathead chub	0	8	8	Native	Estimated based on adjacent records
Golden shiner	0	0	0	Introduced	Pine Savanna impoundments
Golden trout	34	0	34	Introduced	Stream miles linked to occupied Montane lakes
Green sunfish	0	20	20	Introduced	Larger stream pools, impoundments; most widely distributed Pine Savanna invasive fish
Iowa darter	0	3	3	SGCN-MT	Incomplete survey; confirmed in both MT and SD
Lake chub	0	113	113	SGCN-SD	Documented on Ashland district
Lake trout	0	0	0	Introduced	Montane lakes
Largemouth bass	0	0	0	Introduced	Pine Savanna impoundments
Longnose dace	19	98	117	Native	None
Longnose sucker	66	0	66	Native	None
Mottled sculpin	419	0	419	Native	Also known as Rocky Mountain Sculpin
Mountain sucker	43	0	43	Native	None
Mountain whitefish	206	0	206	Native	None
Plains minnow	0	7	7	Native	None
Pumpkinseed	0	1	1	Introduced	Otter Creek
Rainbow trout	706	0	706	Introduced	Also stocked in Pine Savanna impoundments

Fish Species	Montane (stream miles)	Pine Savanna (stream miles)	Total (stream miles)	Status	Comments
River carpsucker	0	0	0	Native	Found at Boxelder Cr FS Road crossing
Sand shiner	0	1	1	Native	Estimated based on adjacent records
Sauger	0	0	0	SGCN-MT	Found at Boxelder Creek FS Road crossing
Shorthead redhorse	0	11	11	Native	None
Smallmouth bass	0	1	1	Introduced	Stocker Branch, Blacks Pond
Stonecat	0	8	8	Native	None
Utah chub	6	0	6	Introduced	Hebgen, Mystic Lakes
Westlope cutthroat	213	0	213	SGCN-MT	None
White sucker	87	560	646	Native	None
Yellow perch	0	0	0	Introduced	Pine Savanna ponds (such as, Exie)
Yellowstone cutthroat	694	0	694	SGCN-MT	None

SGCN-MT= species of greatest conservation need in Montana

On the Custer Gallatin, in the montane units, westslope and Yellowstone cutthroat trout historically approximately occupied 949 and 758 stream miles, respectively. In the Missouri River basin, westslope cutthroat are far less common than their range wide occupancy: the current Custer Gallatin westslope cutthroat distribution constitutes 9 percent of total habitat occupied by the subspecies in the Madison, Gallatin, and upper Missouri River watershed. The Custer Gallatin includes 34 percent of overall occupied cutthroat habitat in the major watersheds intersecting the national forest (Madison, Gallatin, and Yellowstone).

The distribution of non-native salmonids is a primary reason for the reduced range of cutthroat trout. Rainbow and brook trout are the most widely distributed salmonids on the Custer Gallatin, and these species, along with brown trout, may replace, displace, or hybridize native cutthroat (summarized in table 19 and table 20) (Halofsky and Peterson 2016). As such, the Custer Gallatin and partners have built fish passage barriers to protect native trout from non-native trout. In conjunction with fish barrier construction or natural barrier enhancement, non-native trout are also removed chemically or physically from above the barrier site. Of the total mileage occupied by the cutthroat subspecies on the Custer Gallatin, about 73 miles of stream habitat has been secured for westslope cutthroat trout (83 percent of westslope cutthroat trout occupied stream miles) and 78 miles for Yellowstone cutthroat (22 percent of Yellowstone cutthroat miles) over the past decade. Cutthroat conservation will continue to be a priority for the Custer Gallatin, as Montana Fish, Wildlife and Parks has set the goal for cutthroat conservation at a minimum of 20 percent cutthroat occupancy in historically occupied watersheds (Montana Fish Wildlife and Parks 2014b).

In the pine savanna units, native fisheries and aquatic organism conservation work has not historically been at the pace and scale of similar efforts as the montane units. During the last couple decades efforts by various groups have broadened our understanding of prairie fishes across eastern Montana and the western Dakotas. In the last decade on the pine savanna units of the Custer Gallatin National Forest there have been aquatic organism passage culverts installed, riparian plantings, and enclosures built around sensitive spring habitats. More of this work is expected into the future pending available resources.

Table 19. Cutthroat trout habitat occupancy on the Custer Gallatin National Forest

Custer Gallatin Habitat	Yellowstone Cutthroat Trout	Westslope Cutthroat Trout
Historical occupied stream habitat (miles)	758	949
Current occupied stream habitat (miles)	352	88
Historical habitat currently occupied by core/conservation populations (percent)	46	9
Current populations in sympatry with Brook trout (percent)[1]	28	0

1. Sympatry with brook trout is a measure of competition risk.
Note: Secured means nonnatives removed, and precluded from reinvasion by a barrier.

Table 20. Cutthroat trout habitat occupancy rangewide

Rangewide Habitat	Yellowstone Cutthroat Trout	Westslope Cutthroat Trout
Historical range-wide habitat currently occupied (percent)	43	59
Populations occupying historical habitat considered not likely hybridized (percent)[1]	23	15

1. Hybridization can compromise conservation value of populations.

Many montane lentic habitats, as well as some of the montane lotic habitats provide breeding and rearing habitat for western toads (*Anaxyrus boreas*). Western toads are relatively common in some portions of the Custer Gallatin, particularly Hebgen Lake and north in the Madison mountain range (Maxell 2009). The Crazy Mountains and Beartooth Plateau are areas for which additional data are needed to assess species status; the species is considered vulnerable to population crashes, as has happened in other places within its distribution (Maxell et al. 2009). Hebgen Reservoir and adjacent littoral ponds provide breeding and rearing habitat for plains spadefoot (*Spea bombifrons*) which is more commonly found in pine savanna locales. Another amphibian species, northern leopard frog (*Lithobates pipiens*), is also a species of greatest conservation need. This species has not been documented on montane portions of the Custer Gallatin since 1961, in East Rosebud Lake (DuBois 2016b). However, it is quite common in the Northern Great Plains of eastern Montana and the western North and South Dakotas, including the Ashland and Sioux Geographic Areas. The western tiger salamander (*Ambystoma mavortium*) is known to occur in montane and pine savanna areas east of the Continental Divide but is particularly abundant in ponds and intermittent streams of the pine savanna units of the Ashland and Sioux.

A native mussel the Fatmucket mussel (*Lampsilis siliquoidea*) could use habitat in the pine savanna geographic area. They can be found under a number of conditions but prefer sandy-muddy bottoms and shallow (5 to 8 centimeters) quiet water below riffles, and in slowly running water with sand, fine gravel, and mud. Another native mussel, the giant floater (*Pyganodon grandis*) also may be present here and is known to be very abundant in the Little Missouri River system. Also, it can be found in smaller intermittent prairie streams if permanent pools are present as occurs in the pine savanna geographic areas.

Aquatic Forest Service Sensitive Species

Forest Service sensitive species are defined as “plant and animal species identified by a regional forester for which population viability is a concern, as evidenced by significant current or predicted downward trends in population numbers or density; or significant current or predicted downward trends in habitat capability that would reduce a species’ existing distribution.” The current Northern Region sensitive animal species list was developed in 2011. Suitable habitat for nine currently listed Forest Service sensitive aquatic (fish, amphibian, and mussel) species exist on the Custer Gallatin National Forest. Seven of the nine species have known populations that occur on the national forest while two species are not known to occur or likely no longer occur.

Upon final regional forester’s determination of the Custer Gallatin’s Aquatic Species of Conservation Concern list, the regional forester’s sensitive aquatic species list will be replaced with the species of conservation concern list. Analysis of sensitive aquatic species pertain to the current forest plans. Appendix C provides the regional forester’s sensitive species list.

Federally Listed (Threatened) Aquatic Species: Western Glacier Stonefly

The western glacier stonefly (*Zapada glacier*) is an aquatic macroinvertebrate known to occur in alpine streams. It was recently, November 21, 2019, listed as “Threatened” under the Endangered Species Act (Federal Regulation, (2019a). The most robust data for this species comes from Glacier National Park where the species was first described in 1971, from specimens collected and preserved from 1963-1969 (Giersch et al. 2015). This species appears to be most often found in, streams draining glaciers and semi-permanent snowfields. In Glacier National Park the documented decrease in the size of glaciers (Hall and Fagre 2003) among other effects of climate change, such as decreased annual snowpack, are linked to declining habitat and persistence of the western glacier stonefly and other rare invertebrates in alpine habitats (Muhlfeld et al. 2011, Giersch et al. 2016).

Western glacier stonefly has been documented in the Absaroka Beartooth Mountains Geographic Area (in high alpine designated wilderness). It is likely based on confirmed locations that the western glacier stonefly may be more abundant on the Custer Gallatin National Forest than previously thought with more potential habitat available in Absaroka Beartooth Mountain; Madison, Henrys Lake, and Gallatin Mountains; and the Bridger, Bangtail, and Crazy Mountain Geographic Areas.

Western glacier stonefly nymphs (immature stage of aquatic macroinvertebrates residing in aquatic habitats before emerging from the water as sexually mature adults) cannot be identified by hand and instead require genetic analysis, making the time to determine distribution costly. Additionally, their very remote habitat, seasonally limited access, and lengthy treks to potential sites make sampling even more difficult if not inefficient. Researchers are planning to use eDNA technology in the future (if funding becomes available) to speed up determining presence or absence and more detailed habitat requirements (Giersch, 2017 personal communication).

Aquatic Species of Conservation Concern: Western Pearlshell

The western pearlshell (*Margaritifera falcata*) is the only native mussel found in the montane portion of the Custer Gallatin National Forest. Montana Fish, Wildlife and Parks lists this species as a “Species of Concern” and the regional forester has identified it as a species of conservation concern on the Custer Gallatin. (Stagliano 2015) found this species declining by approximately 20 percent over the last decade in Montana. Its range extends throughout the western United States and Canada where it is declining, and even extirpated in some locations. In Montana it is almost certainly extirpated from rivers such as the Bitterroot, Big Hole, Clark Fork, and the Blackfoot. On the Custer Gallatin National Forest is likely the historical distribution of the pearlshell closely matched the historical distribution of the westslope cutthroat.

This species tends to inhabit the runs and riffles of colder streams and rivers that have a stable gravel substrate with a low to moderate gradient wider than 2 meters. The western pearlshell is intolerant to silt and warming stream temperatures. It is dependent on a host fish species, like most other mussels, during its parasitic larval stage. Glochidia (microscopic larval stage of freshwater mussels) attach to the gills of the host fish where they can be transported upstream or downstream. For the Custer Gallatin, and throughout Montana, that fish species is the westslope cutthroat trout. As such, widespread decline in westslope cutthroat has a negative impact on the western pearlshell since the historical distribution of the pearlshell closely matched the historical distribution of the westslope cutthroat. Once they detach form the host fish species and become adults, they are sedentary not moving more than a few meters where they filter feed consuming plant and animal organic matter and expel water, hence the need for clean, silt-free, water. They tend to congregate in boulder protected “beds” and if undisturbed are known to have lengthy life spans. Montana Natural Heritage Program (2018b) demonstrated the western pearlshell can have a lifespan in excess of 60 years.

Aquatic Species of Conservation Concern: Westslope Cutthroat Trout

The westslope cutthroat trout (*Oncorhynchus clarki lewisi*) is a native cutthroat found on the Custer Gallatin National Forest in the Gallatin and Madison River drainages. Montana Fish, Wildlife and Parks lists this as a “Species of Concern” and the regional forester has identified it as a species of conservation concern on the Custer Gallatin. In Montana, its historical range included all of western Montana and the headwater drainages of the Missouri River system, which overall has now shrunk considerably due to hybridization and competition primarily with non-native salmonids and habitat degradation. On the Custer Gallatin the westslope occupies approximately 9 percent of its historical range, where the only genetically pure and secure populations reside upstream of physical barriers, natural and man-made, that keep non-native salmonids out (primarily rainbow and eastern brook trout).

Benefits to People

Aquatic and riparian ecosystems on the Custer Gallatin support a wide variety of direct human uses and benefits, although many of these uses may impair ecosystem function if not properly managed. Among these are angling and other forms of recreation, municipal and residential water supply, and agricultural uses (stock water, irrigation). In addition, these ecosystems provide a variety of additional benefits, such as flow modulation (buffering both flood and base flows), water filtration, erosion control, groundwater recharge, wildlife habitat and migration corridors, and scenery. National forest watersheds moderate both high and low flows through the function of floodplains and wetlands. Water storage and retention in national forest floodplains can both reduce the rate and duration of peak flow response, but also assist in retaining base flows. These processes can be amplified by beaver colonies.

Source Water Protection Areas and Municipal Watersheds

Public water systems are defined under the Safe Drinking Water Act as entities that provide “water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people for at least 60 days a year” (U.S. Environmental Protection Agency 2017). The term “public” in “public water system” refers to the people drinking the water, not to the ownership of the system.

Source water protection areas are established to protect public water systems from contamination in accordance with the 1996 amendments to the Safe Drinking Water Act. Montana Department of Environmental Quality's source water protection program provides guidance and approval of source water protection areas within the state of Montana. Source water protection areas in Montana are divided into distinct regions according to the time water takes to reach a public water system intake. The purpose of subdividing source water protection areas in this way is to prioritize source water protection efforts. Montana Department of Environmental Quality has identified management goals within each of these regions, and these management goals are discussed in the context of the water systems located within, adjacent to, or downstream of the Custer Gallatin National Forest.

Public water system intakes on surface water, for example, streams, are the most susceptible to contamination from land management activities within the Custer Gallatin National Forest. One public water system diverts surface water within the Custer Gallatin. The city of Bozeman diverts water out of Hyalite Creek from within the Custer Gallatin National Forest in the northern Gallatin Mountains. In addition, the city of Bozeman also diverts surface water out of Sourdough Creek, but this diversion is located outside of the national forest. The source water protection areas of all surface water intakes includes a "spill response" area that is a buffer along each source stream measuring a maximum of 10 miles in length, 0.5 mile from both streambanks and 0.5 mile downstream from the surface water intake, confined to the extent within the contributing watershed. These spill response areas are to be managed to prevent releases of contaminants that could be drawn directly into a water intake with little lag time. In addition, the rest of the contributing watershed upstream of the intake is the "watershed region" part of the source water protection area, in which management is to maintain and improve the quality, in the long term, of surface water used by the public water system (Montana Department of Environmental Quality 1999).

In addition to the city of Bozeman, the Christikon Bible Camp also has a spill response region that intersects the Custer Gallatin, and another 17 surface water users located downstream of the national forest have a "watershed region" source water protection area that extends up into the national forest. These 17 surface-water public water systems serve approximately 262,581 people (table 21 and table 22).

Groundwater sources also supply drinking water on the Custer Gallatin. There are 30 public water systems withdrawing groundwater within National Forest System lands on the Custer Gallatin. These groundwater systems are serving approximately 11,433 people. Montana's source water protection program states that areas located within 100 feet of these groundwater sources is the control zone for each intake, and this area is to be managed to protect sources from damage and to prevent direct introduction of contaminants into sources or the immediate surrounding areas. Table 23 and table 24 provide the information for the 3 community and 27 non-community public water systems that have wells or spring water sources located within National Forest System lands. There are four additional public water systems that use groundwater within close proximity on the Custer Gallatin and have 100-feet control zones that intersect National Forest System lands. These public water systems are found in table 23.

Table 21. Public water systems that use surface water and have spill response regions that overlap the Custer Gallatin

PWS Number	PWS Primary Name	Water Source	Class of PWS per the Safe Drinking Water Act	Population served by PWS
MT0000161	City of Bozeman	Hyalite Creek and Sourdough Creek	Community	50,000
MT0001548	Christikon Bible Camp	Boulder River	Non community	100

PWS = public water system

Table 22. Public water systems that use surface water with intakes located downstream of National Forest System lands with source water protection areas whose watershed region overlaps National Forest System lands within the Custer Gallatin National Forest

PWS Number	PWS Primary Name	Water Source	Class of PWS per the Safe Drinking Water Act	Population served by PWS
MT0000153	City of Billings	Yellowstone River	Community	114,000
MT0000156	Lockwood WUA	Yellowstone River	Community	5900
MT0000192	Town of Culbertson	Missouri River	Community	1,700
MT0000215	City of Forsyth	Yellowstone River	Community	1,944
MT0000218	Town of Fort Peck	Fort Peck Lake	Community	240
MT0000229	City of Glendive	Yellowstone River	Community	5,500
MT0000235	City of Hardin	Big Horn River	Community	3,500
MT0000270	City of Laurel	Yellowstone River	Community	6,339
MT0000290	Town of Melstone	Musselshell River	Community	170
MT0000291	City of Miles City	Yellowstone River	Community	8,800
MT0000415	City of Glasgow	Missouri River	Community	3,253
MT0000416	Montana Aviation Research Co	Missouri River	Community	62
MT0000525	City of Great Falls	Missouri River	Community	60,000
MT0000103	Yellowtail Dam Powerplant and Visitor Center	Yellowtail Reservoir	Non community	48
MT0003448	Rock Creek Marina and Campground	Ft Peck Reservoir	Non community	50
MT0042450	Hell Creek State Park	Fort Peck Reservoir	Non community	50
MT0003326	Montana Dakota Utilities Co	Yellowstone River	Non transient Non community	25

PWS = public water system

Table 23. Community public water systems that use groundwater wells/spring water sources located within National Forest System lands

PWS Number	PWS Primary Name	Place Name	Population served by PWS
MT0062294	Soda Butte Campground	Bozeman	40
MT0062303	Red Cliff Campground	Bozeman	70
MT0062306	Madison Slide Visitor Center	Bozeman	500
MT0062307	Rainbow Point Campground	Bozeman	100
MT0062479	Fairy Lake Campground	Bozeman	30
MT0063649	Lonesome Hurst Campground	Bozeman	40

PWS Number	PWS Primary Name	Place Name	Population served by PWS
MT0062299	Hood Creek Campground	Bozeman	30
MT0000331	Silver Gate Water Association Inc.	Cooke City	40
MT0001546	Cinnamon Lodge and Adventures	Gallatin Gateway	76
MT0062579	Pine Creek Campground	Livingston	47
MT0001687	Camp Mimanagish	McLeod	50
MT0002042	Templed Hills Baptist Camp	Pray	40
MT0002505	Red Lodge Mtn Midway Lodge	Red Lodge	150
MT0002906	Yellowstone Presbytery	Red Lodge	30
MT0062224	Limber Pine Campground	Red Lodge	40
MT0062227	Greenough Lake Campground	Red Lodge	50
MT0062228	Parkside Campground	Red Lodge	40
MT0062235	Basin Campground	Red Lodge	50
MT0062237	Emerald Lake Campground	Red Lodge	30
MT0062577	Beartooth Mountain Youth Camp	Red Lodge	75
MT0002507	Timbercrest Girl Scout Camp	Red Lodge	50
MT0062234	Woodbine Campground	Red Lodge	102
MT0001341	Happy Hour Bar and Lakeview Condos	West Yellowstone	58
MT0001349	Campfire Lodge Resort Inc.	West Yellowstone	104
MT0001818	Madison Arm Resort	West Yellowstone	107
MT0062309	Beaver Creek Campground	West Yellowstone	60
MT0003894	Stillwater East Boulder*	Big Timber	380

PWS = public water system

*This PWS also classified as non-transient.

Table 24. Public water systems that use ground water in close proximity to the Custer Gallatin National Forest and have control zones that overlap the Custer Gallatin

PWS Number	PWS Primary Name	Place Name	Class of PWS per the Safe Drinking Water Act	Population served by PWS
MT0001251	Deer Park Chalet	Bozeman	Non community	1,500
MT0003755	Sphinx Mountain Mb Hm Pk	Gardiner	Community	52
MT0004065	Lakeview Suites	Hebgen Lake	Non community	38
MT0062308	Bakers Hole Cg	Bozeman	Non community	82

PWS = public water system

In addition to the control zone, the area within 1 mile of each groundwater public water system sources are typically designated as inventory regions by Montana Department of Environmental Quality, which are managed to minimize susceptibility to contamination. The inventory region encompasses the area expected to contribute water to a public water system within a fixed distance or a specified groundwater travel time. The recharge region is generally the entire area contributing recharge to groundwater that may flow to a drinking water supply over long time periods or under higher rates of usage. The delineation of these inventory regions can be defined using other methodologies than a simple one-mile buffer, depending on the information available and the circumstances. Management in these inventory regions will be focused on pollution prevention activities where water is likely to flow to a public water system well intake within a specified time period. These inventory regions have various degrees of delineation on the Custer Gallatin, and management in these inventory regions will be considered at the site-specific project level. Best management practices can be implemented to control non-point sources of contamination in these areas (Montana Department of Environmental Quality 2002). These public water systems are listed in table 23 and table 24.

Although all water that originates on the Custer Gallatin National Forest could be used for municipal supply at some point downstream, Forest Service Manual 2542.03 states “identify watersheds providing the principal source of community water during land management planning.” As such, municipal watersheds are a specific subset of watersheds that typically receive additional consideration and protection from land management actions on National Forest System lands. Watershed protection direction is provided for municipal supply watersheds in Forest Service Handbook 2509.22. As stated in 36 CFR 251.9(a), “The Forest Service shall manage national forest watersheds that supply municipal water under multiple use prescriptions in forest plans (36 CFR, part 219).” It continues that for a municipality to receive additional protection measures beyond those already specified in the plan, agreements, and special-use authorizations, a “municipality must apply to the Forest Service for consideration of these needs.”

The Custer Gallatin has five municipal supply watersheds recognized in accordance with 36 CFR 251.9 (table 25). Whiskey Spring originates to the south of the city of West Yellowstone and flows into the south fork of the Madison River. There is a water intake for the city that is derived from a spring, directly from the ground. There have been ongoing discussions with the Forest Service and city personnel on the topic of additional municipal water sources for West Yellowstone as there is concern that Whiskey Spring groundwater wells in town will not provide enough water in the near future.

Hyalite Creek and Sourdough Creek originate south of the city of Bozeman and flow north through town to the East Fork of the Gallatin River. Lyman Spring originates in the east end of the Bridger Mountains flowing for less than a mile on Forest Service lands, north of the city of the Bozeman, and flows south into Bridger Creek which eventually drains to the East Fork Gallatin River. Lyman spring municipal water is considered groundwater diverted through spring-boxes. Sourdough, Hyalite, and Lyman supply about 40 percent, 40 percent, 20 percent, respectively, of Bozeman City Water Supply with other off-Forest (primarily groundwater wells in the valley) private water supply systems also supplying water to some users.

Table 25. Municipal watersheds of the Custer Gallatin National Forest

User	Source Water	User Type	Population	Acres of Custer Gallatin National Forest in source watershed	Total acres of source watershed
City of Bozeman	Bozeman Creek	Community	50,000	14,926	18,747
City of Bozeman	Hyalite Creek	Community	50,000	31,045	31,355
City of Bozeman	Lyman Creek*	Community	50,000	5,895	8,405
City of Red Lodge	West Fork Rock Creek*	Community	2,237	18,047	18,967
City of West Yellowstone	Whiskey Spring (South Fork Madison River) *	Community	1,365	15,365	15,933

*Current water drawn from groundwater wells.

In addition, 5,410 private water rights are held on points of diversion on the Custer Gallatin; some of these are for residential use while many of the others are for agricultural purposes (table 26).

Table 26. Number of water rights held on the Custer Gallatin National Forest

Water Rights	Total	Domestic Use	Irrigation	Commercial	Lawn and Garden	Geothermal	Fish and Wildlife
Number of water rights	5,410	2,058	1,183	250	511	4	194

More than half of Montanans and South Dakotans depend on groundwater for their primary water supply (Maupin et al. 2014). However, the current withdrawal in Montana represents a small percent of the available groundwater recognizing that the amount of available groundwater far exceeds that of available surface water. Groundwater provides 94 percent of Montana's rural domestic water supply and 39 percent of the public water supply. Montana uses over 188 million gallons of groundwater per day for domestic use, public water supplies, irrigation, livestock, and industry uses (Maupin et al. 2014). Water generated in the mountains and hills of the Custer Gallatin is an important source of recharge for valley aquifers and is therefore an important ecosystem service provided by the national forest. Demand for water will likely increase in importance with an increasing population, increasing demand for aquatic and riparian resources, and potential effects of climate change on these resources (LeRoy Poff et al. 2012).

Angling

Angling and the regulations guiding anglers are managed by the Montana Fish, Wildlife and Parks in Montana and by the South Dakota Department of Game, Fish and Parks in South Dakota. Montana Fish, Wildlife and Parks strategic vision of management of native and non-native fisheries management from 2019 to 2027 can be found at Montana Fish, Wildlife and Parks (Montana Fish Wildlife and Parks 2019). South Dakota Department of Game, Fish and Parks strategic vision of management of native and non-native fisheries management from 2019 to 2023 can be found at South Dakota Department of Game, Fish and Parks (2019). State plans are likely to be updated and changed throughout the life of the revised plan.

As of 2009, angling on the five most-fished Custer Gallatin waterbodies (Madison, Gallatin, and Yellowstone Rivers; Hebgen and Hyalite Reservoirs) was over 146,000 angler days, with 45 percent of these angler days representing nonresident fishermen (Barndt et al. 2017). These numbers don't account for the secondary benefits of high-quality water, forage, and fish produced on the Custer Gallatin that support mainstem fishing on segments of those streams and others downstream of the national forest boundary. The portion of Madison River downstream of the Custer Gallatin alone supports nearly 121,000 angler days a year, whereas the Yellowstone has over 71,000 angler days.

In addition to these nationally and internationally known fisheries, the Custer Gallatin supports diverse locally and regionally important angling opportunities. Among these are high mountain lakes, where species such as golden and lake trout, and Arctic grayling are destination fisheries for some anglers, and pine savanna reservoirs, where largemouth and smallmouth bass, panfish, and put-and-take rainbow trout are targeted species. Overall, National Visitor Use Monitoring data show that 4.9 percent of Custer Gallatin visitors came to the national forest for the primary purpose of fishing, whereas 8.2 percent of all visitors annually fished (254,000 of the Custer Gallatin's annual visitation of about 3.1 million people). Impacts to fisheries from angling, and the practice of fish stocking, is under the management of state fish and game agencies. The pine savanna units have several warm-water sport-fish ponds, which while they are not nationally recognized, provide angling opportunities primarily for locals.

3.4.3 Environmental Consequences

Current Plans

Management Direction under the Current Plans

The 1987 Gallatin Forest Plan and the 1986 Custer Forest Plan, as amended, include the following forestwide goals, paraphrased as: ensure water resources are in desirable condition, water quality will be maintained at a level that meets or exceeds state water standards, and will remain so into the future.

The 1987 Gallatin Plan, as amended, includes the following forestwide goal: manage and restore aquatic habitats to sustain fully functioning aquatic ecological systems and native species diversity, as determined by the suitability and capability of those systems, and to meet aquatic management goals of Montana Fish, Wildlife and Parks, other agencies, and state water quality standards. The 1986 Custer Plan, as amended, includes the following forestwide goal: the goal of wildlife and fisheries management is to manage and/or improve key wildlife and fisheries habitats, to enhance habitat quality and diversity, and to provide wildlife and fish-oriented recreational opportunities. Most of the critical habitat areas have been incorporated into management areas that maintain or improve these key habitats. Wildlife and fisheries management is considered in all management areas and the level of wildlife habitat will increase over time.

The 1987 Gallatin and 1986 Custer Plans have components that benefit riparian ecosystems. Direction, paraphrased, includes considering utilization levels of livestock in riparian areas and management of timber in riparian areas will be designed to maintain or improve fish habitat. A standard in the Custer Plan stated riparian vegetation would be managed along all perennial streams with defined channels to provide shade, to maintain stream bank stability and in-stream cover, and to promote filtering of overland flows.

Effects of the Current Plans

The Custer Gallatin National Forest is expected to continue improving, enhancing, and maintaining native, and desired non-native aquatic species and their habitat primarily in montane habitats under the direction of the current forest plans. Less direct conservation work has occurred in the pine savanna units, and that would be expected to continue, which is the result of lack of quality data and understanding of prairie aquatic biota species and habitat needs. Additionally, there is less conservation funding available both internally and externally.

Conditions that support sensitive species' population viability are expected to remain stable for all sensitive species on the Custer Gallatin with these plan components. However, climate change and exotic species, such as non-native fish have a high potential for deleterious effects to sensitive species. Habitat quality has the potential to improve, however there are fewer plan components promoting restoration and protection relative to the revised plan alternatives. The current plans are expected to maintain similar habitat quality for sensitive aquatic animal species in all habitat guilds.

The Custer Gallatin National Forest is expected to continue to maintain or restore riparian areas, but the language in the current plan is ambiguous leaving room for riparian areas to be negatively impacted by various land-uses, which is the current state in isolated situations. PacFish Infish Biological Opinion (PIBO) and fish distribution data demonstrate that montane aquatic habitat and biota trends are stable or improving (Archer and Ojala 2016b). PacFish Infish Biological Opinion data are limited for the pine savanna, but for the handful of sites for which it currently exists, the trend is stable for habitat variables (Archer and Ojala 2016a). Watershed and aquatic restoration is in its infancy across this pine savanna landscape, as habitat condition and fish distribution are still being quantified. However, the riparian and biotic data that exist demonstrate that a pressing priority is restoring aquatic diversity in conjunction with perennial spring ecosystems (Stagliano 2010), and in riparian areas overall. Much of the reduction in aquatic diversity is a result of livestock presence, water diversion and impoundments at, and near, headwater springs.

There is a history of permitted mining operations on the Custer Gallatin that occurred before the 1987 Gallatin and 1986 Custer Forest Plans, and cleanup efforts occurred during the life of those plans and would be expected to continue. The McLaren Mine operation started in the 1870s near Cooke City in the Absaroka Beartooth Geographic Area. The historical effects of the mine negatively impacted water quality in Soda Butte Creek. Through large investments in reclamation and rehabilitation, Soda Butte Creek water quality was dramatically improved (Henderson et al. 2018). Soda Butte Creek is now slated to be the first stream on the Custer Gallatin to be taken off the 303(d) list of impaired water bodies. The Stillwater mine (palladium and platinum) has been in operation on, and adjacent to the national forest, since 1986 for the Stillwater operation near Nye, Montana and 1999 for the East Boulder operation. Due to a progressive mining operation, a strong partnership with Custer Gallatin, Montana Department of Environmental Quality, the Stillwater mine, and a geologic formations that is not conducive to acid mine drainage there have been very little impacts to water quality from this large mining operation and that would be expected to continue. An abandoned uranium mine in the North Cave Hills of the Sioux Geographic Area has had adverse impacts to water quality and stream channels, but massive reclamation has been ongoing and would be expected to continue.

Management under current forest plan direction is slowly increasing, or at least keeping steady, the presence of westslope cutthroat trout, which could be beneficial to the western pearlshell because glochidia (microscopic larval stage of freshwater mussels) attach to the gills of the host fish where they can be transported upstream or downstream. For the Custer Gallatin, and throughout Montana, that host fish species is the westslope cutthroat trout (Hovingh 2004, Stagliano 2010). Currently a strong partnership with Montana Fish, Wildlife and Parks and other partners fostering conservation projects (and conversion of non-passable culverts to aquatic organism passages on Custer Gallatin Forest roads in high priority cutthroat streams) has led to this trend of increasing, or holding steady, presence on the national forest.

Revised Plan Alternatives

Management Direction under the Revised Plan Alternatives

A substantial change between the revised plan alternatives and the current plans is the incorporation of forestwide plan components that, together, provide more detail and clarity regarding the conditions and management of watersheds, drinking water, aquatics, and riparian areas that would contribute to the overall goal of maintaining the integrity and resilience of the watersheds on the Custer Gallatin National Forest (the suite of plan components for watershed and aquatics (WTR), riparian management zones (RMZ), conservation watershed network (CWN), FW-DC-INV-01, FW-GO-INV-01-04, FW-STD-INV-01-04, FW-GDL-INV-01, FW-DC-EMIN-01 and 02, FW-STD-EMIN-01 and 02, FW-GDL-EMIN-02, FW-DC-RT-01, FW-STD-RT-01-05, FW-GDL-RT-03 through 11, FW-GDL-FAC-01 through 04, FW-DC-REC-01, FW-OBJ-REC-01, FW-GDL-RECSUP-01, FW-GDL-LAND USE-03 and 04).

All revised plan alternatives would emphasize protection of riparian management zones and would facilitate management of multiple ecological goals and long-term ecological sustainability on a landscape basis. Revised plan alternatives would emphasize more than just fish bearing streams, which has been a historical focus. Instead, fishless streams and other water bodies, such as wetlands, also have protection which is critical to maintaining the overall ecological integrity of watershed resources. Non fish bearing streams comprise approximately 57 percent (at the 1:100,000 scale) or more of the entire forest stream network, providing inputs of wood, sediment, cool water, nutrients, and invertebrates to downstream reaches (Benda et al. 2002, Wipfli and Gregovich 2002); and provide habitat for headwater amphibians and other biota (Meyer et al. 2007). This ecosystem level approach, then, will also provide direct and indirect habitat protection for species (in particular: Westslope cutthroat trout, Yellowstone Cutthroat trout, and Arctic grayling) that the Custer Gallatin forest and partners have historically made progress in restoring and/or protecting habitat and populations. As funding allows then this work would be expected to continue, at the project level, with enhanced management plan direction. Aquatic and riparian desired conditions, objectives, standards, and guidelines would be applied in a consistent manner across the entire forest across all revised plan alternatives.

The Conservation Watershed Network (appendix C of the revised plan) provides a network of watersheds designed to emphasize conservation of westslope cutthroat trout, Yellowstone cutthroat trout, prairie fish assemblages, municipal watersheds, and other aquatic biota by protecting and restoring habitat conditions, processes, and landforms that provide quality habitat. The intent for selecting conservation watersheds is to contain the largest intact populations and provide long-term protection to aquatic biota populations across the Custer Gallatin National Forest. All occupied and expected to be occupied cutthroat streams with perennial water were designated in the Conservation Watershed Network. Pine savanna streams where multiple native fish species are present were also designated in the conservation watersheds network.

The revised plan alternatives vary by the level of plan objectives (FW-OBJ-WTR-01, 02, 03) for number of aquatic organism passage devices installed, number of acres or miles of stream habitat improved, number of recreation facilities removed from the riparian management zone, and road conditions improved or decommissioned.

Effects Common to the Revised Plan Alternatives

Plan components in their totality for aquatic habitat and riparian management zones that have been added to all revised plan alternatives are expected to provide a greater level of protection for aquatic and riparian (including wetlands and other lentic water bodies) resources than the current plans, while still allowing vegetation treatments when they benefit the riparian and thus aquatic resource.

Riparian Areas

Additional riparian protection would be provided since the inner riparian management zone would be increased to 100 feet for all fish bearing streams and intermittent and perennial non-fish bearing streams as compared to 50 feet (on slopes less than or equal to 35 percent) following state stream management zone laws. There would also be a riparian management zone on all ponds and wetlands regardless of size, which is a change from the current plans. The revised plan direction is more comprehensive than the current plans and would be applied across the entire national forest. This would be largely consistent with other forests in the Northern Region and even throughout the Pacific Northwest (Forest Ecosystem Management Assessment Team 1993, Reeves et al. 2016). The Custer Gallatin National Forest riparian management zones would not cover as much area as other forests in Northern Region (200 feet as opposed to 300 feet on either side of fish bearing streams).

Table 27 displays riparian management zone acreages by category of riparian management zone in the six different geographic areas. Each column is listed by the riparian management zone category and then broken up for inner and outer riparian management zone. Total riparian management zone acres are at 363,622 acres within the Custer Gallatin National Forest. Pine savanna (Ashland and Sioux Geographic Areas) riparian acres are at 44,608 acres leaving the remaining 319,014 riparian acres in montane Geographic areas. This difference in riparian acres in pine savanna vs montane appears large but proportionally the difference in riparian acres as compared to total Custer Gallatin National Forest acres is similar with 12 percent of riparian acres and 20 percent of total acres occurring in pine savanna units.

Riparian management zones are not exclusion zones or no-management zones, rather, they limit those actions that could degrade riparian conditions. Standards and guidelines are designed to protect riparian and aquatic resources by taking a multi-scale and multi-resource analysis of stream habitat and riparian conditions prior to entry. Forest management can occur with greater flexibility in the outer portion of riparian management zones than the inner portion. The greater protection provided by plan components, including riparian management zones and conservation watershed networks, are likely to maintain and enhance habitat for aquatic species, including species of conservation concern, more rapidly than the current plans. Implementing the riparian management zone plan components would also maintain or enhance hyporheic groundwater by allowing for surface water-groundwater connections. For example, FW-GDL-FAC-01-03 would encourage the protection of hyporheic flows by not allowing new structures and facilities in the riparian management zones that could interrupt or block subsurface flow paths.

Table 27. Riparian management zone acreage by category and geographic area

GA Name	RMZ 1 Inner	RMZ 1 Outer	RMZ 2 Inner	RMZ 2 Outer	RMZ 3 Inner	RMZ 3 Outer	RMZ 4 Inner	RMZ 4 Outer	Total Acres Inside RMZ	Acres Outside RMZ	Total
AB	17,033	16,761	30,563	12,647	35,059	10,028	7,958	17,124	147,173	1,211,368	1,353,295
Ashland	1,065	1,037	14,984	7,302	63	38	72	50	24,612	411,523	436,124
BBC	3,481	3,409	5,566	2,458	1,511	672	669	3,076	20,842	184,306	205,025
MGH	12,158	11,882	21,432	7,846	24,122	5,006	7,235	50,944	140,626	665,989	805,299
Pryors	416	417	5,119	2,444	0	0	133	1,844	10,373	64,694	75,067
Sioux	317	306	5,565	2,507	86	41	1,029	10,145	19,996	144,464	164,460
Total	34,469	33,813	83,228	35,204	60,843	15,785	17,097	83,182	363,622	2,682,343	3,045,965

GA = geographic area; RMZ = riparian management zone; AB = Absaroka Beartooth Mountains; BBC = Bridger, Bangtail, and Crazy Mountains; MHG = Madison, Henrys Lake, and Gallatin Mountains

Aquatic Species and Habitat

The effects of plan components on aquatic sensitive species would improve habitat conditions allowing them to improve over the life of the plan. For example, similar riparian area policy has been implemented since the 1990s and has improved stream conditions in the Interior Columbia River Basin (Roper et al. 2019). While the Custer Gallatin ecosystem is different than that ecoregion, basic ecosystem processes and functions are essentially the same. The riparian management zone plan components in their totality in all revised plan alternatives would only allow management activities that maintain or enhance those riparian management zones.

Plan components would provide protections for aquatic species categorized as Northern Region sensitive, species of conservation concern, Endangered Species Act species, and at-risk categories. These aquatic species rely on habitat within riparian areas and the riparian management zone plan components in all revised plan alternatives would only allow management activities that maintain or enhance those riparian management zones.

The effects of plan components on Endangered Species Act listed western glacier stonefly would not vary between revised plan alternatives. Riparian management zone guidance would provide protections from potential new trails that may occur in alpine or subalpine western glacier stonefly habitat. Due to the remote habitat, lack of infrastructure anywhere near their habitat, protected status (all current known habitat is designated wilderness), and lack of saleable timber all management actions across alternatives would not impact the western glacier stonefly. The potential effects of climate change (outside the management purview of this plan) would decrease glaciers and permanent snowfields, a key habitat component for this species, which could therefore degrade habitat for the western glacier stonefly. However, Halofsky and Peterson (2016) project the montane portion of the Custer Gallatin to be a relatively cooler aquatic habitat as compared to other areas in the Northern Rocky Mountains. This may be beneficial to local species populations such as cutthroat trout, but more data is needed on western glacier stonefly to determine its specific habitat distribution and niche on the Custer Gallatin. The western pearlshell, a Custer Gallatin species of conservation concern, has low tolerance for sediment. The riparian management zones in the revised plan alternatives would help decrease sediment inputs to streams that would benefit habitat conditions for the western pearlshell mussel. The revised plan alternatives would also benefit the westslope cutthroat trout, a Custer Gallatin species of conservation concern, which in turn benefits the western pearlshell. Continued work by the Custer Gallatin National Forest and partners to increase the abundance of westslope cutthroat, particularly by blocking and then removing non-native salmonids in isolated situations, on the landscape would be beneficial for the western pearlshell. As climate change continues to increase air and water temperature, western pearlshell and westslope cutthroat trout would be negatively affected because increased temperatures would also limit the extent of the temperature sensitive westslope cutthroat trout thereby even further limiting the extent of the western pearlshell.

The Conservation Watershed Network identifies watersheds that would be expected to have cold montane water or intact pine savanna aquatic habitat to support native fish, and other aquatic species, into the future in the face of climate change. A guideline (FW-GDL-CWN-01) for these watersheds is no net increase in road lengths and stream crossings that would hold effects from these management activities constant at a minimum assuming existing infrastructure is maintained or improved through the life of the plan. This would reduce potential new sediment inputs, benefit aquatic species, and improve overall ecological function. Conservation Watershed Network watersheds would be improved by plan objective (FW-OBJ-CWN-01) to storm proof five to eight miles of road per year and replace stream crossing structures to meet aquatic organism passage design criteria making them passable for aquatic organisms such as cutthroat trout or prairie fish species.

Forest management can unintentionally introduce aquatic invasive species, which is one of the greatest threats to native aquatic species. Therefore, components (FW-STD-WTR-03; FW-STD-RMZ-03; FW-DC-INV-01; FW-STD-INV-01, 03, 04) of the plan require mechanisms for addressing aquatic invasive species. The revised plan alternatives require using current best practices for equipment washing before and after entering an area. This better assures that these mechanisms are included as resource protection measures at the project level. These activities would include, but aren't limited to transporting water across drainage boundaries for fire suppression, constructing stream fords, operating equipment in a riparian area and near a watercourse, and the use of pumps and sumps for fire suppression, or construction related dewatering activities. Thus, the revised plan alternatives provide a mechanism for protecting aquatic native species from threats of aquatic invasive species.

Benefits to People and Source Water Protection Areas

Source water protection areas have been delineated by Montana Department of Environmental Quality and South Dakota Department of Environment and Natural Resources on and downstream of National Forest System lands. Over the life of this plan, drinking water demands will increase for towns with fast-growing populations, such as Bozeman, that are dependent on water from the Custer Gallatin. Specific plan components (FW-DC-WTR-08, 12; FW-STD-WTR-01) address the importance of source water protection areas and existing, as well as potential future, municipal watersheds. Additionally, watershed and riparian management zone plan components in their totality have been developed to protect groundwater, surface water, aquatic habitat, water quality, and source water protection areas by ensuring that activities are consistent with state source water protection plans, best management practices that control pollution are implemented, and that beneficial uses are provided for. These plan components are expected to provide adequate protection to source water protection areas and to maintain water quality under all the revised plan alternatives.

Effects That Vary Among the Revised Plan Alternatives

Several plan objectives (FW-OBJ-WTR-01, 02, 03) would improve aquatic species and their habitat, water quality, and riparian ecosystems in both lotic and lentic systems on the Custer Gallatin. The specific restoration activity, and thus effects analysis, would be determined at the project level. An example of stream mile restoration (or lake, wetland, or pond acres restoration) project could be planting willows to stabilize stream banks. Alternative D has the most benefit by restoring 800 stream miles per decade as compared to 600 stream miles per decade in the current plans, alternatives B, C, and F, and only 200 miles per decade in alternative E. Similarly, lakes, ponds, and wetlands would receive the most restoration activity under alternative D with 100 acres of restoration per decade, while the current plans, alternatives B, C, and F would provide 50 acres of restoration activities per decade and alternative E providing for only 10 acres per decade.

At-risk aquatic species would benefit the most from eight to ten enhancement projects in alternative D. Current plans, alternatives B, C, and F, would have five to seven enhancement projects per decade and alternative E would only provide for one to three enhancement projects per decade. Specific projects, and thus specific effects, would be determined at the project level; however, an example could be installing a barrier to protect a native fish species from non-native fish species that could outcompete or hybridize with the native species.

The objective (FW-OBJ-REC-01) to remove recreation sites or facilities to locations outside the riparian management zone would benefit the riparian management zone and aquatic species and their habitat. These locations are developed areas that can increase sediment delivery to lotic or lentic waters and trees are often removed which provide thermal cover and large woody debris input to streams. When these facilities are in the riparian management zone, removing them in some cases may allow for floodplain reconnection, which would improve hyporheic-surface water connections. Removing these facilities or sites would have benefits over the long term once removal and rehabilitation are complete. Alternative D would be the most beneficial by removing seven per decade with the current plans, alternatives B, C, and F, removing five per decade and only two per decade in alternative E.

In summary, alternative D would move toward the watershed, aquatic, and riparian desired conditions faster than the other alternatives. Alternative E would move toward the watershed, aquatic, and riparian desired conditions slower than the other alternatives. The current plans, alternatives B, C, and F, propose the same objectives and the rate of progress toward desired conditions would be between alternatives D and E.

Consequences to Water Quality, Aquatic Species and Habitats, Groundwater, and Riparian Ecosystems from Plan Components associated with Other Resource Programs or Management Activities

Effects from Vegetation, Timber, Fuels, and Fire Management

Vegetation treatments are typically designed and implemented to achieve multiple ecological, social, and economic objectives including those associated with watershed management. This section focuses on the effects of alternatives from timber harvest (including the use of logging systems), fuel-reduction activities, and fire management. While still controversial, forest treatments in or near riparian management zones and riparian management zone protection and enhancement can converge to establish mosaics of habitat beneficial to ecosystem integrity (Rieman et al. 2010, Hessburg et al. 2016, Reeves et al. 2016), particularly when sideboards as this plan presents allows those treatments only for maintenance or enhancement of riparian management zones and watershed resources. Specific effects from roads are treated separately due to their higher risk for affecting water quality and quantity.

Plan objectives (FW-OBJ-TIM-01, 02) for timber harvest would have minimal impacts to water quality as all plan components are protective of watershed, aquatic, and riparian management zone resources. At the project level of analysis, projects would have to demonstrate riparian management zones are being maintained or enhanced.

Impacts, however, would vary slightly across alternatives where indirect impacts could include delivery of sediment from temporary roads. Alternative E has the highest volume of timber and wood products across the fewest acres, by harvesting larger trees, and thus less potential infrastructure such as roads. Fewer roads and less infrastructure, in turn, generally should translate to less risk of sediment delivery to watercourses and less risk of adverse effects to aquatic habitat. Conversely, alternative D has the lowest volume of timber and wood products, across the most acres, potentially requiring more infrastructure such as roads posing greater potential for sediment delivery to watercourses. It should be noted that differences in infrastructure extent (that is, road mileage and associated area available for erosion) is an imperfect metric for evaluating sediment delivery; not all forest roads pose equal risk to watercourses. Regardless of sediment delivery risk from forest harvest infrastructure, riparian management zone and watershed components in their totality clearly outline that management activities are to maintain or enhance riparian management zones.

Water quality effects attributed to timber harvest could include increased sediment, nutrient loading, and changes to water temperature. However, the plan components would not increase the risk of impaired water quality over the current conditions. This is because the plan components provide more robust protections to reduce that risk by increasing the widths of riparian management zones and limiting activities that degrade conditions in the riparian management zone, particularly the inner riparian management zone. Thus, other than where needed to manage infrastructure in the riparian management zone, forest management activities would not occur, especially in the inner riparian management zone, unless it could be demonstrated at the project scale of analysis that this would improve riparian management zones, for example selectively cutting conifers to encourage growth of hardwoods (FW-STD-RMZ-02). This would be conducted at a project specific scale where, for example, it was determined that hardwoods were underrepresented due to excessive fire suppression. By ensuring the inner riparian management zone stays intact, or improves in habitat quality, shading would ensure stream temperatures are moderated from solar input and this would in-turn benefit aquatic species such as cutthroat trout that are sensitive to stream temperature increases. Additionally, the plan components (FW-DC-RMZ-01, 02; FW-STD-RMZ-02; FW-GDL-RMZ-04 to08) placed on vegetation treatments within riparian management zones substantially reduces risk of increased sediment or nutrient loading from adjacent harvest areas by increasing mandated buffer widths, restricting infrastructure extent in riparian management zones, and restricting the scope of permissible management activities in these areas. Overall, the effects from timber harvest on water quality in streams is not expected to vary measurably across the revised plan alternatives.

The revised plan alternatives, similar to direction in the existing Custer and Gallatin Plans, would use best management practices to reduce the potential for off-site transport of sediment to streams, and other waterbodies, from areas influenced by timber or fire management activities. Best management practices would stabilize skid trails and landings and disconnect them from road ditch and stream networks, drawing on Northern Region soil and water conservation practices (Forest Service Handbook 2509.22, Northern Region and Intermountain Region Amendment No. 1). No change in best management practice application and effectiveness is projected under adoption any of the revised plan alternatives. There is a large body of evidence demonstrating the efficacy of best management practice application in addressing water quality concerns on forested lands (for recent Montana-specific examples, (Ziesak 2015;2016;2018).

Differences in potential effects on water quantity between the alternatives may be subtle since the extent of timber harvest within a watershed is typically limited by many factors including plan direction and limitations associated with other resources and physical constraints such as terrain and access. Effects of timber harvest on water yield and peak flows, and associated indirect effects on stream channel morphology and aquatic habitat, are routinely assessed during project planning required by the National Environmental Policy Act (NEPA). The current forest plans require cumulative effects analysis, including assessment of effects on water yield, during the planning phase of projects involving significant vegetation removal. The current Gallatin Plan (not the current Custer Plan) also requires the use of the equivalent clearcut area analysis methodology as the assessment tool when water yield is an issue or concern. Under the revised plan alternatives water yield analysis would be directed by a defined management approach methodology which utilizes a weight-of-evidence approach to determine whether: a) water yield, in particular peak flows, may detectably change as a result of proposed forest management activities and b) whether that change may be of concern from a water quality or aquatic habitat perspective. This management approach would incorporate the use of a screening process, in conjunction with a full equivalent clearcut area water yield analysis when indicated, to evaluate the potential effects on water yield and peak flows and corresponding effects on stream channel morphology and aquatic habitat. The approach would also allow the use of more effective water yield and balance assessment methodologies, which are likely to be developed during the effective life of the revised plan.

Under the revised plan alternatives, prescribed burning would occur to achieve multiple objectives, including, but not limited to, reduction of fuel hazard, preparation of the site for tree regeneration, and stimulation of the growth of shrubs and other plants. Prescribed fires may also be applied to riparian management zones if it maintains or enhances the riparian ecosystem. These management actions may be conducted under the auspices of restoring fire as a natural ecological process and building desired vegetation structure and composition across the landscape. Fire is a tool that can be used to benefit riparian management zones, streams, and lentic habitats such as wetlands. Monitoring these treatments would help guide an adaptive management process.

Across revised plan alternatives, objectives propose 4,000 to 7,000 average annual acres of non-harvest-related prescribed fire for hazardous fuels across the national forest. The amount projected would be lowest under alternative E and highest under alternative D. Where these acres are burned would be determined at the project scale and watershed and riparian management zone plan components would ensure those resources are protected. Where prescribed fire is applied and blackens an area, runoff can increase from reduced infiltration. Blackened soil areas can accelerate runoff due to lack of vegetative cover and to soil sealing from ash that lowers the infiltration capacity of soils (Doerr et al. 2006). These conditions vary spatially and decrease over the first one to three years following implementation as areas revegetate and as products in the soils degrade (Neary et al. 2005, Doerr et al. 2006). Natural forest conditions have hydrophobic characteristics such as plant litter waxes and resist infiltration when soils are dry, but the main difference after a prescribed fire is that burned areas lack the surface roughness to dissipate rain splash energy and interrupt runoff. Impacts from prescribed burning activities across the national forest are expected to be minor since the burning is mostly anticipated to be low- and moderate-severity, with low potential of delivering sediment. The effects of prescribed burning have been identified as generally insignificant with regard to a wide range of hydrologic and water quality variables (Robichaud 2000). Broadcast burning is generally implemented with the intent of emulating a natural disturbance process within the range of variability that would typically be encountered without human intervention. By extension, effects to water resources and riparian and aquatic habitat are generally anticipated to remain within the natural ranges of variability following implementation of these management activities.

Prescribed fire has the potential to offset effects that could occur from high severity wildfire, particularly if high severity fire should occur in unnatural amounts and shortened timeframes as a result of climate change. However, a percentage of fire has always been high severity depending on various conditions and though damaging at a site scale this scenario has historically been a part of natural disturbance regimes affecting streams (Reeves et al. 1995) and uplands (Hutto et al. 2016). In response to disturbance the stream channel and adjacent riparian area, or floodplain, at a large scale reach a balance of erosion and deposition of sediments, and other materials, that forms and maintains the stream channel and aquatic habitat (Stanford et al. 2005). But vegetation-altering wildfire can change the timing and input of sediment into stream channels, causing detrimental impacts to fish and aquatic macroinvertebrates at a site scale, particularly under climate change scenarios where these fires could become more frequent (Goode et al. 2012). Leonard et al. (2017) found that high intensity fire in a headwater stream had adverse effects on salmonid habitat through decreased streamside canopy cover followed by increased stream temperatures, incised and unstable streambanks, and lower nutrient concentrations 21 years post-fire. In the same study Leonard et al. (2017) found macroinvertebrates were virtually temporarily eliminated initially, but had fully recovered to reference conditions for richness, diversity, and abundance 21 years later. From this standpoint effects from severe fires can seem dramatic at the local scale, but stream ecosystems, riparian areas, and the organisms that inhabit them are adapted to this disturbance (Mihuc and Minshall 2005, Malison and Baxter 2010a). Thus, fire is a phenomenon that can reset successional pathways and ultimately benefit aquatic and riparian ecosystems. A wildfire objective of a minimum of 375,000 acres burned per decade would mimic natural disturbance processes. Overall, the expected effects from fire related management actions are expected to be minor. However, there are many local to larger scale climatic factors beyond the control of the Forest Service that may determine how streams and their biota react to these fire events if wildfires move out of a natural range.

Effects from Wildlife Management

In general, wildlife management direction has low impact or a net positive impact on water quality, aquatic species habitat, and riparian management zones. All alternatives would adopt the Grizzly Bear Conservation Strategy. Associated plan components that would require secure habitat to be maintained may limit access, and thus less risk of sediment inputs to waterbodies within the Greater Yellowstone Ecosystem Recovery Zone; thereby benefitting watershed integrity.

Effects of Plan Land Allocations for Recommended Wilderness, Backcountry Areas, and Eligible Wild and Scenic Rivers

Many watersheds in the Absaroka Beartooth; Madison, Henrys Lake, and Gallatin Mountains; and Bridger, Bangtail, and Crazy Mountain Geographic Areas that support the healthiest populations of native trout and other aquatic species, currently have their headwaters protected through lands managed as Congressionally designated wilderness areas (Lee Metcalf and Absaroka Beartooth) or inventoried roadless areas. These areas are the building blocks of a conservation network. Naturally functioning headwaters have a large influence on the function of downstream reaches (Vannote et al.

1980, Meyer et al. 2007) and would be particularly important as refuge habitat for cutthroat trout, and other species, in light of potential effects of climate change (Isaak et al. 2015). The best remaining trout habitat conditions are found in wilderness and unroaded landscapes (Rhodes et al. 1994, Kershner et al. 1997). Across the west, roadless areas tend to contain many of the healthiest of the few remaining populations of native trout, and these are crucial to protect (Kessler et al. 2001). Roadless areas are a source of high-quality water essential to the protection and restoration of native trout. The high-quality habitats in roadless areas help native trout compete with non-native trout because degraded habitats can provide non-natives with a competitive advantage (Behnke 1992). Roadless areas tend to have the lowest degree of invasion of non-native salmonids (Huntington et al. 1996).

Therefore, plan land allocations such as recommended wilderness areas, backcountry areas, and eligible wild and scenic rivers that limit road building can be expected to contribute to naturally functioning headwaters. The revised plan alternatives propose 30 streams as eligible wild and scenic rivers, and new roads would be limited in the 18 rivers with a tentative wild classification. In contrast, the current plans have 11 eligible wild rivers. Alternative D would provide the greatest benefit to aquatic species because it would allocate the highest amount of recommended wilderness and backcountry areas, followed by alternatives C, F, B, E, and the current plans.

Effects from Recreation Management

Recreation use can affect water quality, clean drinking water, and aquatic communities particularly from trail use and recreation facilities located in riparian management zones. Impacts from the use of trails in riparian management zones may include rutting, erosion, and loss of groundcover from user-created trails; trampling of vegetation; vegetation removal; introduction and spread of invasive species; and soil compaction near waterbodies. Rutting may increase surface erosion associated with heavily used trails. High-use campsites in riparian management zones may cause root damage in trees, resulting in reduced vigor and mortality. In combination, these activities can lead to increased erosion and a reduction in water quality.

Current recreation use and increased future recreation use elevates the risks to water quality, clean drinking water, and aquatic communities. Indeed, the largest economic contributor the Custer Gallatin National Forest provides is varying recreation opportunities (economics section provides more details), and the Custer Gallatin has angling opportunities that attract national and even international visits from anglers. One of the greatest threats to native aquatic species from recreation is the potential introduction of aquatic invasive species.

Trail maintenance is a key to decreasing impacts to watershed health. Sediment erosion from trail use outside of riparian management zones mainly is routed onto the national forest floor with no impact on water quality, and these impacts are typically localized. On the Custer Gallatin, observations conclude that nonmotorized trails are generally known to have less impact on aquatic species than motorized trails, but can contribute to decreased water quality through increases in sediment delivery to streams. Nonmotorized trails can have impacts when located close to streams, when particularly steep, at crossings, and there are differences between user types. Subjective observations indicate that certain situations, such as steep slopes combined with equestrian traffic, can have increased erosion compared to other nonmotorized uses.

Plan objective, FW-OBJ-RT-03, proposes maintaining 30 percent of trails to standard per year across all alternatives, though the concentration would be in front country for alternative E. Plan objectives propose some annual trail maintenance (although not to standard) at 80 percent in the current plans, alternatives B, and C, and 30 percent in alternatives D and E. When trails close to water sources are not maintained the probability of affecting water quality by delivering sediment to waterbodies would increase. Trail maintenance inside riparian management zones can affect large wood recruitment and function that influences stream channel morphology and aquatic habitat. Bucking out fallen trees can reduce the tree's length and sever the bole from its root wad. Smaller tree lengths are not likely to contribute as much to stream channel stability and are more likely to be washed out during high streamflow events, but overall trail maintenance is generally beneficial. Smaller instream wood also delays the recovery of channel features needed to maintain habitat for aquatic species, including overhead cover and low-velocity refugia during high-flow events.

Spread of invasive aquatic species is not typically a concern from users on non-motorized trails. Spread of noxious weeds from non-motorized recreation and resultant treatment with chemicals may cause negative impacts if improperly used. Use of chemicals is generally discouraged in riparian management zones.

Plan components (FW-DC-REC-05, FW-GDL-FAC-01 through 04) under all revised plan alternatives direct new developed recreation facilities, including trails, to be located outside of the inner riparian management zone to protect aquatic resources and riparian-associated plant and animal species. This is an improvement from the current plans. Exceptions may occur if actions are to address human health and safety issues or if the new facility is water-related, such as a boat ramp. In addition, new solid and sanitary waste facilities should not be placed in the inner riparian management zone. However, it is assumed that minor, localized impacts to riparian vegetation, woody debris, and water quality would still occur where existing recreational use and facilities are located.

Effects from Scenery Management

The plan scenic integrity objectives do not outright prohibit on-the-ground actions, but may influence the design or the location of watershed projects that would be visible from any of the listed critical viewing platforms. Design features or mitigations may be required to meet or exceed the assigned scenic integrity objective, which describes the lowest threshold of visual dominance and deviation from the surrounding scenic character.

Effects from Access by Roads and Motorized Trails Management

The road network on the Custer Gallatin affects water and watershed resources in both an acute and a chronic manner and this would continue under all alternatives. There are motorized roads open to the public as well as administrative use within the national forest administrative boundary. This includes roads managed by other entities such as state or Federal highways, a variety of county roads, state and Federal land management agencies, and private roads. Many roads and motorized trails are located within riparian management zones (which include many road-stream crossings). Routes located closest to water resources potentially provide a background level of disturbance that contributes to effects to watershed, aquatic, and riparian resources. The plan allows for making changes to road routes where these disturbances occur. FW-GDL-RMZ-03 states that roads, etc. should be avoided in riparian management zones unless those activities would benefit riparian management zones. An example of this scenario may be decommissioning a road adjacent to a stream that causes sedimentation and then installing a stream crossing (one that passes aquatic organisms and allows 100-year events to pass) and taking the road up and out of the riparian management zone.

Past culvert failures and road slumps have impacted water quality and aquatic organism migratory patterns particularly at the site-level scale. Forest roads that are maintained on an annual basis are typically those roads that have the most administrative and visitor use. Closed roads receive less maintenance, and not all these roads were put into proper storage in the long term or had their culverts removed. There are stream crossings located on administratively closed Forest Service roads with some culverts remaining that do not receive regular maintenance.

Aquatic organism passage devices would be installed over the course of this revised plan. These would allow fish and other organisms to move up and downstream where they currently are blocked from doing so by older culvert design or culvert failures. Plan objectives of the current plans, alternatives B, C, and F propose five to seven projects per decade, alternative E proposes one to three projects per decade, and alternative D would provide the most benefit to aquatic species by proposing seven to ten projects per decade.

Forestwide direction under all revised plan alternatives includes guidance that would direct road management (FW-DC-RMZ-01; FW-GDL-RMZ-04; FW-DC-RT-01; FW-STD-RT-01-05; FW-GDL-RT-03-11) on the Custer Gallatin to address the detrimental effects of roads on water quality and aquatic habitat and biota. The removal of stream-crossing culverts and reestablishment of a natural stream grade or installation of fish passable culverts are expected to have a positive impact on water quality and aquatic biota and their habitat. Revised plan alternatives would incrementally improve crossings and reduce the risk of failure across the national forest as funding became available (particularly in the conservation watershed network) and this would potentially decrease the amount of sediment delivery to streams from road failures. These reductions would also result from the application of best management practices that prevent gully formation and down cutting through newly excavated stream channels. For example, establishing a stream bed that mimics the natural stream gradient above and below the crossing, placing cobble-size rock in newly excavated streambeds, distributing any uprooted vegetation, and slash across stream-adjacent disturbed areas.

Roads increase access to sensitive habitats and can fragment habitat, thus, providing an avenue for invasive plant species. Reconstruction and maintenance of designated roads can directly or indirectly affect plant populations by introducing competitive weeds and altering availability of light, nutrients, and moisture. Sudden changes in seral stage, or an abundance of early seral stages, also reduce the available habitats for those plants that require mid-to-late seral stages. Several plan components (FW-DC-RMZ-01, FW-STD-RMZ-02, FW-GDL-RMZ-03, and FW-GDL-CWN-01) would decrease the probability of roads being the vector for invasive plants in riparian management zones.

Under alternative C, about four miles of trail would no longer be suitable for motorized transport and another 34 miles of trail would no longer be suitable for mechanized transport. Under alternative D, about 172 miles of trail would no longer be suitable for motorized transport and another about 264 miles of trail would no longer be suitable for mechanized transport. Under alternative F, about 31 miles of trail would no longer be suitable for mechanized transport, although game carts would continue to be suitable on about 14 trail miles in the Bad Canyon Backcountry Area and two and a half trail miles in the Crazy Mountains Backcountry Area. Neither the current plans nor alternatives B and E make any changes to existing trail suitability.

Alternative D would provide the most benefit to aquatic resources by identifying the most trail miles as no longer suitable for motorized and mechanized transport, thereby reducing potential soil disturbance from these activities. Observations on the Custer Gallatin indicate motorized, more than mechanized, trails function similar to roads in regard to soil disturbance, sediment delivery to streams, and thus potential for water quality issues. However, impacts are generally less than roads as there is less disturbed surface area. There is also the potential that removing motorized transport from some trails could lead to an increase of motorized transport on other trails. This concentrated, or focused, motorized transport could have higher impacts to aquatic resources especially if maintenance and upgrades (for example, surfacing and bridges) are unable to keep up.

Road maintenance is expected to continue at similar levels or slightly decreased levels compared to more recent management. Plan objectives (FW-OBJ-RT-02) for all alternatives propose to maintain 75 percent of passenger roads, pending sufficient funding, per year. High clearance roads would be maintained at 20 percent per year for the current plans, alternatives B, C, and F; five percent per year for alternative D; and 10 percent per year with a focus on timber harvest roads for alternative E. Portions of the road network would be treated to repair and improve drainage structures, improve the running surface of the road, and to clear vegetation along roadsides. Short-term increases of sediment delivery to streams and waterbodies would be expected as a result of road surface grading, and culvert and ditch cleaning near waterbodies. However, road and culvert maintenance and upgrades generally have positive effects for water quality and aquatic species habitat over the long term. Proper maintenance of the Custer Gallatin road system is critical for aquatic resources.

Portions of the road system that are in particularly poor condition or are currently closed and in long-term storage, would be reconstructed periodically; particularly in connection with land management activities, such as timber harvest projects. Road reconstruction includes application of surface rock, replacing damaged or poorly functioning culverts, adding stream-crossing or ditch relief culverts where necessary, some road widening, and removing roadside vegetation that is encroaching on the road surface and preventing vehicular passage. Again, these activities would be expected to create some turbidity increases in nearby waterbodies, but best management practices would be employed to minimize erosion and sediment transport to waterbodies. A potential source for nutrients is phosphorus bonded to sediment (Wood et al. 2005, Ballantine et al. 2008). Detachment of soil particles and associated phosphorus is often linked to soil erosion, which provides a physical mechanism for mobilizing phosphorus from soil into waters (Wood et al. 2005).

Within the recovery zone for grizzly bears, there would be no net increase to the baseline open motorized route density or total motorized route density on National Forest System lands during the non-denning season under all alternatives. In addition, there would be no net increase in the length of roads and stream crossings inside riparian management zones for watersheds within the conservation watershed network. These plan components (FW-STD-WLGB-02-04) would be expected to minimize impacts to aquatic species from motorized activities across all alternatives.

Effects from Permitted Livestock Grazing Management

Objective (FW-OBJ-GRAZ-01) provides about between about 214,000 and 219,000 animal unit months (AUMs) per year among the range of alternatives. The differences among animal unit month objectives would affect water quality and aquatic habitat and species under the current plans, alternative B, C, and F if vacant allotments were to be re-activated. This would require site-specific analysis to determine effects to riparian management zones and aquatic species habitat. Alternatives would require site-specific analysis to determine effects to riparian management zones and aquatic species within active allotments.

The revised plan alternatives may limit livestock effects by having a minimum end-of-season stubble height guideline in low gradient alluvial channels (livestock grazing section guidelines provide more information). Guideline FW-GDL-GRAZ-02, could benefit riparian ecosystems and aquatic species and habitat in those specific stream types. Goss and Roper (2018) demonstrated that generally in salmonid streams higher streambank stubble height, and lower streambank alteration, can be used as a proxy to improve stream habitat conditions. The stubble height method has not been applied rigorously in pine savanna systems. However, in a review of stubble height literature Roper (2016) explains how stubble height also applies to sagebrush grasslands and Palouse prairie. Additionally, the stubble height guideline can be adapted to site-specific conditions and, also states other indicators may be used. The management approaches appendix provides more context. Revised plan alternatives also require new livestock handling or management facilities (for example, corrals) to be located outside of riparian management zones (FW-GDL-RMZ-01). The revised plan alternative plan components direction, as compared to the current plans, would decrease livestock grazing effects while not prohibiting livestock grazing use in riparian areas.

The revised plan alternatives would be an improvement over the current plans. The effects of livestock can be seen across the planning area particularly in riparian areas. Historical grazing led to riparian vegetation changes and stream channel degradation on grazed streams. Livestock grazing infrastructure has also led to changes across the landscape that, in general, have had deleterious effects to watersheds and riparian areas. For example, water impoundments and spring developments (particularly in pine savanna) have likely greatly altered flow regimes and stream or spring functionality. Various riparian areas and waterbodies have seen improvements through best management practices and revised allotment management plans. However, riparian and aquatic habitat improvement within allotments continues to be a challenge. Livestock grazing can reduce bank stability and it often changes riparian vegetation, resulting in insufficient overhead cover for fish (Platt 1991). For montane landscapes an extensive review of PacFish Infish Biological Opinion data in montane streams of the Pacific Northwest and into the Northern Rocky Mountains was conducted (Kovach et al. 2018). The review found land-uses, and livestock grazing with this study, were closely related to summer thermal regimes, and suggested that this land-use may be additive with respect to climate change impacts already underway. Less is generally known about how grazing impacts the pine savanna watersheds and water quality, given these systems are naturally more erodible than montane landscapes and waters are generally more conductive (have higher mineral content). Excessive grazing by both wild and domestic ungulates can remove woody plants (Batchelor et al. 2015), reduce the vigor of perennial forbs and grasses, and cause channel profile and function changes via bank collapse on low gradient streams (Trimble and Mendel 1995, Bengeyfield 2006). Widening channels, increased stream temperature, increased fine sediment, altered bank structure and loss of overhanging vegetation that may occur from excessive grazing (Myers and Swanson 1996, Kershner et al. 2004) is often harmful to aquatic fauna, especially cold-water dependent species (Belsky et al. 1999, Saunders and Fausch 2007). A study of the effects of grazing on North Dakota badlands and prairie stream fish assemblages, conducted by Stephens et al. (2016), (similar guilds occur in Ashland and Sioux Geographic Areas) found it difficult to find any reference streams and recommended building enclosures, for years or even decades as this would be important to accurately assess impacts to prairie stream fishes. This potential management tool could facilitate understanding impacts from permitted livestock grazing, other land uses, or wild ungulate grazing in the Custer Gallatin National Forest pine savanna streams. While not specifically in pine savanna units, riparian enclosures have been used extensively to demonstrate impacts and recovery from livestock grazing, and other factors, on streams, biota, and riparian areas (Hough-Snee 2013, Sievers et al. 2017). While enclosures are not without complications, if this tool was carefully planned with producers and resource specialists, it could provide insight for allotment management. For example, nearly all streams and waterbodies in the pine savanna units are open to livestock grazing with 86 percent of all lands covered by primary rangelands within grazing allotments as compared to 6 percent in montane units.

Effects from Energy and Minerals Management

Suction dredging does occasionally occur on the Custer Gallatin. Large increases in mining activity within the riparian management zones are not anticipated for the future, but cannot be ruled out. The 1872 mining law allows for the development of locatable minerals, including gold and other minerals in streams. All locatable mineral activities are required to meet applicable environmental protection measures as required by both Federal and State laws, regulations, and policies. Proposed locatable mineral activities are subject to review and approval, as well as environmental analysis and reclamation and monitoring requirements.

All revised plan alternatives include direction that would provide adequate protection to water quality and other aquatic resources from the potential impacts due to energy or mineral extraction. Forestwide plan direction addresses the availability, management, and reclamation aspects of energy and mineral resources, with desired conditions (FW-DC-EMIN-01 and 02) that recognize the importance of reclaiming lands developed for mineral resources in an appropriate manner, in order to protect other resource values. Standards and guidelines (FW-STD-EMIN-01, 02; FW-GDL-EMIN-02) direct the implementation of new operations by requiring measures to mitigate for potential impacts to vegetation including invasive species introduction and spread and aquatic and riparian resources (FW-GDL-EMIN-02). If operations within riparian areas cannot be avoided, then measures to maintain, protect, and rehabilitate fish and wildlife habitat would be included in the authorization. Establishment of new sand and gravel (saleable mineral materials) mining and extraction operations within riparian management zones is prohibited.

Cumulative Effects

Cumulative effects are addressed in the context of surrounding land jurisdictions and land ownership. The Custer Gallatin National Forest is intermixed with lands of other Federal jurisdictions, state lands, and private lands. Some geographic areas contain substantial substantially solid inholdings of Federal lands, while some geographic areas are island mountain ranges largely surrounded by private lands.

Portions of the Custer Gallatin National Forest adjoin other national forests, each having its own forest plan. The plans for National Forest System lands adjacent to the Custer Gallatin include the Helena Lewis and Clark, Beaverhead-Deerlodge, Targhee, and Shoshone. Management of aquatic resources vegetation is broadly consistent across all national forests due to law, regulation, and policy. All of the plans contain management direction that addresses aquatic ecosystems and promotes ecological integrity.

Bureau of Land Management lands near the Custer Gallatin are managed by the Dillon plan (2006), Butte plan (2009a), Billings plan (2015a), Miles City plan (2015b) and South Dakota plan (2015c) field offices. Aquatic and riparian components of these plans are complementary to the plan components for the Custer Gallatin.

Federal actions within the montane areas can involve Yellowstone National Park as they manage some headwater streams in the Madison, Gallatin, and Yellowstone Rivers. There would be little to no cumulative effects from park management actions as most areas in the park are managed to protect ecological values.

Northwest Energy manages several dams including those on Hebgen, Quake, and Ennis Lakes in the Madison, Henrys Lake, and Gallatin Geographic Area and Mystic Lake in the Absaroka Beartooth Geographic Area. Dam operations are coordinated closely with the Forest Service and other partners to have the least impact possible on aquatic species habitat and riparian ecosystems. However, given the lack of a normative flow regime, coupled with potential influences of climate change, there is the potential of cumulative effects related to increased stream temperature and lack of flows to provide flood-pulses necessary to drive stream ecological processes. In some locations where Bureau of Land Management or State lands occur adjacent to National Forest System lands, the Forest Service would seek out opportunities for watershed projects that increase the scale of conservation efforts across administrative boundaries.

Non-Federal land management policies are likely to continue affecting riparian and aquatic resources. The cumulative effects across the large, geographically complex, and diverse Custer Gallatin National Forest lands are difficult to analyze considering the uncertainties associated with government and private actions, and ongoing changes to the region’s economy. The isolated nature of the Ashland and Sioux Geographic Areas make them particularly susceptible to changes outside the management purview of the Custer Gallatin. Whether those effects would increase or decrease across the national forest in the future is a matter of speculation; however, based on the growth trends and current uses identified in this section, cumulative effects are likely to increase. Many activities occur on private lands. These include water diversion, irrigation, livestock grazing, farming with varied cash crops, timber harvest, water-based hunting, outfitted and non-outfitted angling, construction of subdivisions, housing, and commercial development, building and stocking of private fishponds, chemical treatment of noxious weeds, flood control and stream channel manipulation, and hydropower management.

Montana State owned school trust lands managed by the Montana Department of Natural Resources and Conservation will continue to support a variety of uses of their lands, from livestock grazing to mining, timber harvest, and recreational fishing and hunting. South Dakota State owned lands managed by the South Dakota Office of School and Public Lands also allow multiple uses. Montana and South Dakota law requires that school trust lands be managed to maximize income for the school trust. Management impacts may be greater on these lands than on other state or Federal lands but typically may not result in loss of fish populations.

In large part, montane stream systems on the Custer Gallatin originate in protected headwaters and eventually flow downstream onto lands owned or administered by entities other than the Forest Service. Many fish populations, whether they move off-forest as part of their life cycle or remain entirely within a localized area, require interconnectivity of these streams to survive as a population. For almost all species, genetic interchange between subpopulations is necessary to maintain healthy fish stocks. The more wide-ranging a species such as westslope and Yellowstone cutthroat trout, the more critical interconnectivity may be for the fish to be able to access important habitat components. Thus, activities off-forest that disrupt fish migration corridors can have substantial to fish populations upstream.

The most complex cumulative effects likely relate to the restoration of westslope and Yellowstone cutthroat trout. The complexity of the life histories of these species exposes them to many factors affecting their abundance and viability. Cumulative effects to native fish include, predation, hybridization, and competition with non-native fish; destruction or degradation of spawning and rearing habitat from logging, grazing, road construction or maintenance, and urban development on private and other non-Federal lands; degraded water quality as a result of polluted runoff from urban and rural areas; and migration barriers that result from roads on private or other non-Federal lands. Though much more difficult to quantify these same factors have the potential to affect prairie stream fish, and aquatic biota, populations in the pine savanna units.

Montana Fish, Wildlife and Parks and the South Dakota Department of Game, Fish and Parks have laws and regulations that are adequate to prevent the overexploitation of fish populations from angling impacts through their management of the fisheries populations across the Custer Gallatin. However, with an increasing human population, particularly in the montane areas, and other cumulative impacts mentioned in this section angling could be an additive stressor in the future if states do not adequately address angling pressure, harvest limits, and other fisheries management concerns.

In municipal watersheds, it is highly probable in frequently used recreation places such as Hyalite and Bozeman Creek (also municipal watersheds or source water protection areas) that the continued projected increase in population would lead to conflicts between recreation and clean public drinking water demand. Project-scale actions under the current revised plan alternatives provide the framework to achieve goals for source water protection requirements, but there is a threshold where these watersheds (and perhaps others on the Custer Gallatin) would reach maximum recreation potential where more activity would degrade the ability of the watershed to provide clean drinking water.

Conclusion

The suite of the revised plan alternatives' watershed, aquatic, and riparian ecosystem plan components are designed to maintain or restore the ecological integrity of the Custer Gallatin National Forest. Additionally, these components will facilitate ecological conditions moving towards desired future conditions. The watershed, riparian management zone, and conservation watershed network plan components would provide protections for those resources greater than has been provided in the current plans. These plan components follow a model that has been in places for decades in the Interior Columbia River Basin, where Roper et al (2019) found stream conditions have improved. The riparian management zone direction would be easy to follow, consistent forestwide, and similar to other forests across the western United States, while recognizing the more arid environment of the Custer Gallatin. While these protections are more stringent than current plans, they would still allow for the multiple use mission of the Forest Service by restricting only those activities, such as road building in the riparian management zone, which would cause deleterious effects to the resource.

Overall, alternative D would provide the greatest ecological benefit to aquatic species habitat, riparian areas, and watersheds. The current plans, alternatives B, C, and F propose more road and trail maintenance than alternatives D and E. Alternative D proposes the greatest acreage of vegetation management activities. Alternative D would allocate the highest amount of recommended wilderness and backcountry areas, followed by alternatives C, F, B, E, and the current plans. Alternative D also proposes to remove motorized and mechanized recreation use from the most miles of trail, while the current plans, alternative B and alternative E would make no changes to these current uses.

Plan objectives that improve ecological conditions for aquatic species habitat, riparian areas, and watersheds are highest in alternative D and lowest in alternative E. Alternative D would move toward the watershed, aquatic, and riparian desired conditions faster than the other alternatives, and alternative E would move toward the watershed, aquatic, and riparian desired conditions slower than the other alternatives.

Occurrences of all regional forester sensitive and at-risk aquatic species are expected to persist on the Custer Gallatin under all alternatives. Riparian management zone, watershed, and the new plan components are more robust across all action alternatives, providing more protection to these species and their habitat compared to alternative A. The 2012 Planning Rule requires that plan components must provide the ecological conditions necessary to maintain long term persistence of each species of conservation concern within the plan area. The Westslope cutthroat trout and the western pearlshell mussel populations are small but have remained on the national forest, or have been re-introduced, over time. Due to the small size of the populations and their limited habitat on the Custer Gallatin the Westslope cutthroat trout and the western pearlshell mussel are vulnerable to stressors beyond the authority of the Forest Service to manage; most notably the risk of non-native trout and climate change effects. In this case, the plan must provide direction that will contribute to maintaining long term persistence of the species within their range. Under all revised plan alternatives, coarse filter plan components provide measures to manage conditions within the authority of the Forest Service to maintain the existing populations of Westslope cutthroat trout and the western pearlshell mussel, allow for habitat improvement projects, and contribute to maintaining the long-term persistence of the species within its range. Under all alternatives, habitat would be maintained for the Westslope cutthroat trout such that, if the existing populations were devastated by competition or hybridization from non-native trout or other non-native fish species then reintroduction of Westslope cutthroat trout could occur from other populations within the range. Under all alternatives, habitat would be maintained for the western pearlshell mussel such that, if the existing populations were decimated by loss of the mussel's host species (the Westslope cutthroat trout) then reintroduction of Westslope cutthroat trout and western pearlshell mussel could occur from other populations within the range.

3.5 At-Risk Plant Species

3.5.1 Introduction

At-risk plant species are federally recognized species under the Endangered Species Act (threatened, endangered, proposed, and candidate species) and species of conservation concern. A species of conservation concern is a "species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area" (36 CFR 219.9(c)). Management actions that disturb or disrupt soil surfaces within a portion of the Custer Gallatin could affect the capacity of that landscape to support at-risk plants.

The 2012 Planning Rule directives (FSH 1909.12) requires coarse-filter plan components (habitat conservation) be developed, and fine-filter plan components (species specific) if necessary (appendix C), to contribute to the recovery of listed species, conserve proposed and candidate species, and to provide the desired ecological conditions necessary to maintain populations of species of conservation concern within the plan area. A key assumption of the course filter approach is that if ecological conditions that provide the habitat that species depend on remain intact (well represented and distributed), most species will be maintained. Moreover, is it assumed that by maintaining these conditions, critical ecological and evolutionary processes such as nutrient and sediment transport, biotic interactions, dispersal, gene flow and disturbance regimes, will also be maintained and provide the necessary environmental conditions for climate adaptation (Beier and Brost 2010).

At-risk plants contribute to diversity on the landscape and opportunities for botany enthusiasts. Refer to the general contributions to society and economic sustainability section for more information about multiple uses, key ecosystem services, and benefits to people.

Regulatory Framework

Endangered Species Act of 1973, administered by U.S. Fish and Wildlife Service: protect and recover imperiled species and the ecosystems upon which they depend.

Forest Service Manual 2670: applies to regional forester's sensitive species.

Record of Decision (2012 Planning Rule) detailed in 36 Code of Federal Regulations [CFR] 219.9 and the associated directives in FSH 1909.12.5: Species at-risk on the Custer Gallatin National Forest includes species of conservation concern designated by the regional forester of the Northern Region where best available scientific information indicates substantial concern about the species' capability to persist on the national forest over the long term. The revised Forest Service manual policy regarding species of conservation concern is forthcoming and the changes and impacts are not known. The current management direction is to evaluate proposed management activities and project areas for the presence of occupied or suitable habitat for any plant species listed under the Endangered Species Act or on the regional forester sensitive species list (the current plans).

Key Indicators and Measures

Species specific and habitat guild (habitat type group) conditions and threats will be qualitatively evaluated. Adverse impacts to at-risk plant species result from plan components that increases surface disturbance and competition from invasive species spread or alters hydrological processes. The principle beneficial impacts include plan components that protect, maintain, or restore habitat conditions in known occurrences or potential at-risk plant species habitat.

Key Indicators Used to Compare Alternatives

Habitat quality, by evaluating changes in plan land allocations generally considered low risk to ground disturbance. This is measured in acres by alternative of designated wilderness areas, wilderness study area, recommended wilderness areas, inventoried roadless areas, backcountry areas (low development areas), designated wild and scenic rivers, and research natural areas.

Potential competition from noxious weed species, by evaluating changes in miles of motorized routes (weed spread pathways).

Methodology and Analysis Process

The U.S. Fish and Wildlife Service is responsible for determining species recognized under the Endangered Species Act as threatened, endangered, and proposed or candidate. Once identified, the Forest Service is responsible to manage for the ecological conditions that would contribute to the recovery of the listed species and conserve proposed and candidate species. Determining effects to federally recognized species by alternative considers the degree of management activities or natural conditions that may pose potential stress or threat to the species.

The 2012 Forest Planning Rule provides direction for determining which of species to be potential species of conservation concern, as described in the previous introduction section. The list of potential species of conservation concern must meet the mandatory requirement (FSH 1909.12 Section 12.52) that the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area. This information may be derived from the scientific literature, species studies, habitat studies, analyses of information obtained from a local area, or the result of expert opinion or panel consensus. Additional information is available in the assessment and the Northern Region Species of Conservation Concern web page.

Once species of conservation concern were defined, ecosystem characteristics for species were evaluated and determinations were made on whether forestwide components maintained the habitat quality needed by associated species of conservation concern. This was done by considering known locations of species and their habitats, as well as key drivers or stressors. Additional species-specific plan components were then considered and developed if needed. In other words, the extent and condition of each ecosystem or special type served as the habitat indicator for individual species, and for assemblages of at-risk species and overall floristic diversity. For most species, extent and condition of habitat typically constitute the best available scientific information indicating whether such populations would continue to persist with enough distribution in the planning area (2012 Rule Sec. 219.19). However, known occurrences, trend data, and known threats to species persistence were used when available to compare each alternative.

Determinations for each species consisted of a persistence evaluation, which examined whether plan components provide ecological conditions necessary to support long-term persistence of each species of conservation concern in the plan area. The persistence evaluation was conducted using both a coarse filter and a fine filter approach (again using known occurrences), habitat extent and condition, and known threats as indicators. For the coarse filter approach, species were grouped by habitat guilds. This coarse filter approach assumes that persistence of species of conservation concern is broadly dependent upon the integrity of the coarse ecosystems where they currently occur. Qualitative, rather than quantitative, evaluations were made, and the coarse filter approach was used along with using habitat guilds and considering species in a broader context to compare the revised plan alternatives to the current plans forestwide plan components. However, the habitat guilds outlined below are roughly, but not exactly, aligned with floristic geographic subdivisions, to which at-risk plant populations are often associated. Since the integrity of whole ecosystems does not necessarily ensure persistence of all species of conservation concern, particularly those with very limited distribution, an additional fine filter analyses was conducted (by species-specific occurrences and habitat indicators) to ensure that persistence is provided for all plant species of conservation concern to compare each alternative.

Impact analyses and conclusions are based on interdisciplinary team knowledge of resources on the Custer Gallatin, review of existing literature, and information provided by other agencies. Effects are quantified where possible. In absence of quantitative data, best professional judgment was used. Spatial analyses were conducted using geographic information system (GIS) data and analyses. Impacts are described using ranges of potential impacts or in qualitative terms, if appropriate.

Other assumptions used in the analysis that are common to all alternatives (include: designated wilderness, wilderness study area, the 2001 inventoried roadless areas, and research natural areas) would continue to be managed designated; there would be a general increase in recreational demand as the human population increases; weeds and weed seeds would continue to be deposited and spread onto and within the Custer Gallatin; and climate change trends would continue as projected, with warming temperatures and variable precipitation. The general management strategies in the revised plan appendix A would be followed for all revised plan alternatives.

At-risk species occupy specific habitats on the landscape. There is limited data regarding trends for many at-risk plant species, so monitoring would be needed to determine the impacts of project activities and management direction.

Information Sources

Primary information sources for at-risk plant species and their occurrences on the Custer Gallatin are the Montana and South Dakota Natural Heritage Program Element Occurrence databases and online Montana Field Guide, NatureServe database, Rocky Mountain Herbaria and the Consortium of Pacific Northwest Herbaria. For some species, threat category information was provided by the Montana Native Plant Society. NatureServe, and the Montana and South Dakota Natural Heritage Programs provide rankings that categorize the risks to persistence associated with each species they evaluate. These rankings, along with the other criteria in Forest Service Handbook 1909.12, Chapter 10, section 12.52, were used to develop the list of species of conservation concern for the Custer Gallatin. The Rocky Mountain Herbaria and Consortium of Pacific Northwest Herbaria online databases provided distribution and habitat information. Various floristic surveys for the Custer Gallatin were used to help determine which plant species to consider as at-risk species. Three recent Rocky Mountain Herbarium floristic surveys (Hartman and Nelson 2010, Hallman 2012, Elliott 2014) added to the species to consider for the Custer Gallatin National Forest.

Most at-risk plant species that are not federally listed do not have the same level of scientific data available as federally listed species. Though there may be uncertainties and gaps in data and knowledge about at-risk plant species, the best available scientific information is utilized in this analysis to assess the condition and determine potential effects between alternatives.

There is little published information about most at-risk plant species concerning their persistence, biology, habitat, population dynamics, and occurrences. Information gaps relevant to at-risk species may be filled in through future inventories, plan monitoring results, or research, and this information would be integrated into the databases and regional forester’s species of conservation concern lists as it becomes available.

Analysis Area

The geographic scope of the analysis for effects to at-risk plant species is the lands administered by the Custer Gallatin National Forest. Some attributes are summarized at large scales to provide context. However, some ecosystem components are described at a more localized scale due to their ecological importance and limited distribution. The specific range of each at-risk species may extend beyond the national forest boundary; however, the lands administered by the Custer Gallatin represent the area where changes may occur to these species or their habitats from activities that might be allowed under the alternatives. In some cases, the best available scientific information for at-risk species’ ecological relationships originated outside the analysis area. The full range of each species was considered to evaluate the persistence and importance of each species’ habitat on the national forest, but only indicator measurements from within the analysis area were used in making conclusions. Cumulative effects consider neighboring Tribal, Federal, State land jurisdictions. The temporal scope of the analysis is the anticipated life of the plan.

Notable Changes between the Draft and Final Environmental Impact Statement

Two important changes were made to plan components in this section. First, a new desired condition was added to encourage management actions that will maintain and restore whitebark pine ecosystems (FW-DC-PRISK-02). This desired condition is supported by an additional objective to treat a minimum of 1,000 acres per decade for the purpose of sustaining or restoring whitebark pine (FW-OBJ-PRISK-02). Next, FW-GDL-PRISK-01 from the draft plan was removed and FW-STD-PRISK-01 was amended to expand protection of at-risk plant populations to all management activities not just “ground-disturbing” activities. Analysis in the final environmental impact statement was amended to reflect these changes to plan components. Analysis of whitebark pine was also updated to include additional recent scientific information on the conservation and management of this species as well as more detail on the affected environment and environmental consequences. Analysis was updated to reflect the change from a candidate to a proposed species under the Endangered Species Act. Finally, analysis was added for alternative F. With respect to at-risk plants, this alternative is the same as alternatives B and C.

3.5.2 Affected Environment (Existing Condition)

Regional Forester’s Sensitive Plant Species

Regional forester’s sensitive species are defined as “plant and animal species identified by a regional forester for which population viability is a concern, as evidenced by significant current or predicted downward trends in population numbers or density; or significant current or predicted downward trends in habitat capability that would reduce a species’ existing distribution.” The current Northern Regional Forester’s sensitive plant species list was developed in 2011. Suitable habitat for 30 currently listed regional forester’s sensitive plant species exists on the Custer Gallatin National Forest. Twenty-four of the 31 have known populations occur on the national forest and seven species are not known, but are suspected to occur. Upon final regional forester’s determination of the Custer Gallatin’s Plant Species of Conservation Concern list, the list will be replaced with the species of conservation concern list. Analysis of sensitive plant species pertain to the current plans. Appendix C provides the regional forester’s sensitive species list.

Federally Listed At-Risk Plant Species

Species federally listed as threatened or endangered, proposed, and candidate are designated by the U.S. Department of the Interior, Fish and Wildlife Service. Under provisions of the Endangered Species Act of 1973, Federal agencies are directed to conserve endangered and threatened species and to ensure that actions authorized, funded, or carried out by these agencies are not likely to jeopardize the continued existence of threatened or endangered species, or result in the destruction or adverse modification of their critical habitats. These species are automatically considered “at-risk” species under the 2012 Planning Rule.

There are no endangered plant species known on the Custer Gallatin National Forest. Whitebark pine (*Pinus albicaulis*), is a proposed species for Federal listing as threatened, due to sufficient information on its biological status and threats.

Whitebark Pine

The large, nutritious seeds produced by whitebark pine (*Pinus albicaulis*), are an important food for birds and mammals, and whitebark pine communities provide important habitat for many wildlife species. Whitebark pine seedlings survive on harsh, high elevation sites and, when fully grown, often act as nurse trees to less-hardy conifers and undergrowth vegetation. At upper subalpine elevations, mature whitebark pine trees help to regulate snowmelt and reduce soil erosion. For these collective functions, whitebark pine is considered both a keystone species for promoting community diversity and a foundation species for promoting community stability (Keane et al. 2012, Keane et al. 2017). Severe population decline in whitebark pine communities is attributed to various causes, most significantly infection with white pine blister rust, recent outbreaks of mountain pine beetles (2000–2014), disturbances in wildland fire ecology (including fire suppression), forest succession, and climate change. In addition to its critical ecological role, the loss of whitebark pine also potentially impacts fire regimes, recreational experiences, and aesthetic perceptions (Tomback and Achuff 2010, Keane et al. 2012, Keane et al. 2017). As a result, whitebark pine was determined by the U.S. Fish and Wildlife Service to be a species warranted for federal listing but precluded under the Endangered Species Act on July 19, 2011 (76 FR 76 42631) (U.S. Department of the Interior 2011a). Following a 12-month review, the U.S. Fish and Wildlife Service determined on July 19, 2011, that whitebark pine is a proposed species, with listing as threatened or endangered warranted but precluded by higher priority actions (U.S. Department of the Interior 2011a) (FR 76(138): 42631-42654). As a result, the Northern Region added whitebark pine to the regional forester sensitive species list on December 24, 2011. U.S. Fish and Wildlife Service reviewed whitebark pine's candidate status and rank December 2, 2016 and determined it to be appropriate as an 8 (U.S. Department of the Interior 2016c) (FR 81(232), 87263). On December 2, 2020, the Service proposed to list whitebark pine as a threatened species under the Endangered Species Act and determined that designation of critical habitat for the whitebark pine is not prudent at this time (U.S. Department of the Interior 2020a).

Habitat

Whitebark pine is a key ecosystem component growing at the highest forested elevations in cold, windy, snowy, and generally moist climatic zones (Arno and Hoff 1989) that are difficult areas for plants and animals to inhabit. Its tolerance to cold, superior hardiness on harsh microsites that exist after a fire, unique method of seed dispersal, and resistance to lower intensity fires, allows it to compete successfully in the upper subalpine zone where is often grows in a krummholz form (stunted, shrub-like growth) above tree line. On productive upper subalpine sites, whitebark is the major seral species that is eventually replaced by more shade tolerant species, mainly subalpine fir and occasionally Engelmann spruce on the Custer Gallatin National Forest, while on harsh upper subalpine forests and at tree line it can successfully dominate as climax vegetation (Keane et al. 2017). Whitebark pine ecosystems were maintained through fire and insect regimes, and regenerate best in open, sunny conditions (Tomback et al. 2001). Whitebark pine has fairly low resistance to fire damage due to its thin bark. However, it is more resistant than its associates, subalpine fir and Engelmann spruce. High-intensity fires are likely to kill even the largest whitebark pine (Keane et al. 2000). However, in areas with low fuel levels and more widely scattered trees, some whitebark pine may survive the higher-intensity fires (Lorenz et al. 2008).

Whitebark pine has a unique method of seed dispersal and regeneration that involves a mutualistic relationship that has evolved between whitebark pine and the Clark's nutcracker (*Nucifraga columbiana*) for seed dissemination. Whitebark pine is entirely dependent on this bird to disperse and sow its seeds for regeneration of the species. The bird extracts the seed from the cones and, if they do not immediately consume it, they cache the seed in small stores often in the ground and sometimes many miles from their source. Unretrieved seeds that are buried in the soil and on sites suitable for seed germination and establishment, such as open or fire-burned areas, are able to germinate, thus establishing new whitebark pine seedlings often further than wind distributed seeds of competing conifers.

Occurrence

Table 28 displays the occurrence of whitebark pine on National Forest System lands on the Custer Gallatin National Forest (both where it is dominant as a cover type and the total area where it is present), based on forest inventory and analysis plots. This data represents the best statistically reliable estimates of whitebark pine occurrence based on plot data. Approximately 70 percent of the whitebark pine present on the Custer Gallatin National Forest occurs on the cold broad potential vegetation group, and to a lesser extent on cool moist and alpine sites.

Table 28. Whitebark pine occurrence on the Custer Gallatin National Forest

Scale	Acres of Whitebark Pine Presence	Acres of Total Whitebark Pine Dominance
Forestwide	433,793 (354,584–483,986)	213,798 (159,585–251,897)
Bridger, Bangtail, and Crazy Mountains	32,073 (14,433–183,319)	16,037 (1,507–34,014)
Madison, Henrys Lake, and Gallatin Mountains	144,946 (104,894–178,542)	58,293 (31,897–77,175)
Absaroka Beartooth Mountains	270,326 (208,023–317,741)	146,427 (105,012–180,460)

Data from national base Forest Inventory Analysis (forest inventory analysis plots), using the Hybrid 2011 and 2015 dataset. The ranges shown are the 90 percent confidence intervals around the estimates. Whitebark pine is not present on geographic areas not shown in Table (Pryor Mountains, Sioux, and Ashland).

Dominance indicates areas where whitebark pine is dominant, as indicated by dominance types (Dom40 attribute). Presence indicates areas where at least one whitebark pine tree is present.

The relationship between cover type and species presence shows that whitebark pine is dominant on far fewer acres than the total area where it is present. This indicates that in many areas whitebark is a minor component growing in areas dominated by other species. This relationship can be demonstrated by summarizing the cover type distribution within the areas where whitebark pine is present, as shown in table 29. These data indicate that where whitebark pine is present, it is often dominated by lodgepole pine or spruce-fir. Whitebark pine is dominant on just 35 percent of the areas where it occurs in the plan area.

Table 29. Distribution of cover types found on areas where whitebark pine is present

Cover Type	Total Whitebark Pine Presence (percent)
Douglas-fir	4
Lodgepole pine	14
Spruce-fir	29
Whitebark pine	35
None (Nonforested)	18

Data source: Hybrid 2011/2015 dataset of base Forest Inventory Analysis (forest inventory analysis) plots.

Although plot data (forest inventory analysis) provides the best estimate of whitebark pine occurrence, maps of whitebark pine must also be used to facilitate a spatial analysis. It is difficult to map all areas where whitebark is present because trees present in the understory or those that are a minor component in the overstory cannot be detected with remote sensing techniques and there is no comprehensive field inventory on the Custer Gallatin National Forest (such as stand exams). The Northern Region VMap is generally the best source of spatial data for vegetation using the Northern Region Vegetation Classification System (Barber et al. 2011, Brown 2016). This Landsat-derived spatial GIS layer depicts, among other things, dominance types across the Custer Gallatin National Forest. Because of the need for spatial data for analysis, VMap was used to analyze the effects of the revised plan alternatives and is the input layer used for vegetation modeling in SIMPPLLE (Chew et al. 2012a). This layer maps a total of 275,368 acres of whitebark pine across the national forest on National Forest System Service lands, which closely resembles the forest inventory analysis estimates. This is the best available spatial information to analyze whitebark pine on the Custer Gallatin National Forest (Figure 3).

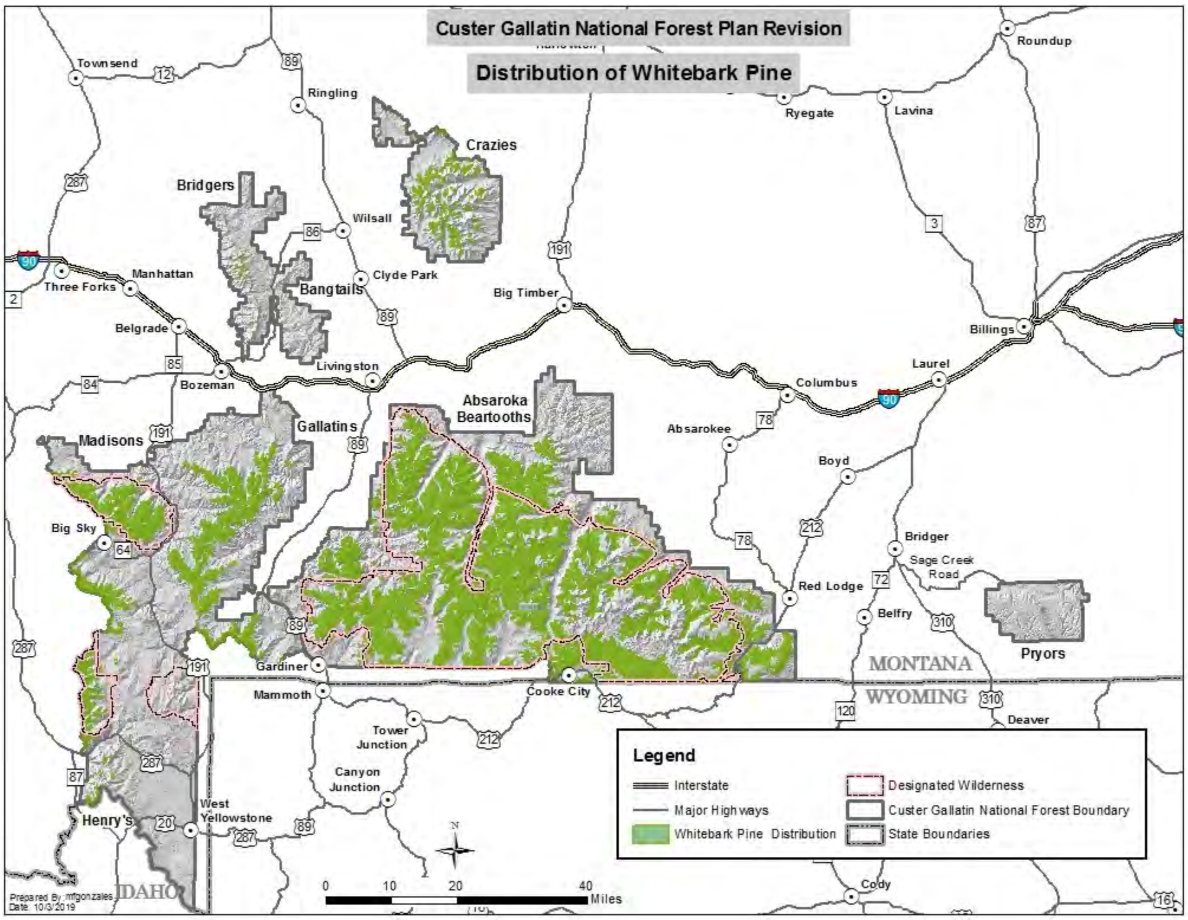

Figure 3. Distribution of whitebark pine dominated forest on the Custer Gallatin National Forest

Trends and Threat Factors

A severe and steep downward trend has been occurring in the whitebark pine population and health over the past few decades, especially in the northern Rocky Mountains (Keane et al. 2012). Recent estimates from aerial surveys (2009) documented greater than 80 percent mortality of overstory whitebark pine throughout the Greater Yellowstone Ecosystem (Macfarlane et al. 2013). This decline is expected to continue into the foreseeable future, although the rate may lessen simply because there are fewer live trees left to be impacted by disease or other threats. The declining trend occurs across the Northern Region. Analysis at the Regional scale indicates that the abundance of live whitebark pine has decreased from 18.3 percent of periodic forest inventory analysis plots containing at least one live whitebark pine tree, to 15.8 percent in the annualized inventory. In the Greater Yellowstone Ecosystem, plot-based surveys implemented by the National Park Service's Greater Yellowstone Inventory and Monitoring Program found similar estimates of mortality in the larger size class of trees that typically comprise the overstory population of whitebark pine. Mortality rates across the range of size classes were estimated to be 26 percent in the Greater Yellowstone Ecosystem (Shanahan et al. 2017). Across the range of size classes, primary mortality factors include exotic white pine blister rust (blister rust; *Cronartium ribicola*), native mountain pine beetle (*Dendroctonus ponderosae*), and wildland fire. Between 2004 and 2015, Greater Yellowstone Whitebark Pine Monitoring Working Group estimated that 32 percent of dead whitebark pine showed evidence of mountain pine beetle only (mainly in the 10-30cm size class), blister rust alone accounted for mortality of 14 percent of mortality, 8 percent was attributed to fire only while the remaining 46 percent showed a combination of these factors (Shanahan et al. 2017). Climate changes interacts with each of these stressors in complicated ways to generally amplify the threat to whitebark pine. Each of these threats and expected trends is addressed below.

White Pine Blister Rust

White pine blister rust is an exotic fungal disease caused by the fungus *Cronartium ribicola* and infects all five-needle pines. It was introduced to eastern North America in the 1890s and into western North America in the first decade of the 20th century on infected eastern white pine nursery stock grown in France and shipped to Vancouver British Columbia. Since then, the pathogen has spread across the ranges of all five-needle pines in the United States and Canada, except for Great Basin bristlecone pine (Keane et al. 2017). As this disease has moved into fragile, high-elevation ecosystems, normal successional pathways have been altered. Because the disease is exotic, whitebark has limited defenses. Blister rust infection or cankers can cause the death of upper canopy cone-bearing branches, thus negatively impacting seed-production; cankers found on the lower portions of the bole will eventually kill an infected tree. Some landscapes in the northern Rocky Mountains contain so few undamaged trees and apparent rust resistant whitebark pine seed sources that there is major concern that whitebark pine seed dispersal is not occurring at any magnitude (McKinney and Tomback 2007).

Some natural selection for resistance to blister rust is likely occurring (Hoff et al. 2001), but the recovery of the species will be slow. Whitebark pine grows slowly and has a long generation time (trees need to be 60 to 80 years old before they produce sizable cone crops), and, as noted, there has been an especially dramatic decline in mature, cone-producing trees. The regeneration potential of the species is further exacerbated by evidence suggesting that stands with less than about 21 square feet per acre of live whitebark pine basal area provide too little cone production to reliably attract nutcracker seed dispersal (McKinney et al. 2009). A recent study suggests that in highly damaged whitebark pine stands, most seeds produced are consumed by nutcrackers and red squirrels rather than dispersed (McKinney et al. 2011). In 2015, monitoring data from the Greater Yellowstone Ecosystem indicated that approximately 25 percent of whitebark pine were infected with blister rust (Shanahan et al. 2017). Shanahan et al. (2016) concluded that in the Greater Yellowstone Ecosystem, smaller size class trees with white pine blister rust infection experienced higher mortality than larger trees suggesting that in the coming decades white pine blister rust may become the most probable cause of whitebark pine mortality.

Mountain Pine Beetle

The primary insect that kills whitebark pine trees is the mountain pine beetle. In the Greater Yellowstone Ecosystem, larger whitebark pine trees were preferentially attacked and killed by mountain pine beetle and resulted in a regionwide shift to smaller size class tree (Shanahan et al. 2016). Since 2000, mountain pine beetles have killed 75 percent of the mature cone-bearing trees in the Greater Yellowstone Ecosystem (Thoma et al. 2019). Mountain pine beetle mortality influences canopy condition, stand structure, species composition, forage production, wildlife habitat, fuel loading, water yields, and aesthetics. Following the death of the overstory, advanced regeneration from shade-tolerant tree species (subalpine fir, for example) is expected to release. Species composition plays a critical role at this time; if the stand has succeeded to shade-tolerant species, it would be expected that the stand composition would shift to that shade-tolerant species mixture (Keane et al. 2012).

Mountain pine beetle are native to high-elevation pine forests and presence of mountain pine beetle in whitebark has been documented for at least 100 years (Arno and Hoff 1990). In high elevation forests, mountain pine beetle was historically limited by cold temperatures. Several large, widespread epidemics of mountain pine beetle caused high mortality of whitebark pine throughout the U.S. Rocky Mountains between 1909 and 1940 and again from the 1970s to the 1980s (Arno and Hoff 1990). However, with a warming climate winter temperatures have become mild enough to allow substantial overwinter survival of all life stages and there is sufficient summer thermal energy to complete an entire life cycle in one year (Logan et al. 2010, Bentz et al. 2016). Projections from climate models indicate future climate conditions will likely provide favorable conditions for beetle outbreaks within nearly all current whitebark pine habitat in the Greater Yellowstone Ecosystem by the middle of this century. Therefore, when surviving and regenerating trees reach ages suitable for beetle attack, there is strong potential for continued whitebark pine mortality due to mountain pine beetle (Buotte et al. 2016).

Wildland Fire

For much of the 20th century, the practice of fire exclusion has kept fire from reaching higher elevations where whitebark pine occurs. Fire exclusion limits the regeneration and restoration of whitebark pine stands and has resulted in widespread successional replacement of whitebark pine with other trees, such as subalpine fir and Engelmann spruce. Whitebark pine has an advantage over its competitors in that it readily colonizes large, stand replacement burns because its seeds are transported great distances by Clark’s nutcracker. Without fire, most seral whitebark pine forests would be replaced by subalpine fir or some other shade-tolerant high-elevation species (Keane et al. 2017). When a fire does occur, it tends to be more severe due to the increase in tree density, ladder fuels and downed woody material as well as the overwhelming presence of non-fire-resistant species. Although open, burned, and favorable habitat for whitebark pine regeneration is created by the fire, the lack of a sufficient number of cone-producing trees within caching distance severely limits the ability of this species to re-establish itself in areas where it historically was present or dominant.

Climate Change

Climate change is expected to interact with the trends and threats discussed above as well as have direct effects on habitat conditions. In general, the impact of projected climate change on whitebark pine is inconclusive and there is an element of uncertainty in the research about the potential effects to the species (Keane et al. 2017). Overall, however, whitebark pine is not expected to do well under future climates, primarily because of the current threats and severely declined population, its confinement to upper subalpine environments, and its lack of ability to regenerate because of nutcracker consumption of seed in areas of low whitebark pine populations (Keane et al. 2017). Direct habitat loss is anticipated to occur due to increased competition from species that normally cannot persist in whitebark pine habitats. Habitat loss will also occur if temperatures exceed the thermal tolerance for whitebark pine and the species is unable to survive the new conditions, though given its wide range and ecological tolerance, this is not likely to be as large a driver of reduced habitat availability. Rapid warming is expected to out-pace species migration to suitable habitats. Some studies suggest that the projected warmer conditions will severely reduce whitebark pine habitat and its distribution, perhaps restricting it to only the highest elevations (Warwell et al. 2007, Belote et al. 2015). Others, however, show that climate-mediated changes in disturbance regimes, such as increased fire frequencies, will reduce whitebark pine populations but not alter its current range (Loehman et al. 2011). Anecdotal evidence suggests that some whitebark pine forests are even experiencing abnormally high growth and more frequent cone crops with warmer summers and longer growing seasons (Keane et al. 2017). Recent models indicate that climate change refugia trends will decrease the area of distribution of what is currently known in the interior distribution and limit its elevational range (Mahalovich et al. 2018). Notably, however, while an average of 85 percent of present-day interior whitebark occurs in designated wilderness, less than 1 percent of the projected refugia are located within the boundaries of these unmanaged areas suggesting opportunities for active restoration. The effect of climate change on whitebark pine is complex because of the high uncertainty in regional climate change predictions, the high genetic diversity and resilience of the species, and the localized changes in disturbance regimes and interactions which may interact in uncertain ways.

At-Risk Plant Species of Conservation Concern

Under the 2012 Planning Rule, in addition to federally listed species, plant species at-risk on the Custer Gallatin includes species of conservation concern designated by the Regional Forester of the Northern Region where best available scientific information indicates “substantial concern about the species’ capability to persist over the long term in the plan area” (36 CFR 219.9; FSH 1909.12 chapter 10, part 12.52).

The process for identifying these species and the listed species of conservation concern for the Custer Gallatin are located on the Northern Region Species of Conservation Concern web page. State conservation rankings, along with the other criteria in Forest Service Handbook 1909.12, chapter 10, section 12.52 and chapter 20, section 21.22a, were used to develop the regional forester’s at-risk plant species list for the Custer Gallatin National Forest. Using NatureServe, Montana Natural Heritage Program (MTNHP), South Dakota Natural Heritage Program databases, the current regional forester sensitive species list, and publications, a master list of State plant species of concern (for both Montana and South Dakota) known or suspected to occur on the Custer Gallatin National Forest was compiled for initial assessment (consisting of 153 species). Of these 153, 40 were determined to be outside the national forest, leaving 112 species known on the Custer Gallatin to be evaluated. Twenty-five plant species were determined by the regional forester to be species of conservation concern.

The final plant species of conservation concern list will replace the sensitive plant species list for the Custer Gallatin National Forest. Table 30 lists the plant species that are determined to be species of conservation concern by the regional forester on the Custer Gallatin National Forest. Information regarding the rationale for identifying these species as species of conservation concern can be found on the Northern Region Species of Conservation Concern web page. See note at bottom of table for interpretation of conservation category codes.

Table 30. At-risk plant species of conservation concern

Name and General Geographic Area	Conservation Categories[1]	Habitat Guild, Distribution, and Abundance in the Plan Area
muskroot *Adoxa moschatellina* (Montane and Pine Savanna)	G3 S3-MT; S4-SD SOC-MT, RFSS, SCC	Sparsely Vegetated: Rock/talus; cold air flow channels beneath rockslides. Four occurrences in the Absaroka Beartooth Geographic Area (three within the Beartooth RD and one within the Yellowstone RD (MTNHP 2018 GIS Dataset)).
oval-leaf milkweed *Asclepias ovalifolia* (Pine Savanna)	G5; S1S2-MT; SOC-MT; RFSS; SCC	Grassland/Shrubland: Sandy, gravelly or clayey soils of prairies and woodlands. Ten occurrences in the Sioux Geographic Area (MTNHP 2018 GIS Dataset; Heidel and Dueholm 1995; Hansen, 2018).
narrowleaf milkweed *Asclepias stenophylla* (Pine Savanna)	G4G5; S2-MT; SOC-MT; SCC	Grassland/Shrubland: Sandy sites on the prairie. Four occurrences on the Custer Gallatin; three occurrences in the Sioux Geographic Area and one occurrence in the Ashland Geographic Area (MTNHP 2018 GIS Dataset; Heidel and Dueholm 1995; Reid and Hallman 2010).
Frenchman's Bluff moonwort *Botrychium gallicomontanum* (Montane and Pine Savanna)	G1G2; S1S2-MT; S1-SD SOC-MT; SOC-SD; SCC	Grassland/Shrubland: Valley grassland, foothill, lower and upper montane, and subalpine. One occurrence in the Absaroka Beartooth Geographic Area within the Yellowstone RD (Elliot 2014, MTNHP 2018 GIS Dataset) and one occurrence on Sioux Ranger District (Hansen 2019).
Peculiar moonwort *Botrychium paradoxum* (Montane)	G3; SOC-MT, RFSS; SCC	Grassland/Shrubland: Meadows (mesic montane/subalpine). One occurrence in the Absaroka Beartooth Geographic Area within the Yellowstone RD (MTNHP 2018 GIS Dataset, Elliot 9009, Elliot 2014).
annual Indian paintbrush *Castilleja exilis* (Montane)	G5; S2-MT; SOC-MT	Grassland/Shrubland: Moist alkaline meadows in valleys. One occurrence in the Absaroka Beartooth Geographic Area within the Yellowstone RD (MTNHP 2018 GIS Dataset).
heavy sedge *Carex gravida var. gravida* (Pine Savanna)	G5; S3-MT; SOC-MT; RFSS; SCC	Broadleaf Woodlands: Mesic/humid open woods, often in ravines with deciduous trees, on the plains. 37 occurrences in the Ashland and Sioux Geographic Areas (MTNHP 2018 GIS Dataset, SDNHP 2016 dataset,Hallman 2012, Lesica and Marlow 2013).
small yellow lady's-slipper *Cypripedium parviflorum* (Montane and Pine Savanna)	G5; S3? -SD; S3S4-MT; SOC-SD PSOC-MT RFSS; SCC	Wetland and riparian: Damp, mossy woods; seeps, moist forest meadows; fens; valley to lower montane. One occurrence in the Sioux Geographic Area. Three historical occurrences in the Absaroka Beartooth Geographic Area (MTNHP 2018 GIS Dataset, Mergen 2006, Hallman 2012, Hansen, 2009).
Dense-leaf draba *Draba densifolia* (Montane)	G5; S2-MT; SOC-MT; SCC	Sparsely Vegetated: Gravelly, open soil of rocky slopes and exposed ridges in montane to alpine zones. Two occurrences in the Absaroka Beartooth Geographic Area within the Yellowstone RD (MTNHP 2018 GIS Dataset, Elliott 2014).

Name and General Geographic Area	Conservation Categories[1]	Habitat Guild, Distribution, and Abundance in the Plan Area
English sundew *Drosera anglica* (Montane)	G5; S3-MT; SOC-MT RFSS; SCC	Wetland and riparian: Floating bogs, swamps, and sedge meadows, with soils that are saturated or in very shallow standing water; weakly acidic or calcareous bogs and fens. One occurrence in the Absaroka Beartooth Geographic Area within the Gardiner RD and one historical occurrence in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area within the Bozeman RD (MTNHP 2018 GIS Dataset,Lesica and Shelly 1991, Wolf et al. 2006, Elliott 2014).
beaked spikerush *Eleocharis rostellata* (Montane and Pine Savanna)	G5; S1-SD; S3-MT; SOC-SD SOC-MT RFSS; SCC	Wetland and riparian: Wet, often alkaline soils, associated with warm springs or fens in the valley and foothill zones. Two occurrences in the Absaroka Beartooth Geographic Area within the Yellowstone and Gardiner RDs (MTNHP 2018 GIS Dataset).
Whitestem Goldenbush *Ericameria discoidea* var. *discoidea* (Montane)	G4G5T4; S2-MT; SOC-MT; RFSS; SCC	Sparsely Vegetated: Rocky, open sparsely wooded slopes or coarse talus near or above tree line. One occurrence in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area within the Hebgen Lake RD (MTNHP 2018 GIS Dataset).
Dakota buckwheat *Eriogonum visheri* (Pine Savanna)	G3; S2-MT; S3-SD; SOC-MT; SOC-SD; RFSS; SCC	Sparsely Vegetated: Badlands, clay barrens, often bentonitic badland slopes and outwashes in the plains. One occurrence in the Sioux Geographic Area (SDNHP 2016 Dataset, Heidel and Dueholm 1995).
hiker's gentian *Gentianopsis simplex* (Montane)	G5; S2-MT; SOC-MT; RFSS; SCC	Wetland and riparian: Fens, wet meadows, seeps. Twelve occurrences in the Absaroka Beartooth and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas within the Beartooth/Yellowstone RDs and Bozeman RD, respectively (MTNHP 2018 GIS Dataset, Shelly 1994, Elliott 2014, Clark 2017).
spiny hopsage *Grayia spinosa* (Montane)	G5; S2-MT; SOC-MT; SCC	Grassland/Shrubland: One occurrence in the Absaroka Beartooth Geographic Area within the Gardiner RD (MTNHP 2018 GIS Dataset).
rockyscree false goldenaster *Heterotheca fulcrata* (Montane)	G4G5; Not yet ranked in MT; SCC	Sparsely Vegetated: Limestone outcrops. One occurrence in the Absaroka Beartooth Geographic Area within the Beartooth RD (MTNHP 2018 GIS Dataset, Elliott 2014)
Nuttall Desert-Parsley (*Lomatium nuttallii)* (Pine Savanna)	G3; S2-MT; SH-SD; SOC-MT; SOC-SD; RFSS; SCC	Sparsely Vegetated: Rocky, open pine woodlands; mid to lower hillslopes on sandstone, siltstone, or clayery shale. Four occurrences in the Ashland Geographic Area (MTNHP 2018 GIS Dataset, Barton and Crispin 2003).
meesia moss (*Meesia triquetra)* (Montane)	G5; S2-MT; SOC-MT; RFSS; SCC	Wetland and riparian: Bogs, wetlands, and wet woods. One occurrence in the Absaroka Beartooth Geographic Area within the Beartooth RD (MTNHP 2018 GIS Dataset).

Name and General Geographic Area	Conservation Categories[1]	Habitat Guild, Distribution, and Abundance in the Plan Area
dwarf purple monkeyflower (*Mimulus nanus)* (Montane)	G5; S2S3-MT; MT SOC; RFSS; SCC	Sparsely Vegetated: Open slopes (low elevation); dry, often gravelly or sandy slopes in the valleys and foothills. Four occurrences in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area within the Hebgen Lake RD (MTNHP 2018 GIS Dataset, Elliott 2014).
wooly twinpod (*Physaria didymocarpa* var. *lanata*) (Montane and Pine Savanna)	G5T2; S2S3-MT; SOC-MT; SCC	Sparsely Vegetated: Sandy, often calcareous soil of open grassland or shrubland slopes in the plains. Three occurrences in the Absaroka Beartooth Geographic Area within the Beartooth and Yellowstone RDs (MTNHP 2018 GIS Dataset, Elliott 2014).
Beartooth large-flowered goldenweed (*Pyrrocoma carthamoides* var. *subsquarrosus* (Montane)	G4G5T3; S3-MT; SOC-MT; RFSS; SCC	Grassland/Shrubland: Grassland and sagebrush habitat; soils tend to be moderately deep, sandy, and high in coarse fragments. Eighteen occurrences in the Absaroka Beartooth and Pryor Mountains Geographic Areas within the Beartooth RD (MTNHP 2018 GIS Dataset, Lesica and Montana National Heritage Program 1995, Handley and Laursen 2002, Beatty et al. 2004).
Barratt's willow (*Salix barrattiana)* (Montane)	G5; S2-MT; SOC-MT; RFSS; SCC	Alpine: Cold, moist soil in the alpine zone. Two occurrences in the Absaroka Beartooth Geographic Area within the Beartooth RD (MTNHP 2018 GIS Dataset, Lesica 1993, Fertig and Markow 2000) Ladyman, 2005).
Shoshonea *(Shoshonea pulvinata)* (Montane)	G2G3; S2-MT; SOC-MT; RFSS; SCC	Sparsely Vegetated: Open, exposed limestone outcrops, ridgetops, and canyon rims, in thin, rocky soils. Six occurrences in the Pryor Mountains Geographic Area and one in the Absaroka Beartooth Geographic Area) within the Beartooth RD (MTNHP 2018 GIS Dataset, Lyman 2005, Heidel 2011, 1988; (Lesica and Achuff 1992).
Oregon checker-mallow (*Sidalcea oregana)* (Montane)	G5; S2S3; SOC-MT; SCC	Grassland/Shrubland: Grasslands in the valley and montane zones. Two occurrences in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area within the Bozeman RD (MTNHP 2018 GIS Dataset, Vanderhorst 1994).
northwestern thelypody (*Thelypodium paniculatum)* (Montane)	G2; SH-MT; SOC-MT; SCC	Wetland and riparian: Moist alkaline meadows. One occurrence in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area within the Hebgen Lake RD (MTNHP 2018 GIS Dataset, Elliott 2014).

1 SCC = species of conservation concern, RD = Ranger District, RFSS = regional forester sensitive species, SOC = state species of concern, Sx-MT = Montana species of concern state ranking; Sx-SD = South Dakota species of concern state ranking; Gx = Global ranking

At-Risk Plant Species by Habitat Guild

All at-risk plant species were grouped into broad habitat guilds (habitat type groupings), based on similar ecological conditions, response to disturbances, and habitat needs for the purpose of identifying and evaluating relevant information about them. These groupings were made based on the ecological conditions necessary to support long-term persistence of associated at-risk plant species. Though there may be variation in specific habitat needs for species within a habitat guild, the potential stressors and associated conservation strategies for the species in the habitat guilds would be very similar. This allows for more efficient analysis and identification of relevant information pertaining to the species.

The 26 at-risk plant species (25 plant species of conservation concern and one Federal proposed species) include one alpine species, one cold forest species, one broadleaf woodland species, eight grassland or shrubland species, nine sparse vegetation species, and six riparian or wetland species. Of the 26 total at-risk species, 16 of the species' habitat components are likely to only occur in the montane areas of the Custer Gallatin (Madison, Henrys Lake, and Gallatin Mountains; Absaroka Beartooth Mountains; Bridger, Bangtail, Crazy Mountains; and Pryor Mountains Geographic Areas), five of the species' habitat components are likely to only occur in the pine savanna areas (Ashland and Sioux Geographic Areas), and five species' habitat components could occur in both the montane and pine savanna areas (*Adoxa moschatellina*, *Botrychium gallicomontanaum*, *Cypripedium parviflorum*, *Eleocharis rostellata,* and *Physaria didymocarpa* var. *lanata*).

Cold Forest Habitat Guild

Whitebark pine is an at-risk plant found within this habitat. It is addressed in "Federally listed At-Risk Plant Species" section above.

Alpine Habitat Guild

Barratt's willow (*Salix barrattiana*) is an at-risk plant found within this habitat. There are two occurrences of Barratt's willow in the Absaroka Beartooth Geographic Area.

Alpine communities are common in the high elevations of the montane units of the Custer Gallatin National Forest. Approximately 121,000 acres of alpine vegetation occurs within the National Forest System lands of the Custer Gallatin. The Beartooth Mountains are primarily composed of the largest expanse of alpine plateau in the lower 48 states. The alpine vegetation is dominated by various grasses, sedges, small shrubs, and forbs that can withstand the severe environment characterized by high winds, low humidity, cold soil temperatures, high ultraviolet radiation, short growing season, low soil moisture, and great daily temperature fluctuations.

Alpine habitats are often fragile systems due to limited growing season and soil development. Although recreation and road construction are threats to rocky habitats, disturbance is often limited due to inaccessibility. Radio structures, mining, trail construction, and recreation are the main management related disturbances. Changes in fire patterns and severities, and associated effects on vegetation succession may be a stressor in some environments. Improper grazing has the potential to negatively impact these habitats, but permitted grazing rarely occurs in these habitats as most allotments do not contain accessible alpine areas. Elevation will play a large role in plant species composition in conjunction with predicted warming trends. High elevation, alpine or other fringe type environments may see plant species composition change first. Invasive plants apparently have not yet become a serious problem in the alpine settings of the Custer Gallatin National Forest, although yellow toadflax and Canada thistle are present above 9000 feet and have the potential to invade such areas in the future.

Barratt's willow (*Salix barrattiana*) montane: This alpine species is at the southern extent of the species' distribution and is largely confined to the designated Line Creek Plateau Research Natural Area on the Custer Gallatin (Lesica 1993, Montana Natural Heritage Program 2018a). The two occurrences are small, but the remote, high-elevation habitat should greatly minimize the potential for any negative impacts to the persistence of the Barratt's willow. One occurrence, encompassing about 100 square meters (Ladyman 2005), straddles the land managed by the Custer Gallatin and Shoshone national forests and consists of a single clone of staminate (male) plants (Fertig and Markow 2000). In this case, no sexual reproduction can occur, and the population must rely on asexual vegetative reproduction. Notwithstanding the absence of sexual reproduction, populations of vegetatively propagated individuals can be very successful (Ladyman 2005). Associated species with the occurrences includes *Salix glauca* and *S. planifolia* found at 9,700 feet elevation. The occurrences on the Custer Gallatin appear to be stable, at least in the short term. However, there is no information on which to evaluate trends in abundance for the population (Ladyman 2005). While the bulk of known occurrences of this species are distributed in Canada and Alaska, one occurrence is known from Glacier National Park (Montana Natural Heritage Program online accessed 2018); two occurrences are known on the Shoshone National Forest (Rocky Mountain Online Herbaria accessed 2018), and one occurrence in Madison County, Montana (Consortium of Pacific Northwest Herbaria, accessed online 2018). No additional populations of Barratt's willow have been located despite a recent floristic survey of wetlands within its range in Montana (Jones 2001).

Broadleaf Woodlands Habitat Guild

Heavy sedge (*Carex gravida var. gravida* - 37 occurrences of heavy sedge in the Ashland and Sioux Geographic Areas) is an at-risk plant found within this habitat guild.

Deciduous broadleaf woodlands in mesic settings include green ash woodlands in the Ashland and Sioux Geographic Areas, which provide habitat for heavy sedge. Green ash woodlands are best developed under conditions that favor snow entrapment, development of deeper soils, and concentration of moisture. These conditions are typical of ravines formed by ephemeral and intermittent streams where flooding is more sporadic or of short duration. Uplands are generally mixed grass prairies, shrublands and ponderosa pine forest. Soils are usually deep loams. Flooding is very short in duration when it occurs, as water is rapidly channeled downslope.

Threats to broadleaf woodlands include fire suppression, improper grazing, noxious species invasion, conifer colonization, and human activity. There may be loss of tree species to disease, insects, freezes, and fire as well as shifts in warming or drying patterns as a result of climate change which may be beneficial to some species.

Heavy sedge (*Carex gravida var. gravida*) – Pine Savanna: In general, heavy sedge has been found at a few widely scattered locations in eastern Montana and is not generally abundant where it occurs. This species is restricted to limited habitat that occurs at the western extent of its range where degree of humidity may be limited. This species and habitat type is vulnerable to improper grazing and weed invasion.

Grassland and Shrubland Habitat Guild

Oval-leaf milkweed (*Asclepias ovalifolia* - ten occurrences in the Sioux Geographic Area), narrowleaf milkweed (*Asclepias stenophylla* - three occurrences in the Sioux Geographic Area and one occurrence in the Ashland Geographic Area), Frenchman's Bluff moonwort (*Botrychium gallicomontanum* - one occurrence in the Absaroka Beartooth Geographic Area and one on the Sioux Ranger District), peculiar moonwort (*Botrychium paradoxum* - one occurrence in the Absaroka Beartooth Geographic Area), annual Indian paintbrush (*Castilleja exilis* - one occurrence in the Absaroka Beartooth Geographic Area), spiny hopsage (*Grayia spinosa* - one occurrence in the Absaroka Beartooth Geographic Area), Beartooth large-flowered goldenweed (*Pyrrocoma carthamoides* var. *subsquarrosus* -18 occurrences in the Absaroka Beartooth and Pryor Mountains Geographic Areas) and Oregon checker-mallow (*Sidalcea* *oregana* - two occurrences in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area) are at-risk plants found within this habitat guild.

Grasslands are dominated by cool-season perennial bunchgrasses and forbs, with sparse shrub or tree representation. Some warm-season grass occurs on the Ashland and Sioux Districts. Grasslands are usually forb species rich and may vary by moisture regime. Various shrub species may occur with low cover. Scattered pockets of ponderosa pine, limber pine, and Rocky Mountain juniper occur on shallow, skeletal soils or resistant bedrock. Grasslands range in size from small patches to large open parks, from montane to foothill zones.

Mesic meadow grassland habitats occur at lower montane to subalpine elevations where soils, snow deposition, or windy conditions limit tree growth. Meadow habitats are generally moist, sometimes seasonally so and may dry up late in the summer. Meadows occur in mosaics with shrublands or forests, or are adjacent to alpine communities across the Custer Gallatin. They are generally dominated by perennial graminoids and mesic forbs. Scattered shrubs or trees may be present, but are not abundant. These meadows are limited on the landscape and occupy fringe habitats adjacent to wetter meadows or forest swales.

Shrublands occurs at all slopes, aspects, and soil types, on the Custer Gallatin. The community can exhibit a variable extent of shrub diversity but is typically dominated by mountain or Wyoming big sagebrush. In some areas of volcanic origin, antelope bitterbrush may be co-dominant. The understory is often high in perennial bunchgrass and forb species diversity. Moist shrublands include shrubby cinquefoil, snowberry, birch, and willow.

General threats to grasslands and shrublands include fire suppression, improper grazing, off-road vehicle use, noxious species invasion, conifer encroachment, off-trail recreation (for example, all-terrain vehicles, bicycles), disturbed hydrological functions by impounding waters and developing seeps and springs, and human development. Warming trends may also contribute to changes in the shrub communities as fire frequency intervals and fire intensities change. In the absence of natural fire and periodic prescribed burns, appropriate grazing management practices can be used to maintain this system. The spread of nonnative grass species has reduced native species diversity in all geographic areas on the Custer Gallatin National Forest.

All at-risk plant occurrences in this habitat guild are vulnerable to noxious weed invasion. Beartooth large-flowered goldenweed is also vulnerable to competition and shading from conifer encroachment.

Sparsely Vegetated Habitat Guild (talus, scree, rocky, exposed, badlands)

Muskroot (*Adoxa moschatellina* - four occurrences in the Absaroka Beartooth Geographic Area), denseleaf draba (*Draba densifolia* - two occurrences in the Absaroka Beartooth Geographic Area), whitestem goldenbush (*Ericameria discoidea var. discoidea* - one occurrence in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area), Dakota buckwheat (*Eriogonum visheri* - one occurrence in the Sioux Geographic Area), rockyscree false goldenaster (*Heterotheca fulcrata* - one occurrence in the Absaroka Beartooth Geographic Area), Nuttall desert-parsley (*Lomatium nuttallii* - four occurrences in the Ashland Geographic Area), dwarf purple monkeyflower (*Mimulus nanus* - four occurrences in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area), wooly twinpod (*Physaria didymocarpa var. lanata* - three occurrences in the Absaroka Beartooth Geographic Area), and Shoshonea (*Shoshonea pulvinata* - six occurrences in the Pryor Mountains Geographic Area and one in the Absaroka Beartooth Geographic Area) are at-risk plants found within this habitat guild.

Sparsely vegetated areas are often described as talus, rocky sites, disturbed sites, exposed sites, or badlands. This setting occupies the fringes of adjacent systems, particularly dry habitats. Tree and herbaceous cover is often low due to limited soil development and dry growing conditions, site disturbance, or rocky conditions. This habitat includes natural rock outcrops as well as scree (that is, talus) and covers a wide range of rock types, varying from acidic to highly calcareous. Bryophytes and lichens often occur in crevices and flourish on open rock surfaces where the competition from vascular plants is absent. Species composition can vary widely, depending on the moisture regime and adjacent communities contributing to the seed source.

Sparsely vegetated habitats are often fragile systems. Although recreation and road construction are threats to these habitats, disturbance is often limited due to inaccessibility in the montane areas. Threats to the sparsely vegetated habitats in the pine savanna areas include weed invasion, trampling from grazing, off-road vehicle use, off-trail recreation (that is, all-terrain vehicles and bicycles), oil, gas, and mineral exploration or extraction, and shifts in warming or drying patterns. Shifts in warming or drying trends may also contribute to a change in range and distribution of plant species.

Muskroot (*Adoxa moschatellina*) – montane and pine savanna: Occurrences are generally small in specialized microhabitat. Though they occur in habitats not generally impacted by human disturbance or invasive weeds, building and use of trails may potentially impact known occurrences.

Denseleaf draba (*Draba densifolia*) – montane: This species occurrence on the Custer Gallatin is on the eastern edge of its range. The Iron Mountain site may be vulnerable to mineral related activities on the national forest.

Whitestem goldenbush (*Ericameria discoidea var. discoidea*) – montane: The one occurrence is vulnerable to improper livestock grazing and weed invasion.

Dakota buckwheat (*Eriogonum visheri*) – pine savanna: This species is a regional endemic. This population grows on sparsely vegetated alluvial outwash in badlands topography and does not appear to be threatened by weeds, livestock grazing, or other activities at this time. This location is potentially vulnerable to livestock trailing.

Rockyscree false goldenaster (*Heterotheca fulcrata*) – montane: This location may be vulnerable to recreational impacts near the developed Nye Picnic Area.

Nuttall desert-parsley (*Lomatium nuttallii*) – pine savanna: This occurrence is disjunct from other main occurrences to the south. This species of is of cultural interest; locally collected by Tribal members in very limited amounts and infrequently. This location is vulnerable to weed invasion.

Dwarf purple monkeyflower (*Mimulus nanus*) – montane: Four occurrences of dwarf purple monkeyflower are documented on the Hebgen Lake District. Habitat is vulnerable to weed invasion, potential recreation use, and bison management activities.

Wooly twinpod (*Physaria didymocarpa var. lanata*) – montane and pine savanna: The Custer Gallatin occurrences are disjunct from Bighorn County, Montana populations. These occurrences are vulnerable to weed invasion.

Shoshonea (*Shoshonea pulvinata*) – montane: This species is a regional endemic to the foothills (Absaroka and Owl Creek Mountains of northwest Wyoming and adjacent Montana) flanking the Bighorn Basin with a global distribution limited to 12 occurrences. Six of these 12 occurrences are located on

Custer Gallatin. Occurrences are composed of mats that are comprised of hundreds or even thousands of individual plants. The total number of plants is estimated to be 12,000 in Montana (Lyman 2005). This species is restricted to relatively barren, calcareous soils, but locally abundant on these sites. The occurrences are vulnerable to regional stochastic (random) events. Some occurrences may be vulnerable to trampling by wild horses.

Riparian and Wetlands Habitat Guild

Small yellow lady's-slipper (*Cypripedium parviflorum* – one occurrence in the Sioux Geographic Area and three historical occurrences in the Absaroka Beartooth Geographic Area), English sundew (*Drosera anglica* – one occurrence in the Absaroka Beartooth Geographic Area), beaked spikerush (*Eleocharis rostellata* – two occurrences in the Absaroka Beartooth Geographic Area), hiker's gentian (*Gentianopsis simplex* – 12 occurrences in the Absaroka Beartooth and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas), meesia moss (*Meesia triquetra* – one occurrence in the Absaroka Beartooth Geographic Area), and northwestern thelypody (*Thelypodium paniculatum* – one occurrence in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area) are at-risk plants found within this habitat guild.

Riparian systems occur along creeks and rivers and occupy floodplains, and stream banks. This system is dependent on a hydrologic regime that has annual to episodic flooding. It is often comprised of a mosaic of communities dominated by trees but also includes a diverse shrub and herbaceous component. Cottonwoods and other dominant trees such as Engelmann spruce indicate riparian, and on drier sites, Douglas-fir, and Rocky mountain juniper may be present. Dominant shrubs may include several species of willow, mountain alder, river birch, dogwood, hawthorn, and on drier sites or the dry fringe, chokecherry, rose, silver buffaloberry, Rocky Mountain maple, and snowberry. Proportionately montane riparian, wetlands and fens make up 3 percent or less of the Custer Gallatin in each landscape area and prairie riparian types are present on less than 1 percent.

General threats to riparian or wetland habitats include invasive species, drought, alteration of the original hydrology or hydric soils (that is, diversion, draining, development, road construction, and improper grazing), and warming trends. Management activities that have the potential to disturb soils and vegetation within riparian areas or adjacent to wetlands include road construction, reconstruction, and maintenance; livestock use; disturbances/exclusions that change vegetation conditions in riparian areas and vegetation adjacent to wetlands, invasive plant treatments, recreation use, trails, visitor trampling and camping in riparian areas. Threats to aquatic plant species can come from changes in hydrology and from aquatic plant invaders that can form dense carpets that block light, warmth and oxygen from the water. Established riparian and wetland protection measures are typically in place during Forest Service activity management such as use of best management practices and use of streamside management zones or riparian management zones.

Small yellow lady's-slipper (*Cypripedium parviflorum*) – montane and pine savanna: There is local conservation concern due to low population numbers in restricted habitat adjacent to a campground on the Custer Gallatin. Because this species often occupies small areas, one small, spatially isolated disturbance event could possibly destroy all reproducing plants.

English sundew (*Drosera anglica*) – montane: The Custer Gallatin occurrences are somewhat disjunct from others in northwest Montana. There is local conservation concern due to low population numbers in restricted fen habitat on the Custer Gallatin. Because this species often occupies small areas, one small, spatially isolated disturbance event could possibly destroy all reproducing plants. Local conservation concern due to low population numbers in restricted habitat on the national forest.

Beaked spikerush (*Eleocharis rostellata*) – montane: There is local conservation concern due to low population numbers in restricted habitat on the Custer Gallatin. Because this species often occupies small areas, one small, spatially isolated disturbance event could possibly destroy all reproducing plants.

Hiker's gentian (*Gentianopsis simplex*) – montane: There is local conservation concern due to low population numbers in restricted fen habitat on the Custer Gallatin. Because this species often occupies small areas, one small, spatially isolated disturbance event could possibly destroy all reproducing plants.

Meesia moss (*Meesia triquetra*) – montane: There is local conservation concern due to low population numbers in restricted fen habitat on the Custer Gallatin. Because this species often occupies small areas, one small, spatially isolated disturbance event could possibly destroy all reproducing plants.

Northwestern thelypody (*Thelypodium paniculatum*) – montane: This species' occurrence in forest is near trailhead activity making it potentially vulnerable to associated impacts.

3.5.3 Environmental Consequences

Effects Common to All Alternatives

Sensitive or at-risk plant species occupying habitats that are often disturbed, such as roadsides, suitable timberlands, and high recreation use areas, would be vulnerable to removal of suitable habitat as well as direct removal of individuals; although some sensitive or at-risk plant species can respond favorably to these disturbances. Various surface-disturbing activities, including mineral exploration and development and the associated roads, rights-of-way, and corridors, can directly affect habitats for sensitive or at-risk plant species. Recreational use, collection of plants, fire, as well as improper livestock or wild horse grazing could remove or trample vegetation and disturb soil, resulting in adverse impacts to sensitive or at-risk plant species.

Surface-disturbing activities also can indirectly affect sensitive or at-risk plant species by contributing to soil erosion and transporting invasive species into these habitats. The spread of invasive species could adversely affect sensitive or at-risk plants due to the limited occurrence size and distribution of these rare plants. Surface disturbance also can result in habitat fragmentation, which can isolate populations of sensitive or at-risk plant species. Populations of sensitive or at-risk plant species typically have a patchy distribution across the landscape; eliminating one or more populations can prevent gene flow among populations if residual populations are too far apart for sufficient cross-pollination. Habitat fragmentation would be a long-term impact to sensitive or at-risk plant species. Utilizing plan components and mitigating project impacts to minimize surface disturbing and disruptive activities minimizes adverse impacts from surface disturbance across all alternatives.

Habitats that are less subjected to land management activities, such as inaccessible areas, rugged terrain, rocky habitats, and riparian and wetlands, are more likely to be intact. There are fewer threats to species in these habitats and the anticipated adverse impacts from surface-disturbing activities are minimal. The main threats to these areas include invasive species and climate change. In the past, roads were built along streams and through wetlands. There are protections for riparian and wetlands in all alternatives, yet some roads are still on the landscape in those areas and may still be affecting those habitats.

Owing to their limited distribution and typically smaller population sizes, risks to the long-term persistence of species adapted to restricted habitats or specific microclimates can be greater than for more common native species that occur in a wider range of habitats, especially if the restricted habitats are altered. Threats to these restricted habitats include direct disturbance (from logging equipment, road building, road maintenance, grazing, and fire suppression activities), habitat alteration (such as canopy removal, edge effects from roads, herbicide, and fire exclusion), invasive species, and climate change.

Climate controls many ecosystem processes including regeneration, vegetation productivity and growth, and disturbance all of which could affect at-risk species on the Custer Gallatin National Forest. While there is some uncertainty regarding the scale, rate, and direction of future climatic conditions in Montana and South Dakota, the majority of published science suggests that warming trends may strongly influence the frequency, intensity, and size of disturbances (such as fire and extensive insect outbreaks) in coming decades on areas of the Custer Gallatin National Forest. Changes in disturbance prompted by climate change are likely as important as incremental changes in temperature and precipitation for affecting ecosystem productivity and species composition. Recent research indicates that these risks may be particularly acute for forests of the northern Rocky Mountains. Conservative future climate scenario models predict that the effects of warming trends result in a lengthened growing season, decreased number of days with snow on the ground, earlier peak snow occurrence, and increased water stress for all sites in the study, which represent temperature and precipitation spectrum in the forests of the Rocky Mountain Region (Boisvenue and Running 2010). Mountain ecosystems can shift upslope, reducing habitat for many subalpine and alpine tundra species. Mountain tree line is predicted to rise by roughly 350 feet for every degree Fahrenheit of warming (U.S. Environmental Protection Agency 1997).

All habitat guilds for regional forester sensitive or at-risk species are expected to be impacted by warming trends. Riparian, wetland, grassland, and shrubland habitat guilds may experience an increase in the rate of desiccation due to increased and prolonged summer temperatures and drought conditions which could result in longer fire seasons and more fire on the landscape. However, the opposite could be true and all guilds could see an increase in precipitation as projections of precipitation are highly variable and uncertain (Halofsky et al. 2018a). Habitat in the alpine habitat guild for sensitive or at-risk plant species may decrease as a result of climate change and an upward shift of lower alpine habitats over time. Increased fire severity or frequency may also affect all habitat guilds either favorably or detrimentally depending upon the species' requirements.

Increases in the severity of disturbances, combined with projected warming trends, may limit habitat for at-risk species over time. Rare and uncommon species, disjunct populations, and species at the edge of their known range are expected to experience a number of barriers when adjusting to warming trends because of the combination of a small number of occurrences, narrow elevation ranges, and requirements of specific soil types. Some sensitive or at-risk species with potential habitat are known to occur on restricted or limited areas within the Custer Gallatin National Forest. Plants confined to outcrops of special soils (for example, Shoshonea) are generally expected to have a far lower chance of successful migration to new suitable sites and thus far greater risks of decline in the face of climate change, than plants that are soil generalists (Harrison et al. 2009). Because of the uncertainty in scale, direction, and rate of climate change, management of sensitive or at-risk plant species on the Custer Gallatin National Forest focuses on maintaining persistent populations throughout the species known range on the national forest.

In the face of warming trends, conservation of plant diversity will likely involve a number of approaches. The geographic ranges and habitat affiliations of sensitive or at-risk plant species will be important considerations in developing conservation strategies. Monitoring of priority species and habitats, coupled with adaptive management, will form the basis for management responses. Ongoing and potential approaches include: control of invasive species to promote vegetation resilience, especially in high-priority habitats; implementation of mitigation measures for land management projects occurring in sensitive or at-risk species occurrences; ecological restoration (that is, for whitebark pine); conservation of at-risk plant species habitats; off-site seed conservation (especially for globally rare species with narrow geographic ranges or habitat affinities); and continued establishment of less developed areas such as research natural areas and botanical special areas.

The Custer Gallatin National Forest is also an active participant in the Greater Yellowstone Coordinating Committee's (GYCC) subcommittee. The mission of the Whitebark Pine Subcommittee is to help ensure the long-term persistence and function of whitebark pine in the Greater Yellowstone Area. In the face of an acute threat to a critical long-lived species, the Greater Yellowstone Coordinating Committee's Whitebark Pine Subcommittee is actively implementing the Whitebark Pine Strategy for the Greater Yellowstone Area (2011) with its associated Adaptive Action Plan – Whitebark Pine in the Greater Yellowstone Area (2015). Ongoing actions include extensive protection and restoration efforts, such as cone collection and planting across the Greater Yellowstone Area, and the establishment of a seed orchard and clone bank on the Custer Gallatin National Forest. In addition, the national forest is an active participant in the Northern Region's tree improvement program for whitebark pine. This includes collecting cones and other materials from seed trees with some resistance traits to blister rust, as well as hosting a seed orchard and test plantation. Contributions to this breeding program are designed to yield rust-resistant seedlings to be used in restoration planting projects. Known areas of whitebark pine are also included in wildfire response decision making tools, and considered in fire management decisions.

Current Plans

Management Direction under the Current Plans

The 1986 Custer and Gallatin Forest Plans provide management guidance to natural resource managers within the framework of congressional intent (36 CFR 217). The Custer Plan provides general management direction (page 3) that indicates "the goal for the management of threatened and endangered plant and animal species is to provide habitat that contributes to the recovery of the species." Within the framework of the 1986 Custer Plan, direction is given to manage for retention of habitat of unique plant species, which include sensitive species (Custer Forest Plan, page 20 and appendix VII). The Gallatin Forest Plan (as amended 2015) includes a forestwide standard that "habitat for regionally designated sensitive species on the Gallatin National Forest will be maintained in a suitable condition to support these species" (pages 11–19). The current plans do not contain specific standards or guidelines related to maintaining whitebark pine.

The 1986 Custer Plan (page 17) indicates that no federally listed threatened or endangered plant species occur on the national forest at that time. Since that time, there continues to be no plants designated as threatened or endangered plant species that occur within the Custer Gallatin National Forest. The combination of Forest Service manual policy for regional forester's sensitive plant species and the existing two plans provide protections that would ensure that sensitive species persist on the national forest. These plans have less of a focus on native vegetation improvements than the revised plan components.

Effects of the Current Plans

The current plans consider the regional forester's sensitive plant species. Long-term persistence is expected for all regional forester's sensitive species on the Custer Gallatin with plan components from both forest plans. Habitat quality has the potential to improve; however, there are fewer plan components promoting habitat restoration compared to the revised plan alternatives. The current plans' components and policies are expected to maintain habitat quality for sensitive plant species in all habitat guilds. Threats would remain similar to current threats for sensitive plants.

Sensitive species' habitat is vulnerable to threats from ground disturbance and weed spread. Available motorized routes were used as an indicator for alternative comparison as they are often cited as a major weed spread pathway. The miles of available motorized routes do not change under the current plans.

Areas considered to have low risks for ground disturbance impacts that could impact sensitive plant species (designated wilderness areas, wilderness study area, recommended wilderness areas, inventoried roadless areas, backcountry areas (low development areas), designated wild and scenic river, and research natural areas) were used as another indicator for alternative comparison. This footprint of reduced threats from ground disturbance and weed spread pathway is comprised of approximately 2,021,800 acres or about two thirds of the Custer Gallatin under the current plans. Ninety-five percent of Whitebark pine occurs within this footprint. Of the overall 145 regional forester's sensitive plant occurrences, 73 occurrences containing 12 sensitive plant species occur in the above reduced threats footprint. They include musk-root (*Adoxa maschatellina*), Barr's milkvetch (*Astragalus barrii*), large-leaved balsamroot (*Balsamorhiza macrophylla*), small yellow lady slipper (*Cypripedium parviflorum* - historical record), English sundew (*Drosera anglica*), beaked spikerush (*Eliocharis rostellata*), hiker's gentian (*Gentianopsis simplex*), meesia moss (*Meesia triquetra*), mealy primrose (*Primula incana* - historical record), Beartooth large-leaved goldenweed (*Pyrrocoma carthamoides var. subsquarrosa*), Barratt's willow (*Salix barrattiana*), and shoshonea (*Shoshonea pulvinata*). The remaining 72 sensitive plant occurrences are outside of the above reduced threats footprint.

There is no plan direction specific to whitebark pine in the current plans for the Custer National Forest or Gallatin National Forest. As a proposed species, whitebark pine is protected as a regional forester's sensitive species in the Northern Region. It is managed within project areas to maintain or increase populations and restoration treatments are typically included in project areas that overlap with whitebark following the whitebark pine restoration strategy (Keane et al. 2012, Keane et al. 2017). Restoration efforts are typically project-related and occur as specialists' time, project timelines and budgets allow. Recently, the Custer Gallatin National Forest averages about 50 acres of whitebark planting a year and treats around 300 acres with verbenone each year.

Custer Gallatin National Forest Regional forester's sensitive plant species that will not carry forward as a species of conservation concern include smallflower columbine (*Aquilegia brevistyla),* upward-lobed moonwort *(Botrychium ascendens),* large-leaved balsamroot *(Balsamorhiza macrophylla),* Barr's milkvetch *(Astragalus barrii),* mealy primrose *(Primula incana),* mountain bluebells *(Mertensia ciliata),* and prairie gentian *(Gentian affinis*), western moonwort *(Botrychium hesperium), stream orchid (Epipactis gigantea), slender cottongrass (Eriophorum gracile), lesser rattlesnake plantain (Goodyera repens), largeflower goldenweed (Haplopappus carthamoides var. subsquarrosus), Hall's rush (Juncus hallii), Mrs. Austin's knotweed (Polygonum douglasii spp. austiniae), alpine meadow-rue (Thalictrum alpinum), Veratrum californicum).* Of these, there are three occurrences of Barr's milkvetch and 16 occurrences of large-leaved balsamroot that fall within the above reduced threats footprint. The regional forester's sensitive species that are not included as at-risk species have been determined to lack threats to persistence on the Custer Gallatin because plan components provide ecological conditions for them, or they are not known to occur on the national forest (see appendix C).

Due to reduced ground disturbance and weed spread pathway potential, the reduced threats footprint area includes quality habitat in all habitat guilds. More quality habitat for these species is present under the recommended wilderness areas and backcountry areas under the revised plan alternatives, in that order. Habitat quality and threats remain consistent with current plans; there are fewer additional protection opportunities (for example, permissible restoration activity, and limited access to motorized vehicles) for at-risk plant occurrences.

Species and associated habitat that do not occur in lands suitable for timber production may still occur within forest projects, including vegetation projects, and subject to potential direct and indirect effects. The sensitive plant species would be protected by current Forest Service manual policy and plan components during vegetation project work. Plant species of conservation concern not included on the current regional forester's sensitive species (2011c) list would not be protected under this alternative.

Revised Plan Alternatives

Management Direction under the Revised Plan Alternatives

Plan components that are relevant to at-risk plants are the same for each revised plan alternative. A complete list of all plan components relevant to at-risk plants may be found in appendix C.

Plan components for all revised plan alternatives state that habitat conditions and ecological processes support the recovery and persistence of at-risk plant species; and that vegetation resilience (such as vegetation composition, structure, and pattern) maintain or restore conditions for the long-term persistence of at-risk plant species.

Goals include collaborating with Federal and State agencies, Tribes, and other partners regarding applicable conservation plans in seeking progress towards conservation of at-risk plant species; working with other agencies and landowners to expand inventories, identify potential habitat for at-risk species, and promote protection and restoration of associated habitats; and cooperating with the Greater Yellowstone Coordinating Committee-Whitebark Pine Subcommittee on whitebark pine conservation strategies and adaptive management of habitat.

See appendix C for a complete list of specific plan components relevant to at-risk plants. In summary, plan components include:

- direction that management activities that have potential to adversely affect the long-term persistence of at-risk plant populations will be avoided or mitigated (FW-STD-PRISK-01);
- decisions authorizing the use of chemicals are to outline protection measures for treatment and measures to minimize injury to at-risk species (FW-STD-INV-02);
- invasive plant treatments in or near at-risk-plant populations are to use methods that are not detrimental to the long-term persistence of the species (FW-STD-INV-01);
- underground mine closures are to be designed to address needs of at-risk species (FW-STD-EMIN-03);

- new or revised allotment management plans are to design grazing practices (such as stocking levels, duration, timing), and allotment infrastructure to meet or move towards desired ecological conditions (FW-STD-GRAZ-01);
- staging areas for material stockpiles and equipment within Beartooth Highway 212 250-foot centerline easement for maintenance are only to be allowed with mitigation for at-risk plant species (AB-STD-RNA-02);
- wildland fire control lines, slash piles and retardant are not be placed within known populations of at-risk plant species with the exception of where they may be allowed for purposes of restoration or being advantageous to the at-risk plant species, or when needed to protect human life or private property or to manage infrastructure (FW-GDL-PRISK-01);
- when conducting management activities in or near whitebark pine trees or stands identified for collection of scion, pollen, or seed; areas identified as important for cone production; and whitebark pine plantations, project-level design criteria, or wildland fire management strategies are to protect them from potential loss to support the recovery or long-term persistence of this species (FW-GDL-PRISK-02);
- salt and supplement placement in grazing allotments are not to be within 0.25 mile of at-risk plant species that are susceptible to livestock impacts (FW-GDL-GRZ-04);
- new allotment infrastructure is to be located to minimize livestock impacts on at-risk plant species (FW-GDL-GRZ-05).
- the Custer Gallatin works with other agencies and landowners to expand inventories, identify potential habitat for at-risk species, and promote protection and restoration of associated habitats (FW-GO-VEGNF-01) and works with permittees to remove or relocate existing allotment infrastructure that attract livestock use in or near at-risk plant occurrences (FW-GO-GRAZ-01).

Management approaches (in appendix A of the plan), describe possible strategies for achieving desired conditions and objectives for at-risk plants. These strategies include:

- evaluating areas proposed for vegetation management activities for the presence of occupied or suitable habitat for at-risk species, focusing botanical surveys on increasing known information about other plant species (such as Montana and South Dakota state species of concern and newly discovered species), and monitoring known occurrences of at-risk species;
- if at-risk plants occur in or near infestations, a weed control plan consistent with protection measures outlined in current weed environmental impact statement decisions is to be developed to help protect the at-risk plant population;
- training is to be provided to weed crews to identify sensitive plants so that new sites can be identified and protected; weed crews or contractors are to be provided with maps of all known at-risk plant populations so that known sites can be identified and protected;
- when considering chemically treating invasive plants within at-risk plant populations, specific chemicals that monocot at-risk plant species tolerate are described;
- and the highest priority for allocation of funding for wells and pipelines are for those that provide offsite water developments to reduce impacts to at-risk plant populations and other identified resources that are susceptible to grazing impacts.

Effects the Revised Plan Alternatives

At-risk plant species' habitat is vulnerable to threats from ground disturbance and competition from weed infestations. Motorized routes were used as an indicator for alternative comparison as they are often cited as a major weed spread pathway (Taylor et al. 2012). There are no changes to open motorized roads in any alternative. Alternatives vary in miles of summer trail suitable for motorized transport. Under the current plans and alternatives B, E, and F, there would be no change to suitability of motorized trails. Under alternative C, about four miles of trails would no longer be suitable for motorized transport. Under alternative D, about 172 miles of trails would no longer be suitable for motorized transport.

Alternative D would be the most favorable to limit the spread of invasive species from motorized transport because it would have the fewest miles of trails suitable for summer motorized transport. The current plans and alternatives B, E, and F would have a higher potential to increase the spread of invasive weed species through motorized transport since these alternatives would have the most miles of trails suitable for summer motorized transport. Alternative C would have fewer miles of trails suitable for summer motorized transport and therefore be more favorable to limit the spread of invasive species from these routes than the current plans and alternatives B, E, and F.

Although alternative D would be the most favorable for slowing the spread of invasive species by motorized transport, the alternative could also create issues for existing weed infestations to go undetected and untreated in new recommended wilderness areas and backcountry areas. Alternative D would change the most miles of trails suitable for motorized transport and possible weed pathways of any alternative, but could also increase treatment difficulty or detection of existing weed populations in new recommended wilderness and backcountry areas.

Areas considered to have low risk for ground disturbance impacts that could impact at-risk plants (designated wilderness areas, wilderness study area, recommended wilderness areas, inventoried roadless areas, backcountry areas (low development areas), designated wild and scenic river and research natural areas) were used as another indicator for alternative comparison.

Table 31 displays the relationship of at-risk plant species with areas considered to have low risk for ground disturbance by alternative.

Table 31. Relationship of at-risk plant species to areas considered to have low risk for ground disturbance by revised plan alternative

Attribute	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Acres considered to have low risk for ground disturbance (designated wilderness areas, wilderness study areas, recommended wilderness areas, inventoried roadless areas, backcountry areas, designated wild and scenic river and research natural areas)	1,955,743	1,987,736	2,001,848	1,912,143	1,975,819
Percentage of national forest	64%	65%	66%	63%	65%
Number of at-risk plant species within low risk areas[1]	15	15	18	15	17
Number of at-risk plant species outside low risk areas[1]	19	19	18	19	19

Attribute	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Number of at-risk plant occurrences within low risk areas[2]	56	56	67	55	61
Number of at-risk plant occurrences outside of low risk areas[2]	116	116	105	117	111
Percentage of whitebark pine within low-risk areas.	95%	95%	95%	95%	95%

1. Areas at low risk for ground disturbance include designated wilderness areas, wilderness study area, recommended wilderness areas, inventoried roadless areas, backcountry areas, designated wild and scenic river, and research natural areas. Species that occurred within these areas were included here even if they were also known to occur outside of low-risk areas. Species occurrence data based on Montana Natural Heritage data and Custer Gallatin floristic surveys.
2. Does not include occurrences of whitebark pine.

Some musk-root, meesia moss, shoshonea, dense-leaf draba, English sundew, hiker's gentian, annual Indian paintbrush, Nuttall's desert-parsley, and beaked spikerush occurrences are within areas considered as low risk for ground disturbance under alternatives B, C, E, and F. Some musk-root, meesia moss, shoshonea, dense-leaf draba, English sundew, hiker's gentian, annual Indian paintbrush, Nuttall's desert-parsley, and spiny hopsage occurrences are within areas considered as low risk for ground disturbance under alternative D.

Due to reduced ground disturbance and weed spread pathway potential, these areas considered to have low risk of ground disturbance generally support quality habitat in all habitat guilds. More quality habitat for these species are present under Alternatives C, D, and F and less quality habitat under alternatives B and E due to differences in the amount of recommended wilderness areas and backcountry areas by alternative.

As a result of the revised plan alternative components summarized above, at-risk plant populations in all habitat guilds are expected to be maintained and provide at-risk plant species persistence with opportunities to restore sites if conditions warrant. Regional forester's sensitive plant species that are not currently on the species of conservation concern list would no longer be specifically protected once the revised plan is implemented. However, coarse-filter vegetation related plan components would provide for their habitat needs. Even without species-specific direction for regional forester's sensitive plant species, the plan will still provide for the diversity of all native species, including these, as required by the 2012 Planning Rule. The regional forester's sensitive plant species occur in habitats with either infrequent project activity (for example, alpine habitat guild), in other habitats protected by plan components or are not known within the plan area.

Some plan components specifically address needs of the at-risk species, while others provide protection to the site and habitats associated with at-risk species (such as riparian management zones). Plan components that ensure the conservation of at-risk plants include:

- desired conditions that support maintaining the ecological processes and vegetation conditions that contribute to the conservation of these species (FW-DC-PRISK-01, 02; FW-DC-VEGNF-01-04) standards and guidelines that provide mitigation and protection measures to maintain species and habitats during planning and implementation of activities that may impact them (FW-STD-PRISK-01; FW-GDL-PRISK-01, 02);

- standards and guidelines that provide management direction within riparian management zones that will also provide protection to at-risk plants associated with these habitats (FW-STD-RMZ-01-05; FW-GDL-RMZ-01-08);
- standards and guidelines that protect soils from undesirable disturbance during management activities (FW-STD-SOIL-01; FW-GDL-SOIL-01-08).

Additional plan components that are likely to have an effect on at-risk plants species or associated habitat guilds are summarized in the following sections.

Cold Forest Habitat Guild

The current forest plans do not contain standards or guidelines related to maintaining whitebark pine. In contrast, the revised plan includes several plan components that specifically address conservation and management of whitebark pine. Together, these plan components will maintain the ecological conditions for the long-term persistence of this species:

1. FW-DC-PRISK-02: This Desired Condition clearly states the long-term goal for whitebark pine management—that is, whitebark pine promotes community diversity and community stability in high mountain ecosystems. Ecological conditions and processes lead to in an increase in cone-bearing trees, particularly in areas projected to be suitable under future climates, and a decrease in susceptibility to succession to more shade tolerant conifers, mountain pine beetle, wildland fire and blister rust.
2. FW-GO-PRISK-01: This Goal expresses the desire and intention for the Custer Gallatin to work closely with the with Greater Yellowstone Coordinating Committee’s Whitebark Pine Subcommittee. Coordinating on tactics and strategies within an adaptive management framework that has been developed by the subcommittee is an essential component of protecting and restoring whitebark pine on the Custer Gallatin and the Greater Yellowstone Ecosystems (Greater Yellowstone Whitebark Pine Subcommittee 2015).
3. FW-OBJ-PRISK-02: In order to help ensure progress towards the desired condition for whitebark pine, this plan component sets an Objective to treat a minimum of 500 to 1,200 acres per decade (depending on alternative) for the purpose of sustaining or restoring whitebark pine.
4. FW-GDL-PRISK-02: This Guideline requires that management actions that could potentially affect whitebark pine—specifically individuals or stands identified for collection of scion, pollen, or seed; areas identified as important for cone production or blister rust resistance; and whitebark pine plantations—must contain project-level design criteria or wildland fire management strategies to protect whitebark pine from potential loss to support the recovery or long-term persistence of this species.
5. FW-DC-VEGF-01 and 02: These desired conditions offer quantitative direction for the targeted amount of whitebark pine-dominated forest and the amount of area containing at least one tree per acre of whitebark pine (species presence). Whitebark is currently below the desired condition for dominance and just within the desired condition for species presence. These desired conditions will guide management actions to increase the amount of whitebark across the forest.

6. FW-OBJ-VEGF-01: This management objective calls for treating 5,000 to 8,000 acres a year (depending on alternative), across all forest types, to move conditions towards desired conditions. Notably, this objective also stipulates that 10 percent of the acres treated should be for the purpose of benefiting ecosystem conditions, including whitebark pine.
7. MON-PRISK-02: This element of the monitoring plan will help to monitor progress towards whitebark pine restoration objectives. This is a critical piece of an adaptive management strategy aimed at restoring whitebark pine.

Whitebark pine is not a targeted commercial timber species on the Custer Gallatin National Forest. In general, there is a high degree of spatial separation between timber harvest locations and where whitebark pine exists, as whitebark pine tends to occur outside suitable timber ground. For example, less than 1 percent of the suitable base is currently dominated by whitebark pine. Accordingly, whitebark pine tends to be only an incidental species where it does occur in association with a timber sale (for example not at levels where impacts could adversely affect the long-term persistence of the species) (Weldon 2011). Indeed, a plan component that made areas occupied by whitebark pine unsuitable for timber harvest would actually be counterproductive to the conservation and restoration of this species as removing competing vegetation the need to create conditions that encourage whitebark pine regeneration, conserve seed sources and promote rust resistance (Keane et al. 2017). Specific conservation and restoration treatments would typically be designed to create openings in sites that are advantageous for reestablishing whitebark pine.

Conservation and restoration of whitebark pine is not dependent upon mitigating ongoing actions, but rather a shift of management focus that proactively and strategically targets whitebark pine habitats. Indeed, active restoration appears to be the best way to maintain and restore whitebark pine ecosystems. Restoration must include the implementation of strategies that hedge the effects of climate warming including: (1) promote resistance to blister rust, (2) conserve genetic diversity, (3) save seed sources, and (4) employ restoration treatments (Keane et al. 2017). However, the high uncertainty in most current climate and ecosystem models limits our ability to design restoration actions that are effective in the face of climate change.

As outlined above, the suite of plan components targeting restoration and protection of whitebark pine demonstrates clear intent and desire to restore the whitebark pine ecosystem along with mitigation and protection measures to maintain the species and its habitat during planning and implementation of activities that may impact them. Specific tactics and management actions to achieve restoration strategies outlined above and management objectives in the plan should be based on best available scientific information and determined at a project-level basis. See management approaches (appendix A of the plan) for examples of possible management actions that could contribute to the restoration of whitebark pine. All projects would be evaluated to assess their potential impacts to the species, especially in cases where there are healthy cone-producing trees present. For whitebark physiology, ecology, genetics, distribution, mortality, and regeneration on the Custer Gallatin, the Whitebark Pine Strategy for the Greater Yellowstone Area, Adaptive Action Plan prepared by the Greater Yellowstone Coordinating Committee (2011, 2015) respectively, the Range-Wide Strategy for Restoring Whitebark pine (Keane et al. 2012), Restoring Whitebark Pine Ecosystems in the face of climate change (Keane et al. 2017) and any new best available scientific information for possible whitebark pine restoration strategies and activities would be used.

Alpine Habitat Guild

One at-risk species occurs within riparian and wetland settings in the alpine habitat guild and known occurrences are within Line Creek Plateau Research Natural Area. Plan components for Line Creek Plateau Research Natural Area prohibits hitching, tethering, or picketing horses, or other livestock within 200 feet of a live stream or other free flowing water (AB-STD-RNA-01). Camping (including building a fire, other than fires confined to liquid fuel stoves) would not be allowed within 200 feet of any lakeshore or 100 feet of any live stream or other free flowing water (AB-STD-RNA-02). These plan components are anticipated to support long-term persistence of the at-risk species associated with this habitat guild. Research natural area direction also does not encourage recreational use, and the existing levels of recreation are not anticipated to adversely impact this species (U.S. Department of Agriculture 2000). This research natural area is, however, apparently popular for mountain biking, which will continue only on system trails under current research natural area management (AB-STD-RNA-03). However, policy directs that special closure orders could be used when needed to protect the research natural area features for which it was designated.

Other plan components, outlined in the riparian and wetland habitat guild section below, would also apply to the particular willow species habitat which are anticipated to support long-term persistence of the at-risk species associated with this habitat guild.

Broadleaf Woodlands Habitat Guild

Plan components minimize stem damage, soil compaction, or root damage from frequent human use, new buildings or other structures associated with developed sites or outfitter and guide camps (FW-GDL-VEGNF-05) and from not allowing construction of new permanent or permanently retaining temporary roads in aspen stands or woody draws (except as needed to cross the area or as needed for restoration purposes) (FW-GDL-VEGNF-07). These components are anticipated to support long-term persistence of the at-risk species associated with this habitat guild.

Plan components minimize browsing pressure or trampling and rubbing damage to vegetation when new allotment infrastructure is designed not to attract livestock into broadleaf woodlands (for example, new water developments should be located away from hardwoods and new fences should not funnel or congregate livestock into hardwoods) (FW-GDL-GRAZ-05). These components are anticipated to support long-term persistence of the at-risk species associated with this habitat guild.

Plan components that do now allow cutting of hardwood trees except for purposes of human safety or selective cuts for regeneration purpose (FW-GDL-VEGNF-08), are anticipated to support long-term persistence of the at-risk species associated with this habitat guild.

Plan component for new or revised allotment management plans (which are to design grazing practices such as stocking levels, duration, timing), and allotment infrastructure to move towards ecological desired conditions in order to maintain or improve resiliency of riparian and upland ecosystems, and associated flora and fauna (FW-STD-GRAZ-01) are anticipated to support long-term persistence of the at-risk species associated with this habitat guild.

Grasslands or Shrublands Habitat Guild

Plan components that restore or maintains this habitat through invasive species control activities and projects to control conifer encroachment (FW-STD-INV-02, FW-OBJ-INV-01, FW-OBJ-VEGNF-01), are anticipated to support long-term persistence of the at-risk species associated with this habitat guild.

Plan component for new or revised allotment management plans (which are to design grazing practices (such as stocking levels, duration, timing), and allotment infrastructure to meet or move toward applicable desired conditions in order to maintain or improve resiliency of riparian and upland ecosystems, and associated flora and fauna) are anticipated to support long-term persistence of the at-risk species associated with this habitat guild (FW-STD-GRAZ-01, FW-GDL-GRAZ-05, FW-GDL-GRAZ-04).

Sparsely Vegetated Habitat Guild

Plan components for new or revised allotment management plans (which are to design grazing practices such as stocking levels, duration, timing), and allotment infrastructure to meet or move toward applicable desired conditions in order to maintain or improve resiliency of riparian and upland ecosystems, and associated flora and fauna) are anticipated to support long-term persistence of the at-risk species associated with this habitat guild (FW-STD-GRAZ-01).

Riparian and Wetlands Habitat Guild

The standard for designation of buffers (riparian management zones) adjacent to streams and wetlands (and restrictions associated with those buffers) will protect at-risk plants associated with fen and wetland habitat (FW-STD-RMZ-01). Width of the buffer for mapped ponds, lakes, reservoirs, and wetlands is a minimum 200 feet for ponds and wetlands greater than one acre. For at-risk plant species in riparian and wetland habitat guild, plan components that limit activity in riparian management zones are anticipated to benefit these species by reducing direct impacts from trampling, mining, and recreational activities (FW-STD-RMZ-02-05, FW-GDL-RMZ-01-08). Meeting or moving toward proper functioning condition across all alternatives improves habitat for sensitive or at-risk plant species.

Plan components for new or revised allotment management plans (which are to design grazing practices (such as stocking levels, duration, timing), and allotment infrastructure to meet or move toward applicable desired conditions in order to maintain or improve resiliency of riparian and upland ecosystems, and associated flora and fauna) and other associated grazing plan components are anticipated to support long-term persistence of the at-risk species associated with this habitat guild (FW-STD-GRAZ-01, FW-GDL-GRAZ-05).

The management approaches outlined in appendix A of the revised plan include recommended actions to review additional information as it becomes available and gather data during field work for project-level reviews. If new pertinent information becomes available indicating a potential threat to long-term persistence on the Custer Gallatin, these species would be reconsidered, and the species of conservation concern list may be adjusted.

Plan components listed above are anticipated to support long-term persistence of the at-risk species associated with this habitat guild. The revised plan alternatives include objectives for restoration activities; however, the current plans and the revised plan alternatives result in similar outcomes for at-risk plants. Habitat quality is expected to improve under these alternatives at a faster rate for all at-risk plant species than the current plans. Threats remain similar between the current plans and the revised plan alternatives for at-risk plants.

Consequences to At-Risk Plant Species from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Timber Management

Timber harvest would occur under all alternatives, though the acres harvested vary. Timber harvest is most likely to occur on lands identified as suitable for timber production and it is projected that 3 to 4 percent of the forested areas would be available for timber management each decade. Harvest increases some threats to at-risk species, but also can create a mosaic pattern on a landscape and promote early successional stands with some treatments, such as regeneration harvest. Vegetation treatments can also increase forest resiliency by treating insect and disease and reducing fuel loads, improving forest health in the long term. Site disturbance and increased weeds without mitigation could negatively impact habitat. Timber management standards are designed to ensure that timber harvest would not have negative ecological impacts which would help protect at-risk plants. Other plan components that guide timber harvest activities, such as those discussed in sections below, would also help protect at-risk species as these plan components were specifically designed to maintain and enhance ecological integrity and biodiversity of ecosystems.

Under the current plans, sensitive plant species would receive site-specific protection following botanical reviews and surveys (Forest Service Manual 2670) and negative effects would be minimized. As discussed above, the plan components for at-risk species under the revised plan alternatives would ensure the at-risk plants will not be negatively affected by timber harvest activities.

All alternatives have varying amounts of land suitable for timber production, but the impact of timber plan components on at-risk species is consistent between the revised plan alternatives. All habitat guilds can be impacted by timber production, even if habitats guilds, such as aquatic, alpine or grassland, are not directly harvested for timber. Mechanical activities include vegetation management treatments, whether for restoration or to meet timber production objectives. Activities, such as logging, can have impacts to plants and plant habitat through canopy removal, soil disturbance and erosion, and stream sedimentation. In addition, mechanical activities for vegetation treatment may require road building. Roads increase access to sensitive habitats and can fragment habitat, thus, providing an avenue for invasive plant species. Reconstruction and maintenance of designated roads can directly or indirectly affect plant populations by introducing competitive weeds and altering availability of light, nutrients, and moisture. Sudden changes in seral stage, or an abundance of early seral stages, also reduce the available habitats for those plants that require mid-to-late seral stages. However, those species that prefer openings, early-seral stages, or some ground disturbance, could benefit from moderate levels of mechanical activities. The restoration of historical fire regimes and conditions within the natural range of variation (with a range of seral stages for different potential vegetation groups) may benefit some at-risk species in the long term.

As a result of the revised plan alternatives' plan components discussed above, at-risk species and their respective habitats would be considered during vegetation projects and grasslands, shrublands, wetland and riparian, sparsely vegetated habitat guilds are expected to be maintained and continue to provide persistence of at-risk plant species despite the potential for impacts in areas used for timber production. The revised plan alternatives are more explicit regarding resource protections, though similar guidelines are applied under the current plans.

Effects from Vegetation Management

All habitat guilds are impacted and supported by the revised plan alternative vegetation desired conditions. Broadly, the desired conditions for terrestrial vegetation on the Custer Gallatin National Forest are characterized by increases in large trees and large forest size classes; more open forest densities; vigorous non-forested plant communities; increasing early-seral shade intolerant species; and maintaining the full suite of native biodiversity of ecosystems on the landscape. More information is available in the terrestrial vegetation section. The desired conditions are consistent with the Forest Service's understanding of the natural range of variation and when met are most likely to be resilient in the future given expected drivers such as climate change, drought, vegetation succession, wildfire, insects and disease, and the demands of people. Desired conditions for vegetation support native species and habitats within their natural range of variation, including at-risk species.

Ground-disturbing activities and changes in site conditions that could impact at-risk species are likely to result from the terrestrial vegetation plan components. As discussed above, plan components are in place that would protect at-risk species from these activities (e.g., FW-STD-PRISK-01). Moreover, the restoration of historical fire regimes and restoration of conditions towards historical range of variation with a range of seral stages for different potential vegetation groups may benefit some at-risk species in the long term.

These revised plan alternative vegetation plan components are expected to maintain and continue supporting at-risk plant species on the Custer Gallatin National Forest. Habitat quality would improve for at-risk species in all habitat guilds under the plan components in the revised plan alternatives. In all action alternatives, FW-GO-PRISK-02 and 03 would encourage the Custer Gallatin to work with other agencies and landowners to expand inventories, identify potential habitat for at-risk species, and promote protection and restoration of associated habitats and species. Threats would remain similar for at-risk plants in regard to vegetation plan components.

Effects from Fire and Fuels Management

All alternatives use fire as a tool to accomplish management goals and objectives. The objectives for fuel reduction are usually complementary to the other desired vegetation conditions, including those beneficial to at-risk species, and especially as related to forest resiliency (e.g., activities associated with FW-OBJ-FIRE-01 and FW-OBJ-FIRE-02). Several factors are important to consider with regard to at-risk plants. The effect of fire on individual at-risk plant species depends on their life history characteristics, the life stage of the plants when the fire occurs, temperature and moisture conditions, and the fuel conditions present when the fire occurs. For example, spring burning may result in negative or positive effects to the survival, flowering and fruiting of plants depending on these factors, and would need to be evaluated in each situation. Considering at-risk species during the project planning process should ensure that the timing and placement of prescribed burns is used to maintain at-risk plant populations as much as possible by timing when phenologically appropriate and avoiding populations of species adverse to fire.

Another factor in many areas of the Custer Gallatin is the risk of uncharacteristic high severity wildfire as a result of high fuel loads which has resulted from various causes, such as fire suppression and the recent outbreak of bark beetles. Without some wildland fire and mechanical fuels treatment introduced to mitigate the threat of high severity fire, at-risk species populations are susceptible to being eliminated in areas on the landscape in all forested habitat guilds. Many species tolerate and in fact require frequent low severity fire to maintain populations on the landscape such as Beartooth large-flowered goldenweed.

Another consideration is that some at-risk species require regular fire to maintain early successional conditions. This includes species in the wetland and riparian, and grassland and shrubland habitat guilds, and could potentially incorporate additional habitat in the future depending on species specific requirements, which can change depending on new best available scientific information and adjustments to the plant species of conservation concern list. Riparian management zone plan components (FW-STD-RMZ-02, FW-GDL-RMZ-06) allow prescribed fire and other restoration activities as long as aquatic and riparian associated resources are maintained or enhanced which would include associated riparian and wetland dependent at-risk plant species.

In general, most plant species would benefit by the restoration of more historical fire regimes. FW-DC-FIRE-02 would guide management towards restored fire regimes. For those at-risk plants that thrive in open areas created by fires, using fire to help restore a more natural fire regime could benefit those species in the long term. There are also impacts to plants associated with wildfire suppression activities, such as fire line construction and other mechanical activities, reforestation following fire, and the increased potential for the spread of noxious weeds. Plan components address the need to protect at-risk plant species from suppression actions (FW-GDL-PRISK-01, FW-GDL-FIRE-03). Emphasis in the revised plan to allow natural fire to function in its ecological role (FW-DC-FIRE-01, FW-OBJ-FIRE-02) would likely benefit native plant species (as a whole) with few exceptions.

As a result of the revised plan alternative components that encourage natural fire regimes on the landscape (FW-DC-FIRE-01), habitat for multiple habitat guilds is expected to be maintained and re-established. This would contribute in the long term to the persistence of at-risk plant populations on the Custer Gallatin, though increased short-term risk would likely occur. Habitat quality would improve for all at-risk species habitat guilds that require frequent fire to maintain desired seral stage under the plan components in the revised plan alternatives by allowing natural fire to play a larger role on the Custer Gallatin. Threats currently exist from uncharacteristic large, high severity fire and from fire suppression tactics. The minimum impact strategy for fire suppression in some locations would reduce threats to at-risk plant species in those habitats (FW-GDL-FIRE-03). Threats from suppression in location where minimum impact strategies are not used and threats from catastrophic fire events would remain. However, some suppression activities within known populations of at-risk plant species could restore or be advantageous to these species if those actions prevent further detrimental impacts to known populations (FW-GDL-PRISK-01).

At-risk plants have various reactions to fire. As a result of the revised plan alternative components cited above, all habitat guilds are generally expected to be maintained and continue supporting at-risk plant species, as well as the species that are currently on the sensitive plant list, but that would not be specifically protected as a species of conservation concern once the revised plan is implemented. Analysis prior to implementation would mitigate populations and habitat that could be detrimentally impacted from vegetation treatments, and overall habitats benefit from fire occurring on the landscape like historical fire regime conditions.

Effects from Watershed, Soil, Riparian, and Aquatic Management

The threats to associated wetland and riparian at-risk plant species include hydrologic and nutrient alterations. Mechanical vegetation treatments, off-road vehicles, roads and trails, improper livestock grazing, and high severity wildfires are some of the actions that affect the hydrologic regimes or nutrient inputs. Subwatersheds provide the distribution, diversity, and complexity of landscape-scale features including natural disturbance regimes and the riparian and wetland habitat guild to which native species, populations, and communities are uniquely adapted within those ecosystems, such as at-risk plant species. The revised plan alternatives include desired conditions that would specifically support vulnerable plant habitat in the previously mentioned habitat guilds (e.g., FW-DC-PRISK-01, FW-DC-RMZ-01, FW-DC-RMZ-02). As discussed in the above section on riparian ecosystems, the revised plan components have additional protection measures and an increased emphasis on the restoration and maintenance of riparian and wetland resources when compared with the existing plans reflected in the current plans.

As a result of revised plan components listed above and in appendix C, wetland and riparian habitats are expected to be maintained and continue supporting ecological conditions for all at-risk plant species that occur in these habitats. The revised plan is more explicit on riparian and wetland ecosystems protections, connectivity in riparian habitats, and groundwater-dependent systems. In addition to following state guidelines and best management practices in the previous plans. Revised plan components are expected to contribute to ecological conditions for all at-risk species in riparian and wetland habitats by preserving required habitat characteristics for these species. Habitat quality would improve for all at-risk species in the riparian and wetland habitat guilds under the plan components in the revised plan alternatives as described above. Threats would be reduced for at-risk plants in these wetland and riparian habitats in the revised plan alternatives.

Effects from Wildlife Management

Wildlife plan components generally support functioning, resilient habitat conditions that would also benefit at-risk species (e.g., FW-DC-WL-03, FW-DC-WLSG-01, FW-DC-WLPD-01). Habitat connectivity would be improved under the revised plan alternatives by the prioritization of certain areas on the Custer Gallatin National Forest to maintain uninterrupted habitat corridors (FW-GDL-WL-01-05). These areas would limit activities and would limit disturbance in certain years. The focus on habitat connectivity would improve effectiveness of the areas to support wildlife and diverse natural ecosystems.

In all alternatives, several of the plan components of the lynx and grizzly bear direction would complement the at-risk plant plan components, by describing a desired condition to manage vegetation to approximate natural succession and disturbance processes, and provide a mosaic of habitat conditions through time (such as Objective VEG 01 in Northern Rockies Lynx Management Direction). FW-GDL-WLBG-01, which requires projects on big game winter range should retain coniferous forest cover, contains an exception for restoration that benefits at-risk species. These components would contribute to the maintenance of habitat for at-risk plant species.

Effects of Plan Land Allocations

Management direction for research natural areas and backcountry areas, retained for all alternatives, would meet the desired condition for at-risk or sensitive plant species (FW-DC-RNA-01, FW-DC-BCA-01). In research natural areas timber production, timber harvest, motor vehicle use, road construction, and mechanical fuel treatment, development are unsuitable uses, under all revised plan alternatives. In effect, research natural areas serve as reserves for at-risk plant species, as well as for many other natural resources. While it is possible that individuals of at-risk plant species inhabiting alpine environments in research natural areas may be affected by authorized activities, these impacts are expected to be minor, and not result in a loss of population persistence on the Custer Gallatin. New trail construction would have to comply with policy and plan components, directing that new trail construction avoid threatened, endangered, or at-risk plant locations (FW-STD-PRISK-01). At-risk plant species found within research natural areas on the Custer Gallatin include Barratt's Willow (Line Creek Plateau Research Natural Area) and *Shoshone pulvinata* (Lost Water Canyon Research Natural Area). For Line Creek Plateau, AB-STD-RNA-02 further requires that staging areas for material stockpiles and equipment within the 250-foot centerline easement for future highway maintenance projects on Highway 212 shall only be allowed with mitigation for at-risk plant species.

In recommended wilderness areas, no timber harvest could occur to contribute to whitebark pine restoration opportunities. However, other restoration activities for whitebark pine could occur, including prescribed burning and tree planting. As with inventoried roadless areas, prescribed fire opportunities may be limited somewhat due to a lack of access or opportunities to mechanically prepare treatment sites. As compared to the existing condition, the action alternatives have more acres of whitebark pine within recommended wilderness. Approximately 1,766 acres of whitebark pine occur within recommended wilderness in the no action alternative, while approximately 16,619 acres (6 percent of mapped whitebark pine) are within recommended wilderness with alternative F. Therefore, roughly 15,000 acres more acres of whitebark would be subject to the direction for recommended wilderness under the alternative F as compared to the existing condition, or no action alternative.

Although amounts of recommended wilderness vary, all revised plan alternatives would have the same level of ability to achieve desired vegetation conditions within recommended wilderness areas and backcountry areas with vegetation treatments. Restoration activities are suitable in recommended wilderness areas if the ecological and social characteristics that provide the basis for wilderness recommendation are maintained and protected (FW-SUIT-RWA-03). Anticipated vegetation treatment activities would largely be associated with the restoration of high elevation ecosystems, and whitebark pine forest communities. The most likely treatment would be prescribed burning (planned ignition), in some cases followed by limited planting of conifer seedlings. Objectives would include restoration of desired forest structure and compositions, and to restore desired landscape patterns.

Effects from Access and Recreation Management

Recreation impacts can include trampling, by hikers, pack animals, and off-road vehicle use. Road building and the development of campgrounds and other facilities used by recreationists can impact plants, as these developments make more areas accessible and concentrate use. Dispersed camping and recreation have similar impacts, which are more difficult to monitor. Parking areas, particularly undesignated areas, pose similar impacts to plants. In addition, there can be long-term impacts of bisecting a rare plant population with a road or similar feature and affecting the reproduction or plant dispersal. Other recreational impacts include off-road vehicle use, which can also disturb soil, affecting both habitat and potential habitat. Roads and trails for recreational use can contribute to the spread of noxious weeds and increase the accessibility of areas to livestock as well as native ungulates, which in turn can increase the impacts of trampling, herbivory, and congregation.

The lack of access in many areas can remove opportunities for cost-efficient restoration such as weed control and lead to habitat degradation overtime. Infrastructure can also provide weed spread pathways and cause unintentional erosion, which can negatively impact at-risk species.

Riparian and wetland guilds are protected from recreational related damages by riparian management zone plan components, reducing risk for species that occur in with these habitats. Designated wilderness plan components in all alternatives that limit group size camping and stock use in certain areas may help reduce competition from potential for invasive weed infestation (FW-STD-DWA-01, 02, 03, 07, FW-SUIT-DWA-05). Plan components direct that recreation facilities, including trails and dispersed sites, have minimal impact on at-risk species (FW-DC-REC-05).

Recreation-associated plan components are expected to contribute to the long-term persistence of at-risk populations in the planning areas by including additional ecosystem protections associated with recreation opportunities (FW-DC-REC-05). Habitat quality would remain similar between the action and no-action alternatives for at-risk species in all habitat guilds under the recreation plan components. Threats would be reduced for at-risk plants by the action alternatives plan components for recreation.

Effects from Minerals Management

Development of energy and mineral resources has the potential to adversely impact at-risk species through all phases of development. Impacts include mortality to individual at-risk plants, or entire populations, as well as habitat loss and fragmentation. Under plan components, at-risk species habitat quality would remain similar between the action and the current plans. Threats would be reduced for at-risk plants by the revised plan alternatives plan components (FW-STD-EMIN-03). Site specific surveys and/or assessments at the project level stage would further reduce these threats.

Effects from Permitted Livestock Grazing

There are nearly 666,230 acres of primary rangelands with permitted livestock in all alternatives. Eight at-risk plant species (oval-leaf milkweed, narrow-leaved milkweed, Nuttall’s desert parsley, Visher’s buckwheat, Beartooth large-flowered goldenweed, heavy sedge, Oregon checker-mallow, and Frenchman’s bluff moonwort) and associated 87 at-risk plant occurrences could have threats from potential grazing related activity. All habitat guilds except alpine have the potential to be impacted by livestock or wild horse grazing, which when grazed improperly can cause hydrologic conditions to change, trampling to individual species, and habitat degradation through invasive species introduction. Improper livestock grazing can greatly impact riparian habitats and at-risk plant habitat. The at-risk plant species would be protected by revised plan components to support the long-term persistence of at-risk plant species during project level allotment planning.

Revised plan alternatives plan component for new or revised allotment management plans which are to design grazing practices (such as stocking levels, duration, timing), and allotment infrastructure to meet or move toward applicable desired conditions in order to maintain or improve resiliency of riparian and upland ecosystems, and associated flora and fauna (FW-STD-GRAZ-01) are anticipated to support long-term persistence of the at-risk species. As a result of this plan component, grasslands, shrublands, wetland and riparian, and sparsely vegetated habitat guilds are expected to be maintained and to continue supporting the persistence at-risk plant species in livestock allotments. FW-GDL-GRAZ-01, 02, 04 and 05 provide additional protections for riparian and hardwood ecosystems that will further protect at-risk species. There would be opportunities in the future to restore habitats that have become degraded over time. The language in the revised plan alternatives is more explicit than the current plans, but management direction to preserve habitat quality is generally similar. Habitat quality would improve with the revised plan alternatives for at-risk species in all habitat guilds under the livestock grazing plan components due to increased monitoring and active management.

Effects from Invasive Species Management

Invasive species can have a major impact on at-risk species on the Custer Gallatin National Forest. In general, increased ground disturbance corresponds with increased weed spread. Roads, trails, livestock, and canopy reduction can provide ideal pathways for the introduction of exotic and non-native species. Introduced, invasive plant species can displace at-risk species through competitive displacement. Competition from invasive nonnative species and noxious weeds can result in the loss of habitat, loss of native pollinators, and decreased at-risk plant species persistence. Additional subsequent impacts include herbicide spraying and mechanical ground disturbance to control noxious weeds once they gain a foothold.

Regarding the risk of weed invasions and expansion of infestations into at-risk habitat guilds, the alternatives would vary in some ways with reduced emphasis on weed treatment in alternative E due to differences in objectives for treatment. As such, under the current plans and alternatives B through F, all habitat guilds would be expected to benefit from the treatment of invasive species, particularly the wetland and riparian, and grassland and shrubland guilds and would contribute to stable at-risk plant populations on the Custer Gallatin. There would be less emphasis on weed control under alternative E due to reduced treatment objectives.

The revised plan alternatives provide similar protections and guidelines for invasive species treatment as the existing plans; however, additional plan components specify treatment of weeds in and near at-risk plant occurrences. Most notably, FW-STD-INV-01 requires that decisions authorizing the use of chemicals shall outline protection measures for treatment and measures to minimize contamination of water resources and injury to non-target desired plants and animals, including at-risk species and PR-STD-VEGNF-01 requires that invasive species treatments are not detrimental to the long-term persistence of regional endemic and peripheral plant species. Further, FW-OBJ-INV-01 sets a management objective to treat invasive species that may have negative impacts on at-risk species. This is expected to increase the opportunities for at-risk plant restoration on the Custer Gallatin. Threats would remain similar to the current plans. Habitat quality would improve for at-risk species occurrences under the revised plan alternatives.

Effects from Soil Management

All habitat guilds depend on soil quality and productivity within their respective habitats. Forest Service activities that lead to soil compaction or soil contamination with toxic materials have the potential to negatively impact sensitive plant habitat. Some activities that can threaten soil quality include mechanized vegetation treatments, roads, and off-road vehicles. As a result of the revised plan alternatives soils plan components threats to soil productivity from mechanized vegetation treatments and roads in particular are minimized and all habitat guilds are expected to be maintain soil quality and productivity, which would contribute to the persistence of at-risk plant populations on the Custer Gallatin (FW-STD-SOIL-01). FW-DC-SOIL-02 is expected to provide additional protection for bryophytes, lichens, and other flora that could exist on the national forest. Habitat quality would improve for all habitat guilds in the revised plan alternatives. Threats would remain similar to the current plans.

Cumulative Effects

Increasing Human Populations

Additional stressors that may increase in the future are increasing population levels, both locally and nationally, with resulting increasing demands and pressures on public lands. At present, local populations are increasing in the counties to the west and north of the Custer Gallatin National Forest, but are declining or stable in other areas. As related to forest and vegetation conditions, these changes may lead to increased demands for commercial and non-commercial forest products, elevated importance of public lands in providing for habitat needs of wildlife species, and changing societal desires related to the mix of uses public lands should provide. The revised plan alternative components would be adequate to support persistent at-risk plant populations and habitat on the Custer Gallatin as human populations and demands increase. Activities known to be threats to at-risk plant habitat guilds as described in the effects common to all alternatives section above that occur or originate on other ownership land can impact populations and habitat on the national forest.

Adjacent Lands and Other Management Plans

The cumulative effects are the same as outlined in the invasive species section relative to consistency with other adjacent national forest management plans, Bureau of Land Management resource management plans, and the Foundation Document for Yellowstone National Park.

The Natural Resources Conservation Service Soil Health strategy (2015e) briefly outlines goals related to promoting soil health and conservation, primarily on agricultural lands. Soil quality is expected to good, but these areas not likely to support at-risk plant populations on agricultural lands. These areas are considered to put at-risk plants in the grasslands' habitat guild at greater risk for impacts with little to no suitable habitat available compared to historical conditions.

The South Dakota and Montana Natural Heritage Program is a member of NatureServe, an international network of biological inventories known as natural heritage programs or conservation data centers that operate in all fifty U.S. states, Canada, Latin America, and the Caribbean. Lists of rare, unique, or vulnerable plants, animals and biological communities are maintained by each heritage program. They provide important tools from the South Dakota and Montana Natural Heritage Databases (a system that allows locations and related information on rare species to be entered and shared for environmental review and conservation purposes) which are complimentary with conservation considerations for Custer Gallatin National Forest at-risk plants and quality habitat.

Montana's 2015 State Wildlife Action Plan identifies community types, focal areas, and species in Montana with significant issues that warrant conservation attention. Every community type in Montana was considered in this plan. Conservation actions were developed for the community types and species considered to be in greatest conservation need, resulting in a document that provides priority conservation direction in Montana which is complementary with conservation considerations for Custer Gallatin National Forest at-risk plants and quality habitat.

South Dakota's 2015 Wildlife Action Plan uses an ecosystem approach to assess the health of South Dakota's fish and wildlife and associated habitats (South Dakota Department of Game Fish and Parks 2014b;2018a). Plant species are not listed as species of greatest conservation need (SGCN) in the plan. However, the plan refers to the terrestrial and riparian and wetland ecosystems' planning approach, which encourages voluntary actions among Tribes, conservation partners, agencies (such as the U.S. Forest Service), and individuals to provide habitats that occurred prior to European settlement of South Dakota, with the concept of using an historical reference is based on the fact that the array and distribution of ecosystems across South Dakota shaped and sustained the region's biological diversity and that most species in South Dakota today resulted from historical ecosystems and associated disturbance regimes in the Great Northern Plains. This plan is complementary to having resilient ecosystems in which at-risk plants can persist.

Montana Department of Natural Resource Conservation (Montana Forest Action Plan (2020)) conducted a statewide assessment of forest resources on all land ownerships in Montana and identified issue-based focus areas with priority areas and associated implementation strategies. Strategies are focused on maintaining forest health and stress maintaining resilience, diversity, and sustainability. The maintenance of native vegetation and emphasis on diversity is expected to benefit at-risk plant species that often occur in rare or sensitive habitats. This management is expected to be complementary, though some impacts to populations could occur.

Some county wildfire protection plans map and define the wildland-urban interface. The Custer Gallatin National Forest notes that these areas may be a focus for hazardous fuels reduction, and other plan components (such as Northern Rockies Lynx Management Direction) have guidance specific to these areas. Managing for open forests and fire adapted species may be particularly emphasized in these areas. Overall, the effect of the county plans would be to influence where treatments occur to contribute to desired vegetation conditions. Species in the grasslands guild in these areas would likely benefit from open forest habitat.

Plants of special concern are protected from new development as provided for in the Madison County growth policy. At-risk plants on private lands are considered to be at greater risk of local extirpation due to lack of protections. The county plans generally aim to maintain native vegetation communities and reduce noxious weeds. The preservation of native habitats would maintain habitat for at-risk species where they occur.

Conclusion

The current plans would maintain the existing separate plans for the Custer and Gallatin National Forest. While all plants are expected to remain stable on the Custer Gallatin as a result of this alternative due to Forest Service manual policy and plan components for sensitive species, there are fewer plan components in the current plans that specifically protect some species’ habitats.

Alternatives B through F have considerable changes to forestwide plan direction that apply to each at-risk species’ habitat on the Custer Gallatin. The revised plan components provide additional protections to at-risk plant habitats. All plan components relevant to at-risk plant species remain the same between the revised plan alternatives. Areas considered to have low risk for ground-disturbing threats include designated wilderness areas, wilderness study areas, recommended wilderness areas, inventoried roadless areas, backcountry areas, designated wild and scenic rivers, and research natural areas. Collectively, alternative D provides the most acreage with the lowest risk for ground-disturbing threats, followed by alternatives C, F, B, and E. Some limitation of mechanical treatment could occur as a result of increased recommended wilderness, though restoration treatments would generally be permissible. This is mainly expected to impact whitebark pine, but future species of conservation concern could also be impacted, especially if more stringent restrictions were to be placed on mechanical treatments if these areas were designated as official wilderness by Congress.

Although the projected acres of timber harvest vary by alternative, there would be little difference in the effect of timber harvest due to plan components designed to minimize impacts to at-risk species.

Motorized transport has a small impact on at-risk plant species on the Custer-Gallatin. The current plans and alternatives B, E, and F would not change the suitability of current motorized transport on any roads or trails. Under alternative C, about four miles of trail would no longer be suitable for motorized transport. Under alternative D, about 172 miles of trail would no longer be suitable for motorized transport. Reduced motorized transport would correspond to reduced threats from weed spread and competition with at-risk species.

The following determinations are supported by the analysis above and rationale provided for identifying the species of conservation concern for the Custer Gallatin (found on the Northern Region Species of Conservation Concern web page):

- Due to the relatively limited amounts of certain habitat conditions within the plan area (specifically, alkaline soils and fens), national forest lands would likely only support a small population for six of the plant species of conservation concern. These species would be vulnerable to ecological stressors from both within and outside the national forest boundary. For these reasons, it is likely not within the inherent capability of the plan area to maintain or restore ecological conditions that would support long term persistence within the plan area for the following species: annual Indian paintbrush (*Castilleja exilis*), English sundew (*Drosera anglica*), beaked spikerush (*Eleocharis rostellata*), spiny hopsage (*Grayia spinosa*), meesia moss (*Meesia triquetra*), and northwestern thelypody (*Thelypodium paniculatum*). However, plan components in all revised plan alternatives would maintain or restore ecological conditions within the plan area to contribute toward maintaining the long-term persistence of these species within their range.
- For Barratt's willow (*Salix barrattiana*) the greatest vulnerability is the small number of disjunct populations in the continental United States of America, where only five small, isolated occurrences are known. The lack of potential for sexual reproduction in some of the occurrences on and near the Wyoming-Montana border on the Shoshone and Custer Gallatin national forests, managed by U.S. Forest Service regions 2 and 1 respectively, appears to be a threat to long-term population sustainability. The clone that straddles the border consists entirely of staminate plants. Without pistillate plants, sexual reproduction is not possible and long-term survival of the clone is in doubt. Currently, the clone reproduces entirely by vegetative means (Fertig and Markow 2000, Ladyman 2005). For this reason, it is likely not within the inherent capability of the plan area to provide the ecological conditions that would support long term persistence of this species in the plan area. Under all revised plan alternatives, plan components are designed to provide ecological conditions that contribute to maintaining the long-term persistence of the species within its range.
- For the remaining 18 plant species of conservation concern, plan components within the revised plan alternatives would provide the ecological conditions necessary to support their long-term persistence in the planning area.
- The regional forester's sensitive species that are not included as at-risk species have been determined to lack threats to persistence on the Custer Gallatin because plan components provide ecological conditions for them, or they are not known to occur on the national forest (see appendix C).
- No specific vegetation-disturbing activities that would affect at-risk plant occurrences are proposed under any of the programmatic revised plan alternatives. Ground-disturbing activities would be considered in a separate environmental analysis prior to implementation and all activities that could harm at-risk plants would be mitigated or the occurrences would be avoided (FW-STD-PRISK-01).

- Although potential threats to at-risk plant habitat guilds from weed invasion are increased under alternative E (due to decreased treatment objectives) when compared to the other revised plan alternatives, specific plan language targets emphasis of treatments in and near known occurrences of at-risk plants which supports restoration in known locations.
- Plan components under the revised plan alternatives would provide desired ecological conditions and management restrictions (for example standards and guidelines) to maintain or restore known at-risk plant occurrences and habitats that will persist and are resilient and adaptable to stressors (see appendix C for at-risk species plan components).

3.6 Terrestrial Vegetation

3.6.1 Introduction

The Custer Gallatin National Forest covers approximately 3,046,000 acres. For planning purposes, the revised plan arranges the national forest into six distinct geographic areas ranging from roughly 75,000 acres to 1.4 million acres. Ecologically, the Custer Gallatin has termed its mountainous area as “montane” and the eastern districts as “pine savanna.” Montane ecosystems of the Custer Gallatin include the Madison, Henrys Lake, and Gallatin Mountains Geographic Area; the Absaroka Beartooth Mountains Geographic Area; the Bridger, Bangtail, and Crazy Mountains Geographic Area; and Pryor Mountain Geographic Area. The pine savanna ecosystem includes the Ashland and the Sioux Geographic Areas.

These two ecosystem areas are nested within the broader ecoregions (Environmental Protection Agency Level III Ecoregions). An ecoregion provides a larger scale for planning and analysis that distinguishes common climatic and vegetation characteristics. Approximately 81 percent of the Custer Gallatin National Forest is in the Middle Rockies consisting of coniferous forest, alpine meadow, and shrubland-grassland steppe. Approximately 19 percent of the Custer Gallatin is in the Northwest Great Plains Province consisting of ponderosa pine-shrubland-grassland steppe. A small amount (less than 1 percent) is in the Wyoming Basin province around the Pryor Mountains consisting of semi-desert shrubland-grassland.

The montane area is characterized by generally glaciated regions with altitudinal zonation of semidesert vegetation, coniferous forests on the lower mountain slopes, and alpine tundra toward the top. Temperature and snowfall vary greatly with altitude. Winds are from the west/southwest, with much of their moisture precipitated where they cross the Pacific ranges. Due to aridity, forests are usually restricted to northern and eastern slopes at lower elevations. Although south- and west-facing slopes receive comparable precipitation, they are hotter and evaporation is higher. Consequently, they support fewer trees and are covered by shrubs and grasses. Lodgepole pine, Douglas-fir, subalpine fir, Engelmann spruce, limber pine, and whitebark pine are the predominant conifer vegetation. The lower slopes of the mountains are dominated by grasslands and shrublands.

The pine savanna area is characterized by rolling plains and tablelands of moderate relief. The plains are notably flat, but there are occasional valleys, canyons, and buttes. Badlands and isolated mountains break the continuity of the plains. The area lies in the rain shadow east of the Rocky Mountains. The climate is a semiarid continental regime. Winters are cold and dry, and summers are warm to hot. Evaporation usually exceeds precipitation, and the total supply of moisture is low. Scattered shrubs, such as sagebrush, are supported in all gradations of cover, from semidesert to woodland. Many species of grasses and forbs grow in this area. Grasses include grama, wheatgrass, and needlegrass. On the driest sites, ponderosa pine is short and generally open grown with grass understories. Moist north-facing sites have dense stands of taller ponderosa pine, with shrub and forb understories, including species of the mountain forests to the west. Draws and gullies (ravines) that support many hardwood trees (green ash, box elder, aspen) and shrubs (wild plum, hawthorn, silver buffaloberry, and snowberry) also dissect the landscape.

Regulatory Framework

2012 Planning Rule (36 CFR 219): Sets out the planning requirements for developing, amending, and revising land management plans for units of the National Forest System, as required by the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976 (16 U.S.C. 1600 et seq). This subpart also sets out the requirements for plan components and other content in land management plans. This part is applicable to all units of the National Forest System as defined by 16 U.S.C. 1609 or subsequent statute.

Clean Water Act of 1948, as amended: This act is the principal law concerned with polluting activity in the nation's streams, lakes, and estuaries. Originally enacted in 1948, it has been revised by amendments in 1972 (Pub. L. 92-500) that gave the act its current form and spelled out ambitious programs for water quality improvements that are now being put in place by industries and cities. Congress refined these amendments in 1977 (Pub. L. 95-217) and 1981 (Pub. L. 97-117). The 1987 amendments added:

- Section 319, under which States are required to develop and implement programs to control non-point sources of pollution, or rainfall runoff from farm and urban areas as well as construction, forestry, and mining sites.
- Section 303(d), which requires states to identify pollutant-impaired water segments and develop total maximum daily loads that set the maximum amount of pollution that a waterbody can receive without violating water quality standards; develop a water-quality classification of streams and lakes to show support of beneficial uses; and establish anti-degradation policies that protect water quality and stream conditions in systems where existing conditions exceed standards.

Endangered Species Act of 1973, as amended: Directs Federal agencies to conserve threatened and endangered species and to ensure that actions authorized, funded, or carried out by agencies are not likely to jeopardize the continued existence of these species or result in the destruction or adverse modification of their critical habitats.

Federal Clean Air Act of 1955 (as amended in 1967, 1970, 1977, and 1990): The act is a legal mandate designed to protect air quality in the interests of public health and welfare. Although this policy creates the foundation for air quality regulation, states and counties are often responsible for implementation of the air quality standards. The task of identifying National Ambient Air Quality Standards is assigned by the Clean Air Act to the Environmental Protection Agency. The Environmental Protection Agency evaluates and updates these standards every 5 years. This act provides for the protection and improvement of the nation's air resources and applies to the effects of wildland fire and can help inform wildfire response.

Multiple-Use Sustained-Yield Act of 1960: Congress has affirmed the application of sustainability to the broad range of resources over which the Forest Service has responsibility. The Multiple-Use Sustained-

Yield Act confirms the Forest Service' authority to manage the national forests and grasslands "for outdoor recreation, range, timber, watershed, and wildlife and fish purposes" (16 U.S.C. 528) and does so without limiting the Forest Service' broad discretion in determining the appropriate resource emphasis or levels of use of the lands of each national forest and grassland.

National Environmental Policy Act of 1969: Requires analysis of projects to ensure the anticipated effects upon all resources within the project area are considered prior to project implementation (40 CFR 1502.16). This act declares that it is a Federal policy to "preserve important historic, cultural, and natural aspects of our national heritage." It requires Federal agencies to use a systematic and interdisciplinary approach that incorporates the natural and social sciences in any planning and decision making that may impact our environment.

National Forest Management Act of 1976: "It is the policy of the Congress that all forested lands in the National Forest System shall be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yields. Plans developed shall provide for the diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet the overall multiple-use objectives, and within the multiple-use objective."

Organic Administration Act of 1897: Provides the main statutory basis for the management of forest reserves. States that the intention of the forest reserves (which later were called national forests) was to "improve and protect the forest" and to secure "favorable conditions of water flows" and provide a "continuous supply of timber for the use and necessities of citizens of the United States." This act also authorizes the Secretary of Agriculture to designate experimental forests and ranges, and to set forth broad direction for establishing and administering these areas.

Secure Rural Schools and Community Self-Determination Act of October 30, 2000 (P. L. 106-393, 114 Stat. 1607; 16 U.S.C.500 note): This act provides provisions to make additional investments in, and create additional employment opportunities through, projects that improve the maintenance of existing infrastructure, implement stewardship objectives that enhance forest ecosystems, and restore and improve land health and water quality. This act was designed to stabilize annual payments to state and counties containing National Forest System lands and public domain lands managed by the Bureau of Land Management. Funds distributed under the provisions of this act are for the benefit of public schools, roads, and related purposes.

Wilderness Act (1964) (16 U.S.C. 1131-1136): This act provides the statutory definition of wilderness and management requirements for these congressionally designated areas. This act established a National Wilderness Preservation System to be administered in such a manner as to leave these areas unimpaired for future use and enjoyment as wilderness.

Key Indicators and Measures

Ecosystem integrity is typically assessed by considering dominant ecosystem components including function, composition, structure and connectivity (Andreasen et al. 2001). *Composition* refers to attributes associated with the species within an ecosystem, such as species dominance, richness or evenness. *Structure* generally refers to physical features, such as stand density or tree size. *Function* encompasses ecological processes such as herbivory, succession and fire. *Connectivity* denotes the degree to which the landscape facilitates or impedes movement among resource patches.

Specific key ecosystem characteristics representing ecological function, composition, structure and connectivity have been identified and serve as the key indicators for describing the affected environment and evaluating differences among the alternatives. Key ecosystem characteristics are also chosen because they are measurable (for example, quantitative or qualitatively) and there is data or means to distinguish and describe them. Differences among the alternatives may be expressed as both qualitative and quantitative, and the estimated changes in key ecosystem characteristics over time serve as the basis for evaluation of ecological sustainability and forest resilience. The key indicators discussed in this section of the environmental impact statement for vegetation are listed below. Although connectivity is primarily addressed in the wildlife section, the discussion below of landscape pattern as a structural element of ecosystems is also an important component of managing for connectivity. Descriptions of indicators and how they are measured are provided in their respective sections. Table 32 lists key ecosystem components and indicators.

Table 32. Terrestrial vegetation key ecosystem characteristics

Ecosystem Component	Key Ecosystem Characteristic	Indicator(s)
Function	Insect disturbance	Hazard ratings for mountain pine beetle, Douglas-fir beetle, western spruce budworm, and root disease
Function	Wildfire disturbance	Fire frequency by severity class
Function	Invasive species	Vulnerable Habitats
Composition	Vegetation composition	Cover types (forested and non-forested)
Composition	Tree species presence	Presence of at least one tree per acre
Structure	Dead trees (snags)	Classes based on diameter classes
Structure	Tree size	Classes based on basal area weighted diameter
Structure	Large tree structure	Presence of a set minimum of large trees per acre
Structure	Tree density	Classes based on canopy cover
Structure/Connectivity	Landscape pattern	Patch composition, size and distribution

Methodology and Analysis Process

Ecological Integrity

As required by the 2012 Planning Rule, the revised plan is using the concept of *ecological integrity* as a guiding framework to plan for social, ecological and economic sustainability. The rule defines ecological integrity as the quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function and connectivity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence (36 CFR 219.19). Notably, by specifically capturing the ability of ecosystems to “withstand and recover from most perturbations,” this definition of ecological integrity describes resilience as a fundamental component of ecological integrity.

Ecological integrity forms a crucial part of the plan’s “coarse-filter” approach for a conservation strategy—for example, a habitat-based approach, versus species-specific management (Hunter et al. 1988). A key assumption of this approach is that intact ecological conditions mean habitats, and the species dependent on them, persist. Moreover, it is assumed that by maintaining these conditions, critical ecological and evolutionary processes such as nutrient and sediment transport, biotic interactions, dispersal, gene flow and disturbance regimes, will also be maintained and provide the necessary environmental conditions for climate adaptation (Beier and Brost 2010).

Wurtzebach et al. (2016) outline some key characteristics and assumptions associated with the ecological integrity framework. They note that ecological integrity:

- Emphasizes the importance of ecological processes such as natural disturbance regimes that provide the structures and functions on which the full complement of species in an ecosystem or landscape depend.
- Assumes that ecological systems that retain their native species and natural processes are more resistant and resilient to natural and anthropogenic stresses over time (including climate change).
- Emphasizes the intrinsic value of native biodiversity of ecosystems, beyond its functional role in supporting the renewal and reorganization of ecosystem function and structure over time
- Uses the natural or historical range of variation as a reference point for promoting resilience (the capacity to reorganize while undergoing change to still retain essentially the same function, structure, identity, and feedbacks).

Consistent with this conceptual framework, desired conditions for vegetation were developed to provide for the ecological integrity of Custer Gallatin National Forest ecosystems. Desired conditions were based on an analysis of the natural range of variation while also considering current and future stressors. Standards, guidelines and objectives were developed, if necessary, to move toward or maintain desired conditions. These plan components form the basis for comparison of alternatives.

Ecological integrity has emerged as a key component of ecological restoration and adaptation to climate change (Suding et al. 2015) and a useful framework to guide management of terrestrial ecosystems (Carter et al. 2019). However, in planning for ecological integrity, it is important to recognize well-known sources of uncertainty that are specific to natural resource decision making (Chambers et al. 2019). These include: 1) partial knowledge - uncertainty in ecosystem and species responses to disturbances, climate change, and management actions and the related the need to estimate and model natural systems because of our inability to directly observe nature; 2) structural uncertainty - uncertainty and error in the models that predict system responses to disturbance, climate change or specific management actions; and 3) partial controllability - the difficulty of actually applying management actions with high precision and timing leading to misinterpretation of the effectiveness of future management actions. Being cognizant of this uncertainty and operating under an adaptive management framework will be critically important to effectively managing for ecological integrity in the future.

Natural Range of Variation

Consistent with the framework of managing for ecological integrity, a key assumption underlying plan development is that the natural range of variation provides insight and a frame of reference for evaluation of ecological integrity and resilience (Wiens et al. 2012). As such, the development of desired conditions are based on a careful consideration of the natural range of variation for key ecosystem components.

It is assumed that the natural range of variation reflects the ecosystem conditions that have sustained the current complement of wildlife and plant species on the Custer Gallatin, and provides context for understanding the natural diversity of the vegetation and what processes sustain vegetation productivity and diversity (Keane et al. 2009). Though humans have shaped the ecosystems of the Custer Gallatin for thousands of years, since the 1800s human presence and activities have increased dramatically, along with associated impacts to ecosystem conditions. Natural range of variation estimates provide a reference for conditions that might have occurred prior to this recent increase in human impacts.

The natural range of variation has been criticized as less relevant in an age of climate change (Millar 2014). There is potential for ecological transformations to occur in temperate ecosystems, based on the potential for interrelated drivers such as chronic and acute drought, wildfire, and insect outbreaks to push ecosystems beyond their thresholds for resilience (Millar and Stephenson 2015, Golladay et al. 2016). In some cases, management intervention might be able to ease the transition to new forest states and minimize losses of ecosystem services (Millar and Stephenson 2015). We do not currently have the capability to predict such possible shifts at the local scale. By basing the desired conditions around the full range of natural variation, with a focus on maintaining the full suite of ecosystem diversity and components that enhance resilience to disturbance, the Custer Gallatin revised plan would guide management toward maintaining functioning ecosystems in the face of uncertainty. In this analysis, additional factors considered in the development of desired conditions included climate change, the existing or anticipated human use patterns or desires for specific vegetation conditions, and the ecosystem services desired and expected from national forest lands (such as reducing fire hazard and producing forest products). See appendix B for additional information on the development of natural range of variation estimates.

Potential Vegetation Types

To stratify and structure the analysis of the terrestrial vegetation, and changes associated with the different management alternatives, two types of vegetation classification were used: potential vegetation and existing vegetation. Potential vegetation type, also called habitat types (Pfister et al. 1977), is the plant community that would be expected under existing environmental conditions in the absence of significant disturbance or human involvement (for example, climax vegetation type). Potential vegetation provides a basis for identifying and mapping unique biophysical conditions (Pfister et al. 1977) which can form as the basis of understanding ecological dynamics including successional development (Arno et al. 1985), fire regimes (Barrett 1988, Morgan et al. 2001) and site productivity (Milner 1992). Some have noted important limitations of the potential vegetation concept (Chiarucci et al. 2010). While there are theoretical and practical limitations to the use of potential vegetation types, the concept is nevertheless extremely powerful when used correctly and key assumptions are well understood (Somodi et al. 2012). For this reason, potential vegetation classifications have been developed for many areas in the United States and are actively used for numerous management applications including the LANDFIRE project (Rollins and Frame 2006) and the Forest Vegetation Simulator (Dixon 2008).

The Forest Service's Northern Region has identified potential vegetation groups that are recommended for use at broad spatial scales to facilitate consistent analysis and monitoring (Milburn et al. 2015). These groups are used in the Custer Gallatin National Forest revised plan with some minor adjustments as described in Reid et al. (2018). The three broad forested potential vegetation types found on the Custer Gallatin are Warm Dry, Cool Moist, and Cold. For this analysis, the Warm Dry potential vegetation type was divided in to two types: Warm Dry-Montane and Warm Dry–Pine Savanna. This was done to better capture the significant compositional and biophysical differences between the montane and pine savanna ecosystems. Potential vegetation types provide the basis of land classification for development of desired conditions and other plan components.

For modeling and analysis, it was necessary to map the distribution of potential vegetation types across the Custer Gallatin. The potential vegetation type map used for this document was developed by the Northern Region in the early 2000s (Jones 2004). Sources of data included field plots and remote sensing. Lands with no field data were populated by extrapolation of plot data and the use of models that integrated site factors influencing vegetation, such as precipitation, slope, and elevation. This layer, referred to as *R1 Potential Vegetation Types* or *R1-PVT,* is the best available potential vegetation type layer. It is the only map of potential vegetation that covers the national forest, and is a mid-level depiction of ecological condition. When necessary, potential vegetation classifications were adjusted to be consistent with current vegetation maps. This logic is available in Reid et al. (2018). Table 33 displays the proportion of Northern Region Broad Potential Vegetation Types in each geographic area.

Table 33. Distribution by percentage of Northern Region broad potential vegetation types on the Custer Gallatin National Forest by geographic area

Northern Region Broad Potential Vegetation Types	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger, Bangtail, Crazy Mountain	Madison, Henrys Lake, Gallatin Mountains
Alpine	0	0	0	8	0	2
Cold	0	0	1	21	4	13
Cool Moist	0	0	15	26	39	54
Grassland	52	45	32	7	10	7
Riparian/Wetland	1	1	1	1	1	1
Shrubland/Woodland	4	4	7	1	1	3
Sparse	2	1	1	21	17	7
Warm Dry	41	50	43	15	29	13

Climate Change Considerations and Assumptions

Climate change is expected to continue and have profound effects on the Earth’s ecosystems in the coming decades(Intergovernmental Panel on Climate Change 2007b). Description and analysis of these effects relied on a broad array of recent scientific literature and in particular a recent meta-analysis of climate change and potential effects published for the Northern Region Adaptation Partnership (Halofsky et al. 2018a;b). Halofsky et al. (2018b;a), and the references cited therein, represent the current state of the science on the effects of climate change in the region and is the source for much of the information in this section and throughout the document. In addition, to better understand the effects of climate change at a more local scale, the Custer Gallatin Plan Revision Team collaborated in a series of workshops with a diverse team of scientists and land managers from universities, government agencies and non-governmental agencies to specifically review and assess the revised plan’s approach to climate change. The results of this effort are discussed in more detail below and are also available at (Hansen et al. 2018).

As summarized by Halofsky et al. (2018b;a), there is little debate that atmospheric carbon dioxide is increasing and that this increase will cause major changes in climate, but there is a great deal of uncertainty about the magnitude and rate of climate change, especially as projections are made at more local scales or for longer time periods. Despite the uncertainty in downscaled projections, scientists expect the impacts of climate change on forest vegetation to be primarily driven by vegetation responses to shifts in disturbance regimes, and then secondarily, through direct effects of vegetation interactions with climate through shifts in regeneration, growth, and mortality processes at both individual plant and community scales. Increased temperatures will result in a reduction in water available to trees and understory plants. Trees will respond to reduced water availability, higher temperatures, and changes in growing season length in diverse manners. Changes in vegetation composition and structure will be the result of changes in both the life cycle processes and responses of a plant to disturbance.

The Northern Region Adaptation Partnership assessed projected climate change responses for 17 tree species, five forest vegetation types, and three resources of concern: landscape heterogeneity, carbon sequestration and timber production. Using the past, current, and future assessments, and the study rated the vulnerability of these elements to climate change. Vulnerability was determined from a number of factors including stressors, exposure, sensitivity to climate change, impact of that response, and adaptive capacity. Vulnerability assessments for the Northern Rockies were also done by Hansen and Phillips (2015), based on the results of five previous studies, and by Piekielek et al. (2015) for the Greater Yellowstone Area (table 34). The assessments are in broad agreement that subalpine tree species are most vulnerable to climate change, particularly whitebark pine, subalpine fir, and lodgepole pine. With warming, suitable habitat for these species shifts to higher elevations and have less total area. Lower elevation forests are also vulnerable with the Douglas-fir zone in the Greater Yellowstone Area being increasingly suitable for juniper and sagebrush communities. Forests at all elevations are projected to have increased outbreaks of forest pest species and more frequent fire.

Table 34. Ranking of vulnerability of tree species in the Northern Rockies and Greater Yellowstone Area

Species	Northern Region Adaptation Partnership 2018 Northern Rockies	Northern Region Adaptation Partnership 2018 Greater Yellowstone Area	Hansen and Phillips 2014 Northern Rockies	(Piekielek et al. 2015) Greater Yellowstone Area
Whitebark pine	2	1	1	1
Douglas-fir	5	2	9	5
Engelmann spruce	9	4	5	2
Subalpine fir	10	5	4	3
Lodgepole pine	11	6	3	4
Cottonwood	13	3	not applicable	not applicable
Aspen	14	7	not applicable	6
Limber pine	15	8	not applicable	7
Ponderosa pine	17	9	10	not applicable
Green ash	18	10	not applicable	not applicable

A ranking of “1” indicates the highest vulnerability.

Considerable uncertainties underlay these projections of vegetation under future climates, including:

- Complex interactions of climate with vegetation and disturbance are difficult to predict in time and space making future projections difficult;
- Abundant scale problems in nature and in the literature that made it difficult to generalize species and ecosystem trends at consistent temporal and spatial scale;
- Uncertainty in climate projections (22 general circulation models, 6 scenarios) made it difficult to project climate change responses at the local level.

Most models predict that northern latitudes will warm while maintaining or increasing precipitation. This combination of factors should enhance productivity on northern and high-altitude rangelands through increased growing seasons for some time. If temperatures continue to rise, however, as suggested in all of the Resources Planning Act climate projections (U.S. Department of Agriculture 2012a), gains in production related to longer growing seasons and increased precipitation may be offset by decreased moisture availability at some time in the future. Despite this possibility, recent research suggests that increased temperatures, when coupled with increased carbon dioxide, actually improve plant water relations because of decreased transpirational demand (Morgan et al. 2011).

Although the vegetation cover types will change with time, habitat types (potential vegetation types) will remain relatively stable because they are based on physical site factors. However, with climate change and shifts in moisture, temperature and other factors, potential vegetation types may change over time. Over the next 50 years, certain environmental influences may negatively impact non-forested vegetation condition and forage production. If temperatures continue to increase, there may be changes in vegetation, shifting from more mesic plant associations to more xeric communities, better adapted to the drier sites. Noxious weeds may continue to spread and increase in abundance and density. Timber canopy may continue to close in areas where wildfires or other disturbances do not occur, and some grasslands/shrublands may see additional conifer colonization and shift to a timber-dominated community. Conversely, there is potential that wildfire may play a larger role in shaping vegetation in some areas, perhaps promoting non-forested vegetation communities, particularly given warmer climate regimes. Fire and climate play primary roles in shaping vegetative types and conditions on the Northern Great Plains (Higgins 1984), which includes the Sioux and Ashland Geographic Areas. Transitory range acreage will fluctuate: timber stands will become more open due to harvest, insects, and fire; with time and succession, overstory canopies will close in once again.

Studies indicate that 20th century measures of climate, including drought, represent only a subset of the full range of conditions experienced in the past as a result of natural variation. Although drivers and feedback mechanisms are not fully understood, there is sufficient indication from past climate records and future projections to prioritize development of effective strategies for coping with the consequences of more frequent, more severe, and longer drought (Halofsky et al. 2018a;b).

Although it is difficult to model a detailed picture predicting the occurrence and extent of future drought, higher temperatures will increase the severity of drought episodes when they occur. Higher temperatures will reduce soil moisture critical to plant productivity, species composition, and erosion potential (Polley et al. 2013). Models of net primary productivity predict overall better growing conditions for the Northern Great Plains (Polley et al. 2013, Reeves et al. 2014) which may have an influence on the Ashland and Sioux Districts.

Drought has always impacted the physical environment and will continue to do so. In the western United States there is a trend toward dry conditions (Vose et al. 1995). Uncertainty arises primarily from limited capacity to predict future precipitation changes, particularly long-term lapses in precipitation. Despite this uncertainty, there is growing consensus that extreme precipitation events (such as, lapses in precipitation and more intense storms) will increase in frequency, and warmer temperatures will exacerbate the impacts of drought on forests and rangelands in the future (Vose et al. 2012)(. Although models predict overall better growing conditions for productivity in the Northern Great Plains, drought in rangelands could reduce forage and water available for livestock grazing and wildlife use. Reduced vegetative cover can lead to wind and water erosion. Drought often affects wildfire-related disturbance. In addition, droughts are predicted to accelerate the pace of invasion by some nonnative plant species into rangelands.

Warmer temperatures will likely result in increased fire frequency and intensity, creating more favorable conditions for invasive species, which would likely decrease overall forage quantity, quality and biodiversity. Management schemes will need to continue to be flexible and sensitive to changes in species composition.

Frequent low-severity drought that selectively favors more drought-tolerant species could create rangelands better adapted to future conditions without the need for management intervention. By contrast, severe drought (especially in combination with insect outbreaks or fire), may threaten large-scale changes that warrant substantial management responses. Actions could range from reducing vulnerability, facilitating post-drought recovery, or facilitating a transition to a new condition. Grazing practices need to continue to adapt to changing drought regimes.

Management actions can either mitigate or exacerbate the effects of drought. A first principal for increasing resilience and adaptation would be to avoid management actions that exacerbate the effects of current or future drought. Options can include altering structural or functional components of vegetation, minimizing drought-mediated disturbance such as wildfire or insect outbreaks, and managing for reliable flow of water. For example, silvicultural treatments can reduce fuel loads and restore desirable vegetation structure (Littell et al. 2009, Spies et al. 2014).

The revised plan and this final environmental impact statement incorporate models, plan components, and resource management strategies developed using the latest understanding of climate and potential changes into the future. Based on Halofsky et al. (2018a), important trends and projections in climate include:

Montane Ecosystems

- Over the historical period of record (1895–2012), the annual mean monthly minimum temperature increased by about 2.9 degrees Fahrenheit, while the annual mean monthly maximum temperature increased by about 1.2 degrees Fahrenheit.
- By 2100, annual mean monthly minimum temperatures are projected to increase 5 to 10 degrees Fahrenheit while the annual mean monthly maximum temperatures are projected to increase 7 to 12 degrees Fahrenheit.
- Annual mean monthly precipitation is projected to increase slightly by 2100, although projections for precipitation have high uncertainty compared to temperature projections.
- Winter maximum temperature is projected to increase above freezing in the mid-21st century. Summer temperatures are projected to increase 5 degrees Fahrenheit by 2060 and 10 degrees by 2100.

Pine Savanna Ecosystems

- Warming trends indicate that future climate will be similar to the Montane Ecosystems described above.
- Even with little or no change in precipitation, there is the potential for summer drying or drought due to the increased heat and increased evapotranspiration.

Revised plan direction incorporates strategies to address the uncertainties associated with climate change and its potential impacts to vegetation. While many effects of climate change are anticipated to be gradual, there is also the potential for interacting disturbances such as insects, drought and fire to drive systems towards sudden large-scale transformations (Millar and Stephenson 2015). For example, dry forests that already occur at the edge of their climatic tolerance are increasingly prone to conversion to non-forests after wildfires due to regeneration failure (Stevens-Rumann et al. 2018, Davis et al. 2019). This trend is likely to continue in the future across all forest types as large wildfires remove local seed source and suitable climate space for tree regeneration becomes increasingly rare (Bell et al. 2014, Harvey et al. 2016b, Andrus et al. 2018). Indeed, the ponderosa pine systems of the pine savanna ecosystems have experienced high rates of cover type conversion due to recent fires. In Ashland, for example, in the 1990s approximately 219,214 acres were classified with forest cover, in 2012 approximately 116,708 acres were classified as forested. The net change is an almost 50 percent reduction of the forest cover from what occurred in the 1990s (U.S. Department of Agriculture 2014a). While most of this area will likely regenerate naturally or with planting efforts, it is likely that a significant portion will remain unforested for at least the next few decades due to a lack of seed source. Desired conditions outlined in the plan are designed to make these forests more resilient to future wildfire and thereby mitigate the potential for large-scale loss of ecosystem services (Millar and Stephenson 2015).

Approaches to address forest and ecosystem management in the face of an uncertain and variable future should be flexible, emphasize ecological processes; and have the capacity to change, and to adapt, to new information as it becomes available (Millar et al. 2007). Approaches commonly published in the literature include promoting resilience to change, creating resistance to change, and enabling forests to respond to change (Holling 1973, Millar et al. 2007, Janowiak et al. 2014, Halofsky et al. 2018a). *Resilience* is defined as the ability of an ecosystem and its component parts to absorb, or recover from the effects of disturbances, and is the most commonly suggested adaptation option discussed in a climate-change context (Millar et al. 2007). Resilient forests accommodate gradual changes related to climate and can cope with disturbances. *Resistance* is the ability of the forest or ecosystem to withstand disturbances without significant loss of structure or function, in other words, to remain unchanged. From a management perspective, resistance includes both the degree to which communities are able to resist change, such as from warming climate; and the manipulation of the physical environment to counteract and resist physical or biological change, such as through burning or harvest treatments (Halofsky et al. 2018b). The *response* approach intentionally accommodates change rather than resists it, with a goal of enabling or facilitating forest ecosystems to respond adaptively as environmental changes accrue. Treatments would mimic, assist, or enable ongoing natural adaptive processes, anticipating events outside the historical conditions, such as extended fire seasons or increased summer water deficits. Response tactics may include such practices as shifting desired species to new potentially more favorable sites through planting, managing early successional forests to “reset” normal successional trajectories to create desired future patterns and structures, and promoting connected landscapes (Millar et al. 2007). No single approach will fit all situations, and integration of various adaptive approaches and management practices is the best strategy (Spittlehouse and Stewart 2003, Millar et al. 2007). A tactic or action may be consistent with two or three of the adaptive approaches.

For the development of the programmatic management direction in the revised plan, all approaches above are integrated to one degree or another, though promoting resilience is the primary approach. The resistance approach is integrated, for example with protection of highly valued habitats, species, or other resources. Approaches that could be considered response options are promotion of landscape connectivity and treatments in young stands to develop desired future forest patterns and structures. Another key plan component that is critical in the context of future climate change is the establishment of a monitoring plan to inform an adaptive management approach. This enables the intentional use of monitoring to evaluate effectiveness of our plan direction and resulting management actions. For example, monitoring tree regeneration will provide critical information on possible climate change effects to this vulnerable life stage (Stevens-Rumann et al. 2018).

It is acknowledged that there is an incomplete understanding of both climate change and its potential impact to forests and ecosystems. To better understand the threats and vulnerabilities posed by climate change and examine how plan direction could promote adaptation strategies and tactics that promote resilience to changing climatic conditions, the Custer Gallatin National Forest worked with partners from other Federal agencies, universities, and non-governmental organizations. A series of workshops in 2018 used best available scientific information to assess the vulnerability of potential vegetation types and cover types to projected climate change and identified and evaluated management options aimed at achieving or maintaining ecological integrity. The explicit goal of the project was to assess climate vulnerability of forest vegetation and evaluate management options in support of the Custer Gallatin National Forest plan revision. Objectives of the effort included:

1. Assessing vulnerability to climate change of key ecosystem characteristics within broad potential vegetation types based on exposure, sensitivity, adaptive capacity.
2. Identifying ecological characteristics for which the stated desired condition is not appropriate given climate change.
3. Identifying and evaluating broad adaption strategies and management options for maintaining the ecological integrity of vulnerable vegetation types in the desired condition under climate change.
4. Evaluating the feasibility of these adaptation strategies and management options and prioritizing them relative to geographic location, need, effectiveness, and feasibility.

Results of this effort were used to inform and refine the development of desired conditions as well as provide important strategies and tactics, many of which are reflected in the Management Approaches (appendix A). The full report from this series of workshops is available in Hansen et al. (2018). The following are a few of the conclusions from workshop members that have been incorporated into the revised plan, the management approaches (appendix A), or the analysis:

- Given uncertainty in some tree species tolerances to climate and soils and high uncertainty in future climate and vegetation response, adaptive management and experiments across biophysical gradients are needed for reducing uncertainty.
- Well-designed monitoring of climate, vegetation, and ecological conditions is important for tracking the condition of key response variables in the context of management and environmental change. Many vital signs of ecological integrity can now be harvested at low cost from remote sensing and

other data sources. The Federal agencies present in the Greater Yellowstone Ecosystem are all doing some level of monitoring and coordination among them is most likely to lead to robust monitoring across the ecosystem.

- It is important to not only identify potential ecological consequences of climate change, but to prioritize the changes to identify which are most important for management action. Relatedly, any recommendations will make will be more likely to be effective if they are actionable by managers.
- While there is high uncertainty in projections of future climate and vegetation response, there is high agreement that some trends are likely, and these should be considered by management. These include more fire, reduced soil moisture effects at lower elevations, warming effects at upper tree line, reduced snowpack and river flows, and increased levels of pests such as bark beetles (such as, increased future fire in the Greater Yellowstone Ecosystem may be analogous to sea level rise in coastal areas, a very likely bet in the long-term). Assume the forest will burn more, that snowpack will decline, and the river flows will be reduced and manage accordingly. Temperature changes will overwhelm precipitation increases, particularly at lower tree line.
- The spatial and temporal patterns with which these trends are manifest may be gradual or episodic due to interactions among natural climate variation, human effects on climate, and random events. For example, the shifting upslope of lower tree line under warming may be gradual with drought induced tree mortality or episodic with a large, intense fire being a regime shift to the community. Management strategies should be robust relative to these varying types of change.
- Many of the tree species may be relatively resilient to projected climate with regards to regeneration and distribution. However, increased fire is likely to shift existing forests to younger age classes and smaller size classes.
- The cold potential vegetation type spans a relatively wide range of climate conditions from dry to wet. Thus, vulnerability may vary within the Cold potential vegetation type and more landscape specific management approaches may be appropriate.
- Successful management of vegetation and ecosystems during this period of rapid environmental change will require “anticipatory” planning and management. Trends in climate, land use, invasives, recreation, etc. should be tracked past to present and forecast into the future so management strategies can be designed to help the ecosystem be resilient to the changes that may be happening in future decades. Plotting the natural range of variation from past periods, trends in condition in recent decades, and forecasted trends provides a context for vulnerability assessment and prioritizing management needs.

In summary, as noted by Halofsky et al. (2018a), a warming climate will rarely be the direct agent of change for terrestrial vegetation on the Custer Gallatin National Forest. Rather, most of the changes will likely result from responses to climate change-induced disturbance or to some combination of other climate-exacerbated stressors. Whether it is invasive species (such as, white pine blister rust), drought, uncharacteristic wildfires, elevated native insect and disease levels, loss of fire-adapted trees, or unusually high forest densities, the most significant effect of climate change is likely to be further exacerbating these stressors and “stress complexes.” Plan direction, which emphasizes ecological integrity and resilience, will be critical to minimizing the undesirable effects of these increasing and interacting stressors. Nevertheless, managers and the public should expect climate change to drive profound and often surprising changes on ecosystem structure, function, and composition in the coming decades.

Vegetation Modeling

This analysis relies on analytical vegetation models to assess both natural range of variation and the potential effects of plan direction on future vegetation conditions. It is important to understand the strengths and limitations of the analytical models to appropriately interpret the results. Out of necessity, the models simplify very complex and dynamic relationships between ecosystem processes and drivers (such as climate, fire and succession) and vegetation over time and space. The models use a given set of assumptions, including fire regimes, insect or disease hazard, the rate of tree growth, stand structure change over time (succession), etc. These assumptions are based on analysis and corroboration of actual data (such as fire history and historical vegetation information) and review of scientific literature, as well as professional judgement and experience of resource specialists familiar with the ecosystems and forest types of the Custer Gallatin. Though best available scientific information and knowledge is used to build these models, there is nevertheless a high degree of variability and uncertainty associated with the model results because of the ecological complexity and imperfect knowledge of system dynamics. When modeling future conditions, the precise timing, magnitude and location of disturbances will differ from that modeled, resulting in different effects to vegetation compared to model outputs. As such, while model results provide a good indication of how vegetation may change over time, they are most useful for assessing broad ranges of ecosystem characteristics under historical disturbance regimes (for example, estimating the natural range of variability) and for comparing *relative* effects among alternatives. Moreover, although models are helpful, they are but one tool used to inform the analysis of effects in this environmental impact statement. Model outputs augment other sources of information, including research and professional knowledge of how ecosystem processes (such as succession) and disturbances or stressors (such as fire, insect, harvest, and climate) might influence changes in vegetation conditions over time, especially at the scale of the planning unit. All these sources of information are used in the evaluation of environmental consequences of the alternatives. Appendix B provides additional detail on vegetation modeling and methodologies.

Modeling Natural Range of Variation

To quantify the natural range of variation, modeling was done to simulate vegetation conditions prior to European settlement. The best available model is *SIMulating Patterns and Processes at Landscape scaLEs* (SIMPPLLE) Version 1.4.0 (September 2017). This model was developed in the Northern Region to assess landscape-level management questions. It is a spatially explicit, dynamic landscape model used for projecting temporal changes in the spatial distribution of vegetation in response to insects, disease, wildland fire, and other disturbances (Chew et al. 2012a). The model is designed to provide a balance between incorporating enough complexity to provide an acceptable level of realism while making enough simplifications to be a useful management tool in planning processes.

One of the main utilities of the model is its stochastic nature. Managers cannot know with precision the specific types, locations, and extents of natural disturbances that will occur on the landscape. Therefore, the SIMPPLLE model will randomly assign fire, insect, and disease processes on the landscape in a manner consistent with what is known about the nature of these disturbances (such as, insect-prone stands have a higher hazard and probability of getting an infestation, especially in a dry climate cycle). The model is typically run for multiple iterations to allow the manager to see a variety of possible projections, look for patterns, and adjust management response accordingly.

The other main utility of the SIMPPLLE model is its spatially interactive nature. Landscape dynamics are inherently spatial. A process or condition occurring on one site is dependent, to an extent, on adjacent sites. Consider a fire event. SIMPPLLE simulates fire by assigning fire *starts* with a probability consistent with what historical records indicate for the area and climate. Each start is then given the opportunity to grow. The size the fire grows to is dependent on the surrounding vegetation as well as the historical probability that it will end with a weather event (or, if simulating fire suppression, whether or not there are enough resources, etc. to put the fire out). The *severity* of fire that spreads (low, mixed or high) is dependent on the vegetation conditions of the site (including past disturbance or treatment), the climate, its elevational position relative to the burning fire (uphill, downhill, etc.) and whether it is downwind or not. Again, the fire process will stop according to the probability of a weather ending event, successful fire suppression, or perhaps it runs up against a natural barrier such as sparse vegetation or a lake. SIMPPLLE will then determine the *effect* of the fire by considering whether there are trees present capable of re-seeding/re-sprouting the site (in the case of a lethal fire), whether the stand’s fuel conditions have been reduced (for semi- or non-lethal fires), and if there has been a change in size or species on the site.

The Custer Gallatin Plan revision modeled vegetation conditions associated with climate conditions from years AD 960 through 2000. This reference period allowed simulation of the conditions associated with much of the time period known as the Medieval Climate Anomaly as well as the other end of the climate spectrum known as the Little Ice Age. The inclusion of the Medieval Climate Anomaly in the simulation is potentially valuable in that it might indicate conditions and processes that could occur in the modern climate regime (Calder et al. 2015).

Details on data sources and key assumptions used in the natural range of variation modeling process can be found in appendix B. Several notable additional pathways and processes in the model were calibrated to accurately reflect the conditions on the Custer Gallatin National Forest specifically, including:

- Successional Pathways: Successional pathways are state and transitional models for each vegetation type that provide the foundation for the model. The existing data was reviewed, and pathways for both forested and non-forested vegetation types were added or modified based on expert judgment, measured vegetation conditions from forest inventory and analysis datasets and successional theory literature to ensure the model depicted the conditions found on the Custer Gallatin National Forest.
- Wildfire Processes: Wildfire processes, including the probability of ignition, fire sizes, fire regimes (severities), weather ending events, and effects to successional pathways are key drivers in the model. Wildfire processes were calibrated using LANDFIRE data, applicable fire history studies and publications, previous modeling efforts, and expert judgment.
- Insect and Disease Processes: The probability and effects of key insect and disease processes (bark beetles, defoliators, and root diseases) were also calibrated using the latest science regarding insect hazard and mortality trends, local data, and expert judgment.

Modeling Vegetation Change during the Planning Period

Vegetation across the Custer Gallatin will change over time, in response to both natural ecological disturbances (such as fire and insects), human elements (such as timber harvest and prescribed burning), and the interaction of these factors with vegetation succession and climate. The desired condition is to maintain vegetation conditions within the desired ranges over time to contribute to forest and ecosystem resilience and sustainability.

Modeling of future vegetation change was done in two steps. First, PRISM (Plan-level forest activity scheduling model) (Nguyen 2018) a linear programming model, was used to project alternative forest management scenarios, schedule vegetation treatments, and provide outcomes; based upon a variety of input parameters, such as management objectives and budget limitations. PRISM was also used to project timber harvest acres and volumes over time under different management scenarios. Appendix B describes the PRISM analysis process in detail, and the resulting timber harvest outputs. Next, the SIMPPLLE model was used to simulate fire, insect and disease disturbances over time (historical and future), and the interaction of these disturbances with vegetative succession and treatment activities. The SIMPPLLE model provides for spatial analysis of landscape dynamics given future management activities as scheduled through the PRISM model. Appendix B and the planning record contain more information on the development and use of the SIMPPLLE model including the raw data outputs from the SIMPPLLE model.

In the PRISM model, vegetation management activities expected to occur over time in each alternative were formulated by considering the different objectives of each alternative coupled with land designations, land suitability, other resource limitations on treatments (such as within Canada lynx habitat or grizzly bear security core), projected fire and insect effects and budget limitations. For each of the alternatives, the PRISM model was run with a set of objectives and constraints that was in keeping with the theme of the alternative. The following summarizes key differences in PRISM model assumptions across alternatives, details of model assumptions can be found in appendix B.

- For all alternatives, the objective of the model was to trend vegetation conditions towards the desired conditions for vegetation.
- For all alternatives, the model was constrained by the minimum amount of saw timber volume to be produced. This range of timber volumes was selected to reflect a reasonable range of potential emphases in terms of vegetation treatment types for the Custer Gallatin National Forest vegetation management program. Timber volumes were used as a minimum constraint, the model was able to schedule higher volumes if doing so would accelerate the rate of achieving the desired vegetation conditions. See Timber section for additional detail.
- For all alternatives, PRISM was required to treat a minimum number of acres depending on the objectives of each alternative. This reflects the full range of treatment types (such as, planned ignitions, planting, and timber harvests). The model could choose which mix of treatments that most efficiently moved vegetation towards the desired conditions. Treatment acres were used as a minimum constraint, the model was able to schedule treating more acres if doing so would accelerate the rate of achieving the desired vegetation conditions while meeting all constraints.
- PRISM was constrained by budget assumptions. For alternatives A through D and F, the budget was assumed to be comparable to fiscal years 2012-2015. For alternative E, the budget for vegetation management was assumed to increase by 33 percent to analyze the effects of a higher level of timber volume. Rather than increasing the national forest’s budget as whole, the increase in budget for vegetation management was assumed to come at the expense of other program areas and the effects of this are also discussed. All alternatives were also analyzed without a budget constraint.
- All alternatives assumed a non-declining flow in timber volume outputs.
- All alternatives assume a doubling in acres burned by wildfire per decade relative to the period from 1986-2015. See appendix B for further information on the scientific basis for this assumption. Notably, a doubling of acres burned relative to this thirty-year time period represents only a modest increase from acres burned in the most recent decade for which data was available (2006-2016).

Using the vegetation treatment schedule developed by PRISM, simulation of vegetation change was then projected across five decades into the future, using the SIMPPLLE model. Fifty years is considered a reasonable time period over which to model potential disturbances and succession, and to capture trends in vegetation condition, considering that some drivers of change occur very quickly (such as fire), while others are much more gradual (such as growth and succession). There is an increasing level of uncertainty associated with ecological and social change beyond five decades, especially as related to climate change. Twenty model simulations were run to better capture the variability and uncertainties associated with disturbance events and resulting vegetation change. Therefore, model results for each alternative provide not a single value but a range of values for vegetation condition across the 50-year projection.

Information Sources

This analysis draws upon the best available scientific information found to be relevant to the ecosystems on the Custer Gallatin National Forest. Literature sources that were the most recent, peer-reviewed, and ideally local in scope or at least directly applicable to the local ecosystem were selected and cited throughout. Uncertainty and conflicting literature was acknowledged and interpreted when applicable.

Northern Region Existing Vegetation Database (VMap): Mapping of current vegetation is based on the USDA Forest Service Northern Region vegetation database. VMap is a geospatial dataset developed using the Northern Region existing vegetation classification system (Barber et al. 2011). It is a remotely sensed product that is derived from satellite imagery, airborne acquired imagery, field sampling and verification. Detailed metadata for this database can be found in the project file. The VMap data used for this analysis was updated in 2015. Accuracy of the VMap data varies between 74 and 90 percent depending on the particular attribute (Brown 2016).

Riparian vegetation classifications in the original VMap do not include hydrological features; therefore, more refined riparian and wetland area data sources were incorporated using National Wetland Inventory data provided by the Montana State Natural Heritage Program which also covered the South Dakota portion of the Sioux District. The National Wetland Inventory maps riparian and wetland areas based on aerial imagery, hydrological feature mapping, soils, and vegetation layers.

For the montane units, the National Wetland Inventory map and the Montana State Natural Heritage Program data and riparian extent model were used for inclusion into VMap. Riparian extent was modeled using a tool developed by Forest Service Washington Office personnel for the montane units. The model made use of a lakes and ponds feature class, digital elevation models, 6th hydrologic unit code watershed boundaries, and NetMap streams data. Parameters are applicable to hydrologic considerations of the montane units as opposed to the Pine Savanna units. While the model will also accept hydric soils and hydrologic soil group information, the lack of these available data precluded their use in the mapping effort. Locations within the modeled riparian area that did not intersect with the Montana State Natural Heritage Program riparian polygons were attributed with Northern Region existing vegetation data via intersection. Where upland vegetation was mapped within the riparian corridor, a local classification was assigned denoting that while the location was not classified as containing riparian vegetation, it fell within the riparian corridor (Reid et al. 2018).

For the pine savanna units, National Wetland Inventory map data and refined green ash woodland data (Biswas et al. 2012) were used for inclusion into VMap. Flow regimes and stream orders were used to differentiate between non-riparian green ash woodlands and riparian-green ash woodlands. The riparian extent model used for the montane units was not used for the pine savanna units due to limited application of model parameters.

Forest Inventory and Analysis (forest inventory analysis) and the Northern Region Summary Database: This analysis draws upon measurements collected on spatially balanced forest inventory and analysis grid plots. The forest inventory and analysis grid is a nationwide grid which includes 517 plots on the Custer Gallatin National Forest. This dataset is used to display estimates for the national forest because it spatially represents all National Forest System lands. Forest inventory and analysis plot data is summarized in the Northern Region summary database, which includes statistical reporting functions and derived attributes (Bush 2015, Bush and Reyes 2015, Bush et al. 2016). In 2015, the Northern Region, in collaboration with the Remote Sensing Application Center and Interior West-forest inventory and analysis, developed a set of protocols to re-measure forest inventory and analysis plots after they were burned by recent wildfires. This was done for the Custer Gallatin National Forest plots and used for this analysis.

Aerial Detection Survey (ADS): Survey data and condition reports that estimate levels of tree mortality and defoliation resulting from insects and diseases (USDA Forest Service: Forest and Grassland Health).

Forest Activity Tracking System (FACTS): The Forest Activity Tracking System is the current activity tracking database used to record all management and natural events. Information from this database is used to quantify the extent and type of management actions that have occurred. Currently, both spatial and tabular information is required when activities occur on National Forest System lands. The geographic information tool was used to create the maps of past harvest, fire, and fuels. The forest activity tracking system database is the newest of several activity tracking databases developed over the years and used by the Forest Service in the Northern Region; older records from previous systems such as the Timber Stand Management Record System are incorporated into forest activity tracking system. The earliest activity records date back generally to the 1940s or 1950s, when activity tracking protocols were adopted. Older records are likely not as accurate due to improvements in modern record keeping. Site-specific records of early harvest activities during the initial settlement of the area are not available but are addressed qualitatively using other information sources such as boundary report notes compiled when the National Forest Reserves were first proposed.

Analysis Area

The affected area for effects to terrestrial vegetation is the lands administered by the Custer Gallatin. This area represents the National Forest System lands where changes may occur to vegetation because of management activities or natural events.

The affected area for cumulative effects to terrestrial vegetation includes the lands administered by the Custer Gallatin, as well as the lands of other ownership, both within and immediately adjacent to the national forest boundaries.

The temporal scope of the analysis is the anticipated life of the plan with some analysis occurring across the longer term (50 years), consistent with the analysis period for key ecosystem characteristics associated with the terrestrial vegetation.

Notable Changes between the Draft and Final Environmental Impact Statement

The desired condition for wildfire was restructured and moved from the Forested Vegetation section to the Fire section of the plan, and now includes all vegetation types (not just forested vegetation). The objectives for vegetation management (FW-OBJ-VEGF-01 and FOR-VEGF-02 in the draft plan) were combined and rephrased to express the objective in terms of acres treated rather than projects accomplished. A new objective was added to the Nonforested Vegetation section (VEGNF) that calls for projects specifically designed to benefit vegetation communities such as hardwoods (including green ash and aspen), grasslands, shrublands and woodlands (including limber pine). FW-GDL-VEGNF-01 (in the draft plan) was deleted and intent was captured in FW-STD-PRISK-01 in the final plan. Similarly, FW-GDL-VEGNF-08 was deleted and intent was captured in FW-GDL-GRAZ-05 in the final plan. The final analysis was amended to 1) reflect these changes; 2) include analysis for alternative F; 3) add analysis of the “unconstrained budget” timber harvest scenario; and 4) add clarity and augment best available scientific information where needed. Minor refinements to vegetation modeling parameters were made and are described in appendix B.

3.6.2 Affected Environment (Existing Condition)

This section describes the primary ecosystem characteristics that affect vegetation, ecological integrity and resilience. An ecosystem is defined as a spatially explicit, relatively homogeneous unit of the earth that includes all interacting organisms and elements of the abiotic environment within its boundaries (Forest Service Handbook 1909.12). Ecosystem integrity is the condition where natural ecological composition, structure, and processes are essentially intact and self-sustaining. The ecosystem is able to evolve naturally with its capacity for self-renewal and biodiversity of ecosystems maintained. As such, resilience is a fundamental characteristic of ecological integrity. Ecosystems are described in terms of structure, composition, function, and connectivity (Code of Federal Regulations 219.8). Composition refers to the types and variety of living things. Structure is the physical distribution and character of components of the ecosystem. Function is the processes or interactions that occur among the elements of the ecosystem; connectivity is the spatial linkage among them.

Additional information about the affected environment can be found in the forest plan assessment and associated vegetation specialist reports (Reid 2017a;b, Sandbak 2017, Thornburgh 2017).

Ecosystem Function

The terrestrial vegetation is constantly changing across space and time as a function of ecological processes and disturbances. The primary causes of vegetation change that are integrated into this analysis are vegetation succession, fire (wild and prescribed), forest insects and diseases, and timber harvest. Climate change is also expected to interact with these processes and have a significant impact on ecosystem function as discussed above and within specific topic areas within this section. Complex interactions between these ecosystem processes, climate and vegetation has resulted in the vegetation composition and structure that currently exists, and will continue to drive changes to vegetation into the future as evaluated in this environmental impact statement. Each is briefly discussed below.

Fire (Wildfire and Prescribed)

Fire is a primary ecological process that has created, maintained, and renewed vegetation on the Custer Gallatin National Forest. Fire fulfills many ecological functions, including carbon and nutrient recycling, snag and tree cavity creation, stimulating seeding and sprouting of vegetation, and increasing biodiversity. Natural fire regimes include low, mixed, and high severity fires. The natural range of variation analysis showed that sites in the Warm Dry broad potential vegetation group tended to burn with mixed or low severity, while the Cool Moist group tended to burn with stand replacing severity. All fire types were well represented in the Cold broad potential vegetation group. Table 35 briefly describes the effects of fire on the vegetation of the Custer Gallatin National Forest based on fire regimes (U.S. Department of Agriculture 2010).

Climate strongly influences fire regimes. Historically, extended periods of warm and/or dry conditions tended to be associated with larger, higher severity, and more widespread fires. Shade intolerant, fire resistant species may still have developed into mid and late successional stages where low severity regimes were maintained; as did shade tolerant species in areas spared from fire. Periods of cool or moist climatic conditions tended to be associated with smaller and less severe fires. Long time intervals (such as, 100 years or more) between major fire events were common during such periods, which allowed more shade intolerant forests to develop into the mid and later stages of succession. Fire sets back natural succession at least temporarily, and generally starts vegetation succession over again at an earlier seral stage than what it was prior to the fire.

Table 35. Fire severity effects on vegetation of the Custer Gallatin National Forest

Fire Regime	Severity, Frequency, and Vegetation Type	Fire Effects on Vegetation of the Custer Gallatin National Forest
I	Low to mixed severity, 0 to 35 years. Ponderosa pine, dry-site Douglas-fir and deciduous woodland draws	Open forest, woodland, shrub and savanna structures are maintained by frequent non-lethal fire. This regime also includes mixed severity fire that creates a mosaic of age classes. Low severity fires result in minimal overstory mortality (less than 25 percent of dominant overstory) and small patch size. The forests in this regime were often dominated by ponderosa pine or Douglas-fir; fire maintained these species and promoted open, often uneven-aged, structures. These species reforest gaps created by fire through the survival of fire-resistant seed-bearing trees. These fires also maintained open, dry forest savannas and a shifting distribution of dry limber pine/juniper ecotone communities.
II	Stand-replacing, 0 to 35 years. Grasslands, mixed grass pine savannas, mountain big sagebrush, and Great Plains shrublands	Shrub or grasslands are maintained or cycled by frequent fire; fire typically removes nonsprouting shrubs, tops of sprouting shrubs and most tree regeneration. These fires are important in vegetation communities such as mountain big sagebrush.
III	Nonlethal and mixed severity, 35 to 100+ years. Wyoming big sagebrush, low sagebrush, riparian systems (cottonwood), limber pine/Rocky Mountain juniper, dry lodgepole pine and moist Douglas-fir	A mosaic of ages, early to mid-seral forest stages, and shrub and herb dominated patches is maintained by infrequent fire. Mixed severity fires kill a moderate amount of the overstory, burning with a mosaic of severities but replacing less than 75 percent of the overstory. Highly variable patch sizes are created, with an irregular pattern with an abundant amount of edge. Fire tolerant species often survived fire, with large, old trees becoming prominent overstory components. These fires also resulted in unburned patches that could develop climax conditions dominated by shade tolerant species.
IV	Stand-replacing, high severity, 35 to 100+ years. Moist lodgepole pine, subalpine fir, Engelmann spruce, aspen and sagebrush steppe	Large patches of similar aged forests are cycled by infrequent fire. Stand replacing fires kill most trees (over 75 percent) over a large area. Lodgepole pine regenerates large areas by storing serotinous cones that open under intense heat. Mature lodgepole pine stands on the Custer Gallatin National Forest generally exhibit a high degree of serotiny. Fire return intervals are generally long; however, shorter intervals also occur, and forests may re-burn after dead trees have fallen. Lodgepole pine produces open cones at a young age to re-seed re-burned or understocked patches. Serotiny in fire-prone ecosystems is typically expressed from 30-60 years of age to ensure that seed is available after the next stand-replacing event.

Fire Regime	Severity, Frequency, and Vegetation Type	Fire Effects on Vegetation of the Custer Gallatin National Forest
V	Any severity, 200+ years. Boreal forest, high elevation conifer forest, whitebark pine and subalpine forbs and grasses	Variable size patches of shrub and herb dominated structures, or early to mid to late seral forest occur depending on the biophysical environment and are cycled by rare fire events. These forests often have complex structures influenced by small gap disturbances and understory regeneration. Fires may result in the regeneration of lodgepole pine but also provide suitable sites for the establishment of whitebark pine at the highest elevations. Many sites become dominated by subalpine fir at the later stages of succession.

Adapted from National Interagency Fuels (2010).

Wildfire will often be a greater disturbance (more often move succession to an early seral stage) than prescribed fire because planned fires are designed through the burning plan to use certain wind, temperature, and moisture conditions at the time of ignition and duration of burning to achieve specified vegetative and fuel conditions. Prescribed fire treatments are used to meet a variety of vegetation-related resource objectives, including improving wildlife habitat, stimulating shrub sprouting, reducing stand densities, reducing forest fuels (downed wood), creating early-successional habitat openings, and restoring natural disturbance processes.

Fire also maintains the diversity of vegetation across grasslands, retards or prevents conifer encroachment in meadows and parks, regenerates aspen stands, and is responsible for maintaining the mixture of vegetation necessary on shrublands for wildlife habitat diversity for such species as elk, deer, antelope, sage grouse, and many non-game species.

For much of the last century, wildfire burned less area than it should have relative to the historical condition. This was due to fire exclusion, forest and grazing management, and climate (Hessburg and Agee 2003, Hessburg et al. 2005, Westerling et al. 2006). Roads, railroads, grazing, urbanization, agriculture, and rural settlement all influenced fire exclusion and contributed to substantial structural and compositional changes, particularly in drier forests characterized by frequent, low intensity fire regimes (Belsky and Blumenthal 1997, Hessburg et al. 2005). Since 1940 most geographic areas on the Custer Gallatin National Forest had a fraction of their area burn in any given decade. From 1984 to 2016, the Custer Gallatin National Forest experienced an average yearly fire deficit of approximately 46,500 acres (McHugh and Finney 2019). The consequences of this departure included:

- Fire in many dry forests, especially in Ashland and Sioux Geographic Areas, shifted from low-severity, high frequency to less frequent, moderate and high-severity, with increases in uncharacteristic large-scale stand-replacing fires (Lehmkuhl et al. 2007). Some research questions these conclusions and suggests that large-scale stand-replacing fires were historically more frequent on the landscape (Baker and Ehle 2001), however, the overwhelming majority of research supports the low severity, high frequency paradigm (Fule et al. 2013). Fires of higher severity can kill fire-resistant seed-bearing trees, disrupting the ability of these forests to regenerate. Large fires in 2006 and 2012 in the Ashland Geographic Area reduced forest cover by 47 percent (U.S. Department of Agriculture 2014a).
- Higher elevation moist forests of the montane ecosystems, which are often dominated by lodgepole pine and subalpine fir, naturally have a long fire interval with higher severity fires (Fischer and Clayton 1983, Arno et al. 2000). Changes to the natural regime are less pronounced than in frequent interval fire regimes (Schoennagel et al. 2004). However, at the landscape scale, fire suppression in lodgepole pine may induce mosaic homogeneity in forests that previously contained a

heterogeneous mix of age classes (U.S. Department of Agriculture 1990, Barrett 1993). In these areas fire suppression had the effect of decreasing acreage burned in normal fire seasons and reducing the variability in landscape patterns.

- Mixed-severity fire regimes experienced changes described for both low- and high-severity regimes. Fire exclusion reduced stand and landscape diversity in subalpine forests so that vegetation aged more uniformly and became less diverse, resulting in stand replacing fires that regenerate extensive areas that were mosaics historically (Barrett et al. 1997).
- Fire regimes in non-forested areas changed in large part due to conifer encroachment that has resulted from fire exclusion, grazing, and climate (Heyerdahl et al. 2006). In areas that historically had a mosaic of grasslands and shrubland with islands or scattered individual conifers, the tree cover has increased exponentially. This is especially prevalent in the Pine Savanna and dry site Douglas-fir/grassland habitats and is largely due to the lack of frequent fire that would have killed conifer seedlings. Climate conditions prior to the 1980s would also have been conducive to the growth of conifers occupying grassland habitats.

On the Custer Gallatin National Forest, increasingly large fires have been occurring since 1980. The increase may be due to 1) fuel buildup in low-severity regimes; 2) the influence of a warm and dry climate on vegetation, fire behavior, and effectiveness of suppression; and 3) fire policies that have allowed natural fires to burn in some areas. The increase in acres burned is consistent with the regional climate shift (Marlon et al. 2012), and a trend of acres burned occurring throughout the western United States.

Fire suppression will likely continue to alter successional processes, generally to favor shade-tolerant species, although vegetation treatments and wildfires may mitigate this influence somewhat. Warmer, drier climates will influence species distributions and successional processes in complex and uncertain ways. For example, species better adapted to warm, dry conditions such as ponderosa pine may gain a competitive advantage in some areas. Vegetation composition influences, and is in turn influenced by, spatial heterogeneity of landscapes and interrelated ecosystem drivers.

Recent large fires have changed the amount and pattern of forest cover across much of the Ashland and Sioux Geographic Areas and smaller proportions across the other districts. Even though many areas of forested cover types burned in recent fires, there is only a minor component of that that is considered as transitory rangeland. Transitory rangelands will shift to more grass and forb species and will eventually shift back to shrubs and tree cover over time. This shift back to tree cover is estimated to take about 20 to 80 years plus, depending on the seed source that remains post-fire. North, northeast, and east aspects will likely sprout mesic shrubs with very little grass forage. West, southwest, and south aspects will likely express a grass/forb cover longer.

The effects of warmer climate may have been more than counteracted by fire suppression activities in the last century, with the net result being an increase in the frequency of succession from grasslands to shrubland, especially shrublands dominated by mountain big sagebrush.

Both fire regime and impacts of fire are assessed as part of watershed condition framework (U.S. Department of Agriculture 2011d). Only 56 (29 percent) montane and 22 (27 percent) pine savanna watersheds are within their natural fire regime or within fully functioning condition, if recently burned. One watershed across the Custer Gallatin National Forest was rated as impaired function, with the vast majority (194) of Custer Gallatin watersheds rate as functioning at risk with respect to fire regime.

Overall, fire suppression has resulted in an increase in conifer colonization into grassland, shrublands, and broadleaf woodlands such as green ash and aspen. Without periodic disturbance, these cover types may be replaced by conifers. Mountain and Wyoming big sagebrush are sensitive to colonization by conifers; studies have shown that in southwestern Montana, mountain big sagebrush is declining due to competition from Douglas-fir and Wyoming big sagebrush is declining due to competition from ponderosa pine. Douglas-fir and ponderosa pine expansion into grass and shrub communities may in part reflect natural ecotone dynamics, but past overgrazing, climate changes, and fire exclusion have likely caused more extensive colonization than would be present naturally. In the absence of natural fire both Rocky Mountain and Utah Juniper is likely more widespread and abundant than it would have been historically in moister sites. Rocky Mountain and Utah juniper expansion can lead to the decline of grass and shrublands and result in altered fire regimes. On xeric sites, fire may never have been as important an influence as climatic fluctuations in governing the rate of tree invasion of shrubland or grassland because of the lack of undergrowth to act as fuel. Moister, more productive sites probably had more extensive and frequent fires when droughty periods occurred (Bradley et al. 1992).

There is potential that wildfire may play a larger role in shaping vegetation in some areas, perhaps promoting non-forested vegetation communities, particularly given warmer climate regimes. Warmer temperatures will likely result in increased fire size and severity, creating more favorable conditions for invasive species, which would likely decrease overall forage quality and biodiversity. Grasses generally recover well following low to moderate severity fires. Some grasses, such as Idaho fescue, may decline following high severity fires. The outcome after a fire varies depending on species present before the fire. Fire combined with prolonged drought periods can shift the species composition and increase noxious weed.

Insects and Disease

Grassland and shrubland ecosystems worldwide are prone to infrequent and periodic outbreaks of native insect herbivores and are a natural part of these ecosystems. Grasshoppers and Mormon crickets are the most common types which contribute significantly to the structure and function of grasslands and other rangelands (Branson et al. 2006). These outbreaks occur periodically on the Custer Gallatin National Forest. The outbreaks can be anywhere from unnoticeable to exceeding 200 insects per square yard. The outbreaks tend to be more prevalent during periods of drought. Grasshopper outbreaks (Kemp and Cigliano 1994) can have severe economic impacts on the grazing industry, especially during periods of drought when available forage is already scarce (Hewitt and Onsager 1983). In general, since most insect infestations are short-lived (a year or two in the same area), the effects on rangeland vegetation are a defoliation (partial or complete) of the current year’s plant growth, but vegetative community succession is seldom affected.

Climate, especially drought, is thought to play a key role in outbreaks of grasshoppers and other insect species on rangelands, but the underlying mechanisms are poorly understood (White 1976, Gage and Mukerji 1977, Capinera and Horton 1989, Kemp and Cigliano 1994). Drought can have both direct effects on the growth and survival of insects and indirect effects via changes in food quality and susceptibility to disease.

Non-severe drought and warm temperatures generally have a positive effect on grasshopper populations. Warm, dry weather in winter and early spring can lead to increased survival, early egg hatch, and faster population growth; warm, dry weather in the fall can extend the life of females and allow them to produce and lay more eggs (Joern and Gaines 1990). Moreover, grasshoppers often prefer to feed on drought-stressed plants, partly due to drought-induced changes in plant chemistry (Haglund 1980, Lewis 1982, Bernays and Lewis 1986). Drought could further promote grasshopper populations by reducing incidence of disease, especially due to fungi as many fungi require moisture (Hajek and St Leger 1994, Finch et al. 2016). However, extreme or prolonged drought can negatively affect grasshoppers through desiccation (especially eggs) or by killing their food plants (Farrow 1979, Joern and Gaines 1990). Therefore, short-term, less severe droughts can increase grasshopper outbreaks, but longer-term, severe droughts will likely have a strong negative effect on grasshoppers and rangeland and grassland biodiversity in general (Tilman and El Haddi 1992, Kemp and Cigliano 1994).

Grasshoppers and Mormon crickets are always present in any given year, but populations change in terms of relative abundance on the landscape. Outbreaks have been known to occur. There has not been any recent insecticide use by the Animal and Plant Health Inspection Service to control and reduce grasshopper or Mormon cricket populations on the Custer Gallatin National Forest, although periodically there have been proposals in and near the Ashland Ranger District.

In the forested ecosystems of the Custer Gallatin National Forest, insects and diseases are important ecosystem drivers as they can influence vegetation on a local and landscape level. There are many insects and diseases that affect the forested vegetation on the Custer Gallatin National Forest. Most of these are native and exist at relatively low population or intensity levels that do not cause notable impacts or have limited localized effects. Insects and diseases can reduce tree growth or result in mortality of specific species or size classes. A few, such as bark beetles can have a more substantial effect as small groups of trees or entire hillsides can be killed in one year. Over time these agents can change forest compositions and structure. The report on the assessment of terrestrial vegetation (Sandbak 2017) provides a detailed description of current conditions for key insects and diseases found on the Custer Gallatin National Forest. Maps A1.5 to A1.9 in appendix A of the terrestrial vegetation report (located in the project record) display cumulative infestations for insects of concern from 2000 to 2015 by geographic area.

Balsam woolly adelgid, *Adelges piceae,* is a non-native pest of true fir species detected within the Madison, Gallatin and Henrys Lake Geographic Area. Susceptibility of true fir species to balsam woolly adelgid varies widely within and among species. Of the native western North American fir species, subalpine fir is the most susceptible. Within five years of infestation, up to 90 percent of stands dominated by subalpine fir died in western Oregon and Washington (Mitchell and Buffam 2001). Five years after balsam woolly adelgid was first detected in Idaho, nearly 60 percent of the subalpine fir died and within 18 years of infestation about 95 percent died (Lowrey and Davis 2018). Host susceptibility is probably influenced by genetic variation within species and environmental effects on the host-agent interaction (Newton and Hain 2005). Generally, larger and faster growing trees on preferred growing sites may be infested before suppressed subalpine fir (Mitchell and Wright 1967). There is a signature for balsam woolly adelgid damage and mortality visible during aerial detection surveys for insects and diseases and it was recorded during aerial detection surveys in 2017 in Gallatin County near the Idaho border, this was after it was confirmed on the ground. Damage from this pest is often not detectable from air until 30 to 50 percent of the stand is damage. Management options are limited for this pest. Biological control attempted between 1957 and 1964 (Mitchell and Wright 1967) may not have controlled populations because of possible confusion about the actual origin of this pest and less effective predators may have been introduced (Montgomery and Havill 2014). Insecticides are effective at controlling balsam woolly adelgid, however they are generally limited to urban forests or developed areas and not a realistic option at landscape scales. Silvicultural options have not proven effective management for balsam woolly adelgid, possibly because this insect can reproduce on true fir of all age classes and disperses passively by wind, birds and mammals. Except for white pine blister rust and balsam woolly adelgid, the insects and pathogens on the Custer Gallatin National Forest are native and have co-evolved with their hosts over millennia. Through selective killing or reducing growth of trees, they influence structure and composition which affects other processes such as fire. They benefit plants and animals that utilize dead or modified wood, or feed on insects or pathogens. These agents have a role in maintaining soil fertility. Climate and weather play a major role in controlling insects, as does availability and quality of food and breeding habitat. Historically, insect populations would periodically build to high levels under favorable climatic and host conditions. Frequency of epidemics varies by species and locality. Cool climate conditions, such as those that predominated from the 1940s through the 1970s, were not conducive to outbreaks. The current warm/dry cycle correlates with the increased extent of outbreaks since the 1980s. Human actions such as fire suppression, past logging practices, and land development in conjunction with succession influence vegetation, which influences the population or intensity of insects and diseases. Higher stand densities increase stress and competition for resources, which renders trees less able to resist insect and diseases.

Invasive Species

Establishment and spread by aggressive non-native invasive plants, is one of the greatest threats to the ecosystems in Custer Gallatin National Forest. Aggressive non-native invasive plants have the potential to alter ecosystems by outcompeting and displacing native plants. Invasive plants have been found to impact wildlife habitat by decreasing the amount of forage, change fire frequency by forming dense stands of flashy fuels, and change soil characteristics by altering soil nutrients. Presence and abundance of invasive plants are a key indicator of condition in grasslands, shrublands, open canopied woodlands and riparian existing cover types (under 9000 feet elevation and less than 65 percent tree canopy cover) which covers about 1.8 million acres, or 53 percent of the Custer Gallatin. These ecosystems are vulnerable to aggressive invasive plant establishment and spread. There are an estimated 58,000 acres of weeds on the Custer Gallatin (Larmont and Reid 2017). The average annual infested acres treated by chemical, biological, mechanical/physical or cultural control methods are about 4,500. This number does not reflect actual infested acres impacted by biological control agents or acres not infested because of preventative measures.

Warmer and drier climate trends are predicted to accelerate the pace of spread by invasive plant species. Anticipated higher fire occurrence and resulting fire effects is also likely to accelerate the pace of spread by invasive plant species. With projected increasing average annual temperatures over the coming decades coupled with continued and/or increasing drought will likely further noxious weed spread along with increase in abundance and density. As springtime temperatures increase, the extent and magnitude of cheatgrass infestations may increase. Continued noxious weed treatment emphasis along spread pathways (predominantly along travel routes) and in rare or special habitats is needed (that is, big game winter ranges, greater sage-grouse habitat, research natural areas, special areas, wilderness study areas, wilderness areas). Invasive plants have not been a serious problem in the alpine settings of the Custer Gallatin National Forest, although a minor amount of yellow toadflax and Canada thistle are present above 9,000 feet and has the potential to invade such areas in the future.

The emerald ash borer, a beetle native to Asia, was first found in North America in 2002 in southeastern Michigan. Across the United States, emerald ash borer has killed tens of millions of ash trees and poses a serious threat to the green ash resources. The broad distribution of emerald ash borer is largely due to the inadvertent movement of infested ash commodities, especially before its original detection. Emerald ash borer was recently detected in eastern South Dakota and northern Colorado and could pose serious threat to the health of green ash resources on the Sioux and Ashland Districts if transported to the area. In its native range emerald ash borer does not cause serious damage to ash trees, however, due to lack of host resistance by North American ash trees as well as lack of predators and parasitoids, emerald ash borer has had a significant impact on the ecology and economy of infested areas.

Herbivory

Herbivory is a disturbance agent typically in rangeland ecosystems. Its effect on succession depends on a number of factors including the level of grazing, timing, frequency, kind of herbivore, and existing seral condition of the vegetation. Herbivory effects can be from grazing and browsing by livestock, bison, big game animals, beaver, and other wildlife.

Bison

Bison were common before settlement, and the density of cactus and lack of grass reported by explorers and trappers suggests that grazing was severe in some areas (Lesica and Cooper 1997). By the middle of the 19th century, bison were exterminated, and cattle replaced them as the primary grazers. In the latter part of the century, livestock grazing was also severe up until the crash of the industry following the winter of 1887 (Lesica and Cooper 1997). Lesica and Cooper (1997) found no evidence that livestock grazing had any greater impacts on the upland vegetation than grazing by bison and that there may be more grass now than before settlement or the end of open range. However, some of the changes in riparian or terrace vegetation in the past 100 to 150 years may be due to differences in grazing behavior between bison and cattle. Early descriptions of bison grazing in southwestern Montana suggest that they spent little time in riparian areas but grazed primarily in the uplands. On the other hand, livestock spend a good deal of time grazing in riparian areas during summer. Declines in some willows may also be partly attributed to livestock grazing (Tucker Schulz and Leininger 1990, Bryant et al. 2004).

Livestock

Currently, approximately 22 percent of the Custer Gallatin National Forest consists of primary rangeland where permitted livestock generally graze (8 percent of the montane units and 86 percent of the pine savanna units). Current prescribed stocking rates, use levels, season of use, and duration of use are well below what existed before the establishment of the Custer and Gallatin national forests. As an example, a summary of historical grazing records for the Pryor Mountains indicate that current forage offtake by permitted livestock is about 14 percent of the use that was occurring in the early 1900s. During the 40s to 60s, stocking rates were reduced, seasons of use were shortened, and cross-fencing for pasture rotation to increase the opportunity for rangeland recovery occurred. Further seasonal restrictions occurred to improve entry dates relative to rangeland readiness. Based on monitoring, other more recent stocking rate reductions have been implemented on several allotments, typically ranging from 10 to 30 percent and as high as 50 percent.

Since the 1986 forest plan timeframe, animal unit months permitted on the Custer Gallatin have decreased 23 percent. Animal unit months permitted on the Gallatin portion of the Custer Gallatin National Forest have decreased 42 percent and animal unit months permitted on the Custer portion have decreased 19 percent. The changes in Gallatin units were primarily due to closing long-standing vacant allotments as well as some stocking rate adjustments. The changes in the Custer units were primarily made to respond to range readiness issues and carrying capacity and stocking rate issues.

For a variety of reasons, 60 allotments (primarily cattle) have been formally closed on the Gallatin portion of the Custer Gallatin National Forest since the 1986 forest plans. Nine of the 60 closures were done through decisions made in the 1986 forest plan while the remaining 51 have been closed since then. Closures were typically done after years of allotments being vacant and were based on allotment viability, logistics, and economics of operations, limited access, ownership changes from land exchanges, failing infrastructure, grizzly bear conservation, and other wildlife considerations.

High historical levels of grazing use across the Custer Gallatin National Forest a century ago were responsible for maintaining large acreages in early to mid-seral condition and for over-utilization in many areas. Reducing grazing use over the last several decades has contributed to improving primary rangelands and plant structure needs of other animals such as for nesting birds, invertebrates, fawn cover, etc. Properly managed by vegetative type and within habitat capacities, ungulate herbivory tends to provide for a mix of seral stages and plant structures across broad landscapes. High-intensity use, repeated use during times of rapid plant growth, frequent use of individual plants or plant communities, or longer periods of use tend to push vegetation toward the early-to-mid stages with lower plant structure. Lighter, shorter, or less frequent use tends to result in a higher percentage of mid and late seral stages with higher plant structure.

Big Game

Big game populations are less predictable. Higher numbers of big game species will move or maintain more acres of rangeland vegetation to an early or mid-seral condition (for example, elk in the meadows and more open grassland types, deer, and antelope in shrublands, grasslands and riparian areas, and moose in riparian, wetlands and willow stands); lower numbers of big game allow more acres to move to a late seral stage.

In addition, seasonal use, such as big game moving up in elevation or turning livestock out too early following spring green-up, can result in herbivory when plants are most vulnerable. This can set back succession and damage wet soils. In the same way, seasonal and intense use on palatable shrubs such as willow can retard succession and result in undesirable vegetative or soil conditions.

Browsing and grazing of mesic shrubs and deciduous broadleaf seedlings can be detrimental to successful stand establishment and maintenance. Some areas may need to be fenced, depending upon extent and location of burned or treated areas or otherwise managed to control use by cattle and wild ungulates until the young trees are big enough to avoid being detrimentally grazed or browsed, which can be when a tree is over 10 feet tall in elk habitat and with a fairly strong bole (girth).

Currently in Montana, elk and deer populations are generally stable to increasing across the Custer Gallatin and moose populations are declining in some areas. On the Ashland and Sioux Districts, elk numbers have increased. In South Dakota on the Sioux Ranger District, elk have recently established breeding herds with an estimate of 150 animals within the greater northwest corner of South Dakota (all land ownerships) (Deisch, 2019a personal communication). Wintering populations of a variety of wildlife species in the Gardiner Basin are causing high use levels on some areas of winter range that in turn result in heavy use of riparian areas and hay fields on deeded lands below the Forest. There is potential for further grazing pressure in the north and west bison tolerance zones on the Gardiner and Hebgen Lake Districts.

Beaver

Beaver are key agents of riparian-wetland succession because the dams they build act as hydrologic modifiers. When a beaver dam is constructed, a flowing stream can be changed to a pond. This in turn can lead to aggradation of the channel, establishment of floodplains, and raising groundwater levels. Elevated water tables also help to keep water in areas that would be otherwise dry during summer months and during drought. This helps to sustain plant and animal life and has been shown to increase productivity of a variety of species (Bouwes et al. 2016).

Riparian shrublands typically occupied by dense willow or riparian shrub cover has often been associated with beaver activity where the slope is flat, but enough to move water through the system of stable dams. Generally, there is little herbaceous undergrowth due to the high shrub canopy cover. Associated community types include all tall and low willow types, alder, birch, red osier dogwood, and hawthorn, etc. (Hansen et al. 1995). Other deciduous broadleaf riparian shrubs and trees also contribute material and food needed for beaver habitat. There are ongoing beaver relocation projects within the Ashland and Sioux Geographic Areas that have resulted in the establishment of dams and improved riparian conditions in some areas.

Historically, riparian communities developed in close proximity to water and were more extensive (structurally and geographically) than those which currently exist due to channel impacts and plan land allocations such as railroads, log drives, diversions and dams, river recreation, timber harvest, improper grazing, and beaver trapping (Dodds et al. 2004, Wohl 2005). Beavers were instrumental in the creation and maintenance of willow, alder, birch, and aspen stands. Water table during historical times were much closer to the surface due to the creation of beaver ponds therefore, soil moisture was more available to support extensive stands of riparian vegetation. Wildlife, primarily bird species, which are tied to riparian communities were probably maintained at a higher population level than those currently documented. In some locations, historic floodplains now appear as dry upland benches, which support little if any riparian vegetation.

The scarcity of cottonwood early in the 19th century appears to be due to beaver (Lesica and Cooper 1997). By the middle of the century, beaver populations had been greatly reduced by trapping, and cottonwoods were able to mature in many riparian areas. Extensive stands originating during the last 100-150 years are now declining. These declines, in part, may be a natural result of tree age. However, decline and an apparent lack of adequate recruitment along some reaches is probably a result of diversion and impoundment (Lesica and Cooper 1997) and domestic and wild ungulate browsing effects.

The near elimination of beaver not only affected the storage and release of water in streams, but also resulted in changes in the riparian vegetation. As dams broke and water tables lowered, vegetation once associated with saturated soils (for example, willows) began to die out. This in turn allowed for greater penetration of the streamside zone by livestock, which accelerated the decline in woody vegetation by browsing and structural damage.

Willows dominated riparian areas along smaller order streams. Beaver decreased willow abundance, but they increased available willow habitat by raising the water table over substantial areas. The decline of beaver due to trapping in the late 19th century likely caused a decline in willows in headwaters areas (Lesica and Cooper 1997).

Beaver populations have declined across much of the Custer Gallatin due to reductions in woody forage species from livestock grazing impacts, mining, road construction, and access related activities. Due to human conflicts with beavers in drainages with roads, beaver are often trapped and eliminated or trapped and translocated by state agencies. Fire suppression is also a factor as riparian areas can convert from the cottonwood, aspen, green ash, and willow species preferred by beavers towards coniferous tree species under the prolonged absence of fire. This reduction in beaver populations and activities creates an altered system that is less able to absorb or compensate for factors that add stress to aquatic systems. Trapping was likely a factor in beaver decline along individual streams, but habitat degradation would need to be addressed before recolonization would occur.

Pollinators

Plants such as flowering shrubs, legumes, forbs, and wildflowers provide consistent foraging habitat during the spring, summer, and fall. Pollen (usually moistened with nectar or floral oil) is used to feed larvae, and nectar is used to fuel the flight of adults. Many pollinators are active above ground as adults for only a few weeks or months. Pollinators require a reliable protein source (nectar and/or pollen) during their active period (generally late April through early October) to carry the adult and offspring through the winter to the next blooming period. Relatively undisturbed conditions with suitable ground and/or nest structure provide nesting sites. Nest sites are important because the further the pollinator must travel the more nutrients the pollinator uses. If the pollinator travels long distances to a “poor” food source, and if the pollinator is stressed, then the pollinator may be more susceptible to environmental factors such as parasites and disease resulting in possible starvation or possible reproductive decline. The average foraging distance for native pollinators ranges from approximately 50 feet to ½ mile. The optimal foraging distance for nonnative pollinators, such as the European honey bee, is approximately three-quarters of a mile to one mile from the colony (U.S. Department of Agriculture 2008).

There is concern that pollinators may be declining at a global scale. Though there are knowledge gaps about the status of most of North America's pollinators, what data does exist suggests that numerous species of invertebrate pollinators are experiencing declines similar to or more severe than the declines seen in honey bees and these declines can impact crop yields and native plant communities (Kevan 1977, Watanabe 1994, Allen-Wardell et al. 1998, Kearns et al. 1998, National Academies Press 2007, Colla and Packer 2008, U.S. Department of Agriculture 2015d). Honeybee populations have experienced steep declines, but there is less information on native bee species. It might be expected that the regional bee fauna as a whole may also show signs of long-term decline, though it could also be possible that despite changes on the landscape, bee species are able to persist in similar levels of diversity (Marlin and LaBerge 2001). One-quarter of North America's bumble bees have experienced significant declines (Hatfield et al. 2015), including declines in species that were formerly some of the most common species (Evans et al. 2008, Grixti et al. 2009, Cameron et al. 2011). Though there is limited data available about all pollinator species known to occur on the Custer Gallatin, the species present may face similar threats and declines.

Pollinators encompass a broad range of habitat requirements on the Custer Gallatin and National Forest System lands have the potential to provide resources needed for all life stages (such as, host plants, nectar plants, and overwintering habitat for butterflies). The general conditions that support pollinators on a landscape are pollinator food sources, shelter and nest sites, habitat heterogeneity, and landscape connectivity. Native plant species and plant community composition requirements vary for different groups. Insect biology influences species needs and ecological roles on the landscape.

The different sizes of bees allow for differences in distance traveled for forage, life cycles and habitat conditions. Strong fliers, such as bumblebees and honeybees, often forage great distances from their hives in order to exploit the most rewarding floral patches. By contrast, weak-flying pollinators, such as solitary wild bees and some butterflies, may have limited ranges and forage for resources only near the nest or roosting site. Species also have specific times for flower visits, such as early or late morning, which is influenced by light intensity (Shelly et al. 1993). Therefore, a habitat fragment may entirely support a population of small bees, support part of a population of mid-sized bees, or act as a single island of resources for large-bodied bees. Taken together, nesting substrate, diet breadth, and foraging range strongly characterize the habitat requirements bee species have and may predict their response to habitat fragmentation (Cane et al. 2006, Gilgert and Vaughan 2011).

Flowering plants are important sources of nectar and pollen for pollinators. A diversity of flowers with a succession of bloom throughout the growing season across different habitat types benefit wild pollinators such as solitary bees and monarch butterflies, as well as managed honeybees, which benefit from a diversity of pollen sources to maintain a healthy immune system (Smallidge and Leopold 1997, Hoffman Black et al. 2011). The availability of floral resources influences the abundance and diversity of butterflies and bees in studies of roadside habitats and grasslands. Bees have floral guilds—a specific group or type of flower resource they use for forage; some pollinator species have very specific habitat requirements that differ between sexes and life stages and could depend entirely on a single plant species, while other species have much more generalized habitat requirements. Pollinators that specialize are more likely to be at risk than generalist pollinators (Allen-Wardell et al. 1998, Cane 2011). Others are much more liberal in their tastes, but in either case, managing for diverse plant communities for native bees will greatly assist in increasing the abundance of butterflies and moths (Gilgert and Vaughan 2011). A lack of forage is frequently cited as a primary contributing factor to declines in honeybee health (National Academies Press 2007). Maintaining diverse and healthy grasslands ecosystems in various seral stages benefits pollinator species. Especially for ground-nesting bees, it seems that carrying capacity in a given habitat is constrained by limited pollen and nectar resources rather than inadequate nesting opportunities (Roulston and Goodell 2011).

Invertebrate pollinators also require shelter sites for nesting or egg-laying, or overwintering habitat. Most species nest underground or nest aboveground in old beetle tunnels in deadwood or pithy or hollow dead twigs or stems. Bees provide for their young by constructing nests in which their offspring develop. Many ground-nesting bees prefer to nest in sunny, bare patches of soil. Such patches can be found around the bases of native bunch grasses that tend to grow in dense bundles, leaving small areas of bare ground exposed between plants. Ground-nesting bees can be more common in roadsides with native plantings in contrast to areas with a tight sod of brome or other nonnative cool season grasses. Vegetation also provides habitat for tunnel-nesting bees, which nest in hollow or pithy stems or other small cavities. Bumble bees require a small, insulated cavity, such as underneath grass clumps or under the thatch of bunch grasses (Hatfield et al. 2012). The breeding and overwintering habitat needs are less understood for other groups of pollinators, but syrphid fly species and soldier beetles have been recorded as overwintering in soil or litter (Schaffers et al. 2011). Butterflies and moths may also utilize similar areas as overwintering habitat or shelter.

Habitat heterogeneity is critical on the landscape to maintain populations of pollinators. The resources needed by many insect pollinators, including mates, nectar and pollen, nesting materials and larval food plants, may occur in different habitats in the landscape. For example, different pollinator guilds (bumblebees, honeybees and large wild bees) prefer patches of different qualities in the mosaic of habitats in an agricultural landscape (Artz and Waddington 2006). Butterfly habitats commonly deteriorate through a reduced intensity and frequency of long-term disturbance regimes or management patterns that result in smaller and fragmented patches of early successional habitat. Many butterflies are more abundant in open sunny woodlands over shady woodlands (Smallidge and Leopold 1997), making them at risk of declining in areas of conifer encroachment and fire suppression. Bumblebees have been documented to have higher fitness in areas that have a meadow complex that provides a variety of habitats over isolated meadows that have a burst of floral resources that quickly disappear as the flowering season progresses. Bumblebee mobility and the varied habitats (such as, difference in wetness, flowering phenology) increases the probability that floral resources would be available throughout the season and is shown to support a more diverse and abundant bumblebee community than single meadows (Hatfield and LeBuhn 2007).

Landscape connectivity on the Custer Gallatin National Forest is important for the populations of many species, because due to urbanization, agricultural intensification, and other human activities, habitat is becoming increasingly fragmented, which is known to have strong effects on pollinator communities and plant visitation (Steffan-Dewenter and Tscharntke 1999, Wettstein and Schmid 1999). Large uninterrupted tracts of native vegetation, such as on the Custer Gallatin, provide areas of refuge for pollinators in an otherwise fragmented habitat. Wild habitat heterogeneity reflects variation in natural habitat types, while habitat fragmentation is caused by human disturbance (such as, farms, grazing, and development). Land use intensification and habitat fragmentation do not only affect pollinator diversity and abundance, but also the effectiveness of pollination services (Jennersten 1988). Moreover, the distance of insect-pollinated populations to high-quality habitats for pollinators affects their pollination and reproductive success (Steffan-Dewenter and Westphal 2008). Habitat fragmentation can result in the local extirpation and extinction of species by several mechanisms acting alone or in combination. Such mechanisms include invasion by exotic competitors or predators, reduced immigration, disturbance in the surrounding matrix, edge effects, changes in community structure, and reduced population sizes (Turner 1996). The Custer Gallatin contains more areas of native plant diversity than adjacent lands and are generally excluded from development and major permanent disturbances. In densely forested landscapes, National Forest System roadsides may provide areas of additional forage for pollinators in an otherwise limited environment.

Climate change is expected to affect the range of pollinators, the range of their food (native plants), the timing of their food (phenology of wildflowers shifting to earlier in the season), and the gap that can exist between when food is available and when the pollinator species are present on the Custer Gallatin over time. Growing seasons of native plants at high elevation sites are usually much shorter in duration than at lower elevation sites. A one-week shift in flowering at a subalpine meadow with a six-week flowering period may have a more significant effect on network structure compared to the same shift in a lower elevation site with a twelve-week long flowering season. Some pollinators may be unable to shift with their key plant species. Plant species have been observed over the past couple decades shifting spatially toward the poles (higher latitudes) as well as flowering earlier in the growing season. Climate can also influence changes in rainfall type and precipitation amount, temperature (which corresponds with pollinator activity), water availability and snowmelt, timing of flowers and floral rewards, and habitat composition (Bronstein et al. 1990, Burkle and Alarcon 2011). Precipitation is a primary factor controlling plant growth and flowering in rangelands, specifically shifting patterns, frequencies, and durations and intensities of droughts, as well as various human water-extraction schemes. The timing and amounts of soil moisture strongly impacts the rangeland wildflower communities upon which bees depend (Cane 2011). Shifts in precipitation amount, seasonality, and variability under future climates remains highly uncertain. Climate change is expected to change the composition of pollinator communities, but effects and pollinator ability to adapt to these changes are uncertain.

Succession

Vegetative succession is the sequential process of long-term plant community development. It entails the change in the composition and structure of plant communities over time, and is based, in part, on the set of environmental conditions under which it will reproduce and grow. Over time ecological succession can result in the conversion of one vegetation type to another.

The successional process follows a pathway with each major step referred to as a seral or successional stage. In a simplified model for a coniferous forest, early successional stages follow a stand-replacing disturbance. Plants immediately start colonizing the site; this is known as the establishment phase. Then follows a series of intermediate successional stages, referred to as mid- and late-successional stages, where established species grow larger and denser based on-site capability. During these stages, new plants may be inhibited by high site occupancy or initiated in gaps as competition-based mortality occurs. Changes in environmental conditions and competition for resources cause some species to decline and others to expand. The classical model of succession culminates in the climax community, a state of relative stability in composition, structure and function, with all existing species able to perpetuate themselves without disturbance.

Plant species are often distinguished as playing either an early- or late-successional role. Species with traits that enable rapid colonization of a site after a disturbance are early successional. They are less shade tolerant, able to flourish under full or nearly full sunlight, and have rapid early height growth. Ponderosa pine, lodgepole pine, aspen, and whitebark pine are early successional tree species on the Custer Gallatin National Forest. In non-forested communities, early seral plants include grasses or forbs that re-sprout quickly. Late successional, or climax, species are typically shade tolerant, capable of reproducing and growing in shady conditions. Douglas-fir, Engelmann spruce, and subalpine fir are climax tree species on the Custer Gallatin National Forest. Late seral non-forested species include woody shrubs that re-seed more slowly, such as sagebrush. Species can play multiple successional roles depending on site conditions and species associations.

In disturbance-prone ecosystems (such as the Warm Dry potential vegetation type) the climax state may rarely be achieved because succession is interrupted by disturbances such as wildfire. Therefore, long-lived, fire tolerant early successional species are influential. They may survive wildfires to grow large and become prominent features of the overstory canopy, providing structural components of late successional forest.

Successional pathways are complex and the rate of change can be variable; simplification of the process is necessary for analysis. The evaluation of forest size classes provides a proxy to evaluate successional change of forests over time. The early successional stage is characterized by the seedling/sapling size class. As trees grow, they transition from smaller size classes into larger size classes. Mid-successional forests are associated primarily with the small and medium forest size classes, but in some cases forests in the large size class are also mid-successional, depending on tree ages and species. Late-successional forests are associated mainly with the large forest size class.

About 65 percent of the Custer Gallatin National Forest lies within some type of designated area including wilderness, inventoried roadless areas, research natural areas, or wilderness study area.

Special area designations tend to reduce the amount of human-caused disturbances, so generally succession of vegetation tends to proceed toward late seral conditions in these areas (barring setbacks from natural disturbance). Wilderness areas, wilderness study areas, and research natural areas are generally managed to promote "natural" succession and disturbances.

Harvest

Timber harvest is defined as the removal of trees for wood fiber use and other multiple-use purposes (FSM 1909.12_zero_code and 36 CFR 219.19). Harvested trees are typically but not always utilized commercially. Harvest activities are utilized to meet multiple resource objectives as allowed for in national forest land management plans, which include providing for jobs and wood products to communities; improving forest health, vigor, and productivity; and providing for vegetation diversity. More recently this tool is used to assist in restoration of ecosystem processes, improve resilience, promote certain wildlife habitats, and/or to reduce or alter fuels to modify or change fire behavior. The following is summary of timber harvest on the Custer Gallatin National Forest since 1940 based on the FACTS database. See Thornburgh (2017) for a more detailed description of the affected environment related to historic timber harvest including acres of harvest by harvest type within each geographic area. The Timber section in Volume 2 further discusses the affected environment relative to timber harvest.

Timber harvest consists of three general types. Table 36 provides a summary of how treatments generally affect vegetation.

Table 36. Description of harvest types and effects

Treatment	Description
Even-aged regeneration harvest	Even-aged regeneration harvest includes clearcuts, seedtree, and shelterwood cuts with or without reserves. These cuts remove the majority of overstory trees and allow new seedlings to establish. The size class changes to seedling/sapling, in either a single or two-storied structure, initially with low canopy cover. Cover type and species presence may change. Woody material (for example, downed wood, snags) may change, often but not always reduced. Natural regeneration and/or tree planting occurs, which influence species composition and forest density. Later, non-commercial thinning may occur in sapling stands, reducing densities and affecting species compositions and structure over the long-term.
Uneven-aged regeneration harvest	Single or group selection are types of uneven-aged silvicultural systems, which establish a new seedling/sapling size class and may change species composition. Unlike even-aged regeneration harvest, the conversion of the existing stand occurs gradually over many decades, creating a multi-age and multi-size stand. Small openings are created with each entry while the remainder of the existing overstory. For example, a stand could have a treatment every 20 years, creating openings on 20 percent of the stand each time, resulting in the entire stand being treated over 100 years. Reforestation and stand tending may occur to affect species composition and structure. Reduction of downed wood and/or snags may occur.
Intermediate harvest	Intermediate harvests enhance growth, quality, vigor, and/or composition of an existing stand, and do not cause a shift to a seedling/sapling condition. Treatments in this category include commercial thinning, liberation harvest, sanitation/salvage, and improvement cutting. These treatments leave a forest that is still dominated by trees larger than saplings. The focus is not on regenerating a new forest, but in changing the condition of the current one. Not only is forest density reduced, but species compositions and forest size class may change. Tree growth is typically accelerated. Reduction of downed wood and/or snags may occur.

Harvest activities occurred on about 155,503 acres on the Custer Gallatin National Forest since about 1940 according to FACTS. This represents about 7 percent of the non-wilderness land base. Of total harvested acres, 97,329 acres were regeneration, 44,679 acres intermediate, and 13,495 acres uneven-aged.

In the montane ecosystems, timber harvest peaked in the 1960s around 33,700 acres. For the 1970s and 1980s, harvest varied from 23,000 to 30,000 acres with the highest in the 1980s. The 2000 to 2009 levels dropped significantly to 3,100 acres, with most occurring as intermediate harvest (salvage, commercial thinning). This decline was likely due to litigation, decreased budgets, and less emphasis on the use of timber harvest as a tool for management of the resource. Because of this, forest managers tended to plan smaller harvest acreage and treatment units over the last 15 years. There has been a steady decline in harvest acres since 1980, however in the last five years there has been a slight increase over the previous decade. Regeneration harvest treatments were dominant through the 1990s and in the last five years no regeneration harvest occurred. Intermediate treatments became more widely used in the 1980s and the last five years are 94 percent of the harvest acres. Uneven-aged treatments peaked in the 1970s and have since been used less.

In the pine savanna, timber harvest peaked in the 1980s at about 7,500 acres. In the early 1990s after the large fires in 1988, managers begin recognizing that without fire or management the existing stand structures that had developed over the last 80 years in these dry forest types were not sustainable nor resilient to large disturbance events such as fire. This was particularly evident in the 58,300-acre, 1988 Brewer fire on the Sioux Ranger District. Seventy one percent of the forested area experienced a high mortality stand replacement fire event significantly reducing forest cover. Beginning in the early 1990s there was an emphasis on creating fuel breaks until further treatments could be planned and implemented. The 1990s harvest acres were largely the result of this effort. In the 2000s, an effort began to treat larger landscapes using timber harvest to help meet objectives and desired conditions. In 2012, one of these planned efforts that had a sale nearly sold, burned up in the Ash Fire on the Ashland District. Since 1980, there has been a downward trend in harvested acres, with a small increase in the 1990s. From 2010 to 2015 timber harvest as a tool has been emphasized less by forest management with declining budgets and the result has been a large downward trend with only 657 acres harvested between 2010 and 2015. Regeneration harvests peaked from 1990 to 2009, with about 2,500 acres in each decade. Intermediate treatments have been the dominated treatment since 1950, occurring on about 57 percent of the total treatment acres. Uneven-aged management, largely individual tree selection harvest occurred on 18 percent. Ninety nine percent of timber harvest from 2010 to 2015 has been intermediate harvest.

Composition

One broad depiction of composition for existing vegetation is lifeform. Lifeform is based on the type of dominant vegetation from the following broad categories: grass, forb, shrub, tree, transitional forest, and other types that include areas of sparse vegetation, water or urban areas. In the montane areas, tree life forms (conifer and broadleaf) occupy 62 percent of the landscape, transitional forest (recently burned forested vegetation) occupies seven percent, shrub life forms occupy 2 percent, and grass life forms occupy 13 percent. In the pine savanna unit, tree life forms (conifer and broadleaf) occupies 31 percent of the landscape, transitional forest (recently burned forested vegetation) occupies 14 percent, shrub life forms occupy 3 percent and grass life forms occupy 51 percent (VMap). The potential for forested conditions are estimated to be higher than existing forested cover types, which is due to recent (about the last 20 years) large-scale wildfires shifting existing vegetation.

The composition of existing vegetation is further characterized by *dominance types* or *cover types*, which describe the species making up the plurality of vegetation (Barber et al. 2011, Milburn et al. 2015). Dominance types describe the most common plant species present. Cover types are groupings of dominance types that are used to simplify analysis for the broad scale. Because the Custer Gallatin contains relatively few tree species, the composition of forested vegetation is characterized by dominance types while cover types are used to describe other, more species-rich vegetation types. Dominance type and cover type describe assemblages of species and are named after the most dominant species. Information on how dominance types are determined is found in Barber et al. (2011), and a description of cover types is found in Milburn et al. (2015) and appendix B.

For forested vegetation, in addition to dominance type, analysis of vegetation composition is also portrayed and analyzed in terms of tree species presence, for example, the geographic distribution of a species regardless of its relative dominance. When considered together, these two attributes provide a clearer picture of the overall forest composition, diversity and species distribution than either would alone. Tree species presence indicates the proportion of an area where there is at least one live tree per acre of a given species. This measure gives an indication of how widely distributed the species is, although it is not necessarily dominant or even common in all the places it occurs. Most stands are composed of more than one tree species. As noted above, dominance types are named for the dominant species. However, individual species may also be found in multiple dominance types. Therefore, the estimates for a dominance type are not the same as the distribution of the individual tree species.

Coniferous Forest

The following provides a summary of the ecological role and current condition of the five major coniferous tree species found on the Custer Gallatin National Forest: Douglas-fir, ponderosa pine, lodgepole pine, Engelmann spruce, subalpine fir and whitebark pine. Other common tree species including Rocky mountain juniper, limber pine, and deciduous species are addressed in sections below. Figure 4 displays the current and desired conditions for forest dominance types, figure 5 shows the current and desired conditions for species presence and table 37 lists the major tree species that will be addressed and summarizes the desired trend in relative abundance and distribution.

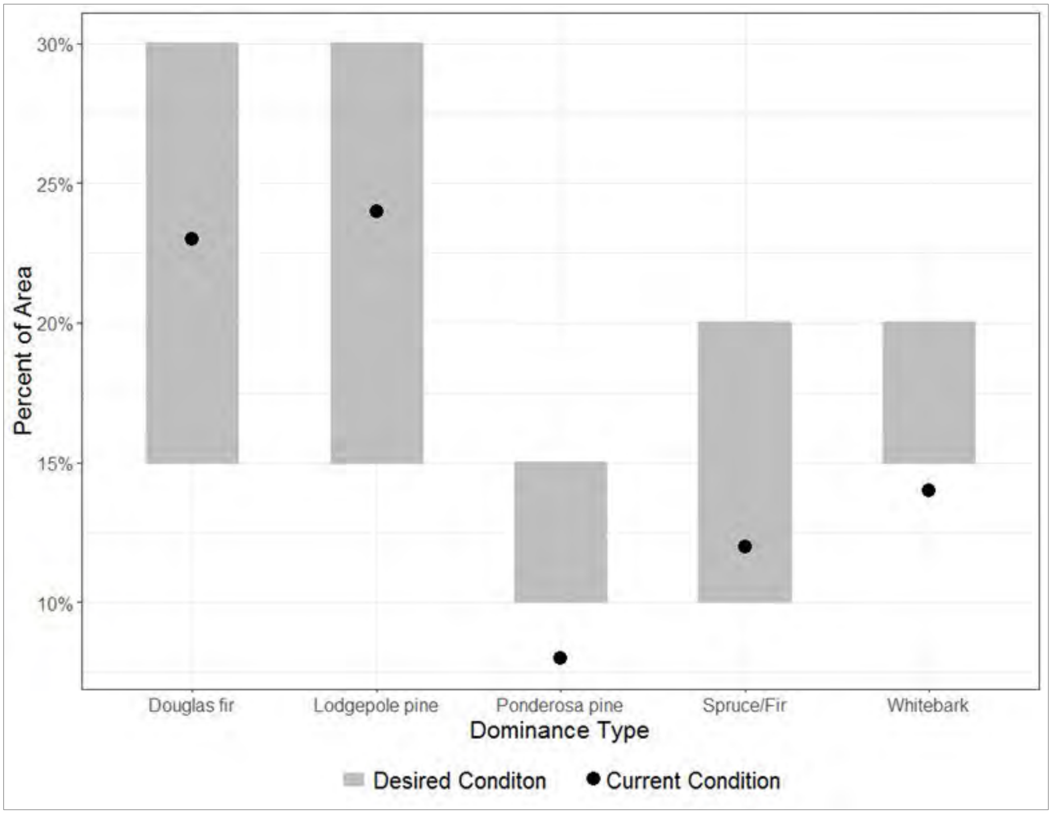

Figure 4. Current and desired conditions of dominance types (current condition is based on VMap data)

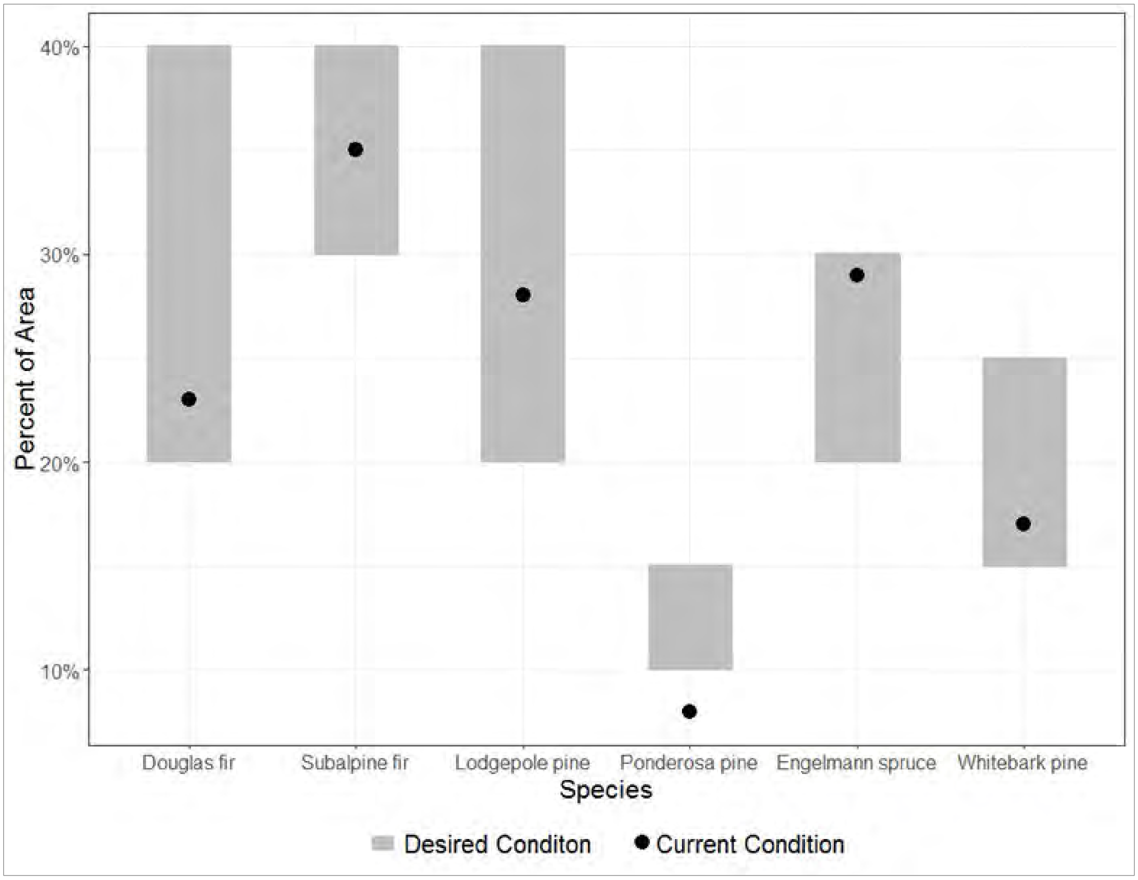

Figure 5. Current and desired conditions of species presence (current condition is based on forest inventory and analysis data)

Table 37. Desired trends over time for coniferous tree species on the Custer Gallatin National Forest

Species	Desired trend dominance type (Forestwide)	Desired trend species presence (Forestwide)
Ponderosa pine	Increase, where soil types indicate non-meadows and non-grasslands with focus on sites previously dominated by ponderosa pine that have not regenerated after recent severe wildfires	Increase, particularly in large size classes
Douglas-fir	Maintain	Maintain near current levels, particularly maintain large size classes in low density at xeric ecotone
Lodgepole pine	Maintain	Maintain
Subalpine fir/Engelmann spruce	Maintain or increase current condition, particularly in Canada lynx habitat	Maintain, particularly in mid and understory canopy
Whitebark pine	Increase, particularly in areas best suited for species success (due to less competition)	Increase in all size classes

Ponderosa Pine

Ponderosa pine (*Pinus ponderosa* var. *scopulorum*) is a shade-intolerant, drought-adapted species of the low-elevation dry forests of the Northern Rockies. It is the only conifer type found in the pine savanna ecosystems. Ponderosa pine dominance type provides important wildlife habitat, particularly as late-successional or old-growth forest on the warm dry potential vegetation type. It is a “drought avoider,” meaning it tolerates dry soil conditions by efficiently closing stomata to avoid water loss and xylem cavitation and stay alive during deep droughts. Ponderosa pine has been associated with several species of ectomycorrhizae, giving it a high capacity to survive in dry environments. Throughout the region, natural regeneration is sporadic; it is best when there is a heavy seed crop followed by favorable weather during the next growing season. Ponderosa pine has a great capacity to survive fire, better than nearly all of its competitors. The most damaging of the tree-killing insects are several species of Dendroctonus and Ips. Currently, the presence and dominance of ponderosa pine is below desired conditions. This is primarily due to large, severe wildfires in the Ashland ranger district which reduced forest cover there by 47 percent relative to the 1990s (U.S. Department of Agriculture 2014a). While mature ponderosa pine will likely handle increasing temperatures and deeper, longer droughts with only moderate difficulty, the species is vulnerable to additional reduction in range on the Custer Gallatin National Forest if it is unable to successfully regenerate after severe wildfire.

Douglas-Fir

Rocky Mountain Douglas-fir (*P. menziesii* var. *glauca*) is one of the most common and important tree species on the Custer Gallatin National Forest. This is largely due to the wide range of site and forest conditions under which it is able to grow and compete successfully. On low-elevation xeric sites, Douglas-fir is associated with ponderosa pine, juniper, and quaking aspen. At upper elevational limits, the species is often found with lodgepole pine, subalpine fir, and Engelmann spruce. Older, larger Douglas-fir trees are tolerant of fire, though less so than ponderosa pine or western larch. The species is a “drought tolerator” in that it keeps stomata open to extract soil water at extremely low soil water potentials, thereby subjecting it to potential xylem cavitation and potential death. Trees can live for many centuries and grow to large diameters. These larger, old trees provide wildlife habitat values, though as snags they typically have less longevity than larch. Douglas-fir is one of the most susceptible conifer species on the Custer Gallatin to serious damage from a variety of insect and diseases which are expected to increase under warming climate. These include Douglas-fir bark beetle, western spruce budworm, and several root diseases and heart rot pathogens. Insect and disease impacts may alter forest structures and forest fuels, increasing susceptibility to high severity fire. With warming temperatures and a possible decrease in summer moisture, Rocky Mountain Douglas-fir may contract from the driest portions of its range.

Subalpine Fir and Engelmann Spruce

Subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) are widely distributed, major components of mid- to high-elevation forests. At mid-elevations, spruce and fir are often found with Douglas-fir and lodgepole pine. Subalpine fir is usually the climax tree species in most subalpine areas of the Northern Rockies, although it sometimes shares climax status with spruce as both species are shade tolerant and fire intolerant. Pure Engelmann spruce communities are found in seasonally wet areas and riparian settings, and in severe frost pockets where all frost-sensitive tree species are excluded. In part due to fire suppression policies, spruce-fir cover types have generally increased in Northern Rockies. Prevalence in understory and density has increased, particularly at the lower elevation extent of their distribution. In contrast, at higher elevations, where forests are generally characterized by more infrequent, high intensity fire; the distribution of subalpine fir and Engelmann spruce and have likely been less impacted by fire suppression. Subalpine fir has recently made gains at the upper tree line as it replaces rust- and beetle-killed whitebark pine. The future of subalpine fir and Engelmann spruce will depend on their likely expansion in the upper subalpine as climate change creates increasingly suitable habitat; countered by possible reductions in the drier, lower extent of their range due to increased fire, drought and associated pathogens. Climate change may allow longer growing seasons and higher productivity in subalpine communities where cold and snowpack duration limit regeneration and growth. Production and regeneration are likely to increase, especially in those high mountain environments where water is rarely limiting. Increased presence is expected where snow historically controlled regenerative success. Moreover, subalpine fir may increase as it replaces rust- and beetle-killed whitebark pine at the upper end of its distribution in the Greater Yellowstone Ecosystem (though whitebark pine can also facilitate subalpine fir establishment by ameliorating harsh environmental conditions). Seedling establishment may be the bottleneck for subalpine fir and Engelmann spruce in the future as years that meet these conditions may be less frequent in the future in the lower subalpine. Andrus et al. (2018) showed that large establishment events of spruce and fir occurred in years of high soil moisture availability and suggested that potential declines in the frequency of establishment events due to climate change are likely to compound the effects of increasing mortality from fire and drought.

Lodgepole Pine

Lodgepole pine (*Pinus contorta*) has wide ecological amplitude, but only the inland form (*P. contorta* var. *latifolia*) is found on the Custer Gallatin National Forest. Lodgepole pine has the widest range of environmental tolerance of any conifer in North America. It is relatively resistant to frost injury and can often survive in frost pockets where other species cannot. Compared to other associated species, lodgepole pine is intermediate in its needs for water, requiring more than Douglas-fir or ponderosa pine but less than spruce and subalpine fir. Lodgepole pine is intolerant of shade but highly tolerant of frost and drought. In the absence of fire, lodgepole pine is usually succeeded by its more tolerant associates, such as Douglas-fir in xeric environments and Engelmann spruce and subalpine fir in subalpine environments. It is seral in most communities. However, on cool dry habitats, such as those found in the Greater Yellowstone Area, it is dominant and tends to be persistent and form near-climax communities. Lodgepole pine has a great ability to regenerate due to a combination of cone serotiny, high seed viability, early rapid growth, and ability to survive a wide variety of microsite and soil conditions. Large quantities of stored seeds are available for regeneration after fire, and annual seedfall from nonserotinous cones helps restocking in areas of relatively minor disturbance and maintaining lodgepole pine presence in mixed stands. On the Custer Gallatin National Forest, most of the season’s total germination occurs during the two weeks following snowmelt in late June when soil is saturated and temperatures most favorable. Typically, many Northern Rockies lodgepole pine forests originated from stand-replacement fires, but extensive fire scars in Northern Rockies lodgepole pine forests indicate the existence of a low-severity, nonlethal fire regime component in these forests. However, most lodgepole pine forests in the region have a mixed-severity fire regime in space and time, where all fire severity types are possible depending on available fuels, antecedent drought, and wind conditions. Consequently, lodgepole as a species will be well adapted to the fires of the future. Repeated fires, however, can eliminate lodgepole pine seed sources if the fires occur before existing lodgepole has become reproductively mature (approximately 10 years). In most cases, lodgepole pine natural regeneration often overwhelms a burned site with abundant seed from serotinous cones and thereby excludes other species. The mountain pine beetle is the most important insect pest and has played a significant role in the dynamics of lodgepole ecosystems. Recent findings have shown that fire and beetles often act independently to influence lodgepole pine dynamics. In response to climate change, lodgepole pine is expected to both expand and contract in range depending on the particular model and assumptions used (Halofsky et al. 2018b), but as long as fire remains on the landscape, the species is likely to maintain its presence on the Custer Gallatin National Forest at roughly the same proportions as during the last 100 years.

Whitebark Pine

Whitebark pine is listed as a proposed species by the U.S. Fish and Wildlife Service, and information on this species is discussed in further detail in the At-Risk Plants section of this environmental impact statement. A brief summary will be provided here.

Whitebark pine is most common on sites in the cold potential vegetation type. It competes best and most often achieves dominance on the harsher, exposed sites. It usually occurs in association with subalpine fir, spruce and sometimes lodgepole pine. It occurs as a minor species in some stands at mid elevations, typically associated with lodgepole pine and subalpine fir. The species is a key ecosystem component of high elevations forests, where it was historically a dominant and widespread species at all stages of forest succession. As the most fire resistant and long-lived species in these forests, it plays an important role in the stability of these high elevation ecosystems and in the quality of wildlife habitat.

In the cold potential vegetation type where this species plays the most important ecological role, whitebark pine presence is well below desired conditions. Maintaining or increasing these levels is desired, both forestwide and especially in the cold potential vegetation type. The species has experienced extensive mortality over the past few decades due to the exotic disease white pine blister rust, as well as other factors such as mountain pine beetle. Almost the entire range of whitebark pine in the Greater Yellowstone Area was affected by mountain pine beetle during this latest epidemic and approximately 50 percent of the area showed severe mortality and 36 percent moderate mortality as indicated by the change in overstory condition (Macfarlane et al. 2013). Though whitebark pine still occurs across the landscape, most trees are small size classes (seedling/sapling or small size class), and larger trees are very scarce across much of its range. This has greatly reduced its regeneration potential. Subalpine fir has increased in abundance with the loss of whitebark pine and the lack of fire and regeneration of whitebark pine.

Mesic Deciduous Woodlands

Woody Draws

About 11,400 National Forest System acres of woody draws (green ash woodlands) occur on the Ashland and Sioux Districts. As a rare and biologically important landscape component, green ash woodlands should be managed to maintain or perpetuate a network of multi-layer and multi-age class of herbaceous plants, shrubs, and trees. Green ash is on the western and most arid margin of its range on the Ashland and Sioux Districts and is likely at the limit of its environmental tolerances. Because of this, extended periods of drought may have an adverse effect on regeneration and probably promote other problems. The current condition of green ash draws may be a reflection more of past (1880 to 1930) grazing pressure than of recent livestock grazing and wildlife use (Lesica and Marlow 2013). Also, conifer invasion of woody draws causes competition and shades out hardwood species. Within primary rangelands of permitted livestock allotments on the Sioux and Ashland Districts, 19 percent of inventoried green ash woodlands are functional, 61 percent are at risk, and 20 percent are non-functional. The at risk and non-functional sites are largely a product of legacy issues due to woodcutting, livestock grazing, deer browsing, introduction of invasive rhizomatous sod grasses (predominantly, Kentucky bluegrass), and periods of prolonged drought. Tree recruitment is reduced by competition with sod grass and conifer invasion. Project level allotment management planning provides a mix of grazing prescription changes to address these conditions. They include reduced stocking rates, improved distribution techniques such as proper salting and off-site water development, and reduced grazing duration and timing considerations. Regardless, there continues to be a need for improved grazing practices and monitoring in woody draws, riparian areas, and in wetlands.

The distribution and structure of green ash woodlands on the Custer Gallatin have been affected by fire exclusion, conifer and non-native grass invasion, wild ungulate browsing, and livestock grazing. Fire exclusion has contributed to expanding stands and density of ponderosa pine with greater competition over green ash and greater risk of stand-replacing fire. Low-elevation ponderosa pine forests of the northern Rocky Mountains historically experienced frequent low-intensity fires that maintained open uneven-aged stands, but fires today are more often conifer stand-replacing fires. Green ash sprouts following fire, allows for regeneration of the species and decadent stands. About 25 percent of the Ashland’s and 16 percent of the Sioux’s green ash woodlands are mixed forest and mixed savanna dominance types which may be indicative of ponderosa pine colonization into green ash woodlands.

The Sioux and Ashland Districts have experienced large-scale wildfires in the past 18 years that have affected green ash woodlands. Some stands in the Long Pines of the Sioux District experienced reburn effects as well (1988 Brewer Fire and 2002 Kraft Springs Fire) setting back recovery. Post-fire recovery depends largely on the pre-fire conditions in the ground level understory. Many of these burned stands had enough sod development to impede green ash seedling/sapling establishment and it is unlikely that functional stand conditions will return in these areas. Green ash recovery in post-fire settings appears to be most successful where there is less sod and more litter and duff.

The northwestern Great Plains semi-arid environment is marginal for tree growth, and green ash is at the western, most arid margin of its range in eastern Montana. Green ash is primarily a tree of humid to sub-humid climates, occurring mainly in bottom lands. Hydrology is an important limiting factor for the growth of green ash in the Sioux and Ashland Geographic Areas. According to Lesica and Marlow (2013), in the first decade of the 21st century, winter (December-February) precipitation was approximately 25 percent lower than the 20th century average and winters averaged more than 3 degrees Fahrenheit warmer than in the last century in southeast Montana. These conditions can result in reduced snow accumulations, early spring flows and the deep-water penetration into the soil compared to the past. Hydrologic conditions conducive to recruitment and growth of green ash seedlings may have been sporadic, even prior to the introduction of Eurasian sod grasses into the woodland understory (Lesica and Marlow 2013). These conditions may be even less common now in a warmer, drier climate.

An increase of more drought-tolerant, grazing and browsing-adapted species and a decline in green ash tree seedling recruitment might be expected with a decrease in precipitation even in the absence of grazing or reduction in browsing (Lesica and Marlow 2013). More open stands are associated with drier sites or regions. It is likely that the future climate of the northwestern Great Plains (in particular) might be characterized by decreased precipitation, increased temperature and increased frequency of extreme climatic events. Such changes could make recruitment of green ash from seed a rare occurrence in many stands at the arid edge of this species’ geographic range (Lesica and Marlow 2013). However, sprouting may still occur.

Green ash has a broad ecological amplitude and can survive droughty conditions, but it grows optimally on moist sites. As soil moisture declines with a warmer, drier climate, marginal sites may become less favorable for regeneration and survival of young green ash trees. With increased fire frequency, there will likely be increased vegetative regeneration and decreased production of seedlings following fire; fire often kills green ash seed on or near the soil surface, restricting seedling recruitment to surviving seed-producing trees. Green ash may benefit from increased temperatures, because seedling and mature tree growth may increase with increasing soil temperatures. However, those green ash populations associated with moist upland microsites (such as, northeast facing residual snow-loaded depressions) may experience severe drought stress as snowpack declines and melts sooner, and regeneration may decrease, eventually resulting in loss of those communities (Halofsky et al. 2018a).

Since most mature green ash communities are somewhat resistant to wildland fire, given that the species can sprout afterward, the projected increases in fire in the future may not impact most green ash stands, especially the moist communities. Low-severity fires might promote regeneration by thinning stands and stimulating sprouting; green ash has both root crown and epicormic sprouts, and both are typical following fire events, especially in the woody draws and riparian areas of the Great Plains. High severity fires, however, may result in mortality. Browsing pressure on green ash communities will also likely increase with increased drought, as upland grasses and forbs desiccate and senesce earlier, or are replaced by invasive, less palatable species (Halofsky et al. 2018a).

Under all alternatives, climate conditions influence effects to mesic deciduous woodlands. The northwestern Great Plains semi-arid environment is marginal for tree growth, and green ash is at the western, most arid margin of its range in eastern Montana. Green ash is primarily a tree of humid to sub-humid climates, occurring mainly in bottom lands, so it is reasonable to assume that hydrology is an important limiting factor for the growth of green ash in eastern portion of the Custer Gallatin. In the first decade of the 21st century, winter (December through February) precipitation was approximately 25 percent lower than the 20th century average in southeast Montana. The winters averaged more than 3 degrees Fahrenheit warmer than in the last century (Lesica and Marlow 2013). Similar precipitation and temperature conditions in the first decade of the century were found in nearby South Dakota (Frankson et al. 2017). These conditions have probably reduced snow accumulations, early spring flows, and the deep-water penetration into the soil compared to the past. Hydrologic conditions conducive to recruitment and growth of green ash seedlings in eastern Montana may have been sporadic, even prior to the introduction of Eurasian sod grasses into the woodland understory (Lesica and Marlow 2013). These conditions may be even less common now in a warmer, drier climate.

An increase of more drought-tolerant, grazing-adapted species and a decline in green ash tree seedling recruitment might be expected with a decrease in precipitation even in the absence of grazing. More open stands are associated with drier sites or regions. It is likely that the future climate of the northwestern Great Plains, in particular, might be characterized reduced precipitation, and increased temperature and frequency of extreme climatic events. Such changes could make recruitment of green ash from seed a rare occurrence in many stands at the arid edge of the tree's geographic range (Lesica and Marlow 2013).

Aspen and Cottonwood

Aspen and cottonwood (black, narrowleaf and plains cottonwood) communities are highly valued for their contribution to biodiversity and habitat. These communities are not abundant in the Custer Gallatin National Forest. There are about 13,600 acres of aspen and 430 acres of cottonwood (less than 1 percent of the land area). Aspen occurs primarily as small groves at middle and low elevations and cottonwood are found at lower elevation, in higher stream order environments. Due to large scale wildfires, the Long Pines on the Sioux District are showing a large release and increase in aspen stands that were previously not well represented on the landscape in recent history. To help with recovery, ponderosa pine may need to be thinned or removed from these regenerating stands.

While there are stable climax aspen communities, most aspen is a fire-maintained, early seral component of a forested community. Stressors include competition with and shading by conifers, typically due to fire exclusion, domestic and native ungulate herbivory, and increasing temperature coupled with declining precipitation. Reduction of soil moisture may cause severe water stress which reduces aspen's ability to survive (for example, sudden aspen decline) and to reproduce both vegetatively and by seed. Similar stressors exist for cottonwood. Through deposition of alluvial material and scouring, flooding often produces suitable establishment sites for cottonwood. Until roots reach the water table, trees are susceptible to drought.

Aspen re-colonized the bare land surface following the retreat of the glaciers about 12,000 years before present (BP). During 10,000-8,000 BP the climate was warmer and moister than it is now. Since then, there has been progressive cooling and drying, so that current conditions are not as good for effective seedling regeneration (Halofsky et al. 2018a). Aspen is also shade intolerant, and its seedlings are very sensitive to competition from pre-existing vegetation; it has been able to persist and spread largely because of its ability to reproduce asexually through root suckers. Following natural disturbance through agents such as fire, windthrow, or insect defoliation, aspen has re-established itself as the dominant tree species in the early successional stages of mixed wood formations largely through asexual reproduction from remnant roots.

Aspen is a species that may experience both gains and losses under future climate, depending on local site conditions, particularly soil moisture. Aspen communities on warmer, drier sites could experience high mortality because of increasing water deficit. Ireland et al. (2014) found that drought was the major factor causing recent high mortality in southwestern aspen stands. In the boreal forests of western Canada, Hogg and Hurdle (1995) estimate that even with an 11 percent increase in precipitation, boreal forests in which aspen is a major component will decline due to drought stress. Sudden aspen decline has been associated with severe prolonged drought, particularly in aspen stands that are on the fringe of the species' distribution (warmer and drier sites than those typically considered optimal for aspen persistence) (Frey et al. 2004). Recent research efforts have found that extreme weather events (such as, drought, thaw–freeze events), insect defoliation, and pathogens have led to aspen mortality (Halofsky et al. 2018a). Bethers Marchetti et al. (2011) found that aspen mortality from various insects and disease was greater in those stands that were drought-stressed and declining due to sudden aspen death. Further exacerbating the situation is that declining stands may have little or no regeneration due to intense ungulate herbivory, and those smaller stands that persist may be smaller and fewer with increased plant stress due to increased severity of summer droughts (Rogers et al. 2013). Increased fire frequency, particularly on moist sites, will likely favor aspen regeneration by removing shading conifers, and younger stands (under 40 years old) created by fire may be more resilient to drought. However, if fires are severe, they may kill the shallow root systems and eliminate aspen. Increased herbivory on regenerating stands may occur as adjacent upland vegetation ages and dries out earlier in the growing season. Areas with mountain pine beetle-caused conifer mortality (especially in lodgepole pine) may release aspen, and it will regenerate once the conifer canopy is thinned or removed, again given sufficient soil moisture (Halofsky et al. 2018a).

In the western part of the Custer Gallatin, the black cottonwood (*Populus balsamifera ssp. trichocarpa)* is dominant with narrowleaf cottonwood (*Populus angustifolia*) and eastern cottonwood (*Populus* *deltoides*) occurring as co-dominants in the riparian-floodplain interface near the mountains. Further east, narrowleaf cottonwood and Plains cottonwood become dominant. In relatively undisturbed stands, willow (*Salix* species), redosier dogwood (*Cornus sericea*) and common chokecherry (*Prunus virginiana*) form a thick, multi-layered shrub understory, with a mixture of cool and warm season graminoid species below. Green ash (*Fraxinus pennsylvanica*) and box elder (*Acer negundo*) form a tree understory in mid-seral and late-seral stands.

As snowpack declines and melts earlier with the trend of warming temperatures, there will be reduced, attenuated river flows (loss of extreme high and low flows), along with a possible shift in timing of peak flows to earlier in the season, before cottonwood seed is viable for germination. These shifts in timing, magnitude and variability may reduce both germination and establishment of young cottonwoods (Whited et al. 2007). There will also likely be increased human demands for water in the future, which will likely result in additional diversions and reservoir expansions. Any alteration of hydrologic flow regime (for example, timing, magnitude, and duration) will affect both floodplain interaction and available water to cottonwoods, which in turn may reduce recruitment and establishment of seedlings (Auble and Scott 1998, Beschta and Ripple 2005). Decreased stream flows and floodplain interactions may result in a conversion of streamside vegetation from cottonwood to upland species, along with reduced growth and regeneration (recruitment) and increased mortality of cottonwood (Beschta and Ripple 2005). Upland conifers (such as, Engelmann spruce, lodgepole pine, and Douglas-fir) typically establish once the stream and local water table have dropped, and they can shade out the remaining cottonwoods. In addition to competition from upland conifers, there may also be increased browsing pressure on cottonwoods, which will further contribute to declines in cottonwood regeneration and recruitment. Plains cottonwood may be more persistent under changing climate because of greater plant available soil water in the unsaturated zone (as a result of finer textured soils) in its habitat. Black and narrowleaf cottonwood typically occur in coarser substrate, which will become much drier as flows are lower and recede earlier than in the past or are attenuated due to diversions. Seedling and sapling mortality may increase in these species. Plains cottonwood regeneration occurs with episodic flooding, whereas black and narrowleaf cottonwood regenerate with 1-3 year bankfull flow return intervals (typically an annual recruitment cycle); therefore, plains cottonwood will likely be more adapted to irregular flows that may occur with climate trends. Black and narrowleaf cottonwood will likely be at greater risk to changing climate because of soil water characteristics in their habitats and their narrow amplitude in terms of germination and flood events on specific fluvial surfaces (Halofsky et al. 2018a).

Xeric Woodlands

There are about 750 acres of limber pine woodland cover type (only in the montane portions of the Custer Gallatin) and 5,800 acres of juniper woodland cover type present in all the geographic areas. Warming trends can impact xeric woodlands due to shifts in temperature and precipitation that may exacerbate existing stressors to these systems. Invasive grass species with higher flammability, such as cheatgrass, can spread and increase fire frequency and range.

Limber Pine

Limber pine (*Pinus flexilis*) is a shade-intolerant, early seral to pioneer species in the Northern Rockies (Steel 1990 in: (Burns and Honkala 1990)) which includes the montane geographic areas of the Custer Gallatin. Its seeds are dispersed by rodents, but more importantly, by a bird (Clark’s nutcracker) that will cache limber pine seed anywhere within the microsite pattern that it uses for finding the seed (Lanner and Vander Wall 1980). Limber pine has difficulty in competing with other encroaching species on more productive mesic sites and is often succeeded by Douglas-fir and subalpine fir. This tree species is very slow growing but long-lived, and some of the oldest trees in the region are limber pine. Limber pine occupies xeric sites across a wide range of elevations (2,600 to 8,900 feet in elevation) in the Northern Rockies Region that are often marginal for timber production (Jackson et al. 2010).

Historically, it was often found on the margins between grasslands and forest ecosystems at the lower tree line. Because limber pine is easily killed by fire, the species was mostly found in fire-protected cove sites where fire was rare and of low severity, such as rocky outcrops, barren areas, and moist north slopes (Steele 1990 in: (Burns and Honkala 1990)). In these lower tree line areas, limber pine is often associated with Douglas-fir, ponderosa pine, and quaking aspen. On upland montane sites, it can often be found on limestone substrates and droughty soils, but in these areas, it is associated with many other Northern Rockies conifers, especially lodgepole pine, subalpine fir, and Engelmann spruce (Langor 2007).

Limber pine seedlings are poor competitors with grass, but do well on rocky substrates and in shrub environments. Limber pine is very tolerant of drought and can establish and grow in some of the most arid environments in the Northern Rockies region (Steele 1990 in: (Burns and Honkala 1990)). Seedlings are very drought tolerant but have a low tolerance to competition, especially from herbaceous plants. The fundamental and realized niche for limber pine is very broad in the region, indicating that this species has a generalist adaptive strategy.

The thin bark and low foliage of limber pine make the species highly susceptible to damage from wildland fire. Limber pine is also highly susceptible to white pine blister rust, and many communities suffer high mortality when the disease infects trees in a new region (Smith et al. 2013). Limber pine also facilitates the expansion of currant (*Ribes* spp.; an alternate host for the rust pathogen *Cronartium ribicola*) into traditional grasslands (Baumeister and Callaway 2006), thus increasing rust infections and mortality. Other insects and pathogens are also impacting limber pine, but at a severity much lower than *C. ribicola*. Some researchers have detected mortality from mountain pine beetle in parts of the limber pine range (Jackson et al. 2010). Others have noted that limber pine stands on mesic sites may have severe dwarf mistletoe infections that could result in mortality levels similar to those observed from white pine blister rust. Porcupine damage is also prevalent east of the Continental Divide.

With fire exclusion, limber pine has expanded its range from fire-protected cove sites into areas where it was historically restricted by frequent fires (Arno and Gruell 1983, Brown and Schoettle 2008). As a result of the diminished fire activity and active nutcracker caching, limber pine has expanded into grass and shrub rangelands (Halofsky et al. 2018a). Evidence suggests that limber pine can facilitate the establishment of other forest species, especially Douglas-fir, in rangeland settings (Baumeister and Callaway 2006). As a result, limber pine in the Northern Rockies region is currently occupying areas that were traditionally grasslands, and it is difficult to determine if this is inside or outside the range of variability of this ecosystem.

Limber pine is a generalist and pioneer species, as well as cold and drought tolerant, making it capable of growing in a wide variety of environmental and physiological circumstances. Even though general trends across the west show some declines due to exotic white-pine blister rust infections, native mountain pine beetle outbreaks, and continued fire exclusion, its presence and distribution on the Custer Gallatin exceed that which has been modelled as its natural range of variation. This is likely due to past fire suppression.

Some anticipate that warming temperatures on the east side of the northern region of the Forest Service, along with increasing but more-variable precipitation, especially during the growing season, and waning snowpack will result in increased growth in many limber pine communities (Ashton 2010). Increased vigor is usually accompanied by larger cone crops, higher seed viability, greater number of seeds per cone, wider seed dispersal, and greater resistance to disease. Increased seed dispersal includes denser caching by birds and mammals, and probably more distant caching by Clark's nutcracker. Increased vigor might also extend to competitors of limber pine, so there could be increased competition from wind-dispersed conifers, especially on the more mesic portions of the limber pine range (Halofsky et al. 2018a).

Warm temperatures, even with increased precipitation, could also result in drier conditions, especially for seed germination and seedling growth. Even if more seeds are cached by mammals and birds, the subsequent establishment of seedlings from the unclaimed caches might be low because of longer drought seasons and hotter ground temperatures. Any dispersal of limber pine seed to new areas, especially non-forested stands, might have limited regeneration success because of the lack of ectomycorrhizal associations and increased competition from grasses and dense shrubs (Coop and Schoettle 2009).

Disturbance interactions with warming climates are likely to be important to future limber pine dynamics. Increasing fire frequency and intensity may result in the burning of more limber pine stands, causing higher mortality (Coop and Schoettle 2009). Increased fire may stem the encroachment of limber pine into grasslands. If future fires are larger and more severe, there may be less competition from other competing conifers, especially in the eastern portions of the Northern Rockies region along the timber-grassland ecotone. Warmer, drier conditions may also reduce blister rust infection by disrupting the blister rust cycle, especially during the late summer when *Ribes* species-to-pine infection occurs, and there may be fewer wave years where temperature and humidity are optimal for pine infection by white pine blister rust. Where precipitation is projected to increase, such as in the eastern portions of the Northern Rockies region, there may be higher rates of blister rust and dwarf mistletoe infection, which may cause higher limber pine mortality. Continued fire exclusion could enhance establishment of currant under mature limber pines and result in even greater white pine blister rust infection and mortality. Warmer temperatures also favor expansion of alternate host species such as currant, lousewort (*Pedicularis* spp.) and Indian paintbrush (*Castilleja* spp.) (Keane et al. 2015).

Limber pine responses to future climates may be minor and governed mostly by wildland fire and white pine blister rust. If fires increase, limber pine forests, some of which are already declining from rust, will suffer major declines, especially where they have encroached as a result of fire exclusion. Given its minor role in the Northern Rockies region prior to European settlement, this species is considered to be at most moderately vulnerable to climate change based on its high tolerance to drought and ability to populate severe environments, but high susceptibility to the introduced white pine blister rust (Halofsky et al. 2018a).

Juniper

Rocky Mountain juniper (*Juniperus scopulorum*) is a minor vegetation cover type on the Custer Gallatin but known from all geographic areas. Rocky Mountain juniper communities in the Sioux and Ashland Geographic Areas are often restricted to steeper, north-facing slopes. Individuals may be scattered across other foothill areas in the montane geographic areas of the Custer Gallatin, such as rocky outcrops, butte tops, draws, and floodplains. Rocky Mountain juniper forms open woodland with sagebrush and grasses, and it is often found mixed with Douglas-fir (*Pseudotsuga menziesii*) or ponderosa pine (*Pinus ponderosa*). It is also found along waterways in pure stands or as understory in the cottonwood (*Populus* species)-willow (*Salix* species) habitat types. It can form pure stands at middle and low elevations on the Custer Gallatin.

The Utah juniper (*Juniperus osteosperma*) ecological system occurs most frequently on moderately steep to very steep slopes in the Pryor mountain range which is on the northern extent of its range. It occurs on rocky outcrops on south and southwestern aspects and forms small- to large stands on dry and rocky soils. Rocky Mountain juniper (*Juniperus scopulorum*) can also occur with Utah juniper in the Pryor Mountains. Conifers such as Douglas-fir (*Pseudotsuga menziesii*), limber pine (*Pinus flexilis*) and ponderosa pine (*P. ponderosa*) may also occur in some stands. Other co-dominant shrubs include mountain big sagebrush (*Artemisia tridentata ssp. vaseyana)* and rubber rabbitbrush (*Ericameria nauseosa*). Other low shrubs such as snakeweed (*Gutierrezia sarothrae*) and fringed sage (*Artemisia frigida*) are common. Undergrowth is dominated by bunchgrasses, usually bluebunch wheatgrass (*Pseudoroegneria spicata*), needle and thread (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*) or Idaho fescue (*Festuca idahoensis*).

Juniper presence and distribution on the Custer Gallatin are considered to be within their natural range of variation on xeric sites due to lack of fuels to typically carry a fire and outside of their natural range of variation on mesic sites that would typically be periodically opened from more natural fire regimes that have tended to be suppressed over time.

Even though prolonged drought, potential for increased fire severity and exotic species invasion can change the dynamics of these juniper systems, Rocky Mountain and Utah Juniper communities are considered to be stable on the Custer Gallatin (Montana Natural Heritage Program 2018b). It is expected that juniper to handle increasing temperatures and deeper, longer droughts with only moderate difficulty. Its ability as a “drought avoider” to close stomata when soil water potential is low which allows juniper to maintain its presence in many low elevation settings (H Stout and Sala 2003).

Grasslands and Shrublands

Warming trends can affect grasslands and shrublands because changes in temperature and precipitation affect vegetation growth and distribution. Expected effects on grasslands and shrublands are difficult to characterize as a result of uncertainty, regional variability, poorly understood vegetation dynamics, and complicated interactions and feedbacks. However, available research suggests some possible future implications of climate change for grasslands and shrublands under all alternatives.

Precipitation and temperature have been reliable predictors of the extent and distribution of plant groups (for example, cool-season C3 and warm-season C4 species) across the landscape (Epstein et al. 1997); (Knapp et al. 2001). Changes in these drivers have implications for vegetation. Rising carbon dioxide levels may complicate these relationships in the future, however. For instance, warmer and drier conditions should favor C4 grasses (Knapp et al. 2001, Winslow et al. 2003) so that short and tallgrass pine savannas may stand to benefit, but rising carbon dioxide should favor C3 species (Reich et al. 2001, Polley et al. 2003, Morgan et al. 2004). Further complicating these relationships are changing temperature and precipitation regimes. Increased variation, intensity, and changes in the timing of precipitation can also influence species composition and productivity of rangelands. For example, as springtime temperatures increase, the extent and magnitude of cheatgrass (a non-native) infestations may increase.

Ellison and Woolfolk (1937) documented the effects of a sustained drought near Miles City, Montana that peaked in 1934; this drought was aggravated by above-average temperatures and preceding years of below-normal precipitation. They documented substantial death of pine, juniper, and cottonwood, but also noted declines in sagebrush and other species. All shrubs experienced considerable dieback. Grass cover was reduced by up to 79 percent depending on the species. Effects of the drought were multiyear despite a favorable season in 1935. Needle-and-thread grass (*Hesperostipa comata*) and Sandberg bluegrass (*Poa secunda*) were able to recover relatively quickly, despite mortality, through the establishment of new seedlings. Stands of big sagebrush experienced considerable mortality and did not regenerate, whereas silver sagebrush (*Artemisia cana*) was able to resprout from the base. Therefore, based on this information, future sustained drought could result in declines in these vegetation types regardless of alternative, while other grass species such as Sandburg bluegrass and needle and thread grass increased. In addition, the study indicated that the favorable season following the drought failed to restore the perennial vegetation to anywhere near its former condition. The study concludes that to be in ecological balance with this droughty environment, forage use should allow for recovery and accumulate a forage reserve against future droughts.

Grasslands

Pine Savanna Grasslands

The Ashland and Sioux Geographic Areas of southeastern Montana and northwestern South Dakota are within the Northern Great Plains ecosystem. Annual precipitation increases from west to east changing from dry temperate steppe to humid temperate prairie. The mixed grass prairie occurring within the Ashland and Sioux Geographic Areas. Vegetation is a mixture of mid- and short-statured grasses with a mix of warm-season (C4) and cool-season plant (C3) species. The C refers to carbon and the number is the number of carbon atoms in the first compound produced by photosynthesis. The two groups have different growth requirements, responding differently to temperature, moisture and light. Warm season grasses require higher temperatures and light with lower requirements for moisture. For cool season grasses, it is the opposite. The presence of both C3 and C4 species can be desirable in an area as they can occupy different niches (for example, C3 species are often more abundant in the shade of trees and on southerly aspects, while C4 species often dominate full-sun conditions and northerly aspects) and thereby provide greater groundcover across a range of conditions. It is not uncommon to find both C3 and C4 species in one area. This has advantages in providing a broader spectrum of production throughout the year for grazers.

Perennial herbaceous components of the Northern Great Plains grasslands consist mostly of rhizomatous and bunch-form graminoids, with a diversity of perennial forbs. Typical grassland vegetation types are characterized by wheatgrass/needlegrass in the west and wheatgrass/bluestem (*Andropogon* spp.)/needlegrass to the east. Rhizomatous western wheatgrass (*Pascopyrum smithii*) is often the dominant component, especially on finer-textured soils and where the moisture balance is favorable. Other grasses include thickspike wheatgrass (*Elymus lanceolatus*), green needlegrass (*Nassella viridula*), blue grama (*Bouteloua gracilis*), Sandberg's bluegrass (*Poa secunda*), and needle and thread (*Hesperostipa comata*). Dryland rhizomatous sedges such as threadleaf sedge (*Carex filifolia*) are common. Common forbs within this system include yarrow (*Achillea millefolium*), scarlet globemallow (*Sphaeralcea coccinea*), western sagewort, (*Artemisia ludoviciana),* boreal sagewort (*Artemisia frigida*), silver lupine (*Lupinus argenteus*), penstemon (*Penstemon* species), prairie cinquefoil (*Potentilla gracilis*), (Knapp et al. 2001) Hood's phlox (*Phlox hoodii*), sandwort (*Arenaria* species), prickly pear (*Opuntia* species), prairie clover (*Dalea purpurea*), gayfeather (*Liatris punctata*), and milkvetch (*Astragalus* species)and Missouri goldenrod (*Solidago missouriensis*). Overall shrub cover is less than 10 percent in this cover type and may include shrubs such as Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), silver sagebrush (*Artemisia cana*) and greasewood (*Sarcobatus vermiculatus*).

Precipitation and temperature have been reliable predictors of the extent and distribution of plant groups in the Northern Great Plains (for example, cool-season C3 and warm-season C4 species (Epstein et al. 1997, Knapp et al. 2001)), which includes the Sioux and Ashland Geographic Areas. Changes in these drivers have implications for vegetation. Rising carbon dioxide levels may complicate these relationships in the future, however. For instance, warmer and drier conditions should favor C4 grasses (Knapp et al. 2001, Halofsky et al. 2018b); but rising carbon dioxide should favor C3 species (Halofsky et al. 2018a). Further complicating these relationships are changing temperature and precipitation regimes. Increased variation, intensity, and changes in the timing of precipitation can also influence species composition and productivity of rangelands. For example, as springtime temperatures increase, the extent and magnitude of cheatgrass infestations may increase.

Soil water availability and water stress are principal driving factors in these semi-arid grasslands; influencing plant species distribution, plant community composition and structure, productivity, and associated social and economic systems of the Northern Great Plains. Soil water availability is influenced by complex interactions among temperature, precipitation, topography, soil properties, and ambient CO2 (Ghannoum 2009, Morgan et al. 2011).

Available soil water is unevenly distributed across landscapes and a function of landform, topography, and soil properties. Soil moisture loss through evapotranspiration is influenced by slope, aspect, and solar loading at the ground surface; and water holding capacity is influenced by soil properties. These characteristics in the Northern Great Plains may modify the effects of climate change and elevated CO2 locally. Landscape patterns of available soil water may result in uneven patterns of vegetation change and productivity under changing temperature and moisture regimes and elevated CO2 levels. The desiccating effect of higher temperature and increased evaporative demand (Morgan et al. 2011) is expected to offset the benefit of higher precipitation, resulting in lower soil water content and increased drought throughout most of the Great Plains (Morgan et al. 2011). Elevated CO2 may counter the effects of higher temperatures and evaporative demand by improving water-use efficiency of plants (Morgan et al. 2011).

Rising CO2 and temperature combined with increased winter precipitation may favor some forbs and woody plants (Morgan et al. 2008). Plant productivity is expected to increase with projected changes in temperature and moisture combined with elevated CO2 (Morgan et al. 2008). Forage quality may decline as a result of less available forms of soil nitrogen and changes in plant species and functional groups (Morgan et al. 2008). A major shift in functional groups from C3 to C4 plants is possible but uncertain, because warmer temperature and longer growing seasons favor C4 grasses, but the effects of higher CO2 on water-use efficiency may benefit C3 grasses. Because most invasive species are C3 plants, they may become more problematic with the benefits of increased CO2 (Morgan et al. 2008).

The adaptive capacity of Great Plains grasslands during the 1930s and 1950s drought was documented for the central plains (Weaver 1968). There was a shift in C4 grasses, in which big bluestem and little bluestem were replaced by the shortgrass species blue grama and buffalograss. Shifts from tallgrass prairie to mixed grass prairie were also documented with an increase in the C3 plants western wheatgrass and needlegrass. This shift was later reversed during the higher precipitation period of the

1940s, indicating an adaptive capacity of Great Plains grasslands to the effects of long-term drought. These shifts were also affected by grazing condition of the grasslands prior to the drought.

Within the Northern Great Plains near the Ashland Geographic Area, (Ellison and Woolfolk 1937) documented the effects of a sustained drought near Miles City, Montana that peaked in 1934; this drought was aggravated by above-average temperatures and preceding years of below-normal precipitation. They documented substantial death of pine, juniper, and cottonwood, but also noted declines in sagebrush and other species. All shrubs experienced considerable dieback. Grass cover was reduced by up to 79 percent depending on the species. Effects of the drought were multiyear despite a favorable season in 1935. Needle-and-thread grass (*Hesperostipa comata*) and Sandberg bluegrass (*Poa secunda*) were able to recover relatively quickly, despite mortality, through the establishment of new seedlings. Stands of big sagebrush experienced considerable mortality and did not regenerate, whereas silver sagebrush (*Artemisia cana*) was able to resprout from the base.

Montane Grasslands

Within the montane units of the Custer Gallatin (Pryor; Absaroka Beartooth; Bridger, Bangtail, Crazy; and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas), montane grassland vegetation is dominated by cool-season perennial bunchgrasses and forbs, with sparse shrub and tree representation. Various shrub and tree species often occur with low cover (typically less than 10 percent). The grasslands on the moister north- and east-facing slopes, or at higher elevations, are generally dominated by Idaho fescue (*Festuca idahoensis*), and other cool season grasses. Other common grasses include bluebunch wheatgrass (*Pseudoroegneria spicata*), tufted hairgrass (*Deschampsia caespitosa*), mountain brome (*Bromus carinatus*), blue wildrye (*Elymus glaucus*), awned sedge (*Carex atherodes*), and small wing sedge (*Carex microptera*). Forb dominated meadows usually comprise a wide species diversity which differs from montane to subalpine elevations. Montane grasslands range in size from small patches to large open parks located on montane to foothill zones.

Other montane graminoids include western needlegrass (*Achnatherum occidentale*), Richardson's needlegrass (*Achnatherum richardsonii*), oatgrass (*Danthonia* species), prairie junegrass (*Koeleria macrantha*), Sandberg's bluegrass (*Poa secunda*), western wheatgrass (*Pascopyrum smithii*), thickspike wheatgrass (*Elymus lanceolatus*), basin wildrye (*Leymus cinereus*), and Liddon sedge (*Carex petasata*). These moister sites support a forb- rich community that includes species such as arrowleaf balsamroot (*Balsamorhiza sagittata*), yarrow (*Achillea millefolium*), silky lupine (*Lupinus sericeus*), sticky geranium (*Geranium viscossisimum*), nine-leaf biscuitroot (*Lomatium triternatum*), sticky cinquefoil (*Potentilla glandulosa*), prairie cinquefoil (*Potentilla gracilis*), penstemons (*Penstemon* species), little larkspur (*Delphinium bicolor*), crazyweed (*Oxytropis* species), prairie gentian (*Gentiana affinis*), wild strawberry (*Fragaria virginiana*), and Indian paintbrush (*Castilleja* species). Shrub cover is usually less than 10 percent and includes species such as shrubby cinquefoil (*Dasiphora fruticosa),* Woods' rose (*Rosa woodsii*), snowberry (*Symphoricarpos* species), and common juniper (*Juniperus communis*). Serviceberry (*Amelanchier alnifolia*), Douglas hawthorn (*Crataegus douglasii*), and common chokecherry (*Prunus virginiana*) often occur as patches on north-facing slopes of foothills where snow persists longer into the growing season.

Most montane grassland species regrow quickly after fire but as fires become hotter and more frequent, there is an increased risk of mortality of native species and invasion by non-native plant species. However, recent research in western Montana grasslands indicates that some grassland species may persist under less-than-optimal conditions, and that invasive plants may not always readily establish and dominate (Ortega et al. 2012, Pearson et al. 2016). In addition, more spring and winter precipitation may facilitate exotic annual grasses, particularly cheatgrass which germinates in the winter/early spring, to establish and set seed earlier than native perennial grasses (Finch 2012). This creates an uncharacteristic, continuous fine fuel load that is combustible by early summer, burning native perennial grasses often before they have matured and set seed (Chambers et al. 2007, Bradley 2009). Other non-native species, such as spotted knapweed (*Centaurea stoebe*), Dalmatian toadflax (*Linaria dalmatica*), butter-and-eggs (*Linaria vulgaris*), and Sulphur cinquefoil (*Potentilla recta*) respond favorably after fire and can increase in cover and density.

Non-native invasive plant species will expand into; or if already established, increase in abundance; in the lower elevation montane grassland communities, regardless of level of disturbance, as these communities become warmer and drier. The rate and magnitude of infestation will likely increase with greater disturbance (Bradley 2009). In addition, drier site conditions coupled with ungulate effects (grazing, browsing, hoof damage) may increase bare ground along with associated increases in surface soil erosion (Washington-Allen et al. 2010). Low-elevation montane grasslands may shift in dominance towards more drought tolerant species. Some model output suggests that cool season (C3) grasslands will decline and that warm season (C4) grasslands will expand based solely on temperature trends. However, research indicates that elevated CO2 favors C3 grasses and enhances biomass production, whereas warming favors C4 grasses due to increased water use efficiency (Morgan et al. 2004, Morgan et al. 2007). Although C3 grasses dominate Western montane grasslands, a warmer and drier climate may allow C4 grasses (primarily northern Great Plains grasses) to expand westward into these grasslands. In general, it is likely that with increased warming and more frequent fires, grasslands will become a more dominant landscape component as shrublands and lower montane conifer forests are burned and less able to regenerate. However, increasing fire would also encourage more invasive species in grasslands (D'antonio and Vitousek 1992, Bradley 2009).

Shrublands

Pine Savanna Shrublands

Pine savanna (Sioux and Ashland Geographic Areas) foothill shrublands usually occur as small dense thickets, narrow bands, or irregular patches. Shrub cover ranges generally from 30 to 100 percent. Chokecherry (*Prunus virginiana)* is frequently the dominant shrub species and others include American plum (*Prunus americana*), hawthorn (*Crataegus* species), currant (*Ribes* species), skunkbush sumac (*Rhus trilobata*), western snowberry (*Symphoricarpos occidentalis*), serviceberry (*Amelanchier alnifolia*), elderberry (*Sambucus* spp.), birchleaf spiraea (*Spiraea betulifolia*), and boreal sagewort (*Artemisia frigida*).

The persistence of many animal species depends on the existence of sagebrush steppe habitat. The greater sage-grouse (*Centrocercus urophasianus*) and other sagebrush obligate animals depend on landscapes of intact habitat of sagebrush and perennial forbs and grasses for their persistence. The majority of the priority and general greater sage-grouse sagebrush habitat on the Custer Gallatin occurs within the Ashland and Sioux Geographic Areas (National Forest System and private inholdings). About 2,127 acres of priority greater sage-grouse habitat is found on National Forest System lands at the lower elevation fringes of the Ashland and Sioux Geographic Areas. About 93,147 acres of the general greater sage-grouse habitat is found on National Forest System lands in the Sioux and Ashland Geographic Areas. Wyoming big sagebrush is an important component of the greater sage-grouse priority and general habitats. However, Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) and silver sagebrush (*A. cana*) are the dominant sagebrush species within South Dakota's occupied sage-grouse range (South Dakota Department of Game Fish and Parks 2014a) on or near the Sioux Ranger District. Three hundred and eighty-one acres of priority Wyoming big sagebrush habitat on the Sioux Geographic Area (18 percent of priority habitat on the Custer Gallatin) recently experienced low severity wildfire effects likely causing some mortality. Silver sagebrush is not as susceptible to fire as other species of sagebrush and mortality after prescribed fall and spring burns is typically related to fire intensity (White and Currie 1983). Silver sage also sprouts following top-kill by fire (Wright et al. 1979). Of the approximate 93,147 acres of the general greater sage-grouse habitat found on the Sioux and Ashland Geographic Areas, approximately 12,484 acres (about 13 percent of the general habitat on National Forest System lands) recently experienced moderate to high mortality due to wildfire effects. Wyoming big sagebrush may require in excess of 100 years to reestablish to pre-burn stature and density.

About 99 percent of priority and general sage-grouse habitats on National Forest System lands in the Ashland and Sioux Geographic Areas of the Custer Gallatin occur within grazing allotments. The existing condition of grassland and shrublands, including greater sage-grouse priority and general habitats, varies across the landscape. In general, they have shown improvement over time with the advent of cross-fencing to move most units from season long to rotation grazing, installing offsite water developments (away from riparian and hardwood draw areas), implementing improved range readiness entry dates, and implementing shorter duration grazing with more opportunity for plant recovery. In addition, several stocking rate reductions have also occurred over time. This is not to discount that there continue to be some areas where issues are still being assessed and managed for improvement. There continues to be a need for improved grazing practices and monitoring in these areas.

Communities Dominated by Wyoming Big Sagebrush and Basin Big Sagebrush

Although the current distribution of Wyoming big sagebrush and Basin Big Sagebrush occur in both the montane and pine savanna ecosystems of the Custer Gallatin, the majority occurs within the Sioux and Ashland Geographic Areas. Wyoming big sagebrush distribution increases from west to east. The distribution of basin big sagebrush habitats is generally restricted to deeper soils of lower elevations, often including alluvial fans.

Lesica et al. (2007) suggest that fire return intervals for Wyoming big sagebrush are longer than for basin big sagebrush and mountain big sagebrush, ranging from 50 to about 150 years at the xeric end of the range of Wyoming big sagebrush (Baker 2006). The long fire return intervals to which Wyoming big sagebrush is adapted are related to its very slow post-fire recovery, as low as 2 percent 23 years after fire (Lesica et al. 2007). The slow recovery of these systems is partly due to slow growth rates and harsher environmental conditions in many sites in the Northern Rockies and Northern Great Plains. In contrast, basin big sagebrush canopy cover development and growth are much faster than for Wyoming big sagebrush (McArthur and Welch 1982, Booth et al. 1990). Slow growth can be exacerbated by invasive annual grasses such as cheatgrass. Cheatgrass invasion poses a continued and heightened threat to big sagebrush ecosystems in the future, because its biomass production and fire frequency are projected to increase in response to rising temperature and CO2 levels (Ziska et al. 2005, Westerling et al. 2006).

Basin big sagebrush ecosystems on the Custer Gallatin are minor. It has some capacity to adapt to climate change. There is high diversity in topography, soils, and climate in this type of sagebrush, suggesting that it can withstand a relatively broad range of ecological conditions and may tolerate shifting climatic conditions. Various subspecies of basin big sagebrush often hybridize and have a high level of polyploidy, providing it with the capacity to undergo selection and adapt to shifting climatic regimes relatively quickly (Poore et al. 2009).

Shrublands Dominated by Sprouting Sagebrush Species (Silver Sagebrush and Threetip)

The main sprouting sagebrush on the Custer Gallatin is silver sage and occurs predominantly on the Sioux and Ashland Geographic Areas. Threetip sagebrush may only occur in very minor amounts on the lower elevations of the western edge of the Custer Gallatin, such as near the southwestern edges of Hebgen Ranger District, and as such, will not be discussed further.

Silver sage can sprout from the root crown following top kill (primarily from fire) (Bunting et al. 1987). With increased fire severity and frequency, there may be some mortality, but overall, this species will generally resprout. Silver sage occur on mesic sites and typically occupies moist riparian benches or moist toeslopes. Although this species will sprout, increased fire frequency and severity may cause a shift in community composition to dominance by fire-adapted herbaceous species or non-native species.

Other fire-adapted shrub species (such as, rubber rabbitbrush, green rabbitbrush, spineless horsebrush) may increase, particularly following fire. In addition, more spring and winter precipitation may facilitate exotic annual grasses to establish and set seed earlier than the native perennial grasses, particularly in lower-elevation communities (D'antonio and Vitousek 1992, Bradley 2009). This creates an uncharacteristic, continuous fine fuel load that can burn by late spring/early summer, burning sagebrush and native grasses often before they have matured and set seed (Chambers and Pellant 2008). Other non-native invasive species (such as, spotted knapweed, Dalmatian toadflax, butter-and-eggs, Sulphur cinquefoil) respond favorably after fire, and if present, will increase in cover and density.

Silver sage is fire adapted and is likely to sprout successfully. Historical fire return intervals for silver sage are relatively short, typically less than 40 years. With warming trends, understory composition may possibly shift to more xeric grassland species (such as, bluebunch wheatgrass, needle-and-thread), which are more adapted to warmer and drier conditions. With warming trends, silver sage may shift landscape position to sites with more moisture and cooler temperature (such as, higher elevation, lower landscape position, and northeast aspects) (Halofsky et al. 2018b).

Montane Shrublands

Within the montane units of the Custer Gallatin (Pryor; Absaroka-Beartooth; Bridger, Bangtail, Crazy; and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas), mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) and snowfield sagebrush (*Artemisia tridentata* ssp. *spiciformis)* are typically found in higher elevations with mountain big sagebrush dominating. Wyoming sagebrush (*Artemisia tridentata* spp. *wyomingensis*) and silver sagebrush (*Artemisia cana* ssp. *viscidula*) can be co-dominant on some lower elevation sites. Antelope bitterbrush (*Purshia tridentata*) may co-dominate, but as a co-dominant is of very limited occurrence, being found primarily on intrusive volcanics such as on the Hebgen Lake District. Little sagebrush (*Artemisia arbuscula*) occurs sporadically. Other shrubs may be present, but usually at low cover values (5 to 10 percent). Species include rubber rabbitbrush (*Ericameria nauseosa*), and green rabbitbrush (*Chrysothamnus viscidiflorus*), wax currant (*Ribes cereum*), Woods rose (*Rosa woodsii*), deerbrush ceanothus (*Ceanothus velutinus*), snowberry (*Symphoricarpos* species) and serviceberry (*Amelanchier alnifolia*). Forb species may include arrowleaf balsamroot (*Balsamorhiza sagittata*), Indian paintbrush (*Castilleja* species), cinquefoil (*Potentilla* species), fleabane (*Erigeron* species), phlox (*Phlox* species), milkvetch (*Astragalus* species), prairie smoke (*Geum triflorum*), lupine

(*Lupinus* species), buckwheat (*Eriogonum* species), yarrow (*Achillea millefolium*), and rosy pussytoes (*Antennaria rosea*).

Priority greater sage-grouse habitat is not found within the montane geographic areas of the Custer Gallatin. However, about 29,254 acres of the general greater sage-grouse habitat is found on National Forest System lands in the montane geographic areas, predominately in the Pryor Mountains of the Beartooth Ranger District. Mountain big sagebrush and Wyoming big sagebrush are important components of the greater sage-grouse general habitats in these montane landscape areas. Minor amounts (less than one percent) of mountain big sagebrush mortality was caused by mixed severity fire effects on general sage-grouse habitat in the Pryor Mountains in the recent past. Mountain big sagebrush is easily killed by fire and often requires ten to 35 years or longer to reestablish to pre-burn stature and density, which is faster than recovery of burned Wyoming sagebrush. Wyoming big sagebrush may require in excess of 100 years to reestablish to pre-burn stature and density.

About 93 percent of the general greater sage-grouse habitat on National Forest System lands in the montane units of the Custer Gallatin occur within grazing allotments, again primarily in the Pryor Mountains Geographic Area. The existing condition of grassland and shrublands, including greater sage-grouse general habitats, varies across the landscape. In general, they have shown improvement over time with the advent of cross-fencing for rotational grazing, installing offsite water developments (away from riparian areas), and implementing shorter duration grazing with more opportunity for plant recovery. In addition, several stocking rate reductions have also occurred over time.

Mountain Big Sagebrush

Mountain big sagebrush is killed by fire. With increased fire severity and frequency, there will be a shift in community composition to dominance by fire-adapted shrub and herbaceous species and possibly non-natives. Fire-adapted shrub species (such as, rubber rabbitbrush, green rabbitbrush, white horsebrush) may increase in abundance following fire (Fischer and Clayton 1983, Smith and Fischer 1997). In addition, more spring and winter precipitation may facilitate non-native annual grasses (particularly cheatgrass which germinates in winter/early spring) establishment, although this is less likely in cooler, moister mountain big sagebrush communities compared to lower elevation Wyoming and basin big sagebrush communities. However, with a warmer, drier climate, the conditions may be conducive to cheatgrass establishment. An abundance of cheatgrass creates an uncharacteristic, continuous fine fuel load that can burn by late spring/early summer, burning sagebrush and native perennial grasses often before they have matured and set seed (Pellant 1989), (Chambers et al. 2007), especially in the Great Basin. However, other research in the northern edge of the Great Basin indicates that some sagebrush communities may be less susceptible to cheatgrass invasion following fire, at least under the current climate (Lavin et al. 2013). Other non-native species (for example, spotted knapweed, Dalmatian toadflax, butter-and-eggs, sulphur cinquefoil) respond favorably after fire and if present, will increase in cover and density.

Historically the fire return intervals in mountain big sagebrush are relatively short (around 40 years) compared to Wyoming big sagebrush (more than 100 years) (Lesica et al. 2005, Heyerdahl et al. 2006, Lesica et al. 2007). Mountain big sagebrush regenerates from seeds shed from nearby unburned plants. It will fully recover between 15-40 years after fire (Bunting et al. 1987), depending on site characteristics and fire severity. In a warmer and drier climate, frequent, high-severity burns (facilitated by cheatgrass) may not cause initial mortality and create unfavorable conditions for post fire regeneration (from sprouting, regrowth, or seed). Because there is no viable sagebrush seed bank, if fires burn large areas and there are no live, seed-bearing sagebrush nearby, there may be a type conversion to grassland. In addition, invasive, non-native species will likely either expand into these areas after fire, or they will increase in abundance due to altered conditions that no longer favor the native plant community (D'antonio and Vitousek 1992, Bradley 2009).

Mountain big sagebrush is not fire adapted, and may decline in cover and density in response to warmer temperatures and increased fire frequency and severity. Over time, especially if fine fuels such as dried cheatgrass are present, more frequent fires may eliminate mountain big sagebrush from a community (D'antonio and Vitousek 1992, Chambers and Pellant 2008). However, because mountain big sagebrush occurs at higher elevations, typically on more productive cooler, mesic sites, these communities are typically less invaded by non-native species. However, if these sites become warmer and drier, herbaceous understory composition could shift to more xeric species that are better adapted, and bare ground may increase. As a result, invasive species, particularly cheatgrass, could expand into and establish dominance in these altered communities.

It is possible that mountain big sagebrush distribution may shift to cooler and moister sites (such as, higher elevation, northeast-facing snow-filled depressions). With climate change, it may be able to persist only in sites with higher moisture and deeper soils than the surrounding landscape. Understory composition may shift to more xeric grassland species (such as, bluebunch wheatgrass, needle-and-thread), which are more tolerant of warmer, drier conditions (Halofsky et al. 2018b).

Short Sagebrush Types (Black and Low Sagebrush)

Low and black sagebrush occur in minor amounts on the Custer Gallatin. Low sagebrush sites are characterized as low production areas over shallow, claypan soils that restrict drainage and root growth. Low sagebrush is found on a range of altitudinal gradients. In contrast, black sagebrush is considerably more restricted in ecological amplitude and is found on shallow, dry, infertile soils.

Despite growing across large altitudinal gradients, low and black sagebrush are relatively more limited than other sagebrush systems. Thus, it is reasonable to assume that as climate changes, ranges could be further restricted, resulting in small islands being isolated, although this is more likely for black sagebrush because of its poor competitive ability. Both species depend heavily on seeding for reproduction and recovery from disturbance. In addition, several traits make low sagebrush sensitive to climate change. There is high mortality in the first year of growth (Halofsky et al. 2018b).

Mesic Montane Shrubs

Mesic montane shrubs are typically associated with montane and subalpine forests, and occur as large patches within forested landscapes. Species such as Rocky Mountain maple, alder, thimbleberry, chokecherry, serviceberry, currant, snowberry, and Scouler willow are common. Mesic shrubs are well adapted to frequent fire, and under the right conditions, can expand and outcompete regenerating conifers. However, with declining snowpack and warmer temperatures, fires may be hotter and sites may be drier; causing variable amounts of mortality, depending on site conditions.

Mesic montane shrubs are well adapted to frequent fire (Smith and Fischer 1997). Most shrub species sprout vigorously following top kill, primarily from fire, and quickly regain dominance on the site. However, as fires become more frequent and severe, and sites become drier, there may be a shift away from mesic species to more xeric, fire-adapted, sprouting shrubs, such as rubber rabbitbrush, green rabbitbrush, and spineless horsebrush. Non-native invasive plant species may also expand into these communities, particularly following fire (D'antonio and Vitousek 1992, Bradley 2009). With warmer temperatures and drier soils, some mesic shrub species that occupy moister sites (such as, alder and Rocky Mountain maple) may shift their distribution up in elevation or to cooler, moister sites (such as, northeast facing depressions).

Riparian, Wetlands, and Groundwater-Dependent Vegetation

Riparian areas are among the most critical elements of biodiversity within the landscape and they provide key ecosystem services available from no other resource. Intermittent streams and seasonal seeps and springs supporting riparian features are also biologically important for hydrological functioning and wildlife in the Northern Great Plains including those of the Sioux and Ashland Geographic Areas. This includes ecosystem-supporting services such as nutrient cycling; provisioning services such as fresh water, forage and habitat for wildlife; regulating services such as carbon storage, water and flood regulation, water quality, and erosion control; and cultural services such recreation, scientific discovery and education, cultural, intellectual and spiritual inspiration. Riparian areas are often important for recreation and scenic values. Riparian areas contribute to nearby property values through amenity and views. Space is created for riparian sports such as fishing, swimming, bird watching, and launching for vessels. However, because riparian areas are relatively small and occur in conjunction with watercourses, they are vulnerable to alteration and damage caused by people and their activities, such as livestock, mining, and recreational uses. Riparian areas supply food, cover, and water for a large diversity of animals and serve as migration routes and stopping points between habitats for a variety of wildlife. In Montana and South Dakota, many vertebrate species use riparian areas for a good portion of their life cycles, and many of these are totally dependent on riparian areas. Likewise, aquatic and fish productivity are directly related to a properly functioning and healthy riparian habitat. Riparian areas help control nonpoint source pollution by holding and using nutrients and reducing sediment. Tree, shrub, forbs, grass, and grass-like species in riparian areas stabilize streambanks and reduce floodwater velocity, resulting in reduced downstream flood peaks. Where riparian areas are intact and functioning, these ecosystem services can be assumed to be stable; but where riparian areas have degraded or been lost, these services are missing or at risk.

About 78,000 National Forest System acres (3 percent) of riparian (perennial and intermittent) and wetlands occur on the Custer Gallatin. Many groundwater-dependent ecosystems also occur such as seeps and springs. As a rare and biologically important landscape component, riparian areas should be managed to provide shade, to maintain streambank stability and in-stream cover, and to promote filtering of overland flows. Of 273 watershed condition framework-rated watersheds forestwide, 19 percent of the watersheds' riparian vegetation condition component rated as functioning at risk, with the remainder rated as functioning properly. At the allotment scale, the same overall pattern was at the watershed scale where 71 percent of the riparian survey sites in allotments were found to be in proper functioning condition, with 27 percent functioning at risk and 2 percent rated as non-functional. The at risk and non-functional sites are largely a result of legacy issues, including roads, uncharacteristic wildfire, developed recreation, dispersed recreation, historically unmanaged grazing by livestock, and water development and diversion on and off National Forest System lands. In general, the trend for all riparian areas is up from a long-term perspective due to decreases in stocking rates over past decades, rest due to periodic non-use, and natural recovery from past wildfire events. However, the trend over more recent timeframes are unknown. Project level allotment management planning provides a mix of grazing prescription changes to address these conditions. They include reduced stocking rates, improved distribution techniques such as proper salting and off-site water development and reduced grazing duration and timing considerations. Regardless, there continues to be a need for improved grazing practices and monitoring in riparian areas along streams, in wetlands, and groundwater-dependent ecosystems.

Riparian conservation measures have been developed for Federal, State, and private lands—helping to preserve and protect the integrity of the riparian and wetland habitats as well as the water quality of associated waterbodies. State streamside management zone protections have been applied on the Custer Gallatin during vegetation management projects. Soil and water conservation best management practices have also been applied to management activities.

Perennial stream reaches in higher-elevation areas that have well-timbered valley bottoms and ground-water entry will be most resilient to warming conditions and changing weather patterns. Lower elevation stream reaches, lacking riparian shade, containing high sediment loads, with impaired width-depth ratios, and losing flows to groundwater will be the least resilient reaches to changing conditions. Warmer, drier climates will influence species distributions and successional processes in complex and uncertain ways. Climate change forecasts include reduced precipitation, longer dry periods, and an increased frequency of extreme weather events. The potential effects on intermittent stream ecologies from these aspects of climate change could decrease runoff with more perennial streams becoming intermittent streams, losing hydrologic connectivity and reducing habitat for species dependent on perennial flow.

Prairie streams, such as those found in the Sioux and Ashland Geographic Areas, are dynamic, tending to vary between periods of floods and flow intermittency, among and sometimes within years. These systems experience regular cycles of drying and rewetting, creating harsh conditions for inhabitants, and repeated recovery sequences (Dodds et al. 2004). Climate change is expected to exacerbate these patterns (Jaeger et al. 2007) and lead to greater extremes, including severe droughts and more intense storms and wet intervals in plains and dryland systems (Starks et al. 2014, Halofsky et al. 2018a).

Perennial stream reaches in higher-elevation areas that have well-timbered valley bottoms and ground-water entry will be most resilient to warming conditions and changing weather patterns. Lower elevation stream reaches; lacking riparian shade, containing high sediment loads, with impaired width-depth ratios, and losing flows to groundwater; will be the least resilient reaches to changing conditions. Warmer, drier climates will influence species distributions and successional processes in complex and uncertain ways. Climate change forecasts for the northern Great Plains include reduced precipitation, longer dry periods, and an increased frequency of extreme weather events. Prairie streams, such as those in the Sioux and Ashland Geographic Areas, are dynamic, tending to vary between periods of floods and flow intermittency, among and sometimes within years (Dodds et al. 2004). It is typical for prairie streams to be reduced to sets of disconnected pools in some years. Climate change is expected to exacerbate these patterns (Jaeger et al. 2014) and lead to greater extremes, including severe droughts and more intense storms and wet intervals in plains and dryland systems (Michels et al. 2007, Starks et al. 2014).

Alpine

Alpine communities are common but unique in the high elevations of the montane units of the Custer Gallatin. Approximately 121,000 acres of alpine vegetation occurs on the Custer Gallatin. The Beartooth Mountains are primarily composed of the largest expanse of alpine plateau in the lower 48 states. The alpine vegetation is dominated by various grasses, sedges, small shrubs and forbs that can withstand the severe environment characterized by high winds, low humidity, cold soil temperatures, high ultraviolet radiation, short growing season, low soil moisture, and great daily temperature fluctuations.

The alpine vegetation occurs in a mosaic of turf, cushion, grassland, snowbed, and wetland associations. Wind exposure, moisture, and timing of snow release have generally been the most important environmental factors determining the arrangement of vegetation above tree line. Wind often results in soil and snow removal on windward sites and soil and snow accumulation, along with increased soil development, on lee sites.

Domestic sheep use in the alpine systems on the Custer Gallatin National Forest occurred during the turn of the century. Because of the resource degradation they were causing, permitted livestock grazing has been closed in these alpine areas. Because alpine areas are slow to recover, evidence of past livestock use still remains in some areas. Historic gold mining in areas near the Cooke City area affected some alpine systems. Extensive and costly reclamation to re-establish soil stabilizing vegetation has been conducted.

Elevation will play a large role in plant species composition in conjunction with predicted warming trends. High elevation, alpine or other fringe type environments may see plant species composition change first. Invasive plants have not yet become a serious problem in the alpine tundra of the Custer Gallatin National Forest, although yellow toadflax and Canada thistle are present above 9,000 feet and have the potential to invade such areas in the future. Other threats in these settings include recreational use and trail construction and maintenance.

Sparse Vegetation Types

Badlands within the mixed grass regions of the Sioux, Ashland, and the south flank of the Pryor Mountains Geographic Areas are shaped by the carving action of streams, erosion, and erosible parent material. The areas are easily recognized by the rugged, eroded, and often colorful land formations, and the relative absence of vegetative cover. In those areas with vegetation, species can include scattered individuals of many dryland shrubs or herbaceous taxa, including curlycup gumweed (*Grindelia squarrosa*), threadleaf snakeweed (*Gutierrezia sarothrae*), greasewood (*Sarcobatus vermiculatus*), Gardner's saltbush (*Atriplex gardneri*), buckwheat (*Eriogonum* species), plains muhly (*Muhlenbergia cuspidata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and Hooker's sandwort (*Arenaria hookeri*). Patches of sagebrush (*Artemisia* spp.) can also occur. The steep and deeply eroded slopes of badland systems tend to be harsh environments, which support only species uniquely adapted to these conditions (Brown 1971).

Sparsely vegetated ecosystems can also be found from foothill to alpine elevations throughout the montane landscape areas of the Custer Gallatin. These ecosystems typically occur on steep cliff faces, in narrow canyons, and on smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types, and includes the unstable scree and talus slopes that typically occur below cliff faces. These ecosystems are characteristically dry and sparsely vegetated, typically having less than 10 percent plant cover. Although there may be small patches of dense vegetation, the system usually consists of scattered trees and shrubs such as Douglas-fir (*Pseudotsuga menziesii*), Ponderosa pine (*Pinus ponderosa*), limber pine (*Pinus flexilis*), aspen (*Populus tremuloides*), or subalpine fir (*Abies lasiocarpa*). Juniper (*Juniperus* spp.) is common at lower elevations. Shrubs adapted to xeric growing conditions and rocky soils are typically present, for example, currant (*Ribes* species), common ninebark (*Physocarpus malvaceus*), wild rose (*Rosa* species), common juniper (*Juniperus communis*), Lewis mock orange

(*Philadelphus lewisii*), creeping Oregon grape (*Mahonia repens*), three leaf sumac (*Rhus trilobata*), American wild raspberry (*Rubus idaeus*) or serviceberry (*Amelanchier alnifolia*). Soil development is limited, as is herbaceous cover. Forbs may include penstemon (Penstemon species), buckwheat (*Eriogonum* species), western sagewort (*Artemisia ludovicana*), Michaux's sagewort (*Artemisia michauxiana*), and spotted saxifrage (*Saxifraga bronchialis*). Because the elevation range is so broad, species composition may vary widely from occurrence to occurrence. Soils are typically thin and poorly developed, and moisture for plant growth is primarily retained in crevices in the rock substrate. Limited soil availability, harsh weather extremes, and water stress impose physiological constraints on plants communities leading to plant species that are uniquely adapted to these conditions. Additionally, within the larger cliff habitat, steep slopes, small ledges, overhangs, cracks and crevices often form a mosaic of microhabitat types (Graham and Knight 2004).

Ecotones (Upper and Lower Tree Line)

Ecotones refers to the transition from one ecosystem to another. Ecotones on the Custer Gallatin occur at edges and physical boundaries, such as where lower elevation woodlands become grasslands or shrublands and the upper elevation treelines give way to alpine ecosystems.

Warming trends are expected to cause gradual changes in the abundance and distribution of tree, shrub, and grass species throughout the Northern Rockies, with drought tolerant species becoming more competitive. The earliest changes will likely be at ecotones between lifeforms (such as, upper and lower treelines) (Keane et al. 2018). Ecological disturbance, including wildfire and insect outbreaks, will likely be the primary facilitator of vegetation change, and future forest landscapes may be dominated by younger age classes and smaller trees. High-elevation forests will be especially vulnerable if disturbance frequency increases significantly.

Dry and wet ecotones are considered to be among the most sensitive to warming trends (Means 2011, Wasson et al. 2013). Lower tree line woodlands are often thought to be invading or colonizing into more desirable sagebrush and grass types due to fire exclusion and other management actions such as grazing; however, ecotones also naturally move elevationally based on the dynamics of vegetation, climate, and fire (Means 2011). Douglas-fir and ponderosa pine colonization can occur in ecotones and sagebrush/grassland areas. Drivers of this trend include fire exclusion, which would have killed colonizing trees when they were of a small size; grazing, which reduced fine fuel loads and further influenced fire exclusion; and summer droughts that enhanced sagebrush which functioned as nurse plants for establishing conifers.

Forest Structure

Size Class

Tree size is an indicator of the successional stage and age of forests across the landscape. Forest size classes are defined based on the predominant tree diameter in the stand. Size class is expressed here as the mean basal area weighted average diameter. Basal area weighted average diameter is the average diameter of the live trees weighted by their basal area. Basal area weighted average diameter is less influenced by small trees than other methods of calculating a stand's average diameter such as quadratic mean diameter. Since management questions typically are concerned with the larger, dominant and co-dominant trees in a setting, and basal area-weighted average diameter is influenced, to a greater extent, by larger trees, it was selected by the Northern Region Vegetation Council to be used in the Northern Region existing vegetation classification system. Details on how forests are classified by size are described by Barber et al. (2011). The five size classes defined for this analysis are shown in table 38. A general association of the size class with tree age and forest successional stage is made based upon knowledge of the successional patterns on the Custer Gallatin National Forest.

Desired conditions for size classes, as well as large and very large trees, are the same across all the revised plan alternatives. These desired conditions would not necessarily apply to the current plans, but are included in the analysis for all alternatives to provide a consistent comparison. The desired conditions for size class reflect our best understanding of resilient forest conditions and based in large part on the natural range of variation analysis. Figure 6 shows the current and desired condition for size class within each Northern Region broad potential vegetation type.

Table 38. Forest size classes

Size Class	Diameter Range	Description
Seedling/ Sapling	0 to 5 inches diameter at breast height	The seedling/sapling size class represents the early successional stage of development. Forests are dominated by seedlings (less than 4 ½ feet tall) and saplings (less than 5 inches diameter). There may be low numbers of overstory larger trees present. Most trees are less than 40 years old and less than 40 feet tall. On sites of lower productivity (higher elevation, poor soils) or in extremely dense stands, trees in in this class may be older because of their slower diameter growth rates. Ample sunlight is able to reach the forest floor and abundant grasses, forbs and shrubs are usually present. When summarizing VMap data, transitional areas (areas recently affected by stand-replacing disturbance) are also included in this size class.
Small	5 to 9.9 inches diameter at breast height	Small size class forests are in the mid-successional stage of development, composed mostly of immature trees 5 to 9.9 inches diameter. Typical tree ages range from 40 to 75 years old. They often have a single canopy layer, but two or more layers are not uncommon, depending on disturbance history and site conditions. Many stands are densely stocked, with limited sunlight reaching the forest floor. Shade tolerant understory grasses, forbs and shrubs dominate. Some forests have a more open canopy where understory plant species requiring greater amounts of sunlight are more prevalent.
Medium	10 to 14.9 inches diameter at breast height	Medium size class forests are also in the mid-successional stage of development, where trees 10 to 14.9 inches diameter dominate. Vertical structures vary considerably. Some forests are densely stocked, where shade tolerant grasses, forbs and shrubs dominate forest floor vegetation. Others are characterized by open densities with shade intolerant plants thriving in the understory. Tree age varies depending on species composition, site conditions, and stand density, but is typically 75 to 110 years old. On sites with harsher growing conditions or in stands of very high densities and low growth rates, trees in this medium size class might be substantially older. Notably, many stands that have a 10-15 inch mean basal area weighted diameter also have many large trees within them. In such cases and depending on the specific circumstances, these stands can potentially be moved from a medium to a large size class by removing small trees that effectively reduce the stand's mean diameter.
Large	Over 15 inches diameter at breast height	Large size class forests are usually older than those in the medium class. Trees greater than 15 inches diameter dominate. Most trees are over 90 years old, and most stands are in the mid or late successional stage of development. There are sites where trees of large tree size classes are substantially younger or much older. Some forests are composed of two or more canopy layers. Some of these forests are open, with shade intolerant plants in the understory, particularly in ponderosa pine. The larger trees are typically over 130 years old, and some may be several centuries in age. Forests are in the late successional stage of development, and some correlate to old growth forest. These forests typically have a more complex structure than other successional stages, with more variability in canopy layers, amounts of snags and down wood, and individual tree sizes.

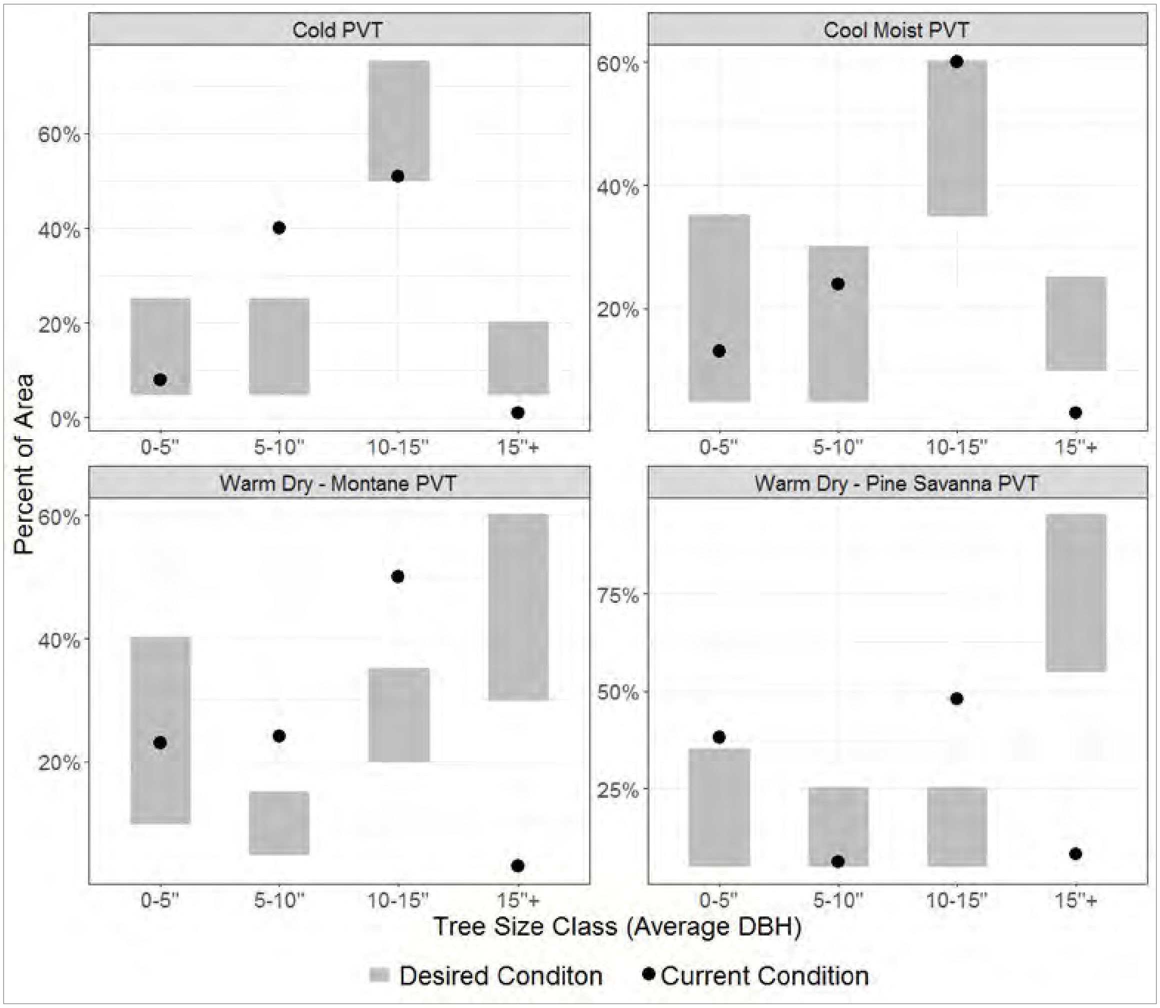

Figure 6. Current and desired conditions of forest size classes (current condition is based on VMap data)

Perhaps the most notable and consistent departure from desired conditions is the lack of large trees (over 15 inches) and the relatively higher levels of small and medium sized trees. This situation is most likely related to historic logging practices and the lack of low and mixed severity fires that historically had the effect of reducing density and thereby increasing growing space and diameter growth on residual trees. Based on forest inventory and analysis data, between 40 and 50 percent of the stands in the medium size class (10 to 15 inches) already have a significant component of large trees. This reflects, in part, an increasing densification within stands due to the lack of mortality from low and mixed severity fire over the past 130 years.

Individual tree growth in the forest is based on the productivity of the site, the amount of precipitation, insect and disease activity that reduces growth, individual species growth traits, and the degree of competition for light, water and nutrients. Short-lived species such as lodgepole pine generally do not get larger than the small or medium class, unless small scale natural disturbances take place or vegetative treatments occur in younger ages. These events reduce competition, which allows increased diameter growth. Longer-lived species such as Douglas-fir, ponderosa pine, and whitebark pine are capable of growing to the larger size classes if open growing conditions are maintained by small disturbance events or vegetation treatments that reduce competition for growth resources (water, nutrients and light). Without disturbance, progression into larger size classes will be slow. In areas where small-scale disturbances have taken place or vegetation thinning treatments have occurred this progression may be more rapid.

Warm Dry Potential Vegetation Type – Both the montane and pine savanna portions of the Warm Dry potential vegetation type show departures in size class from the desired condition that have been widely observed for this potential vegetation type (Hessburg et al. 2005). In the Pine Savanna portion, the existing proportion of small trees (under 5 inches diameter at breast height) is above the desired condition, largely due to the recent effects of large, high severity wildfires on the Ashland Ranger District (U.S. Department of Agriculture 2014a). A significant portion of this area has no surviving trees (and therefore no seed source), and is likely to remain mostly unforested, and hence in the smallest size, for several decades. This potential vegetation type is also characterized by a dearth of the largest size class and an overabundance of medium-sized trees. This is likely primarily due to the relative lack of low severity fire in recent decades leading to increasing stand density, thereby lowering the average stand diameter. Large size class forests would have been relatively open or clumpy patch mosaics (Larson and Churchill 2012, Churchill et al. 2013), with the large trees generally being long-lived and capable of surviving moderate or low severity fire when mature. Vegetation treatments that remove small diameter trees while retaining the largest trees would help decrease the overabundance of medium tree size class while simultaneously increasing the amount of the more resilient large size class.

Cool Moist Potential Vegetation Type - A wide range in proportion of seedling/sapling forest types of the Cool Moist potential vegetation type would be expected and desired, as well as a naturally lower level of large forest size class compared to the Warm Dry potential vegetation type. The abundance of the medium tree class is on the high end of the desired condition. The existing proportion of large size class is somewhat below the desired range but not to the extent as Warm Dry sites. Most of the Cool Moist potential vegetation type is in the medium size class, partly because the high productivity of the Cool Moist potential vegetation type supports high densities of trees. In the absence of an intermediate disturbance, stands can remain in the medium size class for long time periods as tree growth is reduced in higher density stands. Lodgepole pine, a significant component of this potential vegetation type is well adapted to moderate and high severity fire, and seeds in abundantly after fires. Lodgepole pine often does not reach large sizes thereby contributing to the bulge in the medium size class in this potential vegetation type. Subalpine fir and spruce also establish readily on the moist sites and persist for many decades as smaller diameter trees in shaded understory conditions, thereby bringing down average stand diameters. When high densities limit growth, only a portion of the forest in the small size class would progress into the larger size classes before the next stand-replacing disturbance. Less dense forests or forests on more productive sites would transition through the smaller size classes and into the very larger tree size class relatively quickly. In areas with large size classes, a relatively fire tolerant large diameter overstory tree layer would typically exist (Douglas-fir) atop a denser mid and understory tree layer. Large, old Engelmann spruce and subalpine fir should occur in sheltered, moist settings.

Cold Potential Vegetation Type – In the Cold potential vegetation type, the existing proportion of the small tree size class (5-10 inches diameter at breast height) is above the desired range, and the large tree size class is below. The observed departure is in part due to the effects of densification due to the lack of intermediate disturbance (mixed severity fire) in the more productive parts of the potential vegetation type coupled with the devastating effects of blister rust and bark beetles on large whitebark pine trees. Between 2004 and 2009 approximately 80 percent of large size class whitebark pine were killed by an epidemic of mountain pine beetle (Shanahan et al. 2016). See discussion on whitebark pine in At-Risk

Plant Species section for more detail on the current status, threats and vulnerabilities to whitebark pine. Large subalpine fir and Engelmann spruce commonly develop in riparian areas and moist basins.

Large Tree Structure

The "large" forest size class as discussed in the previous section describes an averaged, stand-level diameter (over 15 inches average diameter at breast height). However, individual large trees often occur in stands dominated by smaller trees. In these situations, the stand may have a relatively small average diameter, but the presence of large trees provides important and unique ecological functions. For example, large diameter live trees (over 15 inches diameter at breast height), particularly long-lived fire tolerant ponderosa pine and Douglas-fir, are uniquely valuable ecologically due to their disproportionate contribution to resilience in dry and mixed mesic conifer forests (Hessburg et al. 2015). These trees can survive low to moderate fire, contributing to the recovery of the forest after disturbance, promoting resilience, and providing long-term structural diversity. Where present in sufficient numbers they contribute to late successional forest and, in some cases, old growth. They also provide important wildlife habitat, both as live trees and when they die as snags and downed wood. The decay and snag traits of these species are conducive to cavity formation and long-term snag persistence.

Large and very large trees of species other than ponderosa pine and Douglas-fir are also valuable. Large trees of intolerant species develop where frequent disturbance maintains low density, or on productive sites which provide ample moisture and nutrients for individual tree growth. For example, large Engelmann spruce and subalpine fir can be long-lived and contribute to late successional and old growth forest structures. Unlike ponderosa pine and Douglas-fir, large trees of these species tend to develop in areas protected from disturbance. Lodgepole pine only rarely reaches large sizes and is not fire tolerant. Aspen is less common on the Custer Gallatin National Forest, and is generally short-lived, but when it does reach a large size, it provides unique habitat for cavity nesting wildlife. Whitebark pine and limber pine, although generally short in height, can grow to fairly large diameters. Both provide important structures on the harshest growing environments on the Custer Gallatin; however, they are limited in their occurrence.

A significant proportion of stands in smaller size classes also contain a large tree structure as defined by the minimum criteria in table 39. The criteria shown in table 39 are based, in part, on analysis of old growth found in Green et al. (2011) and indicate thresholds of ecological importance. The methodology and definitions for the minimum requirements for large tree structure are described in detail by Milburn et al. (2019).

Based on forest inventory and analysis data, approximately 30-40 percent of stands in the medium size class (10-15 inches average diameter at breast height) and even 7-14 percent of stands in the small size class (5-10 inches average diameter at breast height) contain large trees at a density equal to or greater than the minimum criteria for large tree structure shown in table 39. Although the mean diameter of these stands is less than 15 inches, the large component represented in these stands are critical pieces of ecosystem diversity and resilience. To address this, in addition to the amount of large size class, the distribution of large tree structure across the landscape is also considered a key ecosystem characteristic.

Table 39. Large tree structure definitions and current and desired conditions, forestwide and by broad potential vegetation group

Broad Potential Vegetation Group	Large Tree Structure Minimum Criteria (at least 15 inches diameter)	Current Condition (percentage of broad potential vegetation type)[1]	Desired Condition (percentage of broad potential vegetation type)[2]
Warm Dry – Montane	At least 5 trees per acre	31 percent (24 to 39 percent)	45 to 80 percent
Warm Dry – Pine Savanna	At least 5 trees per acre	13 percent (8 to18 percent)	55 to 95 percent
Cool Moist	At least 10 trees per acre	33 percent (27 to 40 percent)	30 to 60 percent
Cold	At least 8 trees per acre	26 percent (21 to 30 percent)	45 to 80 percent

Definitions are based on Green et al. (2011) indicating thresholds of ecological importance.

1. Existing condition shown is the mean percent of the area with the 90 percent confidence interval shown in parenthesis. Source is Northern Region Summary Database, forest inventory and analysis data
2. Desired condition is based on natural range of variability

The Warm Dry potential vegetation type is currently below the desired condition for large tree structure with the Pine Savanna portion exhibiting a particularly large departure (table 39). Reductions of large trees in the Warm Dry potential vegetation type likely occurred historically as early settler's used trees for mining timbers, railroad ties, home building and other needs. Additionally, stand replacement fires have likely reduced the prevalence of large trees in recent decades. In high-frequency, low-intensity fire regimes, fire-adapted species such as ponderosa pine and Douglas-fir would be expected to survive historically typical, low-severity fires. However, with fire exclusion, stand densities, ladder fuels and crown bulk density have significantly increased in this forest type across the west (Veblen et al. 2000, Hessburg et al. 2005) and large stand replacement fires are occurring more commonly. On the pine savanna units, the acreage of stand replacement fire since 1988 has increased and has resulted in mortality of large trees. Pine engraver beetle populations increase dramatically post fire on the pine savanna units. Fire damaged individual large ponderosa pine that appear to have survived the fire disturbance are commonly attacked and killed by this beetle.

In the Cold potential vegetation type, the deficit in area with large tree structure is largely attributable to the devastating combined effects of blister rust and mountain pine beetle in recent decades. The Cool Moist potential vegetation type is also below the desired condition. The decreased amount of large tree structure here is likely due to a combination of past logging practices and fire suppression that has decreased the amount of mixed severity fire that would have the effect of lowering stand density and increasing diameter growth on residual trees.

Density

Forest density is a measure of the area occupied by trees. The density of trees can influence tree growth and vigor; susceptibility to drought, insects and diseases, wildfires, and windthrow; and the rate of forest succession as well as other attributes such as vertical structure. These factors in turn affect whether the stand is suitable habitat for certain wildlife species. For this analysis, tree canopy cover is used as the measure of density. *Canopy cover* is the percentage of ground covered by a vertical projection of the outermost perimeter of the tree crowns, considering trees of all heights.

The three canopy cover classes and associated vertical structures are described in table 40. These classes only apply to lands within forested potential vegetation types.

Table 40. Forest density classes

Tree Density Class	Canopy Cover Range	Description
Low	Under 40 percent	Low and medium tree canopy cover classes represent relatively open forests with 10 to 39.9 percent canopy cover. This class is common in young forests. In addition, low densities are found in dry forest types at all stages of succession, particularly in the warm dry broad potential vegetation group, where site conditions or disturbances maintain low tree density. Cool moist or cold forests may also be in this condition particularly where impacted by disturbances such as mountain pine beetle infestations. When summarizing VMap data, transitional areas (areas recently affected by stand-replacing disturbance) are also included in this size class.
Medium	40 to 59.9 percent	The medium to high tree canopy cover class represents a more fully stocked forest, a condition which is common in more moist forests of shade tolerant species, often found on the cool moist broad potential vegetation group. Examples of forests with this density could include mature single-storied lodgepole pine or spruce-fir multistoried stands. Dry forests may also be in this density class particularly where fire has been excluded and understory layers have developed.
High	60 percent or more	The high canopy cover class includes forests with a relatively closed canopy, most often on productive sites on the cool moist broad potential vegetation group. This density class is common in stands with a spruce-fir component in a multi-storied condition. This condition also arises in single-storied lodgepole pine and sometimes Douglas-fir that regenerate to extremely high densities after fire. High tree density can limit tree growth as well as sunlight to the understory, limiting vegetation in the understory. This condition may also occur in dry forests that have missed natural fire entries and developed layers in the understory.

Canopy cover is low when the stand is in the earliest stage of succession and dominated by seedlings. As trees grow, crowns expand to fill up growing space, and canopy cover gradually increases. Growth of understory trees over time also adds to the canopy cover and vertical structure as the forest grows into the later successional stages. Disturbances and competition-based mortality can limit tree density. Site productivity also affects canopy cover, with more productive, moist sites supporting higher densities, and harsh sites with poor soils supporting lower densities. Frequent fire, particularly in the Warm Dry potential vegetation type, can maintain low canopy covers at all stages of forest succession.

Forest density influences tree species composition and vice versa. For example, ponderosa pine and lodgepole pine are intolerant of shade and cannot survive in the lower canopy layers. Shade tolerant species, such as subalpine fir and spruce can prosper in dense stand conditions with limited light. Unless a disturbance reduces competition from shade tolerant species, intolerant species will die out. Some cover types, such as lodgepole pine, naturally grow at high density. Others, such as ponderosa pine, typically grow at more open densities with natural disturbance regimes.

Maintaining appropriate amounts and spatial distribution of high-density forest is a critical component of maintaining ecological integrity as these conditions provide important cover and foraging conditions for native wildlife. However, when high-density forest is too abundant or too spatially aggregated, the resistance and resilience of large landscapes may be at risk. In general, high-density forest has a greater likelihood of supporting a fast-moving intense crown fire due to greater fuel quantities and the vertical and horizontal continuity of fuels. Lower forest densities are therefore desired near communities or other values at risk from fire. In addition, as the density increases, individual tree growth slows, a deficit of soil moisture develops and trees lose their ability to withstand attacks by insects, pathogens, and parasites (Safranyik et al. 1998). Shifts towards lower-density forests would likely increase the large tree size classes and concentrations described above.

Figure 7 displays the current and desired proportions of forest density classes. An array of density classes across the landscape would contribute to desired ecological conditions. Forest density influences wildlife habitat, forest resilience, timber productivity, and fire hazard. More open densities tend to be more resilient to fire as well as insects and diseases, and promote the growth of large trees. Moderate densities tend to maximize timber production. Higher densities provide valuable wildlife habitat conditions particularly in the Cool Moist broad potential vegetation group.

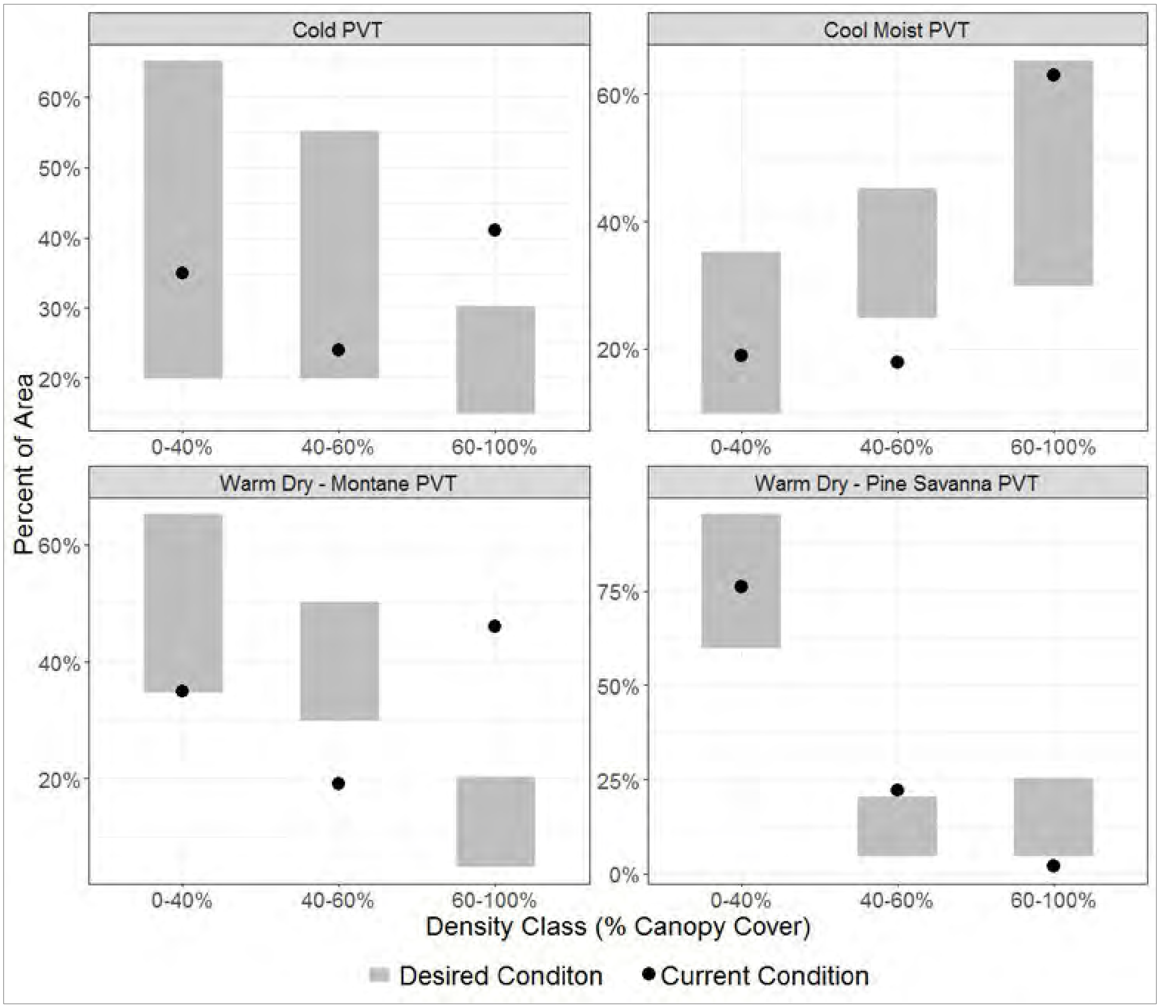

Figure 7. Current and desired conditions for forest density (current condition is based on VMap data)

Warm Dry Potential Vegetation Type – The natural range of variability analysis indicates important differences in density class distribution between the montane and pine savanna portions of the Warm Dry potential vegetation type. These differences reflect a difference in the historical fire regimes of these areas, driven by differences in productivity and species composition that would have supported higher amounts of mixed severity fire in the montane portion of this potential vegetation type. The pine savanna portion, which is composed entirely of ponderosa pine, had very high levels of low-density forest, likely dominated by large trees scattered as individuals and clumps of various sizes separated by large areas of non-forested vegetation (Larson and Churchill 2012). Recent severe, large fires in this area have converted a large portion of what was high density, mature forest to low density forest in an early successional state. The departure analysis indicates that the montane portion of the Warm Dry potential vegetation type, which currently has an overabundance of high-density forest, is in a condition that could support a similar trajectory.

Cool Moist Potential Vegetation Type – The Cool Moist potential vegetation type shows a lack of mid-density (40-60 percent canopy cover) structure while high density forest is as the high end of the desired range. As summarized by Hessburg et al (2016) this mixed-severity dominated fire regime was historically composed of a mosaic of forest densities where south-facing aspects were generally dominated by more open canopies maintained by frequent fires of low to mixed-severity while north-facing slopes and valley bottoms generally contained closed-canopy, multi-layered forests maintained by moderately frequent to infrequent mixed- and high severity fires. Mid-montane settings were a complex mixture of these with a variety of canopy densities depending on time-since-fire, topographic setting, and the severity of prior fires. Due to fire suppression these differences in forest density are less pronounced today, and low (largely post-disturbance) and high-density forest is beginning to dominate.

Cold Potential Vegetation Type – The desired condition of forest density in the Cold potential vegetation type shows a large amount of variation in the low to mid-density classes with a relatively small promotion of the potential vegetation type to a high-density state. This reflects, in part, the large amount of ecological variation in this potential vegetation type which spans from productive spruce-fir forests to whitebark pine parklands. In lower portions of this potential vegetation type, the historical ecological dynamic was likely similar to that described above for the Cool Moist potential vegetation type. Increases in high density proportions within this potential vegetation type also likely reflect, in part, encroachment of subalpine fir into areas that were historically dominated by lower density stands of whitebark pine.

Snags

Tree snags (standing dead trees) are critically important for terrestrial ecosystems. The specific ecological conditions created by high severity fire events, as well as the general level of snags and down wood are all elements of healthy, productive, and biologically diverse forests (Bull et al. 1997) (Hutto 2006;2008). Numerous species depend on snags and down wood for foraging, denning, roosting, and nesting habitat. After snags fall, they also store nutrients and moisture and aid in soil development. See the Soils section for more discussion and analysis of coarse woody debris.

The general levels of snags and down wood as well as the amount of forest that has recently experienced severe fire can all affect the sustainability of particular animal or plant species. Some species are restricted in their habitat distribution to standing dead forests created by stand replacement fires (Hutto 1995). Snags are also the major source of down wood in both upland and riparian areas. Different amounts, ages, species, and sizes of snags typically exist throughout the forest landscape as a result of various disturbance agents and competition-related mortality. At any given point in time, the quantity and extent of snag habitat conditions will vary, but will be greatest following disturbance events, such as wildfire, wind events, and insect and disease outbreaks. Snags and down wood density tend to be higher in riparian areas.

A report on snag conditions in eastern Montana forests was completed by Bollenbacher et al. (2008) using forest inventory and analysis data. Updated data tables were produced in 2017. Medium snags are the most prevalent; relatively few large or very large are present. Large snags tend to occur in the Cool Moist broad potential vegetation group. In areas dominated by lodgepole pine, early seral stands have the most snags due to a greater proportion of stand-replacing fires and species intolerance to fire. The Warm Dry broad potential vegetation group has a more even distribution of snags into later seral stages because of a more frequent, less severe fire regime. All broad potential vegetation groups show fewer mid-seral stage snags as snags transition to downed wood. Snags occur in a clumpy manner, and in all groups the larger the snag the less common it is. This is due to: 1) fewer trees living to an old age; 2) as trees age, they grow slower, not commonly reaching large diameters; and 3) the inability of systems to contain large old trees and snags due to various types of disturbances (Bollenbacher et al. 2008).

Table 41 displays the desired and existing conditions for average snag densities. Table 42 displays the desired condition for the distribution of snags, defined as the percent of the area containing at least one snag of a given size class. A primary assumption used in the development of desired conditions for snags is that the best indication of the natural range of variability is the abundance of snags found in wilderness and Roadless areas, where natural processes have by and large been allowed to occur (Bollenbacher et al. 2008). The analysis area for snags is Forestwide by snag analysis group. Snag analysis groups are consistent with Northern Region broad potential vegetation groups, except areas dominated by lodgepole pine are addressed separately. This is important for the snag analysis because lodgepole pine is relatively short lived, generally smaller in diameter than other species, and subject to stand replacing disturbances which result in unique snag conditions and dynamics.

Table 41. Average existing and desired conditions for snag density; 90 percent confidence limit shown in parentheses

Snag Analysis Group[1]	Snags per acre over 10 inches Existing[2]	Snags per acre over 10 inches Desired[3]	Snags per acre over 15 inches Existing[2]	Snags per acre over 15 inches Desired[3]	Snags per acre over 20 inches Existing[2]	Snags per acre over 20 inches Desired[3]
Lodgepole Pine	22.4 (16.5–29)	30.7 (21.9–40.3)	3.7 (2.3–5.3)	4.2 (2.5–6.1)	0.6 (0.1–1.1)	0.8 (0.1–1.6)
Warm Dry	9.3 (6.6–12.5)	9 (3.9–15.7)	2.1 (1.3–3)	1.5 (0.3–3)	0.5 (0.1–0.9)	0 .2 (0.1–0.6)
Cold	28.4 (23.1–33.6)	27.5 (21.8–33.6)	8.2 (6.2–10.3)	7.9 (5.9–10.1)	2.1 (1.3–3)	2.1 (1.2–3)
Cool Moist	19.9 (15–25.3)	22.5 (16.9–28.7)	6.3 (4.4–8.4)	7.1 (4.9–9.5)	1.6 (0.8–2.6)	1.8 (0.8–3)

Desired condition applies at the forestwide- and geographic-area scales.

1. Snag analysis groups are from Bollenbacher et al. (2008). As explained in Bollenbacher et al. (2008), snag analysis groups are consistent with the Northern Region Broad Potential Vegetation Types except that areas dominated by lodgepole pine are separated because it does not grow as large as other common tree species on eastside Forests, and therefore does not contribute as many large diameter snags.
2. Existing condition (with 90 percent confidence limit) comes from the Northern Region Summary Database based on forest inventory and analysis data.
3. Desired condition is also a Forestwide average and is derived from snag levels (with 90 percent confidence interval) found in predominantly unmanaged areas of the Custer Gallatin National Forest. Data source: Northern Region Summary Data Base based on forest inventory and analysis data.

Table 42. Existing and desired conditions for snags; 90 percent confidence limit shown in parentheses

Snag Analysis Group[1]	Percentage of area with at least one snag per acre over 10 inches Existing[2]	Percentage of area with at least one snag per acre over 10 inches Desired[3]	Percentage of area with at least one snag per acre over 15 inches Existing[2]	Percentage of area with at least one snag per acre over 15 inches Desired[3]	Percentage of area with at least one snag per acre over 20 inches Existing[2]	Percentage of area with at least one snag per acre over 20 inches Desired[3]
Lodgepole Pine	36 (29–43)	47 (37–56)	12 (8–17)	15 (9–21)	3 (1–5)	4 (1–8)
Warm Dry	20 (16–25)	17 (10–25)	8 (5–11)	5 (1–10)	3 (1–5)	2 (1–4)
Cold	43 (37–49)	44 (37–51)	23 (18–28)	24 (18–30)	9 (6–13)	10 (6–13)
Cool Moist	39 (32–47)	44 (36–52)	21 (16–27)	25 (18–32)	9 (5–14)	10 (5–16)

Desired condition applies at the forestwide and geographic area scales.

1. Snag analysis groups are from Bollenbacher (2008). Snag analysis groups are consistent with the Northern Region Broad Potential Vegetation Types except that areas dominated by lodgepole pine are separated.
2. Existing condition (with 90 percent confidence limit) comes from the Northern Region Summary Database based on forest inventory and analysis data.
3. Desired condition is also a Forestwide average and is derived from snag levels (with 90 percent confidence interval) found in predominantly unmanaged areas of the Custer Gallatin National Forest. Data source: Northern Region Summary Data Base based on forest inventory and analysis data.

Snag conditions at a forestwide scale are similar to what might occur under natural regimes and are generally within the natural range of variation. At smaller scales of analysis (such as project level), timber harvest and human access can have substantial impacts on snag density, distribution and longevity (Wisdom and Bate 2008). Presence of localized disturbances could also have substantial influence on snag conditions at smaller scales.

Old Growth

Old growth is distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function. For the purposes of this document, old growth is defined by the minimum criteria established for the Northern Region of the Forest Service (Green et al. 2011); table 43 through table 45). These old growth definitions are specific to forest type and habitat type group. Key attributes of old growth include age, numbers and diameter of the old tree component within the stand, and the overall stand density. Minimum thresholds have been established for these attributes. Associated characteristics are also defined for each old growth type such as probabilities of downed woody material, number of canopy layers, and number of snags over 9 inches diameter at breast height. For this analysis, old growth is estimated with forest inventory and analysis plots and based on the minimum criteria found in Green et al. (2011). Though old growth ecosystems are typically distinguished by old trees, these stands are not necessarily in a late successional condition nor free from anthropogenic disturbance (Foster et al. 1996). There are no specific criteria for minimum patch size for old growth in the Northern Region definitions.

For table 43, the warm and dry broad potential vegetation type for the Custer Gallatin National Forest is described as typically containing large diameter, old Douglas-fir or ponderosa pine; rare types have lodgepole or subalpine fir. A relatively open overstory canopy exists, but Douglas-fir can be dense in the mid and understory canopy layers with lack of disturbance. When this occurs, the large trees become more susceptible to bark beetle-caused mortality.

Table 43. Minimum criteria for old growth[1] and typical stand conditions for the warm and dry broad potential vegetation type[4] on the Custer Gallatin National Forest

Old Growth Type[2]	Habitat type group[3]	Minimum age of large trees	Minimum trees per acre and tree diameter	Minimum basal area (square feet per acre)
1 – Douglas-fir	A	200	4 at least 17 inches	60
2 – Douglas-fir	B, C	200	5 at least 19 inches	60
4 – ponderosa pine	A, B, C	180	4 at least 17 inches	40
5 – limber pine	A, B	120	6 at least 9 inches	50
6 – lodgepole pine	A, B, C	150	12 at least 10 inches	50
7 – Engelmann spruce and subalpine fir	C	160	12 at least 17 inches	80

1. Based on definitions found in Green et al (2011).
2. Old Growth Type - the type is a group of forest cover types that have similar characteristics relative to size, number and age of dominant overstory trees.
3. Habitat Type Group - Habitat types are grouped differently according to geographic zone. The letters identify the zone habitat type groups displayed in appendix A of Green et al (2011). Habitat type groups are grouped into larger groups based on similarity of temperature and moisture regimes within each zone.
4. This crosswalk shows the most dominant relationship between old growth habitat type group and Northern Region broad potential vegetation type; specific habitat types may vary.

For table 44, the cool and moist broad potential vegetation type for the Custer Gallatin National Forest has Douglas-fir, Engelmann spruce, subalpine fir, or lodgepole pine as the dominant large, old trees; rare sites may have whitebark pine. Lodgepole pine may be single-storied, or support a developing understory of spruce and fir. Spruce and fir old growth is typically dense, with multi-canopy layers, with subalpine fir and spruce the most common mid and understory tree species.

Table 44. Minimum criteria for old growth[1] and typical stand conditions for the cool and moist broad potential vegetation type[4] on the Custer Gallatin National Forest

Old Growth Type[2]	Habitat type group[3]	Minimum age of large trees	Minimum trees per acre and tree diameter	Minimum basal area (square feet per acre)
2 – Douglas-fir	D, E, F, H	200	5 at least 19 inches	60
3 – Douglas-fir	G	180	10 at least 17 inches	80
6 - lodgepole pine	D, E, F, G, H	150	12 at least 10 inches	50
8 – Engelmann spruce and subalpine fir	D, E	160	7 at least 17 inches	80
9 – Engelmann spruce and subalpine fir	F, G, H	160	10 at least 13 inches	60
11 – whitebark pine	D, E, F, G, H	150	11 at least 13 inches	60

1. Based on definitions found in Green et al (2011).
2. Old Growth Type - the type is a group of forest cover types that have similar characteristics relative to size, number and age of dominant overstory trees.
3. Habitat Type Group - Habitat types are grouped differently according to geographic zone. The letters identify the zone habitat type groups displayed in appendix A of Green et al (2011). Habitat type groups are grouped into larger groups based on similarity of temperature and moisture regimes within each zone.
4. This crosswalk shows the most dominant relationship between old growth habitat type group and Northern Region broad potential vegetation type; specific habitat types may vary.

For table 45, the cold broad potential vegetation type for the Custer Gallatin National Forest has Engelmann spruce, subalpine fir, and whitebark pine as the most common large, old overstory trees. Because of the harsh conditions, tree growth is slower and old trees are smaller than in old growth at lower elevations. There are typically multi-canopy layers, though tree density may be low. Subalpine fir and spruce dominate the mid and lower canopy.

Table 45. Minimum criteria for old growth[1] and typical stand conditions for the cold broad potential vegetation type[4] on the Custer Gallatin National Forest

Old Growth Type[2]	Habitat type group[3]	Minimum age of large trees	Minimum trees per acre and tree diameter	Minimum basal area (square feet per acre)
6 - lodgepole pine	I	150	12 at least 10 inches	50
9 – Engelmann spruce and subalpine fir	I	160	10 at least 13 inches	60
10 – Engelmann spruce and subalpine fir	J	135	8 at least 13 inches	40
11 – whitebark pine	I	150	11 at least 13 inches	60
12 - whitebark pine	J	135	7 at least 13 inches	40

1. Based on definitions found in Green et al (2011).
2. Old Growth Type - the type is a group of forest cover types that have similar characteristics relative to size, number and age of dominant overstory trees.
3. Habitat Type Group - Habitat types are grouped differently according to geographic zone. The letters identify the zone habitat type groups displayed in appendix A of Green et al (2011). Habitat type groups are grouped into larger groups based on similarity of temperature and moisture regimes within each zone.
4. This crosswalk shows the most dominant relationship between old growth habitat type group and Northern Region broad potential vegetation type; specific habitat types may vary.

Old growth is of particular value to many wildlife species, is an important component of biological diversity, and provides functions such as carbon storage. It also contains biological legacies and seed sources that contribute to landscape resilience. The concept of old growth involves not only the age of a forest but also characteristics such as large trees, size and spacing variation, large dead standing and fallen trees, broken and deformed tops, bole and root rot, multiple canopy layers, canopy gaps and understory patchiness, cessation in height growth of oldest trees, low net productivity, and biochemistry of secondary metabolic products in old trees (Johnson et al. 1995). This late-stage state of succession is not static and as old growth dies, it is replaced by younger forests that age. The proportion and distribution of old growth across the landscape changes naturally over time. Existing old growth is vulnerable to moderate or high severity fire, as well as insects and disease. Fire exclusion, particularly in low elevation warmer sites, has altered vegetation structure and composition in some old growth forests. In many areas, increasing tree densities and canopy layers have increased tree stress and vulnerability to mortality from insects, disease, and fire.

For this analysis, current old growth is estimated with forest inventory and analysis plots using an algorithm based on the definitions found in Green et al (2011). Forest inventory and analysis data is designed to assess forest conditions at a broad scale and cannot be used to map old growth at the stand level. Moreover, as noted by Green et al. (2011), "because of the great variation in old growth stand structures, no set of numbers can be relied upon to correctly classify every stand…do not accept or reject a stand as old growth based on the numbers alone; use the numbers as a guide." As such, field inventories are necessary to accurately identify old growth stands on the ground. However, it is infeasible to maintain a stand examination inventory that covers every acre in a large analysis area and there is no forestwide map of old growth. This type of inventory may occur at the project level, where site specific identification of old growth may be necessary. Using this methodology, figure 8 shows the amount of old growth by cover type and Northern Region Broad Potential Vegetation Types on the Custer Gallatin National Forest.

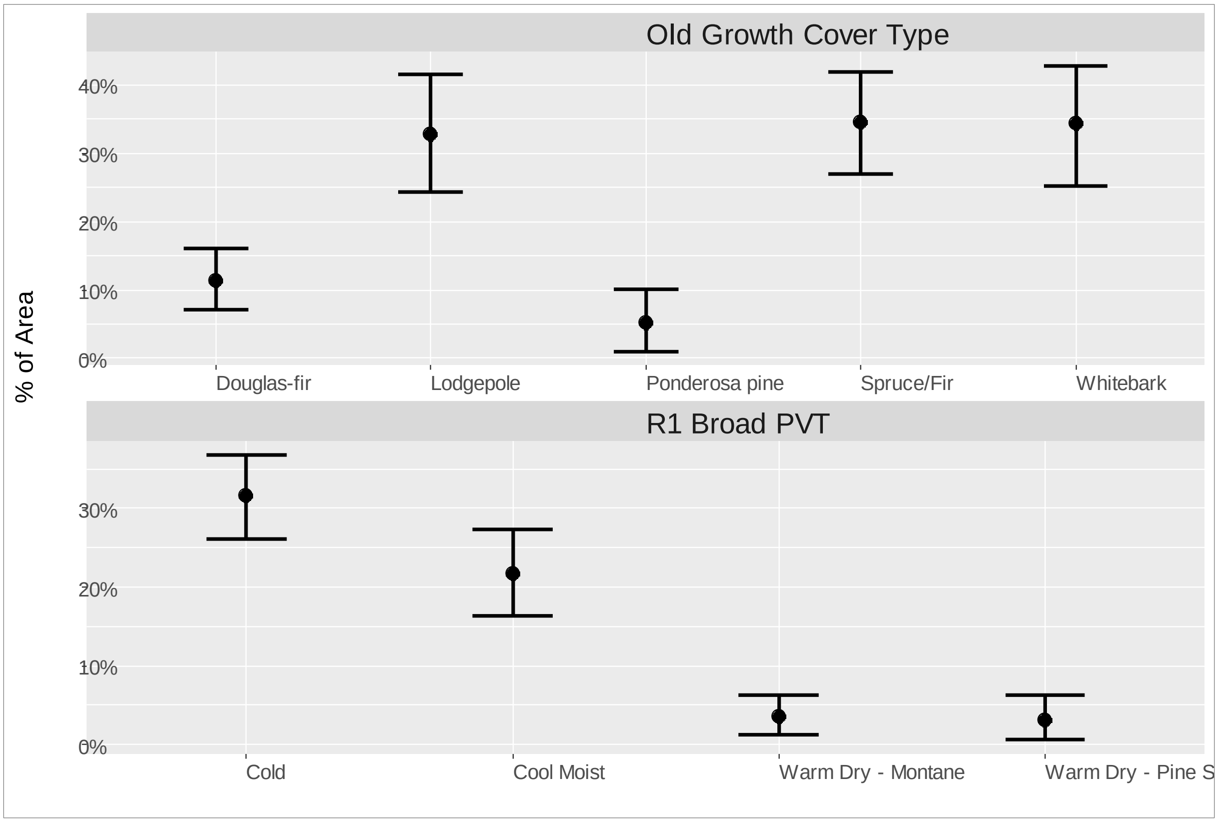

Figure 8. Current amount of old growth forest on the Custer Gallatin National Forest by Old Growth Cover Type (as defined by Green et al. (2011)) and Northern Region broad potential vegetation types. Figure shows estimated mean with 90 percent confidence interval. Data from Northern Region Summary Database v 1.9.12 and based on forest inventory and analysis data.

There is no quantitative estimate of the natural range of variation of the abundance and distribution of old growth because it is not possible to model old growth as currently defined by Green et al. (2011) (that is, a specific number of trees per acre above a certain age and size threshold which varies by potential vegetation type). This is because the specific tree-level information required to classify any given stand as old growth cannot be output with the model used (SIMPPLLE) which provides stand-level averages of size and age. Table 46 displays the current amount of old growth by average stand-level size class across the Custer Gallatin National Forest. As table 46 shows, it is possible for old growth to exist in stands of multiple size classes, even relatively small diameter stands. This level intra-stand detail cannot be output by SIMPPLLE. For this reason, it was not possible to calculate the natural range of variation or precise future trajectory of old growth. For similar reasons, there is not a comprehensive map of all of the old growth across the Custer Gallatin National Forest that can be used at the programmatic level, because complete field inventory would be required.

Table 46. Current amount of old growth[1] by average stand-level size class across the Custer Gallatin National Forest

Average Size Class[2]	Percentage of old growth (90% Confidence Interval)[3]
0 to 5 inches	0%
5 to 10 inches	12% (7–17%)
10 to 15 inches	30% (25–35%)
15 inches	35% (25–45%)

Table is based on forest inventory analysis data.

1. Based on definitions found in Green et al (2011).

2. Details on how forests are classified by size are described by Barber et al. (2011).

3. Based on forest inventory analysis data.

Landscape Pattern

Historically, landscapes were shaped by disturbance regimes interacting with topography, vegetation and climate. The result was an ever-shifting mosaic of diverse vegetation and different patch sizes, shapes, and distributions. This patch mosaic is a critical element of biodiversity creating and reinforcing biological diversity in structure and function but also, just as importantly, conferring resiliency to the system as a whole (Turner et al. 2001). For example, patches created by wildland fire have strong regulating effect on future wildfire occurrence, fire size and fire severity (Harvey et al. 2016a, Parks et al. 2016b) and mountain pine beetle outbreaks are less severe in landscape with diverse age structures (Schoettle and Sniezko 2007). Negative feedbacks associated with landscape heterogeneity are necessary components of self-regulating landscapes including creating and maintaining resilience to future events (McKenzie and Kennedy 2011, Larson et al. 2013). Heterogeneous landscapes may also have more corridors, buffers, and refugia to promote connectivity for wildlife and plant migration, thereby increasing the adaptive capacity of the landscape to climate change (Halofsky et al. 2018b).

As with other key ecosystem characteristics, assessing the natural range of variability for landscape pattern can provide a useful reference condition to manage for resilient forests (Landres et al. 1999, Keane et al. 2009). To this end, an analysis of the natural range of variability was completed to characterize the patch size distribution for four categories of patch sizes (under 40 acres, 40 to 100 acres; 100 to 1,000 acres, and over 1,000 acres) and three broad successional stages: early-seral (under 5 inches average diameter at breast height), mid-seral (5 to 15 inches average diameter at breast height), and late-seral (over 15 inches average diameter at breast height). The analysis was stratified by potential vegetation type to account for broad differences in disturbance regimes. Table 47 shows the desired condition and current status for patch size distribution based on this analysis.

The patch distribution analysis revealed three notable areas of departure. First, large patches (over 1,000 acres) of mid-seral forest (5 to 15 inches average diameter at breast height) are dramatically overrepresented across the Custer Gallatin National Forest. This is likely due to natural succession in the absence of intermediate disturbance events trending the national forest towards a generally more homogenous landscape composed of larger patches of mid successional forest. Second, patches of late-seral forest (over 15 inches average diameter at breast height) are underrepresented for all patch sizes. This reflects both the general effect of fire exclusion leading to densification in smaller size classes (thereby reducing the average stand diameter) as well as the significant effects of recent severe wildfires in ponderosa pine ecosystems and the combined effects of white pine blister rust and mountain pine beetle in whitebark pine ecosystems. Finally, large patches of early-seral forest (under 5 inches average diameter at breast height) are overrepresented in the warm dry potential vegetation type, likely due to recent large, severe wildfires in these areas.

Table 47. Desired condition and current status for patch size distribution

Northern Region Broad potential vegetation type	Patch Size (acres)	Early-Seral Current Condition[1] (0–5 inches diameter[2]): (percentage of potential vegetation type)	Early-Seral Desired Condition (0–5 inches diameter[2]): (percentage of potential vegetation type)	Mid-Seral Current Condition[1] (5–15 inches diameter[2]): (percentage of potential vegetation type)	Mid-Seral Desired Condition (5–15 inches diameter[2]): (percentage of potential vegetation type)	Late-Seral Current Condition[1] (over 15 inches diameter[2]): (percentage of potential vegetation type)	Late-Seral Desired Condition (over 15 inches diameter[2]): (percentage of potential vegetation type)
Cold	under 40	5 %	3–6 %	10 %	11–16 %	1 %	11–14 %
Cold	40–100	1 %	1–2 %	5 %	4–8 %	0 %	4–6 %
Cold	100–500	2 %	1–5 %	11 %	6–14 %	0 %	7–11 %
Cold	500-1,000	1 %	0–2 %	5 %	2–6 %	0 %	3–6 %
Cold	over 1,000	1 %	0–8 %	59 %	3–16 %	0 %	8–32 %
Cool Moist	under 40	6 %	5–11 %	13 %	11–14 %	2 %	12–15 %
Cool Moist	40–100	2 %	1–4 %	8 %	4–6 %	1 %	4–5 %
Cool Moist	100–500	3 %	1–6 %	14 %	6–10 %	1 %	6–9 %
Cool Moist	500–1,000	1 %	0–2 %	6 %	2–5 %	0 %	2–4 %
Cool Moist	over 1,000	5 %	0–8 %	39 %	4–15 %	0 %	8–19 %
Warm Dry - Montane	under 40	7 %	7–15 %	14 %	10–16 %	3 %	19–23 %
Warm Dry - Montane	40–100	2 %	2–4 %	7 %	2–4 %	1 %	6–9 %
Warm Dry - Montane	100–500	2 %	3–6 %	13 %	2–5 %	1 %	7–15 %
Warm Dry - Montane	500–1,000	1 %	1–3 %	5 %	0–2 %	0 %	2–6 %
Warm Dry - Montane	over 1,000	10 %	1–10 %	36 %	0–4 %	0 %	4–23 %
Warm Dry - Pine Savanna	under 40	5 %	1–11 %	8 %	0–9 %	3 %	5–6 %
Warm Dry - Pine Savanna	40–100	2 %	0–1 %	4 %	0–2 %	1 %	2–3 %
Warm Dry - Pine Savanna	100–500	4 %	0–4 %	7 %	0–5 %	1 %	4–7 %
Warm Dry - Pine Savanna	500–1,000	3 %	0- 3 %	4 %	0–3 %	1 %	2–4 %
Warm Dry - Pine Savanna	over 1,000	24 %	0–20 %	32 %	0–21 %	1 %	35–76 %

1. Source is Northern Region VMAP.
2. Diameter is diameter at breast height

3.6.3 Environmental Consequences

Quantitative assessments of ecological effects presented below are the result of models, which, by necessity, simplify very complex and dynamic relationships among ecosystem processes (such as fire and succession), topography, climate, and vegetation. The models use a given set of assumptions, including the amount of stand-replacing fire, insect or disease activity, and the rate of tree growth and stand structure change over time (succession). These assumptions are based on analysis and corroboration of empirical data (such as dendroecological data, fire history and historical vegetation information) and review of scientific literature, as well as professional judgement and experience of resource specialists familiar with the ecosystems and forest types of the Custer Gallatin (see appendix B for details on model assumptions). Though best available scientific information and knowledge is used to build these models, there is a high degree of variability and uncertainty associated with the results because of the ecological complexity and inability to accurately predict timing and location of future events. The actual timing, magnitude, and location of future disturbances, such as fire or bark beetle activity, will certainly differ from that modeled, resulting in different effects to vegetation. As such, results are most appropriately used to compare relative differences among alternatives and general trends in vegetation but are *not* intended to be interpreted as precise values.

All Alternatives

Management Direction under the Current Plans

Vegetative Diversity. Under the plan direction in the current 1986 and 1987 forest plans, as amended, forest lands and other vegetative communities such as grassland, aspen, willow, sagebrush, and whitebark pine will be managed by wildland fire and other methods to produce and maintain the desired vegetative conditions. The current plans do not contain explicit or quantitative desired conditions for ecological diversity, but do provide more general direction to manage for vegetation composition, structures and patterns that would be expected to occur under natural succession and disturbance regimes and providing for long-term recruitment of forest structural elements such as snags and downed wood. The current plans require leaving 20 to 30 snags per acre after harvest. Current forest plans have no direction for retaining large trees, but the 1987 Gallatin Plan has a standard, added as an amendment, to maintain a minimum of ten percent old growth forest on lands classified as forested at the mountain range scale. The current plan does not distinguish between old growth forest types. The 1986 Custer Plan has a standard to maintain sufficient old growth to support old growth dependent species.

Woody Draws. The 1987 Gallatin Plan has no direction for woody draws since the habitat does not occur there. Use of wildland fire in and near woody draws can be conducted to maintain or enhance the unique value associated within riparian zones, as well as a variety of successional vegetative stages.

Under the 1986 Custer Plan, the goal for woody draws is to provide healthy, self-perpetuating riparian plant communities with diverse understory and overstory vegetation.

Woody draws are to be identified and mitigation implemented to retain unique values during project level allotment management planning for permitted livestock grazing. Management practices such as fencing, grazing deferment, burning or planting may be tried on selected areas to determine their effectiveness in maintaining or improving green ash woodland conditions. Large-scale fencing efforts to protect these areas are generally not practical. Structural range improvements will be located to attract livestock out of this management area. Nonstructural range improvements will be done only to improve diversity of habitats or implement practices designed to restore the desired vegetative composition.

Riparian. Both the 1986 Custer and 1987 Gallatin Forest Plans have related goals for riparian areas; to provide healthy, self-perpetuating riparian plant communities with diverse understory and overstory vegetation. Riparian vegetation, including shrub and overstory tree cover, is to be managed along all perennial streams with defined channels to provide shade, to maintain streambank stability and in-stream cover, and to promote filtering of overland flows. Riparian areas are critical for the maintenance of water quality and deciduous trees and shrubs that provide valuable wildlife habitats. Direction includes managing for water quality, diverse vegetation, and key wildlife habitat in these areas from conflicting uses. Uses and activities that could adversely impact these areas are to be mitigated.

Mitigation is to be implemented to retain unique riparian values during project level allotment management planning for permitted livestock grazing. Management practices such as fencing, grazing deferment, burning, or planting may be tried on selected areas to determine their effectiveness in maintaining or improving the riparian zone conditions. Large scale fencing efforts to protect riparian areas are generally not practical. Structural range improvements will be located to attract livestock out of this management area.

Plan direction for timber harvest activities in or near riparian zones includes management prescriptions that will meet needs of riparian zone-dependent species, provide snag recruitment to create pools, enhance spawning gravels for fish habitat, emphasize special logging practices which minimize soil disturbance, and perform directional felling of timber where needed to protect the stream or associated riparian vegetation. Trees or products are not to be hauled or yarded across stream courses unless fully suspended or when designated crossings are used and machine piling is not allowed. Equipment use or time of the activity which causes excessive soil compaction and displacement is to be avoided.

Extraction of saleable mineral materials is not allowed in riparian areas. Surface occupancy for oil and gas exploration and development are not to be permitted in 100-year floodplains or within 500 feet of the high-water mark.

Use of wildland fire in and near riparian zones can be conducted to maintain or enhance the unique value associated within riparian zones, as well as a variety of successional vegetative stages.

Grasslands and Shrublands. The current forest plans call for managing these lands for good condition. For the mixed grass pine savanna ecosystem, this has often been described as providing for a diversity of warm- and cool-season graminoid and forb species and structure that includes tall (for example: big blue stem, pine savanna cord grass, pine savanna sand reed), medium (for example western wheat grass, green needle grass, needle and thread, Idaho fescue) and short grass (for example blue grama, June grass, sun sedge thread leaf sedge) species associated with mixed grass pine savanna communities.

For shrublands, it has often been described as providing a diversity of shrub communities (that is, Wyoming big sagebrush, silver sagebrush, buffalo berry, and chokecherry). For mountain grassland ecosystems, this has often been described as providing a diversity of cool season graminoid and forb species (that is, bluebunch wheatgrass, Idaho fescue, mountain brome, and western needlegrass). For mountain shrublands it has often been described as providing a diversity of shrub communities (that is, mountain big sagebrush, Wyoming big sagebrush, and ninebark).

Noxious weeds are to be reduced and communities should exhibit or be progressing toward a healthy, productive, diverse population of native and or desirable plant species, and functioning disturbance processes appropriate to the ecological site capability.

Conifer Encroachment. Under the Custer Forest Plan, conifer encroachment control may occur where (1) Silvicultural prescription indicates the need; (2) Conifer species exist on sites capable of producing less than 20 cubic feet per acre that are invading rangeland habitat types may be removed in order to maintain the acreage of primary and secondary range. An assessment of wildlife values is required as part of the analysis for any control program; (3) Conifer species existing on sites producing more than 20 cubic feet per acre if the area has been managed as rangeland for some time and the long-term objective is to manage for rangeland; and (4) In rangelands where the invading trees are less than 3-feet high, wildland fire may be the preferred treatment. Mechanical methods may be used in areas where trees are over 3-feet high, including removal for Christmas tree purposes.

Management Direction under the Revised Plan Alternatives

All the revised plan alternatives contain the same desired conditions for forested composition (dominance type and species presence), structure (size class, large tree structure, density and snags) and landscape pattern (patch size distribution). These alternatives also contain direction as to the desired role that ecological processes such as insects and fire (both prescribed fire and natural, unplanned ignitions) would have in affecting forest composition and structure. Forested desired conditions are designed to maintain and enhance ecological integrity, diversity, function, and resiliency while contributing to social and economic sustainability as required by the 2012 Planning Rule. Forested desired conditions are based on an analysis of the natural range of variation for key ecosystem characteristics, which provides an understanding of how ecosystems change over time in a manner that is resilient to perturbations and disturbance. These alternatives also have the same forestwide standards and guidelines designed to move vegetation towards desired conditions. For example, all the revised plan alternatives share guidelines that provide protection and management emphasis for snags, large tree structure and old growth.

The components in the revised plan that would guide management of terrestrial vegetation are summarized in table 48. The plan components outlined in table 48 are the same across all action alternatives and are designed to complement each other and collectively maintain or restore the ecological integrity of the Custer Gallatin National Forest. Objectives and suitability of lands for timber harvest are the primary factors distinguishing management direction for terrestrial vegetation among the revised plan alternatives. Objectives for the revised plan alternatives are outlined in table 10 of chapter 2 and key differences in suitability are described in table 2 of chapter 2.

Table 48. Summary of plan components relevant to terrestrial vegetation – revised plan

Plan Component(s)	Summary of expected effects
FW-DC-SOIL-01 to 03 FW-DC-PRISK-01, 02 FW-DC-VEGF-01 to 09 FW-DC-VEGNF-01 to 04 FW-DC-FIRE-01, 02 FW-DC-INV-01 FW-DC-CARB-01	The desired vegetation conditions collectively describe the function, composition, structure, and pattern of terrestrial ecosystems. The desired conditions are compatible, interrelated and collectively provide a comprehensive and clear articulation of resilient terrestrial ecosystems including habitat conditions for at-risk species and the relative abundance and condition of key ecosystem characteristics at appropriate scales. Collectively, the full suite of desired conditions articulate a detailed description of ecological integrity for the plan area and provide a clear vision to guide management activities.
FW-GDL-SOIL-01 to 07 FW-STD-SOIL-01 FW-GDL-PRISK-01, 02 FW-STD-PRISK-01, 02 FW-GDL-VEGF-01 to 05 FW-GDL-VEGNF-01 to 08 FW-GDL-FIRE-01 to 03 FW-STD-TIM-01 to 10 FW-GDL-TIM-01 to 03	The suite of Standards and Guidelines place clear constraints on management activities to ensure that projects will not prevent achievement of Desired Conditions and protect key ecosystem characteristics and at-risk species. Together, these plan components provide for maintenance and/or re-establishment of desirable vegetation for both non-forested and forested plant communities, including at-risk plants.
FW-OBJ-PRISK-01 FW-OBJ-VEGF-01 FW-OBJ-VEGF-02 FW-OBJ-VEGNF-01	These components specify a minimum desired level of vegetation management to help ensure that active management moves conditions toward the desired conditions for forested and non-forested ecosystems, including at-risk plants.
FW-DC-PRISK-02 FW-GO-PRISK-01 FW-GDL-PRISK-02 FW-OBJ-PRISK-02 MON-PRISK-02 FW-DC-VEGF-01, 02	This suite of plan components is specific to whitebark pine. These plan components articulate the affirmative desire to maintain and restore whitebark pine ecosystems and support this desired condition with an associated guideline to protect whitebark, treatment objectives to ensure active restoration activities, a goal to proactively work with partners on whitebark restoration and a monitoring component to support adaptive management if necessary.
FW-DC-VEGNF-04 FW-DC-GRAZ-03 FW-GDL-EMIN-02 FW-GDL-VEGNF-05 FW-GDL-VEGNF-06 FW-GDL-VEGNF-07 FW-GDL-VEGNF-08 FW-GDL-GRAZ-04 FW-GDL-GRAZ-05 FW-GO-VEGNF-02 FW-GO-GRAZ-01 FW-OBJ-VEGNF-01	This suite of plan components effectively guides the conservation and management of hardwood species and woody draw ecosystems (e.g., aspens and green ash). These plan components provide clear desired conditions for these systems along with measures for their protection and ensure their long-term persistence through management actions and partnerships.
FW-GO-CARB-01	This goal will help the Forest Service to better understand and address the effects of climate change on ecosystems and ecosystem services in order to inform adaptation and mitigation strategies.
Recreation Opportunities; Recreation Special Uses; Land Use	Plan components would guide vegetation conditions and management in developed recreation and special use areas. Managing these small areas for purposes such as public safety would not substantially add to or subtract from movement toward the desired conditions for vegetation.
Designated wilderness, Recommended Wilderness Areas, Wilderness Study Areas, Research Natural Areas, and Inventoried Roadless Areas	Plan components would ensure that vegetation change occurs primarily through natural processes. Inventoried roadless areas would be managed in a manner consistent with the 2001 Roadless Area Conservation Rule, which includes limitations on vegetation management.
Eligible Wild and Scenic Rivers, Nationally Designated Trails, Backcountry Areas	The components include limitations for vegetation management. Managing these site-specific areas for specific purposes would not substantially add to or subtract from movement toward the desired conditions for vegetation.

Effects of All Alternatives

Ecosystem Function

In contrast to the current forest plans, all revised plan alternatives include specific plan components related to ecological processes and disturbance including insects and fire (FW-DC-VEGF-08, FW-DC-VEGNF-03, FW-DC-VEGNF-04, and FW-DC-FIRE-01). This direction is expected to meaningfully contribute to the restoration and maintenance of biodiversity of ecosystems and ecological integrity of the Custer Gallatin. The current plans recognize the importance of maintaining natural processes and ecosystem diversity in general but do not explicitly describe desired conditions for the processes that support this diversity. Compared to the current plans, direction for the revised plan alternatives provides substantially more detail and clarity as to the desired extent, frequency and severity of ecosystem processes which, in turn, drive ecological structure and composition.

Landscape simulation modeling was used to assess trends in forested vegetation characteristics over time. Fire, insects, disease, and vegetation management activities are the primary disturbances that impact and drive vegetation change. These processes interact with climate and vegetative succession to modify ecosystem composition, structure and function over time. Modeling disturbances and vegetation treatments over the next five decades—the period used for assessing effects to forested vegetation—revealed no major differences among alternatives relative to the prevalence or effects of these disturbance processes (figure 9).

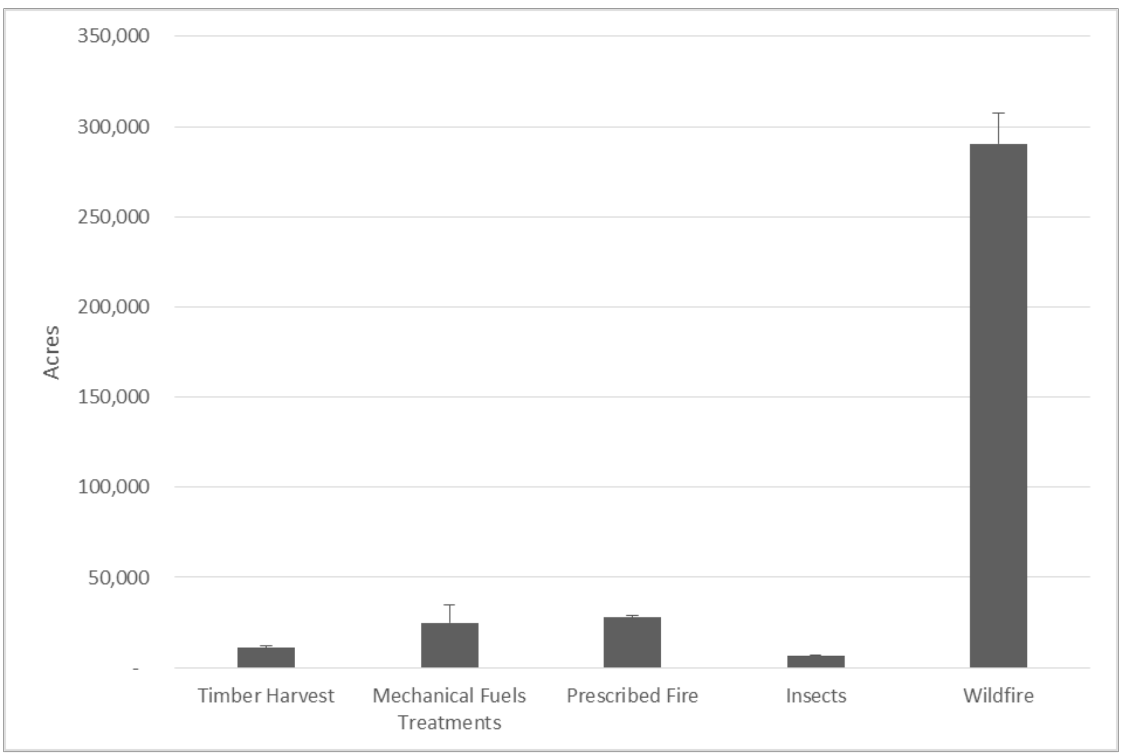

Figure 9. Projected area of forested ecosystems affected per decade by harvest, mechanical fuel treatments, prescribed fire, insects (primarily spruce budworm and bark beetles), and wildfire on the Custer Gallatin National Forest. Because there is relatively little variability across alternatives, figure shows averages (plus 1 SD) across all alternatives over a five-decade period. Source: PRISM model for treatment activity; SIMPPLLE model for wildfire and insect activity.

Although the total number of acres treated through vegetation management actions (such as, timber harvest, prescribed burning, etc.) varies by alternative from a low of approximately 50,000 acres per decade in alternative E to a high of 80,000 acres per decade in alternative D, this only represents a difference of treating approximately 3 versus 4 percent of the forested landscape per decade respectively. Based on landscape dynamic simulation models, a minimum of 25-50 percent of the landscape must be treated per decade to significantly change landscape dynamics (approximately 125,000 to 200,000 acres) (Keane 2019). As such, at the forestwide or geographic area scale, the extent, frequency and severity of ecosystem processes and disturbances are not predicted to vary significantly across alternatives as a function of management actions. It is important to note, however, at a subwatershed or project-area scale (approximately 10,000 to 50,000 acres), strategic management activity would be expected to have a meaningful impact.

Fire (Wildfire and Prescribed Fire)

Wildfire

Of all disturbance agents, wildfires are expected to be the most significant factor influencing ecological structure, function and processes over the coming decades. Although it is not possible to predict exactly where and when fires will occur, there is an emerging scientific consensus that the total number of acres burned by wildfire will increase in coming decades (Spracklen et al. 2009). This analysis assumed that wildfire would approximately double in coming decades relative to the previous 30 years (Erdody and Carnwath 2018); appendix B provides further information on scientific basis for this assumption. This equates to approximately 375,000 acres forestwide including 250,000 to 300,000 acres per decade of wildfire in forested areas including low, mixed and high severity. Though the best understanding of behavior and effects were used to inform the model, there is an inherent degree of uncertainty. One cannot predict with high accuracy where and when fires will occur. There is also a high degree of variability, both spatially and over time, in the amount and location of wildfire. See the Fire and Fuels section for a more detailed discussion on the environmental consequences of wild and prescribed fire.

Under all alternatives, fire will continue to support the diversity of vegetation across grasslands, retard conifer encroachment into meadows and parks, regenerate aspen and green ash stands and maintain the mixture of vegetation on shrublands that help support wildlife habitat diversity. Fire exclusion will likely continue to alter successional processes, generally to favor shade-tolerant species, although vegetation treatments and wildfires may mitigate this influence somewhat. Although fire suppression is expected to continue under all alternatives, FW-DC-FIRE-01 and FW-PBJ-FIRE-02 are expected to promote the use of wildfire for ecological benefit under the action alternatives.

With the projected warming trends and projected increase in wildfire under all alternatives there could be loss of greater sage-grouse priority or general habitats on the Custer Gallatin. Many of the other shrubs on the Custer Gallatin have sprouting capability and can recover from wildfire if browse pressure from both wild and domestic ungulates is not substantial within the first decade of recovery.

Prescribed Fire

Prescribed fire treatments are a planned fire ignition used to meet a variety of vegetation-related resource objectives, including: to improve wildlife habitat, stimulate shrub sprouting, reduce stand densities, reduce forest fuels (downed wood), create openings early successional habitat, and to restore natural disturbance processes. All action alternatives have an objective for fuels treatments (including prescribed fire) that range from 4,000 acres per year in alternative E, 6,000 acres in alternatives A, B, C, and F and 7,000 acres in alternative D (FW-OBJ-FIRE-01). This is expected to encourage the use of prescribed fire to ensure progress towards desired conditions. Alternative A recognizes the use of prescribed fire as a management tool but does not have a comparable plan component. Prescribed fires may be designed to be of low severity (less than 40 percent tree mortality) or high severity (greater than 70 percent tree mortality), depending on the desired post-fire vegetation conditions. Across all five decades analyzed, acres of prescribed fire per decade scheduled by PRISM varies from an average of approximately 2,750 acres per year in alternatives A, B, C, E, and F to nearly 3,000 acres per year in alternative D. This represents a difference of less than one percent of the forested landscape and would not lead to meaningful ecological differences among alternatives at the forestwide scale. Here again, higher levels of treatment could have an important effect at more local scales.

Plan components in all the revised plan alternatives direct that there be no net loss in greater sage-grouse priority and general habitats on the Custer Gallatin (FW-STD-WLSG-01). As such, there should be no effects to this habitat from prescribed fire.

Insects

Insects such as spruce budworm and bark beetles are powerful agents of change in forest ecosystems and will continue play a role in the future. The amount of insect and disease disturbance in forests is closely tied to the abundance of the host species, vegetative succession of forests into susceptible conditions (for example, larger trees, and higher densities), warmer climates and droughts. At the landscape level they influence patch configuration and composition, and at the stand level they kill mature trees, creating gaps and forest openings that are beneficial to wildlife. They also cause overall increases in forest and stand resiliency by promoting variability in sizes and ages of trees and in species compositions. At endemic levels, the ecological consequences are normally beneficial to forest ecosystems (Progar et al. 2007) though impacts can be detrimental to timber values. Unlike alternative A, the action alternatives contain a desired condition (FW-DC-VEGF-08) that forest composition, structure, and pattern allow for native forest insect and diseases to occur across their native extent and affect vegetation at a scope and scale consistent with their natural role. While this acknowledges the important role of insects as a native disturbance agent, there is no difference among alternatives in terms of the predicted scale and frequency of major forest insects. Figure 10 shows expected changes in the forested area with a high insect hazard rating. Model results shown here are based strictly on changes in forest structure and how that relates to insect hazard (Randall et al. 2011). Insect outbreaks are heavily dependent on climate conditions which are difficult to predict and not modeled here.

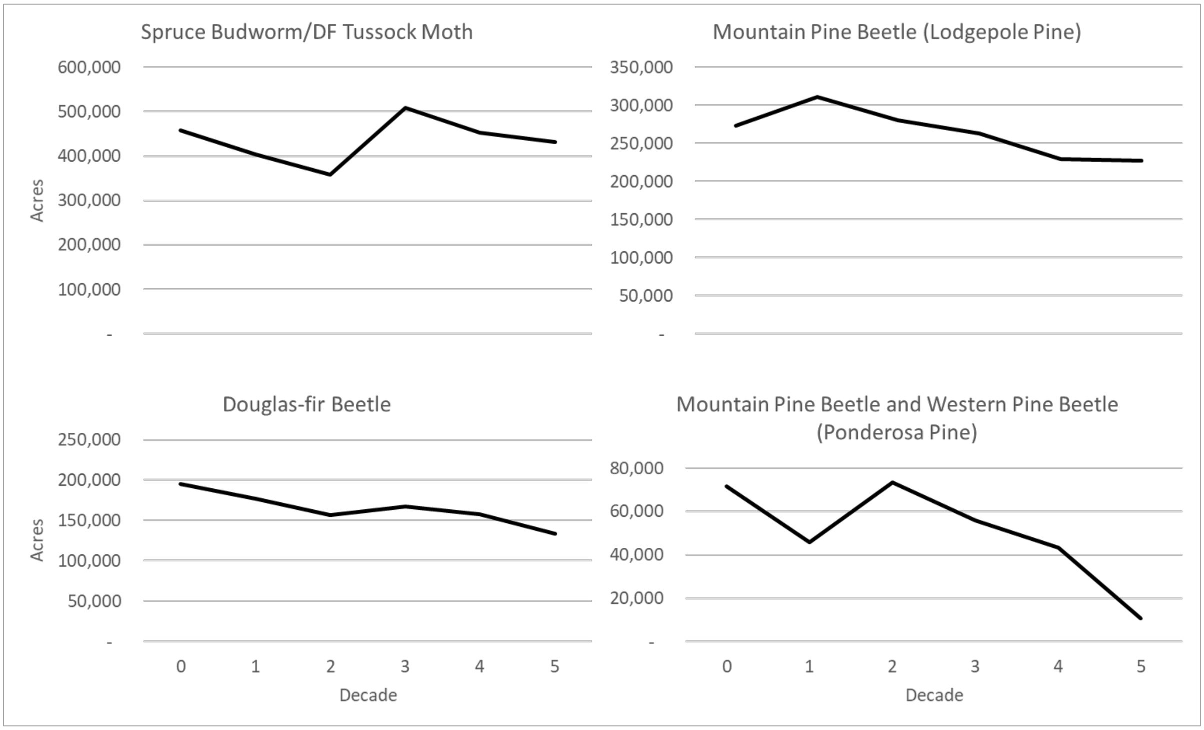

Figure 10. Expected trend in area with high hazard rating for major forest insects over time. See Randall et al. (2011) for how hazard rating is calculated. Because there was little variation among alternatives, the average value across all alternatives is shown. Based on PRISM data.

Grasshoppers and Mormon crickets are always present in any given year, but populations change in terms of relative abundance on the landscape. Under all alternatives, natural outbreaks have been known to occur and can be exacerbated by drought. Grasshopper and Mormon cricket outbreaks can have severe economic impacts on the grazing industry, especially during periods of drought when available forage is already scarce (Hewitt and Onsager 1983). In general, since most insect infestations are short-lived (a year or maybe two in the same area), the effects on rangeland vegetation are a defoliation (partial or complete) of the current year’s plant growth, but vegetative community succession is seldom affected.

Invasive Plant Species

Invasive plant species and other noxious weeds have the potential to substantially outcompete native vegetation and forage when left unchecked. Based on plan components (FW-OBJ-INV-01), impacts are similar across alternatives A, B, C, and F (2,500 to 4,500 acres treated per year) but are highest in alternative D (4,500 to 7,000 acres per year) and lowest in alternative E which has a lower treatment objective than has traditionally been funded (500 to 2,500 acres per year).

In general, increased ground disturbance corresponds with increased weed spread. In general, roads, trails, livestock, and canopy reduction can provide ideal pathways for the introduction of exotic and non-native species. Invasive plant species can displace at-risk and other native species through competitive displacement. Competition from invasive non-native species and noxious weeds can result in the loss of habitat, loss of native pollinators, and decreased at-risk plant species viability. Impacts include herbicide spraying and mechanical ground disturbance to control noxious weeds once they gain a foothold. Alternative D would be the most favorable to limit the spread of invasive species from motorized and non-motorized use because it would have the least number of trails that would be available to motorized and bicycle use and acreage identified in motorized recreation opportunity spectrum classes. The current plans and alternatives B and E would be similar for having a higher potential to increase the spread of invasive species through motorized and non-motorized transportation since the alternatives would have the most miles of trails available to motorized and bicycle use and fewer acres of summer primitive or semi-primitive settings. Alternatives C and F would have fewer miles of trails available to motorized and bicycle use than the current plans and alternatives B and E.

Noxious weed management would continue under direction of both the Gallatin National Forest Weed Environmental Impact Statement (2005) and the Custer National Forest Weed Environmental Impact Statement (2006a) until revised. Any subsequent National Environmental Policy Act decisions would continue to provide direction. Infestation levels of invasive plants would likely slightly increase over time. The rate of increase would be higher under alternative E than the other alternatives due to lower noxious weed treatment objective (FW-OBJ-INV-01). Some noxious weed species may contract in range and density as new treatment and biological options become available, while other noxious weeds will expand in range and density.

As a result of plan components specific to noxious weeds (FW-GDL-INV-01, FW-STD-INV-01 to 04, FW-OBJ-INV-01, FW-GO-INV-01 to 04, FW-DC-INV-01 to 02, all ecosystems are expected to benefit from the management of noxious weed species, particularly in wetland-riparian, ponderosa pine and Douglas-fir open understories, and grasslands-shrublands. The revised plan alternatives provide similar protections and guidelines for invasive species treatment as the existing plan. Threats to native vegetation from noxious weeds would be greatest in alternative E and less so in the current plans and alternatives B, C, F and D based on treatment objectives by alternative.

Effects of invasive species on terrestrial ecosystems is analyzed in more detail in the Invasive Species section below.

Herbivory

For the foreseeable future, management under any of the alternatives would continue to provide forage production and productive livestock grazing. Acres available for livestock grazing and animal unit months for active and vacant allotments would be the same under the current plans and alternatives B and C; and animal unit months under alternatives D, E and F would be at current levels on active allotments only. Acres available for livestock grazing and animal unit months for active and vacant allotments for alternative F would be less than under the current plans and alternatives B and C, but more than alternative D and E. None of the alternatives change existing allotment management since those decisions are made at the allotment level. A plan component (FW-GDL-GRAZ-02), however, does limit livestock use based on end of season stubble height greenline vegetation on low gradient alluvial streams, which is expected to maintain or improve riparian and channel morphology conditions. No active allotments or portions of active allotments are proposed to be formally closed to grazing due to other resource needs. Under all alternatives, changes to livestock management and allowable forage use levels at the site-specific scale would be made during allotment management plan revision. Furthermore, there are resource mitigations and best management practices that are part of allotment plans designed to protect or mitigate forest resources from potential disturbances by livestock grazing. These elements are site-specific for each allotment and not part of this analysis.

Plan components emphasis on improving riparian-wetland and woody draw conditions is expected to continue under all alternatives (FW-GDL-VEGNF-05, FW-GDL-VEGNF-06, FW-GDL-VEGNF-07, FW-GDL-GRAZ-04, FW-GDL-GRAZ-05). Revisions of allotment management plans, or term permit modifications, would continue to implement best management practices and implement end of season allowable use levels that are expected to move riparian areas towards desired conditions. As a result, monitoring and management adjustments may reduce permitted animal unit months for some permittees. Vacant grazing allotments would be evaluated for designation as a forage reserve, opportunities to enhance management or improve resources through combination with adjacent allotment(s), retention of vacant allotment status for potential use demands in the future or allotment closure based on resource conflicts, conservation opportunities, or economic considerations. It is unlikely that permitted animal unit months would be increased through the opening of new allotments under any alternative.

There is potential for further grazing pressure in the north and west bison tolerance zones on the Gardiner and Hebgen Lake Districts that could affect grazing permit holders, necessitating special timing or non-use for resource protection considerations. The potential for this would be greater under alternatives B, C, D, and F since plan components direct that management actions taken to resolve bison-livestock conflicts should favor bison within the tolerance zones.

All revised plan alternatives favor beaver activity (FW-GDL-WTR-03, FW-DC-WTR-09). Effects from beaver activity can reverse or hasten the succession of plant communities while improving watershed conditions. When beaver selectively cut down certain tree species and create sunlit gaps in the forest, species of sun-loving, shade-intolerant plants often regenerate there, converting a mid-successional stand to an early successional stand, although sometimes they release understory conifers and thus hasten succession (Naiman et al. 1988, Johnston and Naiman 1990, Pastor and Naiman 1992).

Pollinators

Pollinators are crucial components of functioning ecosystems. There is evidence that many invertebrate species may be in decline due to a variety of factors, which in turn could affect native plant community pollination. Broadly, the desired conditions in the revised plan alternatives increase habitat quality for invertebrate pollinator species and decrease threats with the revised plan components. All alternatives provide habitat for pollinator species on the Custer Gallatin with native plant species, a variety of habitats, and large areas without the habitat fragmentation that has become characteristic of agricultural and developed land. All the revised plan alternatives include vegetation management plan components specifically designed to maintain and enhance habitat for pollinators (FW-DC-VEGNF-03, FW-OBJ-VEGF-01, MON-VEGF-02). Those components, in addition to the plan components for other resources that improve habitat for pollinators on the Custer Gallatin (such as FW-DC-VEGNF-04), do more to improve habitat quality under the revised plan alternatives than under the current plans. A landscape composed of a mosaic of early to late successional stands, abundant and diverse flowering plants available at all times of years, and a variety of standing or downed dead wood, bare ground, and overgrown vegetation are all hallmarks of rich heterogeneous pollinator habitat with available nesting habitat (Gilgert and Vaughan 2011) that provide overall habitat for pollinator species. The plan components for each revised plan alternative would encourage management options to increase resiliency and improve pollinator habitat on the Custer Gallatin. Appendix A provides best management practices considerations for pollinator habitat.

Areas proposed under the revised plan alternatives as additional recommended wilderness or backcountry areas that were not previously identified under the current plans would see a reduction in threats from ground disturbance and development, and would be managed allowing natural fire regimes to contribute as much as possible to a mosaic of different seral stages and diversity of habitats.

Timber harvest increases some short-term threats to pollinators due to a higher potential for harvest-related ground disturbance, but also can create a mosaic pattern on a landscape, open understories, and promote early successional stands with some treatments, such as regeneration harvest. Vegetation projects can also provide opportunities to improve pollinator habitat, increasing local habitat diversity by using a variety of vegetation treatment types and providing early successional habitats (such as, wildland fire, shelter wood treatment, etc.). Vegetation treatments can also increase forest resiliency by treating insects and disease, and reducing fuel loads, improving forest health in the long term. Based on FW-OBJ-VEGF-01, alternative E would treat the fewest number of acres to promote desired conditions (4,000 acres), followed by alternatives B, C, and F (6,000 acres) and alternative D would treat the most (7,000 acres). Pollinator nest sites and food sources could be impacted in the short term by mechanized equipment and incidental damage from felling trees. Site disturbance and increased weeds could also negatively impact pollinator forage and habitat requirements. Long-term habitat improvements in general include habitat heterogeneity, increased diversity and increased available forage.

Harvest

Table 49 displays the annual average acres of timber harvest scheduled by PRISM (averaged over first two decades). Table 50 displays the same information for model runs unconstrained by budget (see appendix B for additional detail). See table 36 for a description of harvest types. See the Timber section of this environmental impact statement for further discussion of the environmental consequences of timber harvest. Effects of harvest on other key ecosystem characteristics (such as, size class and forest density) are discussed below. Additional information on the PRISM model and associated assumptions can be found in appendix B.

Table 49. Average annual acres of timber harvest by alternative, average of the first two decades (constrained by reasonably foreseeable budget)

Harvest Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Intermediate and Uneven-aged	805	778	769	656	951	758
Even-aged Regeneration	314	319	320	186	500	322

Table 50. Average annual acres of timber harvest by alternative, average of the first two decades (unconstrained by budget)

Harvest Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Intermediate and Uneven-aged	1,459	1,406	1,381	1,440	1,453	1,453
Even-aged Regeneration	613	556	541	528	578	564

Across all revised plan alternatives, desired conditions, standards, and guidelines directing timber harvest activities are the same but there are some important differences in the absolute amounts and projected ratios of treatment types across alternatives that are consistent with the theme and design of each alternative (table 2). For example, the amount of regeneration harvest in the current plans, and alternatives B, C, and F are similar to each other and are between alternative D, which would use the least amount of regeneration harvest, and alternative E, which would use the most. The projected harvest acres shown in table 49 and produced by the PRISM model are incorporated into the SIMPPLLE model, and therefore their influence on the indicators for terrestrial vegetation are reflected in the results shown in this report.

Regeneration harvest would alter forest size class, primarily resulting in seedling/sapling forests. Reforestation (planting or natural regeneration) would occur in these stands and can be used to achieve desired conversions in composition (FW-STD-TIM-10). In contrast to the current plans, maximum opening size limits in the revised plan alternatives have been designed to mimic the average size of natural openings and are expected to contribute to the desired patch size distribution (FW-STD-TIM-08). Other harvests such as precommercial thinning and intermediate treatments primarily reduce tree density but may also change forest composition towards desired conditions or increase average stand diameter when smaller trees are removed. Alternative A has the most amount of land that would be suitable to use timber harvest as a management tool (approximately 22 percent of the Custer Gallatin) while the current plans and alternatives B through F are relatively similar (18 to 19 percent) (table 50). As noted above, the effect of timber harvest on forest vegetation is expected to be small relative natural disturbance agents. Nevertheless, for all the revised plan alternatives, plan components help assure timber harvests are designed to help meet desired vegetation conditions (FW-OBJ-VEGF-01). As such, for the revised plan alternatives, timber harvest is expected to contribute to achieving more resilient conditions across the national forest.

Composition

Coniferous Forest

All the revised plan alternatives include specific plan components related to vegetation composition that will contribute to biodiversity of ecosystems and ecological integrity of the Custer Gallatin (FW-DC-VEGF-01 and 02). Compared to the current plans, which do not explicitly describe desired conditions for forested vegetation composition, this direction provides substantially more detail and clarity as to vegetation conditions and species compositions management.

As discussed in the affected environment, most of the major coniferous species in the Custer Gallatin National Forest are within the desired ranges for both species' presence (the distribution of individual species) and dominance (the distribution where a given species is the most common within a stand). This includes Douglas-fir, lodgepole pine, subalpine fir and Engelmann spruce. Model results indicate that these species will be maintained within their desired range over the next five decades and the trend is the same across all alternatives (figure 11). An unconstrained budget scenario was also analyzed for alternative F. Results indicated that the effect of an unconstrained budget on species dominance would be minimal and within the margin of error shown for the budget-constrained alternatives.

Whitebark pine dominance type is currently below the desired condition. Although model results indicate relatively little change over the coming decades, there remains a high degree of uncertainty about the future of whitebark on the Custer Gallatin National Forest. As reviewed in Hansen et al. (2018), both climate suitability models and mechanistic models project substantial reductions in area of suitable habitat and loss of larger size classes. Moreover, in association with warming temperatures, bark beetle outbreaks are projected to increase in future decades and blister rust is also expected to inflict increased mortality on whitebark pine under a warming climate. However, restoration actions such as planting rust-resistant seedlings and employing other strategies such as protection from mountain pine beetle and thinning treatments to reduce completion and fire intensity may help mitigate the negative effects of climate change (Keane et al. 2017, Ireland et al. 2018). In addition, several efforts are underway that will incorporate both macro and micro-refugia sites which can improve the efficacy of restoration efforts by taking into consideration climate and site characteristic (for example, aspect, soils, slope, elevation) interactions at specific locations on the ground to improve tree survival (resilience and persistence). See At-Risk Plants section for further discussion of whitebark pine.

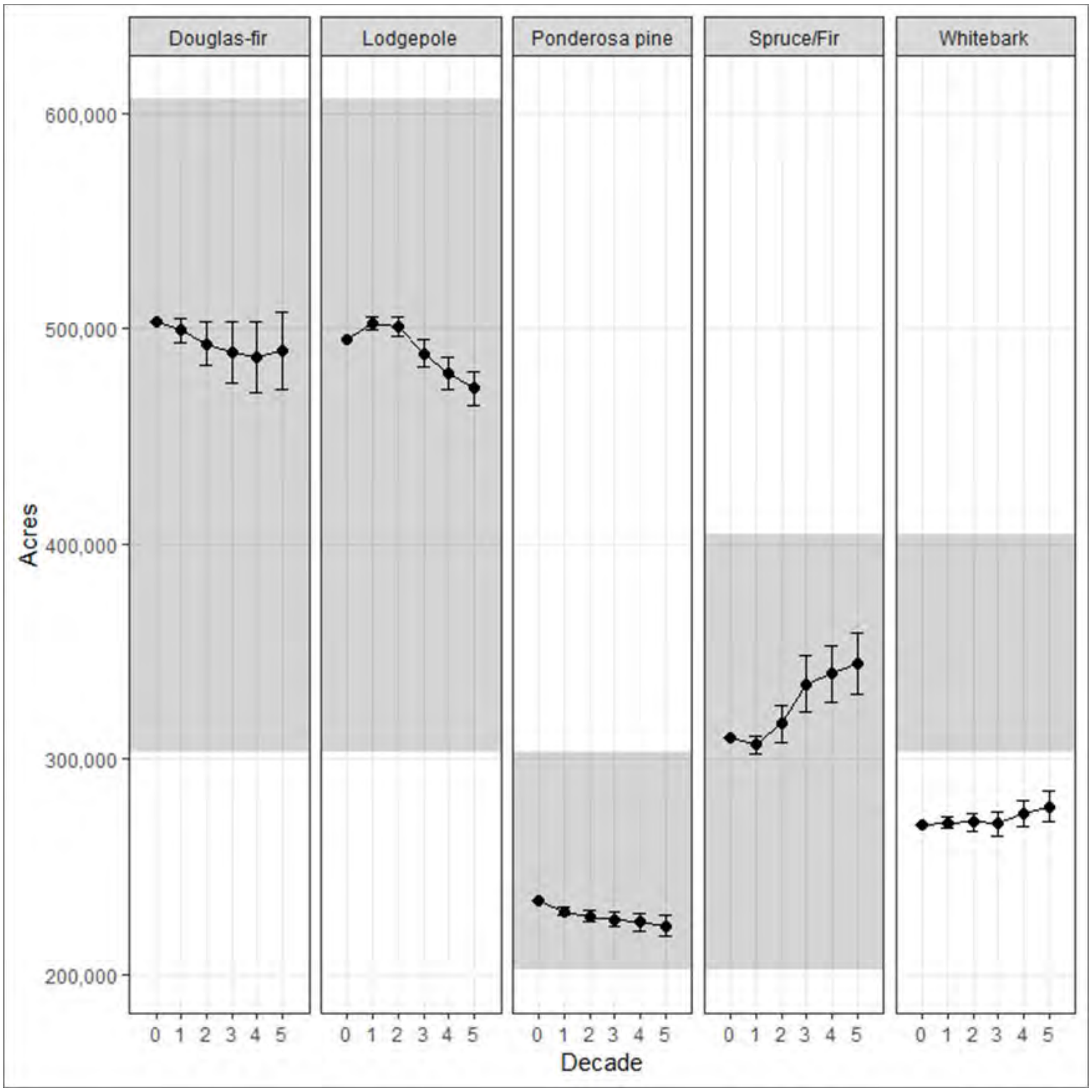

Figure 11. Change in species dominance over time based on the SIMPPLLE model. Shaded area indicates the desired condition. Because there was little variability among alternatives, figure shows averages across all alternatives (plus one standard deviation).

Model results also predict a slight downward trend in presence and dominance for ponderosa pine in all alternatives. Here again, the actual trend in ponderosa pine is somewhat hard to predict and will depend on the balance between the species ability to expand into previously occupied habitat, where it has been reduced by large, severe wildfires, and the potential for future wildfire to further reduce its distribution even further. Dry forests, such as these that already occur at the edge of their climatic tolerance, are increasingly prone to conversion to non-forests after wildfires due to regeneration failure (Stevens-Rumann et al. 2018). This trend is likely to continue in the future as suitable climate space for tree regeneration becomes increasingly rare (Bell et al. 2014).

Given that the presence of balsam woolly adelgid has been detected on the Custer Gallatin National Forest, it is possible that this pest may become more active and spread into additional geographic areas in the future, with an associated risk of damage and mortality to subalpine fir forests. The level of potential damage is not known, although mortality from this pest in Oregon, Washington, and Idaho has been extensive as discussed in the *affected environment* section. The model did not include potential activity from the non-native insect balsam woolly adelgid, which can cause mortality of subalpine fir. There is therefore a risk that the spruce-fir cover type may be less prevalent in the future than indicated by model results; however, the potential impact of this insect is not known.

Mesic Deciduous Woodlands

All the revised plan alternatives include specific desired conditions related to vegetation composition that will contribute to biodiversity of ecosystems and ecological integrity of mesic deciduous woodlands (FW-DC-VEGNF-04). Compared to the current plans, which do not explicitly describe desired conditions for mesic deciduous woodlands, this direction provides more detail as to what vegetation conditions and species composition to maintain or move toward. Unlike the no action alternative, action alternatives also address their protection (FW-GDL-EMIN-02, FW-GDL-VEGNF-05, FW-GDL-VEGNF-06, FW-GDL-VEGNF-07, FW-GDL-GRAZ-04, FW-GDL-GRAZ-05) and ensure their long-term persistence through management actions (FW-GO-VEGNF-03, FW-GO-GRAZ-01, FW-OBJ-VEGNF-01).

The emerald ash borer, a devastating invasive wood boring beetle native to Asia, is responsible for killing millions of ash trees throughout much of the Midwestern USA including green ash. The current closest infestations occur in eastern South Dakota, Colorado, and Minnesota. Movement of ash material from infested areas is now prohibited by Federal quarantine regulations. However, unintentional movement may still occur due to lack of awareness of the quarantine regulations into the plan area (for example, transported firewood, pallets). Detection of emerald ash borer infestations is difficult when trees are first attacked, showing few signs that emerald ash borer is present. However, healthy ash trees are killed in 2-4 years. Management strategies are outlined in appendix A of the revised plan.

Xeric Woodlands

All the revised plan alternatives include specific desired conditions related to vegetation composition that will contribute to biodiversity and ecological integrity of xeric woodlands (FW-DC-VEGNF-04). Compared to the current plans, which do not explicitly describe desired conditions for xeric woodlands, this direction provides more detail as to the vegetation conditions and species composition to maintain or move toward. Further, FW-OBJ-VEGNF-01 sets an objective to maintain and enhance biodiversity and conserve rare and unique habitats, progress towards conservation and restoration of non-forest vegetation types is made by completing at least six to eight projects per decade with explicit primary or secondary purposes of benefitting vegetation communities such as woodlands (including limber pine). PR-GDL-VEGNF-02 further requires that live Utah juniper trees should not be cut except for purposes of human safety or research.

Grasslands and Shrublands

All the revised plan alternatives include specific plan components related to vegetation composition that will contribute to biodiversity and ecological integrity of grasslands and shrublands (FW-DC-VEGNF-04). Compared to the current plans, which do not explicitly describe desired conditions for grasslands and shrublands, this direction provides more detail as to the vegetation conditions and species composition to maintain or move toward. Plan components common to all revised plan alternatives require that vegetation management shall result in no net loss of priority or general sagebrush habitat or be beneficial to greater sage-grouse which is more limiting than the current plans directions (FW-STD-WLSG-01). In addition, the revised plan alternatives also require that vegetation management projects in greater sage-grouse habitat be designed to remove or reduce invading conifers (FW-GDL-WLSG-05), control or stop the spread of invasive annual grasses (FW-GDL-WLSG-02), and to reduce the extent of existing nonnative plants (FW-OBJ-INV-01). Plan components under all revised plan alternatives promote habitat heterogeneity, by creating a mosaic of burned and unburned areas (including different fire regimes for example, frequency, season, extent, intensity, type and time since last burn) during prescribed burns (FW-GDL-VEGNF-01). Ecologists understand that rangeland ecosystems evolved with fire and grazing as disturbances, but the resulting spatial patterns and habitat heterogeneity of these disturbances has recently been fully appreciated (Fuhlendorf and Engle 2001, Briske 2017). Desired conditions in the revised plan include managing for heterogeneity (FW-DC-VEGNF-04) and this concept is reinforced by a guideline (FW-GDL-VEGNF-01). Habitat types, ecological site descriptions, or similar descriptions can provide project-specific desired conditions for resilience, which are consistent with the plan's coarse-filter ecosystem desired conditions (FW-DC-VEGNF-04). Livestock grazing can directly affect grasslands and shrublands. Plan components in the revised plan require that allotment management plans will meet or move toward desired conditions for these habitats (FW-DC-VEGNF-04, FW-STD-GRAZ-01). Fire management is also suspected to help support and sustain productive and functioning grasslands and shrublands (FW-DC-FIRE-01, FW-OBJ-FIRE-01 and 02).

Riparian, Wetlands, and Groundwater-Dependent Ecosystems

All the revised plan alternatives include specific plan components related to vegetation composition that will contribute to biodiversity and ecological integrity of riparian, wetlands, and groundwater-dependent ecosystems (FW-DC-VEGNF-04, FW-DC-WTR-01, FW-DC-WTR-04, FW-DC-WTR-07, and FW-DC-WTR-11). Compared to the current plans, which do not explicitly describe desired conditions for riparian, wetlands, and groundwater-dependent ecosystems, this direction provides more detail as to what vegetation conditions and species composition to maintain or move toward. All revised plan alternatives would establish and protect riparian management zones (FW-RMZ-STD-01 to 05, FW-GDL-RMZ-01 to 08, FW-SUIT-RMZ-01 and 02, FW-CWN-GDL-01. This would ensure management of multiple ecological goals and long-term ecological sustainability on a landscape basis. Updated aquatic and riparian desired conditions, objectives, standards, and guidelines would be applied in a consistent manner across the Custer Gallatin National Forest.

The road network on the Custer Gallatin and culvert failures/road slumps affect riparian vegetation on both a short- and a chronic, long-term basis. There are motorized roads open to the public as well as administrative use within the national forest administrative boundary, including roads managed by other entities such as state highways, a variety of county roads, Federal and state land management agencies, and private timber companies. Many roads and motorized trails are located within riparian management zones that include many stream crossings. Routes located closest to riparian areas potentially provide a background level of disturbance that contributes to direct and indirect effects on riparian soils, vegetation, and function such as compaction and channel alteration. Motorized trails function similar to roads in regard to soil disturbance depending on frequency of use and traffic volume. FW-GDL-RMZ-03 ensures that no new permanent or temporary roads would be built in riparian management zones. FW-STD-RT-04 requires that newly constructed or reconstructed roads shall not encroach into streams and riparian areas riparian management zones in ways that impact channel and floodplain function, geometry, or sediment delivery in the long term.

Livestock grazing can have numerous direct and indirect effects on riparian soils and vegetation. Soil trampling can cause decreased infiltration, greater soil compaction, and loss of vegetation cover on both upland and riparian sites. Reduced infiltration by soil compaction can lead to overland flow of sediment. Soil and water quality can be indirectly affected by the resulting increased soil runoff and erosion, and sediment delivery to riparian areas and streams.

Removal of riparian vegetation through livestock management can influence the amount of solar radiation and alter water temperature regimes. Greater temperature fluctuations (diurnal and seasonal) can occur when riparian vegetation is removed, decreased, or changed to more upland species. These changes can ultimately lead to shifts in dissolved oxygen and pH. In addition, removal of riparian vegetation and increased temperatures combined with increased nitrate levels can increase undesirable or nuisance biological production in water.

The effects of livestock can be seen across the national forest, particularly in riparian areas. Historical grazing led to riparian vegetation changes and stream channel degradation on grazed streams. Various allotments have seen improvements through best management practices and interdisciplinary review and updates to allotment management plans. However, riparian and aquatic habitat improvements within grazing allotments continue to be addressed and fine-tuned across the nation forest on an allotment-by-allotment basis. FW-STD-GRAZ-01, FW-GDL-GRAZ-01, FW-GDL-GRAZ-02, FW-GDL-GRAZ-04 and FW-GDL-GRAZ-05 would protect riparian, wetland and ground water dependent ecosystems from potential adverse effects from grazing.

Riparian Management Zones

Riparian management zones are areas where riparian-dependent resources receive primary emphasis and management activities are subject to specific standards (FW-STD-RMZ-01 to 05) and guidelines (FW-GDL-RMZ-01 to 08). These areas consist of riparian and upland vegetation adjacent to streams, wetlands, and other bodies of water and help maintain the integrity of aquatic ecosystems by (1) influencing the delivery of coarse sediment, organic matter, and woody debris to streams, (2) providing root strength for channel stability, (3) shading the stream, and (4) protecting water quality. Refer to the riparian management zone topic in the Watershed, Aquatics and Riparian Ecosystem section for definitions and extent of riparian management zones by geographic area (acreage).

Riparian conservation measures have been developed for Federal, State, and private lands—helping to preserve and protect the integrity of the riparian and wetland habitats as well as the water quality of associated waterbodies. Similar to riparian management zone protections, state streamside management zone protections have been applied on the Custer Gallatin in the past, but the plan component direction under the revised plan alternatives is more comprehensive, will be applied across the entire national forest, and will largely be consistent with other national forests in Northern Region.

All revised plan alternatives include new plan direction that establish designated widths of an inner and outer riparian management zone bordering streams, lakes, wetlands and other water features as well as requires plan direction for management actions within the inner and outer riparian management zones in order to achieve watershed desired conditions (FW-STD-RMZ-01). Some activities are prohibited or restricted in the inner zone, whereas more active management is allowed in the outer zone. Riparian management zones are not intended to be “no touch zones,” but rather “carefully managed zones” with an increase in protections in close proximity to water resources. Riparian management zones are portions of watersheds where riparian-associated resources receive primary emphasis, and management activities are subject to specific plan components including standards and guidelines. In order to achieve watershed desired conditions, some vegetation management activities are prohibited or restricted in the inner riparian management zone (FW-STD-RMZ-02, FW-SUIT-RMZ-02), whereas more active management is allowed in the outer riparian management zone so long as ecosystem functions in the inner riparian zone are protected (FW-GDL-RMZ-06). Other Riparian Management Zone plan components protect the entire zone from management activities associated with the use if toxicants (FW-STD-RMZ-03, FW-STD-RMZ-04), extraction of minerals (FW-STD-RMZ-05), road construction (FW-GDL-RMZ-03), livestock (FW-GDL-RMZ-01), fire management (FW-RMZ-GDL-02), harvest activities (FW-GDL-RMZ-04, FW-GDL-RMZ-05, FW-GDL-RMZ-07, FW-GDL-RMZ-08). Riparian management zones are not suitable for timber production (FW-SUIT-RMZ-01).

Recent research has documented that active riparian zone management can advance riparian condition while preserving the functional attributes for riparian, aquatic, and water resources (Boyer et al. 2003, Beechie et al. 2010, Dwire et al. 2016, Roper et al. 2019). Even though similar concepts are currently being applied using state streamside management zone direction, the riparian management zone plan components in the revised plan alternatives are more prescriptive and were designed to improve riparian vegetation within the riparian management zones, while limiting activities that create long-term degradation, such as road building and clearcutting. Treatments would be designed to reflect the composition, structure and pattern of vegetation that would be consistent with the natural range of variability, as described in the desired conditions (FW-DC-RMZ-01). The riparian management zone standards in all revised plan alternatives differentiate between the inner and outer portions of streamside riparian management zones and riparian management zones around other water bodies regarding limitations on vegetation management. Management of the outer riparian zone would allow for other management objectives such as reducing uncharacteristic fire as long as treatments did not create long-term degradation to riparian and aquatic condition (FW-GDL-RMZ-06). The revised plan alternative plan components were developed to explicitly recognize that riparian management zones can benefit from active management and that the areas closest to water have greater importance for protection of water quality and aquatic resources based on the best available scientific information.

The 2012 Planning Rule emphasizes integration of management direction in recognition of ecological sustainability and the interdependence of ecological resources, and the proposed riparian management zones would also contribute to wildlife habitat connectivity and protection of plant species and animal communities associated with wetlands. Riparian management zone direction under all revised plan alternatives was defined through plan components to guide appropriate management based upon best available scientific information. The entire riparian management zone is classified as not suitable for timber production, based on the determination that a scheduled flow of commercial timber products using a rotation age could not be expected to occur on these lands due to management requirements and desired conditions for other resources (FW-SUIT-RMZ-01). However, timber harvest is allowable, with restrictions as specified in the plan (FW-STD-RMZ-02, FW-GDL-RMZ-06). Other vegetation management activities that may occur and are expected to occur to maintain riparian conditions include prescribed fire, thinning, planting of trees or shrubs, and fuel reduction. Vegetation management in the inner riparian management zones would occur expressly to restore or enhance riparian, fish and aquatic resources, with specific exceptions (FW-STD-RMZ-02). Vegetation management in the outer riparian zone, would allow more opportunity to manage vegetation resources to achieve desired vegetation and riparian conditions so long as conditions in the inner riparian management zone were not adversely affected and wildlife needs were met to achieve desired conditions (FW-GDL-RMZ-06).

Fire is a natural disturbance process that has historically influenced vegetation within watersheds, including riparian areas, grasslands, and forests adjacent to water features. The natural role of fire, as well as other natural disturbances, in creating the diversity of successional stages, species compositions and structures in riparian areas is incorporated into the design of the desired vegetation conditions outlined in the plan components (FW-DC-FIRE-02, FW-OBJ-FIRE-02, and FW-GDL-FIRE-03). In areas where use of fire (including wildfire) or other natural disturbances is limited or not feasible, vegetation treatments could be applied where determined appropriate to achieve desired conditions within riparian management zones (FW-STD-RMZ-01, FW-STD-RMZ-06).

Existing grazing permits would continue to be administered under current allotment management plans. However, they would be required to meet or be moving towards desired conditions for riparian areas as outlined in the revised plan. Plan components applicable to livestock grazing (including the end of season stubble height guideline) will be incorporated through permit modification(s), reissuance of existing term permits, issuance of new term grazing permits, and/or as Allotment Management Plan revisions and sufficiency reviews occur. Monitoring data will be used to prioritize both allotments and stream reaches.

Forestwide plan components would protect riparian resources. Plan components specific to grazing, require that adverse effects to riparian habitats be avoided (FW-STD-GRAZ-01). Indicators such as forage use, bank alteration or riparian stubble height would be used to move rangeland vegetation, riparian function and wildlife habitat towards desired conditions (FW-GDL-GRAZ-02). Forestwide guidelines would limit livestock handling and facilities management activities inside riparian management zones (FW-GDL-GRAZ-04, FW-GDL-GRAZ-05).

Riparian management zone plan components for grazing provide additional protection to riparian areas compared to the current plans. There are no differences in effects among the revised plan alternatives as all would adopt the riparian management zone standards and guidelines.

Protective measures for riparian areas include the delineation of riparian management zones around all water resources and the extent of unstable areas. Management activities within the riparian management zone must comply with all proposed direction, as well as the previously mentioned Federal and State best management practices and other State water quality regulations.

Floodplains would be managed by locating critical facilities outside of floodplains or by using structural mitigation measures (FW-STD-RT-04). Additional protections are provided in forestwide standards and guidelines for management of riparian management zones.

The revised plan alternatives components are more prescriptive within riparian management zones than the current plans, which increases the likelihood of protecting wetlands or floodplains. Wetland values and functions would be protected in all revised plan alternatives through the implementation of the riparian management zone and by following the Forest Service’s National Best Management Practices for Water Quality Management on National Forest System Lands. Under the requirements of Executive

Order 11990 and Clean Water Act, Section 404, wetland protection would be provided by ensuring that new construction of roads and other facilities would not have an adverse effect on sensitive aquatic habitat or wetland functions. In addition, wetland evaluations would be required before land exchanges or issuance of special-use permits in areas where conflicts with wetland ecosystems may occur.

Plan components cited above have been designed to conserve riparian, wetlands, groundwater-dependent ecosystems and protect floodplains under the revised plan alternatives which are more prescriptive than the current plans' components. Executive Order 11988 also requires site-specific analysis of floodplain values and functions for any project occurring within the 100-year floodplain zone, and prior to any land exchange involving these areas.

Implementation of the riparian management zones plan directions would result in an improving water quality trend under all revised plan alternatives. There is no differences in effects among the revised plan alternatives, as all would adopt the riparian management zone plan components across the Forest. As the proposed plan directions are implemented in allotment management through terms and conditions of the permit, it is concluded that degraded riparian areas would move toward desired conditions.

Alpine

All the revised plan alternatives include desired conditions that will contribute to biodiversity and ecological integrity of alpine areas (FW-DC-VEGNF-04, FW-DC-WLWV-01). Current forest plans do not explicitly describe desired conditions for alpine areas. FW-GDL-VEGNF-02 further requires that to minimize erosion from ground disturbance in fragile alpine or subalpine settings, new facilities should be directed away from alpine or subalpine vegetation or rehabilitated to reduce erosion.

Under all alternatives, climate conditions influence effects to alpine vegetation. Elevation will play a large role in plant species composition in conjunction with predicted warming trends. High elevation, alpine or other fringe type environments may see plant species composition change first (Murphy and Weiss 1992). Invasive plants apparently have not yet become a serious problem in the alpine tundra of the Custer Gallatin National Forest, although yellow toadflax and Canada thistle are present above 9,000 feet and others have the potential to invade such areas in the future.

Long-term monitoring for some rare plant species indicated population resiliency or stability during the fluctuating climatic conditions that have occurred during the last two decades in the northern Rockies (Shelly et al. 2016). Peripheral populations to 12 arctic and boreal species were monitored over the last 20 years in Glacier National Park and The Nature Conservancy's Pine Butte Preserve. It was found that of the 20 populations of 12 species monitored, 10 populations showed a significant decline; 9 were stable; and only 1 increased (Lesica and Crone 2017). Therefore, alpine rare plants may have increased stressors from warming trends in the future.

Sparse Vegetation Types

The revised plan alternatives include specific plan components related to vegetation composition that will contribute to biodiversity and ecological integrity of sparse vegetation types (FW-DC-VEGNF-04). Compared to the current plans, which do not explicitly describe desired conditions for sparsely vegetated areas, this direction provides more desired condition detail as to what vegetation conditions and species composition to maintain or move toward. FW-GO-VEGNF-01 also encourages the Custer Gallatin to collaborate with Tribes, Federal and State agencies, and other partners regarding applicable conservation plans in seeking progress towards conservation of sparsely vegetated lands.

Sparsely vegetated habitats are often fragile systems. Although recreation and road or trail construction can be threats to these habitats in the montane geographic areas, disturbance is often limited due to inaccessibility in the landscapes. Threats to the sparsely vegetated habitats on the Sioux and Ashland Geographic Areas include weed invasion, trampling from grazing, as well as shifts in warming and drying patterns. Shifts in warming or drying trends may also contribute to a change in range or distribution of these types (Halofsky et al. 2018a). Warming or drying climatic patterns could impact this system and the distribution of the peripheral, endemic, and rare species that occur within it. Historically, stand-replacing fires occur frequently in adjacent forests, woodlands and shrublands. Lightning strikes can cause fire within these systems, however due to minimal vegetation cover fire severity and spread is generally low.

Ecotones (Upper and Lower Tree Line)

The revised plan alternatives include specific plan components related to vegetation composition that will contribute to biodiversity and ecological integrity of ecotones (FW-DC-VEGNF-04). Compared to the current plans, which do not explicitly describe desired conditions for ecotones, this direction provides more detail as to what vegetation conditions and species composition to maintain or move toward. A decrease in non-forest cover types may occur as both a result of desirable reforestation of disturbed areas, as well as the loss of historical grass and shrubland communities to conifer encroachment. Plan components directed at the conservation and management of whitebark pine (FW-DC-PRISK-02, FW-GO-PRISK-01, FW-GDL-PRISK-03, FW-OBJ-PRISK-02, MON-PRISK-02, FW-DC-VEGF-01 and 02) are also expected to contribute to the maintenance and restoration of ecosystems at upper treeline.

Conifer expansion into aspen, woody draws, shrublands, grasslands, and meadows may in part reflect natural ecotone dynamics, but fire exclusion, climate, and grazing history have likely caused more extensive ecotone conifer colonization and infilling of more open-canopied pine savanna ecosystems than would be present under historical disturbance regimes. At the broad scale, the expected effects of future warm, dry climate and drought include the maintenance or expansion of non-forested communities (particularly xeric types) as sites become drier or too frequently disturbed to support forest cover. Xeric ecotones are among the most sensitive ecosystems to climate change (Means 2011). Lower tree line woodlands are often thought to be "invading" desirable sagebrush and grass types due to fire suppression and grazing; however, ecotones are also naturally more elevationally based on the dynamics of vegetation, climate and fire (Means 2011). Studies done near the Forest found that areas of mosaic sagebrush-grasslands with stable islands of Douglas-fir savanna have become dominated by Douglas-fir (Heyerdahl et al. 2006). Drivers of this trend include fire exclusion which would have killed encroaching trees when they were of a small size; grazing which reduced fine fuel loads and further influenced fire exclusion; and summer droughts that enhanced sagebrush which functioned as nurse plants for establishing conifers (Heyerdahl et al. 2006). Threats to the xeric ecotone include loss of tree species to insects and fire as well as shifts in warming and drying trends. Plan components in the revised plan alternatives that encourage the use of fire for ecosystem maintenance and restoration (FW-DC-FIRE-01, FW-OBJ-VEGF-01) are expected to help sustain xeric ecotones.

Forest Structure

All revised plan alternatives include specific plan components related to structural ecological components including size class distributions (FW-DC-VEGF-03), the prevalence of large trees (FW-DC-VEGF-07, FW- GDL-VEGF-05), forest density (FW-DC-VEGF-04), snags (FW-DC-VEGF-05, FW-GDL-VEGF-03 and 04, FW-GDL-TIM-01and 02), old growth (FW-DC-VEGF-09, FW-GDL-VEGF-01 and 02) and landscape pattern (FW-DC-VEGF-07). This direction is expected to meaningfully contribute to the restoration and maintenance of biodiversity of ecosystems and ecological integrity of the Custer Gallatin. The current plans recognize the importance of diversity and heterogeneity in general but do not explicitly describe desired conditions for forested vegetation size classes. Direction in the revised plan alternatives provides substantially more detail and clarity as to what vegetation conditions to strive for.

Size Class and Large Tree Structure

Several desirable trends in forest size class were identified in the assessment and affected environment that would contribute to the overall Forest strategy of managing for ecological integrity and resilience. These include 1) increase the relative amount of large tree size class (over 15 inches average diameter at breast height) in all potential vegetation types; 2) decrease the amount of the medium size class (10 to 15 inches average diameter at breast height) in the Warm Dry and Cool Moist potential vegetation types; 3) decrease the relative amount of pole size class (5 to 10 inches average diameter at breast height) in the Cold and Warm Dry-Montane potential vegetation types; and 4) decrease the amount of seedling/sapling size class (under 5 inches average diameter at breast height) in the Warm Dry-Pine Savanna, primarily resulting from recent large, severe wildfires in this area. Figure 12 shows the predicted trends in forest size class over the next fifty years within each potential vegetation type. Because there was little variability in size class trends among alternatives, figure 12 shows averages across all alternatives. An unconstrained budget scenario was also analyzed for alternative F. Results indicated that the effect of an unconstrained budget on size class distributions would be minimal and within the margin of error shown for the budget-constrained alternatives in figure 12. As noted earlier, models are of greatest value for comparison among alternatives and are not intended to be precise estimates. Model outputs augment other sources of information, including research and professional knowledge of how ecosystem processes (such as succession) and disturbances and stressors (such as fire, insect, harvest, and climate) might influence changes in vegetation conditions over time, especially at the scale of the planning unit. Refer to appendix B for further details on model development and results.

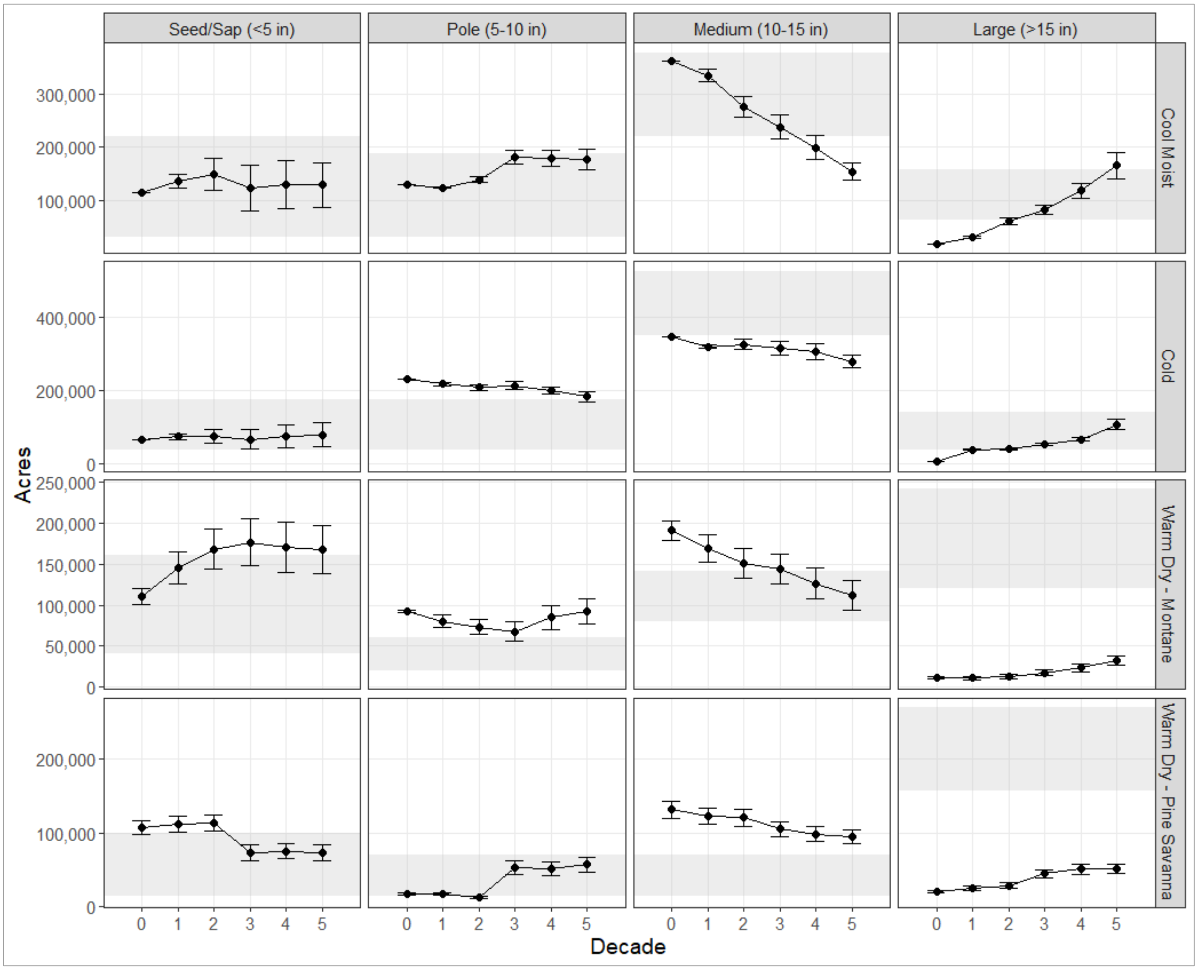

Figure 12. Change in size class over time. Shaded area indicates the desired condition. Because there was little variability among alternatives, figure shows averages across all alternatives (plus one standard deviation).

Modeling results indicated that differences in the trends of size classes among alternatives is minimal and size class would generally maintain or trend towards the desired condition. These trends include an increase in the large tree size class as well as improvement in the other desirable trends identified above. Here again, the lack of difference among alternatives is due to the overwhelming effect of natural processes on ecological change—primarily wildfire and succession—relative to the effects of active vegetation management or differences in vegetation management objectives among alternatives.

The prevalence of the large tree size class is expected to increase in all potential vegetation types but particularly in the Cool Moist and Warm Dry potential vegetation types. This is due, in part, to the effects of plan components that protect and encourage management for large trees (FW-GDL-VEGF-01, FW-GDL-VEGF-05, FW-DC-VEGF-03). As table 39 shows, the Cool Moist potential vegetation group is currently within the desired range for large tree structure. For this reason, the minimum number of large trees to retain in this area is slightly lower than the definition of large tree structure (8 trees vs. 10 trees per acres).

Notably, the projected rate of increase for the large size class in the Warm Dry potential vegetation types is projected to be small, likely reflecting the generally low productivity and anticipated effects of large wildfires in these areas. The increases in the large size classes correspond to the reductions in the medium size class, attributable to natural succession as well as disturbances or management that reduce stand densities and remove smaller trees. Although SIMPPLLE is not able to model change in the "Large Tree structure" attribute directly (as defined by table 39 above), it is reasonable to expect the amount of large tree structure to also increase. These shifts will result in enhanced resilience to disturbance and structural diversity, contributing to the diversity of successional stages for wildlife habitat as indicated by the natural range of variation. The effects are the same across all alternatives. In contrast to the current plans, plan components in all action alternatives articulate the express desire to increase presence of large trees (FW-DC-VEGF-03, FW-DC-VEGF-07) and require retention of large trees in treatment areas (FW-GDL-VEGF-05). These plan components will have the effect of maintaining and increasing large trees, a key ecosystem characteristic.

Density

Analysis presented in the assessment and affected environment indicated a need to reduce high density forest vegetation in the Cold and Warm Dry–Montane potential vegetation types. Maintaining the desired distribution of forest density classes will help maintain/improve overall forest resilience and resistance, which is a key component of the Custer Gallatin's strategy for responding to future uncertainties such as climate change. The relative distribution of forest density classes will change though time, trending towards the desired condition (figure 13). An unconstrained budget scenario was also analyzed for alternative F. Results indicated that the effect of an unconstrained budget on forestwide size class distributions would be minimal and within the margin of error shown for the budget-constrained alternatives in figure 13.

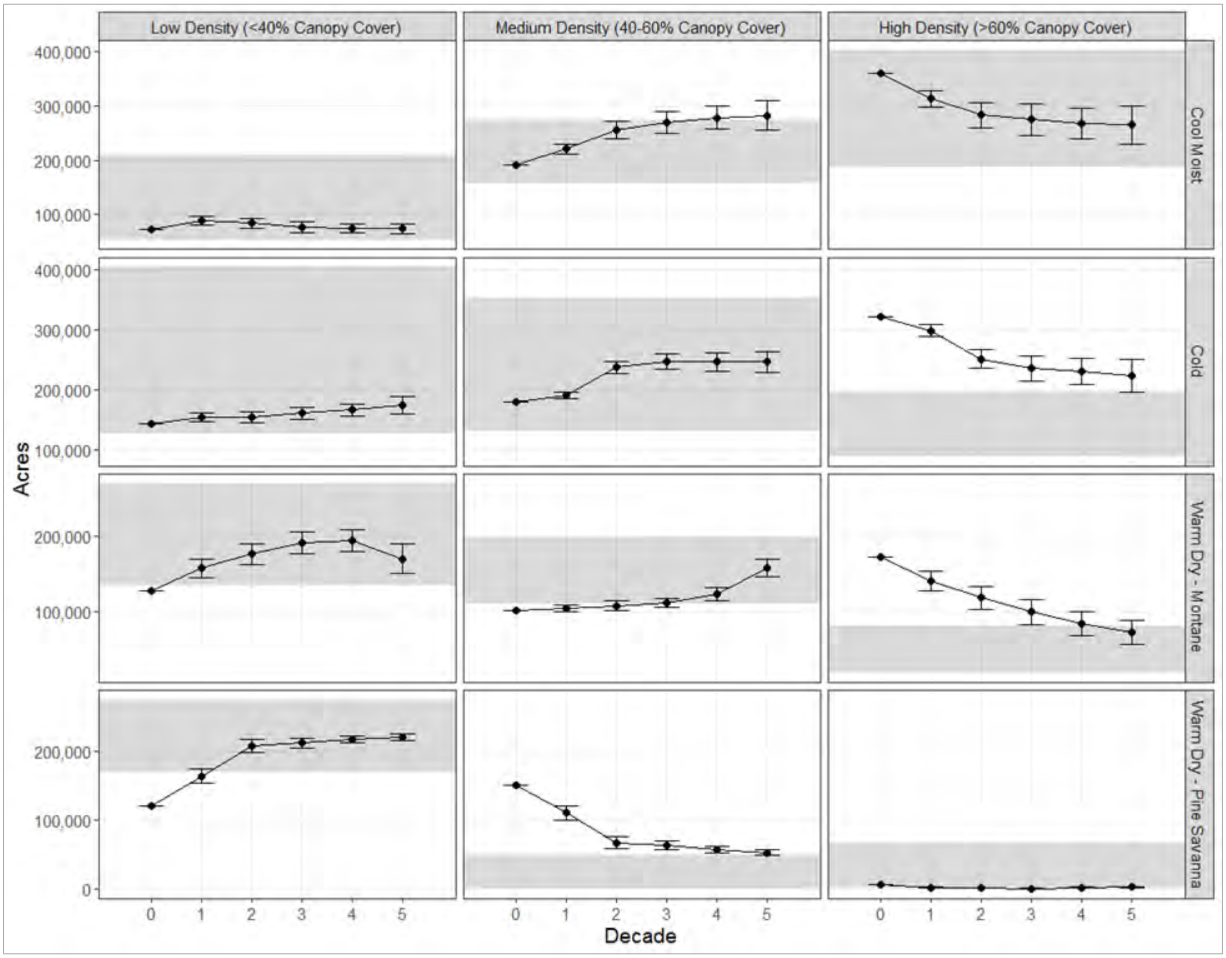

Figure 13. Change in density class over time. Shaded area indicates the desired condition. Because there was little variability among alternatives, figure shows averages across all alternatives (plus one standard deviation).

At the forestwide scale, the expected trend of density class distribution would generally move towards the desired condition (FW-DC-VEGF-04), including increases in the low/medium class and decreases in the high class where desirable. There is no appreciable difference among alternatives and the expected trends are conducive to promoting ecological integrity and resilience.

Snags

Forestwide, the Custer Gallatin National Forest is currently within the desired condition for snag density and distribution. While it is not possible to model the creation and decomposition of snags directly, one can assess the expected trends in the primary processes that create snags—fire and bark beetles—as a proxy to compare alternatives. Wildfire and prescribed burning would generally create snags in the short term, most often of the smaller size classes, although some snags and downed wood could be consumed. Bark beetles would tend to create medium, large or very large snags and not consume any existing snags or downed wood. After these events, the longevity of the snags would vary depending on species and site-specific conditions. For the purposes of this comparison, it is also assumed that timber harvest would generally reduce snag recruitment and retention, although appropriate levels of snags and downed wood would be retained as required by plan components (FW-DC-VEGF-05, FW- GDL-VEGF-03 and 04, FW-GDL-TIM-01 and 02).

As discussed above, it is assumed that acres burned by wildfire will likely double relative to current planning period in the coming decades and this is the same across all alternatives (see appendix B For further information on this assumption). This equates to approximately 200 to 250 thousand acres per decade of wildfire in forested areas with a combination of low, mixed and high severity fire. An additional 25,000 to 40,000 acres of prescribed burning per decade, mostly low severity fire, will also help contribute to the recruitment of snags across the landscape. Bark beetles, another snag-producing ecological process, are expected to affect approximately 30,000 acres per decade. Although these are the most important producers of snags at large scales, snags will also be created though interacting effects of drought, pathogens, and competition.

While it is not possible to predict the precise extent and location of fires and bark beetles, the majority of forested lands are within areas where natural ecological processes and disturbances will be emphasized, such as wilderness areas and inventoried roadless areas. These areas range from approximately 64 to 67 percent of the forested area depending on alternative. Timber harvesting or firewood cutting would be very minor or non-existent in these areas. In these areas, natural processes are expected to create snags and downed wood conditions that would generally be within the natural range of variation, with the diversity of conditions at the forestwide scale that would provide habitat for wildlife species associated with dead wood components.

It is expected that lands managed for timber production will have lower snag densities than areas managed to allow natural processes (Ohmann and Waddell 2002, Wisdom and Bate 2008). While the amount of lands suitable to be managed for timber production varies by alternative, the difference among alternatives is relatively minor, ranging from a low of 18 percent of National Forest System lands in alternative D to 22 percent in the current plans. In lands suitable for timber production, all alternatives have plan direction that direct management of snags and downed wood within timber harvest units. These are designed to address the unequal distribution of snags and downed wood across the Custer Gallatin National Forest that may be the result of timber management or fuel reduction activities, and supports the active role that is more likely to be needed to achieve desired distribution of snag habitat conditions within these actively managed landscapes.

In summary, at the forestwide scale, the Custer Gallatin is currently within the desired conditions for snag density and distribution. In the coming decades, the primary snag-producing agents (fire and insects) are expected to increase in all alternatives, thereby increasing snag density and distribution across the landscape. In the revised plan alternatives, snag recruitment from wildfire is expected because of FW-DC-FIRE-01 and FW-OBJ-FIRE-02. Prescribed fire will also contribute to creation of snags albeit at a much smaller scale (FW-OBJ-FIRE-01). In all revised plan alternatives, the number of snags required after timber harvest (4 per acre) is higher than in the current plans (FW-GDL-VEGF-03). Moreover, FW-GDL-VEGF-03 requires that the largest snags available be retained after vegetation management projects. Four snags per acre was chosen as the minimum retention level across all forest types because it is well above the desired condition for snags greater than 20 inches diameter at breast height, and in the middle of the range for snags greater than 15 inches diameter at breast height, thus ensuring that if large snags are available, they will be maintained at levels consistent with the desired condition. As discussed above, small and medium size snags are expected to be maintained by natural processes including fire, insects, disease and competition-induced mortality. FW-GDL-VEGF-03 and FW-

GDL-VEGF-04 are expected to promote the appropriate distribution of snags in managed areas, and thereby maintain the desired condition. In addition, in contrast to the current plans, the revised plan alternatives contain guidelines directing the retention of snags during salvage (FW-GDL-TIM-01 and FW-GDL-TIM-02). In addition, salvage is not allowed in the inner RMZ (FW-GDL-RMZ-08). As such, it is expected that snag density and distribution will be sustained or likely increase in the future, particularly under the revised plan alternatives.

Old Growth

As discussed above, it was not possible to directly model the trajectory of old growth as defined by Green et al. (2011). Moreover, predicting future old growth levels is challenging because of the uncertainty associated with the type and extent of ecosystem disturbance (Abella et al. 2007). Nevertheless, the trajectory of large tree size class and prevalence of large tree structure (discussed above) indicate that the amount of old growth should also be increasing forestwide under all alternatives. This is primarily due to natural succession of the forest combined with the effects of three plan components designed specifically to protect and promote old growth: FW-DC-VEGF-09, FW-GDL-VEGF-01 and FW-GDL-VEGF-02. The combined effect of these plan components is to 1) recognize the ecological importance of old growth and 2) provide the requisite protection and management direction to ensure its persistence. In short, the desired condition will guide management efforts to maintain or increase old growth forestwide while the guidelines limit any management action in old growth to actions with the express purpose of restoring or maintaining old growth. More specifically, under all action alternatives, FW-GDL-VEGF-01 would ensure that all management actions in old growth are done with the express purpose of maintaining or restoring old growth (with narrow exceptions to manage infrastructure) while FW-GDL-VEGF-02 would further protect old growth from road construction or other developments. FW-DC-VEGF-09 articulates the desire to maintain and increase old growth over time. This desired condition would have the effect of encouraging management actions that would promote the retention and development of old growth. Importantly, FW-GDL-VEGF-05, will also contribute to developing and protecting old growth forest by requiring large trees to be retained during vegetation management activities.

Old growth amounts and distribution would be dynamic and variable over time. Succession will continue to be the primary means by which old growth forest is developed. However, plan components ensure that management actions will also contribute to the recruitment of old growth (FW-GDL-VEGF-05, FW-DC-VEGF-09, FW-DC-VEGF-03). In all alternatives, fire and other natural disturbances would continue to influence vegetation and would remain the main cause of loss of old growth forest. Predictions for warmer springs and warm, dry summers suggest that forests of the northern Rockies and the western United States will experience longer fire seasons, with larger and potentially more severe fires in the future (Halofsky et al. 2018a) . Therefore, while new old growth is developing though succession and active management, existing old growth would be vulnerable to loss due to fire, as well as insects and disease, especially in drought prone areas. Fire exclusion and suppression in areas where a low or mixed severity historical fire regime occurred can alter vegetation structure and composition in old growth and may make these stands more vulnerable to fire. Particularly on the Warm Dry potential vegetation type, increasing tree densities have increased tree stress and vulnerability to mortality from insects, pathogens, and high intensity crown fires. In these areas, silvicultural treatments in old growth with the purpose of increasing resilience are expected to have the effect of maintaining existing old growth longer into the future (Fiedler et al. 2007).

As directed by FW-GDL-VEGF-01, the desired result of active management within old growth is to promote or maintain resilient old growth conditions while retaining old growth characteristics. Based on the current literature, this appears to be a reasonable approach to maintaining resilience in old growth ecosystems (Hawe and Delong 1998, Fiedler 2000, Steeger and Quesnel 2003). Numerous studies have shown that timber harvest can be used in both moist and dry forest types as an effective tool for restoring, promoting and maintaining old growth and forest resilience in general. For example, harvest activities could reduce risk of high severity fire, stimulate growth and resilience in old trees, provide for growth of smaller, younger trees into larger old overstory trees, and create gaps in canopy that allow establishment of new seedlings of fire-resistant species (Fiedler 2002, Sala and Callaway 2004, Agee and Skinner 2005, Spies et al. 2006, Franklin et al. 2007, Kolb et al. 2007). Silvicultural treatments can also maintain sufficient stand structure to provide habitat requirements for cavity nester species and a diversity of birds and small mammals, as well as maintain or improve understory plant diversity (Steventon et al. 1998, Steeger and Quesnel 2003, Metlen and Fiedler 2006). However, some uncertainty and need for caution associated with treatment of old growth for the purpose of improving forest conditions and resilience is also acknowledged (Baker and Ehle 2003, DellaSala et al. 2013).

In summary, given the projected trends in large tree size class and plan components designed to protect and recruit old growth, it is expected that old growth will increase relative to current levels under all alternatives. However, in contrast to the current plans, all revised plan alternatives have a desired condition to specifically maintain or increase all old growth types above current levels and a guideline that ensures timber harvest in old growth will be done only with the express purpose of increasing resilience of old growth. In addition, unlike the current plans, the revised plan alternatives contain a desired condition and associated guideline for retention of large tree structure—which are based on the Green et al. (2011) old growth criteria—which will also contribute to the maintenance of old growth over time.

Old Growth – Lodgepole Pine

While the desired condition to increase old growth in the revised plan alternatives (FW-DC-VEGF-09) would apply to all old growth types, FW-VEGF-GDL-01, which limits vegetation management in old growth, would not apply to lodgepole dominated forest that meets the minimum criteria of Green et al. (2011). Lodgepole is a shade-intolerant, fire-adapted pioneer species that usually regenerates in dense, structurally homogenous, even-aged stands (Lotan and Perry 1983). Most lodgepole-dominated forests occur as early- to mid-successional forests persisting for 50-200 years on warmer, lower elevation forests, and 150-400 years in subalpine forests. Lodgepole pine stands in the montane and lower subalpine zones, which are on less well-drained soils, are usually seral to mixed conifer stands, including species such as Douglas-fir, Engelmann spruce, whitebark pine and subalpine fir. Because old growth lodgepole is naturally structurally homogenous, compositionally pure, relatively short-lived (a seral stage of a more shade tolerant climax community), and smaller in diameter than other species, it generally does not provide the high degree of structural complexity and enduring ecological legacies as other old growth types.

Based on VMap data, there are approximately 477,000 acres of lodgepole pine cover type on the Custer Gallatin and approximately 50 percent is currently in a size class greater than or equal to 10 inches diameter at breast height. Approximately 30 percent is currently classified as old growth (according to FIA data). Most mature lodgepole pine stands range in age from 100 to 250 years old, have slow or stagnated growth and high mortality rates, and are slowly transitioning to younger stands dominated by more shade-tolerant species. Figure 14 shows the current size class distribution of the lodgepole cover type. Once lodgepole pine reaches this size, it is most likely experiencing high rates of mortality and being replaced compositionally by more shade tolerant species such as Engelmann spruce and subalpine fir. Moreover, as discussed below, lodgepole pine stands of this size are highly vulnerable to stand-replacing mortality from mountain pine beetle. Notably, approximately 40 percent of lodgepole cover type is currently in the 5 to 9 inches size class and will likely be growing into larger size classes in the coming decades. Currently, based on VMap data, only about 8 percent of lodgepole pine is in a size class less than 5 inches.

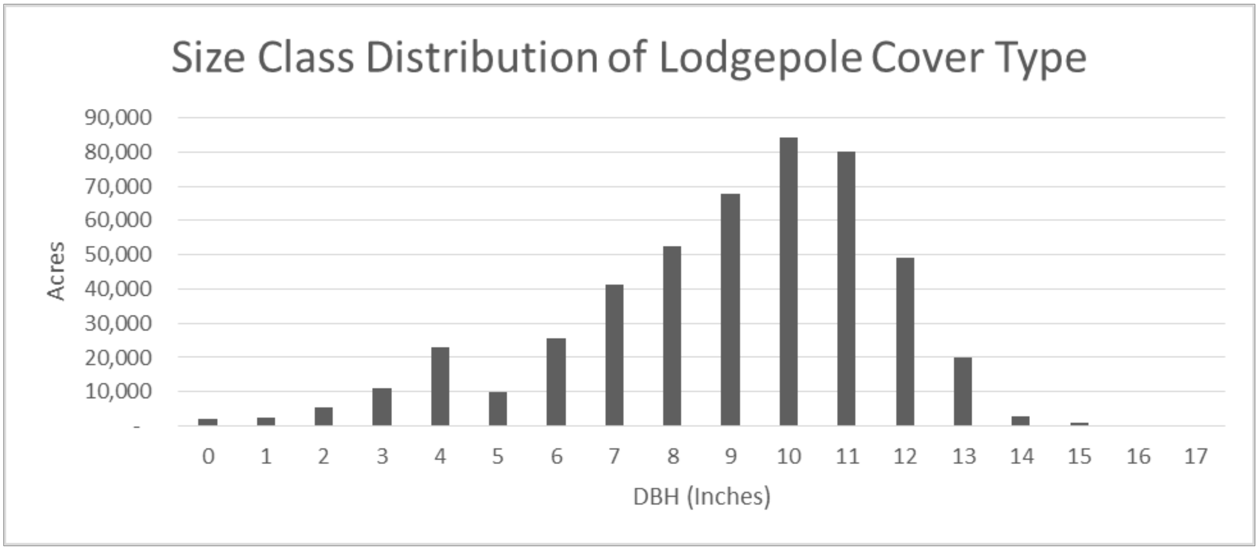

Figure 14. Size class distribution of lodgepole cover type on Custer Gallatin National Forest. Based on VMap data.

In the coming decades, old growth lodgepole pine on the Custer Gallatin faces a significant threat of major loss to mountain pine beetle—a particularly aggressive native bark beetle that has caused extensive mortality in mature lodgepole pine forests in the western United States and western Canada since the early 2000s (Egan 2014). It is well-documented that mountain pine beetle infestations occur primarily in dense stands with an abundance of large-diameter trees (Raffa et al. 2008). Mountain pine beetle attack in lodgepole pine is highly correlated with tree age and diameter because thicker bark and phloem are beneficial for successful mountain pine beetle colonization and reproduction (Raffa et al. 2013). Therefore, under a conducive climate, a high severity outbreak is likely in old growth lodgepole due to the abundance and quality of susceptible-sized host trees. In the future, warmer climates are predicted to increase bark beetle outbreak frequency, severity, and range, underscoring the threat to mature lodgepole pine on the Custer Gallatin (Kurz et al. 2008, Bentz et al. 2009, Six et al. 2014).

Analysis of a large, destructive mountain pine beetle outbreak in Montana in the 2000s indicated a threshold for outbreak occurrence anytime more than 26 percent of a subwatershed is comprised of highly susceptible forest condition (figure 15; (Egan et al. 2019), manuscript in progress). In general, landscape heterogeneity is considered to make lodgepole pine forests more resistant and resilient to insect-caused disturbance (Safranyik et al. 1998, Whitehead et al. 2003). However, fire exclusion in lodgepole pine forests has created landscapes that are more uniform and less diverse spatially and compositionally, and resulted in increased susceptibility to pine beetles and shifted stands from mixed severity to stand-replacing fore regime (Barrett et al. 1997). Based on VMap data, currently, over 50 percent of the lodgepole pine cover type is greater than 10 inches diameter at breast height and over 75 percent is high density (greater than 60 percent canopy cover). Based on forest inventory analysis data, approximately 32 percent of the lodgepole forest type on the Custer Gallatin is currently classified as old growth. Given the current size and age class distribution of lodgepole pine on the Custer Gallatin discussed above, coupled with predicted future climate conditions that more conducive to large outbreaks, mountain pine beetle represents a major threat to old growth lodgepole pine in the coming decades.

Forest management recommendations to reduce forest susceptibility to severe and widespread beetle-caused mortality often include various silvicultural treatments to promote species and age class heterogeneity (Whitehead et al. 2003). Because of its life history traits, silvicultural treatments in lodgepole have focused on clearcutting to recreate compositionally pure, even-aged, structurally homogenous stands. Although less common, lodgepole pine forests also occur in two-aged stands and in mixed -severity fire regimes (Arno 1980, Agee 1993, Axelson et al. 2009). However, uneven-aged silvicultural systems are less common because lodgepole pine tends to be easily wind-thrown and seedlings are very shade-intolerant, but it can be an ecologically and economically viable option in certain situations (Hood et al. 2012, Keyes et al. 2014).

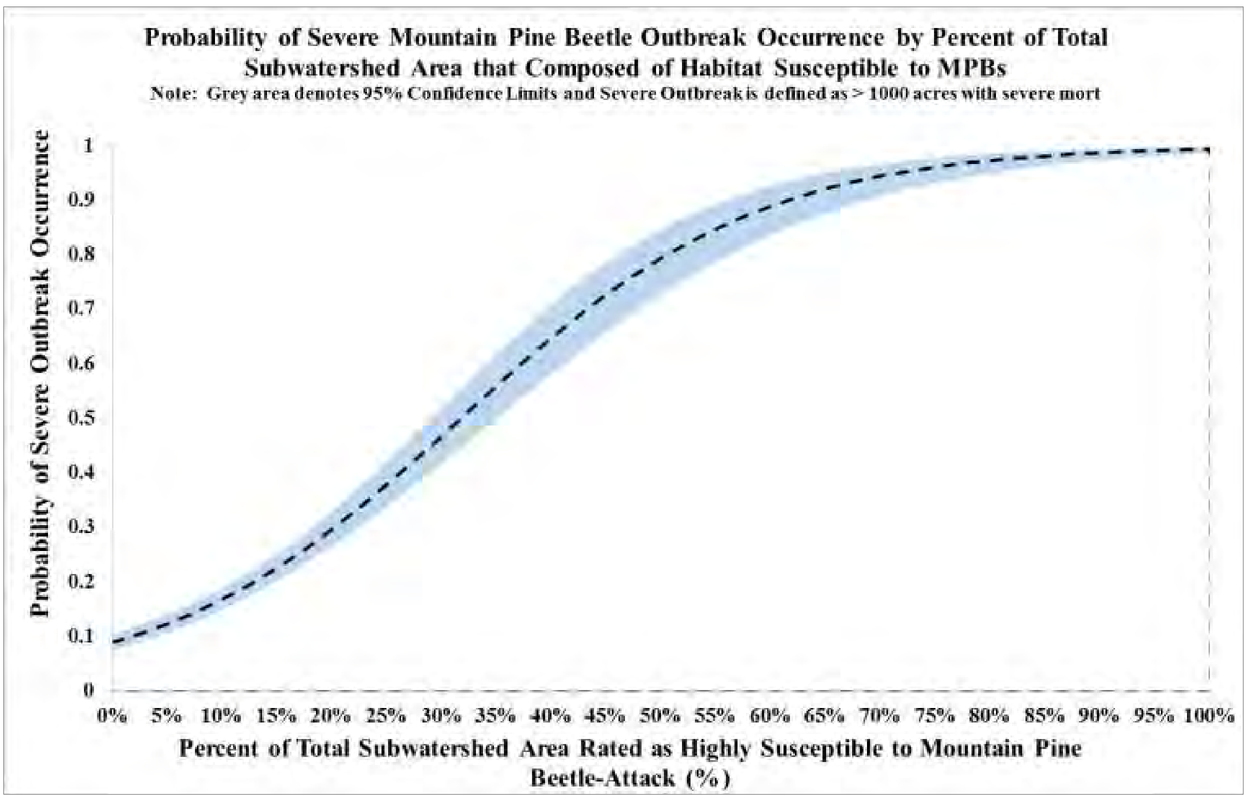

Figure 15. Chart depicting probability of severe mountain pine beetle outbreak by percentage of landscape with susceptible pine host. (Egan et al. 2019, manuscript in progress – data available).

In short, because, (1) the current size and age distribution of lodgepole dominated forest on the Custer Gallatin, is highly vulnerable to mountain pine beetle outbreak (Williams et al. 2018), (2) in the coming decades, warmer climates are predicted to further increase bark beetle outbreak frequency, severity, and range (Kurz et al. 2008, Bentz et al. 2009, Six et al. 2014), and (3) silvicultural treatments in mature lodgepole pine are the most useful tool managers have to promote landscape heterogeneity and sustain lodgepole pine ecosystems (Whitehead et al. 2003, Coops et al. 2008, Hood et al. 2016), excluding lodgepole forests from FW-VEGF-GDL-01 is expected to help maintain mature lodgepole on the landscape and not detract from ecological integrity. Notably, although old growth lodgepole is currently abundant (approximately 33 percent of lodgepole cover type based on FIA data), it is relatively inaccessible to active management. Moreover, as noted above, although FW-VEGF-GDL-01 would not apply to lodgepole, FW-DC-VEGF-09 would. As such, management actions would be designed to maintain or increase the amount of lodgepole old growth over the long term. Results from monitoring (MON-VEGF-01) will be used to ensure that old growth lodgepole pine is indeed being maintained over the planning period.

Landscape Pattern

Unlike the 1986 and 1987 plans, the revised plan explicitly recognizes the importance of forest patterns in contributing to overall ecosystem and landscape resilience. The revised plan alternatives place greater emphasis on managing for landscape patterns that would be resilient to uncharacteristically large disturbance events and better provide for the connectivity of wildlife species (refer to wildlife section for details on wildlife effects). The desired condition is for spatial pattern and patch size distribution to be consistent with what would occur under natural disturbance regimes (FW-DC-VEGF-07). This is supported by desired conditions to maintain ecological processes within their natural range of variation (FW-DC-VEGF-08, FW-DC-VEGNF-03, FW-DC-VEGNF-04, FW-DC-FIRE-01) which would, in turn, contribute to creating and maintaining landscape patterns consistent with the natural range of variation. In addition, the revised plan direction for maximum size of regeneration harvest units of 75 acres (FW-STD-TIM-08) is more consistent with the natural range of variation than existing direction, making it more conducive to managing for a desirable landscape pattern. See appendix B for additional detail on the analysis informing FW-STD-TIM-08.

As described in the affected environment section, an analysis of the natural range of variability was done to characterize the desired patch size distribution using four categories of patch sizes (under 40 acres, 40 to 100 acres; 100 to 1,000 acres, and over 1,000 acres) and three broad successional stages: early (under 5 inches diameter at breast height), mid (5 to 15 inches diameter at breast height), and late (over 15 inches diameter at breast height). The analysis was stratified by Northern Region broad potential vegetation type to account for broad differences in disturbance regimes and be used to evaluate trends in landscape pattern and any important differences among alternatives. See appendix B for more detail on results of the patch analysis.

In summary, this analysis revealed that, here again, because the amount of treatment (management action) is predicted to be small relative to the amount of natural disturbance in all alternatives, there is minimal difference in the predicted trajectory of landscape pattern among alternatives. Moreover, landscape pattern will be overwhelmingly driven by natural processes, not vegetation management actions. However, across all alternatives, landscape pattern is generally expected to remain within or trend towards the desired condition. This is largely due the expectation that increased wildfire will begin to disaggregate large patches of mid-seral forest while natural succession increases the prevalence of late-seral forest, particularly in small to medium patch sizes. If, however, wildfires are larger and generally more severe than anticipated, it is possible that large patches of mid-seral forest will be converted to large patches of early seral forest. To avoid this, wildfires should be allowed to burn under less extreme conditions as reflected in the Desired Conditions and Objectives for wildfire management in the revised plan alternatives (FW-DC-FIRE-01, FW-OBJ-FIRE-02).

Consequences to Terrestrial Vegetation from Plan Components Associated with other Resource Programs or Management

Effects from Watershed, Soil, Riparian, and Aquatic Management

All revised plan alternatives contain direction that protects watershed integrity (FW-STD-WTR-01), soil productivity (FW-STD-SOIL-01, FW-GDL-SOIL-07, riparian values (FW-STD-RMZ-01 and 02, FW-GDL-RMZ-07) and aquatic habitat management (FW-STD-WTR-04). Compared to alternative A, revised plan alternatives are much more specific and based on the concepts of the natural range of variation and focused on maintaining ecosystem integrity. As such, these plan components may influence project design locally but would generally complement and not preclude the achievement of the terrestrial vegetation desired conditions. In contrast to the current plans, revised plan components addressing watershed protection, soils, and riparian areas are much more specific and quantitative in the revised plan alternatives which is expected to better facilitate protection of these resources. See sections on Riparian, Wetlands, and Groundwater-Dependent Ecosystems and Riparian Management Zones above for additional detail.

Effects from Timber Management

Timber management is one of the tools available to change vegetation conditions for purposes of maintaining or moving towards desired vegetation conditions (FW-OBJ-VEGF-01). Plan components in all alternatives provide direction for timber harvest including identifying areas that are suitable for timber harvest. Alternative A has the most amount of land that would be suitable to use timber harvest as a management tool (approximately 22 percent of the Custer Gallatin) while the current plans and alternatives B through F are relatively similar (18 to 19 percent). All alternatives also have standards that limit the quantity of timber that may be sold per decade (FW-STD-TIM-07) and that ensures restocking of trees in harvest areas (FW-STD-TIM-10). Plan direction limiting timber harvest activities are provided in a number of other sections of the revised plan alternatives for purposes of protecting other values associated with vegetation conditions such as harvest in riparian areas (FW-STD-RMZ-01, FW-GDL-RMZ-06, FW-GDL-RMZ-07), in old growth (FW-GDL-VEGF-01), in areas of known plant or animal species of conservation concern or threatened and endangered species (FW-STD-PRISK-01) and in designated areas (refer to respective sections of the plan for direction). The revised plan alternatives also include components to protect burned forest conditions and the habitat it provides for associated species (FW-GDL-TIM-01, FW-GDL-TIM-02, FW-GDL-RMZ-08).

In contrast to the current plans, the revised plan alternatives contain direction that would protect important structural characteristics such as large trees (FW-GDL-VEGF-05) and snags and downed wood (including within salvage areas) at levels that provide for snag-associated wildlife species (FW-GDL-SOIL-07, FW-GDL-VEGF-03). Over half of the Custer Gallatin National Forest is in wilderness or inventoried roadless areas, where harvest, including salvage, would be prohibited or greatly limited, and natural disturbances would be predominant, including fire that creates abundant burned forest conditions. Finally, the revised plan alternatives include direction for timber management that increases the maximum opening size that may be created through regeneration harvesting. Based on an analysis of the natural range of variability, FW-STD-TIM-08 sets the maximum opening size at 75 acres. Compared to the current plans, this direction is designed to be more consistent with the natural range of variation for early successional forest. See appendix B for additional detail on the natural range of variability analysis for maximum opening size.

In total, the plan components addressing timber harvest cited above will result in harvest activities helping to move vegetation towards desired conditions and, in turn, promote ecological diversity and integrity. Based on the PRISM model, alternative D contains the most acreage of predicted timber management activity (emphasizing cutting of small diameter trees) followed by the current plans and alternatives B, C, and F, which are all similar. Alternative E has the least amount of timber management acres total, but the highest number of acres scheduled for regeneration harvest and the highest predicted timber volume due to the emphasis on timber production.

Effects from Fire and Fuels Management

Components associated with fire and fuels management in the revised plan alternatives strive to restore natural fire regimes and will help achieve vegetation desired conditions, and therefore generally result in positive impacts to terrestrial vegetation (FW-DC-FIRE-01, FW-OBJ-FIRE-01 and 02, FW-GDL-FIRE-01). Management of unplanned ignitions can be the only feasible management option in landscapes where mechanical treatments are not allowed or are impractical. For the revised plan alternatives, objectives for both managed wildfire and fuels reduction are complementary to other desired vegetation conditions, especially related to forest resiliency. In contrast to the current plans, the revised plan components are designed to explicitly and affirmatively recognize the natural role of fire on the landscape and its importance in shaping the ecosystem, while also protecting values at risk (FW-DC-FIRE-02, 03, FW-STD-FIRE-01, FW-GDL-FIRE-02).

The PRISM model was used to schedule treatments of future prescribed fire to move towards desired conditions while considering resource constraints and management guidance for each alternative. The PRISM model projects that all alternatives would apply similar levels of prescribed burning, approximately 27,500 to 28,000 acres per decade on average. Alternative D would apply the most prescribed fire to the forested landscape, approximately 30,000 acres on average per decade. Fuels treatments are expected to follow a similar pattern with alternative E having the least (approximately 12,000 acres per decade), alternatives B, C, and F in the middle (approximately 23,000 acres per decade) and alternative D with the highest amount of fuels treatment (approximately 40,000 acres per decade). Alternative D differs in this way because it emphasizes treating the greatest number of acres to achieve desired conditions and prescribed burning and fuels treatments are often a cost-efficient tool for achieving this objective.

In lands within the wildland-urban interface and near communities, there would likely be a continued emphasis on fuels management (FW-OBJ-FIRE-01). To achieve plan components associated with fire and fuels management in wildland-urban interface, there may be areas where forest conditions are created and maintained over the long term at lower densities, for example, generally open and park-like conditions. This would often be consistent with the natural disturbance regime found on many sites, such as in the warm dry potential vegetation group. However, in cases where cool moist forest types are found in the wildland-urban interface the site-specific conditions could be more open than what would occur under natural disturbance regimes. This effect is common to all alternatives.

Effects from Air Quality Management

The consequences to terrestrial vegetation from air quality related plan direction are the same for all alternatives. All alternatives have direction to meet air quality standards established by Federal and State agencies and meet the requirements of state implementation plans and smoke management plans (FW-GO-AQ-01). The direction limits how much can be burned and when and where it can occur. The costs of conducting prescribed fires increases as a result of the burning regulations, which affect how much is burned. The ability to implement the vegetation treatments that would occur as a result of the alternatives is dependent upon prescribed burning as well as using natural, unplanned ignitions to meet resource objectives. Therefore, to the extent that air quality regulations may become more stringent in regard to the quantity and timing of smoke emissions, there could be limitations to conducting prescribed burning.

All revised plan alternatives contain direction that protects watershed integrity (FW-STD-WTR-01), soil productivity (FW-STD-SOIL-01, FW-GDL-SOIL-07, riparian values (FW-STD-RMZ-01 and 02), FW-GDL-RMZ-06 and 08) and aquatic habitat management (FW-STD-WTR-04). Compared to alternative A, revised plan alternatives are much more specific and based on the concepts of the natural range of variation and focused on maintaining ecosystem integrity. As such, these plan components may influence project design locally but would generally complement and not preclude the achievement of the terrestrial vegetation desired conditions. In contrast to the current plans, revised plan components addressing watershed protection, soils, and riparian areas are much more specific and quantitative in the revised plan alternatives which is expected to better facilitate protection of these resources. See sections on Riparian, Wetlands, and Groundwater-Dependent Ecosystems and Riparian Management Zones above for additional detail.

Effects from Wildlife Management

By and large, terrestrial vegetation may be influenced by wildlife-associated plan components that limit the location, access, timing or duration of vegetation management, and in some cases require certain vegetation conditions (e.g., FW-GDL-WL-02, FW-DC-WL-03, FW-DC-WLSG-01, FW-DC-WLPD-01, FW-DC-WLWV-01). Plan direction for grizzly bears and lynx will follow regional guidance associated with these species which is the same across all alternatives. In the current plans, many of these elements are blended into management area guidance. In all alternatives, several of the plan components of the lynx and grizzly bear direction would complement the at-risk plant plan components by describing a desired condition to manage vegetation to approximate natural succession and disturbance processes and provide a mosaic of habitat conditions through time (for example Objective VEG 01 in Northern Rockies Lynx Management Direction). Wildlife plan components generally support functioning, resilient habitat conditions that would also benefit terrestrial vegetation. The vegetation-related wildlife plan components would provide for the wildlife habitat conditions that support the full suite of native species. Species–specific direction in the revised plan alternatives would not compromise the integrity of terrestrial vegetation as a whole, but would provide additional restriction as necessary to maintain or restore populations. This is the basis of the coarse-filter or fine-filter approach to providing ecological integrity as described above.

Effects from Plan Land Allocations

Plan components related to management of areas such as wilderness areas, wilderness study area, recommended wilderness areas, inventoried roadless areas, research natural areas, special areas, wild and scenic rivers, backcountry areas, and recreation emphasis areas, etc. can affect vegetation management by requiring specific design criteria and considerations for management activities or by restricting availability of lands to harvest, a primary tool of vegetation management. All alternatives vary by the amount of land managed under the direction of specific land designations (table 2 in chapter 2).

For some areas, the effect to terrestrial vegetation forestwide would be minimal. For example, public safety issues in developed and undeveloped recreation sites may limit the ability to maintain the desired snag levels that are indicated under the revised plan alternatives. However, because these recreation areas are generally small in size, the effect of having fewer snags or the ability to meet the forestwide desired conditions is negligible.

Plan components associated with recommended wilderness or backcountry areas could have substantial effects on the vegetation management tools available and the design of vegetation treatments that may be suitable (FW-SUIT-BCA-01, FW-SUIT-RWA-01, and FW-SUIT-RWA-03). Although timber harvest is not suitable in these areas, management actions that restore natural processes and vegetation would be permitted. The most likely treatments would be associated with whitebark pine restoration and prescribed burning (planned ignition), in some cases followed by limited planting of conifer seedlings for the purposes of restoring desired forest structure and composition, and to restore desired landscape patterns. Recommended wilderness areas by in large overlap inventoried roadless areas. Although limited, some harvest could occur in inventoried roadless areas; therefore, while generally small, there is an additive impact of restricting harvest with the recommended wilderness area allocation, and thus the potential to contribute to vegetation desired conditions with timber harvest, as described in the timber section. While some studies have shown timber harvest and prescribed fire can decrease the susceptibility of forests to severe wildfire and insect outbreaks (Amman and A. 1998, Shore et al. 1999, Agee et al. 2000, Hessburg et al. 2005, Egan et al. 2014), other studies have concluded that at a broad scale, beetle outbreak outcomes or fire severities are not lessened in managed lands (Six et al. 2014, Bradley et al. 2016)). However, regardless of the mix of plan land allocations, forestwide vegetation desired conditions would be the same under all revised plan alternatives and comparable to the current plans. As such, the primary effect of recommended wilderness and other plan land allocations would be limiting the management flexibility (such as, timing, design, available tools, size of treatments, etc.) to achieve or maintain these conditions in these areas. Restrictions associated with plan land allocations (and the associated variability across alternatives) were incorporated into the modeling process and effects are embedded in the outputs shown above.

Effects from Access and Road Management

Past road construction has reduced acres of native meadows and shrublands. Roads constructed in and along valley bottoms have reduced or altered riparian vegetation and sometimes changed stream channel location and function. Roads tend to create one of the largest impacts on the health and sustainability of stream/riparian/wetland systems. General effects include lowered water tables, fragmented riparian areas, altered morphology, changed sediment regimes, and removal of canopy cover and other vegetation. Unauthorized off-road vehicle travel has an effect in moving vegetation to an earlier seral condition. Plan components associated with road management strive to have minimal impacts on ecological integrity and diversity, which generally result in positive impacts to terrestrial vegetation (FW-STD-RT-02, FW-STD-RT-04, FW-STD-RT-05, FW-GDL-RMZ-04, and FW-GDL-VEGNF-07). In all alternatives, limits related to road access on existing roads as well as construction of new roads (both permanent and temporary) could have an impact on the ability to conduct vegetation treatments that require road access, particularly mechanical treatments, across portions of the Custer Gallatin (FW-SUIT-IRA-02, PR-STD-WHT-01, MG-STD-CCRW-01, MG-STD-WSA-01, FW-STD-RWA-01, AB-STD-LBCBCA-01, BC-STD-BPBCA-01, BC-STD-CMBCA-01, MG-STD-BHBCA-01, MG-STD-SCBCA-01, MG-STD-LHBCA-01, MG-STD-WPBCA-01). Limited access to conduct desired vegetation treatments would affect the ability to achieve desired vegetation conditions in some areas.

Effects from Recreation Management

Under the no-action alternative, developed recreation sites would be managed for public safety. Under the action alternatives, recreation plan components more specifically address the desired vegetation conditions in these areas, and may result in vegetation conditions in small, isolated areas to be managed in ways that do not contribute toward the attainment of desired conditions due to other considerations such as public safety (e.g., FW-SUIT-RECORGCAMP-01, FW-SUIT-RECSKI-01, FW-SUIT-RECDEV-01, FW-GDL-RECDEV-01, and FW-DC-RECDEV-01). The overall influence of this would be minor, and similar across alternatives due to the small scope and scale of these areas, and because in some cases the desired vegetation conditions would be consistent with terrestrial vegetation desired conditions.

Recreation use can affect vegetation especially in the case of repeated or continual uses such as camping, fishing, and hiking, horseback riding, snowmobiling, recreational gold panning, or off-road vehicle use. Generally, the number of acres impacted is a very small but can nevertheless have site-specific impacts. Under all alternatives, plan components associated with recreation management strive to have facilities, trails, and dispersed camp sites contribute minimal impacts on ecological integrity and diversity, which generally result in positive impacts to terrestrial vegetation (FW-GDL-RECDEV-01).

Recreation opportunity spectrum designations regulate motorized and nonmotorized recreation and may also influence the design or the location of on-the-ground projects as described in the associated plan components. For example, FW-DC-ROS-07 sets a desire for vegetation management does not dominate the landscape or detract from the experience of visitors. The consequences that would result from the current plans are fairly similar to the revised plan alternatives. To the extent that Recreation opportunity spectrum designations influence potential motorized access, the feasibility of conducting timber harvest to influence vegetation may be affected as described in the Timber section.

Effects from Scenery Management

Direction for scenery and recreation management in the revised plan alternatives affect the type of vegetation treatments that could occur in some areas across the national forest. For example, scenic integrity objectives (lowest scenic levels allowable) do not outright prohibit vegetation management but may influence the design or the location of on-the-ground projects that would be visible from any of the listed critical viewing platforms. Design features or mitigations may be required to meet or exceed the assigned scenic integrity objective, which describes the maximum threshold of visual dominance and deviation from the surrounding scenic character.

Effects from Permitted Livestock Grazing

In all alternatives, livestock grazing would occur on portions of the Custer Gallatin National Forest. Plan components would enable grazing activities to complement terrestrial vegetation management, such as reducing fine fuels to lower fire risk, where appropriate. Livestock that use rangelands can remove plant material, trample soils, and alter water flow patterns. However, with proper management (rest and recovery) these impacts are often not substantial when compared with the natural resilience of ecosystems (Chambers et al. 2019). While grazing and trampling from livestock can damage native plants and tree seedlings and saplings, FW-STD-GRAZ-01 would ensure that grazing is managed to promote sustainable and vigorous native plant communities (as described by FW-VEGNF-DC-04). FW-STD-GRAZ-01 would also ensure that grazing is managed in a manner that would not lower site productivity (through damages such as compaction) and limit the spread of invasive plant species into native plant communities. Further, existing policy (FSH 2472) would ensure that grazing does not adversely impact the regeneration of forests, or re-seeding of non-forested areas with desirable native vegetation.

Perennial riparian vegetation on or near the water's edge (greenline) encounters the most erosional stress during floods. Flooding is a natural disturbance process that maintains heterogeneity in riparian and in-stream structure, function, and composition (Naiman and Decamps 1997). The natural disturbance regime effects of flooding can be compounded by various land-use practices resulting in decreased riparian function. Riparian vegetation has the best opportunity to slow velocity and induce deposition of materials, stabilize banks, and re-create channel pattern, profile, and dimension appropriate for the landscape setting. Where streambank instability or changes in channel form may arise from channel widening or channel incision, vegetation along the greenline is most critical. Depending on site potential, greenline, riparian, and floodplain plant communities also contribute wood and aid floodplain energy dissipation, sediment and nutrient sequestration, and aquifer recharge (Swanson et al. 2015).

Annual indicators of livestock grazing use, such as within season or end of season stubble height, streambank alteration, woody species utilization, and upland utilization or residual, are valuable tools in providing a link between on-the-ground management and attainment of long-term desired conditions. When properly designed and supported by best available scientific information, and properly implemented, annual indicators provide a reasonable assurance that if they are consistently met, long-term desired condition attainment would be expected within reasonable timeframes. As such, they provide a short-term means of adapting management on an annual basis to meet or move toward the long-term desired conditions.

All the revised plan alternatives have an end of season stubble height guideline that would improve potential effects to aquatic habitat from livestock grazing on specific stream types (FW-GDL-GRAZ-02). End of season stubble height of greenline vegetation has been shown to be a good indicator of two primary factors: 1) the effect of grazing on the physiological health of herbaceous, hydrophilic plants, and 2) the ability of the vegetation to provide streambank protection and bank building function. In addition, indirect benefits occur as well. Using stubble height to monitor foraging behavior (for example, shifts to browsing willows) and physical impacts (for example, trailing) can be as important as maintaining stubble heights that support plant vigor and sediment deposition (Skinner 2002). Other grazing plan components will protect rare or unique terrestrial vegetation including woody draws and riparian areas by minimizing sediment delivery and trampling (FW-GDL-GRAZ-01, FW-GDL-GRAZ-04, FW-GDL-GRAZ-05).

Effects from Minerals Management

Exploration and production activities could disturb or otherwise affect vegetation, but the extent is dependent upon the amount of exploration, reclamation requirements and resultant production. Under all alternatives, the expected effects to vegetation are considered minimal across the Custer Gallatin given the amount of anticipated minerals activity coupled with plan components for energy and mineral resource development that consider other resources.

Cumulative Effects

The effects that past activities have had on all of the components of forest vegetation (such as, forest composition and structure, landscape pattern, etc.) were discussed in the "Affected Environment" section and are reflected in the current condition of the forest vegetation. Therefore, unless otherwise noted, past activities are not carried forward into the following cumulative effects analysis. Present and foreseeable future activities that could affect forest vegetation are summarized below.

Increasing Human Population

Additional stressors that may increase in the future are increasing population levels, both locally and nationally, with resulting increasing demands and pressures on public lands. As related to forest and vegetation conditions, these changes may lead to increased demands for commercial and non-commercial forest products, elevated importance of public lands in providing for habitat needs of wildlife species, and changing societal desires related to the mix of uses public lands should provide.

Regulations and Public Concerns Regarding Smoke Emissions

The ability to implement the vegetation treatments that would occur as a result of the alternatives is highly dependent upon prescribed burning (both associated with timber harvesting and without it) as well as using natural, unplanned ignitions to meet resource objectives. Therefore, public concern about smoke and associated air quality regulations could have substantial effects in limiting vegetation treatments using fire and meeting desired vegetation conditions.

Management of Adjacent Lands

Portions of the Custer Gallatin National Forest adjoin other national forests, each having its own land management plan. The Custer Gallatin National Forest is also intermixed with lands of other ownerships, including private lands and state lands. Some geographic areas contain substantial inholdings of such lands, while others are more unfragmented in terms of ownership. The geographic areas that are island mountain ranges are largely surrounded by private lands. Harvesting or conversion of forests on adjacent lands would affect vegetation conditions at the landscape level. State law applies to all activities regardless of ownership; therefore, basic resource protections would be consistent. However, vegetation management practices on other lands, particularly private lands, would not necessarily be conducted to meet the same desired conditions as those outlined in the Custer Gallatin Plan.

The management plans for National Forest System lands adjacent to the Custer Gallatin include the Helena-Lewis and Clark, Beaverhead-Deerlodge, Targhee, and Shoshone. All of the plans contain direction that addresses terrestrial vegetation and promotes ecological integrity. Management of vegetation is broadly consistent across all national forests due to law, regulation, and policy. The cumulative effect would be that the management of vegetation would be complementary. Some adjacent lands are subject to their own resource management plans relevant to terrestrial vegetation.

Montana Fish Wildlife and Parks Strategic Plan 2015–2020 (2014a) complements vegetation management on the Custer Gallatin by including strategies related to increased resilience, wildfire safety, and providing wildlife habitat. State forest lands may be actively managed to a greater degree than National Forest System lands and would likely contribute to achievement of desired vegetation conditions across the landscape. The cumulative effect would likely be additive, in terms of moving towards the vegetation desired conditions as described in the revised plan. The Montana State Parks and Recreation Strategic Plan guides the management of state parks, some of which lie nearby or adjacent to National Forest System lands. Terrestrial vegetation is a component of these parks, although not always the primary feature. Specific vegetation conditions would not necessarily contribute to the desired conditions as described for the Custer Gallatin. Both South Dakota's and Montana's State Wildlife Action Plans describes a variety of vegetation conditions related to habitat for specific wildlife species. These plans would likely result in the conservation of these habitats on State lands, specifically wildlife management areas. These plans would be likely be consistent with desired conditions of the Custer Gallatin.

South Dakota's Wildlife Action Plan uses an ecosystem and science-based approach to assess the health of South Dakota's fish and wildlife and associated habitats (South Dakota Department of Game Fish and Parks 2014b). The plan not only evaluates the challenges species of greatest conservation need face and outlines actions to help conserve them for the long term, but it also refers to the terrestrial and riparian-wetland ecosystems' planning approach which encourages voluntary actions among Tribes, conservation partners, agencies (such as the U.S. Forest Service), and individuals to provide habitats that occurred prior to European settlement of South Dakota. The expectation is that this approach will accommodate the needs of the majority of species. The concept of using an historical reference is based on the fact that the array and distribution of ecosystems across South Dakota shaped and sustained the region's biological diversity. Most fish and wildlife species in South Dakota today resulted from historical ecosystems and associated disturbance regimes in the Great Plains. This plan is complementary to having resilient ecosystems in which at-risk plants can persist.

The identified terrestrial and riparian habitats for South Dakota's species of greatest conservation need use a coarse filter or fine filter strategy to assure that terrestrial and riparian-wetland habitat needs are met. This approach is complementary to the plan components for the Custer Gallatin National Forest. The approach establishes a baseline condition (historical reference) at a time prior to European settlement. A critical consideration in the terrestrial approach is an understanding of natural disturbance regimes, such as fire, flooding, and grazing patterns, which acted upon habitats. For example, the Sioux Ranger District terrestrial habitats would be classified under the Natural Resources Conservation Service Ecological Sites of Northern Rolling High Plains (Eastern Part) and a small portion of Rolling Soft Shale Plain. The riparian hierarchical framework was adapted from the Missouri River Gap Analysis Project to identity Conservation Opportunity Areas.

Bureau of Land Management lands near the Custer Gallatin are managed by the Dillon plan (2006), Butte plan (2009a), Billings plan (2015a), Miles City plan (2015b) and South Dakota plan (2015c) field offices. These plans components related to resilient terrestrial vegetation are complementary to the plan components for the Custer Gallatin; timber management would generally be conducted in a similar manner and with similar results.

The Foundation Document for Yellowstone National Park calls for preserving natural vegetation, landscapes, and disturbance processes. Broadly, the terrestrial vegetation characteristics in this area are therefore likely similar to the wilderness areas in the adjacent Absaroka Beartooth and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas and would complement these conditions. By managing for ecologically based desired conditions and resilience, any vegetation management activities in non-wilderness areas adjacent to Yellowstone National Park would also be consistent with this plan.

Many of the county growth plans associated with the Custer Gallatin National Forest emphasize an interest in resilient forests and promoting the sustainability of forest landscapes. As such, vegetation management would remain an important feature in the local communities. Some county wildfire protection plans map or define the wildland-urban interface. The Custer Gallatin notes that these areas may be a focus for hazardous fuels reduction, and other plan components (such as Northern Rockies Lynx Management Direction) have guidance specific to these areas. Vegetation management, including harvest, may be emphasized in these areas more so than others. Managing for open forests and fire adapted species may be particularly emphasized in these areas. Overall, the effect of the county plans would be to influence where treatments occur to contribute to desired vegetation conditions.

Conclusions

The following key points summarize the conclusions for terrestrial vegetation:

- The suite of components associated with terrestrial vegetation in the revised plan alternatives is designed to maintain or restore the ecological integrity of the Custer Gallatin National Forest. Desired conditions describe increases in large trees and large forest size classes, more open forest densities in some potential vegetation types, vigorous non-forested plant communities dominated by native species and maintaining the full range of the biodiversity of ecosystems on the landscape. These conditions are consistent with the modeled natural range of variation and most likely to be resilient to future environmental conditions.
- The current plans generally recognize the importance of ecosystem diversity and heterogeneity, but the revised plan alternatives reflect substantially more ecological thinking and provide more detail regarding vegetation conditions that will provide for ecological integrity and resilience.
- Expected trends for key indicators of terrestrial vegetation forestwide show progress towards desired conditions but little variability across alternatives. This is primarily due to the limited scope and impact of vegetation management treatments (which vary slightly by alternative) relative to the size of the national forest and the effects of natural disturbances, particularly fire (which does not vary by alternative).
- Regardless of alternative, models of future vegetation conditions predict:
    - Wildfire will be the dominant force driving change in ecosystem composition, structure and function at the forestwide scale.
    - The amount of large tree size class and large tree structure will increase. This will likely result in an increase in old growth forest.
    - The distribution and dominance of whitebark pine and ponderosa pine will increase. However, despite these model results, there remains a high degree of uncertainty about these species as discussed above.
    - High density forest will decrease, primarily due to the effects of wildfire.
    - The distribution of patch sizes will generally stay within or move towards desired conditions, largely due to the anticipated effects of wildfire.

3.7 Fire and Fuels

3.7.1 Introduction

Fire is a necessary and critical ecological function across the Custer Gallatin National Forest that plays a central role in providing quality habitat for both plant and wildlife species. Wildland fires consist of wildfire (unplanned ignitions) and prescribed fire (planned ignitions). Fire management includes the strategies and actions used before and during wildland fire events. Management of wildland fire influences whether fire effects create beneficial or negative impacts to water and air quality, habitat, recreation areas, or communities. Wildfire management, and subsequently risk management, include a spectrum of responses from protection to resource objectives. Suppression is a management strategy used to extinguish or confine an unwanted wildfire. Fuels management is the manipulation of vegetation to change fire characteristics when it burns.

Wildland Fire Management

Fire on the landscape is considered a natural process and many fires on the Custer Gallatin are started by lightning. However, humans have also been a source of fire on the landscape for centuries, and intentional or not, have influenced vegetation successional dynamics. Fire is not a simple process and many factors influence its character, including fuel loadings, climatic and weather conditions, topography, vegetation structure and composition, and elevation.

All wildfires are managed on a continuum between meeting protection and resource objectives; the mix of these objectives are based both on the location of a wildfire (or a portion of) and the condition under which it is burning. These objectives come from the desired conditions in the land management plan. The burning conditions change through the season and from year to year, providing both opportunities and restrictions.

Forest Service policy dictates that every wildfire has some aspect of a protection objective in a fire management response (National Interagency Fire Center 2017). This response can vary from monitoring the fire under conditions that are conducive to obtaining resource benefits, to an aggressive suppression effort to protect communities and values at risk from potential damages. Factors in all wildfire management decisions include firefighter and public safety, risk to property, fire resource availability and national/regional priorities, costs, and potential resource benefits; wildfires are not allowed to just burn.

Effective management sees to the nature of wildfire and its contributing factors, recognizes the positive and negative consequences involved, addresses uncertainty, and develops responses that reduce the chances of catastrophic losses (U.S. Department of Agriculture and U.S. Department of the Interior 2011). Forest and fire managers need to manage both short- and long-term risk. In the long term, risk to communities and assets will be reduced when potential positive and negative consequences of fire are recognized and management actions to obtain positive outcomes are matched; fire will be restored as an ecosystem function to the landscape, and smoke impacts to communities will be reduced.

Wildfire Risk Management

The wildfire risk management process involves making decisions and taking actions to control and accept risks. This is done by identifying, assessing, and prioritizing risks followed by the coordinated and economical application of resources to minimize, monitor, and control the probability or impact of unfortunate events (Thompson and Calkin 2011). The Forest Service uses scientific assessments to determine where individual wildfires are likely to have negative or positive outcomes. Assessments are based upon a detailed quantitative analysis of the location of values at risk (such as water sources, communities, or recreation sites) and the likelihood of fire starts (often called “ignitions”), fire spread, and fire intensity.

A wildfire risk assessment can be visually depicted with the “wildfire management continuum,” which was created to show how wildfires may be managed for one or more objectives (Thompson et al. 2016). The basics of the wildfire management continuum can be described according to four dimensions (figure 16).

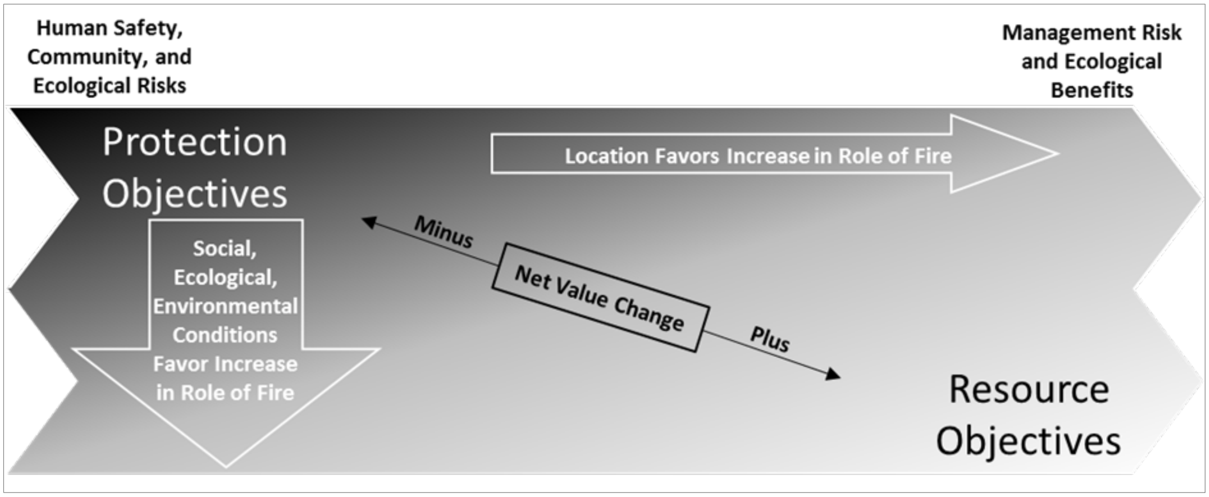

Figure 16. Wildfire management continuum (adapted from Thompson et al. 2016).

The length (side to side) of the continuum shows the spatial component, or the location on the landscape. The location also affects the mix of objectives: on the left, it favors protection objectives, whereas on the right it favors resource objectives.

The width (up and down) of the continuum illustrates the different social, ecological or environmental conditions affecting the mix of objectives. On the top, protection objectives prevail, whereas on the bottom resource objectives are easier to obtain.

The gray scale depicts the range of objectives, taking in the combination of both location and conditions. Black (upper left) represents how the combination of conditions and landscape location can experience higher risks to communities or ecological resources, which result in protection as the predominate objective. White (lower right) has the combination of low-risk conditions and landscape location that make managing for resources the primary objective. The colors also represent the net value change to natural resources and community assets; black indicates a negative change (damage) while white indicates a positive change (benefit). The fire management response is to protect from potential damage and to obtain benefit. As risk is lowered on the landscape, more positive net value change opportunities exist over more locations and conditions, therefore increasing the ratio of white to black.

The teeth on each end of the continuum indicate that it wraps around to form a cylinder. A wildfire on the far left could be near an area with high risk and management of that portion of the fire would be to meet protection objections. Whereas a fire on the right side being managed primarily for resource objectives may change to a fire managed for protection objectives due to environmental changes that caused it to grow and threaten resources and assets.

Fuels Management

Fuels reduction treatments primarily consist of thinning and prescribed fire, but can include other treatments such as mowing, herbicide application, and seeding. In accordance with applicable laws, policies, and regulations to meet specific objectives, prescribed fires are intentionally ignited. Mechanical treatments include the use of equipment, such as feller-bunchers or chain saws, to perform activities that change vegetation composition and structure and alter fuels to reduce hazard. Prescribed burning often follow mechanical treatments. The focus of the fuels management program has been to modify the fuel conditions to meet varying objectives to reduce threats to values at risk, increase suppression success by minimizing crown fire likelihood, decrease fire intensity, or decrease rate of spread.

Fuels reduction treatments center on the part of fire environment that can be altered, resulting in a change in the amount, configuration, and spacing of live and dead vegetation. The costs, environmental impacts, and effectiveness of different fuel treatment types vary. Strategically located fuels treatments provide opportunities to proactively manage the size and costs of future wildfires (Thompson et al. 2013). In addition to modifying fire behavior, fuels treatments achieve multiple resource benefits, such as meeting desired vegetation conditions, creating desired wildlife habitat, and producing timber products.

As human development expands into more remote areas, the wildland-urban interface will continue to grow. The wildland-urban interface designation affects all fire management decisions in those interface areas. Although a wide variety of fire management strategies are available to implement, these options are usually narrowed down due to concerns that fire may move from Federal to private lands. Hazardous fuels treatments in the wildland-urban interface focus on manipulating the vegetation to enhance the success of fire suppression activities.

Regulatory Framework

Wildfire Suppression Assistance Act of April 7, 1989 (HR 4936): Authorizes reciprocal fire protection agreements with any fire organization for mutual aid with or without reimbursement and allows for emergency assistance in the vicinity of agency facilities in extinguishing fires when no agreement exists.

Healthy Forests Restoration Act of 2003 (HR 1904): Aimed at expediting the preparation and implementation of hazardous fuels reduction projects on Federal land; encouraging collaboration between Federal agencies and local communities; requiring courts to balance effects of action versus no-action prior to halting implementation; and requires Federal agencies to retain large trees under certain conditions.

"Urban Wildland Interface Communities within the Vicinity of Federal Lands That Are at High Risk from Wildfire" Federal Register Vol. 66, No. 3, 2001: List of communities in the vicinity of Federal lands that are at high risk from wildfire.

Forest Service Manual 5100: Provides direction on wildland fire including suppression and fuels management, including prescribed fire in general and within wilderness.

Forest Service Handbook 5109: Provides direction for wildland fire managers.

National Fire Plan, August 2000: Outlines a plan of action for Federal agencies in order to protect wildland-urban interface and be prepared for extreme fire conditions.

Federal Wildland Fire Management Policy of 1995 (updated January 2001): Guides the philosophy, direction, and implementation of wildland fire management on Federal lands.

2002 President's Healthy Forests Initiative: Emphasizes administrative and legislative reforms to expedite fuels treatments and post-fire rehabilitation actions.

Interagency Prescribed Fire Planning and Implementation Procedures Guide 2017: Provides standardized procedures, specifically associated with the planning and implementation of prescribed fire.

Guidance for Implementation of Federal Wildland Fire Management Policy 2009: Guidance for consistent implementation of the 1995/2001 Federal Fire Policy.

National Cohesive Wildland Fire Management Strategy 2014: A strategic document to work collaboratively among all stakeholders and across all landscapes, using best science, to make meaningful progress towards three goals: 1) Restore and Maintain Landscapes; 2) Fire Adapted Communities; and 3) Wildfire Response.

Interagency Standards for Fire and Fire Aviation Operations 2019 (NFES 2724): A reference guide that documents the standards for operational procedures and practices for the Forest Service fire and aviation management program.

Key Indicators and Measures

- Future wildfires and fire regimes as measured by projected acres of wildfire and severity class within fire regime groups.
- Future fuels treatments as measured by acres of projected mechanical treatments and prescribed fire.
- Flexibility for fire management as measured by the acres of plan land allocations that influence the flexibility to carry out mechanical and prescribed fire treatments and manage unplanned natural ignitions.

Methodology and Analysis Process

Fire is a primary natural disturbance process within the Custer Gallatin ecosystems that changes vegetation conditions. Fuels management consists of management activities designed to alter vegetation conditions to achieve desired results. Therefore, the analysis process for determining vegetation conditions, past, present, and future provides the basis for the analysis of fire and fuels treatments within this section of the environmental impact statement. While described briefly here, please refer to the terrestrial vegetation section for greater detail.

The vegetation management strategy for the Custer Gallatin is to manage the landscape to maintain or trend towards vegetation desired condition. Modeling was used to estimate extent and effects of disturbance processes, such as fire, to develop a natural range of variation to project future wildfire. Fire (planned and unplanned), insects (such as bark beetles), disease (such as root disease), weather events (drought, wind throw), and harvest treatments are the main drivers of vegetative change, interacting with climate, and the process of vegetative succession. The main analytical models used were the SIMPPLLE model (Simulating Patterns and Processes at Landscape scales) (Chew et al. 2012b) and the PRISM model (Plan-level forest activity scheduling model) (Nguyen 2018).

The SIMPPLLE and PRISM models are used in the plan revision, for details refer to the terrestrial vegetation report and appendix B. The analysis assumes climate trends will continue to be warmer and drier than historical conditions, naturally ignited wildfire will continue to be the largest contributor to fuels management and development in the wildland-urban interface will continue (Intergovernmental Panel on Climate Change 2007b). Additionally, under warmer and drier conditions, it is anticipated that large fire activity will continue to increase in the future (Westerling et al. 2011, Barbero et al. 2015) and that fire seasons will be longer than historically observed (Yue et al. 2013).

Naturally ignited wildfire will continue to be the largest contributor to fuels and vegetation management (FIRESTAT data, FACTS data) and the use of wildland fire as a tool may occur on all acres in all alternatives. Prescribed fire and other vegetation treatments will continue to contribute to fuels management as budgets and conditions allow.

With continued development into wildfire hazard areas (Radeloff et al. 2018), wildland-urban interface boundaries will also change over the life of the plan, as there will be an increased need to focus fuels treatments in these areas. An increase in human caused ignitions is associated with increased wildland-urban interface (Syphard et al. 2007).

Information Sources

This analysis also draws upon the best available scientific literature citations that were found to be relevant to the ecosystems on the Custer Gallatin. Literature sources that were the most recent, peer-reviewed, and local in scope or directly applicable to the local ecosystem were selected. Uncertainty and conflicting literature were acknowledged and interpreted when applicable. In addition, local studies and anecdotal information that is not peer-reviewed is included where appropriate to provide context.

Best available scientific information was used to build the fire suppression logic and assumptions within the SIMPPLLE and PRISM models, including corroboration with actual data and professional experience and knowledge. The terrestrial vegetation section provides a detailed discussion on model development and outputs associated with fire and resulting vegetation changes (appendix B).

The historical fire occurrence and fire size data used for calibrating fire probabilities in the SIMPPLLE and PRISM model were derived from multiple sources. Forest fire occurrence data were gathered from the FIRESTAT database for fire ignition point data. Next, large fire polygons where obtained from Custer Gallatin spatial records and the Forest Activity Tracking System (FACTS) database. Fire severity data was taken from Monitoring Trends in Burn Severity (MTBS) data, which uses only fires greater than 1,000 acres. This analysis did not include unburned acres or areas of increased greenness within fire perimeters.

Wildland-urban interface areas, as identified in Community Wildfire Protection Plans, were used for analysis. However, there are inconsistencies in development, methods, and coverage of the wildland-urban interface across the 11 counties of the Custer Gallatin National Forest. Some counties consider nearly their entire county as some type of wildland-urban interface, while others only recognize small buffers around certain communities. Some counties followed the 2003 Healthy Forest Restoration Act wildland-urban interface boundaries quite closely and others did not. Community Wildfire Protection Plans are “living” documents and are subject to change, therefore the extent of wildland-urban interface will also change over the life of the plan. As of February 14, 2020, the extent of the wildland-urban interface on the Custer Gallatin National Forest is 1,361,668 acres. However, limitations due to budget, plan land allocation and resource protections restrict where fuels treatments can be conducted (see Environmental Consequences section).

Analysis Area

The analysis area for the fire and fuels management effects include the lands administered by the Custer Gallatin National Forest as well as lands of other ownership, both within and adjacent to the national forest. The temporal scope of the analysis is the anticipated life of the plan with some analysis occurring across the longer term (50 years), consistent with the analysis period for other key ecosystem characteristics associated with the terrestrial vegetation.

Notable Changes between the Draft and Final Environmental Impact Statement

In addition to supplementing the final environmental impact statement with new information and citations, clarifying language, minor edits, and analysis of alternative F, the notable changes in the plan include a revised desired condition (FW-DC-FIRE-01), objective (FW-OBJ-FIRE-01) and guideline (FW-GDL-FIRE-03). FW-DC-FIRE-01 was re-written and combined with FW-DC-VEGF-06, which has been deleted, to provide a desired condition that is easier to understand. The associated analysis in the final environmental impact statement also includes the same data in further detail to highlight where fire deficits are most pronounced and how the current conditions of fire severity compare to what would historically have been expected, based on the fire regime. FW-OBJ-FIRE-01 was amended to include an emphasis on treatments within the wildland-urban interface and updated language regarding the wildland-urban interface was also added to the final environmental impact statement. FW-GDL-FIRE-03 was re-written to ensure that minimum impact suppression tactics be used forestwide instead of only within certain plan land allocations and designated areas.

3.7.2 Affected Environment (Existing Condition)

Natural Fire Regimes and Natural Range of Variation

A fire regime represents the periodicity and pattern of naturally occurring fires, described in terms of frequency, biological severity, and aerial extent (Anderson 1982). The natural fire regime is a classification of the role fire would play across a landscape in the absence of modern human intervention, but including the influence of aboriginal fire use. Five natural fire regimes are classified based on the average number of years between fires (fire frequency or mean fire interval) combined with severity (the amount of vegetation replacement) and its effects to the dominant vegetation (U.S. Department of Agriculture 2010) (table 51).

The existing and desired average acres burned per decade from 1984 to 2017 by geographic area, fire regime, and severity are shown in table 52 through table 57. This is the same data used in FW-DC-FIRE-01, but more in-depth to capture where fire deficits are most pronounced (McHugh and Finney 2019), based on methods in (Ager et al. 2014). This deficit is most evident in the geographic areas with a greater proportion of shorter fire return intervals (0 to 35 years). With a fire return interval of 35 years or less, all areas in fire regimes I and II would be expected to have burned at least once, considering the data uses the last 34 years of available severity data. This is not the case, however, with large deficits in Ashland and Sioux and to a lesser extent, the Bridger, Bangtail, and Crazy Mountains. Deficits in the moderate frequency regimes (35 to 100 plus years) are less pronounced but still significant, especially in the Madison, Henrys Lake, and Gallatin Mountains.

Table 51. Fire regime, vegetation type, acres, and percentage of distribution on the Custer Gallatin

Fire Regime[1]	Definition[1]	Existing Vegetation Types[1,2]	Acres of National Forest System Land[3]	Percentage of Landscapes
I	0 to 35-year frequency; non-lethal, low/mixed severity	Ponderosa pine; dry Douglas-fir; deciduous woodland draws/ravines	216,324 - Pine savanna 124,847 - Montane	32% - Pine savanna 5% - Montane
II	0 to 35-year frequency; replacement (high severity)	Grasslands; mixed grass pine savannas; mountain big sagebrush; Great Plains shrublands	387,267 - Pine savanna 43,070 - Montane	57% - Pine savanna 2% - Montane
III	35 to 200-year frequency; mixed/low severity	Wyoming big sagebrush; low sagebrush; riparian systems (cottonwood); limber pine/Rocky Mountain juniper; dry lodgepole pine; moist Douglas-fir; whitebark pine	34,288 - Pine savanna 973,770 - Montane	5% - Pine savanna 35% - Montane
IV	35 to 200-year frequency; replacement (high severity)	Aspen; moist lodgepole pine; subalpine fir; Engelmann spruce; sagebrush steppe	38,660 - Pine savanna 251,146 - Montane	6% - Pine savanna 9% - Montane
V	Greater than 200-year frequency; any severity	Poor-site lodgepole pine; subalpine forbs and grasses; whitebark pine	0 - Pine savanna 1,105,911 - Montane	0% - Pine savanna 40% - Montane
Sparsely Vegetated	National Land Cover database class	not applicable	1,579 - Pine savanna 170,718 - Montane	less than 1% - Pine savanna 6% - Montane
Barren	National Land Cover database class	not applicable	2,019 - Pine savanna 72,135 - Montane	less than 1% - Pine savanna 3% - Montane
Snow/Ice	National Land Cover database class	not applicable	0 - Pine savanna 7,226 - Montane	0% - Pine savanna less than 1% - Montane
Water	National Land Cover database class	not applicable	114 - Pine savanna 24,420 - Montane	less than 1% - Pine savanna less than 1% - Montane

(Landfire 2010, v.1.2.0)

1. Table information is adapted from (U.S. Department of Agriculture 2010).
2. Vegetation types are not the same as existing vegetation types discussed elsewhere in this chapter.
3. Acre summaries in this section may differ slightly due to the data source (raster data versus vector GIS data)

The only fire regimes at or above average is fire regime V in the Absaroka Beartooth Mountains and fire regime IV in Ashland. The activity in the long fire return interval, replacement severity regime in the Absaroka Beartooth Mountains was mainly driven by large fires in 1988, 2006 and 2007. This was due to drought and extremely dry fuels at higher elevations. The activity in the moderate fire return interval, replacement severity regime in Ashland was driven by large fires in 2000 and 2012, which burned big sagebrush steppe vegetation.

Table 52. Existing and desired conditions* for average amount and severity of wildland fire per decade within the Absaroka Beartooth Mountains Geographic Area and fire regime group

Fire Regime Group[1]	Average Desired Acres Burned per Decade[2]	Existing Average Acres Burned per Decade[3]	Desired Fire Return Interval (Frequency)[1]	Desired Fire Severity[1,4]	Existing Low Severity Acres per Decade[5]	Existing Moderate Severity Acres per Decade[5]	Existing High Severity Acres per Decade[5]
I	500 to 700	12	0–35 years	**Low**/mixed	6	3	2
II	4,000 to 4,900	382	0–35 years	**High**	176	115	90
III	72,500 to 83,200	36,355	35–100+ years	**Mixed**/low	7,954	9,791	18,610
IV	11,200 to 12,600	6,709	35–100+ years	**High**	1,771	1,775	3,163
V	15,200 to 23,300	33,531	200+ years	**High**/mixed /low	5,989	7,389	20,152
Total	**103,400 to 124,700**	**76,988**	not applicable	not applicable	not applicable	not applicable	not applicable

*Desired condition applies to all potential vegetation types.

1. Fire regime groups, fire return intervals, and fire severity types as defined in the FRCC Guidebook (U.S. Department of Agriculture 2010).
2. Expected acres are the average range derived from Mean Fire Return Interval data from LANDFIRE 2012, v.1.3.0. Rounded to nearest hundred where applicable.
3. Existing comes from 1984 to 2017 Monitoring Trends in Burn Severity data, wildfires greater than 1,000 acres. Does not include unburned areas within wildfire perimeters.
4. Bold lettering indicates dominant severity. Mixed severity is defined as a combination of low to high fire severity within the perimeter of a single fire, or across consecutive events.
5. Fire severity classification is defined by Monitoring Trends in Burn Severity. Existing fire severity comes from 1984 to 2017 Monitoring Trends in Burn Severity data.

Table 53. Existing and desired conditions* for average amount and severity of wildland fire per decade within the Ashland Geographic Area and fire regime group

Fire Regime Group[1]	Average Desired Acres Burned per Decade[2]	Existing Average Acres Burned per Decade[3]	Desired Fire Return Interval (Frequency)[1]	Desired Fire Severity[1,4]	Existing Low Severity Acres per Decade[5]	Existing Moderate Severity Acres per Decade[5]	Existing High Severity Acres per Decade[5]
I	112,300 to 153,000	28,299	0–35 years	**Low**/mixed	10,838	10,528	6,933
II	175,500 to 239,400	36,861	0–35 years	**High**	19,006	15,161	2,695
III	4,100 to 4,900	3,374	35–100+ years	**Mixed**/low	1,394	1,316	664
IV	4,200 to 4,700	4,962	35–100+ years	**High**	3,250	1,541	171
V	Not applicable	Not applicable	200+ years	**High**/mixed /low	Not applicable	Not applicable	Not applicable
Total	**296,100 to 402,000**	**73,497**	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

*Desired condition applies to all potential vegetation types.

1. Fire regime groups, fire return intervals, and fire severity types as defined in the FRCC Guidebook (U.S. Department of Agriculture 2010).
2. Expected acres are the average range derived from Mean Fire Return Interval data from LANDFIRE 2012, v.1.3.0. Rounded to nearest hundred where applicable.

3. Existing comes from 1984 to 2017 Monitoring Trends in Burn Severity data, wildfires greater than 1,000 acres. Does not include unburned areas within wildfire perimeters.
4. Bold lettering indicates dominant severity. Mixed severity is defined as a combination of low to high fire severity within the perimeter of a single fire, or across consecutive events.
5. Fire severity classification is defined by Monitoring Trends in Burn Severity. Existing fire severity comes from 1984 to 2017 Monitoring Trends in Burn Severity data.

Table 54. Existing and desired conditions* for average amount and severity of wildland fire per decade within the Bridger, Bangtail, and Crazy Mountains Geographic Area and fire regime group

Fire Regime Group[1]	Average Desired Acres Burned per Decade[2]	Existing Average Acres Burned per Decade[3]	Desired Fire Return Interval (Frequency)[1]	Desired Fire Severity[1,4]	Existing Low Severity Acres per Decade[5]	Existing Moderate Severity Acres per Decade[5]	Existing High Severity Acres per Decade[5]
I	31,400 to 36,300	94	0–35 years	**Low**/mixed	14	26	53
II	5,000 to 5,900	0	0–35 years	**High**	0	0	0
III	3,900 to 4,800	199	3–100+ years	**Mixed**/low	34	35	130
IV	6,700 to 8,100	209	35–100+ years	**High**	59	49	102
V	200 to 300	16	200+ years	**High**/mixed /low	4	5	6
Total	**47,200 to 55,400**	**518**	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

*Desired condition applies to all potential vegetation types.

1. Fire regime groups, fire return intervals, and fire severity types as defined in the FRCC Guidebook (U.S. Department of Agriculture 2010).
2. Expected acres are the average range derived from Mean Fire Return Interval data from LANDFIRE 2012, v.1.3.0. Rounded to nearest hundred where applicable.
3. Existing comes from 1984 to 2017 Monitoring Trends in Burn Severity data, wildfires greater than 1,000 acres. Does not include unburned areas within wildfire perimeters.
4. Bold lettering indicates dominant severity. Mixed severity is defined as a combination of low to high fire severity within the perimeter of a single fire, or across consecutive events.
5. Fire severity classification is defined by Monitoring Trends in Burn Severity. Existing fire severity comes from 1984 to 2017 Monitoring Trends in Burn Severity data.

Table 55. Existing and desired conditions* for average amount and severity of wildland fire per decade within the Madison, Henrys Lake, and Gallatin Mountains Geographic Area and fire regime group

Fire Regime Group[1]	Average Desired Acres Burned per Decade[2]	Existing Average Acres Burned per Decade[3]	Desired Fire Return Interval (Frequency)[1]	Desired Fire Severity[1,4]	Existing Low Severity Acres per Decade[5]	Existing Moderate Severity Acres per Decade[5]	Existing High Severity Acres per Decade[5]
I	30 to 40	0	0–35 years	**Low**/mixed	0	0	0
II	800 to 1,000	58	0–35 years	**High**	18	19	20
III	47,700 to 53,600	5,090	35–100+ years	**Mixed**/low	1,293	1,397	2,401
IV	5,800 to 6,600	375	35–100+ years	**High**	140	121	114
V	16,400 to 25,000	8,950	200+ years	**High**/mixed /low	1,656	2,405	4,889
Total	**70,730 to 86,240**	**14,473**	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

*Desired condition applies to all potential vegetation types.

1. Fire regime groups, fire return intervals, and fire severity types as defined in the FRCC Guidebook (National Interagency Fuels 2010).
2. Expected acres are the average range derived from Mean Fire Return Interval data from LANDFIRE 2012, v.1.3.0. Rounded to nearest hundred where applicable.
3. Existing comes from 1984 to 2017 Monitoring Trends in Burn Severity data, wildfires greater than 1,000 acres. Does not include unburned areas within wildfire perimeters.
4. Bold lettering indicates dominant severity. Mixed severity is defined as a combination of low to high fire severity within the perimeter of a single fire, or across consecutive events.
5. Fire severity classification is defined by Monitoring Trends in Burn Severity. Existing fire severity comes from 1984 to 2017 Monitoring Trends in Burn Severity data.

Table 56. Existing and desired conditions* for average amount and severity of wildland fire per decade within the Pryor Mountains Geographic Area and fire regime group

Fire Regime Group[1]	Average Desired Acres Burned per Decade[2]	Existing Average Acres Burned per Decade[3]	Desired Fire Return Interval (Frequency)[1]	Desired Fire Severity[1,4]	Existing Low Severity Acres per Decade[5]	Existing Moderate Severity Acres per Decade[5]	Existing High Severity Acres per Decade[5]
I	11,500 to 14,400	83	0–35 years	**Low**/mixed	32	30	21
II	5,800 to 7,300	224	0–35 years	**High**	37	33	155
III	500 to 600	173	35–100+ years	**Mixed**/low	19	26	128
IV	4,600 to 5,000	746	35–100+ years	**High**	255	261	230
V	50 to 70	1	200+ years	**High**/mixed /low	0	0	1
Total	**22,450 to 27,370**	**1,228**	not applicable	not applicable	not applicable	not applicable	not applicable

*Desired condition applies to all potential vegetation types.

1. Fire regime groups, fire return intervals, and fire severity types as defined in the FRCC Guidebook (U.S. Department of Agriculture 2010).
2. Expected acres are the average range derived from Mean Fire Return Interval data from LANDFIRE 2012, v.1.3.0. Rounded to nearest hundred where applicable.
3. Existing comes from 1984 to 2017 Monitoring Trends in Burn Severity data, wildfires greater than 1,000 acres. Does not include unburned areas within wildfire perimeters.
4. Bold lettering indicates dominant severity. Mixed severity is defined as a combination of low to high fire severity within the perimeter of a single fire, or across consecutive events.
5. Fire severity classification is defined by Monitoring Trends in Burn Severity. Existing fire severity comes from 1984 to 2017 Monitoring Trends in Burn Severity data.

Table 57. Existing and desired conditions* for average amount and severity of wildland fire per decade within the Sioux Geographic Area and fire regime group

Fire Regime Group[1]	Average Desired Acres Burned per Decade[2]	Existing Average Acres Burned per Decade[3]	Desired Fire Return Interval (Frequency)[1]	Desired Fire Severity[1,4]	Existing Low Severity Acres per Decade[5]	Existing Moderate Severity Acres per Decade[5]	Existing High Severity Acres per Decade[5]
I	25,300 to 32,400	5,700	0–35 years	**Low**/mixed	2,016	2,447	1,237
II	78,400 to 106,900	12,682	0–35 years	**High**	5,872	4,467	2,342
III	1,400 to 1,600	858	35–100+ years	**Mixed**/low	397	343	118
IV	40 to 50	16	35–100+ years	**High**	13	2	0
V	Not applicable	Not applicable	200+ years	**High**/mixed /low	Not applicable	Not applicable	Not applicable

Fire Regime Group[1]	Average Desired Acres Burned per Decade[2]	Existing Average Acres Burned per Decade[3]	Desired Fire Return Interval (Frequency)[1]	Desired Fire Severity[1,4]	Existing Low Severity Acres per Decade[5]	Existing Moderate Severity Acres per Decade[5]	Existing High Severity Acres per Decade[5]
Total	**105,140 to 140,950**	**19,256**	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

*Desired condition applies to all potential vegetation types.

1. Fire regime groups, fire return intervals, and fire severity types as defined in the FRCC Guidebook (U.S. Department of Agriculture 2010).
2. Expected acres are the average range derived from Mean Fire Return Interval data from LANDFIRE 2012, v.1.3.0. Rounded to nearest hundred where applicable.
3. Existing comes from 1984 to 2017 Monitoring Trends in Burn Severity data, wildfires greater than 1,000 acres. Does not include unburned areas within wildfire perimeters.
4. Bold lettering indicates dominant severity. Mixed severity is defined as a combination of low to high fire severity within the perimeter of a single fire, or across consecutive events.
5. Fire severity classification is defined by Monitoring Trends in Burn Severity. Existing fire severity comes from 1984 to 2017 Monitoring Trends in Burn Severity data.

Recent Wildfire History and Trends

Fire data in the Custer Gallatin's geographic information system database shows wildfire areas burned since 1940. In this dataset, the earliest records may not be complete and often include only large fires or active fire years, creating the potential to underestimate the quantity and extent of older fires. The data are based on fire start records on National Forest lands, and do not include ignitions that went out prior to being detected.

Historically, large fires have occurred across the Custer Gallatin National Forest, as shown by fire history studies (Barrett et al. 1997) recent data (1940 to present), and anecdotal evidence (pre-1940). The Custer Gallatin Assessment Fire and Fuels Report contains additional information on fire history.

The trend of large fires decreased between the 1940s and 1980s and then increased again starting in 1988 (figure 17) (FIRESTAT data). This cycle has many influences, including fuels, weather (daily, monthly, and long term), ignition sources, and suppression efforts. The lull in the cycle is likely the combination of cooler climatic conditions (Littell et al. 2009), reduced fuels from the earlier high fire cycle (pre-1940), the increasing capability of technology (such as, air tankers, dozers), and agency focus on suppression. Recent increases in large fires also can be attributed to climate change (Abatzoglou and Williams 2016), changes in national wildland fire policy since 1980, the recognition and implementation of the role of fire on the landscape, and the integration of the changing policy into the management of the Custer Gallatin wildfire program. Despite the overall trend in increased acreage, the northern Rocky Mountains are still experiencing a fire deficit, where acres burned historically have been less than what is expected and with longer fire rotations (Parks et al. 2015b).

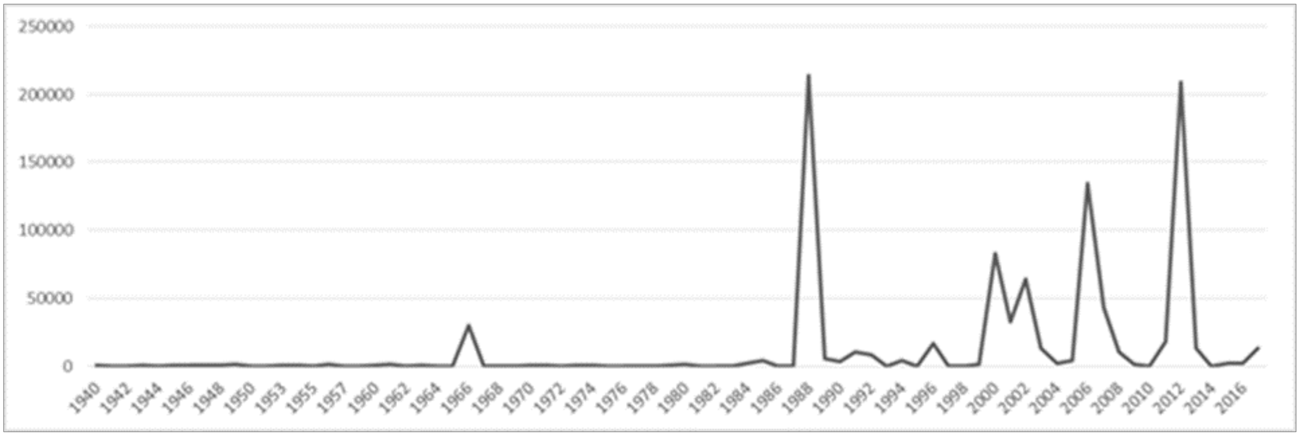

Figure 17. Total acres burned, Custer Gallatin National Forest, 1940 to 2017; includes all acres within wildfire perimeters

Recent wildfire history is shown in figure 18, which displays the acres of large fire (greater than 1000 acres in size) that have occurred on the Custer Gallatin over the past 30 years (Monitoring Trends in Burn Severity data).

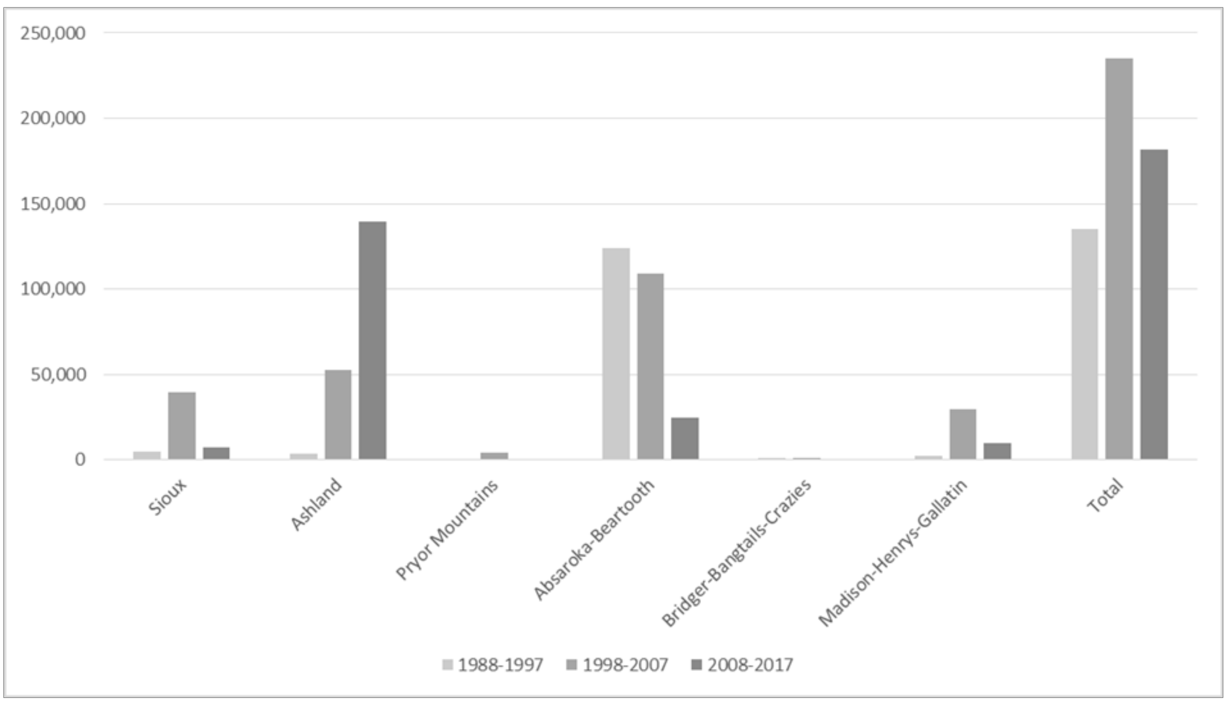

Figure 18. Large wildfire acres (larger than 1,000 acres) burned by geographic area, Custer Gallatin National Forest, 1988 to 2017 (does not include unburned areas within wildfire perimeters)

In the pine savanna landscapes, acres burned by decade from large fires have increased since 1988. The increase in burned area may be in part due to fuel buildup caused by fire exclusion and the influence of a warm/dry climate on vegetation, fire behavior, and effectiveness of suppression. The increase in acres burned is consistent with other observations in the northern Rocky Mountains. Alterations in fire regimes due to climate changes (Westerling et al. 2006) and human caused climate change have accounted for half of observed increases in fuel aridity (Abatzoglou and Williams 2016) and increases in wildland fire frequency over the last twenty years. Almost 95 percent of recorded fire ignitions are by lightning (FIRESTAT data). Wildfires started by exposed coal seams, which can burn for years above and below the ground, are a unique source of ignitions in the area.

In the montane landscapes, acres burned by decade from large fires have decreased since 1988, but this is not an indication that this trend will continue as it is predicted that large fires will be more common in the future (Westerling et al. 2011). The majority of these landscapes are in mixed to high severity fire regimes where wildfires need the right conditions to become large and are driven by topography, climate, and extreme wind events (Rollins et al. 2002, Schoennagel et al. 2004, Keyser and LeRoy Westerling 2017). Almost 70 percent of recorded fire ignitions are by lightning (FIRESTAT data).

Across the Custer Gallatin National Forest as a whole, from 1940 to 2016, lightning accounted for 74 percent of recorded ignitions (FIRESTAT data), but is highly variable (figure 19). The Custer Gallatin annually manages approximately 93 percent of all-natural ignitions with control, confine, and point-protection strategies and has managed naturally ignited fire as a natural process exclusively within the designated Absaroka-Beartooth Wilderness and the Lee Metcalf Wilderness since the early 1990s.

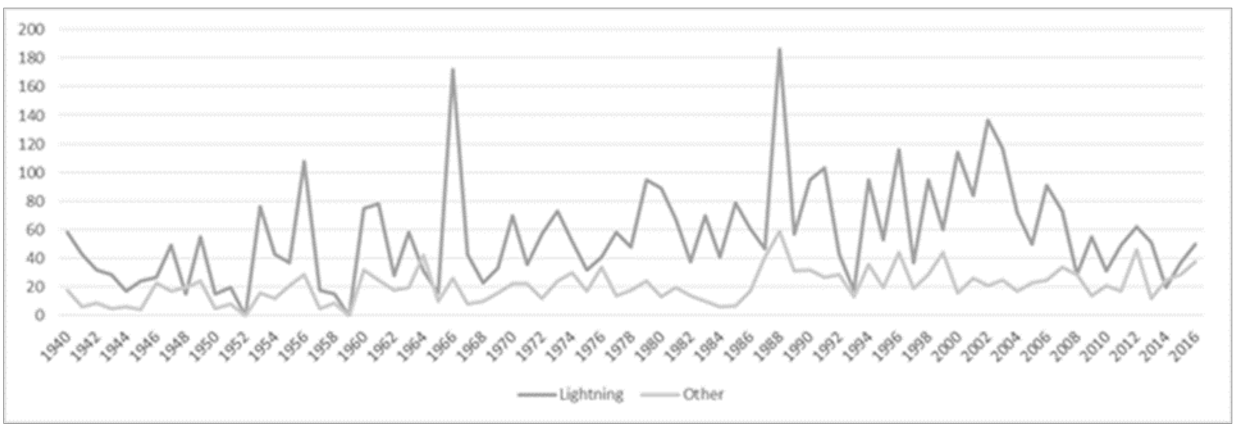

Figure 19. Number of starts of lightning-caused and human-caused fires, Custer Gallatin National Forest, 1940 to 2017

Climate Change

Of all the ongoing and foreseeable future actions that have the potential to affect fire, especially unwanted wildfire, climate change is likely to be the single most important factor. In general, the fire seasons are expected to become longer, large wildfires are expected to occur more often, and total area burned is expected to increase (Halofsky et al. 2018b). A recent comprehensive synthesis of the science surrounding climatic change and ecosystems concluded that all fire regimes in Montana forest ecosystems would experience some increase in fire risk (Whitlock et al. 2017). More fires would also occur in all forests because of longer fire seasons and higher human populations (Vose et al. 2012). There is also evidence that increasing drought could lead to decreased post-fire tree regeneration, conversion to non-forest vegetation types, and decreased resilience (Harvey et al. 2016b, Stevens-Rumann et al. 2018). Additional information on climate change and vegetation can be found under Climate Change Assumptions and Considerations in the Terrestrial Vegetation section, 3.6.1.

Fire intensity and severity would probably be higher in low severity fire regimes because of fuel drying from hotter temperatures and higher fuel loadings (that is, tree mortality, increased forest densities). In mixed severity fire regimes, an increase in fire risk is projected with short-term increases in fire severity and could convert lands to more of a low severity fire regime, where frequent fires favor more open stand conditions and tree species resistant to fire damage. Increased fire risk and fire sizes in high severity fire regimes are projected to increase with no change in severity (Rocca et al. 2014) and could have significant local effects, especially in the wildland-urban interface.

3.7.3 Environmental Consequences

Current Plans

Management Direction under the Current Plans

The current Custer and Gallatin Forest Plans, as amended, are the existing management direction being used by the Custer Gallatin to address fire and fuels management. However, because the current plans are the baseline to which the revised plan alternatives are compared, it is important to understand what actions would continue under the current plans.

The 1987 Gallatin Forest Plan, as amended, includes the following forestwide standard: One or more fire management strategies may be considered and implemented for any unplanned wildland fire to achieve a variety of resource management objectives, while minimizing negative effects to life, investments and valuable resources. It also allows for the use of planned, prescribed fire to achieve resource objectives throughout all management areas as provided in the 1987 plan. Mechanical treatments are not allowed in management area 4 (wilderness and recommended wilderness).

The 1986 Custer Forest Plan, as amended, allows for the forestwide use of all management response options for wildfire (control, contain, confine). Exceptions are for management area F (developed recreation sites) and management area P (administrative sites), where control is the only option, and management area E (energy and mineral production), management area M (riparian areas), management area N (woody draws), and management area O (National Natural Landmarks), where contain and control are the only options. Prescribed fire is allowed forestwide except in management area H (recommended wilderness) and management area O (National Natural Landmarks). Mechanical treatments are allowed forestwide except in management area I (wilderness) and management area L (research natural areas). Direction for the management of natural unplanned wildfires in the Absaroka-Beartooth Wilderness from the 1993 Absaroka-Beartooth Wilderness Fire Management Guidebook allows for the full range of fire management strategies.

Revised Plan Alternatives

Management Direction under the Revised Plan Alternatives

All revised plan alternatives contain the same desired conditions, standards and guidelines that articulate what role fire should play. Management direction recognizes that risks to important values change depending on seasonal changes in weather and fuels, providing the opportunity to use fire as a management tool when conditions are conducive to meeting various plan objectives. The revised plan continues to recognize that with certain weather, fuels, and topography, fires can be managed with minimal risk to values.

The plan objective for a minimum of 375,000 acres per decade of natural unplanned wildfire (FW-OBJ-FIRE-02) assumes that wildfire acres would double in the coming decades relative to the previous 30 years as described in appendix B. This acreage is for all vegetation types, is on the low to moderate spectrum of the natural range of variation and is consistent with model outputs.

In the revised plan, all management response options are available to use for unplanned fires, forestwide. Prescribed fire is also allowed forestwide. Mechanical treatments are allowed forestwide, but will be limited in designated wilderness, Hyalite-Porcupine-Buffalo Horn Wilderness Study Area, recommended wilderness and Cabin Creek Wildlife Management Area. The acres of each designated area, specifically recommended wilderness, influence how fire management can be implemented for each alternative.

All Alternatives

Effects Common to all Alternatives

Future Fuels Treatments

All alternatives contain desired conditions (FW-DC-FIRE-01, 02) and objectives (FW-OBJ-FIRE-01) for treating vegetation, through wildland fire and mechanical treatments, to improve structure and composition. This includes reducing surface fuels, ladder fuels, and canopy density in order to reduce fire intensity (FW-GDL-FIRE-02). Desired outcomes of fuels treatments include more manageable fire behavior and reduced severity during wildfires (Reinhardt et al. 2008), although under extreme weather conditions these benefits can be sustained, reduced, or even negated (Graham 2003). In dry conifer forests, mechanical and prescribed fire treatments have been shown to mitigate fire growth and fire severity under extreme weather conditions (Finney et al. 2005, Stephens et al. 2009). Additional benefits consist of minimizing impacts to values at risk and reducing fire spread to other ownerships. While mechanical treatments alone cannot fully mimic the ecological effects of fire, they are a valuable tool in creating stand structures that are more resilient to future disturbances (Schwilk et al. 2009).

Prescribed fire is essential to reducing fuels; (Reinhardt et al. 2008) found that it is possible to craft treatments to achieve both ecological restoration and fire hazard reduction. However, ecological restoration will also include reintroducing fire and other active management; the most effective ecosystem treatments should include prescribed fire. Prescribed fire on the landscape in all alternatives would be expected to partially offset predicted effects from climate change (Wiedinmyer and Hurteau 2010).

Flexibility for Fire Management

Key considerations for fire management are described in this section. A large number of burnable acres of national forest lands cannot be actively managed by mechanical means. Additionally, mechanical treatments in designated wilderness is limited, except as necessary to meet the minimum needs for protection and administration of the area as wilderness. Administrative use of motorized equipment is allowed in Wilderness Study Areas and in recommended wilderness. Appropriately managing wildfire in places with an opportunity to obtain resource benefits and a low risk of potential damages may be the only way in many areas to increase the pace and scale of ecosystem restoration activities. Informed management of wildfire would also be needed to maintain areas once restoration has occurred. Wildland fire also exhibits self-regulating effects, in which a burned area will act as a fuel break and reduce the probability of subsequent fire spread (Parks et al. 2018). This effect is dependent upon many factors, including vegetation type, previous burn severity, and climate, but can be reduced by climate-induced extreme weather events (Parks et al. 2015a) which are predicted to be more common in the future (Westerling et al. 2011).

The alternatives vary from the fuels management perspective on the allocation of acres and different designated areas; the primary designated area that impacts fuels management is recommended wilderness. Other management limitations apply to all alternatives. In inventoried roadless areas, which comprise the majority of recommended wilderness areas, there are limitations on road construction and timber cutting, relating to the purpose and location of treatments in relation to identified wildland-urban interface. Additionally, the implementation of the Northern Rockies Lynx Management Direction (U.S. Department of Agriculture 2007b) constrains treatments in lynx habitat outside the wildland-urban interface where multi-storied hare habitat or stand initiation hare habitat is present.

The use of prescribed fire within the wildland-urban interface is a high-risk action and is often more expensive than prescribed fire in the non-wildland-urban interface. This is due to the extra steps taken to ensure public safety and mitigate hazards to private property. Additionally, impacts from smoke emissions adjacent to homes for extended periods limit the number of acres that can be treated. Within the wildland-urban interface, there is an increased need to rely on mechanical and hand treatments rather than fire. In addition, social issues (for example, effects of treatments on scenery, air quality, noise, and wildlife viewing) can be more contentious.

Future Wildfires and Fire Regimes

Natural, long-term variations in temperature and precipitation patterns have resulted in continuously changing fire regimes (Whitlock et al. 2008), and thus continually changing forest conditions. This past climatic variability has had major effects on the timing, frequency, intensity, severity, and extent of wildfires, as would future changes in climate. The effect may be due to direct climate-related factors, such as increased temperature and greater drying of forest fuels; or indirectly, related to potential changes in forest composition and structure due partly to climate change. These climate-induced changes in fire regimes could have substantial impacts on ecosystems, with associated effects to communities and economies (Littell et al. 2009).

Wildfire has been and will be the greatest driver of vegetation change on the Custer Gallatin National Forest (FIRESTAT data, FACTS data) and under all alternatives, natural unplanned wildfire would be allowed to play its ecological role (FW-DC-FIRE-01, FW-GDL-FIRE-01), although less so under the current plans. Along with prescribed fire, unplanned wildland fire on the landscape will help in alleviating the fire deficit (Parks et al. 2015b, Vaillant and Reinhardt 2017) as well as providing many ecological benefits. Climate effects (Halofsky et al. 2018a;b) as well as plan components that encourage the ecological role of fire will increase the amount of wildfire on the landscape under all revised plan alternatives.

The Forest Service manages wildfires to meet resource objectives; using unplanned natural ignitions to achieve these objectives and ecological purposes to foster resilient ecosystems. The benefits of managing wildfires to meet resource objectives may include reducing fuels so that future fires burn in that area with lower severity (Parks et al. 2014), increasing biodiversity (Martin and Sapsis 1991), cycling nutrients back into the soil (Hungerford et al. 1991), or reducing forest density to favor fire resistant species (Agee 1993). The increased use of unplanned ignitions in the revised plan alternatives (FW-OBJ-FIRE-02) would also lead to greater fuels reduction and forest vegetation would be restored to more resilient conditions, which could mitigate climate change effects (Parks et al. 2016a). However, due to potential circumstances in which fires burn outside the desirable range of severity, not all natural unplanned wildfires will achieve or maintain desired conditions and therefore some natural unplanned fires will not contribute to FW-OBJ-FIRE-02.

In all alternatives, fire suppression would continue to be an option for unplanned natural ignitions. Circumstances where wildfires are suppressed consider certain fuel and weather conditions, proximity to values at risk, time of year, or fire effects that are predicted to move the landscape away or not maintain desired conditions (FW-DC-FIRE-03, FW-STD-FIRE-01). However, when natural fires are suppressed in fire-adapted ecosystems, there could be detrimental effects to vegetation composition and structure, ecosystem processes, soil dynamics, wildlife habitat and biodiversity of ecosystems (Keane et al. 2002). In combination with climate change, land-use change, and 20th century fire exclusion, suppression of wildfires also increases the existing fire deficit (Marlon et al. 2012). Fire suppression actions can also have direct negative impacts to resources (Ingalsbee 2004) and are sometimes ineffective at achieving objectives (Ingalsbee 2017). However, plan components to mitigate suppression impacts to resources include the use of minimum impact suppression tactics (FW-GDL-FIRE-03). Other plan components that mitigate suppression impacts to soils, aquatics, watersheds, riparian management zones, wildlife, and special areas can be found in the following section: Consequences to fire and fuels management from plan components associated with other resource programs or management activities.

Simulation modeling (SIMPPLLE) was used to estimate wildfire activity on the Custer Gallatin National Forest for five decades into the future. Best available scientific information was used to build the fire suppression logic and assumptions within the model, including corroboration with actual data, and professional experience and knowledge. Refer to appendix B for detailed discussion on model development and outputs. The model predicts that wildfire will continue to a similar degree under all alternatives, which equates to an average of approximately 250,000 acres per decade in forested vegetation types. The similarity across all alternatives is due to both natural and human caused ignitions, an expansive fuel source and climate effects. It cannot be predicted with high accuracy where and when fires will occur. There is also a high degree of variation, spatially and temporally, in the amount and location of fire.

Effects that Vary by Alternative

Future Fuels Treatments

In all alternatives, prescribed fire would continue to be used to move the Custer Gallatin National Forest toward desired future conditions. The amount of anticipated prescribed fire within forested areas varies by alternative (table 58). All alternatives are projected to result in similar acres being treated with prescribed fire with alternative D being only slightly higher. Additional potential treatments in non-forested vegetation types are not reflected in the projections.

Table 58. Average decadal prescribed fire acres over five decades, by alternative

Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
27,460	27,560	27,660	28,280	27,320	27,440

Acres are from the PRISM model and only include forested areas. Non-forested area is not included in these figures. Figures include areas both inside and outside the wildland-urban interface.

Harvest treatments can also be used to achieve fuel management objectives, such as reducing forest densities and favoring fire-resistant species, but effectiveness is dependent upon harvest type (Hartsough et al. 2008). Relative to impacts to fire and fuels, treatments that may occur in the wildland-urban interface may be the most important for protecting values at risk. Each alternative result in differing amounts of projected harvest treatments inside the wildland-urban interface, as shown in table 59. The current plans, alternative B, C, and F treat similar amounts of the urban interface where alternative D treats more acres. Alternative E treats less as a result of maximizing timber production which would harvest larger trees on fewer acres. Alternative E emphasizes harvesting in high productivity forests, whereas the current plans, alternative B, C, D, and F focus treatments on dry vegetation sites that are most departed from desired conditions. Alternative E would be the least responsive in obtaining desired fuel conditions within the wildland-urban interface.

Table 59. Average decadal harvest acres in the wildland-urban interface over five decades, by alternative

Current plans	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
10,837	11,169	10,880	18,233	8,941	12,207

PRISM model, average acres per decade, all harvest types, projected to occur in the wildland-urban interface.

Flexibility for Fire Management

The alternatives vary from the fuels management perspective on the allocation of acres to different designated areas. The primary designated area that impacts fuels management is recommended wilderness due to limitations on mechanical treatments (FW-SUIT-RWA-01, 03). However, most recommended wilderness areas are inventoried roadless areas, which would already limit mechanical treatments due to constraints on road building and access. This is most important where recommended wilderness overlaps with the wildland-urban interface, where it is assumed that most of the fuels mitigation would occur. Due to the objectives of fuels treatments, such as reducing canopy density and ladder and ground fuels, fuels treatments in the wildland-urban interface would produce vegetation structure that is most likely not compatible with wilderness characteristics, especially in higher elevation vegetation types (FW-DC-FIRE-02, FW-GDL-FIRE-02). Due to this constraint, wildland-urban interface mechanical fuels treatments within recommended wilderness would be very limited as they would not meet their purpose and need and could be ineffective.

Within recommended wilderness, wildfire would primarily be used to meet resource objectives (FW-DC-RWA-03), with less emphasis on mechanical treatments and prescribed fire. However, fuel management would be dependent upon the use of unplanned ignitions and the risk assessment associated with each season and event that may require suppression actions instead. Due to constraints on mechanical treatments, there would be limited opportunities to pretreat areas that would serve as buffers for naturally ignited wildfires and the ability to use wildfire for resource benefit would likely be reduced. Additionally, the location of the ignition would weigh heavily on decisions relating to suppression.

Table 60 displays the total amount of recommended wilderness by alternative and the acres of recommended wilderness that occur within the wildland-urban interface.

Table 60. Recommended wilderness acres and wildland-urban interface by alternative

Area of Recommended Wilderness and Wildland-Urban Interface in Recommended Wilderness	Current Plans	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Acres Recommended Wilderness	33,741	113,382	145,777	711,422	0	139,425
Acres of Wildland-Urban Interface in Recommended Wilderness (percentage of recommended wilderness area)[1]	21,562 (64)	65,763 (58)	79,265 (54)	40,844 (57)	0 (0)	60,360 (43)

1. Using the Healthy Forests Restoration Act wildland-urban interface definition. Wildland-urban interface will change over time as population growth continues; these values are current as of the date of this environmental impact statement.

Alternative B would have more acres of recommended wilderness compared to the current plans. However, of all the revised plan alternatives that have recommended wilderness, alternative B has the least amount of recommended wilderness acres but the second highest amount of recommended wilderness acres in the wildland-urban interface.

Alternative C would be similar to alternative B except there would be more acres of recommended wilderness and more recommended wilderness acres in the wildland-urban interface. This may result in reduced flexibility for unplanned natural ignitions used to meet the revised plan desired conditions.

Alternative D has the greatest amount of recommended wilderness and the most acres of recommended wilderness in the wildland-urban interface. Based on plan land allocations, this alternative provides for the least flexibility for fire management, resulting in the fewest opportunities of mechanical fuels treatments within wildland-urban interface areas of recommended wilderness. With less flexibility in conducting associated fuel management activities, unplanned natural ignitions may require suppression actions and desired conditions may not be met.

Alternative E provides for the most flexibility for fire management by including no recommended wilderness, resulting in the greatest opportunities for mechanical treatments and prescribed fire, which could lead to more opportunities to effectively use natural unplanned fires for desired conditions.

Alternative F has slightly more acres of recommended wilderness as compared to all the revised plan alternatives, except for alternative E, which has the least number of acres of recommended wilderness acres in the wildland-urban interface. Of all the revised plan alternatives with recommended wilderness, this alternative provides the most flexibility for fire management.

Consequences to Fire and Fuels Management from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Air Quality Management

The consequences to fire from air quality are the same for all alternatives. All alternatives have the same plan components to meet air quality standards established by Federal and state agencies (FW-GO-AQ-01). The Forest Service would meet the requirements of state implementation plans and smoke management plans. Laws and regulations on smoke emissions can limit opportunities to conduct prescribed burning. These limitations are most frequently encountered in high population density areas.

Effects from Timber Management

Consequences from timber management are generally the same for all alternatives in that timber management direction complements fuels management by reducing fuel loads and increasing resilient landscapes. Vegetation treatments are typically designed and implemented to achieve multiple resource, social and economic objectives, including those associated with fuels management. However, there are some differences by alternative that affect the location of treatments. The current plans, alternatives B, and C have a similar amount of timber harvest that is well-balanced with fuels management. Alternative E will see a reduction in fuels treatments due to focus on timber production, and the timber harvest areas that could also see fuel reduction benefits won't necessarily be in the most strategic location for fire management. Timber management will have the least effect under alternative D, where the focus will not be on timber production. All alternatives also recognize that not all fire is detrimental to timber production (FW-DC-TIM-02). Therefore, there is opportunity to allow wildfires to burn and help maintain/restore fire adapted ecosystems. Plan components for post-fire salvage harvests will also enable a balance of timber production and ecosystem diversity (FW-GDL-TIM-01, 02, FW-GDL-RMZ-08).

Effects from Watershed, Soil, Riparian, and Aquatic Management

Plan components recognize that wildland fire, along with mechanical fuels treatments, will play a key role in maintaining and restoring watersheds and riparian ecosystems (FW-DC-WTR-01, FW-DC-RMZ-01). Consequences from these components would be generally similar for all alternatives. However, in order to meet the plan direction associated with these resources there could be occasions where prescribed fires or mechanical treatments cannot be used if there are potential negative effects to aquatic and riparian-associated resources. Fuels management activities occasionally require some soil disturbing activities or road construction, which may be limited to meet other plan components. Although it is difficult to quantify the effects, all the alternatives have components that would limit fire or fuels treatments for ecosystem maintenance or restoration.

All alternatives would contain components that limit equipment use on steep slopes (FW-GDL-SOIL-01). However, the revised plan alternatives also include guidelines that require a minimum amount of organic matter to be present following treatments (FW-GDL-SOIL-07), which may be difficult to achieve in some cases. The revised plan alternatives also contain guidelines for the retention of snags and coarse woody debris (FW-GDL-SOIL-07, FW-GDL-VEGF-03, 04, FW-GDL-RMZ-05), which would also factor into vegetation management prescriptions. Finally, the revised plan alternatives include the adoption of riparian management zones, which are greater in size from the riparian zones currently identified for streams east of the Continental Divide. The plan components associated with aquatics, watersheds, and riparian management zones would also influence fuels treatments and fire suppression actions to ensure minimal impacts and ecological benefits (FW-STD-WTR-02, 03, FW-GDL-WTR-01, 05, FW-STD-RMZ-02, 04, FW-GDL-RMZ-02, 03, 04, 05, 06, 07, FW-SUIT-RMZ-01).

In summary, all alternatives include plan components for the protection of water, soil, and aquatic resources. The components for the revised plan alternatives (B, C, D, and E) are more specific and potentially limiting to fuels treatments than those in the current plans.

Effects from Wildlife Management

In general, wildlife management direction has low impact on fire and fuels management, especially within the wildland-urban interface, because management direction recognizes the importance of managing vegetation to modify fire behavior. Fire on the landscape is also an important part of the natural function of the ecosystem, and as such, helps create and maintain habitat conditions for native wildlife species (FW-DC-WL-02 to 06).

Specific plan components for wildlife may limit fuels management activities. For example, all alternatives include plan components that would limit disturbance to some species during critical times, such as nesting or calving in specific areas (FW-GDL-WL-08). These species include raptors (FW-GDL-WL-06), bats (FW-GDL-WLBAT-01, 02), and ungulates (FW-GDL-WL-01). Such timing restrictions may result in missed prescribed fire windows at times. There are also plan components that specify habitat conditions such as thermal cover, security, or hiding cover for species such as elk (FW-GDL-WLBG-01, 02), although hazardous fuels projects are generally exempt from these guidelines.

All alternatives would adopt the Grizzly Bear Conservation Strategy (Yellowstone Ecosystem Subcommittee 2016a). Associated plan components that would require secure habitat to be maintained may limit access, and thus treatments such as prescribed burning, within the Greater Yellowstone Ecosystem Primary Conservation Area. This would apply to the Absaroka Beartooth and the Madison, Henrys Lake, and Gallatin Geographic Areas.

In addition, there are plan components that specify how sage-grouse habitat should be preserved and restored which would affect the Ashland and Sioux Geographic Areas (FW-GDL-WLSG-01, 02). In order to achieve no net loss of habitat, prescribed fire would be limited in general and priority sage-grouse habitat (FW-STD-WLSG-01). Fuels treatments that would allow removal of invading conifers would be allowed (FW-GDL-WLSG-05).

The Northern Rockies Lynx Management Direction (U.S. Department of Agriculture 2007b) would be implemented under all alternatives. This direction recognizes the importance of fuel treatments within the wildland-urban interface. However, opportunities to conduct vegetation treatments, including prescribed fire or mechanical fuels reduction treatments, outside the wildland-urban interface are limited under current lynx management direction. Restrictions on treating within these forest conditions is likely to reduce the ability and effectiveness of achieving desired forest and fuel conditions outside the wildland-urban interface.

Lynx management direction restrictions on treatments in multi-story hare habitat and young seedling/sapling forests have the most impact. These forest conditions affect 10 to 20 percent of the forested cover types in the Custer Gallatin and consist of subalpine fir-spruce forests. Fire is the primary natural disturbance process that creates areas of seedling/sapling forest. Thinning of dense sapling stands is typically designed to create future forests composed of larger trees and desired species (such as fire-resistant Douglas-fir). These forests are more resilient in the face of future wildfire events, and may burn less severely, reducing potential future impacts to values at risk. Thinning in these young stands is generally not allowed under lynx management direction.

Treatments in multi-story forests hare habitat, which would result in it no longer qualifying as multi-story hare habitat, are also not allowed outside the wildland-urban interface. This includes both mechanical (for example, harvest) and prescribed burn treatments. Typically, the objective of prescribed fires is to reduce stand densities by removal of the understory, and in some forest types (such as subalpine fir and lodgepole-dominated forests), removal of portions of the overstory to create patches of more open forest conditions across the landscape. Prescribed fire management with these objectives would not be able to occur in multistory hare habitat, limiting the ability to manage landscape patterns and fuel conditions to achieve desired conditions. Use of wildfire (unplanned ignitions) to achieve desired conditions is allowed for the purposes of restoring ecological processes and maintaining and improving lynx habitat.

Effects of Plan Land Allocations for Backcountry Areas

Backcountry areas could result in reduced flexibility and options for vegetation and fuels management to achieve desired conditions, depending on alternative (FW-SUIT-BCA-01). The ability to use unplanned ignitions (wildfire) as a tool would be very limited within some of the backcountry areas due to proximity to the wildland-urban interface. This is because of the small size or in locations that likely have to be aggressively suppressed to protect identified values (for example, private lands). Building new permanent roads would not be allowed in any backcountry area, and building new temporary roads in support of fuels management activities would not be allowed in backcountry areas that are also inventoried roadless areas, which would limit access. These effects would be most pronounced under alternative C, then alternative F, and then alternative B. There would be little impact under alternative D. Current plans, where backcountry areas are classified as Low Development Areas, and alternative E, would see no effect as all backcountry areas are already classified as inventoried roadless areas.

Effects from Scenery Management

Under all alternatives, the revised plan scenic integrity objectives do not outright prohibit on-the-ground actions. However, it may influence the design or the location of on-the-ground fuels projects that would be visible from any of the listed critical viewing platforms (FW-GDL-SCENERY-01, 04). Design features or mitigations may be required to meet or exceed the assigned scenic integrity objective, which describes the maximum threshold of visual dominance and deviation from the surrounding scenic character.

The plan’s scenic integrity objectives also do not affect unplanned ignitions under all alternatives. Wildfires are a natural process that have altered vegetation for millennia and the ecological context of these disturbances are considered part of the Custer Gallatin’s natural scenic character.

Effects from Permitted Livestock Grazing

In all alternatives, livestock grazing would occur on portions of the Custer Gallatin National Forest. Plan components would enable grazing activities to complement fire and fuels management, such as reducing fine fuels to lower fire risk. However, grazing can alter grassland and shrubland fire regimes through soil disturbance, increased competition from invasive annual grasses, and reduction in fine fuels (Knick et al. 2005). Duration and intensity of grazing could affect prescribed fire implementation by reducing available fuels. Location and timing of grazing could also affect prescribed fire implementation by restricting available burn units. Coordination with affected grazing allotment permittees should occur for all fuels treatments in order to meet objectives.

Cumulative Effects

Human Population Increases and Shifts towards Wildland-Urban Interface

More human development is occurring near the boundary of lands administered by the Custer Gallatin National Forest. This trend is expected to continue in the future and is likely to have effects on the forest vegetation. The wildland-urban interface will evolve over time and the need for vegetation treatments being implemented within the wildland-urban interface will increase. The objective is to reduce hazardous fuels, as well as having fewer vegetation treatments being conducted in areas located away from communities. In addition, the types of fuel treatments used in the wildland-urban interface are often more expensive than methods elsewhere, and the social issues (for example, the effects of treatments on scenery, air quality, noise, wildlife viewing, etc.) can be more contentious. Therefore, higher public involvement, planning, and implementation expenses are likely to lead to fewer acres being treated within a given budget level.

The wildland-urban interface has become the focus of wildland fire suppression resources. Despite efforts to suppress human-caused fires, these types of fires are more likely in the wildland-urban interface as more people live and recreate in the area. The future increase in the wildland-urban interface will continue to challenge wildfire management during large fire events as “Firefighters will likely have to protect dispersed housing over an extremely large area of fire-prone forest” (Gude et al. 2008). To work individually with property owners is costly and creates a patch work of defendable properties among those that are not. Over the last 26 years the number of homes being built in high wildfire hazard areas has doubled in Montana (Pohl 2018) which will add to the protection problem at the local level.

Relative to current levels, more wildfire in the future is expected and policies that foster adaptive resilience in the wildland-urban interface are needed (Schoennagel et al. 2017). Building homes with fire-resistant materials and landscaping will reduce ignitability and result in fire-resilient properties, able to withstand future fires (Cohen 2000). This is consistent with goal 2 of the National Cohesive Wildland Fire Management Strategy; creating fire adapted communities, which is primarily the responsibility of private landowners, local and state governments. The structure ignition zone, which is the area that determines ignition potential of structures in the wildland-urban interface, largely occurs on private lands and is the responsibility of the property owner (Reinhardt et al. 2008). While the Forest Service cannot directly engage in any private structural fire strategy, tactics are used to prevent a wildland fire from reaching private structures (U.S. Department of Agriculture 1991). The other two goals of the National Cohesive Wildland Fire Management Strategy are for restoring and maintaining landscapes and wildfire response, which is the focus of forest service fire and fuels management. By working together across boundaries, all three goals can come together to better facilitate managing wildland fire on the landscape in closer proximity to the wildland-urban interface.

Increased Regulation and Concern over Smoke Emissions

The ability to use fire to maintain and restore the fire-adapted ecosystems on the Custer Gallatin National Forest, or to use fire to reduce hazardous fuels in the wildland-urban interface, is dependent upon air quality regulations. As air quality regulations become stricter, the ability to use fire as a management tool becomes limited. If past trends of increasing regulations and decreasing burn opportunities continue, the effects would likely result in not being able to use fire enough to make meaningful improvements to forest and fuel conditions and meet objectives.

Timber Product Manufacturing Infrastructure and Economics

The ability of the Custer Gallatin to positively affect forest vegetation is partially dependent upon the ability to sell forest products to manufacturing companies and to use harvesting processes (including the residual slash disposal activities) as a means to positively affect the forest vegetation and reduce hazardous fuels. If the forest products industry declines in areas surrounding the Custer Gallatin to the degree that it is difficult to sell forest products, or if "stumpage prices" decrease substantially, it would affect how many acres could be treated. While some treatments could be accomplished by using prescribed burning only, it is generally very risky in the wildland-urban interface and expensive, leading to fewer acres treated.

Other Plans

Since they were developed, national level plans, initiatives, and acts such as the National Fire Plan, Healthy Forest Initiative, Healthy Forest Restoration Act, and National Cohesive Wildland Fire Management Strategy have influenced the vegetation and fuel management programs on the Custer Gallatin National Forest. Therefore, they have had some effects on hazardous fuels and it is anticipated that they will continue to do so for the foreseeable future. In general, these plans have resulted in more vegetation treatments being implemented near wildland-urban interface areas with the objective of reducing hazardous fuels, and fewer vegetation treatments being conducted in areas located away from communities. Not only do these plans emphasize the need to reduce hazardous fuels in the wildland-urban interface, but they also stress the need to restore the natural fire regimes and forest conditions to the larger national forest landscape. These plans encourage the development of more resistant and resilient forest vegetation that would be less susceptible to large undesirable wildfires and/or insect outbreaks.

Portions of the Custer Gallatin National Forest adjoin other national forests, each having its own land management plan. The Custer Gallatin National Forest is also intermixed with lands of other ownerships, including private lands, other Federal lands, and state lands. Some adjacent lands are subject to their own resource management plans. The cumulative effects of these plans in conjunction with the Custer Gallatin National Forest revised plan are summarized below, for those plans applicable to fire and fuels.

The management plans for National Forest System lands adjacent to the Custer Gallatin include the Helena-Lewis and Clark, Beaverhead-Deerlodge, Targhee, and Shoshone national forests. All plans address fire and fuels and generally speaking, management of fire and fuels is consistent across all national forests due to law, regulation, and policy. The cumulative effect would be that the management of fire and fuels would be generally complementary. This includes specific adjacent landscapes that cross national forest boundaries, such as the Crazy Mountains, the Madison Range, and the Beartooth Plateau.

Other adjacent Federal lands include ownership by the National Park Service, Bureau of Land Management and Bureau of Indian Affairs. The Yellowstone National Park Fire Management Plan (2014) allows for fire to play its natural role in the ecosystem. Broadly, the fire and fuels characteristics in this area are therefore likely similar to the plan components for the Custer Gallatin and would likely complement these conditions. The Bureau of Land Management has Resource Management Plans for lands near the Custer Gallatin which are managed by the Butte plan (2009a), Billings plan (2015a), Dillon plan (2006), Miles City plan (2015b), and South Dakota (2015c) field offices. These plans contain components related to fire and fuels and would therefore likely be complementary to the plan components for the Custer Gallatin. The Bureau of Indian Affairs, (U.S. Department of the Interior 2010a) has fire management strategies that are similar to the Custer Gallatin and would thus be complementary to fire and fuels management.

The Montana Forest Action Plan (Montana Department of Natural Resources and Conservation 2020) and South Dakota Statewide Forest Resource Strategy (2020) guide fire and fuels management on state lands in Montana and South Dakota, respectively. They include many concepts that are complementary to revised plan components for the Custer Gallatin, for example, and state direction for suppression of wildfires. While specific desired conditions are not stated in the same terms as the Custer Gallatin, it is likely that some elements such as providing for firefighter and public safety would be similar. State forestlands may be actively managed to a greater degree than national forest system lands and would likely contribute to achievement of some desired fire and fuels conditions across the landscape. However, management and use of wildfires for ecological benefit on state lands is not encouraged and would lead away from some desired conditions. The South Dakota Forest Resource Strategy also has direction for the use of prescribed fire, however, there is no mention that fire is a necessary ecological process.

Montana's State Wildlife Action Plan and South Dakota Wildlife Action Plan describe a variety of vegetation conditions related to habitat for specific wildlife species. These plans would likely result in the preservation of these habitats on state lands, specifically wildlife management areas. These plans would interact with the Statewide Forest Resource Strategies and the vegetation conditions described would be complementary to the conditions being managed for in the Custer Gallatin revised plan.

Some county wildfire protection plans map and/or define the wildland-urban interface. The Forest Service notes that these areas may be a focus for hazardous fuels reduction; other plan components (such as Northern Rockies Lynx Management Direction) have guidance specific to these areas. Managing for open forests and fire adapted species may be particularly emphasized in these areas. Overall, the effect of the county plans would be to influence where treatments occur to contribute to desired vegetation conditions.

Conclusion

Fire is a critical ecological function that plays a central role in providing quality habitat for both plant and wildlife species. All alternatives would ensure fire remains a part of the ecological system and would move the Custer Gallatin National Forest toward desired future conditions. This is achieved through a variety of management actions including wildland fire and mechanical treatments.

Future wildfire and fire regimes: The projected levels of future wildfire, and their subsequent impact on fire regimes, are generally the same across alternatives. This is because vegetation over time is generally the same for all alternatives, and projected future treatments are also similar. Factors such as climate have a greater bearing on vegetation change and potential wildfire activity than active management.

Future fuels treatments: Alternative E would achieve the least amount of fuel reduction and prescribed fire in forested areas, including in wildland-urban interface areas due to focusing on maximizing timber harvest. All other alternatives would tend to treat more dry forest types in wildland-urban interface areas, especially alternative D (except for the large area of wildland-urban interface within recommended wilderness). However, other factors affect the number of acres treated to meet revised plan desired conditions relating to fire and fuels management. Some of these factors include budget allocation, climate and seasonal weather variation, and wildfire occurrence. Budget directly affects to the extent of the national forest can treat mechanically and with prescribed fire. Climate and seasonal weather variation affect the ability to conduct prescribed burns. Wildfire activity requires the use of personnel and other resources that would be used for implementing mechanical and prescribed fire treatments.

Flexibility for fire management: Different management designations, specifically recommended wilderness, affect where management tools such as mechanical treatments can be used, especially in the wildland-urban interface. The current plans and alternatives B, C, D, and F would all limit mechanical treatment options within recommended wilderness areas, with D having the most area restricted and the largest extent within the wildland-urban interface. If these areas became designated wilderness, then additional constraints on treatments would exist. Alternative E has the greatest flexibility for fire and fuels management, followed by alternatives F, B, C, D, and then A (the current plans).

3.8 Carbon Storage and Sequestration

3.8.1 Introduction

The Forest Service recognizes the vital role that our nation's forests and grasslands play in carbon sequestration. Accordingly, carbon storage and associated climate regulation has been identified as a key ecosystem service provided by the Custer Gallatin. This section of the environmental impact statement addresses and compares the existing conditions and expected trends of carbon pools on the Custer Gallatin, specifically the aboveground carbon pool. The potential effects of alternatives are analyzed relative to carbon storage (sequestration) potential.

The current levels of carbon dioxide in the atmosphere far exceed the concentrations found over the past 650,000 years (Ryan et al. 2010). As a result, global surface temperatures have increased since the late 1800s, with the rate of warming increasing substantially. This warming will have an impact on the earth's climate, climate variability, and ecosystems (Intergovernmental Panel on Climate Change 2007a). The effects of climate change observed to-date and projected to occur in the future include changes in temperature, precipitation, and disturbance patterns that drive and stress ecosystems and the benefits they provide, including degraded air quality, water resources, wildlife, carbon storage, and the quality of recreational experiences. Refer to the terrestrial vegetation section of this document for a summary of possible climate trends and projections relevant to the Custer Gallatin's ecosystems. Carbon sequestration is one way to mitigate greenhouse gas emissions by offsetting losses through capture and storage of carbon. The relationship between climate change and other resources is addressed throughout this analysis. In the context of global atmospheric carbon dioxide (CO_2), even the maximum potential forest management levels described by the plan alternatives would have a negligible effect on global emissions and climate. This analysis considers the potential effects of management actions on climate change as indicated by consideration of changes in carbon sequestration and storage arising from natural and management driven processes.

Regulatory Framework

There are no applicable legal or regulatory requirements or established thresholds concerning management of forest carbon or greenhouse gas emissions. The 2012 Planning Rule and regulations require an assessment of baseline carbon stocks and a consideration of this information in management of the national forests (FSH 1909.12.4).

Key Indicators

- Carbon pools (carbon stocks), carbon uptake, CO2 emissions
- Natural and human-caused influences on carbon stocks, uptake, and emissions.

Methodology, Analysis Process, and Information Sources

The affected environment section summarizes the revised Forest Carbon Assessment for the Custer Gallatin National Forest which is included in the project record. The carbon assessment draws largely from two recent U.S. Forest Service reports: the Baseline Report (U.S. Department of Agriculture 2015a) and the Disturbance Report (Birdsey et al. 2019). These reports provide assessments of forest ecosystem and harvested wood product (HWP) carbon stocks and flux, and the factors that have influenced carbon dynamics. The Resource Planning Act (RPA) assessment (U.S. Department of Agriculture 2016a) and a regional vulnerability assessment (Halofsky et al. 2018a;b) also provide information on potential future carbon conditions. These reports incorporate advances in data and analytical methods and collectively represent the best and most relevant scientific information available for the Custer Gallatin National Forest.

Potential carbon effects are discussed qualitatively, with supporting estimates where possible. This is accomplished by drawing on the quantitative analysis of the impacts of past management activities on forest carbon stocks and fluxes, as well as through future-looking analysis where available (see updated carbon assessment in project record for additional detail).

Analysis Area

The spatial scale of this analysis includes the forested lands of the Custer Gallatin National Forest. Based on forest inventory analysis data, the national forest consists of approximately 2.5 million acres of forest land. The effects analysis for greenhouse gas emissions is the global atmosphere given the mix of atmospheric gases can have no bounds. The temporal scale for analyzing carbon stocks and emissions focuses on the expected lifespan of the plan. This report includes analysis and discussion beyond this expected lifespan to provide context for potential forest carbon dynamics and factors influencing these dynamics in the future. However, estimates of future carbon stocks and their trajectory over time remain unclear because of uncertainty from the multiple interacting factors that influence carbon dynamics.

Notable Changes between the Draft and Final Environmental Impact Statement

An updated baseline carbon assessment was conducted, utilizing new available tools from the USDA Forest Service Office of Sustainability and Climate, and is incorporated into project record of the final environmental impact statement. This analysis is updated based on that information, which draws upon many of the same data and literature sources described in the draft environmental impact statement.

3.8.2 Affected Environment (Existing Condition)

Forests are dynamic systems that naturally undergo ebbs and flows in carbon storage and emissions as trees establish and grow, die with age or disturbances, and re-establish and regrow. Through photosynthesis, growing plants remove CO2 from the atmosphere and store it in forest biomass, such as in plant stems, branches, foliage, and roots. Some of this organic material is eventually stored in forest soils through biotic and abiotic processes (Ryan et al. 2010). Carbon can also be transferred and stored outside of the forest ecosystem in the form of wood products, further influencing the amount of carbon entering the atmosphere (Gustavsson et al. 2006, Skog et al. 2014). Many management activities initially remove carbon from the forest ecosystem, but they can also result in long-term maintenance or increases in forest carbon uptake and storage by improving forest health and resilience to various types of stressors (McKinley et al. 2011).

According to results of the Baseline Report (U.S. Department of Agriculture 2015a), carbon stocks in the Custer National Forest increased from 26.3±4.2 teragrams of carbon (Tg C) in 1990 to 33.7±6.1 teragrams of carbon in 2013, a 22 percent increase in carbon stocks over this period (figure 20). On the Gallatin National Forest, carbon stocks increased from 83.9±6.9 teragrams of carbon in 1990 to 105.1±10.2 teragrams of carbon in 2013, a 20 percent increase. For context, the total 105.1 teragrams of carbon is equivalent to emissions from approximately 84 million passenger vehicles in a year. Despite some uncertainty in annual carbon stock estimates, reflected by the 95 percent confidence intervals, there is a high degree of certainty that carbon stocks on the Custer Gallatin National Forest have been stable or increased from 1990 to 2013 (figure 20).

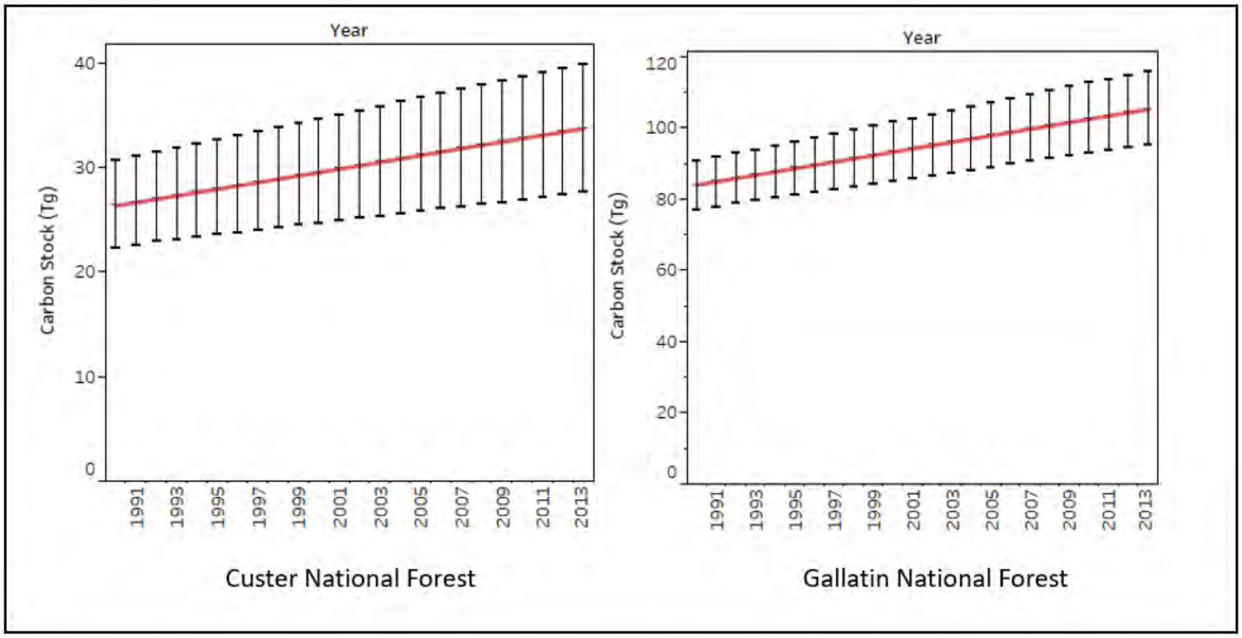

Figure 20. Total forest carbon stocks (Tg) from 1990 to 2013 for the Custer Gallatin National Forest, bounded by 95 percent confidence intervals. Estimated using the CCT model.

Approximately 47 and 68 percent of the Custer and Gallatin national forests, respectively, are middle-aged and older (greater than 80 years), although there is also a strong representation of stands less than 20 years old due to recent wildfires (figure 21 (a)). There is also a pulse of stands over 200 years old on the Gallatin National Forest. If the national forests continue on this aging trajectory, the pulse of middle-aged stands will reach a slower growth stage in coming years and decades (figure 21 (b)) potentially causing the rate carbon accumulation to decline and the national forests may eventually transition to a steady state in the future. However, the pulse of young stands will also be moving into a maximum productivity stage, which may offset the declines in the middle-aged stands to a degree. In the middle aged stands, although yield curves indicate that biomass carbon stocks may be approaching maximum levels (figure 21 (b)), ecosystem carbon stocks can continue to increase for many decades as dead organic matter and soil carbon stocks continue to accumulate (Luyssaert et al. 2008). Furthermore, while past and present aging trends can inform future conditions, the applicability may be limited, because potential changes in management activities and particularly disturbances could affect future stand age and forest growth rates (Davis et al. 2009, Keyser and Zarnoch 2012).

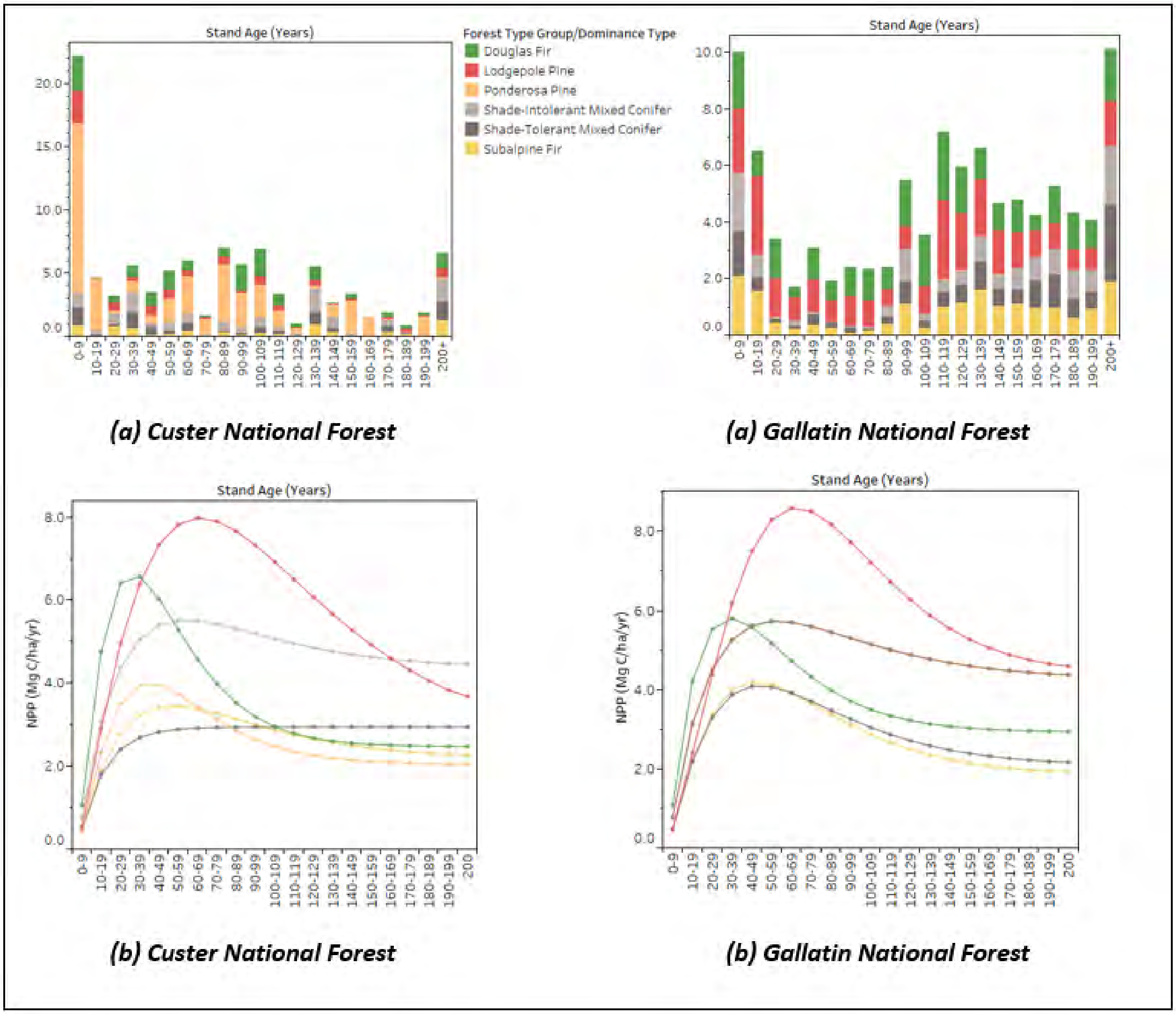

Figure 21. Stand age distribution in 2011 and (b) net primary productivity-stand age curves by forest type group in the Custer Gallatin National Forest. Derived from forest inventory data

Wildfire and insects have been the dominant disturbance types detected on the Custer Gallatin National Forest from 1990 to 2011, in terms of the total percentage of forested area disturbed over the period (figure 22 (a)). However, according to the satellite imagery, these disturbance agents affected a relatively small area of the forest during this time. In most years, wildfire affected less than 1 percent of the total forested area of either national forest in any single year from 1990 to 2011. However, in 2006, approximately 1.3 percent of the Custer National Forest burned, while in 2007 about 2.5 percent of the Gallatin National Forest experienced fire. On the Custer National Forest, wildfire in total affected less than 5 percent (approximately 13,250 ha) of the forested area during this period. Wildfire affected approximately 5.3 percent of the Gallatin National Forest from 1990 to 2011 (approximately 32,000 ha); and insects affected just under 5 percent (28,000 ha). Harvest also occurred on both national forests, but impacted less than 1 percent of either. Disturbance resulted in a range of canopy cover loss depending on disturbance type and year (figure 22 (b)).

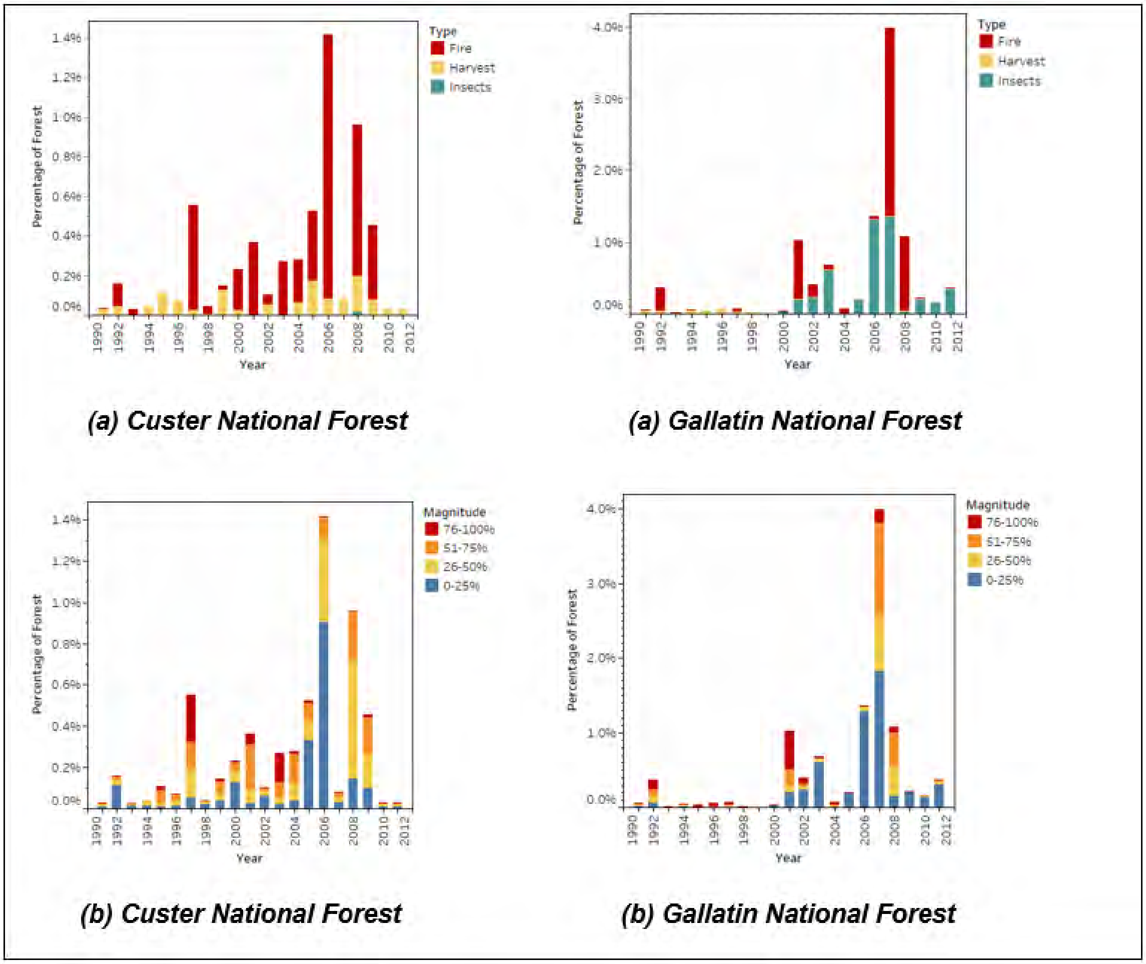

Figure 22. Percentage of forest disturbed from 1990 to 2011 in Custer Gallatin National Forest

The Custer Gallatin National Forest contains approximately 170,000 hectares of non-forest lands. Grasslands, shrublands, and riparian and wetland areas cover most of these lands, accounting for approximately 14 percent of the total area on the national forest. The vast majority of the carbon in these non-forest systems, such as grasslands and shrublands, is stored belowground in soil and plant roots (McKinley and Blair 2008, Janowiak et al. 2017). By contrast, forests typically store roughly one-half of the total carbon belowground (Domke et al. 2017). Soils generally provide a stable ecosystem carbon pool relative to other ecosystem carbon pools.

Climate change introduces additional uncertainty about how forests—and forest carbon sequestration and storage—may change in the future. Climate change causes many direct alterations of the local environment, such as changes in temperature and precipitation, and it has indirect effects on a wide range of ecosystem processes (Vose et al. 2012). Further, disturbance rates are projected to increase with climate change (Vose et al. 2018), making it challenging to use past trends to project the effects of disturbance and aging on forest carbon dynamics.

3.8.3 Environmental Consequences

In a global atmospheric CO2 context, even the maximum potential management levels described by the plan alternatives would have a negligible impact on national and global emissions and on forest carbon stocks, as described below. As in this case, when impacts on carbon emissions (and carbon stocks) are small, a quantitative analysis of carbon effects is not warranted and thus is not meaningful for a reasoned choice among plan alternatives (U.S. Department of Agriculture 2009b). Although advances in research have helped to account for and document the relationship between greenhouse gas and global climate change, it remains difficult to reliably simulate observed temperature changes and distinguish between natural or human causes at smaller than continental scales (Intergovernmental Panel on Climate Change 2007a).

Even more difficult is the ability to quantify potential carbon consequences of management alternatives in the future due to potential variability in future conditions and the stochastic nature of disturbances. The result of such uncertainty is often a very low signal-to-noise ratio: small differences in carbon impacts among management alternatives, coupled with high uncertainty in carbon stock estimates, make the detection of statistically meaningful differences among alternatives highly unlikely.

Management Direction under the Current Plans

The existing forest plans contain no plan components or direct acknowledgment related to carbon sequestration, or the use of management approaches to mitigate greenhouse gas emissions and climate change. Both existing plans contain direction aimed at promoting the sustainability of vegetation.

Management would continue similarly as in the recent past, resulting in a similar pattern of carbon storage and flux as discussed in the affected environment section. Direction in the current plans aimed at promoting the sustainability of vegetation could trend the Custer Gallatin towards greater resiliency, and thus enable the national forest to provide carbon sequestration over both the short and long term.

Management Direction under the Revised Plan Alternatives

All action alternatives provide the same desired conditions for terrestrial ecosystems and the standards and guidelines that help achieve or maintain those conditions. These plan components will help maintain critical ecosystem functions into the future, in part by balancing the maintenance of carbon stocks and rates of carbon uptake. The revised plan recognizes the important role of the forest related to carbon storage and sequestration, establishing a desired condition that directly addresses carbon sequestration (FW-DC-CARB-01). This desired condition applies to all revised plan alternatives and focuses on sustaining this key ecosystem service through maintenance or enhancement of ecosystem biodiversity and function and managing for resilient forests adapted to natural disturbance processes and changing climates. In addition, FW-GO-CARB-01 would promote cooperation and collaboration with interested partners in the development and implementation of research, management practices, and monitoring programs to better understand and address the effects of climate change on ecosystems and ecosystem services in order to inform adaptation and mitigation strategies.

Effects Common to all Alternatives

As required by planning regulations, the strategy for vegetation management on the Custer Gallatin National Forest under the revised plan alternatives is to provide for ecological integrity and resilience, supporting a diversity of plant and animal communities, and to provide for social and economic contributions to local communities. In response to this direction, all revised plan alternatives incorporate an ecologically based approach to vegetation management, including direction to manage for conditions that would occur under a natural disturbance regime, and be more resilient in the face of future uncertainties. The revised plan also explicitly recognizes the importance of the role of the Custer Gallatin related to carbon storage and sequestration, establishing a desired condition that directly addresses carbon sequestration (FW-DC-CARB-01). This desired condition focuses on sustaining this key ecosystem service through maintenance or enhancement of ecosystem biodiversity and function and managing for resilient forests adapted to natural disturbance processes and changing climates. The full suite of ecological plan components is consistent with and support this desired condition. This approach to management of forests for purposes of contributing to climate change mitigation is supported by a number of scientific sources (Ruddell et al. 2006, Hurteau et al. 2008, Reinhardt and Holsinger 2010, Ryan et al. 2010, Wiedinmyer and Hurteau 2010, North and Hurteau 2011, Schaedel et al. 2017). Plan direction in the revised plan alternatives provide more clarity and stronger integration of ecological concepts and management for resilient forest conditions than current plans.

In general, management activities (such as timber harvest) would initially directly reduce carbon stocks on the national forest, though minimally. However, this initial effect would be mitigated or even reversed with time, reducing the potential for negative indirect and cumulative effects. These short-term losses and emissions are small relative to both the total carbon stocks on the forest and national and global emissions. Further, the proposed activities would generally maintain and improve forest health and supply wood for forest products, thus having positive indirect effects on carbon storage. The Custer Gallatin National Forest will continue to be managed to maintain forests as forests and the many ecosystem services and co-benefits the forests provide, including carbon uptake and storage. The following management strategies are available under all alternatives and influence carbon uptake and storage potential:

- Manage the forest to provide a mosaic of forest structure and composition that is consistent with the natural range of variability to support ecological integrity, resilient ecosystems and provide wildlife habitat. Managing for younger stands where appropriate may cause a decline in carbon stocks in the short term, but compared with older stands, doing so promotes relatively high rates of carbon uptake over time as forests regrow (Pregitzer and Euskirchen 2004).
- Preserve, enhance or accelerate the development of large trees stands and structures and maintain or increase old-growth conditions to support higher carbon stocks in mature forests compared with younger stands (Harmon et al. 1990).
- Decrease forest densities and fuel conditions to reduce the risk of large, stand-replacing disturbance from insect, disease, and fire. Although this strategy initially reduces carbon stocks, it can lower risk for greater carbon stock losses and emissions in the future (Wiedinmyer and Hurteau 2010).
- Ensure successful reforestation after harvest or mortality-inducing disturbances to ensure continued carbon uptake and storage (Intergovernmental Panel on Climate Change 2014).
- Promote desired composition, structure, function, and pattern (ecological integrity) which will support long-term carbon uptake and storage in the face of changing environmental conditions (Millar et al. 2007).
- Use harvested wood for valuable and renewable products to store carbon over the long-term and substitute for energy-intensive materials or fuels, reducing the net carbon emissions into the atmosphere (Gustavsson et al. 2006, Lippke et al. 2011).

Each of the alternatives include a similar number of acres to be treated, thus they are projected to have similar effects on carbon. Plan direction in all alternatives would support the Custer Gallatin National Forest towards continued resilience at both the stand and landscape scales. Alternative F is the preferred alternative, and therefore is evaluated here as an indicator of the level of influence of the alternatives on carbon dynamics. Refer to the terrestrial vegetation and timber analyses for full discussions of projected treatment areas under each action alternative.

The estimated treatment area for harvests and thinning under alternative F would average approximately 1,000 acres per year or about 0.04 percent of total forested area on the Custer Gallatin National Forest. This is similar to the no-action alternative, and a 150 percent from the average annual harvest levels recorded from 1990-2011 based on the Landsat satellite imagery. If the annual carbon impact also increases up to 1.5 times above past levels, harvest treatments under alternative F may result in a maximum removal of about 30,000 Mg of carbon per year from aboveground pools. Alternative F also includes prescribed burning on an average of about 3,000 acres annually. Wildfires generally burn at higher severities and result in greater carbon losses than prescribed burns. By reducing hazardous fuels, prescribed burning may indirectly reduce the risk of more severe wildfires and greater carbon losses in the future (Agee and Skinner 2005, Wiedinmyer and Hurteau 2010).

Considering the maximum area treated with harvesting and prescribed fire, the amount of carbon that might be removed is small relative to the approximately 110 million metric tons (Tg) of carbon stored in the forest ecosystem of Custer Gallatin National Forest. With maximum intensification, potential management actions would affect up to less than 0.25 percent of the forested area and much less than 1 teragrams of carbon annually. The alternatives will not substantially, adversely, or permanently affect forest carbon storage, but would rather achieve a more resilient forest condition that will improve the ability of the Custer Gallatin National Forest to maintain carbon stocks and enhance carbon uptake.

Consequences to Carbon Storage and Sequestration from Plan Components associated with Other Resource Programs or Management Activities

Effects from Terrestrial Vegetation Management

Under all revised plan alternatives, plan components for terrestrial vegetation would make sure forested and non-forested plant communities are managed to be resilient (e.g., FW-DC-VEGF-01 to 09) and FW-DC-VEGNF-01 to 04), therefore ensuring that the carbon sequestration capacity is maintained over the long term on the Custer Gallatin National Forest. The current plans do not prescribe desired conditions based on the natural range of variation but would also result in the lands of the Custer Gallatin National Forest being managed for native vegetation communities and therefore would provide a similar potential for carbon sequestration.

Effects from Fire and Fuels Management

Fire, (both natural and human ignitions) pose the greatest potential for short-term reductions in carbon sequestration by removing vegetation as well as causing carbon emissions. However, fire is also a primary mechanism for restoring and maintaining native vegetation with conditions consistent with the natural range of variation, thereby contributing to carbon sequestration potential over the long term. Plan components for fire and fuels management would help make sure the long-term sustainability of vegetation communities while also allowing for flexibility in allowing fire to play its natural role on the landscape (FW-DC-FIRE-01, FW-DC-FIRE-02). These factors would generally be the same for all alternatives.

Effects from Timber Management

Plan components for timber management would allow for the short-term, localized reduction of carbon sequestration through the removal of living vegetation. The magnitude of this is greatest in alternative E and least in alternative D, but the difference between alternatives relative to effects on carbon is negligible. However, plan components that guide timber management, including desired vegetation conditions (FW-DC-TIM-03) and forested vegetation management objectives (FW-OBJ-VEGF-01), would make sure that forest resiliency is promoted by these activities; therefore, timber management would contribute to the long-term capacity of forests to sequester carbon.

Effects from Permitted Livestock Grazing

In all alternatives, livestock grazing would occur on the Custer Gallatin National Forest. Plan components would make sure that grazing is managed in a manner that would maintain desirable vegetation communities (FW-STD-GRAZ-01), and therefore would not preclude the carbon sequestration potential of rangelands under any alternative.

Effects from Watershed, Soil, Riparian, and Aquatic Management

Measures to protect aquatic habitat, riparian management zones, and watersheds would generally result in vegetation being maintained as needed for watershed function and would result in a greater likelihood of vegetation cover being maintained within riparian management zones (for example FW-DC-RMZ-01, FW-STD-RMZ-01, FW-STD-RMZ-02). These measures would be greater for the revised plan alternatives than the current plans. The retention of vegetation in riparian areas would provide areas of refugia (potential old growth), and seed sources to contribute to the larger resilience (and therefore carbon sequestration potential) of vegetation on the landscape over time.

Cumulative Effects

Climate change is a global phenomenon, because major greenhouse gases mix well throughout the planet's lower atmosphere. Estimated emissions of greenhouse gas in 2010 were 13,336 ± 1,227 teragrams carbon globally (Intergovernmental Panel on Climate Change 2014) and 1,881 teragrams carbon nationally (U.S. Environmental Protection Agency 2015). All plan alternatives are projected to contribute negligibly to overall greenhouse gas emissions. Furthermore, it is difficult and highly uncertain to ascertain the indirect effects of emission from multiple, generally small projects that make up these alternatives on global climate. Management actions are directed at a very small percentage of the total forest land on the Custer Gallatin National Forest; even in the near-term, these alternatives would have a minimal direct effect on carbon emissions and carbon stocks relative to total carbon stocks in the Custer Gallatin National Forest. Because the potential direct and indirect effects of alternatives would be negligible, the contribution of the plan's proposed actions to cumulative effects on global atmospheric greenhouse gas concentrations and climate change would also be negligible.

Conclusions

A large body of science agrees that future climate conditions will include increasing average annual temperatures over the coming decades, which will have impacts to natural resources.

Plan components in the action alternatives are designed to provide for ecological integrity and resiliency to disturbances. Potential negative effects may be mitigated and completely reversed with time as the forests regrow. Over the longer term, the activities allowed by the plan are likely to increase carbon storage and reduce emissions, by reducing disturbance risk and storing carbon in wood products. The management mechanisms applied in all plan alternatives are consistent with internationally recognized climate change adaptation and mitigation practices identified by the IPCC (Intergovernmental Panel on Climate Change 2007a).

Carbon stocks on the Custer Gallatin National Forest would likely continue to increase or remain stable under all plan alternatives in the foreseeable future. Natural ecosystem processes, including forest growth (succession) and small-scale disturbances (for example fire, insects, harvests) would continue to influence carbon stocks and emissions, but they are not expected to substantially change current trends in carbon over the span of the plan. All plan alternatives would preserve existing forest lands and forests by improving forest conditions and retaining forest characteristics by maintaining current land use. Given the likely changes in land use in coming decades on adjacent land ownerships, this is a critical goal.

3.9 Invasive Species

3.9.1 Introduction

A species is considered to be invasive if it meets two criteria: (1) it is nonnative to the ecosystem under consideration, and (2) its introduction causes, or is likely to cause economic or environmental harm or harm to human, animal, or plant health (Obama 2016). Invasive species includes all taxa, including plants (such as state and county designated noxious weeds), vertebrates, invertebrates (such as emerald ash borer, non-native mussels), and pathogens (such as blister rust or white-nosed syndrome fungus).

Management activities for aquatic and terrestrial invasive species (including vertebrates, invertebrates, plants, and pathogens) are based upon an integrated pest management approach on all areas within the National Forest System, and on areas managed outside of the National Forest System under the authority of the Wyden Amendment (PL. 109-54, section 434), prioritizing prevention and early detection and rapid response actions as necessary (FSM 2900). Integrated pest management is an ecosystem-based strategy that focuses on long-term prevention of invasive species or their damage through a combination of techniques such as physical, biological or chemical control, habitat manipulation, modification of cultural practices, or ultraviolet light (for white-nose syndrome pathogen control). While each situation is different, the following major components are common to all integrated pest management programs: prevention, early detection/rapid response, control and management, restoration, and collaboration (U.S. Department of Agriculture 2013).

Regulatory Framework

All Invasive Species

The Federal Insecticide Fungicide and Rodenticide Act (Public Law 92-516) requires all pesticides to be registered with the Environmental Protection Agency. It also states that it is unlawful to use any registered pesticide in a manner inconsistent with its labeling.

Executive Order 13112 directs Federal agencies to prevent the introduction of invasive species; detect and respond rapidly to and control populations of such species in a cost-effective and environmentally-sound manner; to monitor invasive species populations accurately and reliably; to provide for restoration of native species and habitat conditions in ecosystems that have been invaded; to conduct research on invasive species and develop technologies to prevent introduction; to provide for environmentally sound control of invasive species; and to promote public education on invasive species and the means to address them. Federal agencies are also called to collaborate with Federal, State, and local partners to address invasive species that can spread from adjacent lands. All actions are subject to the availability of appropriations.

Executive Order 13571 amends Executive Order 13112 and directs actions to continue coordinated Federal prevention and control efforts related to invasive species. This order maintains the National Invasive Species Council and the Invasive Species Advisory Committee; expands the membership of the Council; clarifies the operations of the Council; incorporates considerations of human and environmental health, climate change, technological innovation, and other emerging priorities into Federal efforts to address invasive species; strengthens coordinated, cost-efficient Federal action; and revises several definitions.

The desired condition inferred from Executive Order 13112 and 13571, FSM 2900 and the national strategy is the prevention of new infestations (within the area where activities would occur or from the use of travel routes associated with those activities) and to manage the infestations currently established on the Custer Gallatin through control measures. For all forests, management goals for invaders are to:

- Potential invaders—prevent establishment, and if found, promptly eradicate
- New invaders—for small infestations, eradicate, and for larger infestations, reduce
- Widespread invaders—contain areas that are already infested and reduce populations.

U.S. Department of Agriculture 2013 provides broad and consistent strategic direction on the prevention, detection, and control of invasive species and incorporates the Invasive Species Systems Approach to respond to threats over the next 5 to 10 years. This framework directs the Forest Service to 1) Determine the factors that favor establishment and spread of invasive plants; 2) Analyze invasive species risks in resource management projects; and 3) Design management practices that reduce these risks.

Forest Service Manual 2900 ensures that forest management activities are designed to minimize or eliminate the possibility of establishment or spread of invasive species on National Forest System lands or to adjacent areas (U.S. Department of Agriculture 2011a). FSM 2900 lists applicable laws and regulations, objectives, responsibilities, and definitions.

Forest Service Manual 2070 Vegetation Ecology provides direction for the use of native and non-native seed use on National Forest System lands. It emphasizes the use of native seed mixes in all revegetation, rehabilitation, and restoration projects on National Forest System lands.

Pesticide Use Management and Coordination Policy Forest Service Manual 2150 provides agency policy and guidance on the use of pesticides as part of an integrated pest management approach. Additional guidance provided in the Pesticide Use Management Handbook (FSH 2109).

Forest Service National Strategic Framework for Invasive Species Management of 2013 provides broad and consistent strategic direction on the prevention, detection, and control of invasive species. It incorporates the invasive species systems approach to respond to threats over the next five to ten years.

A National Road Map for Integrated Pest Management (Revised September 2018) goal is to increase the adoption and efficiency of effective, economical and safe integrated pest management practices. The Road Map is intended to be updated periodically by the Federal Integrated Pest Management Coordinating Committee.

Noxious Weeds

Plant Protection Act of 2000 (as amended by the Noxious Weed Control and Eradication Act of 2004 (P.L. 108-412)) defines the term “noxious weed” for the Federal Government as any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment. The term typically describes species of plants that have been determined to be undesirable or injurious in some capacity. Federal noxious weeds are regulated by USDA-Animal and Plant Health Inspection Service under the Plant Protection Act of 2000, which superseded the Federal Noxious Weed Act of 1974.

The Carlson-Foley act of 1968 (Public Law 90-583) authorizes and directs heads of Federal Departments and Agencies to permit control of noxious plants by State and local governments on a reimbursement basis in connection with similar and acceptable weed control programs being carried out on adjacent non-federal land. In other words, this act permits county and state officials to manage noxious weeds with herbicides on Federal lands and to be reimbursed for that management, given that other applicable laws such as the National Environmental Policy act are also met.

The State of South Dakota Code. There is a regulatory designation of certain terrestrial and aquatic plants which are identified as “noxious weeds” defined through individual State statutes. A noxious weed is defined by South Dakota Code (chapter 38-22, article 12:62:02:01) as “a weed which the commission has designated as sufficiently detrimental to the state to warrant enforcement of control measures.”

The State of Montana Code. There is a regulatory designation of certain terrestrial and aquatic plants which are identified as “noxious weeds” defined through individual State statutes. A noxious weed is defined by Montana Code Annotated (MCA 7-22-2101) as “any exotic plant species established or that may be introduced in the state that may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities.”

The State of Montana County Noxious Weed Management Act states that it is unlawful for any person to permit any noxious weed to propagate or go to seed on the person's land, except that any person who adheres to the noxious weed management program of the person's weed management district or who has entered into and is in compliance with a noxious weed management agreement is considered to be in compliance with this section.

South Dakota Portion of the Sioux Ranger District, Custer Gallatin National Forest Weed Seed Free Order 2007. National Forest lands in the South Dakota Portion of the Custer Gallatin National Forest, possessing or storing any hay, hay cubes, straw, grain, or other forage or mulch product, without original and current documentation from a state certification process which meets or exceeds the North American Weed Free Forage or comparable certification standard is prohibited. Tags, twine, or other certification marking is required on all individual bales, containers, sacks, etc., as required or provided for by the product’s state of origin. Exempt from this order are: 1) Persons with a permit specifically exempting them from this order; 2) Any member of an organized rescue force in the performance of an official duty under emergency conditions; 3) Feed pellets one inch in diameter and smaller or steam-rolled feed grains; 4) Persons transporting forage products across National Forest System lands without unloading or using the products on National Forest System lands, roads, or trails.

National Forest System Lands in Montana Weed Seed Free Order 1997. For National Forest System lands in Montana the possession or storage of hay, grain, straw, cubes, pelletized feed or mulch that is not certified as being noxious weed free or noxious weed seed free by an authorized State Department of Agriculture official or designated county official is prohibited; each individual bale or container must be tagged or marked as weed free and reference the written certification. Exempt from this Montana National Forest System Special Order are: 1) Persons with a permit specifically authorizing the action or omission; and 2) Transporting feeds, straw, or hay on Federal, State, and county roads that are not Forest Development Roads or Trails.

Custer National Forest Noxious Weed Management Environmental Impact Statement and Record of Decision [2006] and the Gallatin National Forest Noxious and Invasive Weed Treatment Project Environmental Impact Statement and Record of Decision (2005)]. Protection and prevention measures outlined in these applicable forestwide weed management National Environmental Policy Act decisions provide invasive plant species management direction.

Aquatic Invasive Species

The State of Montana Code 80-7-1001-1019 establish a mechanism for Montana to take concerted action to detect, control, and manage invasive species.

The State of Montana Aquatic Invasive Species Administrative Rules ARM Rule 12.5.706 and 707 address the prevention, inspection, and decontamination processes for aquatic invasive species in Montana. Leech Rules (ARM Rule 12.7.540 through 12.7.542) regulate leach importation and development of approved leech dealers.

South Dakota Administrative Rules 41:10:04:01-09 list aquatic species classified as invasive, restrictions, and decontamination requirements.

Vertebrates

The State of Montana Code transplantation of wildlife regulations (MCA 87-5-701 through 87-5-721) provides the authority to regulate importation, introduction, and transplantation of wildlife species, including aquatics. Prohibited species are live, exotic wildlife species, subspecies, or hybrid of that species, including viable embryos or gametes, that may not be possessed, sold, purchased, exchanged, or transported in Montana, except as provided in MCA 87-5-709 or ARM 12.6.2220.

The State of South Dakota Code SD ADC 12:68:18:01 to 09 regulates non-domestic animal control.

Key Indicators and Measures

The following are indicators used for the analysis of noxious weeds:

- Acres of noxious projected to be treated as outlined by alternative objectives.
- Acres of the Custer Gallatin that are most vulnerable to noxious weed invasion.
- Miles of motorized routes that could serve as pathways for noxious weed spread.
- Acres potentially disturbed by vegetation treatment (timber and fuels) activity that could serve as a correlation to potential for ground disturbance at risk for weed invasion.

Other invasive species such as invertebrates, pathogens and insects will be evaluated qualitatively.

Methodology and Analysis Process

In general, the analysis assumes increased ground disturbance corresponds with increased risk of weed spread. Roads, trails, livestock, and canopy reduction and/or ground disturbance from fire and vegetation management can provide ideal pathways for the introduction of invasive species. Invasive plant species can displace at-risk and other native species through competitive displacement. Competition from invasive non-native species and noxious weeds can result in the loss of habitat, loss of native pollinators, and decreased at-risk plant species persistence. Subsequent impacts from management actions include herbicide spraying and mechanical ground disturbance to control noxious weeds once they gain a foothold.

Information Sources

The Montana and South Dakota Noxious Weed, Aquatic Invasives, and Prohibited Wildlife Lists are used to identify which invasive species to manage across the Custer Gallatin National Forest, as well as project specific invasive plant risk assessments (risk assessments). Risk assessments help identify threats to native vegetation as a result of project related ground disturbance and invasive species within or near the project area. They also prescribe mitigation measures to reduce these threats. As project areas are surveyed, new infestations are inventoried. These data are entered into the Natural Resource Manager's Threatened, Endangered, and Sensitive Plants, and Invasive Species (TESP-IS) database, a system of database tools for managing Forest Service data across the Custer Gallatin National Forest. Invasive plant infestation data (spatial and tabular) is stored and can be retrieved for later reference and analyses. This database has been continually updated with inventoried infestations. Invasive plant treatments are also recorded and entered into the Natural Resource Manager System, which allows the national forest to track invasive plant treatment accomplishments.

Analysis Area

The geographic scope of the analysis for invasive species are the National Forest System lands of the Custer Gallatin National Forest. This area represents the lands where changes may occur to vegetation as a result of management activities or natural events. For cumulative effects, the analysis area also includes the non-National Forest System lands within and adjacent to the administrative boundary of the Custer Gallatin National Forest. The temporal scope is the life of the plan.

Notable Changes between the Draft and Final Environmental Impact Statement

Changes include, updated acreage in table 61 and table 62 to include recent findings of ventenata and curlyleaf pondweed infestations. Additionally, information on invasive grasses has been added. The notable change in the final plan is removal of draft plan standard FW-STD-INV-01 because it repeats Forest Service policy.

3.9.2 Affected Environment (Existing Condition)

Invasive Terrestrial and Aquatic Plants

Invasive plant species (hereafter), including those that are formally designated by states as noxious weeds, have disrupted natural processes on nearly 100 million acres in the United States and are spreading at an estimated rate of 14 percent per year (U.S. Department of Agriculture 2001). On National Forest System lands in the United States, noxious weeds have been estimated to be increasing at 8 to 12 percent per year (U.S. Department of Agriculture 1998, Sheley et al. 2011). The most widespread weed in Montana is spotted knapweed. It has been estimated that spotted knapweed has increased at a rate of 27 percent per year (Sheley et al. 2011).

Weed management have evolved over time to overall ecosystem response to weed management and not simply by the degree to which the target weed is suppressed. Using tools without carefully considering the collective outcome can actually make conditions worse (Pearson and Callaway 2003, Lehnhoff et al. 2008). Understanding the ecology of the ecosystems, the nature of the threats to be mitigated, and the efficacy of the tools employed improves ecosystem management when considering the following factors: invader impacts such as reduced abundance of individual native organisms and altered community interactions, management side effects such as reduced vigor or abundance of native or desirable species, and secondary invasion such as when the suppression of the target weed results in the proliferation of another invader (Pearson and Ortega 2009).

Part of understanding overall ecosystem response to weed management actions includes understanding concepts of weak versus strong invaders. The majority of invader species that establish within native communities tend to be ‘‘weak’’ invaders that coexist with native species as minor community components (Huston 1994, Davis et al. 2000, Brown and Peet 2003, Ortega and Pearson 2005). However, ‘‘strong’’ invaders that attain community dominance can dramatically impact native species and processes (Williamson and Fitter 1996, Levine et al. 2003, Ortega and Pearson 2005). It is widely recognized that invader species threaten biological diversity and the functioning of natural ecosystems. Strong invaders are the primary basis for this threat. Studies in bunchgrass communities in western Montana found that measures of native species diversity and susceptibility to invasion were positively correlated in communities with low levels of invasion where both weak and strong invaders occurred at low densities, but negatively correlated in communities with high levels of invasion where the strong invader of spotted knapweed dominated (Ortega and Pearson 2005). Given the increasingly serious threat of strong invaders to diversity and function of natural ecosystems and the difficulties associated with reversing these impacts, invasion ecology is shifting away from the current debate over the biotic resistance hypothesis (which predicts that the more diverse communities should be less susceptible to invasion) to developing an understanding of the behavior of weak versus strong invaders. Regardless of diversity, few natural communities can escape the entry of invasive species and the impact of strong invaders (Ortega and Pearson 2005). Another study in west-central Montana identified found that local invader abundance (canopy cover) had a significant influence on the likelihood of impact, but range (number of plots occupied) did not. This study also found that the noxious weed list captured 45 percent of the high-impact invaders, but missed 55 percent suggesting that noxious weed lists help guide invasive species management, but that an understanding of susceptibility to invasion is important for weed management (Pearson et al. 2016).

Numerous studies describe the ecological impacts of weeds when they are at high density levels. Most infestations on the Custer Gallatin are at low densities but there are occasional high-density infestations. Regardless of density, weeds are very expensive to control, and native plants are difficult to restore.

Ecological impacts of weeds at high density levels include a reduction in forage for livestock and wildlife. Research has indicated that elk will use knapweed and cheatgrass, but native grasses make up the majority of the diet (Kohl et al. 2012). Herbicide treatment of spotted knapweed increased perennial grass biomass by 7.5 times where knapweed density averaged 36 mature plants per square meter—more than 60 percent canopy cover (Sheley et al. 2000). This is an indication of the amount of native grass that is lost with high density levels of spotted knapweed.

High density levels of spotted knapweed have been found to increase surface run off and stream sediment levels, and to change soil nutrients. For example, changes in phosphorus were detected when spotted knapweed canopy cover was 60 to 80 percent (Thorpe et al. 2006). Likewise, research studies found an increase in surface runoff and sediment in sites of heavy knapweed infestation (90 percent) compared to sites in which native grasses dominate (Lacey et al. 1989). The runoff was 56 percent higher and the stream sediment yield was 196 percent higher on sites dominated by spotted knapweed compared to sites dominated by native bunchgrasses. Water infiltration was greater on sites with grasses than on sites with spotted knapweed.

Weeds can also change the frequency and severity of wildland fires. Cheatgrass has been found to increase fire frequency in areas where it is abundant (Balch et al. 2013). More frequent fires are causing populations of native grasses and shrubs to decrease and the cheatgrass to increase.

Currently there are 53 invasive species listed for the Montana and South Dakota portions of the Northern Region, including lists from states, counties, and other national forests. Of these, 33 species are currently known to be on the Custer Gallatin National Forest. The status of each invasive plant species is considered when determining the appropriate management strategy and priority. Some of the most common species are spotted knapweed, Canada thistle, hounds-tongue, nodding thistle, leafy spurge, cheatgrass, yellow toadflax, and Dalmatian toadflax. Species that are particularly aggressive and have a high risk of outcompeting native vegetation are of highest priority for treatment and containment are spotted knapweed, leafy spurge, toadflax species (yellow and Dalmatian), orange hawkweed and meadow hawkweed; as well as those species that are on the State noxious list but not currently present on the Custer Gallatin National Forest (for example, yellow starthistle). Reduction of particularly aggressive species is critical for the protection of intact plant communities and associated habitats. Avoiding the establishment of additional species is equally important in the maintenance of healthy landscapes.

Presence and amount of invasive species and noxious weeds is a key indicator for overall ecosystem health. The 2016 watershed condition framework assessment for the national forest identified that most noxious weeds affect less than 10 percent of each individual watershed (sixth code hydrological units). However, six watersheds were identified as having a noxious weed footprint of between 21 and 54 percent of the watersheds. Weeds in Lower Mill watershed (Yellowstone District and Bloom Creek, Paget Creek, and Horse Creek watersheds (Ashland District) were exacerbated by wildfires in those areas. Some weeds in these areas have been treated, but seed banks likely exist where weeds can persist over time. As infestations increase in size, a containment strategy is typically used to treat the periphery of the area rather than attempting eradication, which is generally not feasible given limited resources. Biological control with insects and goats have been used to manage more dense infestations.

Species that have limited occurrence, in either number of acres or number of sites, are considered new invaders. New invaders on or near the Custer Gallatin include hawkweeds (both orange and meadow), tamarisk, Eurasian water-milfoil, purple loosestrife, blueweed, knotweed, yellow starthistle, and dyer’s woad.

Given the limited funding levels, the Custer Gallatin has developed a management strategy that gives priority to prevention and early detection and rapid response (FSM 2900), and secondary priority to treatment of areas impacted by construction, recreation, fire, and vegetation projects, and pathways such as roadsides and recreation sites, and areas with specific funds designated for treatments.

There are some areas where nonnative species such as timothy grass, smooth brome, Kentucky bluegrass, and crested wheatgrass occur. Some areas have smooth brome (all geographic areas) or crested wheatgrass (minor amounts in the Sioux Geographic Area) due to old reseeding practices. Due to adjacent land activities during settlement and historical grazing overuse at the turn of the 20^{th} century, some areas have large amounts of Kentucky bluegrass (all geographic areas), and timothy grass (all montane geographic areas) as part of the landscape. The problem with these species is that they can form monocultures to the exclusion of most native species.

There is an estimated 57,600 acre known footprint of noxious weed infested area on the Custer Gallatin (less than 2 percent of the national forest). Not all of the Custer Gallatin has been surveyed so there is the potential for additional infestations to exist in areas that have not been surveyed. Table 61 displays the amount of inventoried noxious weeds (infested acres), by species for each geographic area.

Since each area of the Custer Gallatin National Forest is distinct with respect to invasive weeds, a more detailed description is provided below.

Sioux Geographic Area

The Sioux Ranger District includes 174,758 acres and 99 percent is vulnerable habitat with 4 percent of the vulnerable area being infested. Infestations of Canada thistle, leafy spurge, spotted knapweed, absinthium wormwood and houndstongue occur in disturbed areas. Wildland fires have exacerbated weeds such as leafy spurge in the Ekalaka Hills and Canada thistle and spotted knapweed in the Long Pines.

Ashland Geographic Area

The Ashland Ranger District includes 496,558 acres and 99 percent is vulnerable habitat with three percent of the vulnerable area being infested. Most common weed species include spotted knapweed, leafy spurge, Russian knapweed, and St. Johnswort. Large forest fires have caused a substantial increase in spotted knapweed and leafy spurge. New invader species include tamarisk and sulfur cinquefoil.

Pryor Mountains Geographic Area

The Pryor Mountains includes 77,944 acres, and 74 percent is vulnerable habitat with 3 percent of the vulnerable area being infested. Most common weed species include spotted knapweed, Canada thistle, houndstongue, leafy spurge, field bindweed and Dalmatian toadflax. New invader species include meadow hawkweed and oxeye daisy.

Table 61. Acres of Montana and South Dakota state and county listed noxious weeds (net infested acres) for each geographic area

Species	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger, Bangtail, Crazy Mountains	Madison, Henrys Lake Gallatin Mountains
Absinthium (*Artemisia absinthium*) (noxious in Carbon County, MT and noxious in SD)	87	no data	no data	under 1	no data	no data
Hoary alyssum (*Berteroa incana*) (noxious in MT)	no data	no data	under 1	64	1	690
Cheatgrass (*Bromus tectorum*) (regulated in MT)[1]	no data	no data	no data	1,819	no data	331
White top (*Cardaria dradba*) (noxious in MT and SD)	no data	no data	under 1	2	under 1	36
Nodding thistle (*Carduus nutans*) (noxious in SD; noxious in Gallatin County, MT)	5	no data	no data	2,432	2,463	976
Spotted knapweed (*Centaurea maculosa*) (noxious in MT and SD)	689	5,607	769	6,153	275	2,416
Diffuse knapweed (*Centaurea diffusa*) (noxious in MT and SD)	no data	no data	no data	no data	no data	1
Russian knapweed (*Centaurea repens*) (noxious in MT and SD)	under 1	19	no data	no data	under 1	under 1
Oxeye daisy (*Chrysanthemum leucanthemum*) (noxious in MT and SD)	no data	no data	24	377	233	362
Canada thistle (*Cirsium arvense*) (noxious in MT and SD)	4,148	37	871	5,948	1752	1,176
Bull thistle (*Cirsium vulgare*) (noxious in SD)	7	no data	no data	1,321	201	20
Poison hemlock (*Conium maculatum*) (noxious in Gallatin, Powder River, and Rosebud Counties, MT; noxious in SD)	no data	no data	no data	no data	no data	11
Field Bindweed (*Convolvulus arvensis*) (noxious in MT and SD)	51	no data	552	160	no data	1
Houndstongue (*Cynoglossum officinale*) (noxious in MT and SD)	368	2	403	5,258	2515	1109
Leafy spurge (*Euphorbia esula*) (noxious in MT and SD)	491	6,350	3	553	96	25
Orange hawkweed (*Hieracium aurantiacom*) (noxious in MT)	no data	no data	no data	73	21	22
Meadow hawkweed (*Hieracium* spp.) (noxious in MT)	no data	no data	under 1	46	no data	1
Black henbane (*Hyoscyamus* niger) (noxious in Stillwater and Powder River Counties, MT; noxious in SD)	no data	no data	no data	101	no data	no data
St. Johnswort (*Hypericum perforatum*) (noxious in MT and SD)	no data	12	no data	60	15	2
Field scabiosa (*Knautia arvensis*) (noxious in Gallatin County, MT)	no data	no data	no data	no data	under 1	5

Species	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger, Bangtail, Crazy Mountains	Madison, Henrys Lake Gallatin Mountains
Dalmatian toadflax (*Linaria dalmatica*) (noxious in MT and SD)	no data	no data	418	770	under 1	91
Yellow toadflax (*Linaria vulgaris*) (noxious in MT and SD)	no data	no data	no data	848	481	825
Curlyleaf pondweed (*Potamogeton crispus*) (noxious in MT)	no data	no data	no data	20[3]	no data	no data
Sulfur cinquefoil (*Potentilla recta*) (noxious in MT and SD)	under 1	no data	no data	324	74	26
Tall buttercup (*Ranunculus acris*) (noxious in MT)	no data	no data	no data	20	no data	under 1
Tamarisk (*Tamarix* spp.) (noxious in MT and SD)	no data	under 1	no data	no data	no data	under 1
Common tansy (*Tanacetum vulgare*) (noxious in MT and SD)	no data	no data	no data	271	50	38
Ventenata (*Ventenata dubia*) (noxious in MT)	no data	no data	no data	1[3]	no data	no data
Common mullein (*Verbascum thapsus*) (noxious in Stillwater County, MT; noxious in SD)	12	1	no data	516	166	138
Total infested acres (2018 data)[2]	**5,863**	**12,032**	**3,046**	**27,140[3]**	**8,348**	**8,302**

1. Cheatgrass (*Bromus tectorum*) in Montana is considered a "regulated plant" and not a listed noxious weed. Regulated plants have the potential to have significant negative impacts. The state recommends research, education and prevention to minimize the spread of this species.
2. There are 64,731 total infested acres, which include overlapping species-specific infestations (57,633 total footprint without overlapping acres).
3. Two invasives, Ventenata and Curlyleaf Pondweed, not known previously on the national forest were found and added to list in December 2019, no other species acres in the table were updated. This adjusted the total infested acres in Beartooth Geographic Area by 21 acres and total infested acres to 64,731.

Absaroka Beartooth Mountains Geographic Area

The Absaroka Beartooth Mountains Geographic Area includes two mountain ranges totaling 1,459,500 acres; about 13 percent of this area is vulnerable to invasive plants with 11 percent of the vulnerable area being infested. Large infestations of invasive plants occur mostly in disturbed areas and along motorized routes. Other disturbances are from large forest fires, recreational activities (campsites, trailheads, developed recreational areas, fishing access), timber harvest, and livestock grazing. New invaders include orange hawkweed.

Bridger, Bangtail, and Crazy Mountains Geographic Area

This area includes three mountain ranges and includes 321,701 acres; about 60 percent is vulnerable habitat with two percent of the vulnerable area being infested. Large infestations of thistles, houndstongue, spotted knapweed, and oxeye daisy occur in disturbed areas. Many of the weeds are on old logging areas, livestock allotments and on lands acquired through land exchanges. New invaders include orange hawkweed, leafy spurge, and St. Johnswort.

Madison, Henrys Lake, and Gallatin Mountains Geographic Area

The Madison, Henrys Lake, and Gallatin Mountains Geographic Area includes three mountain ranges totaling 952,813 acres; about 42 percent of this area is vulnerable to invasive plants with two percent of the vulnerable area being infested. Large infestations of invasive plants occur mostly in disturbed areas and along motorized routes. Other disturbances are from large forest fires, recreational activities (campsites, trailheads, developed recreational areas, fishing access), timber harvest, and livestock grazing. New invaders include orange hawkweed, blueweed (adjacent to the national forest), dyer's woad, field scabiosa, tall buttercup, Eurasian watermilfoil (adjacent to the national forest), tamarisk, and yellow starthistle.

Other Areas of Interest

Designated and other areas of interest on the Custer Gallatin where the presence of invasive plants may substantially compromise ecological integrity and habitat quality include the two wilderness areas, the wilderness study area, Forest Service recommended wilderness areas, inventoried roadless areas, research natural areas, botanical special areas, and areas of important wildlife habitat (such as sage grouse habitat and elk winter range). Table 62 lists the current level of weeds for each of these areas.

Table 62. Acres of inventoried invasive weeds in wilderness areas, roadless and recommended wilderness areas, research natural areas, elk winter range, and sage grouse habitat [1, 2, 3]

Infested Areas	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger Bangtail, Crazy Mountains	Madison, Henrys Lake, Gallatin Mountains
Wilderness Areas	not applicable	not applicable	not applicable	Absaroka Beartooth 2,123 acres	not applicable	Lee Metcalf 56 acres
Wilderness Study Area	not applicable	not applicable	not applicable	not applicable	not applicable	Hyalite/Porcupine/Buffalo Horn 186 acres
Roadless and Recommended Wilderness	not applicable	King Mountain 9 acres	Lost Water Canyon 17 acres	Chico Peak 44 acres, Beartooths less than 1 acre, Black Butte 11 acres, Fishtail Saddleback 1 acre, Line Creek Plateau 35 acres, Burnt Mountain 14 acres, North Absaroka 5,653 acres, Red Lodge Hellroaring 408 acres	Bridgers 92 acres Crazy Mountain 525 acres	Dry Canyon 3 acres, Reef 14 acres, Cabin Creek Wildlife Management Area 41 acres, Gallatin Fringe 65 acres, Lionhead Roadless 45 acres, Lionhead Recommended 3 acres Madison 276 acres
Research Natural Areas and Special Areas	not applicable	Poker Jim Research Natural Area no acres inventoried	Lost Water Canyon Research Natural Area 1 acre	Line Creek Research Natural Area 8 acres, Sliding Mountain Research Natural Area 2 acres	Bangtail Botanical and Paleontological SA 447 acres	Black Sands Spring Botanical Study Area 1 acre, East Fork Mill Creek Research Natural Area 5 acres, Obsidian Sands Research Natural Area less than 1 acre
Percentage of elk winter ranges with weed infestations and number of acres infested	not applicable	not applicable	not applicable	Big Timber – 2 percent (1,643 acres) Paradise Gardiner- 4 percent (7,064 acres) Beartooth 6 percent (4,369 acres)	Bridgers under 1 percent (230 acres) Crazy under 1 percent (116 acres)	Gallatin Madison – 2 percent (1,655 acres) Hebgen – 3 percent (2,454 acres)

Infested Areas	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger Bangtail, Crazy Mountains	Madison, Henrys Lake, Gallatin Mountains
Percentage of Sage grouse priority and general habitat with weed infestations and number of acres infested on National Forest System lands	Less than 1 percent of sage grouse general habitat is infested (28 acres) and 5 percent of sage grouse priority habitat is infested (96 acres)	2 percent of sage grouse priority habitat (5 acres) and 4 percent of general habitat is infested (3,460 acres).	Under 1 percent of sage grouse general habitat is infested (80 acres).	About 8 percent of general habitat is infested (207 acres)	No sage-grouse habitat on National Forest System lands in this geographic area	No infestations recorded in sage-grouse habitat

1. All weed infested acres were dissolved so overlapping areas were not double counted.

2. Larmont and Reid (2017) Assessment Forest Plan Revision Final Invasive Plants Report. 38.U.S. Forest Service Custer Gallatin Nation Forest.

3- Sage Grouse acres from GIS, 2020.

Vulnerable Habitats

Another useful attribute for describing the current weed infestation problem is to consider the number of acres infested compared to the potential acres of vulnerable habitat. Each weed species has a preferred habitat where the weeds will thrive and out-compete the native plants. Given the parameters of canopy cover, elevation, and aquatic and riparian habitat almost all areas are vulnerable except for dense forest (canopy cover greater than 60 percent) and areas above 9,000 feet.

Vulnerable areas may develop large infestations of weeds that alter ecological processes or site productivity. Conversely, areas not vulnerable have few or no weeds, and weeds that are present are generally limited to highly disturbed areas. Table 63 lists the total acreage for each area, the acreage of vulnerable habitat, and the current footprint of weed acreage.

Table 63. Vulnerable habitat (acres - all terrestrial and aquatic habitat less than 9,000 feet and less than 60 percent canopy cover) and current infestation footprint (acres) [1, 2]

Attribute	Sioux	Ashland	Pryor Mountains	Absaroka Beartooth Mountains	Bridger, Bangtail, Crazy Mountains	Madison, Henrys Lake, Gallatin Mountains
Total Acres	178,625	501,596	77,944	1,459,500	321,701	952,813
Acres of vulnerable habitat	174,758 99 percent of total area	496,558 99 percent of total area	58,063 74 percent of total area	187,805 13 percent of total area	192,680 60 percent of total area	395,706 42 percent of total area
Acres Infested footprint	7,477 4 percent of vulnerable area	16,122 3 percent of vulnerable area	2,025 3 percent of vulnerable area	19,812 11 percent of vulnerable area	4,485 2 percent of vulnerable area	7,961 2 percent of vulnerable area

1. Acreages are likely underestimations since not all acres have been inventoried.
2. Lamont and Reid.2016. Assessment Forest Plan Revision Final Invasive Plants Report.38. U.S. Forest Service Custer Gallatin Nation Forest.

Climate Change

Climate change is likely to result in differing responses among invasive plant species, due to differences in their ecological and life history characteristics. Climate change could result in either range expansion or contraction of an invasive species (Halofsky et al. 2018b). For example, modeling indicates that leafy spurge is likely to contract, and spotted knapweed is likely to shift in range. Invasive species are generally adaptable, capable of relatively rapid genetic change, and many have life history strategies (such as, prolific seed production, extensive deep roots) which can enhance their ability to invade new areas in response to changes in ecosystem conditions. Warmer temperatures, and associated drier conditions, more severe or frequent droughts, and more favorable conditions for wildland fire may increase the ability of invasive plants to establish and out-compete native plants. These changes may provide more opportunities for invasive plants to gain an advantage over native species, and spread within and beyond the Custer Gallatin National Forest's boundaries. This potential effect is common to all alternatives.

Studies have shown that elevated carbon dioxide levels can lead to a reduction in herbicide efficacy (Ziska and R. 2000, Ziska 2010). Reduced treatment effectiveness coupled with the potential for increased opportunities for growth and vigor has the potential for invasive plants to gain an even greater advantage over native species.

The effects of climate change on species' distributions are likely to be complex given the potentially differing climatic controls over upper and lower distribution limits (Harsch and Ris Lambers 2015). Some studies predict a movement in some invasive plant species range closer to the poles or upward in elevation (Chen et al. 2011). Some studies suggest that the threat posed to high-elevation biodiversity by invasive plant species is likely to increase because of globalization and climate change (Pauchard et al. 2009). Other studies suggest that distribution shifts in response to recent climate change could occur in either direction (upward or downward) (Harsch and Ris Lambers 2015).

Fire is another factor affected by climate change. When combined with climate change, fire/invasive plant relationships may be exacerbated leading to greater invasive species populations and spread. Other disturbances or shifts in historical patterns may be affected by climate change and in turn affect the spread of invasive species. As the agency responds to climate change by new, different, or more land and vegetation management actions, those disturbances could provide suitable conditions for invasive plants.

Aquatic Invasive Species

Aquatic invasive species damage ecosystems and threaten commercial, agricultural, and recreational activities. High densities of aquatic invasive plants can decrease the quality of fishing and swimming areas, and such infestations have been found downstream of the Custer Gallatin National Forest area. Eurasian watermilfoil will form dense mats of vegetation that provide poor habitat for waterfowl and fish, alter water quality by raising pH, decrease oxygen, increase water temperature, and limit access for fishing and swimming (Williamson and Fitter 1996, Parkinson et al. 2010, Parkinson et al. 2016). This plant was found in the Madison River and Jefferson River in 2010, and present in Carbon and Stillwater Counties, Montana. Curly leaf pond weed is another aquatic invasive weed that has similar ecological impacts as Eurasian watermilfoil (Parkinson et al. 2016) and it was found in Hebgen Lake, MT in 2011. In South Dakota, curly leaf pondweed has spread to at least three of four Missouri River reservoirs and several reservoirs within the Black Hills. Purple loosestrife was first found in Montana in 1992 in the western part of the state; now it is present in Meagher, Carbon and Rosebud Counties, Montana. Tamarisk is yet another invasive weed that forms thick clumps of vegetation adjacent to stream banks; the plant limits access to streams and displaces native plants. Tamarisk was first discovered in Montana in 1971 and now is present in more than eight counties; small infestations were found on both the Ashland and Beartooth Ranger Districts.

Other aquatic invasive species are present in a few locations on the Custer Gallatin, and prevention of their spread as well as new introductions is an ongoing management concern (Montana Fish Wildlife and Parks 2016). Among species documented on the Custer Gallatin, are New Zealand mudsnails (*Potamopyrgus antipodarium*), and American bullfrog (*Lithobates catesbiana*) (Montana Fish Wildlife and Parks 2016). The former species occupy Hebgen and Quake Lake, and New Zealand mudsnails are present in the Yellowstone River reaches near the Custer Gallatin. The spread of aquatic invasive species can occur through various pathways including moving watercraft between water bodies without removing invasive plants and animals, and releasing bait into water bodies. American bullfrog is present in the Stocker Branch above Blacks Pond; the species was apparently introduced into a private pond many years ago. Additionally, bullfrogs are present and spreading in the Yellowstone River system near Billings, Montana (Sepulveda et al. 2014) and as such could eventually reach national forest lands in other locations. The Yellowstone River has a new (or species which has been present for some time, but warmer water temperatures and lower base flows have allowed it to thrive) invasive species, *Tetracapsula bryosalmonae*, which can infect a variety of fish species and result in proliferative kidney disease. An outbreak in the Yellowstone River occurred in August 2016, killing thousands of fish. The South Dakota Department of Game, Fish and Parks and Montana Fish, Wildlife and Parks have aggressive programs to educate the public, require boat and equipment disinfection to help stop the spread of aquatic invasive species.

Emerald Ash Borer

The emerald ash borer (*Agrilus planipennis*), a beetle native to Asia, was first found in North America in 2002 in southeastern Michigan. Across the United States, emerald ash borer has killed tens of millions of ash trees and poses a serious threat to the green ash resources. The broad distribution of emerald ash borer is largely due to the inadvertent movement of infested ash commodities, especially before its original detection. Emerald ash borer was recently detected in eastern South Dakota and northern Colorado, and could pose serious threat to the health of green ash resources on the Sioux and Ashland Districts if transported to the area. In its native range emerald ash borer does not cause serious damage to ash trees, however, due to lack of host resistance by North American ash trees as well as lack of predators and parasitoids, emerald ash borer has had a significant impact on the ecology and economy of infested areas. Near the Sioux Ranger District, South Dakota Department of Game, Fish and Parks restricts the import of out-of-state firewood or from quarantined areas within the state, to help prevent the spread of emerald ash borer.

White Pine Blister Rust

White pine blister rust is a non-native disease that entered the U.S. at the turn of the 20th century. Its primary host species on the Custer Gallatin are whitebark pine and limber pine. It also infects *Ribes* species (currants and gooseberries), and possibly louseworts and Indian paintbrush, which are alternative hosts required for the disease to complete its life cycle. As blister rust has moved into fragile, high-elevation ecosystems, successional pathways have been altered, hastening the conversion to climax species such as subalpine fir. Blister rust infections range in severity, but often progress from infecting and girdling branches to killing trees of all sizes over time. Surviving trees are weakened and susceptible to other mortality agents such as the mountain pine beetle. The interaction of warming climates, mountain pine beetle, fire exclusion (which has allowed shade tolerant species to out-compete whitebark pine), and blister rust has resulted in a bleak outlook for whitebark pine in many areas.

Because it is non-native, all levels of blister rust infection are outside the natural range of variation. There is no known method for eradicating the disease, although actions such as pruning can reduce infections. A small percentage of host trees display one or more resistance traits that enable them to avoid or survive infection; encouraging regeneration (natural or artificial) from these seed sources provides hope for perpetuation of the species. There is currently no statistical means to estimate blister rust infection or hazard across the national forest. Based on field experience, however, white pine blister rust is generally present wherever five-needled pines are found. Many of these forests have become dominated by snags, with only a few seed-bearing survivors that possess one or more resistance traits. Still, in many areas, seedlings continue to establish.

There is a great deal of uncertainty surrounding climate change and its potential effect on vegetation conditions. Whether it is invasive species such as white pine blister rust or other stressors such as drought, uncharacteristic wildfires, elevated native insects and disease levels, unusually high forest densities, or some other agent or combination of agents that serves to stress trees and forest ecosystems; recent research suggests that climate change will likely exacerbate those stressors and "stress complexes" will continue to manifest themselves (Halofsky and Peterson 2016).

White-Nose Syndrome

Several bat species, particularly those in the genus *Myotis*, are vulnerable to White-Nose Syndrome, a disease that is caused by a fungus (*Pseudogymnoascus destructans)* (*Pd*) that can be transmitted by other bats as well as by humans visiting caves where bats are roosting. The disease erodes bat skin tissue and often appears white when it infects the skin of the nose, ears, and wings of hibernating bats. Migrating bats carry spores hundreds of miles. Spores can be found in cloth and people (cavers, researchers and casual visitors) can inadvertently spread it by visiting affected sites and then unaffected sites (caves, mines, or buildings where bats hibernate). Millions of bats in northeast US and Canada are being lost to white-nose syndrome with experts being concerned that some bats are becoming extinct in certain regions. Currently, white-nose syndrome has not yet been detected in Montana but was recently confirmed in the Black Hills National Forest in South Dakota just south of the Sioux District. The disease was also recently confirmed at Badlands National Park in South Dakota and the Fort Laramie National Historic Site in eastern Wyoming. Any entity wishing to capture, handle, or inventory bats on the South Dakota portion of the Sioux Ranger District, must obtain a permit from the South Dakota Department of Game, Fish and Parks and follow guidelines to avoid the spread of *Pd*.

3.9.3 Environmental Consequences

Invasive species cause undesirable ecological impacts. Species arrived in this country with few or no natural pathogens or controlling agents such as insects; consequently, they increase in density and out-compete native species. Terrestrial and aquatic noxious weeds are capable of successfully expanding their populations into new ecosystems and can create lasting negative impacts to native plant communities. Impacts from noxious weeds can be exacerbated by fire, native pests, weather events, human actions, and environmental change (U.S. Department of Agriculture 2013). It is still unknown what the total consequences of white-nose syndrome has on various bat species, but it poses a substantial threat.

All Alternatives

Management Direction under All Alternatives

The Records of Decision for noxious weed control signed for the Gallatin and Custer national forests in 2005 and 2006, respectively, would continue to be implemented under all alternatives. These decisions implement an integrated pest management approach. These weed control decisions also adopts an adaptive management approach to new infestations and broadens herbicide application methods to include aerial treatment options as well as provides the ability to apply herbicide in wilderness areas. The analysis in the final environmental impact statements also evaluated the use of new herbicides and imposed new environmental safeguards. Existing and newly approved biological control agents can also be applied to infestations where appropriate. The selected alternatives contained environmental protection measures to reduce non-target species exposure to herbicides caused by spray drift through wind speed restrictions during application, buffering of sensitive areas, weather monitoring, boundary marking, and restrictions on areas to be sprayed, and use of drift reduction agents.

To avoid the spread of non-native disease, pathogens, or other taxa to native wildlife, the state wildlife agencies require permits to capture, handle, or collect species. States require permit holders to follow state protocol. On bodies of water managed by or jointly managed with States, there are requirements to disinfect boats and equipment.

Effects Common to All Alternatives

Noxious and other invasive weeds have the potential to substantially outcompete native vegetation and forage when left unchecked. Impacts are similar between all alternatives, including the current plans. Invasive plants will continue to have a presence on the Custer Gallatin National Forest landscape, with existing infestations and continual introductions of new invaders. Ventenata and Medusahea are two invasive grasses that have potential to alter landscapes (Averett et al. 2016, Fryer 2019), and recently one infestation of ventenata was found on the national forest. Some invasive species have become "naturalized" to vegetation communities on the Custer Gallatin National Forest, and some level of their presence will persist in all alternatives. Canada thistle, cheatgrass, houndstongue, Kentucky bluegrass, smooth brome, and timothy are all examples of invasive species that have spread to many herbaceous plant communities across the national forest. Infestations, known and yet to be discovered, are a concern for weed managers under all alternatives. Management under alternatives would attempt to slow the spread and introductions of new invaders as well as prevent existing weed species from establishing to new non-infested areas. The Custer Gallatin National Forest will continue to conduct weed treatments with the most effective options (chemical, mechanical/physical, cultural, and biological) as they become available and to implement mitigations such as the weed-free forage program, use of weed-free sires during fire and other incidents, and vehicle washing/inspections for contract work.

Invasive plants have increased across the Custer Gallatin National Forest, with a present infestation footprint of approximately 57,600 acres. Assuming the national average annual rate of spread of 8 to 12 percent applies, the Custer Gallatin National Forest can expect to encounter an increase in invasive plant infestations at a rate of up to approximately 4,600 to 6,900 acres per year.

Of additional importance is the current and predicted continuation of globalization, or the free movement of goods, capital, services, people, technology, and information. Globalization processes will most likely significantly affect the States of Montana and South Dakota, especially as the human population continues to grow. Globalization facilitates and intensifies the spread of invasive alien species (Meyerson and Mooney 2007). As a result, the extent and density of invasive plant infestations as well as the number of invasive plant species has the potential to increase on the Custer Gallatin.

Current Plans

Management Direction under the Current Plans

The 1986 Custer Forest Plan and 1987 Gallatin Forest Plan are similar with respect to invasive plants and noxious weeds. Both plans direct managers to use an integrated pest management program to control noxious weeds and to work with partners (other agencies and adjacent landowners) to control weeds. Differences between the two plans include the following:

The Custer Plan prioritizes control based on size of infestation; focused on eliminating new starts and small infestations. For bigger patches, containment or reduction in size is specified (Custer Plan, pages II-3 and II-24). This element of the plan provides consistent direction for the strategy and priority of treatment areas across the national forest.

The Gallatin Plan standard states that funding for weed control on disturbed sites will be provided by the resource that causes the disturbance (Gallatin Plan, (2015b) amended, page II-32). This plan standard provides incentive for all resource areas to minimize the spread of weeds and to help fund weed control.

Forestwide environmental impact statements for weed management were completed on both national forests (Custer National Forest (2006a), Gallatin National Forest (2005)) and provide further direction. They adopted an adaptive strategy to determine where, when and how to treat sites, considering such factors as weed species and treatment prioritization, ecological importance of the site and funding.

Neither of the current plans contain direction related to aquatic invasive species, emerald ah borer or white nose syndrome.

Effects of the Current Plans

In spite of its lack of specificity in the actual 1985 and 1986 forest plan direction, as amended, the current plans encompass current practices and is considered appropriate to address invasive plant species while being flexible to budget constraints. Prioritizing treatment areas and control strategies have been effective only to the extent that resources have been available to implement them. There is still a trend of increasing weed introduction and spread given limited resources for prevention and treatment.

Revised Plan Alternatives

Management Direction under the Revised Plan Alternatives

The purpose of the invasive species plan components is to ensure that all Forest Service management activities are designed to minimize or prevent establishment or spread of invasive species on national forest lands, or to adjacent areas, and to provide for healthy resilient and resistant ecosystems.

All the revised plan alternatives contain multiple-use resource management objectives with varying degrees of forest vegetation management. Timber production, livestock grazing, and recreational activities continue to provide endpoints for introduction and subsequent seed dispersal, as well as the environmental disturbance that enhances germination and establishment of non-native plants.

The revised plan alternatives standard FW-STD-INV-05 requires mechanisms for addressing aquatic invasive species. More general or universal procedures, such as using current best practices for equipment washing before and after entering an area, are included in the management approaches appendix (appendix A) of the revised plan.

The revised plan alternatives, goal FW-GO-INV-04, encourages a coordinated approach to invasive species management, awareness, and education. The management approaches outlined in appendix A of the revised plan provide educational prevention information and suggested guidance if emerald ash borer does become discovered in or near the national forest. The National Response Framework for Emerald Ash Borer is intended to assist the national forest to prepare for and respond to Emerald Ash Borer by providing an overview of the resources available and guidance in obtaining additional information.

As outlined by management approaches in appendix A of the revised plan, the U.S. National White-nose Syndrome Decontamination Protocol (U.S. Department of the Interior 2016e) is intended to assist the Custer Gallatin to prepare for and respond to white-nose syndrome by providing decontamination procedures to effectively clean and treat clothing, footwear, and equipment that may have been exposed to the fungus. Management approaches also include prevention measures and educational messages in limiting white-nose syndrome spread.

Effects Common to all Revised Plan Alternatives

Invasive Plants

Noxious weed management would continue under direction of both the Gallatin National Forest Weed Environmental Impact Statement (2005) and the Custer National Forest Weed Environmental Impact Statement (2006a), until revised. Any subsequent decisions would continue to provide additional direction. Infestation levels of invasive plants would likely remain steady to slightly increasing over time. The rate of increase would be higher under alternative E than the other alternatives due to lower treatment objectives. Some species may contract in density as new treatment and biological options become available, while other weeds would expand in range and density.

The revised plan alternatives provide similar protections and guidelines for invasive species treatment as the existing plans.

Aquatic Invasive Species

The current plans do not contain specific standards or guidelines related to aquatic invasive species. Spread and introduction pathways are inherent to most projects and types of forest use. The revised plan alternatives standard FW-STD-INV-04 requires prevention measures at the project level. These activities would include but are not limited to proactive measures to avoid accidental introduction, transporting water across drainage boundaries for fire suppression, constructing stream fords, operating equipment in a riparian area and near a water course, and the use of pumps and sumps for fire suppression, or construction related dewatering activities.

Emerald Ash Borer

The current plans do not contain specific standards or guidelines related to emerald ash borer. Spread and introduction pathways are not inherent to most projects or forest use. However, the distribution of emerald ash borer is largely due to the inadvertent movement of infested ash commodities such as unprocessed logs, firewood, or pallets. The revised plan alternative goals FW-GO-INV-01, 03 and 04 encourage prevention and interagency coordination. These goals and the information outlined in the management approaches in appendix A of the revised plan can better equip the Forest Service for their efforts to proactively manage to avoid this insect, and then prepare for and/or respond to emerald ash borer impacts, and minimize those impacts and costs.

White Pine Blister Rust

The current plans do not contain specific standards or guidelines related to white pine blister rust and its relationship to five-needle pines such as whitebark pine. The revised plan alternatives include objective FW-OBJ-PRISK-02 outlining treatments for the purpose of sustaining or restoring whitebark pine, which includes white pine blister rust considerations.

Goal FW-GO-PRISK-01 and management approaches for the revised plan alternatives include cooperation with the Greater Yellowstone Coordinating Committee-Whitebark Pine Subcommittee on whitebark pine conservation strategies and adaptive management of habitat which incorporates principles of restoration documented in Whitebark Pine Strategy for the Greater Yellowstone Area and

Adaptive Action Plan prepared by the Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee (2011, 2015) and any new best available scientific information for possible whitebark pine restoration strategies and activities (Keane et al. 2012).

- Promoting rust resistance, by a) supporting selective breeding programs to develop and deploy blister-rust resistant whitebark; b) facilitating and accelerating natural selection for rust resistant trees by reducing competition, providing openings for natural seed dispersal and seedling survival; and c) planting seedlings from trees known to have some level of resistance.
- Saving seed sources, by protecting mature seed-producing resistant whitebark pine trees so that apparent rust-resistant seeds can be harvested in the future; and
- Employing restoration treatments, including limiting the spread of blister rust, using fire to encourage regeneration, implementing silvicultural cuttings to reduce competition and increase vigor and reduce likelihood of mountain pine beetle attacks, planting blister rust-resistant seedlings to accelerate the effects of selection, and promoting natural regeneration and diverse age class structures to maintain ecosystem function and reduce landscape level beetle hazard, and to provide large populations for selection for rust resistance.

The revised plan alternatives propose guideline FW-GDL-PRISK-03 that states when conducting management activities in or near whitebark pine trees or stands identified for collection of scion, pollen, or seed; areas identified as important for cone production or blister rust resistance; and whitebark pine plantations, project-level design criteria or wildland fire management strategies should protect them from potential loss to support the recovery or long-term persistence of this species.

White-Nose Syndrome

Spread and introduction pathways are not inherent to most projects or forest use. However, the distribution of white-nose syndrome is largely due to the movement of this non-native fungus from migrating bats that can carry spores hundreds of miles. Spores can be found in cloth and people (spelunkers, researchers and casual visitors) who can inadvertently spread it by visiting affected sites and then introducing the pathogen to unaffected sites (caves, mines, or buildings where bats hibernate or roost. The information provided as management approaches in appendix A of the revised plan can better equip the Forest Service for their efforts to proactively manage to avoid this pathogen and prepare for and/or respond to white-nose syndrome impacts, and better manage and minimize those impacts and costs.

Effects that Vary by Revised Plan Alternatives

Plan objective FW-OBJ-INV-01 varies in amount of weed treatment by alternative, with the lowest objective for acres treated in alternative E. Threats to native vegetation would be reduced by revised plan alternatives B, C, D, and F and less so in alternative E.

Consequences to Invasive Species from Plan Components Associated with other Resource Programs or Management Activities

Effects from Timber and Vegetation Management

Ground-disturbing activities, equipment transport and use associated with management activities such as timber harvesting, fire treatments and fire suppression, or other authorized uses can contribute to the introduction and expansion of invasive species. Most of these risks are minimized with prevention (contract clauses to decontaminate equipment) and integrated pest management techniques, such as, pre and post project treatments and localized site restoration and rehabilitation with native plant material.

Vegetation management activities such as timber harvest, the use of skidders and mechanical harvest techniques and equipment have contributed to the introduction, spread, establishment and persistence on the landscape. Contract specifications help prevent introduction of invasive species to units from outside or within the National Forest System lands by requiring cleaning of equipment. Other best management practices include pre- and post-implementation treatment of haul routes and native plant material seeding disturbed areas after implementation to prevent establishment of infestations.

For analysis of potential of invasive species spread, the objectives for harvest (FW-OBJ-VEGF-01) and fuels treatment acres (FW-OBJ-FIRE-01) were used to assume the amount of ground disturbance expected to occur. The direct correlation between ground disturbance and potential of invasive species to establish in those areas was used to differentiate effects between alternatives. Table 64 provides a comparison of the harvest and prescribed fire objectives (acres) per decade by alternative.

Table 64. Acres of objectives for vegetation treament (fuels and timber harvest) per decade by alternative

Objective	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Total acres of vegetation treatment	60,000	60,000	60,000	80,000	50,000	60,000

The potential ground-disturbing activities associated with overall amount of timber harvest and prescribed fire objects per decade would be similar for the current plans and alternatives B, C, and F, and therefore, potential weed spread would be similar. Alternative D could present more ground-disturbing activities with alternative E presenting the least ground disturbance. However, for all alternatives plan components are in place that would limit or mitigate this potential.

Effects from Fire and Fuels Management

Site-specific projects are evaluated under the National Environmental Policy Act (NEPA) for the impact of invasive species and generally projects have requirements to prevent their spread as mitigations for project implementation. For fire treatments, both wildfire, and planned ignitions, invasive species introduction, spread, establishment and persistence have a potential for occurrence. These circumstances result in a change of treatment priorities for the invasive species management program, under all alternatives.

Fire can result in an increase in non-native species diversity and cover, whether it is a prescribed burn, wildfire, or suppression actions (Zouhar et al. 2008). Invasive species such as cheatgrass may alter fire regimes in drier forests, shrublands and grasslands, which comprise much of the Custer Gallatin.

Wildfires would occur in the future under all alternatives, although uncertainty exists as to extent and location. Weather and climatic factors along with fuels conditions would affect intensity and spread of a fire event. Effects of wildfire on invasive species spread potential is the same across alternatives. Effects of fire suppression actions that could spread non-native terrestrial and aquatic invasive species would also be the same across alternatives, however plan components address the need for preventing spread (FW-STD-INV-03, 04). Generally, prescribed fire implementation would be similar under all alternatives as well. There is potential for establishment and spread of invasive plant species within burned areas, depending largely upon site-specific conditions, such as fire location, vegetation types that were burned, presence of weed infestations pre-fire, potential pathways, and fire characteristics. Weed infestations within burned areas would be addressed by following revised plan management direction, which is similar for all alternatives (FW-STD-INV-03, 04).

Effects from Watershed, Soil, Riparian, and Aquatic Management

Plan components and activities related to watershed, soil, riparian, and aquatic habitat with the greatest influence are those associated with riparian management zones. The revised plan alternatives would adopt riparian management zones and result in more acres subject to riparian area plan components as compared to the current plans, in which streamside management zones would be used.

With the revised plan alternatives, standard FW-STD-RMZ-03 limits the use of herbicide treatments within riparian management zones to instances where they are needed to maintain, protect, or enhance aquatic and riparian resources or to restore native plant communities. Policy (national forest's weed EIS decisions) and plan components limit the treatment methods for some invasive plants in riparian areas and near groundwater-dependent ecosystems; for example, buffers, hand pulling, or glove wicking may be required instead of herbicide use.

All the revised plan alternatives have desired conditions (FW-DC-VEGNF-02 and FW-DC-INV-01) of non-existent or low abundance invasive species, including aquatic invasive species, which do not disrupt ecological functioning. Aquatic invasive species management approaches include education and outreach efforts and decontamination measures for both public and agency.

Effects from Wildlife Management

Noxious weed expansion is most likely occurring to some degree with transport of seed from wildlife. Several satellite patches of noxious weeds are located on the Custer Gallatin National Forest that are far from roads and trails, have no possible livestock or pack animal access, and are far from any known infestation. Native ungulates can move seeds from infested areas and relocate them in remote or off-the-grid areas. Hounds tongue has been and will continue to be on the move throughout the Custer Gallatin, but other species such as spotted knapweed and toadflax species are showing up in unexplainable places. Birds could be another transporter of weed seed. These transport issues from wildlife will continue under all alternatives.

Under revised plan alternatives, permitted grazing of domestic sheep would be precluded inside the recovery zone/primary conservation area for grizzly bears, except for the targeted use of domestic sheep or goats for the express purpose of weed control would be allowed in alternatives B, C, E, and F (FW-STD-WLGB-06 and 07). The grizzly bear recovery zone/primary conservation area is in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, Gallatin Mountains Geographic Areas, but does not cover the entirety of the geographic areas.

The current plans, along with alternatives B, C, E, and F allow for sheep or goats for weed control forestwide with appropriate risk assessment relative to risk of disease transmission with bighorn sheep while alternative D does not allow for sheep or goats for weed control forestwide (FW-STD-GRAZ-03). Under alternative D biological control by sheep or goats is removed as a treatment method in the Sioux; Ashland; and Bridger, Bangtail, Crazy Mountains Geographic Areas where bighorn sheep do not occur and where risk of contact is extremely low. Under alternative D biological control by sheep or goats is removed as a treatment method in the remaining geographic areas and forecloses opportunities to conduct site-specific risk of contact assessments for targeted and tightly controlled grazing for weed control. Use of domestic livestock grazing for targeted weed control lends itself well to tight restrictions on timing, number of animals, location of use, and oversight requirements, so risk of contact with bighorn sheep could be effectively minimized.

All revised plan alternatives have the desired conditions (FW-DC-INV-01, FW-DC-VEGNF-02) of having invasive species, including white-nose syndrome fungus, be non-existent or in low abundance, and do not disrupt ecological functioning. Management approaches for white-nose syndrome address educational efforts and disinfection measures for both publics and agency personnel for prevention measures.

Effects of Plan Land Allocations for Designated Wilderness

Generally, wilderness areas and large roadless lands are less likely to contain invasive weeds due to less widespread public access, especially via motorized means. However, these large roadless areas are vulnerable to invasive species infestation and spread from recreational uses. Seed transport happens inadvertently, by humans, dogs, and pack stock. Trails that receive high uses, including those in wilderness areas, are vulnerable to invasive weed infestation. Areas of high use and ground disturbance occur within wilderness areas and are as vulnerable to noxious weed infestation as developed sites outside wilderness and are more difficult to treat due to limited access. Designated wilderness plan components in all alternatives that limit group size and restrict certain areas to camping and stock use may help reduce potential for noxious weed infestation (FW-STD-DWA-01, 02, 05, 06 and 07). Integrated pest management techniques would be modified by restrictions within designated wilderness.

Effects from Access and Recreation Management

A main pathway for noxious weed spread is vehicle use (Taylor et al. 2012). Many existing infestations can be found along, or have originated from, roadsides because vehicle traffic provides ideal means for noxious weed spread. Primitive two-track roads also provide opportunity for noxious weeds to become established on areas of bare soil and disturbance. If vigilant monitoring and treatments do not occur, the likelihood of noxious weeds spreading into adjacent native plant communities increases once noxious weeds establish on road or trailside prism. An even greater threat for spread of noxious weeds is from unauthorized cross-country travel. Infestations can go undetected for years, resulting in a well-established population that oftentimes are difficult to access.

Transportation of weed seed by contractor or special use vehicles, or equipment, on National Forest System roads is managed to a degree. Contract stipulations require specific actions, such as, vehicle and equipment washing, to lessen the possibility of weed transport to reduce the risk of new infestations. Recreational use of roads and motorized trails as well as unauthorized cross-country travel by the general public presents a greater risk, because of the lack of control measures and the lack of knowledge about invasive species spread.

In all alternatives, inadvertent seed spread could decrease in areas that either are no longer suitable motorized transport or are more difficult to access. During road closure and decommissioning activities that require short-term ground disturbance, there could be short-term invasive plant establishment until invasive weed treatments are applied to the disturbed area. Additionally, road closures and decommissioning make administrative access more difficult to treat invasive species in some areas of the Custer Gallatin National Forest.

Summer motorized transport poses the greatest risk of invasive weed transport. In general, the potential for weed infestation threats would be heavily correlated to the amount of open summer motorized routes.

There are no changes to open motorized roads in any alternative. Alternatives vary in miles of summer trail suitable for motorized transport. Under the current plans and alternatives B, E, and F, there would be no change to suitability of motorized trails. Under alternative C, about four miles of trails would no longer be suitable for motorized transport. Under alternative D, about 172 miles of trails would no longer be suitable for motorized transport.

Alternative D would be the most favorable to limit the spread of invasive species from motorized transport because it would have the fewest miles of trails suitable for summer motorized transport. The current plans and alternatives B, E, and F would have a higher potential to increase the spread of invasive weed species through motorized transport since these alternatives would have the most miles of trails suitable for summer motorized transport. Alternative C would have slightly fewer miles of trails suitable for summer motorized transport and therefore be more favorable to limit the spread of invasive species from these routes than the current plans and alternatives B, E, and F.

Although alternative D would be the most favorable for slowing the spread of invasive species by motorized transport, the alternative could also create issues for existing weed infestations to go undetected and untreated in new recommended wilderness areas. Alternative D would identify the most miles of trails as no longer suitable for motorized transport and possible weed pathways of any alternative, but could also increase treatment difficulty or detection of existing weed populations in new recommended wilderness. If resources continued to be devoted to monitoring and treatment of weeds on routes no longer suitable for motorized transport, minimal negative effects would result from all revised plan alternatives.

Road maintenance, reconstruction and construction can contribute to the establishment and spread of invasive plants. Gravel pits can oftentimes become infested with invasive species (e.g., plant material and snails) if not routinely checked and treated. Invasive species can be spread onto lands far from the gravel pit when gravel is used for road surfacing or other purposes. This potential for this effect would be the same under all alternatives; however, standards FW-STD-INV-01 and FW-STD-RT-02 and policy would mitigate this. Management direction to address noxious weeds is in place for all alternatives and would continue to be followed (Forestwide Weed Management EIS decisions, (2005) and (2006a)).

Recreational activities, including non-motorized, are pathways for potential seed establishment and dispersal. Recreation activities and areas receive concentrated and frequent use and continual ground disturbance. Frequently, infestations are found around trailheads, trails, campgrounds, and other developed recreation sites. These seed sources pose a risk of further spread into wilderness and undeveloped lands. Areas located immediately adjacent to and surrounding developments tend to experience the most disturbance, while the peripheries of these areas are less disturbed and less likely to be favorable for invasive species establishment and persistence.

The revised plan alternatives include goal FW-GO-INV-04 encouraging public education. Methods used to help prevent invasive species from being introduced and spreading into recreation areas include public education and requirements for use of weed-free hay for pack stock. Public education efforts, such as the Play Clean Go campaign, have helped raise invasive species awareness for many recreational activities. Lack of public knowledge, combined with limited enforcement and/or monitoring options for recreational activities is a concern for weed introductions, and would be similar for all alternatives.

Effects from Permitted Livestock Grazing Management

Invasive species expansion may occur with the transport of seed by livestock from infested areas. Seeds can be spread through livestock feces, fleeces, and hooves, and many can pass through an animal's digestive system and retain the ability to germinate (Belsky and Gelbard 2000). Native grazers such as mule deer, bighorn sheep and elk, and some birds can also perform this same method of seed spread. Conversely, prescribed livestock grazing has also been shown to be an effective method in managing some large invasive plant infestations while assisting the ecological succession process (Sheley et al. 2011).

Localized areas where congregation can occur, such as water developments and supplement locations, contribute to reduced ground cover and can become potentially susceptible to invasive plant establishment. All alternatives would have equal impacts from livestock grazing relating to invasive species establishment on acres where disturbance results in reduced native plant vigor and cover. The revised plan alternatives include plan components that would enhance rangeland vegetation communities (VEGNF), which would be more resistant to invasive species. Options to adjust livestock grazing management in the future may involve more range improvement infrastructure, thus increasing acres disturbed by construction activities in the short run. Some initial ground disturbance from new off-site water development and fencing may cause some ground disturbance, and therefore, provide a niche for invasive plants to establish. Typically, supplemental feeding with hay on National Forest System lands is not permitted which reduces opportunity for a potential invasive species spread vector. In the long term, the revised plan alternatives would improve livestock grazing management, which in turn promotes the enhancement of desirable native plant communities. The revised plan alternatives provide plan components (PRISK, VEGF, VEGNF, and INV) to increase the resistance and resilience of native plant communities and pursue the best available invasive species management options while maintaining multiple uses such as livestock grazing.

Effects from Energy and Minerals Management

All energy and mineral management activities on national forest lands are required to meet applicable environmental protection measures as required by law, regulation, and policy. Proposed energy and mineral activities are subject to review and approval, as well as environmental analysis, review, application of best management practices, including those for invasive species, reclamation and monitoring. Standards FW-STD-EMIN-01 and 02 direct that energy and mineral activities only be authorized when the associated reclamation plan includes provisions to return disturbed areas to stability and land use comparable to adjacent lands and/or pre-operational site conditions, which would include weed monitoring and treatments.

Cumulative Effects

Invasive species spread without regard to administrative boundaries. As such, the cumulative effects of the Custer Gallatin National Forest invasive species management under any alternative, including the current plans, may negatively or beneficially impact adjacent Federal, State and private lands depending upon the specific site treatment or lack thereof. Adjacent or nearby landowners specific site conditions and weed treatment efforts also would affect weed conditions and treatments on National Forest System lands. Many acres of individual and other private entity lands lie within the boundaries the

Custer Gallatin, and adjacent to National Forest System lands. Under all the alternatives, coordination with state and local agencies and communication with the public would continue to combat the spread of undesirable non-native invasive species.

Portions of the Custer Gallatin National Forest adjoin other national forests, each having its own land management plan. The Custer Gallatin National Forest is also intermixed with lands of other ownerships, including private lands, other Federal lands, and state lands. Some adjacent lands are subject to their own resource management plans. The cumulative effects of these plans in conjunction with the Custer Gallatin National Forest revised plan cumulatively affect to invasive species management.

The plans for national forest system lands adjacent to the Custer Gallatin National Forest include the Helena Lewis and Clark, Shoshone, Targhee, and Beaverhead-Deerlodge national forests. All plans address invasive species. In general, management of invasive species is consistent across all national forests due to law, regulation, and policy and plan components are relatively consistent and compatible with overall goals.

Bureau of Land Management lands near the Custer Gallatin are managed by the Dillon plan (2006), Butte plan (2009a), Billings plan (2015a), Miles City plan (2015b) and South Dakota plan (2015c) field offices. The resource management plans are the Bureau of Land Management equivalent to a national forest management plan and would manage for healthy native plant communities and aquatic systems by addressing invasive species.

The Greater Yellowstone Area Coordinating Committee Terrestrial Invasive Species subcommittee includes Forest representatives. This committee coordinates annually on various invasive plant species topics such as overall coordination, coordinated weed management areas, Greater Yellowstone Area weed database; gravel pit maintenance and monitoring, and new invaders. Plan components are consistent and compatible with overall goals of this subcommittee.

The Yellowstone National Park Foundation Document (2014c) calls for preserving environmental integrity, which allows natural processes to shape ecosystem functions. Broadly, the terrestrial and aquatic resources characteristics in this area and guidance toward invasive species are therefore likely similar to the wilderness areas in the adjacent Absaroka Beartooth and Madison, Henrys Lake, Gallatin Mountains Geographic Areas and would likely complement these conditions.

The NRCS Soil Health strategy (U.S. Department of Agriculture 2015e) briefly outlines goals related to promoting soil health and conservation, primarily on agricultural lands. Soil quality is expected to be good; however, these areas may still support invasive species on agricultural lands.

Montana conducted a statewide assessment of forest resources and identified issue-based focus areas with implementation strategies including forest biodiversity and resiliency (Montana Department of Natural Resources and Conservation 2020). Strategies include managing ecosystem and biotic composition to achieve ecological integrity through recovery of species diversity, water quality and quantity, soil quality and function by implementing best available scientific information and adaptive management; and increasing terrestrial carbon sequestration and soil carbon sinks. The maintenance of native vegetation and emphasis on diversity is expected to contain or reduce invasive species. This management is expected to be complementary.

Noxious weed treatment routinely occurs in each county in and near the national forest. County plans generally aim to maintain native vegetation communities and reduce noxious weeds.

Conclusion

Invasive species will continue to have a presence on the Custer Gallatin National Forest landscape, with existing infestations and continual introductions of new invaders. Some invasive species have become "naturalized" on the Custer Gallatin National Forest, and some level of their presence will persist in all alternatives. Management under all alternatives would attempt to slow the spread of weeds and introductions of new invaders. However, in comparison to the other alternatives, alternative E would do less to slow the spread since objectives for weed treatment are about one quarter of recent annual levels of treatment that have been done. All alternatives provide prevention measures to keep weed species from establishing into new non-infested areas. The Custer Gallatin National Forest will continue to conduct invasive species treatments with the most effective options (chemical, mechanical, cultural, and biological) as they become available and to implement mitigations such as the weed-free forage program, use of weed free sites during fire and other incidents, watercraft inspections, and vehicle washing/inspections for contracts.

The revised plan alternatives update the 1986 and 1987 forest plans for management of nonnative invasive plants by formalizing current, effective invasive species management practices. Plan components in the revised plan alternatives would have a positive effect to slow the spread of invasive plants as well as manage existing infestations by moving towards adopting best tools and practices available in the future.

Alternatives A, B, C, and F have potential to create similar amounts of disturbance relating to timber harvest and prescribed fire with alternative D having potential to create the most amount of disturbance by vegetation management activities. Alternative E may be the most favorable as far as limiting the total harvest and prescribed fire footprint on the Custer Gallatin. Vegetation management projects would have plan components that prescribe best management practices that should limit the introduction of invasive species as well as implement treatment options if they are found.

Plan components under all alternatives regarding livestock grazing should generally have positive effects on rangeland vegetation condition. In turn, rangelands within grazing allotments should have more resilient and resistant plant communities that can compete with invasive species to a certain degree. Small, localized areas of disturbance relating to range improvement construction may be vulnerable to weed infestation and will need monitoring and treatment actions built into project design. However, these improvements should help improve vegetation condition and grazing management that will benefit rangeland vegetation in the future.

Alternative D, with more recommended wilderness areas, would have fewest spread pathways by vehicles since it would have 172 fewer miles suitable for motorized transport than the next lowest alternative C, which would have about 4 fewer miles. The current plans and alternatives B, E, and F would have no change. All alternatives have options to implement best management practices and treat weeds on open motorized and bicycle routes.

All alternatives except D allow sheep or goats for weed control forestwide with appropriate risk assessment relative to risk of disease transmission with bighorn sheep while alternative D does not allow for sheep or goats for weed control forestwide. Under alternative D biological control by sheep or goats is removed as a treatment method in the Sioux; Ashland; and Bridger, Bangtail and Crazy Mountains Geographic Areas where bighorn sheep do not occur and where risk of contact is extremely low. Under alternative D biological control by sheep or goats is removed as a treatment method in the remaining geographic areas and forecloses opportunities to conduct site-specific risk of contact assessments for targeted and tightly controlled grazing for weed control. Use of domestic livestock grazing for targeted weed control lends itself well to tight restrictions on timing, number of animals, location of use, and oversight requirements, so risk of contact with bighorn sheep could be effectively minimized.

Ultimately, consequences to invasive species from plan objectives associated with balance of funding with other resource programs or revision topics are similar under the current plans and alternatives B, C, and F, while alternative D places more emphasis on weed treatment and alternative E provides less emphasis on treatment. Management activities mitigate risk, but lower treatment objectives under alternative E has the greatest risk of spread due to less treatment of spread vectors. An aggressive integrated pest management approach must be implemented in order to keep invasive species from expanding beyond existing infestation levels.

All revised plan alternatives provide sufficient plan components and prevention management approaches and best management practices for aquatic invasive species, emerald ash borer, white pine blister rust and white-nose syndrome.

3.10 Wildlife Diversity

3.10.1 Introduction

The following sections address consequences to wildlife and their habitat from the range of alternatives considered. This analysis deals primarily with terrestrial wildlife species, including land-dwelling birds, mammals, and reptiles. Aquatic and semi-aquatic species, including fish, amphibians, beavers, and aquatic invertebrates, are addressed in the Watershed, Aquatic, and Riparian sections of this document. Terrestrial invertebrate species such as pollinators, are addressed in the Terrestrial Vegetation section of this document.

The 2012 Planning Rule requires national forest land management plans to provide the ecological conditions to maintain the diversity of plant and animal communities and support the persistence of native species over time. The Custer Gallatin National Forest provides a complex, and widely variable range of habitats, which in turn supports a high diversity of wildlife species. According to the Montana Natural Heritage Program website (http://mtnhp.org), as of June 2018, over 360 different species of mammals, birds and reptiles have been recorded within the national forest boundary. Some of these species are migratory, and may spend only a season here, or may just pass-through during travels between seasonal ranges elsewhere, while others may spend their entire lives within the national forest boundary. Many of the terrestrial wildlife species on the Custer Gallatin National Forest are habitat generalists, and as a result, are common and widespread across the entire national forest. However, due to substantial ecological differences between the higher elevation, mountainous west side (referred to as the montane ecosystem) and the lower elevation, gentler terrain on the east side (referred to as the pine savanna ecosystem), some species are found only in parts of the Custer Gallatin National Forest.

A number of “keystone” species on the Custer Gallatin National Forest can, and often do, have a major effect on plant and animal distribution and habitat diversity. The Custer Gallatin hosts a variety of predators, ranging in size from bears to weasels, eagles to kestrels, and rattlesnakes to garter snakes. Predators can influence population levels and distribution of big game species as well as small mammals, birds, reptiles, and insects. Ecological engineers are also present within the national forest. Herbivores, such as large ungulates (including native species as well as domestic livestock), can influence vegetation structure, composition, and distribution. Insects can have a notable effect on habitat conditions, including reductions in live tree canopy and associated cover, as well as increased availability and distribution of snags and down woody debris. At the same time, many bird and bat species are insectivorous, and help keep insect populations in check. People can also have a notable effect on wildlife habitat and associated species abundance and distribution.

The remarkable habitat diversity of the Custer Gallatin National Forest is a function of topography, hydrography soils, climate, and disturbance processes. These factors create the vegetation and structural conditions that provide food, water, and shelter for wildlife. In general, areas of high habitat diversity not only provide for greater wildlife species diversity, but also tend to be more resilient to stressors such as fire, floods, insects, disease, drought, and climate change. Habitat diversity facilitates wildlife movement between different conditions necessary to support various life cycle stages, while habitat conditions, such as fragmentation and connectivity also influence the flow of animals and genetics across landscapes.

The Custer Gallatin National Forest contains habitat for a number of wildlife species either previously or currently, federally recognized under the Endangered Species Act as threatened, endangered, or proposed for Federal listing. In addition, the Regional Forester has identified species of conservation concern, which include species other than federally recognized species, known to occur in the plan area, and for which the Regional Forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area.[2] Collectively, these are referred to as "at-risk species."

The status of at-risk species can change over time. For example, at-risk species may be removed from Federal lists as populations recover, or if new information indicates a species is more abundant, widely distributed, or more persistent than previously thought. Species' status may change from one category to another, such as when a species proposed for listing is found warranted, and officially becomes federally listed as threatened or endangered. Finally, new species may be added to lists of at-risk species by the U.S. Fish and Wildlife Service or the Regional Forester at any time based on new information about population trends, habitat conditions, and known threats. Because the status of at-risk species is subject to change, plan components neither rely upon the particular status of a species, nor change automatically with a species' change in status. Plan components remain in effect unless and until an amendment removes or updates them. Current lists of species federally recognized under the Endangered Species Act that may be present on the Custer Gallatin National Forest are maintained by the U.S. Fish and Wildlife Service field offices in Montana and South Dakota. The current list of species of conservation concern for the Custer Gallatin National Forest and the process used to identify these species are maintained at the Forest Service Northern Region Headquarters and can be viewed on the Northern Region's website.[3]

Wildlife and habitat on the Custer Gallatin National Forest provide many social, economic, recreational, spiritual, and scientific benefits to people. Hunting and trapping of wildlife are a long-standing tradition in western culture and present a major economic driver in western states, including both Montana and South Dakota. Viewing and photographing wildlife are popular recreation activities, as well as careers that support local, national, and international economies. In addition to recreational pursuits, there are many wildlife-related jobs in communities associated with the Custer Gallatin, including both technical

[2] See 36 CFR 219.9(c)

[3] www.fs.usda.gov/goto/R1/SCC.

and professional careers for biologists, managers, researchers and advocates, as well as wildlife-related vocations in the recreation industry, such as outfitters, guides, taxidermists, writers, artists, photographers, and filmmakers. Because of the incredible wildlife diversity, and presence of rare species in this area, the wildlife resource is locally, nationally, and internationally recognized and cherished.

Regulatory Framework

Several statutory authorities affect wildlife and habitat management on National Forest System lands. These laws work in concert with other laws, regulations, and policy described elsewhere in this document, to support ecological conditions and processes, while also providing societal goods and services. Following are key laws and regulations pertaining to wildlife and habitat management on the Custer Gallatin National Forest.

Migratory Bird Treaty Act of 1918: Prohibits unauthorized take of migratory birds, as defined through subsequent regulations. Executive Order 13186 (66 FR 3853) outlines the responsibilities of Federal agencies to protect migratory birds in furtherance of the Migratory Bird Treaty Act.

Bald and Golden Eagle Protection Act of 1940: Prohibits unauthorized take of bald and golden eagles, as defined through subsequent regulations.

Endangered Species Act of 1973, as amended: Provides requirements for Federal agencies with regard to species listed as threatened or endangered, proposed for listing, or candidates for consideration under the act. Section 2 requires all Federal agencies to "seek to conserve endangered species and threatened species," and section 7 requires Federal agencies to ensure that the actions authorized, funded, or carried out by them are not likely to jeopardize the continued existence of any threatened or endangered species or result in the destruction or adverse modification of their critical habitats.

Sikes Act of 1974, as amended: Directs the Secretaries of Interior and Agriculture to cooperate with the States in developing comprehensive plans to maintain, and coordinate the conservation and rehabilitation of, wildlife, fish, and game, including but not limited to protection of species considered threatened or endangered pursuant to section 4 of the Endangered Species Act, or considered to be threatened, rare, or endangered by the State agency.

National Forest Management Act of 1976, as amended: States that the Secretary (of Agriculture) shall promulgate regulations, under the principles of the Multiple-Use Sustained-Yield Act of 1960, to provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives. The 2012 Planning Rule is based upon, and determined to be consistent with, this act (77 FR 21162).

Native American Treaties: Custer Gallatin National Forest lands are governed by eight separate treaties that reserve hunting and other rights for Native American Tribes. See the Areas of Tribal Importance section of this document for more details on these treaties**.**

2012 Planning Rule: Relative to wildlife species and habitats, this rule directs national forest planners[4] to consider:

1. habitat conditions for at-risk species;

[4] See 36 CFR 219.10(a)(5); 219.8; and 219.9(b)(1)

2. habitat conditions for wildlife commonly enjoyed and used by the public for hunting, trapping, gathering, observing, subsistence, and other activities in collaboration with federally recognized Tribes, other Federal agencies, and State and local governments;
3. dominant ecological processes, disturbance regimes, and stressors such as natural succession, wildland fire, invasive species, and climate change;
4. the ability of the terrestrial and aquatic ecosystems in the plan area to adapt to change;
5. habitat connectivity; and
6. riparian areas.

If the responsible official finds that it is beyond the authority of the Forest Service or not within the inherent capability of the plan area to maintain or restore the ecological conditions to maintain a viable population of a species of conservation concern in the plan area, then the responsible official must show that the plan includes plan components, including standards or guidelines, to maintain or restore ecological conditions within the plan area to contribute to maintaining a viable population of the species within its range. The Planning Rule defines viable population as “a population of a species that continues to persist over the long term with sufficient distribution to be resilient and adaptable to stressors and likely future environments.[5]

Key Stressors and Measures

Key ecosystem characteristics were identified as indicators of ecological integrity of biological resources in terms of composition, structure, function, and connectivity. Some of these components are addressed in detail in other sections of this document including Watershed, Aquatic, and Riparian Ecosystems and the Terrestrial Vegetation sections. Since wildlife habitat depends upon hydrologic and vegetative conditions, the wildlife and habitat analyses presented here often tier to affected environment and effects analyses found in the aforementioned sections. Key stressors for wildlife habitat quality vary by wildlife species and unique habitat types, and are therefore, addressed in the wildlife sections that follow. Unless noted otherwise for a particular species or habitat, key factors considered for indirect and cumulative effects include quantitative measures, where available, of anticipated changes to species habitats, as well as qualitative descriptions of plan component contributions to, or potential to address, key stressors for species and their habitats.

Methodology and Analysis Process

In developing plan components, alternatives, and the associated effects analyses, the forest planning team considered information on local wildlife populations and habitat factors, including presence, abundance, distribution, population trends, habitat condition trends, known stressors, and responses to management actions. This process involved:

- compiling species-specific observation and use data;
- identifying and assessing key ecosystem characteristics and trends;
- assessing known or potential system drivers and stressors and their influence on key ecosystem characteristics and wildlife populations;

[5] See 36 CFR 219.19

- assessing existing wildlife habitat conditions relative to the natural range of variation;
- assessing projected changes in wildlife populations and habitat that could result from implementation of the range of planning alternatives identified; and
- assessing projected changes in wildlife populations or habitat that could result from cumulative effects of management actions and land uses that could occur under other land management plans.

Wildlife analyses relied on quantitative and spatial outputs from a number of modeling exercises, using geographic information systems, and other tools. Such models were used to evaluate:

- motorized route densities and the amount and distribution of secure habitat for grizzly bears and other species;
- proportions of unique habitat types affected by permanent human developments such as roads and other infrastructure (GIS queries);
- amounts and types of habitat for species such as lynx, wolverine, sage-grouse, and bison;
- important areas for wildlife habitat connectivity; and
- predicted changes in climate patterns and potential impacts to wildlife and habitat.

Similar models were used to evaluate existing conditions, and predict environmental consequences in the aquatic and riparian ecosystems, terrestrial vegetation, and fire and fuels. These assessments often provided the basis for some wildlife habitat evaluations. Analysis methods, processes and models used for these assessments are found in separate sections of this document.

Effects analyses, including some of the modeling efforts, are based on a number of assumptions, including the following:

- The plan provides a programmatic framework that guides site-specific actions, but does not mandate, authorize, fund, or carry out any particular project or activity. Before any ground-disturbing activities may take place, they must first be authorized in a site-specific decision document with supporting environmental analysis. Therefore, the plan itself neither results in direct effects to wildlife or habitat, nor causes any unavoidable adverse impacts or irreversible and irretrievable commitments of resources. However, the plan may result in indirect and cumulative effects to wildlife and habitat, as future projects are implemented, and management actions occur in a manner consistent with the programmatic framework provided in the plan.
- All applicable laws, regulations, and policy will be followed when planning or implementing new site-specific projects and activities under the guidance of the plan.
- Desired conditions listed in the plan will determine how projects are designed and resources are allocated over the life of the plan. The Custer Gallatin National Forest staff will strive to meet goals and objectives stated in the plan. Suitability allocations, standards, and guidelines will be followed when planning and implementing new site-specific projects and activities.
- There is some degree of uncertainty with all modeling efforts, but the models used in the effects analysis provide a reasonable approximation of past, current, and predicted future environmental conditions upon which to base assessments and form conclusions.

- Data collected at the national forest, regional and national scale have varying levels of accuracy, but provide a reasonable representation of wildlife occurrence, abundance, distribution, and habitat conditions on the Custer Gallatin National Forest.
- The natural range of variation reflects ecosystem conditions that have sustained the current complement of wildlife and habitats on the Custer Gallatin National Forest, and provides the context for understanding the natural diversity of ecosystems and processes, such as wildfire, insects and disease, and natural plant succession.
- Population trends of wildlife species may change as a result of effects from national forest management practices. However, due to the natural range of vegetation patterns and disturbance processes in the northern Rocky Mountains and Great Plains, fluctuations in wildlife populations and distribution are normal, and often result from natural factors such as predation, starvation, disease, or wide-scale habitat changes resulting from fire, flood, drought, and other natural disturbance processes. For migratory species, a change in population may not reflect a change in local habitat conditions, but rather occur as a result of activities or conditions experienced elsewhere in the United States or even in other countries.
- Global and State species rankings are accurate indices of species status at the relative scale, but may or may not be indicative of local wildlife populations in the Custer Gallatin National Forest.

Finally, wildlife habitat occurs as a function of the biophysical composition of the landscape. Habitat for wildlife is a product of the vegetation, water, soils, topography, and associated ecological processes (including both natural and human-induced changes) from the micro-site level to local, regional, and even global extents. To this end, the wildlife analyses rely on, and often tier to, information and analysis presented in other sections of this document.

Information Sources

Wildlife habitat analyses in this document are based upon extensive review of, and reference to, the best scientific information available for documenting the status, habitat relationships, potential threats, and response to management activities of terrestrial wildlife species known to occur within the Custer Gallatin National Forest. Literature sources that were the most recent; peer-reviewed; and local in scope or directly applicable to the local ecosystem were selected. Articles found to be the most relevant were those based upon local studies; such as those conducted in southwestern, southcentral, or southeastern Montana, or northwestern South Dakota. Literature from more distant regions, but with habitats or ecological conditions similar to those found in the plan area, were also pertinent. Uncertainty and conflicting conclusions found in literature are acknowledged and interpreted when applicable. In addition, key information on population trends, life history, and status of terrestrial wildlife species in the plan area was obtained from the Montana Field Guide (http://fieldguide.mt.gov), state wildlife management agencies for Montana and South Dakota, natural heritage programs, Nature Serve, the U.S. Fish and Wildlife Service, and the Interagency Grizzly Bear Study Team. Finally, local data collected by Forest Service personnel, contractors, and agency partners informed analyses with respect to species occurrence, abundance, and distribution, as well as local habitat conditions and trends.

Habitat modeling efforts specific to the Custer Gallatin National Forest were used in the analysis, as described above in the methods section. Details about these local models and the data used in them are contained in species- or habitat-specific sections below. In addition to Custer Gallatin-specific models, a number of external modeling efforts were consulted for relevant information. Given the importance of habitat connectivity for maintaining species persistence and associated biological diversity, a great deal of attention has been devoted to identifying potential movement corridors for many different species in recent years, particularly in the Greater Yellowstone Area. Such models provide concepts that are useful for identifying high-priority areas for protection and restoration to sustain functional connectivity across the landscape. However, most of the research and resulting wildlife movement modeling efforts have had a single species focus, whereas the 2012 forest planning requirement is to provide habitat connectivity for all native species. Further, while methods for validating connectivity models against empirical data exist, they have not been standardized (McClure et al. 2016). On the other hand, without any validation, the reliability of a model is basically unknown.

Downscaled climate models are used to predict the effects of a changing climate for a number of resources. For planning and analysis purposes, we used a compilation of climate change effects published for the Northern Region Adaptation Partnership (Halofsky et al. 2018b;a) that summarizes climate change projections by sub regions. As part of that effort, McKelvey and Buotte in (Halofsky et al. 2018b) provide a summary of modeled climate change impacts on wildlife in the northern Rocky Mountains. In addition, to better understand the effects of climate change at a more local scale, the Custer Gallatin Plan Revision Team collaborated in a series of workshops with a diverse team of scientists and land managers from local universities, government agencies and non-governmental agencies to review and assess potential impacts to wildlife habitat resulting from predicted climate change over the life of the revised plan (Hansen et al. 2018).

Wild animals are mobile and wary, and often actively avoid humans. Therefore, it can be difficult to locate and study individuals, let alone obtain meaningful scientific information for entire populations. Population trend information is extremely difficult to obtain, because it requires data for at least a reasonable reference set of individuals, including information on survival and reproduction rates, as well as immigration and dispersal. Considering the large number of wildlife species inhabiting the vast expanse of the Custer Gallatin National Forest for at least part of their life cycle, there is limited scientific information on biology, ecology, and population trends for the majority of species present that is specific to the plan area. Some species are rarer or associated with remote, rugged environments, or are present here for a relatively short time before moving elsewhere, making detection and observation even more difficult.

Habitat, on the other hand, is generally stationary, and can be readily surveyed, monitored, and studied over time. However, the large geographic extent and wide range of habitat diversity within the Custer Gallatin National Forest generates considerable complexity for research and monitoring purposes. Demonstrating causality and relationships between the myriad of factors affecting wildlife habitat is not only difficult, but also costly. As a result, uncertainty exists regarding the direct, indirect, and cumulative impacts of various collective management activities on individual animals, habitat, and wildlife populations. Further, the science surrounding climate change is still relatively new and somewhat limited. While there is an appreciable body of science on the topic, and information is growing at a considerable rate, there is still much ambiguity and scientific disagreement on not only the potential impacts to habitat, but also how such impacts might affect wildlife populations.

Analysis Area

The analysis area used to examine indirect effects of plan components for most wildlife species and their habitats includes the National Forest System lands within the Custer Gallatin National Forest boundary. The cumulative effects analysis area for most species is the same as that used for indirect effects, but may expand beyond the national forest boundary for large ranging species such as the grizzly bear, as well as for larger landscape concepts such as habitat connectivity. On the other hand, some species' ranges are quite limited on the Custer Gallatin, for example the greater sage-grouse and white-tailed prairie dog. For these species, the spatial scale used for analysis is limited to the geographic areas in which the species is either known to occur, or where habitat is present. Unless noted otherwise in the following species-specific sections, the spatial scale for indirect and cumulative effects is the area within the Custer Gallatin National Forest boundary.

The temporal scope of the analysis is the anticipated life of the plan, with longer-term consideration (up to 50 years) for consequences resulting from implementation of the plan. This timeframe is consistent with the analysis period for key ecosystem characteristics associated with terrestrial vegetation.

3.10.2 Federally Listed Wildlife Species

This section addresses effects of plan alternatives on wildlife species federally protected under the Endangered Species Act. This includes those currently listed as threatened or endangered, as well as species proposed by the U.S. Fish and Wildlife Service to be listed under the Endangered Species Act. Candidate species are those species for which the U.S. Fish and Wildlife Service has sufficient information on vulnerability and threats to support a proposal to list, but for which no proposed rule has yet been published. At the time this analysis was prepared, no terrestrial wildlife species that were candidates for Federal listing were known to occur on the Custer Gallatin National Forest. A current list of species that may be present on the Custer Gallatin was obtained from the U.S. Fish and Wildlife Service (U.S. Department of the Interior 2019b). The 2012 Planning Rule requires national forest land management plans to provide the ecological conditions necessary to contribute to the recovery of federally listed threatened and endangered species, and conserve proposed and candidate species (36 CFR 219.9(b).

Notable Changes between the Draft and Final Environmental Impact Statements

The U.S. Fish and Wildlife Service maintains lists of federally protected species. The Montana Field Office of the Fish and Wildlife Service maintains species lists specific to the national forest boundaries, whereas the South Dakota Field Office lists species by county. For the draft environmental impact statement, the species list for South Dakota covered all of Harding County. For this document, the Fish and Wildlife Service informed the Forest Service that of the threatened and endangered species listed as may be present in Harding County South Dakota, only the whooping crane (*Grus Americana*) may be present on National Forest System lands within the Custer Gallatin National Forest boundary (U.S. Department of the Interior 2019c). Therefore, effects analyses for the least tern (*Sternula antillarum*) and red knot (*Calidris canutus rufa*) were not carried forward into the final environmental impact statement. The remaining federally listed species that may be present on the Custer Gallatin National Forest are addressed below.

The discussion and analysis of wolverine has been moved from the Federally Listed Wildlife Species section and placed in the General Wildlife section due to the 2020 U.S Fish and Wildlife Service decision to not list wolverine under the Endangered Species Act.

Whooping Crane

The whooping crane was listed as endangered in the United States in 1970, and "grandfathered" in under the Endangered Species Act in 1973. The species was also listed as endangered in 1978 in Canada, and the species remains endangered in both countries because of low population size and limited range of the single remaining wild population. Whooping cranes only occur in North America. They nest in Canada and winter along the central Gulf Coast of Texas. Spring and fall migrations occur through the central Great Plains of the United States (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005). The migratory flyway overlaps with the eastern portion of the national forest, but there are no documented occurrences of whooping cranes on National Forest System lands within the Custer Gallatin National Forest boundary (http://mtnhp.org, Deisch 2018a personal communication). Since the species is not known to occur here, they were not analyzed in detail. However, since they may be present at some point, they are addressed briefly here.

Analysis Area

The Custer Gallatin National Forest is well outside the breeding and wintering areas for whooping cranes, and there is no critical habitat for the species located on the national forest. The Sioux Geographic Area is nearest the primary migratory pathway whooping cranes use, and the South Dakota units of the Sioux Geographic Area comprise the only portion of the Custer Gallatin where the U.S. Fish and Wildlife Service (U.S. Department of the Interior 2019c) indicated that the species may be present. Therefore, the analysis area for this section includes only the Sioux Geographic Area.

Affected Environment (Existing Conditions)

The whooping crane is a migratory bird species that was historically associated with the pine savanna ecosystem found in the eastern part of the Custer Gallatin during spring and fall migrations (Marks et al. 2016). The whooping crane's natural habitat includes marshes, estuaries, lakes, ponds, wet meadows, and rivers. They follow the same pathway during spring and fall migrations, where they regularly stop to feed and rest. Whooping cranes are omnivores, known to feed on frogs, fish, plant tubers, crayfish, insects, and agricultural grains during migration. Much of the foraging during migration occurs in harvested agricultural fields, while roosting typically occurs in marshy wetlands within a kilometer (0.6 mi) of a suitable foraging area (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005).

There are no agricultural crops on National Forest System lands in the Sioux Geographic Area, but there are some marshy wetlands that could be suitable roosting and foraging habitat for migrating whooping cranes. Within the Sioux Geographic Area, vegetation modeling exercises predict that there are currently about 458 acres of riparian-associated habitat dominated by graminoid species, such as sedges and reeds. These areas represent the best estimate of wetland habitats on the Custer Gallatin that may provide suitable roosting and foraging areas for migrating whooping cranes. This estimate amounts to less than one-third of one percent of the National Forest System lands in the Sioux Geographic Area. Given that the Sioux Geographic Area covers only about 5 percent of the entire national forest, the amount of migratory stopover habitat for whooping cranes on the Custer Gallatin is extremely limited.

Key Stressors

The whooping crane's natural habitat has been degraded by permanent conversions for agriculture, energy, and other human developments (Canadian Wildlife Service and U.S. Fish and Wildlife Service 2005). Whooping crane populations are also affected by DDT, an insecticide widely used during the mid-20th century; however, the use of this pesticide has since been banned in the United States. More recent threats to whooping cranes include collisions with powerlines and wind turbine blades (Marks et al. 2016).

Climate change may also affect migratory stopover habitat for the whooping crane. Impacts of climate change on the pine savanna aquatic and riparian ecosystems are less predictable than for other parts of the Custer Gallatin National Forest, in part because less is known about hydrologic flow regimes, but also because these systems are already very dynamic. Therefore, these habitats and the species that depend on them are well adapted to a high degree of variation in temperature, precipitation, and stream flow conditions. In general, the pattern expected for the pine savanna ecosystem is warmer temperatures and static to slightly increased precipitation, with a net effect of less water available in summer months, as well as more extreme and variable weather events (Halofsky et al. 2018a). Such changes could affect food availability for the whooping crane. However, some of the impact may be moderated by stronger constraints on management actions within riparian habitats in the revised plan. A more thorough analysis of climate change impacts on grassland, riparian, and aquatic habitats in the pine savanna ecosystem can be found in the Terrestrial Vegetation section as well as the Watershed and Aquatics sections of this document.

Environmental Consequences

Effects Common to all Alternatives

The least tern, whooping crane and red knot are all associated with open water or wetlands (explorenature.org). These are all migratory species, for which the Custer Gallatin National Forest provides potential stopover habitat during migration between breeding and wintering grounds. Stopover habitat for these species would also be open water or wetlands, which are protected by aquatic and riparian habitat plan components under all alternatives.

Management Direction under the Current Plans (Alternative A)

The whooping crane may be present in a very small portion of the Sioux Geographic Area, for which existing plan direction is contained in the Custer National Forest Management Plan (U.S. Department of Agriculture 1986). The Custer Plan contains a goal to provide habitat that contributes to the recovery of threatened and endangered species, with the objective of considering the needs of each species in site-specific analyses, through appropriate coordination and consultation with the U.S. Fish and Wildlife Service. The Custer Plan identifies the whooping crane as an endangered species that may occur on the national forest, but notes that verified occurrences are rare, and dated. Further, the Custer Plan in 1986 included portions of present-day Dakota Prairie Grasslands, and it is unclear whether some of these rare sightings for whooping crane occurred within present-day Custer Gallatin units, or were in what is now the Dakota-Prairie Grasslands.

Aside from general plan components for threatened and endangered species, the Custer Plan contains no specific plan components for whooping cranes. However, the species is an aquatic and riparian habitat associate. Custer Plan direction for riparian habitat is geared toward managing for water quality and vegetation diversity, while protecting key wildlife habitat. Specific management practices are prescribed for riparian habitat (Management Area M). In addition, the Custer Plan provides direction for other resource areas, such as permitted livestock grazing, timber harvest, minerals management, recreation uses, and other uses to maintain or improve aquatic and riparian habitats.

Effects of the Current Plans

The Custer Gallatin National Forest does not provide breeding or wintering habitat for the whooping crane, but parts of the national forest are located along seasonal migratory routes potentially used by the species. Small wetlands within the Sioux Geographic Area provide stopover habitat during migration periods, although there has been no recent documented use. Detailed analyses of aquatic and riparian habitat conditions under the current plan can be found in the Watershed Aquatic and Riparian Ecosystems section and the Terrestrial Vegetation section of this document. Since the Custer Plan contains specific direction for managing riparian areas, stopover habitat for whooping cranes would likely be maintained or improved under the current Custer Plan. However, the language in the existing plan is somewhat vague and subject to interpretation, resulting in greater potential for intentional or unintentional impacts to aquatic and riparian habitats compared to the revised plan alternatives.

Management Direction under the Revised Plan Alternatives

Forestwide management direction (plan components) that may affect the whooping crane would be the same under all revised plan alternatives (alternatives B through F). Revised plan alternatives include desired conditions for a complete suite of native species in sufficient numbers and diversity that helps contribute to ecological processes, habitats that contribute to recovery needs for federally listed species, and vegetation conditions within the natural range of variation (FW-DC-WL-01 to 03). In addition, the revised plan alternatives also contain descriptive desired conditions for aquatic systems that are diverse and complex, resilient to disturbances, provide habitat connectivity as well as feeding and sheltering opportunities for wildlife (FW-DC-WTR All). Standards and guidelines are provided to facilitate movement toward these conditions. The revised plan alternatives also include desired conditions for riparian management zones (FW-DC-RMZ-01, 02). Wetlands, fens, peatlands, seeps, springs, ponds, and lakes, which may provide foraging and resting habitat for whooping cranes, have been defined (FW-STD-RMZ-01; Category 3 and 4), and contain explicit direction with an entire suite of plan components addressing riparian system health (FW-STD/GDL-RMZ All). In addition, revised plan alternatives contain descriptive desired conditions for grasslands, riparian areas, and wetlands (FW-DC-VEGNF-04). Finally, the revised plan alternatives include a guideline to protect airborne migratory species from impacts associated with new wind energy development (FW-GDL-WL-07).

Effects of the Revised Plan Alternatives

Revised plan alternatives carry forward desired conditions for all wildlife including endangered species similar to current plans, but with more emphasis on ecological characteristics and providing for complete suites of native fauna (FW-DC-WL-01 to 03). Compared to the current plans (alternative A), the more detailed and restrictive plan components in alternatives B through F would provide greater protection for aquatic and riparian habitats, as well as grasslands that may be used as stopover areas during seasonal migrations by whooping cranes. Detailed analyses for aquatic, riparian and grassland habitats can be found in the Watershed and Aquatics section, as well as the Terrestrial Vegetation section of this document. Individual projects would be designed so that the resulting habitat conditions contribute to the recovery needs for federally listed species. In addition, special considerations for new wind energy developments (FW-GDL-WL-07) would reduce the risk of migrating cranes colliding with wind turbines, which would reduce the potential for injury or mortality of individuals.

Consequences to Whooping Crane from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Watershed, Riparian, and Aquatic Management

All revised plan alternatives contain desired conditions for watershed, aquatic, and riparian ecosystems (FW-DC-WTR/RMZ All), which set the coarse filter strategies that would help maintain and restore habitats suitable as stopover sites for migrating whooping cranes. The revised plan alternatives provide more detailed guidance (FW-STD/GDL-WTR/RMZ All) compared to current plans for protecting watersheds, riparian areas, and aquatic habitats. The revised plan alternatives adopt riparian management zones forestwide (FW-STD-RMZ-01). These zones would be greater in size than any riparian zones currently identified for streams on the eastern side of the national forest. Specifically, the riparian management zone direction restricts management activities with few exceptions, to allow only those intended to restore or enhance ecological integrity of aquatic and riparian associated resources (FW-STD-RMZ-02).

Wetland and riparian communities can be highly susceptible and sensitive to the presence of chemical pollutants. Use or contamination within these systems may result in the degradation of habitat condition for whooping crane by reducing forage quality and abundance. Whooping cranes are omnivores that feed on fish, amphibians, insects, and crayfish, which can be highly sensitive to the presence of chemicals. Reducing the availability of these prey species could affect habitat quality for whooping cranes. The revised plan alternatives include restrictions regarding the use of pesticides, toxicants, other chemicals, and refueling activities to protect these sensitive and important habitats (FW-STD-RMZ-03, 04). These components would protect or improve foraging habitat conditions in areas that may serve as migratory stopover points for whooping cranes.

Effects from Vegetation Management

Like water and riparian resources, terrestrial desired conditions in all revised plan alternatives provide coarse filter plan components that would help maintain and restore potential migratory stopover habitats for whooping cranes. The revised plan alternatives include desired conditions for native plant communities that are self-sustaining and diverse, and generally free of non-native species (FW-DC-VEGNF-01, 02). The revised plan alternatives include specific and detailed descriptions of grasslands, wetlands, and riparian habitats (FW-DC-VEGNF-04) that would help guide future management toward maintenance or restoration of structure, function, or vegetation composition characteristics that could provide suitable habitat for migrating whooping cranes. Guidelines would help minimize future impacts to important wetlands and grassland habitats by limiting developments that could fragment intact grasslands or impact sensitive wetlands (FW-GDL-VEGNF-03 to 05).

Effects of Fire and Fuels Management

The revised plan alternatives all include desired conditions and objectives for wildland fires within the natural range of variation to maintain resilient ecological conditions (FW-DC-FIRE-01, FW-OBJ-FIRE-02), which would support natural disturbance processes that maintain healthy grassland and wetland communities, contributing to plant and animal diversity that would provide suitable foraging and resting conditions for whooping cranes. Revised plans contain desired conditions for minimal detrimental impacts to values at risk from wildland fire (FW-DC-FIRE-02, 03); with associated plan components to minimize such risk (FW-OBJ-FIRE-01, FW-STD-FIRE-01, FW-GDL-FIRE-02). Hazardous fuel reduction operations and fire suppression activities can alter natural vegetative conditions in ways that could impact resting and foraging habitat for whooping cranes. Minimum impact suppression tactics would be used to minimize damage to wetland and riparian habitats from wildland fires (FW-GDL-FIRE-03) and riparian management zone components would add further protection with restrictions on vegetation management (such as fuel reduction), refueling activities, and temporary fire facilities (FW-STD-RMZ-02, 04; FW-GDL-RMZ-02).

Effects from Permitted Livestock Grazing Management

All revised plan alternatives contain a desired condition that grazing allotments supply livestock forage and contribute to local ranching operations, while maintaining or moving toward desired ecological conditions (FW-DC-GRAZ-01). Livestock grazing has the potential to affect migratory stopover habitat for whooping cranes. Riparian areas support higher bird diversity relative to the proportion on the landscape than any other habitat type. Just as these areas are important to birds and other wildlife, they also attract domestic livestock. Riparian areas can be seriously degraded by overgrazing (Rich et al. 2004). All revised plan alternatives include a number of plan components to protect riparian and upland habitats from undue pressure from domestic livestock grazing. These include a goal to work with permittees to remove allotment infrastructure that may attract livestock use in riparian areas or wetlands (FW-GO-GRAZ-01). New or revised allotment management plans would include provisions to maintain or improve resiliency of riparian and upland ecosystems (FW-STD-GRAZ-01). Grazing-specific guidelines contain measures to maintain or improve stream habitat, water quality, and riparian habitat, protect sensitive areas from grazing pressure, and ensure plant community health with specific, quantifiable forage utilization measures within riparian areas (FW-GDL-GRAZ-01, 02, 04, 05). Finally, riparian management zone components restrict livestock management activities such as permanent livestock handling facilities, watering structures, and trailing routes within buffers around wetlands (FW-GDL-RMZ-01). Collectively, these plan components would minimize grazing management impacts to potential whooping crane foraging and resting areas under all revised plan alternatives.

Effects of Timber Management

All revised plan alternatives include desired conditions for timber harvest that contributes to ecological integrity and sustainability while also contributing to economic sustainability, providing jobs and product to local communities (FW-DC-TIM-01). Vegetation management has the potential to reduce the quality of whooping crane habitat through removal of forested structure within or near wetland and riparian areas. Riparian management zones, which include buffers around wetlands, fens, and seeps (FW-STD-RMZ-01), are not suitable for timber production, although vegetation management may occur in certain circumstances (FW-SUIT-RMZ-01). Salvage harvest and firewood gathering is limited in the inner riparian management zone (FW-GDL-RMZ-08, FW-SUIT-RMZ-02). Timber would not be harvested on lands where soil, slope, or other watershed conditions may be irreversibly damaged by harvest activities, as identified in project-specific findings (FW-STD-TIM-02). Vegetation management within the inner riparian management zones would only be allowed for restoring or enhancing aquatic- and riparian-associated resources (FW-STD-RMZ-01). These plan components would prevent the alteration of potential whooping crane habitat through timber harvest unless for the express purpose of restoring or enhancing the wetland community.

Effects from Energy and Minerals Management

All revised plan alternatives contain desired conditions for minerals and renewable energy resources to be available in consideration of other resource values, and for mineral and energy development areas to be reclaimed or restored once extraction activities are complete (FW-DC-EMIN-01, 02). Mineral and energy development actions have the potential to impact suitable whooping crane habitat. Leaching of chemicals and pollutants from drainage can affect aquatic and riparian resources. Noise and human presence associated with resource extraction can cause disturbance, which could result in underutilization of otherwise suitable stopover habitat for whooping cranes. All revised plan alternatives would require mineral and energy development permits to include provisions to reclaim disturbed areas (FW-STD-EMIN-01) and minimize adverse effects to aquatic and riparian resources (FW-GDL-EMIN-02).

Under all alternatives, extraction of saleable mineral materials would not be allowed in riparian management zones (FW-STD-RMZ-05). Finally, all alternatives include a provision for wind energy developments to minimize impacts on birds (FW-GDL-WL-07), which would reduce the risk of migrating whooping crane collisions with wind turbines.

Effects from Infrastructure Management

Infrastructure such as roads, trails, and facilities associated with administrative and visitor use has the potential to affect riparian and wetland systems and associated whooping crane habitat through sediment delivery, discharge of wastewater, introduction of invasive species, and general degradation of these areas. All revised plan alternatives contain desired conditions for a transportation system that provides safe and efficient access to the national forest, while minimizing impacts on resources including endangered species, watershed, water quality, and aquatic species (FW-DC-RT-01, 03, 04). All revised plan alternatives include plan components to address potential impacts to whooping crane habitat from location of roads and trails, water drainage systems, sediment delivery, invasive species, barriers to aquatic organism passage, application of chemicals to road surfaces, and groundwater use developments (FW-STD-RT-01 to 05). To protect the condition of riparian areas and avoid the degradation of unique habitats, the revised plan alternatives indicate that permanent and temporary facilities, buildings, and other structures should not be located or developed within riparian management zones and woody draws (FW-GDL-FAC-01 to 03; FW-GDL-RMZ-03, FW-GDL-VEGNF-04, 05). In addition, a number of transportation guidelines establish practices such as avoidance of wetlands and unstable areas, streambank stabilization for crossings, sufficient drainage features, and limited side casting of plowed materials (FW-GDL-RT-03 to 08). These plan components would limit adverse effects of human infrastructure and use on whooping crane migratory stopover habitat.

Effects from Recreation Management

All revised plan alternatives highlight the importance of recreation resources on the Custer Gallatin (FW-DC-REC-01 to 03). However, they also include desired conditions for recreation uses and developments to have minimal impacts on ecological integrity, at-risk species, water quality, and aquatic species (FW-DC-REC-05), in addition to an objective to remove or relocate some existing recreation facilities out of riparian areas (FW-OBJ-REC-01). The revised plan alternatives reflect the desire for recreation developments that are compatible with natural resources, with specific attention to dispersed camping, river access, or unmanaged recreation with potential to degrade riparian resources (FW-DC-RECDEV-02, 07). Plan components address construction and maintenance of new and existing recreation facilities such as boat ramps, docks, and interpretive trails within or near riparian areas (FW-GDL-FAC-03, 04). Implementation of revised plan components would protect potential migratory habitat for whooping cranes from impacts associated with recreation management.

Effects of Plan Land Allocations for Recommended Wilderness and Backcountry Areas

The revised plan alternatives include land use allocations that indicate how particular areas of the national forest are to be managed. While land use allocations vary by alternative across the Custer Gallatin, there are no plan land allocations in the South Dakota units of the Sioux Geographic Area under any alternative. Alternatives D and F include a plan land allocation of backcountry area in the Chalk Buttes unit of the Sioux Geographic Area, but it is located at the edge of the migratory flyway used by whooping cranes, and outside of the area where the species may be present (U.S. Department of the Interior 2019c). Therefore, land use allocations in the revised plan would have no effect on whooping cranes under any alternative.

Cumulative Effects

Most of the cumulative impacts to whooping cranes and their habitats result from past actions, as well as from impacts occurring on breeding or wintering grounds in locations far beyond the management jurisdiction for the Custer Gallatin National Forest. However, indirect effects of plan components on habitat conditions may combine with ongoing effects of human activities and other disturbances on or near the Custer Gallatin. Cumulative effects may also occur because of indirect effects of forest planning combined with possible future stressors, such as climate change. Some threats to whooping crane habitat still exist, but generally at much lower levels than occurred historically. For example, some native grasslands, including wetlands, are still being converted for agricultural, residential, or energy development purposes on other ownerships outside the national forest boundary, but this is a relatively minor factor in northwestern South Dakota compared with other parts of prairie ecosystems in the United States. DDT, the pesticide that impacted whooping crane populations during early and mid-20th century, has since been banned in the United States. Finally, the whooping crane is listed as endangered in both Canada and the United States. As such, their breeding habitat is protected in Canada, while wetlands, water sources, and whooping cranes are protected in the United States under the Endangered Species Act. Therefore, management actions on Federal lands in the United States along the migratory corridors for these species, including those adjacent to the Custer Gallatin National Forest, are subject to stipulations under the act that prohibit any taking of, or causing intentional harm to whooping cranes or their habitats.

Conclusion

All alternatives would generally protect, maintain, or restore the grassland, wetland, riparian, and aquatic habitats that provide suitable migratory stopover habitat for whooping cranes. Effects from all revised plan alternatives (B through F) would be the same for whooping cranes and their habitat. However, the revised plan alternatives contain more specific language, more restrictions on certain types of management actions and developments, and factors to address emerging issues in riparian habitats to a greater degree than language in the current plans (alternative A).

Collectively, revised plan components for managing fire use and suppression, timber harvest, permitted livestock grazing, mineral and energy development, and administrative and recreational facilities would help protect, maintain, and restore aquatic and riparian habitats and minimize human disturbance in such habitats. Combined with the forestwide, comprehensive, detailed, and specific plan direction for water, aquatic, riparian and grassland habitats, the revised plan alternatives would provide protection for, and potential improvement of, stopover habitats that may be used by whooping cranes, which would contribute to recovery of the species.

Canada Lynx (*Lynx canadensis*)

The Canada lynx is a medium-sized forest carnivore that is strongly associated with one primary prey species—the snowshoe hare (*Lepus americanus*). Both the lynx and its primary prey are highly adapted to survive in boreal climates, where winters are characterized by deep accumulations of soft, fluffy snow (Koehler and Aubry 1994). The lynx’s long legs and large, furry feet that make it well-adapted to travel across deep snow in pursuit of hares, give this species a competitive advantage for hunting in wintery conditions over other more generalist predators such as bobcats (*Lynx rufus*), mountain lion (*Felis concolor*) and coyotes (*Canis latrans*) (Bell et al. 2016). Lynx and snowshoe hares are dependent on forested environments, where a diversity of structural stages may be used to meet various life cycle needs. The Canada lynx was listed as a threatened species under the Endangered Species Act in March 2000. Following this listing, critical habitat was designated for the Canada lynx in 2009, and then updated in 2014 (U.S. Department of the Interior 2000a;2009b;2014a). In a recently completed 5-year review, the U.S. Fish and Wildlife Service concluded that the Canada lynx distinct population segment in the contiguous United States is "not in danger of extinction throughout all of its range or likely to become so in the foreseeable future… and recommended removing the Canada lynx distinct population segment, currently listed as threatened, from the list of threatened and endangered species" (U.S. Department of the Interior 2018b).

As its name implies, the Canada lynx is mainly found in Canada, and its distribution is associated with the North American boreal forest habitats. In the northern part of their range including Canada, lynx population cycles correspond with fluctuations in snowshoe hare population cycles. Lynx presence in the southern part of the range including the contiguous United States is likely due, in part, to influxes of dispersing lynx at the peak of population cycles in the north (Interagency Lynx Biology Team 2013). In the contiguous United States, lynx naturally occur at low densities compared with the larger population in Canada, because the habitat in the more southern latitudes is naturally more fragmented, as it transitions from true boreal forest of the north to boreal/subalpine and montane forests. This patchy habitat distribution limits densities of the lynx's primary prey species, the snowshoe hare, preventing both hare and lynx populations in the United States from reaching the high numbers found in Canada (U.S. Department of the Interior 2009b).

In the western United States, lynx are most common in the northwestern part of Montana, decreasing in abundance to the south and east (Koehler and Aubry 1994). Lynx on the Custer Gallatin National Forest would be part of the Greater Yellowstone population. At the time the lynx was listed, the Greater Yellowstone Area was considered to be occupied by a small but persistent population of lynx (U.S. Department of the Interior 2014a). While there is evidence indicating lynx presence in the Greater Yellowstone Area over time, it is unclear whether lynx occupation of the area has been consistent, or whether a few individuals come and go relative to habitat conditions. It may be that lynx travel here and survive for a time when habitat conditions are good and hare densities are favorable, but those individuals either disperse or starve when conditions are less favorable and hare populations decline. In other words, the Greater Yellowstone population may be one that "winks on and off" in terms of Canada lynx metapopulations in the contiguous United States. A status review the U.S. Fish and Wildlife Service conducted in 2016 concluded there are likely fewer than 10 individual lynx, and possibly none, present in the entire Greater Yellowstone Area (Bell et al. 2016).

Analysis Area

Lynx habitat is only found in the montane ecosystem on the Custer Gallatin National Forest. Lynx analysis units provide a fundamental scale at which to evaluate and monitor the effects of management actions on lynx habitat. Lynx analysis units do not depict actual lynx home ranges, but their size and configuration generally approximate the scale of area used by an individual lynx, with habitat components necessary for year-round use. The montane geographic areas on the Custer Gallatin have been delineated into lynx analysis units based on presence of contiguous lynx habitat. However, because the plan neither mandates nor authorizes any site-specific actions, effects analyses for programmatic direction cannot be attributed to specific lynx analysis units with any degree of certainty. Therefore, the analysis area used to evaluate indirect and cumulative effects to lynx is the montane ecosystem, which includes the Bridger, Bangtail, and Crazy Mountains; Madison, Henrys Lake, and Gallatin Mountains; Absaroka Beartooth Mountains; and Pryor Mountains Geographic Areas. The Ashland and Sioux Geographic Areas were excluded because they do not produce boreal forest conditions suitable for lynx and snowshoe hares.

Notable Changes between the Draft and Final Environmental Impact Statements

Notable changes made to this section involve more explanation of, and analysis for, the integration between coarse filter plan components from a variety of resource areas with the fine filter plan components adopted from the Northern Rockies Lynx Management Direction. More detailed analysis was incorporated to address habitat connectivity for lynx, potential impacts associated with climate change, and how plan components relate to recent science relative to lynx habitat use patterns. Two standards were added to the plan: FW-STD-WLLX-01 that requires application of the Northern Rockies Lynx Management Direction; and FW-STD-WLLX-02 that addresses vegetation management projects for fuel treatment in wildland-urban interface that reduce snowshoe hare habitat within designated lynx critical habitat.

Affected Environment (Existing Conditions)

Lynx were historically present in low numbers on the Custer Gallatin National Forest, as evidenced by trapping and other records. However, total documented occurrences on the Custer Gallatin are rare, with the most recent in 2009. Low numbers of lynx recorded may reflect lynx habitat that is naturally fragmented by intervening open or drier habitats, resulting in patchy distribution, which provides marginal conditions for lynx with limited capability to support snowshoe hares. Track and pellet surveys combined with incidental observations indicate that natural conditions on the Custer Gallatin support low densities of hares (Zimmer et al. 2008). The Greater Yellowstone Area is farther from the true boreal forest of Canada than most other regions that support lynx in the contiguous United States. As part of the Greater Yellowstone Area, lynx habitat on the Custer Gallatin follows suit.

Most of the research on lynx in Montana has occurred west of the Continental Divide, where habitat conditions are more contiguous with lynx habitat in Canada, and generally more favorable for snowshoe hares and lynx with larger, more connected patches of boreal forest (Interagency Lynx Biology Team 2013). As a result, lynx habitat use patterns in the Greater Yellowstone Area, including the Custer Gallatin National Forest, are not well known, and lynx habitat indicators used in this analysis were derived from research on lynx in other areas, including northwestern Montana.

Habitat Designations

In a Recovery Outline for Canada Lynx, the U.S. Fish and Wildlife Service (U.S. Department of the Interior 2005) categorized lynx habitat in the continental United States as “core,” “secondary,” or “peripheral” based on historical and current occupation by lynx. Areas with verified records of lynx presence over time and recent evidence of reproduction are identified as core areas. Areas with historical records of lynx presence, but no documentation of reproduction, are identified as secondary areas. Peripheral areas are those with only sporadic detections of lynx. On the Custer Gallatin National Forest, the Absaroka Beartooth Mountains Geographic Area is identified as core habitat; the Bridger, Bangtail, and Crazy Mountains; and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas are classified as secondary lynx habitat; and the Pryor Mountains Geographic Area is identified as peripheral habitat.

Secondary and peripheral habitat contribute to lynx distribution and persistence by providing dispersal habitat to and from core areas, but otherwise, the role of these areas in sustaining lynx populations remains relatively unknown (Interagency Lynx Biology Team 2013).

An important distinction for applying plan components from the Northern Rockies Lynx Management Direction (U.S. Department of Agriculture 2007b) is whether lynx habitat is currently designated as occupied per the 2006 Amended Conservation Agreement and Northern Rockies Lynx Management Direction (U.S. Department of Agriculture and U.S. Department of the Interior 2006, U.S. Department of Agriculture 2007b). According to the Amended Conservation Agreement and Northern Rockies Lynx Management Direction, the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas are currently designated occupied, even though lynx may not be detected in these areas for periods of time. According to the Amended Conservation Agreement and Northern Rockies Lynx Management Direction, the Bridger, Bangtail, and Crazy Mountains and the Pryor Mountains Geographic Areas contain potential lynx habitat, but are currently designated unoccupied. Although unoccupied areas may have occasional transient use by lynx traveling between more suitable areas, such use is believed to be rare. Henceforth, the terms "occupied" and "unoccupied" used in reference to lynx habitat indicate areas designated as such in the 2006 Amended Conservation Agreement and Northern Rockies Lynx Management Direction (U.S. Department of Agriculture 2007b). The Ashland and Sioux Geographic Areas in the pine savanna ecosystem contain only warm, dry forest conditions and non-forest habitats that are not capable of supporting lynx or snowshoe hares.

Habitat Suitability

In the contiguous United States, boreal forest transitions to subalpine and montane forest in the western states (Ruggiero et al. 1999). In these areas, including the Custer Gallatin, lynx habitat is typically found in the subalpine and upper montane forest zones. Subalpine fir and Engelmann spruce dominate lynx habitat, with increasing presence of lodgepole pine and pockets of aspen appearing toward the transition with upper montane forest types. In cool, moist conditions, Douglas-fir may be a minor component of lynx habitat in the upper montane forest zone, often in mixed forests that also contain subalpine fir, spruce, lodgepole pine, or aspen. The warmer, drier forests dominated by Douglas-fir or limber pine do not support snowshoe hares or lynx (Interagency Lynx Biology Team 2013). Likewise, pure whitebark pine forest found at higher elevations generally does not provide good snowshoe hare or lynx habitat, but whitebark pine may be found in mixed forests with spruce, subalpine fir or lodgepole pine in lynx habitat. Large meadows, alpine areas, rock, and other non-forest types generally do not provide lynx habitat, but may be crossed by lynx moving between patches of suitable habitat.

Lynx use a variety of successional stages for different life cycle needs. Recent research (Holbrook et al. 2017b, Holbrook et al. 2018, Holbrook et al. 2019) in northwestern Montana examined habitat relationships in areas occupied by resident lynx. These studies confirmed that while a variety of boreal forest composition and structure is important, lynx use mature spruce-fir forest cover types more than any other forest structural stage or tree species. Proportion and connectivity of mature forest structure, along with interspersions of younger, smaller-diameter, regenerating forest were shown to be of high importance for lynx. This relationship is largely driven by food availability, since the younger, regenerating forest supports the highest densities of snowshoe hares, but the mature forest structural stage is where lynx are able to hunt hares most efficiently.

Foraging habitat and reproductive denning habitat are the two factors of most importance to lynx. Lynx are strongly tied to their primary prey species, the snowshoe hare. Therefore, conditions that provide a prey base of hares also provide the best habitat for lynx. Snowshoe hares select for dense horizontal cover that provides hares with food, protection from predators, and thermal cover from extreme weather conditions (Interagency Lynx Biology Team 2013). Winter is the most limiting time for lynx in terms of finding sufficient prey to survive. The lynx winter diet is primarily restricted to snowshoe hares, due to both species' adaptation to snow, combined with the ecology of alternate prey species and competing predators. Winter snowshoe hare habitat consists of places where young trees or shrubs grow densely, and are tall enough to protrude above average snowpack, both in younger regenerating stands and multi-story mature stands (U.S. Department of Agriculture 2007a).

Since lynx and snowshoe hares are snow-adapted species with strong ties to boreal forest conditions, climate change could influence the availability of winter snowshoe hare habitat and associated lynx foraging habitat. Climate change has been cited as one of the primary human-caused drivers influencing lynx habitat in the continental United States, and a number of studies predict the ranges of both the lynx and snowshoe hare will move northward and to higher elevations as temperatures increase, because of global climate change. Shifting distribution of lynx and snowshoe hares may occur as a result of climate-related factors such as changes in snow depth, condition, or persistence; changes in the frequency and scale of natural disturbance events; and changes in predator-prey dynamics, should lynx lose their competitive advantage in snow (Interagency Lynx Biology Team 2013). A variety of climate models predict that the Greater Yellowstone Area (including the Custer Gallatin) will experience a reduction in persistent snow cover, a change from boreal to temperate conifer forest types, and loss of potential lynx habitat by the year 2100 (Gonzalez et al. 2007). However, some experts suggest that the Greater Yellowstone Area may have a future role as a refuge for lynx in the face of climate change, because of its relatively high elevation and associated potential to maintain winter snow levels and conditions (Bell et al. 2016). The lynx summer diet may contain a broader range of prey species including squirrels, grouse, beaver (*Castor canadensis*), mice, voles, shrews, weasels, fish, ungulates, and ungulate carrion (Squires et al. 2010, Interagency Lynx Biology Team 2013). These food sources may be found in any stage of lynx habitat, and are less likely to be influenced by climate change.

Female lynx begin to reproduce at one to two years of age, and are capable of reproducing annually in good quality habitat with adequate prey. Breeding generally occurs in spring, with kittens typically born late April through May in Montana. Female lynx select areas with abundant coarse woody debris for reproductive den sites. Snags, logs, or root wads of fallen trees provide cover from predators and other environmental threats to lynx kittens. Denning areas must be reasonably close to foraging habitat (high-quality snowshoe hare habitat), so that the female lynx can hunt while leaving the kittens unattended nearby (Interagency Lynx Biology Team 2013). The amount of coarse woody debris is the key component of lynx reproductive denning habitat, rather than the age of the forest stand (U.S. Department of Agriculture 2007b). The structural components of denning habitat may be present in younger forests affected by disturbance, as well as mature and older stands, where tree mortality occurs as a result of disturbance as well as through natural aging processes. Climate change may also influence the availability of denning habitat. Warming temperatures relative to predicted precipitation levels are expected to result in larger, more frequent fires and other disturbances that produce the coarse woody material used by lynx as denning structure.

Other habitats used by lynx include boreal forest types in early- to mid-succession that lack the dense horizontal cover required by snowshoe hares, but still provide vegetative cover for lynx to travel through or rest in. These types include young to mature forests that result through natural succession as stands grow and lower branches are lost through the trees' self-pruning process, as well as mechanically thinned areas where tree spacing provides little horizontal cover for hares. Lynx will travel through these areas when moving between patches of snowshoe hare habitat, and may occasionally find alternate prey species in these areas (Squires et al. 2010). These stands may contain large logs and root wads, providing structure associated with denning habitat. Stands that currently have low horizontal cover have the potential to produce snowshoe hare habitat through natural succession as young trees and shrubs fill gaps, or through deliberate silvicultural management by opening the canopy to allow more light penetration to stimulate growth of grasses, forbs, shrubs, and small trees in the understory (Zimmer et al. 2008, Holbrook et al. 2017a).

Finally, early stand-initiation stage lynx habitat has experienced recent disturbance such as stand-replacing fire, wind events, timber harvest, or other processes that removed or dramatically reduced live standing trees, temporarily reducing the suitability as foraging, denning, or daily travel areas for resident lynx. Warming climates are predicted to increase the frequency, severity, and extent of natural disturbance processes, which could increase the proportion of lynx habitat in a condition that does not support snowshoe hares (Interagency Lynx Biology Team 2013). As these areas begin to regenerate, low-level vegetation may provide habitat for snowshoe hares and other prey species in summer, but would not provide winter snowshoe hare habitat until natural succession increases tree height and density to achieve adequate horizontal cover above average snow depth (U.S. Department of Agriculture 2007b). Resident lynx tend to avoid, or travel quickly through large open areas (Squires et al. 2010). However, Ruediger et al. (2000b) reported that dispersing lynx (in other words, those leaving their natal area or existing home range in search of a new home range) are known to travel through large areas of limited forest cover.

Lynx Habitat Modeling and Mapping

Most lynx research in Montana has occurred west of the Continental Divide, where habitats are more contiguous (less fragmented), adjacent to source populations in Canada, and generally more favorable for snowshoe hares and lynx with larger, more connected patches of boreal forest (Interagency Lynx Biology Team 2013). As a result, lynx habitat use patterns east of the Continental Divide, including the Greater Yellowstone Area (and Custer Gallatin Forest), are not well understood. Lynx habitat mapping recommendations were outlined in the Lynx Conservation Assessment and Strategy (Ruediger et al. 2000b), and adopted as direction in the Northern Rockies Lynx Management Direction (U.S. Department of Agriculture 2007b). This direction was later clarified by a Forest Service Regional Office memo (Marten 2016b). In 2010, national forests east of the Continental Divide in the Northern Region (Helena, Lewis and Clark, Custer and Gallatin) began collaborating on a uniform method to map lynx habitat categories consistent with the Lynx Conservation Assessment and Strategy and Northern Rockies Lynx Management Direction (Ruediger et al. 2000a) (U.S. Department of Agriculture 2007b). This effort, referred to as the "East Side Assessment" (Canfield 2016), was intended to develop reliable, consistent lynx habitat mapping and modeling protocols that could be used for mid- to large-scale assessments such as forest planning. Due to a lack of local data on lynx habitat use, lynx habitat characteristics used in the East Side Assessment were derived from research on lynx in other areas, including, but not limited to, northwestern Montana. The methods developed in the East Side Assessment are consistent with direction presented by the regional forester (Marten 2016a).

Using methods established in the East Side Assessment, a geographic information system was used to estimate amounts of lynx habitat within the Custer Gallatin National Forest boundary. Lynx habitat areas were predicted by selecting potential vegetation types deemed capable of producing the boreal to subalpine forest conditions most frequently used by lynx and snowshoe hares. Potential vegetation type information was obtained from a regional (Northern Region, U.S. Forest Service) database (R1 Broad PVT data layer), which classifies broad areas based upon assemblages of potential natural vegetation (or habitat types) with similar biophysical characteristics (for example, slope, aspect, elevation), disturbance regimes, species composition, structural characteristics, productivity and successional trends into mature forests (Milburn et al. 2015). In other words, potential vegetation types provide a very coarse filter system for predicting potential lynx habitat, based on a broad-scale estimate of indicated climax plant species. The cool, moist forest potential vegetation type accounts for the majority of mapped lynx habitat, with some inclusions of cold forest types. Riparian and shrubland types account for secondary lynx habitat where they are associated with the cool, moist, or cold forest types. Table 33 in the terrestrial vegetation section shows the proportion of broad potential vegetation types by geographic area for the portion of the Custer Gallatin with mapped lynx habitat.

Forested habitats go through a range of successional stages from the time of setback due to disturbance until reaching the full site potential, or climax stage. Various forest succession stages may be used by lynx and snowshoe hares for different purposes as described previously. Therefore, lynx habitat mapping was further refined by evaluating existing forest cover types and structural conditions based on dominant tree species, average tree size, canopy cover, and time since last disturbance (Canfield 2016). Existing cover type information was extracted from the Northern Region vegetation database (R1 VMap), which represents current vegetative conditions based on remotely sensed reflections of the Earth's surface (satellite imagery). VMap classifications are also informed by aerial photography and ground-based, field-verified sampling of vegetation communities (Barber et al. 2011).

As with all models, there is uncertainty in the mapping process used to estimate lynx habitat potential on the Custer Gallatin National Forest, particularly given the lack of empirical data for lynx habitat use patterns in this area, but also considering the limits of available data. R1 Broad PVT contains a coarse grouping of forested habitat types found in Montana (Pfister et al. 1977), with reasonable accuracy at a very broad scale, but for which accuracy declines as scale decreases. R1 VMap is the primary vegetation data set used to estimate current amounts and distribution of various lynx habitat structural stages. VMap is useful for predicting many aspects of potential lynx habitat. For example, it classifies vegetation by lifeform, such as conifer (tree), shrub, or herbaceous (grass/forb), and can distinguish between vegetation and non-organic cover like rock. It also contains information about dominant tree species, size class, and canopy cover, which are good indicators of potential lynx habitat. However, understory structure is important for lynx, as this component is what provides, or lacks, the dense horizontal cover selected by snowshoe hares. Since VMap data are acquired remotely from satellites, understory structure is not well captured because the imagery often cannot penetrate through the forest canopy to reflect conditions closer to the ground. For this analysis, time since last major disturbance, tree size, and canopy cover, combined with local knowledge, were assumed to provide reasonably accurate representations of forest structure, including the presence of dense horizontal cover for hares and coarse woody debris for lynx reproductive dens sites, in the forest understory. Further validation of lynx habitat structural stages will be necessary at the project level.

Using methods established in the East Side Assessment for lynx and updating to incorporate regional protocol for lynx habitat mapping (Marten 2016a), potential lynx habitat was mapped for the montane ecosystem geographic areas. Results of this process reflect a point in time, and are subject to change over time, since lynx habitat components may change because of natural succession or disturbance. For example, an area currently in early stand-initiation stage that is not yet providing winter snowshoe hare habitat may grow and naturally progress into snowshoe hare habitat within the life of the plan. Similarly, an area of mature forest currently providing lynx denning and foraging habitat may revert to early stand-initiation stage not suitable as denning or foraging habitat, due to wildfire, vegetation management, or other disturbance events. Lynx habitat occurs over a large scale. The montane ecosystem of the Custer Gallatin covers well over 2 million acres. Given this large landscape and the programmatic nature of the plan, remotely sensed data informed by field-verified information and local knowledge, provide the best available information upon which to base modeled lynx habitat for this analysis. Refinement of broad-scale lynx habitat mapping is expected to occur as better data or technology become available (Ruediger et al. 2000a, U.S. Department of Agriculture 2007b) (U.S. Department of the Interior 2007, Interagency Lynx Biology Team 2013). Site-specific validation of lynx habitat types and structural stages could greatly improve lynx habitat mapping reliability for future projects implemented under the plan, as well as provide a basis for updating forestwide lynx habitat mapping over time.

Early stand-initiation stage lynx habitat reflects recently disturbed areas in which all or the vast majority of trees have been removed by fire, harvest, or other disturbance, and new trees are not yet tall enough to protrude above the average snow depth in winter. Early stand-initiation stage lynx habitat may provide summer foraging opportunities for snowshoe hares, but does not provide winter snowshoe hare habitat. This category is estimated based upon the potential vegetation (R1 Broad PVT) predicted to be capable of producing boreal forest conditions, combined with recent imagery (R1 VMap) indicating a lack of forest cover. Fire and timber harvest databases (MTBS and FACTS, respectively) indicate that these areas have been recently altered by fire or mechanical harvest. As with other elements of the lynx habitat modeling process, assumptions are made for early stand-initiation stage that may affect the overall accuracy of habitat estimates. Areas that were previously forested and recently harvested or burned by high-severity fire are usually obvious and accurately represented by modeling. However, with no record of recent harvest or high-severity fire, some areas predicted (by R1 Broad PVT) to be capable of producing boreal forest conditions, but currently shown (by R1 VMap) as having no trees present, are more difficult to assess. These typically involve areas within a fire perimeter, but within a low to moderate fire severity class, where some evidence of tree survival or regeneration is expected, but not indicated by VMap classification. These areas may be capable of producing boreal forest cover types, but regeneration is slower or less evident, or they may have always been, or recently converted to, natural openings that will not likely grow dense trees in the near future. To err on the conservative side, the Custer Gallatin lynx habitat model assumes these types are potential lynx habitat that is currently in an early stand-initiation stage. This assumption may result in an overestimate of this particular lynx habitat component, and further validation will be needed at the project level to verify habitat conditions.

Winter snowshoe hare habitat most commonly develops in the stand-initiation stage several years after a disturbance, when trees are tall enough to protrude above the snow, or during understory re-initiation in mature and late-succession forest structural stages. On the Custer Gallatin, stand-initiation stage snowshoe hare habitat can be detected with a reasonable level of accuracy from remotely sensed imagery, because the young trees are not shielded from view by overstory trees. Multi-storied forest structure can also be reasonably predicted based on stand age, dominant tree species, size class and canopy cover. However, the amount of horizontal cover (snowshoe hare habitat) is difficult to predict through a modeling process for reasons listed previously. It is likely that there is considerable overlap between stands modeled as “multi-storied mature” and “other;” that is, it is quite possible that stands modeled as other habitat may actually provide multi-storied snowshoe hare habitat and vice-versa.

“Other” lynx habitats include young to mature forests that have grown beyond the stand-initiation stage, and have lost lower branches through a self-pruning process, or have been thinned through mechanical treatment or natural processes that leave many live trees standing, but with low levels of horizontal cover near the ground (or snow surface). Structural conditions within these types of lynx habitat are modeled based on tree species dominance type, size class, and canopy cover. Identifying these types is also susceptible to vulnerabilities of the modeling process described previously; however, there is reasonable consensus among local foresters and ecologists that these types of stands generally do not have well-developed understories that provide adequate food and cover for snowshoe hares (Canfield 2016), but they may contain coarse woody debris that could contribute to lynx denning habitat.

Lynx reproductive denning habitat is characterized by large amounts of coarse woody debris (such as large down logs and root wads from fallen trees), which can occur over a wide range of successional stages in forest habitat. Quality of denning habitat is influenced by proximity to foraging habitat, meaning the best quality denning habitat is where coarse woody debris is abundant within or adjacent to areas that provide habitat for snowshoe hares. The presence of coarse woody debris can be difficult to detect under a live forest canopy using remotely sensed imagery. However, due to recent large-scale ecological disturbance processes such as fire, wind, insects and disease, tree mortality has been widespread across the Custer Gallatin, and as a result, coarse woody debris is abundant and well distributed in lynx habitat, with equally abundant dead-standing trees available to contribute to coarse woody debris over time. Due to potential occurrence of coarse woody debris within a wide range of forest successional stages, lynx reproductive denning habitat is not modeled as a separate habitat component, but rather is assumed to be readily available and well distributed throughout lynx habitat on the Custer Gallatin National Forest.

Finally, not all habitat types within the montane geographic areas of the national forest are considered (that is, modeled or mapped as) potential lynx habitat. Warmer, drier forested types, as well as non-forest vegetation types (such as grass, forb, shrub) and non-vegetation types (for example, rock, water), do not provide boreal forest conditions selected by lynx and snowshoe hares. These habitat types are often interspersed with, or surround lynx habitat on the Custer Gallatin, and account for considerable proportions of the montane ecosystem in which lynx habitat occurs. Such types are referred to as “non-habitat” for lynx in this analysis.

Lynx Habitat Distribution on the Custer Gallatin National Forest

Lynx habitat is found only in the montane geographic areas on the Custer Gallatin. Within these geographic areas, only about 40 percent of the area contains the cool, moist boreal forest types that will support snowshoe hares and lynx. The terms “lynx habitat” or “potential lynx habitat” only refer to these types. The total amount of lynx habitat relative to non-habitat remains relatively constant over time, but the various structural stages of lynx habitat change over time through processes of disturbance and natural succession.

At the time of this analysis, the amount and proportion of early stand-initiation stage lynx habitat was quite low, at about 3 percent of the total lynx habitat across the entire montane ecosystem, and ranging from 1 percent in the Madison, Henrys Lake, and Gallatin Mountains and the Bridger, Bangtail, and Crazy Mountains geographic areas to 6 percent in the Absaroka Beartooth Mountains Geographic Area. The low percentage is generally reflective of most individual lynx analysis units as well, although four lynx analysis units with past fires are higher than the range stated for the geographic areas. Fire is the most common disturbance in lynx habitat. Typically, large stand-replacing fires burn every 40 to 200 years, with smaller, lower intensity fires occurring in the intervals between stand-replacing fires (U.S. Department of Agriculture 2007b). Large stand-replacing fires in lynx habitat on the Custer Gallatin occurred in 2012, with the Millie Fire in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area and the Pine Creek Fire in the Absaroka Beartooth Mountains Geographic Area. Though these fires were large at over 10,000 acres each, they were small relative to the size of the geographic area in which they were located, and did not occur entirely in lynx habitat. At the time of this analysis, the most recent large-scale fire in lynx habitat was the Bacon Rind Fire, which burned roughly 3,650 acres on the Custer Gallatin near Yellowstone National Park, in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area. Preliminary modeling estimates that of the acres burned on the national forest, the Bacon Rind fire affected roughly 1,200 acres of lynx habitat with low-, moderate-, or high-severity fire. This relatively small acreage does not appreciably change the amount of early stand-initiation lynx habitat in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area.

Large-scale disturbances produce early stand-initiation habitats that are temporarily low-quality habitat for snowshoe hares and lynx, in that trees are not yet tall enough to protrude above the snow to provide winter habitat for snowshoe hares, and because trees may not be dense enough to provide even summer foraging habitat for snowshoe hares. However, the affected areas often regenerate to produce a stand-initiation structural stage, with high-quality snowshoe hare habitat as trees become tall and dense enough to protrude above the snow and provide year-round food and cover for hares. On the Custer Gallatin National Forest, it takes an average of about 16 years after a disturbance to produce tree height and density selected by hares, and stands can persist as snowshoe hare habitat for up to 40 years or more after a disturbance. Mature, multi-storied snowshoe hare habitat takes much longer to produce through natural succession, but currently a large proportion of mature and older successional forest habitat on the Custer Gallatin has potential to provide multi-storied snowshoe hare habitat.

Currently, the younger stand-initiation stage snowshoe hare habitat component accounts for approximately 7 percent of lynx habitat, while the multi-story structural stage is estimated to occur in approximately 40 percent of lynx habitat. The multi-story structural stage is modeled based upon the best available information using remotely sensed data for a large area. However, horizontal cover is difficult to detect or model using remotely sensed vegetation data, so while the multi-storied structural stage is the most likely area to support snowshoe hares in mature lynx habitat, the model cannot accurately predict how much of the multi-story structural stage actually contains sufficient horizontal cover to support snowshoe hare use. Combining the stand-initiation stage with the multi-story structural stage indicates that nearly half (47 percent) of the lynx habitat on the Custer Gallatin is potential snowshoe hare habitat at the time of this analysis. However, the fact that snowshoe hares occur at lower densities on the Custer Gallatin than in more productive environments elsewhere suggests that the amount of potential snowshoe hare habitat may be overestimated, or it may be that the habitat is patchily distributed over such a large area that snowshoe hares cannot make efficient use of it.

Looking at individual geographic areas, the Madison, Henrys Lake, and Gallatin Mountains Geographic Area has the most acres and greatest proportion of potential snowshoe hare habitat. The Pryor Mountains Geographic Area has the fewest acres of snowshoe hare habitat, but due to its relatively small size and lower levels of recent disturbance, shows the second highest proportion of potential snowshoe hare habitat. The Bridger, Bangtail, and Crazy Mountains Geographic Area has an average proportion of snowshoe hare habitat, but relatively few acres compared to the larger geographic areas, while the Absaroka Beartooth Mountains Geographic Area has the lowest proportion of potential snowshoe hare habitat, but the second highest total acreage. The Absaroka Beartooth Mountains is the largest geographic area on the Custer Gallatin, and it has the highest amount of recently disturbed lynx habitat with potential to grow into snowshoe hare habitat within the life of the plan. Large areas that burned in this geographic area in the early 2000s are expected to begin to produce winter snowshoe hare habitat in the near future. As with early stand-initiation structural stage, individual lynx analysis units are generally consistent with the management plan geographic areas in which they occur for the proportion of stand-initiation and multi-storied mature structural stages that provide winter snowshoe hare habitat.

Reproductive denning structure is an important element of lynx habitat that can occur across a variety of forest successional stages. Due to fairly regular large fires, wind events, and widespread insect and disease outbreaks across the Custer Gallatin National Forest, coarse woody debris is generally abundant, and therefore, potential lynx denning habitat is readily available and well-distributed throughout lynx habitat on the Custer Gallatin, although there are no recent records of lynx reproduction occurring here.

At the time of this analysis, about half of the lynx habitat on National Forest System lands was classified as other types that do not provide high-quality snowshoe hare habitat. Individual geographic areas range from the highest proportion of this type in the Absaroka Beartooth Mountains (at 58 percent of total lynx habitat), and the lowest in the Madison, Henrys Lake, and Gallatin Mountains (at 43 percent), but all geographic areas have a considerable amount of other lynx habitat. This proportion is reflective of individual lynx analysis units as well, although they span a larger range. The primary difference between areas identified as mature, multi-storied snowshoe hare habitat and those identified as other is the presence and amount of high horizontal cover. Since horizontal structure in the understory is difficult to model or estimate, there could be considerable overlap between these habitat components, emphasizing again the need for further validating lynx habitat mapping at the project level.

Research in northwestern Montana where lynx are known to occur and snowshoe hares are relatively abundant indicates that it is not only the proportion of snowshoe hare habitat, but also the dominant tree species type, juxtaposition of early versus later successional habitat, and overall habitat connectivity that are important to lynx survival and reproduction (Holbrook et al. 2017b, Holbrook et al. 2018, Kosterman et al. 2018, Holbrook et al. 2019). It is important to note that the habitat structural classes referenced in these studies are not directly comparable with structural classes used to develop the Northern Rockies Lynx Management Direction (U.S. Department of Agriculture 2007b) which defines how lynx habitat was mapped for the Custer Gallatin National Forest. Further, since there are no known resident lynx on the Custer Gallatin at this time, there are no comparable data for lynx habitat use patterns within a known home range. However, these studies from northwestern Montana present science that is meaningful for evaluating lynx habitat conditions in the plan area.

In northwestern Montana, lynx use mature spruce-fir forest types more than any other habitat conditions (Holbrook et al. 2017b). These forest conditions are more readily available in northwestern Montana than they are in southwestern Montana on the Custer Gallatin National Forest. For example, on the Flathead National Forest, which makes up a considerable portion of the study area examined by Holbrook et al. (2017b), spruce and fir dominant forest cover types occur more frequently than any other tree species, ranging from 30 to 45 percent of the forested habitat at any point in time, and currently estimated at the high end of that range. Not only do subalpine fir and spruce dominate forest cover types on the Flathead, but also, they are the two most common tree species, occurring on all but the driest sites on the national forest (U.S. Department of Agriculture 2018). In contrast, the Custer Gallatin naturally produces spruce-fir dominated forest cover types in only 10 to 20 percent of the forested habitats, currently estimated at about 12 percent (figure 4). It is noteworthy that Holbrook et al. (2017b) only looked at habitat within known lynx home ranges, and the figures reported above for the Flathead National Forest and the Custer Gallatin National Forest are forestwide. However, there are no known lynx home ranges to examine for the Custer Gallatin, and the Northern Rockies Lynx Management Direction does not break out lynx habitat in a way that is directly comparable to the science presented by Holbrook et al. (2017b). Therefore, at this time, the best measures for comparison are the forestwide figures developed through land management plan revision for the two national forests.

In an earlier publication, Holbrook et al. (2017b) indicated that lodgepole pine is also an important tree species for snowshoe hares, particularly in winter, because lodgepole pine produces higher levels of digestible protein than other conifer species, including spruce and subalpine fir. Consistent with this research, Zimmer et al. (2008) also showed lodgepole pine as an important food species for snowshoe hares on the Custer Gallatin National Forest. Lodgepole pine is widespread in the montane geographic areas on the national forest. It is most prevalent in the cool, moist potential vegetation types that produce lynx habitat, and is more abundant in these types than either Engelmann spruce or subalpine fir. However, spruce, subalpine fir, and lodgepole pine often occur together in mixed conifer stands that are mapped as potential lynx habitat.

Currently on the Custer Gallatin, mature to late seral stage lynx and snowshoe hare habitat is predicted to occur in greater proportion than the younger, regenerating snowshoe hare habitat, a pattern that is consistent with conditions in occupied lynx home ranges in northwestern Montana. These relative proportions hold true at the geographic area scale, as well as for most individual lynx analysis units on the Custer Gallatin. However, the distribution, juxtaposition and overall connectivity of potential snowshoe hare habitat on the Custer Gallatin tends to be more disjointed than that indicated for occupied lynx territories in northwestern Montana. While there are large amounts of mature and older lynx habitat in all geographic areas as well as individual lynx analysis units, the younger, stand-initiation stage snowshoe hare habitat is more concentrated in areas of past large-scale fires, which occurred mainly in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas. As a result, there is generally good connectivity in mature and older lynx habitat across the Custer Gallatin, which is important for snowshoe hares and lynx. However, at the lynx analysis unit scale, there is currently less of the younger, advanced regeneration habitat shown by Holbrook et al. (2017b) to produce higher densities of snowshoe hares.

Kosterman et al. (2018) and Holbrook et al. (2019)reported that reproductive female lynx in northwestern Montana require large amounts of highly connected mature forest. The probability of a female producing kittens was associated with the connectivity of mature, multistoried forests (Holbrook et al. 2019). In addition to connectivity of mature multistoried habitats Holbrook et al. (2019) suggests that high quality mosaic habitat contains a portion of advanced regeneration forest (≈18-19%). The relative density of snowshoe hare was nearly three times greater in advanced regeneration stands when compared to different structural classes. In the Greater Yellowstone Ecosystem (Kurzen et al. 2020) examined snowshoe hare habitat use across multiple forest cover types, stand ages, and treatment levels. The greatest level of snowshoe hare use was observed in regenerating lodgepole pine stands associated with silviculture activity (Kurzen et al. 2020). The Greater Yellowstone Ecosystem (which includes the Custer Gallatin) is generally higher elevation, more open, and often more precipitous than northwestern Montana, resulting in a more non-forest, drier forest, and steep, rocky terrain conditions that do not support snowshoe hares or lynx. These habitats are often interspersed among the boreal forest types that could support lynx, producing more patchy overall conditions with naturally lower connectivity than found in northwestern Montana (U.S. Department of the Interior 2014a). It should be noted that Kosterman et al. (2018) and Holbrook et al. (2019) looked at 50 percent annual home ranges or "core areas" for female lynx, which is a subset of the total annual home range for individuals, and therefore, not directly comparable to the lynx analysis unit scale used in the Northern Rockies Lynx Management Direction. Across the montane ecosystem of the Custer Gallatin, about 60 percent of the cool, moist forest types with average tree size greater than 5 inches diameter, have a contiguous patch size of greater than 100 acres and nearly 39 percent of those same forest types in patch sizes over 1,000 acres (see 47in the Terrestrial Vegetation section). Large patch size suggests a pattern of reasonably good connectivity for mature forest lynx habitat on the Custer Gallatin at the time of this analysis. However, interspersions of drier forest types, open meadows, rock, and sparse vegetation types frequently occur between large patches of lynx habitat on the Custer Gallatin, which can affect connectivity of habitat for lynx. Further, patch-size figures represent conditions across the entire montane ecosystem, since lynx habitat mapped per the Northern Rockies Lynx Management Direction for the Custer Gallatin has not been measured in the same way as Kosterman et al. (2018) or Holbrook et al. (2019), and there are no known reproductive female lynx home ranges on the Custer Gallatin to use for comparison purposes.

Finally, not all habitat types within the montane geographic areas are considered lynx habitat. Warmer, drier forested types, as well as non-forest types do not provide boreal forest conditions selected by lynx or snowshoe hares. These habitat types are interspersed with, or surrounding lynx habitat within the montane ecosystem, and account for considerable proportions of each of the montane geographic areas, as well as individual lynx analysis units. About 60 percent of the National Forest System lands within the montane ecosystem are classified as non-habitat for lynx. These areas do not currently provide habitat suitable for lynx or snowshoe hares, nor do they have the site potential to become good lynx habitat over time. Lynx and snowshoe hares may travel through such areas, but are not expected to reside in these habitats. The Absaroka Beartooth Mountains Geographic Area has the largest acreage of non-lynx habitat primarily because of the considerable amount of area above timberline. The Pryor Mountains Geographic Area has the lowest acreage of non-lynx habitat, but the highest proportion, given its relatively small size. Table 65 represents current estimates of lynx habitat by geographic area for National Forest System lands in the Custer Gallatin National Forest.

Table 65. Lynx habitat on National Forest System lands by geographic area

Geographic Area	Total NFS Acres	Total Lynx Habitat[1]	Percentage[2] Early Stand Initiation	Percentage[2] Snowshoe Hare	Percentage[2] Other	Percentage Non-lynx Habitat[1]
Absaroka Beartooth Mountains	1,358,541	399,398 29%	6%	36%	58%	71%
Madison, Henrys Lake, Gallatin Mountains	806,616	447,208 55%	1%	56%	43%	45%
Bridger, Bangtail, and Crazy Mountains	205,148	123,377 60%	1%	49%	50%	40%
Pryor Mountains	75,067	13,707 18%	3%	52%	45%	82%
Totals	2,445,372	983,690 40%	3%	47%	50%	60%

NFS = National Forest System.

1. Percent = proportion of total National Forest System acres.

2. Percent = proportion of National Forest System lynx habitat acres.

Designated Critical Habitat

Lynx habitat is based on site potential to produce boreal forest conditions. In addition, the U.S. Fish and Wildlife Service designated critical habitat for lynx in 2009, and later revised the designation in 2014. The Custer Gallatin National Forest is within the Greater Yellowstone Area (Unit 5) of critical habitat for lynx. Approximately 25 percent of the designated critical habitat in the Greater Yellowstone Area Unit falls within the Custer Gallatin National Forest boundary. Areas designated as critical habitat contain the primary constituent elements, or those specific elements of physical or biological features that provide for a species' life history processes and are essential to the conservation of the species. Primary constituent elements specific to lynx in the contiguous United States include boreal forest landscapes supporting a mosaic of differing successional forest stages containing:

a) Presence of snowshoe hares and their preferred habitat conditions, which include dense understories of young trees, shrubs or overhanging boughs that protrude above the snow, and mature multi-storied stands with conifer boughs touching the snow surface;

b) Winter conditions that provide and maintain deep fluffy snow for extended periods of time;

c) Sites for denning that have abundant coarse woody debris, such as downed trees and root wads; and

d) Matrix habitat (such as hardwood forest, dry conifer forest, non-forest, or other habitat types that do not support snowshoe hares) that occurs between patches of boreal forest in close juxtaposition such that lynx are likely to travel through such habitat while accessing patches of boreal forest within a home range (U.S. Department of the Interior 2014a).

Critical habitat is designated in those portions of the Custer Gallatin with the highest potential to support residential lynx use over time. Roughly 56 percent of the montane ecosystem containing lynx habitat is designated critical habitat. Critical habitat for lynx is located only in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, and covers about 63 percent of the land base in these geographic areas combined. The areas with potential lynx habitat outside of designated critical habitat contain conditions that may support transient use by lynx, but are not considered to provide adequate quantities or combinations of elements essential to meeting all life cycle needs of the lynx (U.S. Department of the Interior 2014a).

As with lynx habitat, critical habitat components change over time. For example, an area that provides stand-initiation stage snowshoe hare habitat today, may grow, drop lower branches, and no longer provide snowshoe hare habitat within a relatively short amount of time. Quantities of snowshoe hare habitat and denning habitat (primary constituent elements (a) and (c) above) are estimates as of the time this analysis was prepared. Primary constituent element (a), winter snowshoe hare habitat, was described above in terms of lynx foraging habitat. An estimated 18 percent of the designated critical habitat on the Custer Gallatin National Forest is predicted to provide snowshoe hare habitat, including both the younger, stand-initiation structural stage as well as multi-storied mature structural stage.

Element (b), winter snow condition, is less well-defined and difficult to quantify, but because both the lynx and snowshoe hare are morphologically adapted for efficient travel over deep, soft snow, winter snow conditions are important. The Custer Gallatin National Forest is part of the Greater Yellowstone Area Unit of designated critical habitat for lynx. This unit is at higher elevation than most other areas that support lynx. Winters can be severe here, and deep snow is rarely in short supply. However, because the Greater Yellowstone Area is naturally more open than other areas that support lynx, snow may be more exposed to sun and wind, which can form crust on the snow surface. Freeze-thaw events, or wind loading, can change the consistency of snow, which may affect the competitive advantage for lynx. Snowpack accumulation has been on a downward trend since historical times, and much of this is attributed to lower levels of winter precipitation in the interior northern Rocky Mountains (Luce 2018) which includes the montane geographic areas of the Custer Gallatin.

Lynx have a competitive advantage over more generalist predators in deep, soft snow, a condition that as noted previously, is difficult to quantify. However, in predicting suitable habitat for wolverines, Copeland, and others (2010) examined a number of factors to predict where winter snow accumulation persists well into the spring. Although snow conditions on the national forest are not always deep, soft, or fluffy, areas of persistent snowpack (per (Copeland et al. 2010)) were used as a proxy to quantify where primary constituent element 1b is most likely to occur on the Custer Gallatin. This modeling effort indicates that roughly 73 percent of designated lynx critical habitat on the national forest occurs in areas of persistent snow cover. This figure includes all primary constituent elements of designated critical habitat for lynx, including both the boreal forest lynx habitat as well as matrix habitat, since deep snow can benefit lynx and snowshoe hares wherever it occurs. Only about 36 percent of the modeled persistent snowpack in critical habitat overlaps the boreal forest types most likely to be used by lynx; the other 64 percent of modeled persistent snowpack overlaps with the matrix element of critical habitat. This configuration is at least partly due to large alpine areas that have persistent snowpack due to high elevation, but do not provide lynx denning or foraging habitat. Another way to look at this is that approximately 61 percent of the boreal forest types in designated critical habitat are within the modeled persistent snowpack, whereas about 83 percent of the matrix habitat is within modeled persistent snowpack.

Over the expected life of the plan, average daily temperatures are predicted to increase, including winter temperatures. Precipitation is also expected to increase slightly, but there is greater uncertainty about projections for precipitation than for temperatures (Joyce *in (Halofsky et al. 2018a)*). Projected increases in precipitation are not expected to offset effects of warming temperatures. Snow water equivalent is expected to decline, which could affect snow consistency and persistence. The dense forest canopy associated with boreal forest types (lynx habitat) generally helps retain snowpack and snow consistency, and the dominant tree species in lynx habitat (lodgepole pine, Engelmann spruce, and subalpine fir) have shown high resiliency to past climate fluctuations (Hansen et al. 2018). Reduced snow accumulation, changes in snow consistency and persistence could affect the competitive advantage lynx have over other predators in winter (Interagency Lynx Biology Team 2013).

Element (c), denning habitat, was also described previously for lynx habitat in general. Due to recent disturbance processes such as fire, wind, insects and disease, tree mortality has been widespread across the Custer Gallatin, and as a result, coarse woody debris such as down trees and rootwads are abundant and well distributed in lynx habitat. Based on historical fire regimes and recent natural disturbance patterns, roughly 38 percent of the National Forest System lands in designated critical habitat are predicted to contain both the boreal forest attributes of lynx habitat in general, as well as the down woody materials lynx use for denning purposes. Denning habitat may also provide snowshoe hare habitat, which is ideal for lynx, but not all potential denning habitat contains adequate horizontal cover for snowshoe hares. Therefore, proximity of denning habitat to snowshoe hare habitat is also important for lynx. Because coarse woody debris is abundant and widespread across the montane ecosystem, denning habitat for lynx is not currently a limiting factor. Given the nature and frequency of disturbance events in the montane ecosystem of the Custer Gallatin, denning habitat is likely to remain readily available over the life of the plan.

Element (d), matrix habitat, is a catchall for non-lynx habitat that does not provide the cool, moist (boreal) forest conditions most important to lynx and snowshoe hares. Matrix habitat includes drier forest types as well as natural openings that do not produce the dense horizontal cover required by snowshoe hares. Since matrix habitat contains neither suitable habitat for snowshoe hares, nor the site potential to become suitable for hares over time, it does not provide current or future high-quality foraging opportunities for lynx. However, matrix habitat may be intermingled with snowshoe hare habitat such that lynx are likely to travel through it to access better hunting grounds. Because boreal forest types are naturally fragmented and patchily distributed on the Custer Gallatin National Forest, a considerable amount (approximately 57 percent) of the designated critical habitat on the national forest falls into the matrix category. Table 66 shows the amount of designated critical habitat for lynx and proportion of each primary constituent element within the Custer Gallatin.

Table 66. Designated critical habitat for lynx and proportion of each primary constituent element

Critical Habitat	Primary Constituent Element 1a Snowshoe Hare Habitat[1]	Primary Constituent Element 1b Persistent Snow[2]	Primary Constituent Element 1c Denning Habitat[3]	Primary Constituent Element 1d Matrix[4]	Total Acres Designated Critical Habitat
Absaroka Beartooth Mountains	13%	78%	31%	64%	1,040,829
Madison, Henrys Lake, Gallatin Mountains	35%	58%	61%	33%	322,985
Totals	18%	73%	38%	57%	1,363,814

1. Includes stand-initiation stage and multi-storied; percent is of total designated critical habitat.
2. From Copeland et al. 2010: modeled persistent snow cover for wolverines; percentage of total designated critical habitat.
3. Includes multi-storied and other mature lynx habitat; percentage of total designated critical habitat.
4. Includes non-lynx habitat within designated critical habitat; percentage of total designated critical habitat.

Key Stressors

Lynx populations occur at low densities in the continental United States relative to lynx populations in Canada, and this has likely been the case historically, due to naturally fragmented and lower quality habitat for lynx and their primary prey species, the snowshoe hare (U.S. Department of the Interior 2000a). The Greater Yellowstone Area, which includes the Custer Gallatin National Forest, is farther south than most other areas of the United States that currently support lynx, and it is geographically isolated from source populations in Canada. Habitat for lynx on the Custer Gallatin is naturally fragmented and patchily distributed, due to relatively high elevation, extreme topography, and related ecological conditions, resulting in marginal habitat for snowshoe hares and lynx.

Due to the strong association between lynx and snowshoe hares, the primary system drivers that affect lynx are those events or processes that affect snowshoe hare habitat and populations. Natural factors that affect these conditions in the plan area include climate, topography, soil conditions, disturbance and forest succession.

Other predators may compete with lynx for access to prey species, or prey directly on lynx (Interagency Lynx Biology Team 2013). The Custer Gallatin hosts a complex suite of native predators, including large, medium, and small mammals as well as avian species, most of which will take snowshoe hares as prey if the opportunity presents. Mountain lions, coyotes, wolverines (*Gulo gulo*), and wolves (*Canis lupus*), which are common or at least present on the Custer Gallatin, have been known to prey on lynx.

Due to their affiliation with deep, soft snow conditions, winter management and recreation activities that result in snow compaction have potential to affect snowshoe hares and lynx.

Lynx were legally harvested (mainly trapped) as a furbearer species in Montana until they were listed as threatened under the Endangered Species Act in 2000, at which time trapping and snaring of lynx became prohibited. However, as with most wild cats, lynx are vulnerable to trapping and can be inadvertently caught in traps legally set for other furbearer species (Interagency Lynx Biology Team 2013).

Vegetation management activities such as timber harvest and prescribed fire have the potential to affect lynx habitat in ways that can be detrimental, neutral, or even beneficial to lynx. Fire suppression, fuels treatment, and habitat fragmentation associated with roads pose potential threats to lynx related to vegetation management (U.S. Department of the Interior 2014a).

Since lynx and snowshoe hares are snow-adapted species with strong ties to boreal forest conditions, climate change is a potential stressor and possible driver for persistence of these species on the Custer Gallatin and elsewhere in the contiguous United States (Gonzalez et al. 2007).

Increased traffic volume and speed on roads that divide designated critical habitat for lynx could reduce habitat connectivity for lynx and could result in increased mortality of lynx (U.S. Department of the Interior 2014a).

Environmental Consequences

Management Direction under Current Plans

Current plans for the Custer and Gallatin national forests incorporated Northern Rockies Lynx Management Direction through a plan amendment (U.S. Department of Agriculture 2007b). The direction includes goals, objectives, standards, and guidelines common to 18 national forests in the continental United States, including the current Custer and Gallatin Plans. The Northern Rockies Lynx Management Direction would be adopted in its entirety under all revised plan alternatives. Plan components from the Northern Rockies Lynx Management Direction are designed to conserve and promote recovery of the Canada lynx. The direction applies to all National Forest System lands that are designated occupied by Canada lynx. For areas of the Custer Gallatin with potential lynx habitat that are currently designated unoccupied by lynx, the Northern Rockies Lynx Management Direction is to be considered when planning and designing management actions. See the discussion in the Affected Environment section for more detailed information about occupied and unoccupied lynx habitat.

The Northern Rockies Lynx Management Direction contains standards to maintain lynx habitat connectivity within and between lynx analysis units, by limiting permanent development and vegetation management, as well as requiring identification of potential crossing areas for highway construction in linkage areas. Vegetation management standards limit actions that produce early stand-initiation stage forest (habitat that does not provide forage or cover for snowshoe hares or lynx). Standards also restrict the amount of precommercial thinning and other vegetation treatments that could reduce existing snowshoe hare habitat. Exemptions to these standards allow for fuel treatment within the wildland-urban interface. The Northern Rockies Lynx Management Direction also contains a number of guidelines that address factors such as maintenance of habitat for alternate prey species and distribution of denning habitat for lynx. Guidelines are also included to make livestock grazing practices compatible with conserving lynx habitat, as well as to manage human uses such as recreation, travel, mineral and energy development to maintain lynx habitat conditions and connectivity, and to limit human-caused snow compaction in lynx habitat.

Effects of the Current Plans

Under current plans (alternative A), the Custer Gallatin National Forest would continue to operate under the Northern Rockies Lynx Management Direction, as well as additional plan components that may affect habitat for snowshoe hares and lynx. A full analysis of the potential impacts of implementing the Northern Rockies Lynx Management Direction was done when the direction was amended to current plans, and this can be found in the documents final environmental impact statement (U.S. Department of Agriculture 2007b), as well as the associated biological assessment (U.S. Department of Agriculture 2007b). More recently, the Forest Service completed a biological assessment for designated critical habitat (U.S. Department of Agriculture 2017). These analyses are not repeated here, but key parts are referenced where pertinent to specific conditions on the Custer Gallatin National Forest. In response to these biological assessments through formal consultation, the U.S. Fish and Wildlife Service concluded that implementation of the Northern Rockies Lynx Management Direction is not likely to jeopardize the continued existence of lynx within the contiguous United States distinct population segment (U.S. Department of the Interior 2017a), and is not likely to result in the destruction or adverse modification of designated critical habitat for lynx (U.S. Department of the Interior 2017a). Continued implementation of the Northern Rockies Lynx Management Direction would conserve lynx habitat under current plans by ensuring that adequate habitat and connectivity are maintained, and by limiting management actions that convert lynx habitat to early stand-initiation conditions that are temporarily unsuitable for use by snowshoe hares and lynx.

Core habitat for lynx on the Custer Gallatin is located in the Absaroka Beartooth Mountains Geographic Area, of which roughly 59 percent of the mapped lynx habitat is within designated wilderness. Timber harvest is prohibited and fire suppression has been negligible in the wilderness area. Outside of wilderness, a substantial portion of the lynx habitat in this geographic area is within inventoried roadless areas, which have fewer restrictions than wilderness, yet some limitations are placed on certain management actions. As a result, natural disturbance and successional processes have largely shaped lynx habitat conditions in core habitats. Similarly, most of the secondary habitat on the Custer Gallatin that is considered occupied, is in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, which contains designated wilderness (Lee Metcalf), the Cabin Creek Wildlife and Recreation Area, and the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area.

Designated areas all have land use restrictions that provide some level of protection for lynx habitat. Secondary unoccupied lynx habitat is found in the Bridger, Bangtail, and Crazy Mountains Geographic Area. While there is some inventoried roadless area in this geographic area, there is no designated wilderness, and more of the lynx habitat in this geographic area is in multiple-use lands open to a wider variety of management actions, compared to the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas. Finally, only peripheral lynx habitat is found in the Pryor Mountains Geographic Area. Like the Bridger, Bangtail, and Crazy Mountains Geographic Area, the Pryor Mountains Geographic Area has no designated wilderness and a relatively small proportion of inventoried roadless areas. While many of the designated areas apply land use restrictions that protect lynx habitat from permanent alterations, these designations also limit the potential to use tools such as timber harvest or prescribed burning to improve lynx habitat through deliberate creation of young, regenerating snowshoe hare habitat. Since a large proportion of lynx habitat is within wilderness and other designations that limit management actions, natural disturbance processes are, and would continue under current plans, to be the primary factor driving lynx habitat conditions on the Custer Gallatin. Therefore, under current plans, the effects of management actions would be expected to have minor impacts to lynx habitat relative to natural disturbance processes.

Under the current plans, the Northern Rockies Lynx Management Direction is the only plan language that is specifically directed at conservation of lynx, and by association, snowshoe hare habitat. However, both the current (Custer and Gallatin) plans contain language geared toward recovering threatened species through habitat conservation and coordination with the U.S. Fish and Wildlife Service. In addition, both plans contain direction to provide habitat diversity by managing for a variety of age and size classes and associated successional stages within forested habitat, as well as forestwide (Gallatin) and area-specific (Custer) direction for management of snags and coarse woody debris. Forest successional stage and structural diversity is important for snowshoe hares and lynx, while snags and coarse woody debris are components of lynx denning habitat. Under the current plans, habitat for snowshoe hares and lynx would be conserved by following the Northern Rockies Lynx Management Direction. Additional language in current plans is complementary to the Northern Rockies Lynx Management Direction, and may contribute to the creation or maintenance of lynx habitat, but is not specifically designed to do so. Both current plans also contain management direction that affords some protection of riparian areas and associated vegetation, which can provide foraging and denning habitat for lynx. Riparian areas also provide habitat connectivity, and may be used as travel corridors by lynx, so limiting impacts in these areas will help to conserve lynx habitat.

Management Direction under the Revised Plan Alternatives

Like the current plans, the revised plan alternatives would all carry forward all plan components from the current Northern Rockies Lynx Management Direction (see appendix E of the plan). In addition to this plan direction, the revised plan alternatives address species recovery needs. Revised plan alternatives include desired conditions specific to lynx (FW-DC-WLLX-01), a requirement to follow the Northern Rockies Lynx Management Direction (FW-STD-WLLX-01), and to limit impacts on designated critical habitat for lynx (FW-STD-WLLX-02). In addition to direction specific to lynx, the revised plan alternatives include complementary coarse filter components in the form of desired conditions for wildlife habitat. These plan components speak to the commitment to engage in management practices that emulate natural disturbance patterns and facilitate ecological processes in concert with Northern Rockies Lynx Management Direction.

The revised plan alternatives provide substantial detail regarding the desired extent, frequency, and severity of ecosystem processes, which in turn, drive ecological structure, composition and function, ultimately resulting in the habitat diversity important to lynx. The revised plan alternatives address factors related to climate change, such as carbon storage and sequestration, as well as resiliency of ecosystems. All revised plan alternatives include quantitative estimates of the natural range of variation for key ecological characteristics of forested habitats, which would guide management actions and facilitate monitoring for changes in lynx habitat over time. The revised plan alternatives include guidelines for managing old-growth forest, large tree structure, and snags, which are important elements of lynx habitat. Similarly, the alternatives provide specific plan components for deciduous woodlands and shrublands that can be important secondary habitat for lynx. Additionally, the revised plan alternatives include a comprehensive set of detailed and specific plan components for protecting riparian areas, which can function as snowshoe hare habitat (lynx foraging habitat), reproductive denning habitat for lynx, and potential travel corridors for lynx to move between patches of boreal forest habitat. The alternatives include plan components for other wildlife species that could affect management actions in lynx habitat. For example, within maternal habitat for wolverines, the revised plan alternatives would limit increases in special use authorizations that could affect snow conditions. Finally, the revised plan alternatives identify key linkage areas and provide land use restrictions beyond those specifically required for lynx habitat connectivity under the Northern Rockies Lynx Management Direction. These specific plan components are identified in the following effects analyses.

Effects of the Revised Plan Alternatives

All revised plan alternatives contain a desired condition for habitat that contributes to species recovery needs, population trends that are stable to increasing across the species' range, and for critical habitats designated by the U.S. Fish and Wildlife Service to provide the physical and biological features identified as essential to the conservation of the species (FW-DC-WL-02). Specific to lynx, the revised plan alternatives include a desired condition for habitat with diverse structure to provide for the various life cycle needs of lynx, and habitat connectivity to facilitate lynx movement between boreal forest patches within a home range as well as dispersal between lynx analysis units (FW-DC-WLLX-01). The revised plan alternatives add a requirement to follow the Northern Rockies Lynx Management Direction (FW-STD-WLLX-01), as well as to ensure that vegetation management projects do not have disproportional effects on designated critical habitat for lynx (FW-STD-WLLX-02). In addition to a desired condition specific to lynx, the revised plan alternatives include complementary coarse filter components in the form of desired conditions for wildlife in general that vegetation conditions are within the natural range of variation to provide habitat for assorted life cycle needs of a diverse suite of wildlife species (FW-DC-WL-03). This plan component addresses the need to engage in management practices that emulate natural disturbance patterns and facilitate ecological processes to provide habitat conditions comparable with those to which native wildlife have adapted over time (NRLMD Objective VEG O1).

Under all revised plan alternatives, coarse filter plan components for wildlife are supported by measurable plan components for terrestrial vegetation, fire, and fuels management, which provide substantial detail regarding the desired extent, frequency, and severity of ecosystem processes (FW-DC-FIRE-01, FW-OBJ-FIRE-02). And, in turn, they drive ecological structure, composition and function described in vegetation plan components (FW-DC-VEGF-01, 03, 06 and 08). Compared to current plans, coarse filter plan components for the revised plan provide a clearer trajectory for desired vegetation conditions, which would promote habitat conditions and biodiversity important to lynx, and are consistent with and complementary to Northern Rockies Lynx Management Direction (NRLMD) Objectives VEG O1, VEG O3 for lynx habitat conditions over time, which call for management actions to approximate natural processes and fire use that restores ecological processes.

Substantial research from northwestern Montana lynx populations indicates that lynx use mature, spruce-fir forest types more than any other habitat conditions, these habitat types typically represent at least 50 percent of the lynx habitat within a female lynx home range (Holbrook et al. 2017a)(Holbrook et al. 2017a), and connectivity of mature spruce-fir forest types is an important factor in core use areas for reproductive female lynx (Kosterman et al. 2018). Lynx occurrence on the Custer Gallatin National Forest is rare, and consequently, no such parameters are available for lynx habitat use on the national forest, nor have there been any documented home ranges or core use areas for reproductive female lynx on the

Custer Gallatin. However, coarse filter plan components for forested habitats address similar habitat elements, although at a broader scale, while plan components adopted from Northern Rockies Lynx Management Direction address these factors at the lynx analysis unit scale, which is intended to represent a theoretical female lynx home range (Ruediger et al. 2000a, U.S. Department of Agriculture 2007b).

The revised plan alternatives include a desired condition that the amount and distribution of forest cover types supports the natural diversity of seral stages, habitats and species diversity across the landscape, and allows for appropriate recruitment and responses following disturbances (FW-DC-VEGF-01). Plan direction adopted from the Northern Rockies Lynx Management Direction also seeks to provide a mosaic of habitat conditions through time that support dense horizontal cover and associated high densities of snowshoe hares (Objective VEG O2). The revised plan alternatives identify the desired range of coniferous forest dominance types across the landscape, based on estimates of the natural (historical) range of variation of forested vegetation on the Custer Gallatin National Forest (FW-DC-VEGF-01). Engelmann spruce and subalpine fir-dominated coniferous forest types have historically represented 10 to 20 percent of the forested habitats on the national forest, and future management actions would be designed to maintain spruce-fir cover types within this range. Lodgepole pine and Douglas-fir are more prevalent on the Custer Gallatin National Forest landscape, and often occur in mixed species forest cover types along with spruce and subalpine fir in potential lynx habitats. Under all revised plan alternatives, lodgepole pine and Douglas-fir-dominance types would be managed within the desired range of 15 to 30 percent (each) for forested habitats across the Custer Gallatin. Collectively, these species could be expected to dominate 40 to 80 percent of the forested habitats on the Custer Gallatin National Forest over the life of the plan.

Cool, moist potential vegetation types typically produce the boreal forest conditions selected by lynx and snowshoe hares. The revised plan alternatives contain desired conditions for tree size classes within these broad potential vegetation types (FW-DC-VEGF-03). Holbrook et al. (2018) defined mature forest cover selected by lynx as stands at least 40 to 50 years old (post-disturbance). Tree size classes identified in revised plan desired conditions for forested vegetation include seedling or sapling (less than 5 inches diameter at breast height), small tree (5 to 9.9 inches diameter at breast height), medium tree (10 to 14.9 inches diameter at breast height) and large tree (15+ inches diameter at breast height) (FW-DC-VEGF-03). It can easily take trees in cool moist forest types 40 to 50 years or more to grow larger than 5 inches in diameter, so using the age class provided by Holbrook et al. (2018) for mature forest, the small, medium and large tree size classes could all provide the mature forest structure that lynx prefer. In the cool, moist forest types that produce potential lynx habitat, these size classes combined would be managed under all revised plan alternatives to represent approximately 65 to 95 percent of the cool, moist forest types. Therefore, at the broad scale, coarse filter plan components for forested habitats would maintain adequate amounts of forest habitats within a size class that meets the definition of mature forest for lynx in northwestern Montana (2018). However, it is important to note that forest conditions in the Greater Yellowstone Area are somewhat different from those studied for lynx in northwestern Montana (see Affected Environment discussion).

In addition to desired conditions for forest size classes, all revised plan alternatives include desired conditions for forest density (as measured by canopy cover; FW-DC-VEGF-04), which would maintain forest canopy cover of at least 40 percent in the majority (65 to 90 percent) of the cool, moist forest types selected by lynx. On the Custer Gallatin, cool moist forest types with canopy cover of at least 40 percent are most likely to contain the high horizontal cover required by snowshoe hares, and thus targeted as foraging habitat by lynx (Canfield 2016). The revised plan alternatives include desired conditions for presence of large (greater than 15 inches diameter at breast height), live trees to be present in at least 30 percent of the cool, moist forest habitat (FW-DC-VEGF-07), and include a desire that the amount of old-growth forest is maintained or increased relative to current conditions (FW-DC-VEGF-09). Presence of large trees and old-growth structure are common elements in multi-storied mature spruce-fir forest on the Custer Gallatin. Guidelines are included (FW-GDL-VEGF-01, 02, 05) that specify how future projects should be implemented to achieve these desired conditions. At the project level, direction adopted from the Northern Rockies Lynx Management Direction to focus management in areas that have potential to improve winter snowshoe hare habitat in both stand-initiation stage and multi-story mature forest (Objective VEG O4, Guideline VEG G1) would help inform design criteria for projects consistent with coarse filter plan components for forest structural stage.

Kosterman et al. (2018) showed that connectivity of mature forest structure was positively correlated with reproductive success of female lynx within a 50 percent core use area of the female's home range. Holbrook et al. (2019) found the probability of a female producing kittens was associated with the connectivity of mature, multistoried forests. All revised plan alternatives include desired conditions for patch sizes in forested habitats to be maintained within the natural range of variation (FW-DC-VEGF-06). Kosterman et al. (2018) measured connectivity of mature forest in terms of "correlation length," which measures the extent of homogenous patch connectedness, rather than patch size per se. However, at the national forest landscape scale, patch size provides a good relative measure of habitat connectivity. To meet these desired conditions for patch size in the cool, moist forest types (FW-DC-VEGF-06), the mature structural stage (mid- to late-seral) would be managed for large patch sizes (at least 500 acres) on a minimum of 16 percent of the landscapes that are capable of providing boreal forest types lynx prefer. Current patch sizes of mature trees in cool, moist forest types are well above the desired range in the mid-seral stage (represented by size class) of tress 5- to 15-inches diameter at breast height, with roughly 39 percent of this size class in patch size greater than 1,000 acres and another 6 percent in patch size between 500 to 1,000 acres. Conversely, the late-seral, or oldest and largest size class in the cool, moist forest types is currently well below the desired range for patch size, with less than 1 percent presence at patch sizes greater than 500 acres on the landscape. Early seral stages (small trees, less than 5 inches diameter at breast height) are currently within the desired range for patch size. Under all alternatives, plan components adopted from the Northern Rockies Lynx Management Direction would help maintain habitat connectivity for lynx with a standard for vegetation management projects to maintain habitat connectivity in occupied lynx analysis units (Standard ALL S1).

Therefore, under the revised plan alternatives, future management would likely be designed to break up the large, contiguous patches of medium-sized, closed canopy forest (mid-seral stage), leaving large live trees (per FW-GDL-VEGF-05), and creating openings that would stimulate growth of both understory shrubs, small conifers, and larger trees to contribute to the later seral stage patch sizes, thereby producing the multi-storied canopy that provides high-quality snowshoe hare habitat, which is consistent with direction adopted from the Northern Rockies Lynx Management Direction to provide a mosaic of habitat conditions through time (Objective VEG O2). Holbrook et al. (2019) suggests that given the relative density of snowshoe hare was nearly 3 times greater in advanced regeneration stands high quality habitat mosaic contains a portion of advanced regeneration forest. While regeneration harvest would not be precluded in lynx habitat, and in fact may be used to achieve a variety of management goals including timber volume, the strategy to move toward desired conditions for patch size would more likely be accomplished using intermediate silvicultural treatments, because the early seral stage (produced by regeneration harvest methods), is already within the desired range for both the amount and patch size conditions, while the late seral stage is currently below desired condition. Northern Rockies Lynx Management Direction (Guideline VEGG 1) supports projects designed to recruit conifer, hardwood and shrub regeneration to provide forage and cover for hares. Since mid-seral and late-seral stages are both within the "mature" forest structure (as measured by (Holbrook et al. 2018) and (Kosterman et al. 2018), conversion from mid-seral to late-seral stage would neither decrease the amount of mature forest structure, nor reduce the connectedness of mature forest habitat at the landscape scale.

Collectively, coarse-filter vegetation plan components in all revised plan alternatives would ensure that future projects are designed to maintain or restore conditions that would contribute to the mature, multi-story foraging habitat component for lynx at the landscape scale. At the project level, plan components adopted from the Northern Rockies Lynx Management Direction would require consideration of habitat connectivity at the lynx analysis unit scale (Objective ALL O1, Standard ALL S1), and would prohibit vegetation management actions that reduce snowshoe hare habitat in mature forest types, except for fuel reduction projects in wildland-urban interface, which could occur on no more than 6 percent of the lynx habitat across the Custer Gallatin (Standard VEG S6).

In addition to ensuring consideration for the mature forest structure preferred by lynx, the revised plan alternatives would also address the need for coarse woody material to provide for lynx reproductive denning needs. Coarse-filter plan components in all revised plan alternatives include desired conditions that coarse woody debris is present and well-distributed across the national forest (FW-DC-SOIL-01 to 03), followed with a guideline containing specific retention levels for coarse woody materials following vegetation management activities (FW-GDL-SOIL-07). Forested vegetation plan components also address snag management (FW-DC-VEGF-05; FW-GDL-VEGF-03), which would provide recruitment materials to contribute to lynx denning habitat over time. Guideline (VEG G11) adopted from the Northern Rockies Lynx Management Direction provides complementary direction regarding the distribution of coarse woody debris to provide adequate representation for lynx denning habitat. Similarly, the revised plan alternatives contain management direction to maintain healthy deciduous woodlands and shrublands (FW-DC/GDL-VEGNF all), which can provide important secondary habitat for lynx. Additionally, the revised plan alternatives include a comprehensive set of detailed and specific plan components for protecting riparian areas (FW-DC/STD/GDL RMZ all), which can function as snowshoe hare habitat (lynx foraging habitat) and reproductive denning habitat for lynx in forested areas, and provide potential travel corridors for lynx to move between patches of boreal forest habitat.

All revised plan alternatives adopt components from the Northern Rockies Lynx Management Direction to maintain or restore lynx habitat connectivity within and between lynx analysis units and in linkage areas (NRLMD Objective ALL O1, Standard ALL S1, Guideline ALL G1, Guideline HU G7, Objective LINK 01, Standard LINK S1, Guidelines LINK G1 and G2). Wildlife and forested vegetation plan components to manage habitat and vegetation within the natural range of variation (FW-DC-WL-03; FW-DC-VEGF-01) provide a foundation for minimizing habitat fragmentation. Revised plan alternatives further address this factor (for lynx and other species) in response to the 2012 Planning Rule requirement that the plan must include components to maintain or restore the ecological integrity of ecosystems, including connectivity. As it pertains to wildlife, connectivity is defined as the ecological conditions that exist at several spatial and temporal scales that provide landscape linkages, which permit the daily and seasonal movements of animals within home ranges, the dispersal, and genetic interchange between populations, and the long-distance range shifts of species, such as in response to climate change. To address the 2012 Planning

Rule requirement to provide for connectivity, the revised plan alternatives take a more affirmative, proactive approach to maintain or restore habitat connectivity for wildlife, by incorporating specific, science-based desired conditions and goals for coordinated management, which are supported by a series of objectives and guidelines that promote habitat enhancement and limit management actions with potential for negative impacts on wildlife habitat connectivity.

All revised plan alternatives include desired conditions for landscape patterns throughout the Custer Gallatin to provide habitat connectivity for wildlife, particularly wide-ranging species such as medium to large carnivores and wild ungulates, including structural and functional diversity to increase resilience and support natural wildlife movement patterns (FW-DC-WL-05, 06). Alternative F (preferred) adds a desired condition to limit human disturbance to allow for wildlife movement within key linkage areas (FW-DC-WL-07). Resulting habitat connectivity would facilitate daily and seasonal movement, as well as long-range dispersal of wildlife to support genetic diversity, allowing animals to adapt to changing conditions over time. An assumption for these components is that by providing adequate conditions for larger-bodied, wide-ranging species such as lynx, habitat conditions will also be met for smaller-bodied species with shorter dispersal capabilities, such as snowshoe hares. This assumption is supported by connectivity modeling results in which locations of core habitat for smaller-bodied species exhibited strong overlap with high-value connectivity areas for larger-bodied species with similar habitat preferences. To help achieve and maintain this desired condition for all wildlife, the revised plan alternatives contain a guideline that management actions should not create movement barriers to wide-ranging species, except where necessary to provide for human or wildlife safety (FW-GDL-WL-01). Plan components adopted from the Northern Rockies Lynx Management Direction contain complementary direction specific for lynx to maintain or restore lynx habitat connectivity (Objective ALL O1), with a mandate that new or expanded permanent development and vegetation management projects must maintain habitat connectivity within and between lynx analysis units (Standard ALL S1).

While certain conditions on the ground may impede movement for lynx, there are few management actions in which the Forest Service engages that would create a true barrier to lynx movement, since lynx have the ability go over, under, through, across, or around most obstacles. Some authors (Ruediger et al. 2000a, Vanbianchi et al. 2018) have reported that dispersing lynx (those leaving their natal area or existing home range in search of new home range) are known to travel through suboptimal conditions, including movement through large areas of limited forest cover. However, large-scale developments or features strategically placed in concert with natural barriers such as a large reservoir or cliff wall, can notably affect permeability of the landscape for wildlife. The revised plan alternatives would ensure that management actions that could alter the natural environment would be evaluated for possible impacts on movement patterns of all wide-ranging species, and lynx specifically, within or between lynx analysis units (FW-GDL-WL-01; NRLMD Standard ALL S1). These components would require mitigation for those actions that would not maintain or restore habitat connectivity for wildlife, and particularly for lynx. On the other hand, all revised plan alternatives would allow for management actions specifically designed to restrict wildlife movement when needed to provide for human or wildlife safety (FW-GDL-WL-01). An example would be construction of a fence or other barrier deliberately designed to prevent wildlife from approaching and crossing a highway at an area where vehicle collisions with wildlife are an issue for both human and wildlife safety. Additional modifications could be made to funnel wildlife movement to an area of higher visibility, or even to a wildlife crossing structure. This guideline addresses an issue that is not covered under current plan direction. These measures would also be supported by components adopted from the Northern Rockies Lynx Management Direction to reduce impacts to lynx associated with highway construction or reconstruction, where methods could include fencing, underpasses, or overpasses (Guideline ALL G1).

Plan components adopted from the Northern Rockies Lynx Management Direction (Objective ALL O1, Standard ALL S1, Guideline ALL G1) would ensure consideration and possible mitigation for future projects that could impact lynx movement within and between lynx analysis units. The Northern Rockies Lynx Management Direction defines linkage areas for lynx as areas that provide connectivity between blocks of lynx habitat. Some potential linkage areas occur outside the national forest boundary, where the Forest Service has no authority to either limit or dictate management actions that could affect lynx habitat connectivity. However, all revised plan alternatives include goals to work with other agencies and landowners to cooperatively manage habitat and provide for connectivity across administrative boundaries, acquire non-Federal lands or seek conservation easements where needed to maintain or restore connectivity, and work with highway administrators to reduce vehicle collisions with wildlife (FW-GO-WL-02, 03, 05; FW-GO-LAND-01, FW-GO-RT-03). Plan components adopted from the Northern Rockies Lynx Management Direction encourage similar conservation measures specific to lynx (Objective LINK O1, Standard LINK S1, Guideline LINK G1; Objective HU O6). Collectively, direction in the revised plan alternatives would ensure that lynx habitat connectivity and potential impacts to lynx from highway crossings, are considered in future project design criteria as well as cooperative efforts between the Forest Service and other agencies and landowners.

Key linkage areas in revised plan alternatives B, C, D, and F, are designed to support wildlife movement. They are located near the national forest boundary where wildlife movement is desirable for genetic exchange between blocks of public land, but where such movement may be restricted by permanent development such as highways, railroads, agricultural lands and residential areas. The locations identified as key linkage areas include the north end of the Gallatin Range and the west side of the Bridger Mountain Range. These areas provide good habitat connectivity value for forested habitat associates, and forest management actions have potential to impacts forested habitats. Interstate 90 and nearby development present a major impediment or barrier to north-south movement for most land-dwelling wildlife species that occur on the Custer Gallatin. Those individuals capable of crossing the highway face high mortality risk to do so.

As with many potential linkage areas for lynx, Interstate 90 and associated development occur outside the national forest boundary, and thus beyond Forest Service jurisdiction. The key linkage areas in alternatives B, C, D, and F, encapsulate the portions of the Custer Gallatin that are nearest Interstate 90, and occur as relatively narrow bands of public land that create a natural ecological flow pattern funneling wildlife movement to a point where crossing the Interstate may be attempted by dispersing individuals. Managing these lands for habitat connectivity would provide potential staging opportunities for dispersing lynx to remain relatively secure until a safe crossing of the highway and associated development may be executed. Managing for limited new development and limited human disturbance on National Forest System lands in these areas may provide opportunities for lynx to disperse between occupied and unoccupied habitat on the Custer Gallatin, or possible lynx dispersal between ecosystems. Outside of key linkage areas, all revised plan alternatives retain a configuration of designated wilderness, wilderness study area, and inventoried roadless areas that, combined with plan land allocations for recommended wilderness and backcountry areas, would provide a reasonably well-connected system of large blocks of land with some level of use restrictions that would help maintain habitat connectivity, and limit habitat fragmentation impacts for lynx over the life of the plan.

Consequences to Canada Lynx from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Fire and Fuels Management

Fire is the predominant disturbance process that affects forested habitats in the northern Rockies, and is an ecological factor to which lynx and their primary prey have adapted over time. Wildland fire has potential to affect habitat in ways that are negative, neutral, or beneficial to lynx. Under all revised plan alternatives, direction adopted from the Northern Rockies Lynx Management Direction would support vegetation management that mimics or approximates natural success and disturbance processes, including fire use (Objectives VEG O1, O3). The revised plan alternatives contain complementary coarse filter desired conditions for the amount and severity of wildland fires to be within the natural range of variation to maintain resilient ecological conditions, and vegetation conditions that support natural fire regimes (FW-DC-FIRE-01), with an objective for wildland fire to occur at a larger scale than has been the case under current plans (FW-OBJ-FIRE-02).

Unless a broad-scale assessment has been completed that substantiates different historical levels of stand-initiation structural stage lynx habitat, plan direction adopted from the Northern Rockies Lynx Management Direction limits the amount of lynx habitat that can be converted to an early stand-initiation stage by vegetation management including prescribed fire, to no more than 30 percent of mapped lynx habitat within a lynx analysis unit (NRLMD Standard VEG S1). The revised plan alternatives include a broad-scale assessment of the natural range of variation for forest structure. This assessment indicates that the stand-initiation stage (seedling and sapling trees less than 5 inches diameter at breast height) ranges from 5 to 35 percent of the cool moist forest types on the Custer Gallatin (FW-DC-VEGF-03), which is consistent with existing direction in NRLMD Standard VEG S1. Therefore, natural processes and management actions combined may produce early stand-initiation stage habitat below, at, or above 30 percent of the mapped lynx habitat, but once the 30 percent cap is reached or exceeded, no additional lynx habitat may be regenerated by vegetation management actions, including prescribed fire. This direction in all revised plan alternatives allows for some conversion of lynx habitat to early successional stages to perpetuate the cycle of diversity by mixing young regenerating forest with mature and older multi-story forest in lynx habitat.

While fire is widespread and often occurs at large scales, it rarely produces uniform burn patterns. Different forest conditions, weather patterns, and topography can affect fire behavior. Variations in burn patterns can create a diversity of age and density structure within and between forest stands. High-intensity, stand-replacing fires can remove cover and forage for snowshoe hares, reducing potential foraging habitat and security cover for lynx. If fires reduce a large proportion of snowshoe hare habitat at the scale of a lynx home range, negative consequences to lynx would be expected over the short term. However, fires that burn in a mosaic pattern can create the diversity of habitat conditions required by lynx over a home range scale. Such events are expected to provide sustainable habitat for lynx over time and contribute to recovery of the species. Fires that burn in warm, dry forest types, shrublands and grasslands have little impact on lynx or snowshoe hares.

Fire and fuel management in the wildland-urban interface can have impacts on lynx habitat, since the desired condition under all revised plan alternatives is for vegetation that supports low-intensity fire to protect infrastructure and other values at risk (FW-DC-FIRE-02), which is contrary to structural conditions that provide high horizontal cover for snowshoe hares. Hazardous fuel management would occur in the wildland-urban interface to achieve this desired condition. Fuel treatments in the wildland-urban interface are expected to occur under all revised plan alternatives, with objectives for hazardous fuel mitigation projects ranging from a minimum of 4,000 acres per year in alternative E to a high end of 7,000 acres per year in alternative D. Alternatives B, C, and F are in the mid-range, at about 6,000 acres per year (FW-OBJ-FIRE-01). Not all fuel reduction projects would affect lynx habitat, since some treatment would occur in warm, dry forest types that do not support snowshoe hares, so effects to lynx would be less than the stated objectives. Plan components adopted from the Northern Rockies Lynx Management Direction allow exemptions to standards designed to protect lynx habitat, but only for the purpose of hazardous fuel reduction within the wildland-urban interface to protect communities at risk. The direction limits such projects so that no more than 6 percent of occupied lynx habitat on the national forest may be affected over the life of the plan (NRLMD Standards VEG S1, S6).

Outside of the wildland-urban interface, direction adopted from the Northern Rockies Lynx Management Direction would encourage prescribed fire use (Objective VEG O3) in all revised plan alternatives to improve lynx habitat over time by strategically placing fire on the landscape in lynx habitat currently lacking high horizontal cover, as fire often promotes recruitment of a high density of conifers, hardwoods, and shrubs needed to support snowshoe hares. Prescribed fire as a vegetation management tool can have similar effects to timber harvest, but prescribed burning differs from harvest in that burned trees are typically left behind, leaving a biological legacy that contributes to nutrient cycling, as well as to the availability of coarse woody debris for lynx denning habitat. Prescribed fire could also be used outside of the wildland-urban interface for other resource management needs, which could result in a reduction of existing snowshoe hare habitat in the stand-initiation (advanced regeneration) stage. Plan components adopted from the Northern Rockies Lynx Management Direction would restrict prescribed fire projects outside of wildland-urban interface that reduce multi-storied mature snowshoe hare habitat, to a small list of very narrow purposes (NRLMD Standard VEG S6).

Fire suppression can affect lynx habitat by limiting the amount of stand-initiation stage snowshoe hare habitat present on the landscape, as well as through the construction of fire lines or fuel breaks that could fragment habitat and inadvertently create travel routes that attract new human-use patterns, which could facilitate additional snow compaction in lynx habitat. Conversely, where large-scale disturbances have occurred recently, fire suppression may benefit lynx by preserving forest cover or multi-storied snowshoe hare habitat. The revised plan alternatives include a guideline to use minimum impact suppression tactics in sensitive habitat for at-risk species (FW-GDL-FIRE-03), which would be consistent with fire and fuels-related Northern Rockies Lynx Management Direction guidance to avoid creating new permanent travel routes for people and to avoid placing permanent firebreaks on saddles and ridges that may be important travel routes for lynx (NRLMD Guideline VEG G4). Lynx habitat types typically have long natural fire return intervals and high intensity fire. It is generally agreed that overall, fire suppression activities have had little impact on lynx habitat (U.S. Department of the Interior 2000a).

Effects from Carbon Storage and Sequestration Management

Both the lynx and its primary prey are highly adapted to survive in boreal climates, where winters are characterized by deep accumulations of soft, fluffy snow (Koehler and Aubry 1994). As such, climate change has been identified as a human-caused driver with potential to influence lynx habitat (Interagency Lynx Biology Team 2013).

Hansen et al. (2018) looked specifically at the Custer Gallatin National Forest portion of the Greater Yellowstone Area to assess vulnerability to climate change. They noted that the cool, moist vegetation types highly suitable for lynx and snowshoe hares has broad distribution across the Greater Yellowstone

Area portion of the Forest. This study projected increased presence of Douglas-fir in potential lynx habitat due to warming temperatures and less frost during the growing season. At the same time, lodgepole pine, subalpine fir, and spruce are projected to decrease due to drying soils and more frequent fires. The timing and extent of such projections are imprecise, but rather predicted to occur at a relatively broad scale in coming decades, indicating potential for such changes to become notable over the life of the plan. Natural ecological processes are the primary drivers of climate, precipitation, and resulting forest species composition. However, revised plan alternatives include plan components to manage forested habitats within their natural range of variation (FW-DC-VEGF-01 to 04, 07), which would help minimize forest management contributions to impacts associated with climate change.

The Forest Service recognizes the vital role that our nation's forests play in carbon sequestration and associated impacts on climate regulation. Accordingly, all revised plan alternatives contain a desired condition for carbon storage and sequestration sustained by biologically diverse and resilient vegetation conditions that are adapted to natural disturbance processes and changing climates (FW-DC-CARB-01), as well as a goal to collaboratively engage with universities, research stations and other entities to improve upon existing knowledge and develop management approaches to address the effects of climate change (FW-GO-CARB-01). The revised plan alternatives also contain plan components that explicitly provide for ecosystem resiliency, and acknowledge carbon storage as an important function of National Forest System lands (FW-DC-SUS-03). All revised plan alternatives emphasize resilience in desired conditions for multiple resources (FW-DC-WTR-01; RMZ-01; VEGF-02, 03, 04, 09; VEGNF-04; FIRE-01; CARB-01; WL-06; RECSUP-04; RNA-01), and include standards and guidelines (FW-STD-GRAZ-01; FW-STD-TIM-08; FW-GDL-VEGF-01, 05) as proactive measures to improve ecosystem resilience relative to predicted changing climates. Collectively, these components in the revised plan alternatives would ensure that potential impacts of climate change are considerations for projects that could affect snowshoe hare and lynx habitat.

Effects from Timber Management

Mechanical harvest of timber has the potential to affect lynx habitat in ways that can be detrimental, neutral, or even beneficial to lynx. Negative impacts to individual lynx could occur through management actions that remove, change, or reduce the amount or density of horizontal cover in boreal forest types that are naturally capable of supporting snowshoe hares. Vegetation management in areas that have no potential to support snowshoe hares, or actions designed to maintain a stand's existing condition, would be neutral to lynx. Finally, vegetation management can benefit lynx habitat in mature forest types where understory cover is lacking. Mechanical removal (harvest) of mature trees in the overstory can stimulate conifer regeneration, which may subsequently increase browse and cover availability for snowshoe hares (Interagency Lynx Biology Team 2013).

All revised plan alternatives contain desired conditions for timber production that supports economies as well as sustaining ecosystem health by creating environments that are resistant to natural disturbances (FW-DC-TIM-01). Under all alternatives, plan components require that mechanical harvest for purposes of timber production occur only on lands classified as suitable for timber production (FW-STD-TIM-01). Under the current plans (alternative A), the area suitable for timber production (also referred to as the "suitable base") includes about 17 percent of the National Forest System acres in the montane geographic areas (where lynx may be present). The area suitable for timber production decreases under all revised plan alternatives, ranging from a low of about 12 percent of the montane geographic areas under alternatives C and D, to 14 percent in alternative E. In alternatives B and F, the area suitable for timber production is in the mid-range, at about 13 percent of montane geographic areas. The area suitable for timber production includes lynx habitat as well as warmer, drier forest types that do not provide denning and foraging opportunities for lynx. Therefore, the amount (acres) of lynx habitat within the suitable timber base is even less than indicated for the entire montane ecosystem and individual geographic areas.

Not only would the total amount of National Forest System lands in the suitable timber base decline under revised plan alternatives, but the amount of potential lynx habitat types that are suitable for timber production would decrease as well. Under all alternatives, mechanical harvest of timber could occur on lands not suitable for timber production to address a variety of resource needs, including salvage of damaged trees, fuels management, and wildlife habitat maintenance or enhancement, among other possible resource reasons (FW-GDL-TIM-03). Timber harvest, whether for timber production, or for other resource purposes, has the potential for short-term impacts to lynx, with summer snowshoe hare habitat expected to regenerate within 5 to 15 years post-harvest, but winter snowshoe hare habitat expected to take longer, possibly returning within 16 to 40 years after harvest. Under all alternatives, direction adopted from the Northern Rockies Lynx Management Direction would emphasize vegetation management projects designed to recruit a high density of conifers, hardwoods and shrubs where lynx habitat is lacking these components (Guideline VEG G1). Over the life of the plan, harvested areas in potential lynx habitat generally would be expected to contribute to a matrix of habitat structure required by lynx.

Under all alternatives, any future timber harvest proposed in lynx habitat would be subject to revised plan requirements adopted from the Northern Rockies Lynx Management Direction (NRLMD Standards VEG S1, S2, S5 and S6), which would prohibit vegetation management projects (including timber harvest) that reduce or remove existing snowshoe hare habitat, except for fuels reduction projects in the wildland-urban interface. Timber harvest could affect lynx habitat when used for timber production (within the suitable base) as well as when used for other resource benefits, but only in areas not currently producing adequate horizontal cover to provide winter snowshoe hare habitat. Timber harvest in such conditions may have beneficial, neutral, or negative effects on lynx habitat, depending on the existing structure, type of harvest implemented, and other environmental conditions. Northern Rockies Lynx Management Direction standard VEG S1 limits the amount of regeneration harvest that, combined with natural and prescribed fire, would set lynx habitat back to an early stand-initiation stage, to no more than 30 percent of the total mapped lynx habitat in any single lynx analysis unit. Northern Rockies Lynx Management Direction standard VEG S2 limits the effects of regeneration harvest to no more than 15 percent of the lynx habitat in a lynx analysis unit in a 10-year period.

The Northern Rockies Lynx Management Direction contains exemptions to standards VEG S1, S2, S5 and S6 for fuel reduction treatment in the wildland-urban interface to protect communities at risk, which could be achieved through timber harvest or other methods such as prescribed burning. In such cases, the intent would be to maintain the results of the treatment over time, rather than allow natural succession to regenerate snowshoe hare and lynx habitat. Therefore, fuel reduction treatment in the wildland-urban interface has the greatest potential for longer-term negative effects on lynx. However, standards adopted from the Northern Rockies Lynx Management Direction cap the amount of lynx habitat that can be altered for fuel reduction in the wildland-urban interface using exemptions, to no more than 6 percent of the occupied mapped lynx habitat over the life of the plan. Not all fuel reduction projects would occur in lynx habitat, and not all of those that could occur in lynx habitat would require use of the exemptions for treating snowshoe hare habitat. Based on revised plan objectives for hazardous fuel reduction (FW-OBJ-FIRE-01), it is reasonable to assume that fuel treatment projects in lynx habitat using the Northern Rockies Lynx Management Direction exemptions would be accelerated relative to projects implemented under current plans. However, such projects would not exceed the Northern Rockies Lynx Management Direction limits for impacts to snowshoe hare habitat over the life of the plan.

Plan components adopted from the Northern Rockies Lynx Management Direction also contain exceptions to standards VEG S5 and S6 that allow for some precommercial thinning or other treatment that would reduce snowshoe hare habitat under certain circumstances, such as removing fuel around administrative sites or other buildings, for research studies, to achieve desired outcomes based on new information, conifer removal to enhance aspen, whitebark pine restoration, and incidental removal of understory trees during salvage harvest operations. Collectively, these types of vegetation management projects in occupied lynx habitat are anticipated to be small and projected to affect less than 1 percent of the lynx habitat on the Custer Gallatin.

Plan components with associated exemptions adopted from the Northern Rockies Lynx Management Direction only apply to occupied lynx habitat. Potential lynx habitat exists in unoccupied areas as well, and it is likely that vegetation management implemented under the revised plan will affect lynx habitat in these areas. To date, treatment in unoccupied lynx habitat has met all Northern Rockies Lynx Management Direction provisions that apply in occupied lynx habitat, and there is an expectation that projects in unoccupied lynx habitat should consider the goals, objectives, standards, and guidelines that apply in occupied lynx habitat. Assuming that consideration of Northern Rockies Lynx Management Direction components results in similar management of lynx habitat in unoccupied areas, then 6 percent of lynx habitat is a reasonable estimate for future vegetation management projects in unoccupied lynx habitat that could reduce snowshoe hare habitat in unoccupied areas, or that would fall under the Northern Rockies Lynx Management Direction exemptions, should lynx occupy the currently unoccupied areas.

In addition to Northern Rockies Lynx Management Direction, forestwide plan components in the revised plan alternatives would require that harvest units be designed to reflect natural terrain patterns (FW-STD-TIM-05) with maximum size limits on openings created by timber harvest (FW-STD-TIM-08), and design criteria that include considerations for wildlife habitat (FW-STD-TIM-04). Mechanical harvest for timber production would be used only in areas where there is reasonable assurance of restocking (conifer regeneration) within 5 years after harvest completion (FW-STD-TIM-10). This would promote establishment of young, dense forest that could eventually provide snowshoe hare habitat when it occurs in boreal forest types.

Whether used for timber production or other resource purposes, timber harvest prescriptions fall into three main categories:

- even-aged regeneration harvest, which removes all or nearly all trees to produce openings intended to regenerate even-aged stands;
- intermediate harvest, which typically removes the majority of trees, resulting in more open stands with multiple age classes and multiple stories in the tree canopy; and
- harvest that removes generally small trees for purposes such as promoting individual tree growth, or removing ladder fuels.

Each type of harvest has the potential to affect lynx habitat when performed in boreal forest conditions. Even-aged regeneration harvest creates openings that are typically only provide marginal (or summer) foraging habitat for snowshoe hares and lynx in the short term (0 to 15 years after harvest), but have high potential to grow into high-quality, stand-initiation stage winter snowshoe hare and lynx habitat in the mid-term (16 to 40 years after harvest). Intermediate harvest can have similar effects, such as reducing horizontal cover for snowshoe hares and lynx in the short term, with potential to create high-quality snowshoe hare and lynx habitat in the mid- to long-term by producing multi-storied stands with dense horizontal cover in the understory. Harvest such as precommercial thinning in dense, young stands and mechanical fuel reduction treatments that remove ladder fuels, typically decrease the amount of horizontal cover near the ground, reducing the amount and quality of snowshoe hare habitat, thereby impacting potential lynx foraging habitat. This third type of harvest has the greatest potential for negative effects to lynx because these methods tend to result in more open forest structure, with lower horizontal cover near the ground for longer periods of time than regeneration or intermediate harvest methods. However, these are the types of activities most constrained by the Northern Rockies Lynx Management Direction (NRLMD Standards VEG S5, S6). Harvest that would reduce snowshoe hare habitat is allowed only for fuel reduction in the wildland-urban interface, and is subject to a forestwide cap of 6 percent as described above.

Salvage and sanitation harvest involves the removal of dead or dying trees in areas that have been affected by fire, insects and disease. Coarse woody debris such as down logs and root wads, are important elements of lynx denning habitat, and removal of dead and dying trees could reduce the quality and availability of existing and potential future denning habitat. Direction adopted from the Northern Rockies Lynx Management Direction specifies that denning habitat should be distributed in each lynx analysis unit with pockets of large woody debris, requiring retention of coarse woody debris where it may be lacking (Guideline VEG G11). The revised plan alternatives include a complementary guideline that would require retaining a certain amount of coarse woody debris in vegetation treatment units (FW-GDL-SOIL-07). Compared to current plans, the plan components for coarse woody debris in the revised plan would be more ecologically relevant, as they are customized to potential vegetation types to reflect a more natural range of variation. In addition to plan components for coarse woody debris, the revised plan alternatives include a standard that would limit salvage harvest in riparian management zones (FW-STD-RMZ-02), and guidelines (FW-GDL-TIM-01, 02) that would require retaining live, dying, or dead trees in post-burn salvage units. Finally, the revised plan alternatives contain plan components for retaining snags (FW-DC-VEGF-05, FW-GDL-VEGF-03), which are standing dead trees that could eventually contribute coarse woody debris for lynx denning habitat. Under all revised plan alternatives, direction for snag management would require more and generally larger snags to be left in treatment units where snags may be lacking, compared to current plans.

Ultimately, the effects of vegetation management would be negligible compared to effects of natural disturbance processes on lynx habitat. A large proportion of lynx habitat is within wilderness and other designations that limit management actions, so natural disturbance processes are, and will continue to be, the primary factor driving lynx habitat conditions on the Custer Gallatin. Therefore, the effects of management actions implemented under all revised plan alternatives would be minor relative to natural processes. A landscape dynamic simulation model (SIMPPLLE) was used to evaluate this notion by predicting changes to lynx habitat structural stages over time, including those anticipated from management actions constrained by lynx management direction in the plan, as well as changes due to natural disturbance events. As expected, when both management and natural processes were simulated over a 50-year period into the future, no notable difference at the geographic scale used by lynx could be attributed to management actions. This modeling exercise predicted that within the life of the plan, the amount of stand-initiation stage snowshoe hare habitat would increase relative to early stand-initiation habitat for the first two decades, then the trend would reverse between the second and third decade. Likewise, the amount of multi-storied snowshoe hare habitat is predicted to increase relative to other habitat over the first two decades, and that trend would also reverse between the second and third decades (figure 23). Again, these trends are largely driven by natural disturbance processes, because the amount of management actions that could affect lynx habitat would be limited by lynx management direction, management restrictions in designated areas, and budget constraints. It should be noted that SIMPPLLE is a simulation model that runs on a different data set, with slightly different parameters than the GIS queries used to model lynx habitat for current conditions. What is meaningful from the SIMPPLLE exercise is the predicted trends, not the actual numbers generated.

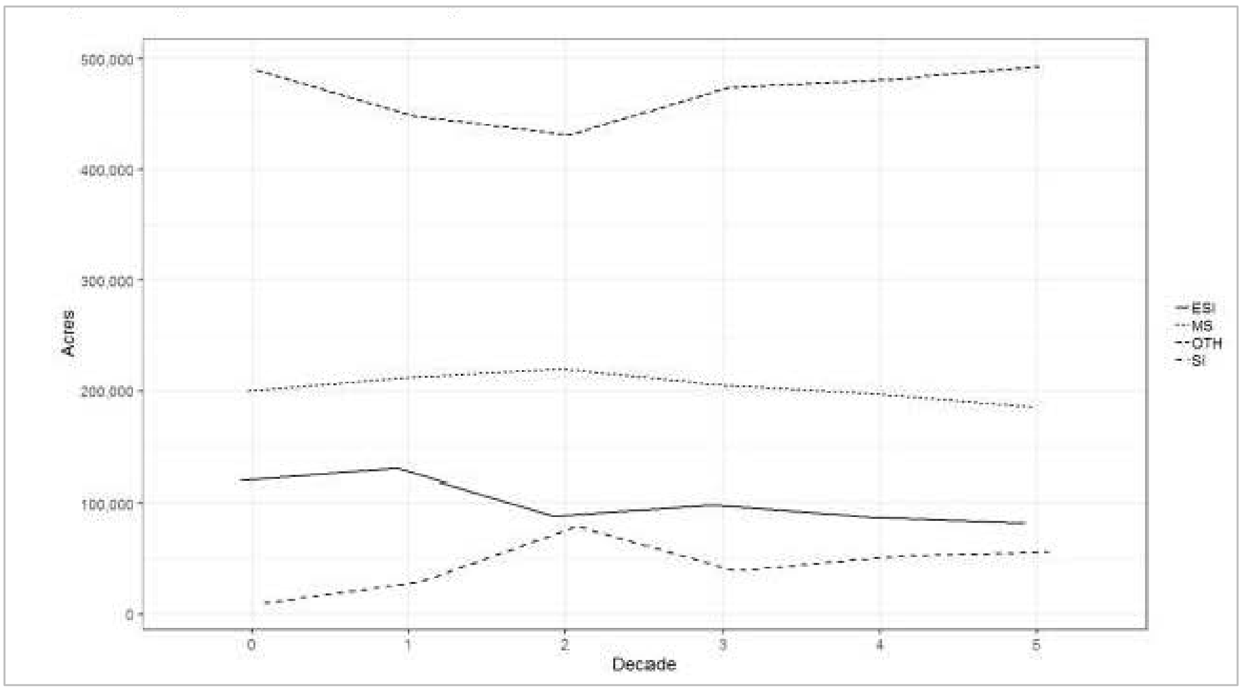

Figure 23. Lynx habitat structure by decade

ESI = early stand initiation; MS = multi-storied; OTH = other; SI = stand initiation

Effects from Designations and Plan Land Allocations

Areas designated by authorities beyond the Forest Service, including those designated by statute such as wilderness areas, inventoried roadless areas, and wilderness study areas, do not vary between alternatives. Roughly 73 percent of the mapped lynx habitat in occupied and unoccupied areas combined, is within designated areas with land use restrictions that generally maintain ecological characteristics in a natural condition. Designated wilderness areas stand alone and have no overlap with other designations or land management plan allocations. Plan land allocations, such as recommended wilderness, backcountry area, and key linkage area, often spatially overlap with existing land use designations for wilderness study area and inventoried roadless areas, and there is overlap between the designations as well. For example, all of the wilderness study area is also inventoried roadless area. Unless or until Congress enacts new legislation, the wilderness study area will be managed per the Wilderness Study Act of 1977, and inventoried roadless areas will be managed as per the 2001 Roadless

Area Conservation Rule. Wherever designated areas and plan land allocations overlap, the more restrictive guidance in the plan would apply.

Of the plan land allocations, recommended wilderness has the greatest level of management restrictions, including no new roads, energy and utility structures, or developed recreation sites, and no timber harvest allowed (FW-DC/STD/GDL/SUIT-RWA). These plan components are consistent with direction adopted from the Northern Rockies Lynx Management Direction objectives to manage recreational uses, mineral and energy developments, to minimize impacts on lynx habitat (Objectives HU O2 and O5). Restrictions associated with these plan components would result in more natural conditions resulting primarily from ecological processes to which lynx have evolved. However, management restrictions in recommended wilderness would limit the types of vegetation management tools available to implement silvicultural prescriptions specifically designed to improve lynx habitat. Management actions would be allowed to some degree in recommended wilderness areas for ecological restoration purposes, including low-impact habitat improvement projects (FW-SUIT-RWA-03). For example, prescribed fire could be used to improve lynx habitat, but might be constrained by limited access from prohibitions on new road construction. Also, inability to pre-treat high fuel loads with mechanical timber removal could affect the ability to effectively use prescribed fire for restoration purposes. Although some restoration activities would be allowed in recommended wilderness areas, the combination of restrictions on certain types of equipment, limited access, and potentially high fuel loads tends to result in much higher cost for some restoration projects, resulting in budgetary constraints that could also limit restoration projects. The amount of recommended wilderness areas in the montane geographic areas where lynx occur varies by alternative, including nearly 34,000 acres in current plans (alternative A). The largest amount of recommended wilderness occurs in alternative D, with over 674,000 acres in the montane geographic areas. On the other end of the spectrum, alternative E has no recommended wilderness. Alternative F is between alternatives B and C, with over 139,000 acres of recommended wilderness in the montane geographic areas.

Backcountry area is a new plan land allocation on the Custer Gallatin National Forest, which would occur in lynx habitat in all revised plan alternatives except D. Backcountry areas would be maintained as generally undeveloped or lightly developed with no or few roads or other permanent human developments (FW-DC/STD/GDL/SUIT-BCA; see also plan components for individual backcountry areas by geographic area in the plan). As with recommended wilderness, backcountry areas often spatially overlap with wilderness study area or inventoried roadless areas, and the more restrictive land use direction would apply in areas of overlap. With an emphasis on low development, backcountry areas would preclude new permanent roads and limit most new permanent developments, which would prevent habitat fragmentation. However, land uses are somewhat less restricted in backcountry areas than in recommended wilderness areas. For example, existing mechanized and motorized transport would generally continue to be suitable in backcountry areas, where such uses would no longer be suitable in recommended wilderness in alternatives C, D, and F. In lynx habitat, temporary roads would only be allowed in backcountry areas in the Pryor Geographic Area, which is peripheral lynx habitat.

Key linkage areas are another new allocation under the revised plan that occurs in all revised plan alternatives except alternative E. Key linkage areas and associated plan components (FW-DC-WL-07, FW-GDL-WL-02 to 04) are included in revised plan alternatives B, C, D, and F to formalize habitat protection measures in areas recognized as highly significant in providing habitat connectivity for wildlife, including lynx. Alternative F added a bit more acreage to the south end of the key linkage areas outlined in alternatives B, C, and D. The western boundary adjacent to the Hyalite Recreation Emphasis Area differs in alternative F relative to alternatives B and D. In alternative F the boundary was shifted to allow heavily recreated areas south and west of Bozeman Creek to be managed in the Recreation Emphasis Area. Generally speaking, key linkage areas would limit future infrastructure development to administrative purposes, while prohibiting additional recreation development designed solely to accommodate increased recreation use (FW-GDL-WL-03). Key linkage areas would affect vegetation management with requirements for design criteria to restore, maintain, or enhance habitat connectivity for wildlife (FW-GDL-WL-02) and timing restrictions limiting the duration of vegetation management projects (FW-GDL-WL-05) to limit disturbance impacts. Plan land allocations and associated management direction for key linkage areas are consistent with, and complementary to components adopted from the Northern Rockies Lynx Management Direction for vegetation management actions to maintain or restore lynx habitat connectivity (Objective ALL O1, Standard ALL S1).

Collectively, revised plan land allocations of recommended wilderness areas, backcountry areas, and key linkage areas would impose some additional land use restrictions that would help maintain habitat conditions for lynx by limiting the means of management actions that could occur, as well as limiting permanent developments and motorized and mechanized access to these areas by varying degrees. These factors would limit fragmentation of lynx habitat due to management actions, which would be augmented by project-level considerations to maintain lynx habitat connectivity (NRLMD Standard ALL S1).

Effects from Recreation Management

Effects of recreation on lynx and lynx habitat are not well understood. Potential ways recreation may affect lynx include disturbance from noise or human presence associated with recreation use; habitat loss resulting from removal of forest cover for development of permanent facilities such as ski runs, roads, campgrounds, reservoirs, or other facilities; and snow compaction, which may reduce the competitive advantage lynx have in deep snow conditions. Little is known about disturbance impacts to lynx from noise and human presence, as few studies have directly examined this aspect of lynx ecology. Available information suggests that while some lynx may tolerate human presence. However, it is likely that lynx exhibit a range of behavioral responses to various types of human activity, which may include heightened sensitivity to human disturbance near reproductive den sites. Habitat loss can reduce prey availability, as well as produce more fragmented landscapes that could affect lynx movement patterns within or between home ranges (Interagency Lynx Biology Team 2013).

Plan land allocations such as recommended wilderness areas, backcountry areas, and key linkage areas could affect the types and levels of public recreation use by limiting access or by limiting the types of recreation developments allowed. Under alternatives C, D, and F, recommended wilderness areas in the revised plan would no longer be suitable for mechanized or motorized transport by the recreating public, whereas such transport would still be suitable where presently occurring under alternative B (FW-SUIT-RWA-02). Alternative E has no recommended wilderness areas, but has sizeable backcountry areas. New developed recreation sites (such as campgrounds, picnic areas, ski lifts, and rental cabins) would not be allowed in recommended wilderness or backcountry areas (FW-STD-RWA-04, FW-STD-BCA-03) under any of the revised plan alternatives. Existing motorized and mechanized transport would continue to be suitable in most backcountry areas, but it varies by alternative as well as by individual area. Most backcountry areas in the montane ecosystem (where lynx may be present) are not suitable for motorized recreation under all revised plan alternatives.

Key linkage areas would allow public recreational developments (roads, trails, etc.) to continue, as currently authorized, but new recreation developments would be limited under alternatives B, C, D, and F (FW-GDL-WL-03). Therefore, combined with existing designated wilderness, these management plan allocations would generally promote low development, quiet use patterns over the majority of lynx habitat under all revised plan alternatives. Alternative D would provide the most protection for lynx in terms of limiting types of use, whereas alternative E has the least amount of land use restrictions outside of designated wilderness. Although effects to lynx resulting from human disturbance are not well understood, based on some evidence of lynx sensitivity to human presence, particularly near reproductive den sites, it is logical to conclude that lower disturbance levels associated with more restrictive land use allocations could benefit lynx.

All revised plan alternatives also include land use allocations that would emphasize public recreation use, but the number, size, and location of these areas vary by alternative. Alternative D has the lowest acreage of recreation emphasis areas, while alternative F has the highest. Recreation emphasis areas currently have, and are expected to continue to receive relatively high levels of motorized and non-motorized recreation use, and may have a high density of recreation-related infrastructure relative to other parts of the Custer Gallatin. These areas are typically located in reasonable proximity to human population centers with good access, and consequently, tend to be in areas already heavily used by the recreating public. Lynx habitat in the Greater Yellowstone Area is naturally more patchily distributed than other areas where lynx are found. Recreation emphasis areas may further fragment habitat due to higher densities of access routes and other recreation-related infrastructure than found elsewhere on the Custer Gallatin National Forest. Some of the recreation emphasis areas in the revised plan alternatives are small relative to the scale at which lynx are likely to use the landscape. However, the smaller-acreage recreation emphasis areas tend to be linear and associated with water courses, and therefore, have potential to affect lynx movement patterns. The largest recreation emphasis area (Hebgen winter) overlaps one entire lynx analysis unit and part of another, and occurs in all revised plan alternatives except for alternative D.

Recreation emphasis areas are often adjacent to areas with land use restrictions such as designated wilderness, recommended wilderness, backcountry area, or key linkage areas. Concentrating human use in recreation emphasis areas may consolidate use and associated habitat loss or fragmentation into relatively small areas, rather than spreading out impacts through greater investments in dispersed recreation. This is consistent with direction adopted from the Northern Rockies Lynx Management Direction to concentrate activities in existing developed areas, rather than developing new areas in lynx habitat (Objective HU O3). All revised plan alternatives include a desired condition for recreation emphasis areas to provide sustainable recreation opportunities that are responsive to changing recreation demands (FW-DC-REA-01), and a guideline to reduce the likelihood of establishing unplanned visitor use patterns (FW-GDL-REA-01). Direction adopted from the Northern Rockies Lynx Management Direction calls for new recreation developments to be designed to maintain effective lynx habitat and provide for lynx movement (Guideline HU G3). Collectively, this plan direction would continue concentrating human use and temper future impacts on surrounding lynx habitat from increasing recreation use.

Winter recreation effects have been studied because lynx and snowshoe hares share an adaptation for deep, soft snow conditions. Direction adopted from the Northern Rockies Lynx Management Direction seeks to maintain the lynx's natural competitive advantage over other predators in deep snow by discouraging the expansion of snow-compacting activities in lynx habitat (Objective HU O1). Research suggests a differential response to winter motorized recreation such as snowmobiling based on the type and location of use. Squires et al. (2010) found no evidence that lynx avoided roads used by snowmobiles in winter. However, off-trail snowmobiling increased avoidance behavior compared to off-trail non-motorized activities (Squires et al. 2019). This suggests a higher degree of tolerance for non-motorized backcountry recreation. Researchers have explored another hypothesis that human activities resulting in snow compaction (such as skiing, snowmobiling, snowshoeing, and plowing roads) could impact lynx by lending a competitive advantage to other carnivores, such as coyotes, bobcats, or mountain lions, which do not travel efficiently in deep soft snow conditions. Studies and observations in northwestern Montana have shown that coyotes did not travel on or near snowmobile routes more often than randomly expected (2007), while others in Utah and Wyoming indicated that the presence of compacted snowmobile routes did influence winter coyote distribution (Burghardt Dowd 2010). Natural variation in snow penetrability between the different geographic areas where these studies occurred might explain the apparent contradictory results (Interagency Lynx Biology Team 2013). No comparable studies have occurred directly on the Custer Gallatin. But, as part of the Greater Yellowstone Area, snow conditions (and associated lynx habitat) on the Custer Gallatin are more similar to those studied in northwestern Wyoming by Burghardt Dowd (2010) than snow conditions studied in northwestern Montana by Kolbe et al. (2007). Which suggests that snow compaction on the Custer Gallatin could possibly influence coyote distribution, allowing for overlap with lynx habitat in winter. Even so, researchers in both locations also examined prey associations of coyotes and lynx, finding little if any dietary overlap between the species, indicating low levels of competition for prey (Interagency Lynx Biology Team 2013).

Alternatives B, C, E, and F identify two winter recreation emphasis areas—Cooke City and Hebgen. The expected high levels of concentrated winter use in these areas would likely result in substantial areas of snow compaction within and near occupied lynx habitat. Winter recreation emphasis areas are expected to receive increasing levels of winter use, commensurate with human population growth and increasing popularity of the Greater Yellowstone Area for recreation opportunities. Such increased use could result in even larger areas of snow compaction, as numbers of recreationists increase and technology evolves. However, these areas are currently managed and heavily used, for winter recreation with limited geographic opportunities for expansion, and plan components adopted from the Northern Rockies Lynx Management Direction (Guideline HU G11) would limit new designated over-snow routes and designated play areas to consolidate use to improve lynx habitat. The Hebgen Winter Recreation Emphasis Area is the largest of all the recreation emphasis areas, and is located in the Madison, Henrys Lake, and Gallatin Geographic area, which is classified as secondary, occupied lynx habitat. Although the recreation emphasis area contains potential lynx habitat, part of the area within the Hebgen winter recreation emphasis area (east-southeast of Hebgen Lake) is not lynx habitat because of soil conditions that are not conducive to producing boreal forest conditions.

The Hebgen winter recreation emphasis area is currently, and has been for many years, a popular winter recreation area with groomed snowmobile and ski trails, as well as large areas open to dispersed winter recreation. Consequently, this area is subject to high levels of noise disturbance and snow compaction associated with human uses. This recreation emphasis area is adjacent to Yellowstone National Park, where snowmobiling is allowed, but only on designated routes. The Lionhead area, Taylor-Hilgard area, and Lee Metcalf Wilderness Area to the northwest of the Hebgen winter recreation emphasis area would not allow snowmobile use under all alternatives. Skiing and snowshoeing may occur in these adjacent areas, but trails generally would not be groomed in these areas.

The other winter recreation emphasis area in alternatives B, C, E, and F is the Cooke City area, located in the Absaroka Beartooth Geographic Area, which is designated as core, occupied lynx habitat. Given the alpine nature of the area, only about 26 percent of this winter recreation emphasis area is potential lynx habitat. The Cooke City area has been a popular local and destination winter recreation for many years. The Cooke City winter recreation area is surrounded by the Absaroka-Beartooth Wilderness Area. Winter recreation may impact lynx as described previously, but emphasis areas can also consolidate such use, thereby potentially limiting impacts from dispersed winter recreation in surrounding lynx habitat, because many people might prefer the amenities associated with the recreation emphasis areas. Winter recreation emphasis areas occur under all revised plan alternatives except alternative D. However, none of the existing features that attract high levels of winter use to these areas would be removed or otherwise altered, and management would continue to focus on recreation opportunities in these areas under alternative D.

Alternative E includes a recreation emphasis area associated with the Bridger Bowl ski area in the Bridger, Bangtail, and Crazy Mountains Geographic Area, which is designated as secondary, unoccupied lynx habitat. In alternative F, this recreation emphasis area is expanded to the north to include the Fairy Lake area, which is also a very popular, primarily summer recreation area, but also receives considerable use by snowmobiles and backcountry skiers in winter. High levels of recreation use in this area would continue to result in snow compaction, which could impact potential lynx use of the area. The role of secondary lynx habitat is not well understood, but may provide important connecting areas for lynx to move between core areas or between ecosystems. Lynx dispersal from the home range typically occurs in summer (Squires and Laurion 1999). While winter recreation in this area may not have notable impacts on potential lynx movement through the area, permanent habitat alterations such as tree removal to clear runs for skiing could affect habitat connectivity. However, dispersing lynx have been reported to move through suboptimal habitats that may be avoided by residential individuals (Ruediger et al. 2000a, Vanbianchi et al. 2018). In alternative F, the west Bridger key linkage area would be located adjacent to the Bridger recreation emphasis area, providing potential alternate travel routes for lynx.

In addition to the recreation emphasis areas specifically allocated for winter use, a number of recreation emphasis areas are allocated for year-round recreation, which could include motorized or non-motorized winter recreation. Recreation emphasis areas tend to have better access with paved and plowed roads than other parts of the national forest, which may consolidate winter recreation use, thereby, limiting potential impacts to lynx from snow compacting activities that would otherwise be dispersed over larger areas. All revised plan alternatives include a guideline to manage and rehabilitate administrative infrastructure such as temporary roads, skid trails and landings to reduce the likelihood of establishing unplanned visitor use patterns (FW-GDL-REA-01), which may discourage use for winter recreation. In addition, the Northern Rockies Lynx Management Direction contains guidelines that limit expansion of winter use areas and designated over-snow routes (NRLMD Guidelines HU G2, G3, and G11) that would limit impacts to lynx within and outside the winter recreation emphasis areas. Likewise, all revised plan alternatives include direction to prohibit new winter special use permits and new winter routes in wolverine maternal habitat (FW-GDL-WLWV-01), which would further reduce impacts from snow compaction in lynx habitat, since these species' habitat overlaps.

Under all revised plan alternatives, plan land allocation for recreation emphasis areas is a way to acknowledge existing and anticipated future use levels. By incorporating the Northern Rockies Lynx Management Direction, and additional plan land allocations that restrict access and certain types of use outside of recreation emphasis areas, the revised plan alternatives provide tools for managing high-use areas and effectively consolidating such use, which would be consistent with the intent of the Northern Rockies Lynx Management Direction for conserving lynx habitat.

Olson et al. (2018) studied the effects of developed and dispersed winter recreation on lynx in Colorado. They found that lynx reduced their rate of movement and became more nocturnal in areas with high levels of backcountry skiing and snowmobiling. Lynx in this study tended to avoid areas of intense motorized use, but used areas near non-motorized trails. Lynx avoided highly developed ski resorts in Colorado, particularly during peak human use times. This study concluded that lynx did not show strong negative responses to dispersed recreation, but altered behavior patterns, indicating potential avoidance of recreationists. Lynx avoidance of developed recreation sites with high intensity of human use suggests there is some level of human disturbance that is not tolerated by lynx. Two alpine (downhill) ski areas and three Nordic (cross-country) resorts operate on the Custer Gallatin National Forest, all within potential lynx habitat; although one alpine area and one Nordic area are in unoccupied lynx areas. All revised plan alternatives contain a standard that new downhill ski areas would only be approved if existing permitted areas cannot accommodate additional use (FW-STD-RECSKI-01) and a guideline that would require emerging recreation uses such as zip lines, alpine slides, and downhill mountain bike trails to be located at existing downhill ski areas if possible (FW-GDL-RECSKI-01). In addition, provisions are adopted from the Northern Rockies Lynx Management Direction to provide for lynx habitat needs and connectivity in developed ski areas by retaining patches of lynx habitat between ski runs (Objective HU O4, Guideline HU G1, G2). Again, the idea is that concentrating human recreation activities has less impact on wildlife, including lynx, than allowing additional development in relatively secure areas, consistent with NRLMD Objective HU O3.

The revised plan identifies a range of recreation experiences available on National Forest System lands, using a classification tool called the recreation opportunity spectrum. The recreation opportunity spectrum is consistent and highly correlated with land use designations and allocations in the revised plan, but also applies to non-designated areas of the national forest. Effects of recreation in designated areas and plan land allocations were addressed above. Under all revised plan alternatives, the recreation opportunity spectrum outside of designated areas and plan land allocation areas tends to be in the roaded natural and semi-primitive motorized categories. These areas likely have higher levels of human use and noise that could have greater disturbance impacts on lynx, and more potential for snow-compaction from winter recreation use.

Effects from Permitted Livestock Grazing

Permitted livestock grazing occurs in lynx habitat on the Custer Gallatin National Forest, although livestock are present at lower densities in the montane ecosystem geographic areas where lynx habitat is present than in the pine savanna geographic areas. All revised plan alternatives include desired conditions for livestock grazing allotments to maintain or trend toward desired ecological conditions stated for a variety of habitats (FW-DC-GRAZ-01), which include boreal forest types that could support lynx (NRLMD Objective GRAZ O1), as well as important intervening types that provide connectivity between patches of lynx habitat. To this end, the revised plan alternatives would require new or revised allotment management plans to incorporate grazing practices that avoid, minimize, or mitigate adverse impacts to ecosystems and wildlife (FW-STD-GRAZ-01, FW-GDL-GRAZ-03, 07, 08). Generally, livestock are not attracted to densely forested stands that provide high-quality habitat for lynx and snowshoe hares, unless seeking shelter from weather. Livestock use of forested stands for shelter has little effect on the structural characteristics of lynx habitat components. However, livestock may be attracted to recently disturbed (such as burned or harvested) forests by a flush of high-quality forage that often appears soon after disturbance. In such cases, livestock can delay the regeneration of dense, young forest selected by snowshoe hares, by trampling and damaging deciduous shrubs or conifer seedlings soon after they sprout. Plan components adopted from the Northern Rockies Lynx Management Direction provide a guideline (NRLMD Guideline GRAZ 01) to prevent such impacts.

If not properly managed, livestock can have negative effects on vegetation due to overgrazing, trampling, and heavy browsing. The revised plan alternatives contain a number of plan components to manage livestock impacts in riparian habitats and deciduous woodlands such as aspen stands (FW-GDL-GRAZ-01, 02, 04, 05). These forestwide plan components are complementary to direction adopted from the Northern Rockies Lynx Management Direction (Guidelines GRAZ G2, G3 and G4), which collectively, would minimize livestock impacts in areas that function as important secondary habitat for lynx, and help maintain connectivity between patches of primary (boreal forest) habitat. Under the revised plan alternatives, vacant allotments may continue to be used for livestock production (for example, be restocked or serve as grass banks), but they could also be permanently closed to address resource concerns (FW-GO-GRAZ-02). This management plan goal could be used to the benefit of lynx if livestock use is having detrimental effects to lynx habitat.

All revised plan alternatives except for alternative E, would prohibit stocking of grazing allotments with domestic sheep or goats for livestock production within occupied and unoccupied lynx habitat (FW-STD-GRAZ-02). There is little scientific information regarding potential dietary overlap with, or related forage competition between, domestic livestock and snowshoe hares (Interagency Lynx Biology Team 2013). If forage competition with snowshoe hares were a significant factor, then the alternatives that ban domestic sheep and goat production in lynx habitat would eliminate at least part of that threat. On the other hand, all revised plan alternatives except alternative D, do allow for targeted use of domestic sheep and goats for weed control (FW-STD-GRAZ-03). Again, there is little scientific information regarding the impacts of noxious weeds on snowshoe hares or lynx. However, noxious weeds can have notable impacts on native vegetation, and targeted grazing by domestic sheep and goats has proven effective at reducing the spread of noxious weeds in some circumstances. Revised alternatives (except alternative D) include a number of measures to maintain tight control over domestic sheep or goats used for weed control (FW-STD-GRAZ-04).

Effects from Energy and Minerals Management

There are three types of mineral and energy resources on the Custer Gallatin National Forest: locatable minerals including commodities such as gold, silver, copper, etc.; saleable minerals such as sand, stone, and gravel; and leasable minerals such as oil, gas, and other natural commodities. Nationally, mining levels have dropped substantially from historical levels in lynx habitat, and modern mines operate under more stringent environmental protections than existed historically (Interagency Lynx Biology Team 2013). On the Custer Gallatin, more than 1 million acres (over one-third of the National Forest System lands), have been formally withdrawn from mineral entry, effectively prohibiting activities related to exploration, development, and production of mineral resources. To date, mineral withdrawals on the Custer Gallatin have occurred in the montane geographic areas, which is also where lynx habitat is located.

In areas open to mineral development (not withdrawn), the General Mining Law of 1872 provides strong rights for prospecting, exploration, and development of minerals on National Forest System lands, including the right to reasonable access for such purposes. Activities associated with locatable, salable, or leasable mineral resources could affect lynx habitat by altering or removing native vegetation for developing roads, mines or other related facilities. Such activities could result in temporary or permanent reductions or loss of lynx habitat, as well as long-term fragmentation. Winter access to mineral or energy developments could impact lynx habitat through snow compaction if access requires plowing or grooming access routes, or if sites are accessed regularly by over-snow vehicles. All revised plan alternatives include desired conditions that energy and mineral resources are available for use (FW-DC-EMIN-01), but also include plan components to manage access commensurate with the stage of operations, and further require that lands affected by energy and mineral development are reclaimed to preoperational site conditions as much as possible once mining operations are complete (FW-DC-EMIN-02, FW-STD-EMIN-01, 02). Plan components adopted from the Northern Rockies Lynx Management Direction include guidelines (NRLMD Guidelines HU G5, G12) to reclaim mined sites and minimize snow compaction related to mineral and energy management.

Effects from potential future mineral development across the entire national forest are difficult to determine, as there is much speculation involved regarding what, when, and where private mineral rights may be invoked. To date, the majority of locatable mineral operations active on the Custer Gallatin are located in the Stillwater complex in the Absaroka Beartooth Mountains Geographic Area. The Stillwater area has shown high potential for mineral development, specifically its unique platinum and palladium resources. As such, the Stillwater complex would receive plan land allocation as a mining emphasis area in all revised plan alternatives except for alternative D. Even under alternative D, mineral development would be expected to continue and perhaps expand, as a recognized value and use in the Stillwater mining complex area, with associated impacts to lynx habitat as described above. In alternative D, much of the Stillwater complex area would be allocated as recommended wilderness. While this allocation would not preclude new minerals activities, it would provide greater flexibility for imposing mitigation measures to minimize alteration of lynx habitat and reduce potential snow compaction compared to other alternatives. Under all alternatives, plan components adopted from the Northern Rockies Lynx Management Direction (noted above) would support mitigation measures to protect resources, including location of facilities and timing of use, to be imposed on any new proposals for minerals or energy development within the Stillwater complex.

Effects from Infrastructure Management

Administrative use and public recreation on the Custer Gallatin is often associated with infrastructure such as roads and trails, which provide access, and recreation in the form of pleasure driving, sightseeing, and walking or riding, but also provide access to off-route recreational opportunities. Construction and maintenance of infrastructure can result in permanent loss of lynx habitat if it results in the removal of boreal forest cover, and can cause fragmentation of lynx habitat if large areas of non-lynx habitat are permanently altered between patches of boreal forest. While the physical presence of roads can impact lynx habitat, the use of roads by humans affects lynx in various ways depending on the size of road, combined with traffic volume and speed. Highways facilitate high volumes of high-speed traffic, which can create barriers to lynx movement if lynx choose to avoid crossing, or can result in direct mortality if a vehicle strikes a lynx attempting to cross. However, lynx have been known to successfully cross highways (Interagency Lynx Biology Team 2013). National Forest System roads are categorized by their associated maintenance levels. Maintenance Level 5 corresponds with roads that are usually double lane, paved routes that accommodate a higher volume and higher speeds of traffic than most forest system roads. Maintenance Level 5 roads have the greatest potential for direct impacts on lynx, but account for a very small proportion (less than 1 percent) of roads within the national forest boundary. However, direction adopted from the Northern Rockies Lynx Management Direction calls for mitigation to avoid or reduce impacts to lynx in rare instances where forest roads may be upgraded from Maintenance Level 4 to Maintenance Level 5 (Guideline HU G6). Over 90 percent of the National Forest System roads on the Custer Gallatin are Maintenance Level 2 or 3, which are generally narrow (often single track), gravel or other natural surface that accommodate low levels of slow-moving traffic. Of these, nearly half (about 48 percent) are open for administrative use only (are not open for public use). In northwestern Montana, in an area with relatively high road density (5.13 miles per square miles), Squires et al. (2010) found little avoidance of gravel forest roads by lynx. There are no records of lynx mortality resulting from vehicle collision on National Forest System roads in the Custer Gallatin National Forest.

While National Forest System roads may have little direct effect on lynx as described above, the roads can have an indirect effect in providing access routes for human uses that may result in winter snow compaction in lynx habitat. Forest roads may be plowed or groomed to provide access in winter, or they may also experience snow compaction from winter recreation use such as snowmobiling, skiing, or hiking. Snow compaction may reduce the competitive advantage lynx have over other predators in winter. Also, winter routes may facilitate access for fur trappers. Trapping of lynx for fur trade is prohibited by law, yet some federally protected lynx have been incidentally caught in traps or illegally shot by hunters in Montana. However, none of these incidents has occurred on the Custer Gallatin National Forest (Inman, 2019 personal communication).

All revised plan alternatives include desired conditions to provide a safe, efficient transportation system for public and administrative use, while imparting minimal impacts on other resources, including threatened and endangered species (FW-DC-RT-01). To minimize impacts, the revised plan alternatives include forestwide plan components that place restrictions on road construction and administrative facilities in old-growth forest and riparian areas (FW-GDL-VEGF-02, FW-STD-RT-01 to 05), encourage use of technologies that reduce impacts to other resources, and facilitate removal and restoration of roads and facilities no longer needed (FW-GDL-RT-01, 02). The emphasis on plan components for infrastructure management is to protect water and riparian resources, which are important habitat elements for lynx, as they can provide foraging and denning opportunities as well as important travel routes. All revised plan alternatives provide plan components with more detailed guidance, and more restrictions on construction of new roads and other facilities, than currently contained in current plans. In addition, all alternatives adopt components from the Northern Rockies Lynx Management Direction, which would avoid impacts to lynx associated with road upgrades, avoid locating new roads in important connecting areas for lynx, limit brush removal along forest roads, and limit use of project roads to administrative purposes (NRLMD Guidelines HU G6-G9). Direction in the revised plan alternatives would limit habitat alterations due to new road construction in important lynx habitat, manage traffic volume and speed for lower levels to minimize disturbance and mortality risk, and limit use on project roads to administrative purposes over which the agency has more control. These collective plan components would minimize habitat impacts to lynx under all revised plan alternatives, while still providing management flexibility to maintain or restore lynx habitat where needed, as well as meet other multiple-use mandates.

Effects to Non-lynx Habitat

Non-lynx habitat (also referred to as “matrix” in designated critical habitat for lynx) includes the warm dry forest, deciduous forest, and non-forest habitat types that do not support snowshoe hare populations of sufficient density for persistent use and occupation by lynx. Non-lynx habitat occurs between patches of boreal forest at a scale proportionate to a lynx home range such that resident lynx are likely to travel through such habitat while accessing patches of boreal forest. The general condition of non-lynx habitat is not thought to be a limiting factor for lynx, and human activities that change vegetation structure within these habitats are not considered to have an adverse effect to lynx habitat unless they create a barrier, or otherwise impede lynx movement between patches of foraging habitat or between denning and foraging habitat (U.S. Department of the Interior 2014a).

All revised plan alternatives include integrated resource desired conditions to provide wildlife habitat, forested vegetation, non-forested vegetation, riparian areas, and ecological disturbance processes within the natural range of variation (FW-DCs: WL-03; VEGF-02, 06; VEGNF-04; WTR-04, 06, 07; and FIRE-01), and to provide for habitat connectivity (FW-DCs: WL-05 to 07; WTR-02, 10; VEGF-09; LAND-01). These desired conditions, and associated management applications or restrictions would maintain ecological characteristics within the historical range of conditions to which native species, such as lynx and snowshoe hares, have evolved.

Specifically, the revised plan alternatives contain measurable indices to maintain or restore natural structural characteristics in warm, dry, and cold forest types that provide non-lynx habitat. Plan components spell out management sideboards related to successional stage, forest density, presence of snags, patch size, distribution of large trees, natural disturbance processes, and presence of old-growth forest (FW-DC-VEGF-03 to 09). Similar plan components are provided for deciduous woodlands, shrublands, riparian areas, and wetlands that may occur within non-lynx habitats (FW-DC-VEGNF-04; FW-GO-VEGNF-03; FW-OBJ-VEGNF-01; FW-DC-RMZ-All; FW-STD-GRAZ-01). Complementary direction is adopted from the Northern Rockies Lynx Management Direction (Guideline LINK G2), which addresses grazing management practices that could impact shrub-steppe structure and condition within matrix habitat. Collectively, these factors would all influence the amount of vegetative cover available to provide potential travel routes and resting areas for lynx, as well as suitable habitat for alternate lynx prey species, such as squirrels, grouse, and other species that may be present in non-lynx habitats.

Effects to Designated Critical Habitat for Canada Lynx

Critical habitat is designated in those portions of the Custer Gallatin with the highest potential to support residential use by lynx. Roughly 55 percent of the National Forest System lands on Custer Gallatin where lynx may be present is designated critical habitat for lynx, and about 60 percent of the mapped lynx habitat on the national forest is within designated critical habitat. All alternatives contain plan components that specifically address the primary constituent elements of designated critical habitat for lynx, including habitat management standards that limit impacts to snowshoe hare habitat (element 1a), guidelines that limit snow compacting activities (element 1b), guidelines for providing well-distributed denning habitat (element 1c), and standards for maintaining habitat connectivity within and between lynx analysis units, which includes managing matrix or non-lynx habitat (element 1d), so as not to create barriers or impede lynx movement. These conditions were all addressed for effects to general lynx habitat above. Therefore, effects to designated critical habitat for lynx are similar to those described above, but occur on a slightly smaller scale.

Cumulative Effects

The Canada lynx is protected as a threatened species with designated critical habitat, requiring conservation measures by all land management agencies, resulting in a collective suite of management plans geared toward conserving lynx and designated critical habitat for the species. All national forests with Canada lynx habitat in Forest Service regions covering parts of Montana, Idaho, and Wyoming formally adopted the Northern Rockies Lynx Management Direction through plan amendments (U.S. Department of Agriculture 2007b), and the national forests are still operating under this direction. Lynx management direction focuses on protecting the key components of lynx habitat and primary constituent elements of designated critical habitat for lynx. Therefore, cumulative effects for Canada lynx and designated critical habitat for lynx would result in consistent management across Greater Yellowstone Ecosystem national forests, as well as national forests in northwestern Montana that provide connectivity with source populations in Canada. The general management plan for Yellowstone National Park calls for preserving natural resources, including natural vegetation, landscapes, and disturbance processes, resulting in large proportions of backcountry managed similar to wilderness areas on adjacent Custer Gallatin lands. The cumulative effects are large, contiguous areas of low human impact for lynx. Bureau of Land Management lands near lynx habitat on the Custer Gallatin are managed by the Dillon plan (2006), Butte plan (2009a) and Billings plan (2015a) field offices. These plans follow guidance from the Lynx Conservation Assessment and Strategy (Ruediger et al. 2000a, Interagency Lynx Biology Team 2013), which lead to management consistent with national forest direction contained in the Northern Rockies Lynx Management Direction.

The Montana Department of Natural Resources and Conservation has a Habitat Conservation Plan (Montana Department of Natural Resources and Conservation 2010) for managing forested State trust lands. The Habitat Conservation Plan commits to protecting lynx habitat by minimizing impacts of forest management on important habitat elements for lynx and prey species, with a goal to support Federal lynx conservation efforts in a manner consistent with the Northern Rockies Lynx Management Direction. In addition, Montana Fish, Wildlife and Parks developed a State Wildlife Action Plan (Montana Fish Wildlife and Parks 2015c), which identifies habitat community types, focal areas, and wildlife species that warrant conservation attention. The State Wildlife Action Plan does not identify Canada lynx as a species of greatest conservation need, but does identify conifer-dominated forest and riparian areas as community types of greatest conservation need in the ecoregions that support lynx, which is consistent with Northern Rockies Lynx Management Direction habitat management provisions. Since the lynx was listed as threatened, Montana Fish, Wildlife and Parks has revised trapping regulations to minimize the potential for lynx to be caught in traps set for other species.

Conclusion

Compared to the current plans, coarse filter plan components for the revised plan alternatives provide a clearer trajectory for desired vegetation conditions, which would promote plant and animal diversity, and maintain or restore ecological integrity by managing habitats within a range of conditions to which lynx have adapted use patterns over time. The fine filter components contained in the Northern Rockies Lynx Management Direction, as well as those listed above for other species, would limit potential impacts to lynx habitat to a greater degree than is likely to occur with the current plans.

The purpose of the Northern Rockies Lynx Management Direction is to incorporate management direction into national forest plans that will conserve lynx habitat and promote recovery by reducing or eliminating negative effects of land management activities on National Forest System lands. At the same time, the Northern Rockies Lynx Management Direction was designed to complement the multiple-use directive for the Forest Service. Implementing the direction benefits lynx under all alternatives by incorporating protective measures to maintain, as well as proactive measures to improve or restore lynx habitat. Additional plan components for wildlife and vegetation management in the revised plan alternatives are complementary to the Northern Rockies Lynx Management Direction measures, and would promote more strategic planning, timing, and design of projects that could improve overall habitat conditions for lynx in a more affirmative manner than the more general plan direction provided under the current plans.

The majority of coarse filter plan components that would influence ecological aspects of lynx habitat, as well as fine-filter components adopted from the Northern Rockies Lynx Management Direction, are the same under all revised plan alternatives. The primary differences between alternatives that could affect habitat for lynx are in the land use allocations of recommended wilderness, backcountry areas, and key linkage areas, which provide more limits on management actions that could permanently alter lynx habitat, versus recreation emphasis areas and Stillwater mining complex allocations, which provide more management flexibility with greater potential for permanent alterations to lynx habitat. The revised plan alternatives each have different combinations of these plan land allocations, with alternative D being the most restrictive in terms of land uses, and alternative E having the greatest potential for permanent alterations to lynx habitat as a result of management actions. Alternative F, which is preferred, strikes a balance by providing well-connected corridors of more protected land use allocations, and concentrating management and recreation emphasis areas where such uses already occur. In conclusion, all alternatives would continue to contribute to recovery of lynx by providing large blocks of low-disturbance areas and limiting management actions that could adversely affect lynx.

Grizzly Bear (*Ursus arctos*)

Grizzly bears on the Custer Gallatin National Forest are part of the Greater Yellowstone Ecosystem population that occurs in parts of Montana, Idaho, and Wyoming. In 1975, the grizzly bear was listed as a threatened species under the Endangered Species Act of 1973 (as amended) in the lower 48 states. Critical habitat for grizzly bears was not designated. The Greater Yellowstone grizzly bear population met demographic recovery targets by 1998, and has generally met or exceeded most recovery targets since. As a result, Federal and State agencies developed a conservation strategy for managing Yellowstone grizzlies in 2003, which was updated in 2007, and again in 2016 (U.S. Department of the Interior 2016b, Yellowstone Ecosystem Subcommittee 2016a). The conservation strategy was developed by an interagency team consisting of representatives from the U.S. Fish and Wildlife Service, Interagency Grizzly Bear Study Team, National Park Service, U.S. Forest Service, and wildlife management agencies from Montana, Idaho, and Wyoming. This team brought a wealth of knowledge and experience to the task, and developed the conservation strategy using this combined expertise, as well as drawing upon the best available scientific research and literature relative to grizzly bear management. The U.S. Fish and Wildlife Service identified Greater Yellowstone Ecosystem grizzlies as a distinct population segment, and delisted (removed from the endangered species list) the distinct population segment in July 2017[6]. In September 2018, a District Court ruling vacated the Fish and Wildlife Service delisting rule, restoring Endangered Species Act protection for the Yellowstone grizzly bear population. However, the District Court ruling acknowledged a 2011 Ninth Circuit Court of Appeals decision, which validated that the conservation strategy, when incorporated into legally binding land management plan direction, provides adequate regulatory mechanisms to maintain a recovered population of grizzly bears.

At the time of this analysis, the Greater Yellowstone Ecosystem grizzly bear population was stable to increasing, with a total population estimate of 737 grizzly bears in 2019 (van Manen et al. 2020). With no evidence of a population decline, but rather a slowing of the rate of population growth in recent years, it

[6] U.S. Department of the Interior, Federal Register 80(82) 2017

may be that the Greater Yellowstone Ecosystem grizzly bear population is nearing carrying capacity (van Manen et al. 2013b). There is no estimate of the number of grizzly bears currently using portions of the Custer Gallatin National Forest. However, grizzly bears are present and well distributed in the Madison, Henrys Lake, and Gallatin Mountains and the Absaroka Beartooth Mountains Geographic Areas, where they occupy most of the suitable habitat within these geographic areas (see figure 27 for current grizzly bear distribution in the Greater Yellowstone Ecosystem).

Doak and Cutler (2014) questioned the methods used by the Interagency Grizzly Bear Study Team (as reported by van Manen et al.) to estimate grizzly bear population numbers and trends. They suggested that population increases reported in recent decades were likely due to increased survey efforts and improved ability to sight bears, rather than the result of actual increases in bear numbers. In response to these critiques, van Manen et al. (2014) on the Interagency Grizzly Bear Study Team demonstrated that the perceived increase in survey effort was attributed to a notable increase in grizzly bear distribution; in other words, bears occupying a much larger area required additional survey effort. The Interagency Grizzly Bear Study Team's grizzly bear population estimates and associated demographic analyses are conducted by a team of about a dozen scientists, using methods that are critically reviewed and evaluated. Therefore, the population estimates the Interagency Grizzly Bear Study Team provided are based on sound scientific principles and present the best available scientific information for this analysis.

Analysis Area

A number of spatial scales are relevant to grizzly bear use of the plan area. The Greater Yellowstone Ecosystem for grizzly bears covers parts of Montana, Idaho, and Wyoming surrounding Yellowstone and Grand Teton National Parks. The Greater Yellowstone Ecosystem includes parts of five national forests, including the Custer Gallatin. The grizzly bear recovery zone (also referred to as the primary conservation area) is at the core of the Greater Yellowstone Ecosystem. Legal status of the grizzly bear (whether the distinct population segment is listed under the Endangered Species Act or not) affects the terminology used to describe the specific area to which plan components apply. While the Greater Yellowstone grizzly population is listed under the Endangered Species Act, plan components adopted from the conservation strategy apply within the recovery zone as delineated in the Grizzly Bear Recovery Plan (U.S. Department of the Interior 1993). If the grizzly bear is successfully delisted, the term "primary conservation area" replaces the term "recovery zone." Regardless of the terminology used, the spatial extent to which the plan components apply remains the same as the boundary for the recovery zone.

The Greater Yellowstone grizzly bear recovery zone is about 6 million acres, with just over 1 million acres inside the Custer Gallatin National Forest boundary. Inside the recovery zone, bear management units were delineated to facilitate the assessment of habitat characteristics and recovery objectives. Bear management units represent the spatial scale of the lifetime home range of a female grizzly bear in the Greater Yellowstone Ecosystem. Bear management units are further divided into subunits, which provide additional landscape resolution to account for seasonal differences in grizzly bear use patterns within a bear management unit (U.S. Department of the Interior 2016b). The Custer Gallatin intersects 9 of the 18 bear management units, and 14 of 40 subunits in the Greater Yellowstone grizzly bear recovery zone. Bear management units and subunits on the Custer Gallatin average about 482 and 217 square miles in size respectively. Figure 24 shows the alignment of bear management units and subunits within the Custer Gallatin National Forest and the Greater Yellowstone Ecosystem grizzly bear recovery zone.

Figure 24. Greater Yellowstone Area grizzly bear recovery zone – bear management units and subunits

Outside the recovery zone, bear analysis units were developed to provide consistent analysis units for monitoring changes to grizzly bear habitat, and are roughly the size of bear management subunits (Schwartz et al. 2009a). Eleven bear analysis units are monitored for the Custer Gallatin. Of these, eight are contiguous with the recovery zone and are located in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas. Three additional bear analysis units encompass isolated mountain ranges in the Bridger, Bangtail, and Crazy Mountains and the Pryor Mountains Geographic Areas. At the time of this analysis, the grizzly bear distribution area (where grizzly bears are known to occur) covered nearly all of the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas on the Custer Gallatin (see figure 27 for current distribution of grizzly bears in the Greater Yellowstone Ecosystem). For analysis purposes, the term “grizzly bear distribution area” refers to the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas combined. Roughly, 44 percent of the grizzly bear distribution area is inside the recovery zone. This analysis considers effects at the ecosystem, recovery zone, bear management unit, bear analysis unit, or geographic area scale depending on the particular issue. The Ashland and the Sioux Geographic Areas are outside the analysis area for grizzly bears. Figure 25 shows the alignment of bear analysis units.

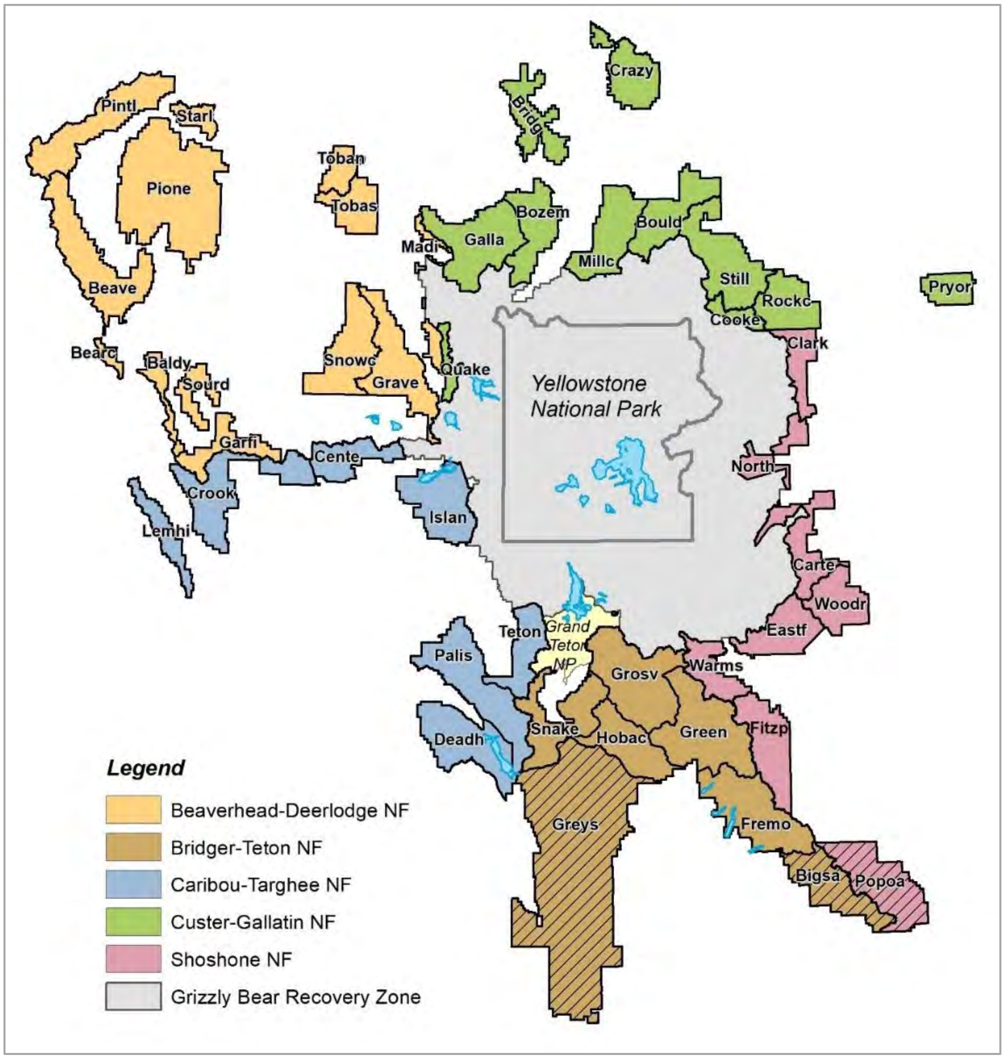

Figure 25. Bear analysis units – outside the Grizzly Bear Recovery Zone
Source: van Manen et al. 2019

Notable Changes between the Draft and Final Environmental Impact Statement

The description of the analysis area was revised to clarify that different terminology (“recovery zone” versus “primary conservation area”) may be used to describe the same geographic boundary based on the legal status of the grizzly bear under the Endangered Species Act. The analysis was expanded to address how monitoring items in the revised plan would help inform future management decisions relative to grizzly bears and human uses on the Custer Gallatin National Forest. Notable changes to the plan include:

- Addition of a goal to support or assist in interagency efforts to track, record, and report grizzly bear-human and grizzly bear-livestock conflicts (FW-GO-WLGB-03) and a goal to support or assist in interagency efforts to monitor key grizzly bear food items (FW-GO-WLGB-04);
- Converting the draft plan objective to identify grizzly bear relocation sites to a goal (FW-GO-WLGB-02); and
- Modification of the developed sites standards (FW-STD-WLGB-04 and 05) to apply to the authorized footprint of a site that existed in 1998 or the area within 300 meters of a primary road that existed in 1998, based on pending changes to the grizzly bear conservation strategy, as alluded to in the draft environmental impact statement.
- Developed sites standards FW-STD-WLGB-04c and FW-STD-WLGB-05c were further modified after the objection period at the request of the U.S. Fish and Wildlife Service. Standard FW-STD-WLGB-04c was modified to limit infrastructure associated with new developed sites along primary roads to no more than 10 percent of the existing mapped primary road corridors. Standard FW-STD-WLGB-05c was modified to apply only to overnight use, to define the parameters more clearly for replacing overnight dispersed recreation sites with new campgrounds, and to limit the number of potential new campgrounds. A management approach was added to convey possible implementation approaches for revised standard FW-STD-WLGB-05c. Language in both standards was clarified regarding the intent and application of exceptions.
- Livestock grazing allotments standard FW-STD-WLGB-06c was added after discussion with the U.S. Fish and Wildlife Service, and provides clarification regarding potential changes to existing boundaries of allotments and acres not previously part of allotments.
- Developed sites guideline FW-GDL-WLGB-02c was added after discussion with the U.S. Fish and Wildlife Service, and provides clarification regarding developed site overnight capacity expansion.

The analysis was revised to evaluate potential effects of the modified standards for developed sites.

Affected Environment (Existing Conditions)

The U.S. Fish and Wildlife Service identified over 11 million acres of suitable habitat for grizzly bears in the Greater Yellowstone Ecosystem (U.S. Department of the Interior 2016b). Notably, the Custer Gallatin National Forest administers approximately 19 percent of the total suitable habitat, and roughly 16 percent of the recovery zone. Approximately 54 percent of National Forest System lands in the Custer Gallatin portion of the recovery zone is within designated wilderness, with an additional 28 percent in wilderness study area and inventoried roadless areas that contain restrictions on land uses. Outside the recovery zone, roughly 44 percent of Custer Gallatin National Forest lands in the current grizzly bear distribution area fall within designated wilderness, with another 33 percent in wilderness study area and inventoried roadless area. Altogether, approximately 81 percent of the portion of the Custer Gallatin National Forest occupied by grizzly bears is within some sort of protective land use designation. Grizzly bear distribution has been expanding on the Custer Gallatin since the original plans were implemented in the mid-1980s (figure 26). Current distribution (figure 27) covers nearly all of the suitable habitat within the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas on the national forest (figure 28). Inside the recovery zone, the best available scientific information (van Manen et al. 2020) indicates that reproductive females with cubs were present for the past six consecutive years in all nine of the bear management units intersecting the Custer Gallatin

National Forest, indicating good distribution of the reproductive cohort of the population within the plan area.

Grizzly bears are habitat generalists that employ an opportunistic, omnivorous foraging strategy by using a wide range of plant and animal food sources (Gunther et al. 2014). Although grizzly bears in the Greater Yellowstone Ecosystem exhibit a high level of dietary variation, four key food groups have been identified that provide concentrations of proteins and fats that are essential sources of energy and nutrients for bears. These include ungulate biomass (obtained through direct predation as well as scavenging on carcasses), spawning cutthroat trout, whitebark pine seeds, and army cutworm moths (*Euxoa auxillaris*) (Schwartz et al. 2010, van Manen et al. 2015, Costello et al. 2016). Of these key food sources, only ungulate biomass and whitebark pine are known to be important food sources for bears on the Custer Gallatin National Forest.

Ungulate biomass is readily available within the plan area, due to the presence of large herds of elk (*Cervus elaphus*), which are well distributed across the national forest, as well as mule deer (*Odocoileus hemionus*) and moose (*Alces alces*), which are less abundant than elk, but still well distributed. Bison (*Bison bison*) are present seasonally in areas near Gardiner and West Yellowstone, whereas white-tailed deer (*Odocoileus virginianus*) and pronghorn antelope (*Antilocapra americana*) generally occur at lower elevations across the Custer Gallatin, relative to grizzly bear use areas. Over a period of 25 years, spring surveys in the Greater Yellowstone Ecosystem showed elk and bison carcasses made up 95 percent of the ungulate carrion used by grizzly bears (van Manen et al. 2018).

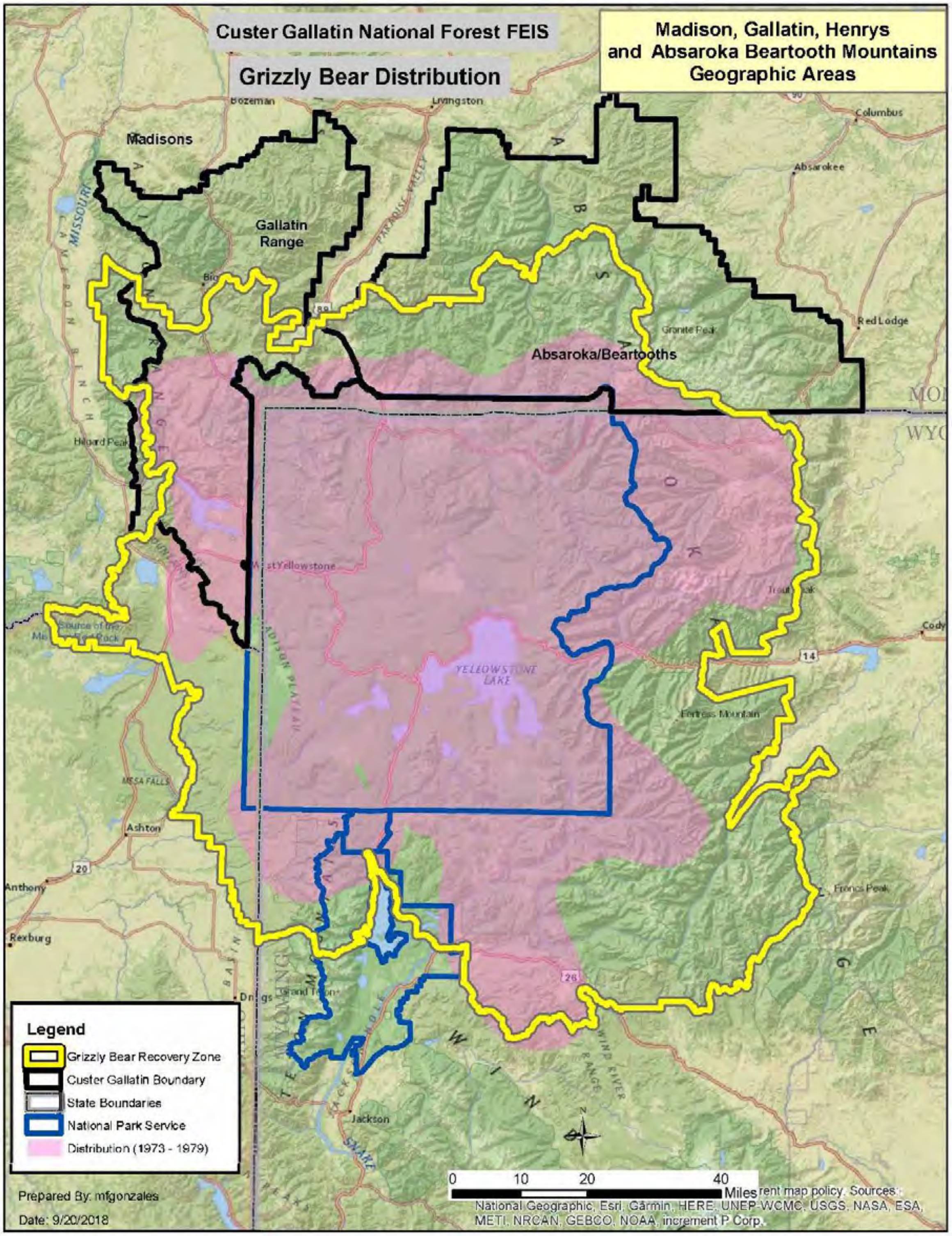

Figure 26. Grizzly bear distribution, 1970s

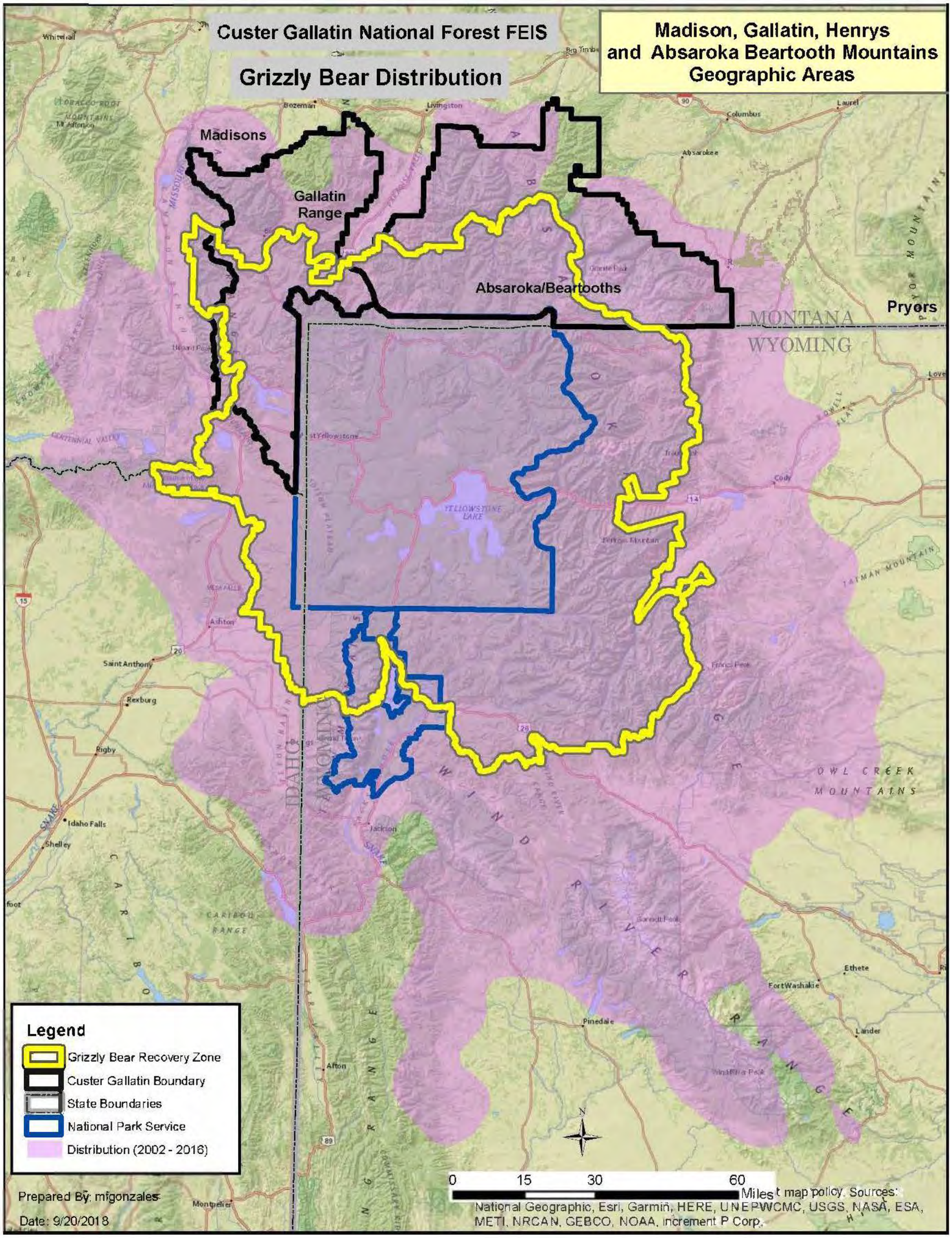

Figure 27. Current grizzly bear distribution

Elk are the most abundant and widespread of the big game species on the Custer Gallatin, and as such provide the bulk of ungulate biomass for grizzly bears. In the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas where grizzly bears are known to occur, Montana Fish Wildlife and Parks reported that elk herds were above population objectives in most of the areas monitored (hunting districts) in 2018. In the areas currently occupied by grizzlies, only one hunting district (310) just northwest of Yellowstone National Park, is currently below state population objectives for elk. Likewise, in the Bridger, Bangtail, and Crazy Mountains Geographic Area, which provides potential habitat connectivity for grizzly bear dispersal between the Greater Yellowstone Ecosystem and other grizzly bear ecosystems, elk herds are primarily over State population objectives for elk (Montana Statewide Elk Management).

Yellowstone bison spend most of their time inside Yellowstone National Park. However, during winter, some bison migrate onto the Custer Gallatin National Forest in the Gardiner Basin area north of the park boundary, while others migrate west of the park boundary and onto the national forest in the Hebgen Basin area near the town of West Yellowstone, Montana. Bison first began leaving Yellowstone Park to winter on the Custer Gallatin in the 1980s (Meagher et al. 2002). Since then, bison numbers using the Custer Gallatin have been rising. According to the most current data, over 400 bison were observed in the Gardiner Basin area, and over 600 bison were counted in the Hebgen Basin area during the spring of 2019 (Interagency Bison Management Plan 2019a). Bison that leave Yellowstone Park and move onto the national forest are hunted by Tribal members as well as the public. Hunter harvest, which largely only occurs on National Forest System lands, has increased over the years, from a low of one bison harvested in 2009 to a high of 468 taken in 2016–2017. Bison harvest on the Custer Gallatin went down for the first time to 375 animals in 2017–2018 (Geremia et al. 2018), and declined again to 107 animals harvested by state-licensed and Tribal hunters in 2018–2019 (Interagency Bison Management Plan 2019b).

Grizzly bears obtain ungulate biomass from scavenging carcasses, primarily on winter ranges, as well as direct predation, generally on calves and fawns. They also obtain ungulate carcasses by taking fresh kills from other predators such as wolves and mountain lions. Grizzly bears are also known to use ungulate biomass left by big game hunters in the form of gut piles or hunter-wounded animals that are not retrieved. Occasionally, grizzly bears claim entire carcasses of big game animals killed by hunters, which can lead to bear-human conflicts that may result in injury or death of either bears or humans (Ebinger et al. 2016).

Whitebark pine is a masting tree species that is cyclic, producing a large seed crop every 2 to 3 years (Schwartz et al. 2014). The seeds of whitebark pine are large relative to other tree species, and when abundant, provide a highly valuable food source for grizzly bears, as the seeds are easily digested and high in protein and fat content. Whitebark pine seeds mature late summer to fall, and bears most commonly consume this food source in September and October. Since whitebark pine grows at high elevations (roughly at or above 8,200 feet) and in remote environments, it typically occurs in areas that are relatively secure from human influence. Whitebark pine distribution and seed production has declined markedly in recent years, largely due to mortality from mountain pine beetle infestations and to a lesser extent, damage from white pine blister rust (van Manen et al. 2013b, Schwartz et al. 2014), (Gunther et al. 2014, Ebinger et al. 2016, U.S. Department of the Interior 2016b). Fortunately, there is evidence that whitebark pine mortality levels may be diminishing (Schwartz et al. 2014). Climate change has had a role in recent whitebark pine mortality (Hansen et al. 2018). Some climate models have predicted continued declines in whitebark pine distribution over the next half century, although due to the relatively high elevation, range reductions may be less evident in the Greater Yellowstone Ecosystem compared to other ecosystems at lower elevations (van Manen et al. 2013a).

Grizzly bears have a high degree of dietary plasticity and are capable of shifting to alternate food sources when key food items are scarce or unavailable. Although whitebark pine remains an important and desirable food source for grizzly bears in the Greater Yellowstone Ecosystem, research has documented a substantial number of grizzly bear home ranges with little or no whitebark pine in them (Costello et al. 2014). Other bears that did show habitat selection for whitebark pine showed no notable changes in home range size, movement patterns or body condition as whitebark pine declined in the Greater Yellowstone Ecosystem (van Manen et al. 2013a, Costello et al. 2014). However, Schwartz et al. (2010), reported an increase in grizzly bear-human conflicts in years of poor whitebark seed production. A more detailed analysis of whitebark pine status, condition, and trends on the Custer Gallatin National Forest can be found in the At-Risk Plant and Terrestrial Vegetation sections of the environmental impact statement.

Although ungulate biomass and whitebark pine are of high importance to grizzly bears, these food sources are not evenly available on a spatial or temporal scale; that is, not all high-calorie, energy-rich food sources are available in all areas, or of sufficient or predictable quantity to support all grizzly bears across the Greater Yellowstone Ecosystem from year to year. The same is true for the Custer Gallatin portion of the Greater Yellowstone Ecosystem, as ungulate populations ebb and flow, weather influences the amount and distribution of winter kill, and whitebark pine seed production fluctuates from year to year. That is why the highly adaptable foraging strategy of grizzly bears serves the species so well. In geographic areas or during times of low availability of these key food sources, grizzly bears shift their attention to a wide range of alternate food sources that are of lower caloric value, but tend to be more readily available across the landscape (Gunther et al. 2014). The broad diversity of habitat types across the Greater Yellowstone Ecosystem provides a wide variety of alternate food for bears to supplement their diet when key foods are less available, or unavailable. Refer to the Terrestrial Vegetation section for details on vegetation diversity on the Custer Gallatin National Forest.

Gunther et al. (2014) documented 266 species of plant, animal, fungi, algae, and soil consumed by grizzly bears in the Greater Yellowstone Ecosystem. Some of these items were incidental, and believed to be consumed through exploratory behavior or accidentally during consumption of other foods. The most common food items found in the grizzly bear's diet include grasses, ants (*Formicidae* spp), whitebark pine seeds, clover (*Trifolium* spp.), and dandelion (*Taraxacum* spp.), all of which are widely distributed across the Custer Gallatin National Forest. Although berries occur in the Greater Yellowstone Ecosystem grizzly bear diet (Gunther et al. 2014, Costello et al. 2016), the Greater Yellowstone Ecosystem differs from other grizzly bear ecosystems because of the lower proportion of berry-producing shrubs and relatively large populations of wild ungulates (Ebinger et al. 2016). This condition is reflective of the Custer Gallatin as well. Climate change has the potential to affect vegetation, hydrology, fire regimes, and insect populations, which in turn could influence the quantity, distribution, and elevational presence of important plant and animal food sources for grizzly bears. Such changes may reduce or even eliminate the availability of some food sources, while other sources may increase, or be unaffected. Climate change could affect species composition if new species move into the area or existing species are lost (Gunther et al. 2014). Due to a high level of dietary plasticity, habitat generalists such as grizzly bears tend to fare better in response to changing conditions than do habitat specialists (Costello et al. 2014).

Grizzly bears spend most of the winter in dens as a strategy to reserve energy in times of low food availability. Cubs are born during the winter denning period, placing additional energetic demands on reproductive females (Podruzny et al. 2002). Grizzly bear dens on the Custer Gallatin tend to be located at relatively high elevations, often on north-facing slopes to help maintain stable temperature and humidity conditions with a thick insulating layer of snow. Some scientists have noted a potential concern over warming temperatures associated with climate change impacting the winter denning habits of grizzly bears, and associated potential for increased grizzly bear-human conflicts if bears spend less time in dens (Cross and Servheen 2010). Over 1 million acres within the grizzly bear distribution area on the Custer Gallatin are at elevations at or above 8,200 feet, which not only provides abundant denning habitat for grizzly bears, but also at high elevations where climate change is expected to have fewer notable impacts. Most of this habitat is in wilderness or other areas where winter access for humans is limited.

The Interagency Grizzly Bear Committee recognized the impacts of human access on grizzly bear habitat security. Specifically, motorized vehicle access has been shown to increase human interaction with bears and potentially increase associated grizzly bear mortality risk, increase grizzly bear displacement from important habitats, increase bear habituation to human presence and reduce habitat security. Secure areas are a major component of grizzly bear habitat because they provide opportunities for bears to meet energetic needs with low potential for disturbance from human intrusions (U.S. Department of the Interior 2016b). Secure habitat for Greater Yellowstone Ecosystem grizzly bears is defined as those areas at least 10 acres in size that are at least 0.3 mile away from open or gated motorized access routes (Schwartz et al. 2010, van Manen et al. 2013a, Costello et al. 2014, Yellowstone Ecosystem Subcommittee 2016a). A key part of the secure habitat definition is distance from an open motorized route. Mattson et al. (1987) found that grizzly bears in Yellowstone National Park consistently used areas within 500 meters (0.3 mile) of roads less than expected. The 10-acre minimum patch size for secure habitat is a reasonably sized area that is useable by an individual grizzly bear, while avoiding disturbance associated with motorized use on roads and trails. The 10-acre minimum patch size represents the minimum size area that would be protected by plan components for secure habitat. If the minimum patch size for secure habitat were much larger, it would mean that larger patches of secure habitat could be eliminated by road building, and still comply with plan components to maintain secure habitat (van Manen et al. 2016).

Secure habitat is calculated with a suite of geographic information system (GIS) geospatial tools, collectively referred to as the Greater Yellowstone Ecosystem Motorized Access Model (U.S. Department of the Interior 2017b), using a database of linear motorized access routes (roads and trails) developed by each administrative unit in the Greater Yellowstone Ecosystem. The data are then compiled and maintained by the Greater Yellowstone Ecosystem Grizzly Bear Database Coordinator. While the Greater Yellowstone Ecosystem access model is the best available tool for measuring and monitoring changes in the proportion of secure habitat over time, like all models, it is based on a set of assumptions, and outputs are only as accurate as the data fed into the model. Model and data accuracy have improved over time, but errors are still occasionally found. Corrections to the database are often due to errors of omission (such as roads or motorized trails that existed in 1998, but were not included in original mapping). The conservation strategy specifies procedures for making corrections to the database (Yellowstone Ecosystem Subcommittee 2016a). During Forest Travel Management planning efforts in the early 2000s, the motorized access database for the Custer and Gallatin national forests came under scrutiny, and consequently, the accuracy of the linear database used to calculate secure habitat inside and outside the recovery zone was improved considerably. The accuracy of this database was further improved when it was again closely reviewed by the Custer Gallatin National Forest personnel in coordination with the Yellowstone Ecosystem Subcommittee Technical Team that recently revised conservation strategy recommendations for developed sites and related habitat security.

Within the Greater Yellowstone Ecosystem recovery zone, secure habitat levels generally are high, averaging about 87 percent over the entire recovery zone. Secure habitat is also generally high for individual bear management subunits, but ranges from a low of 46 percent secure to a high of 100 percent secure. Subunits that fall within the Custer Gallatin National Forest boundary are within that range, with a low of 51.8 percent secure to a high of 99.6 percent (van Manen et al. 2020). Secure habitat is monitored by bear management subunits because subunits are delineated based on features that are biologically meaningful to bears. Therefore, subunits tend to overlap administrative boundaries, as is the case on the Custer Gallatin (figure 24). Of the 14 bear management subunits that fall within the Custer Gallatin boundary, only one, Boulder/Slough 1, is entirely within the plan area; all others are shared with at least one other administrative unit (other national forest, Yellowstone National Park, or both). Considering only the Custer Gallatin portion of subunits, the area inside the recovery zone on the Custer Gallatin is roughly 79 percent secure.

Secure habitat values for each subunit on the Custer Gallatin are shown in table 67. Secure habitat proportions are presented for baseline conditions in 1998 as well as current levels. The year 1998 is used as a baseline for measuring secure habitat because habitat conditions leading up to that time provided an environment that resulted in substantial growth of the Yellowstone grizzly bear population and subsequent achievement of all demographic recovery targets by 1998 (Yellowstone Ecosystem Subcommittee 2016a). Secure habitat levels have increased in all but two subunits on the national forest since 1998. The two that have not increased have been maintained at over 96 percent secure since 1998. Three subunits: Gallatin 3, Henrys Lake 2, and Madison 2, were identified in early versions of the conservation strategy as in need of improvement relative to 1998 levels. As a result, notable increases in secure habitat have been achieved in these three subunits through implementation of the Gallatin Forest Travel Management Plan. Secure levels achieved at full implementation of the Gallatin travel plan have been formally adopted as new secure habitat baseline levels for the Gallatin 3, Henrys Lake 2, and Madison 2 subunits. In addition, substantial increases in secure habitat from the 1998 baseline have resulted from implementation of the Gallatin travel plan in the Hilgard 1 and 2, and Madison 1 subunits, although 1998 remains the baseline level for these subunits.

Table 67. Secure habitat for Custer Gallatin bear management subunits, 1998 and 2019

Bear Management Subunit Name and Number	Geographic Area	Size Square Miles	Percentage Secure 1998 (new baseline)*	Percentage Secure 2019	Change since 1998
Boulder/Slough 1	Absaroka Beartooth Mountains	282	96.6	96.6	0.0
Boulder/Slough 2	Absaroka Beartooth Mountains	232	97.7	97.7	0.0
Crandall Sunlight 1	Absaroka Beartooth Mountains	130	81.1	81.9	+0.8
Crandall Sunlight 2	Absaroka Beartooth Mountains	316	82.3	82.7	+0.4
Gallatin 3*	Madison, Henrys Lake, and Gallatin Mountains	218	55.3 (70.7)	72.5	+17.2
Hellroaring/Bear 1	Absaroka Beartooth Mountains	185	77.0	80.4	+3.4
Hellroaring/Bear 2	Absaroka Beartooth Mountains	229	99.5	99.6	+0.1
Henrys Lake 2*	Madison, Henrys Lake, and Gallatin Mountains	140	45.7 (51.7)	51.8	+6.1
Hilgard 1	Madison, Henrys Lake, and Gallatin Mountains	201	69.8	83.1	+13.3
Hilgard 2	Madison, Henrys Lake, and Gallatin Mountains	141	71.4	80.2	+8.8
Lamar 1	Absaroka Beartooth Mountains	300	89.4	89.9	+0.5
Madison 1(van Manen et al. 2020)	Madison, Henrys Lake, and Gallatin Mountains	228	71.5	80.7	+9.2
Madison 2*	Madison, Henrys Lake, and Gallatin Mountains	149	66.5 (67.5)	67.5	+1.0
Plateau 1	Madison, Henrys Lake, and Gallatin Mountains	286	68.8	70.6	+1.8

*New baseline established with implementation of Gallatin Forest Travel Management Plan.
Source: van Manen et al. (2020)

National forests in the Greater Yellowstone Ecosystem incorporated habitat management and monitoring recommendations from the Grizzly Bear Conservation Strategy into forest land management plans in 2006 (U.S. Department of Agriculture 2006b). The basic premise of the conservation strategy is that habitat conditions inside the grizzly bear recovery zone should be maintained or improved relative to secure habitat levels, number and capacity of developed sites, and acres of permitted livestock grazing on public lands. Since the conservation strategy was first formally adopted into forest management plans in 2006, public visitation on federal lands in the Greater Yellowstone Ecosystem has increased dramatically. In Yellowstone National Park alone, annual visitor numbers increased by more than 40 percent from 2008 to 2018, surpassing 4 million visitors annually since 2016 (National Parks Website). Three of the five entrances to Yellowstone National Park are accessed from the Custer Gallatin National Forest, which influences visitor use on the national forest. Existing habitat standards in the conservation strategy lack flexibility to allow land management agencies to respond adequately to these extraordinary increases of human presence in areas occupied by grizzly bears. As a result of this administrative challenge, federal land managers from the Yellowstone Ecosystem Subcommittee of the Interagency Grizzly Bear Committee expressed the need to re-evaluate existing habitat standards in the conservation strategy, particularly how secure habitat and developed sites are measured, monitored, and restricted (Landenburger 2019 *in (van Manen et al. 2019)*).

The "Footprint" Approach to Developed Sites – Impacts to Secure Habitat

The 2016 edition of the conservation strategy acknowledged Yellowstone Ecosystem Subcommittee managers' concerns by proposing an interagency review of the 1998 baseline for developed sites, to identify possible solutions for visitor overflow at existing sites in a manner that does not threaten grizzly bear habitat, and results in minimal departure from the 1998 baseline (Yellowstone Ecosystem Subcommittee 2016a). As a result, the Interagency Developed Sites Technical Team (Tech Team) was established and tasked with examining alternative scenarios and recommending appropriate changes to the habitat standards and application rules in the conservation strategy that would provide added management flexibility to address demands associated with increased public visitation and aging infrastructure. Constraints were imposed on the Tech Team to strike a balance between management needs for accommodating public access and use with habitat protection, while making every attempt to remain true to the original intent of the habitat standards in the conservation strategy relative to the 1998 baseline (Landenburger 2019 in *(van Manen et al. 2019)*). A primary recommendation from the Tech Team was to change the methods for measuring and tracking developed sites within the grizzly bear recovery zone, which led to what is referred to as the "footprint" approach. This new approach changes how larger developed sites are delineated and categorized, and also accounts for measurable impacts on secure grizzly bear habitat due to areas of concentrated human use (Developed Site Technical Team 2019). Different categories of developed sites are discussed further relative to the developed site standard. Here, the intent is to acknowledge the full influence of developed sites on secure habitat for bears.

To accurately reflect human influence associated with developed sites, spatially explicit data pertaining to site infrastructure and motorized access to this infrastructure, was thoroughly reviewed for accuracy. The Greater Yellowstone Ecosystem grizzly bear motorized access GIS database was a crucial part of this review, and in some areas, it was discovered that the database lacked detail, such as small road segments that provide access to individual structures at a given developed site. In such instances, more spatially accurate data were integrated into the motorized access database. Through this review, the accuracy of linear features (roads and trails) in the database was also compared with current and historical aerial photo imagery, with special attention focused near developed sites identified for the footprint approach. Digital motorized route features were spatially aligned where needed to accurately represent georeferenced photo imagery, and routes determined to exist in 1998, but not previously captured in the access database were added. In previous (up through 2016) versions of the conservation strategy, secure habitat was based solely on proximity to motorized routes. The Tech Team recommendations include revising the definition for secure habitat as "any contiguous area greater than or equal to 10 acres in size and greater than 500 meters from an open or gated motorized route, recurring low level helicopter flight line, or perimeter of a prescribed developed site footprint" (Yellowstone Ecosystem Subcommittee 2016a).

To account for the revised definition of secure habitat, prescribed footprints around selected developed sites are now buffered by an additional 500 meters (approximately one-third mile) and the entire area, including the footprint and associated buffer, are subtracted from secure habitat. As a result of this new methodology for measuring impacts of larger developed areas on grizzly bears, and also partly due to improved accuracy of the motorized access database associated with developed sites and surrounding areas, the 1998 baseline, and current values for secure habitat in the Greater Yellowstone Ecosystem have now changed slightly. Across the Greater Yellowstone Ecosystem, the collective results of improving the accuracy of linear features and subtracting secure habitat within developed site footprints and associated buffers have reduced 1998 baseline secure habitat values in some bear management subunits by up to one percent. The relatively minor change in secure habitat is due to the fact that most of the area delineated by the 500-meter buffer around a developed site footprint was previously captured (in other words, detracted from secure habitat) by the 500-meter buffer associated with motorized access routes, both within and outside the developed site footprint (Yellowstone Ecosystem Subcommittee 2016a). Changes in secure habitat for subunits intersecting the Custer Gallatin range from a 0.4 percent reduction to a 0.1 percent increase, with a number of subunits showing no change due to the new method. Reductions in secure habitat are due to the new footprint around some developed sites, improved accuracy (additions) of linear routes, or a combination thereof, whereas the single increase in secure habitat is due to improved accuracy of the linear routes present in 1998. Table 68 shows differences in 1998 baseline secure habitat using the traditional method and the new footprint approach. The table also shows new calculations for full travel plan implementation secure habitat in bear management subunits that intersect the Custer Gallatin National Forest. These new calculations change the (Gallatin travel plan*) baselines for subunits in need of improvement (relative to 1998), by using the footprint approach.

Table 68. Secure habitat value changes due to footprint approach for developed sites

Bear Management Unit Subunit Name	1998 Baseline % Secure: Pre-revision	1998 Baseline % Secure: Post-revision	1998 Baseline % Secure: % Change	Full Travel Plan Implementation % Secure: Post-revision	Full Travel Plan Implementation % Secure: % change from new 1998 baseline
Boulder/Slough #1	96.6	96.5	-0.1	96.6	+0.1
Boulder/Slough #2	97.7	97.6	-0.1	97.6	0.0
Crandall/Sunlight #1	81.1	81.0	-0.1	81.7	+0.7
Crandall/Sunlight #2	82.3	82.3	0.0	82.7	+0.4
Gallatin #3*	55.3	55.1	-0.2	71.1*	+16.0
Hellroaring/Bear #1	77.0	76.6	-0.4	80.3	+3.7
Hellroaring/Bear #2	99.5	99.5	0.0	99.6	+0.1
Henrys Lake #2*	45.7	45.6	-0.1	52.0*	+6.4
Hilgard #1	69.8	69.5	-0.3	80.5	+11.0
Hilgard #2	71.4	71.5	+0.1	80.1	+8.6
Lamar #1	89.2	89.0	-0.2	89.5	+0.5
Madison #1	71.5	71.5	0.0	80.6	+9.1
Madison #2*	66.5	66.3	-0.2	67.4*	+1.1
Plateau #1	68.8	68.6	-0.2	70.6	+2.0

Source: (Landenburger 2019), unpublished.

*New baseline adopted at full implementation of the Gallatin Forest Travel Management Plan.

Grizzly bears are known to frequent suitable habitat outside the recovery zone as well. Areas outside the recovery zone are important to bears in that they allow for population expansion, and provide additional habitat for ecological resiliency, which presents options for grizzly bear responses to changing environmental conditions. Outside the recovery zone, secure habitat is monitored by bear analysis units and reported every 2 years in even years, so 2018 is the most current year reported. Unlike bear management units, the bear analysis units on the Custer Gallatin are wholly within the national forest boundary (in other words, not shared with other administrative units). The footprint approach to tracking larger developed sites does not affect secure habitat outside the recovery zone. In 2018, secure habitat outside the recovery zone averaged about 65 percent across the entire Greater Yellowstone Ecosystem (Landenburger *in (van Manen et al. 2019)*). This amount indicates about a 2 percent increase in secure habitat outside the recovery zone since 2008, which is the first year there was a reliable dataset for motorized access outside the recovery zone (Landenburger *in (van Manen et al. 2019)*). Accuracy of road and trail data improved during this time on the Custer Gallatin, due to a comprehensive review associated with travel management planning. By comparison, secure habitat averaged about 71 percent across all bear analysis units on the national forest in 2018 (Landenburger 2019) (Landenburger *in (van Manen et al. 2019)*), which is about a 5 percent increase since 2008. Figure 24 shows the location of bear analysis units in the Greater Yellowstone Ecosystem, and table 69 shows secure habitat for each Custer Gallatin bear analysis unit for the years 2008 and 2018.

Table 69. Secure habitat in Custer Gallatin National Forest bear analysis units in 2008 and 2018

Bear Analysis Unit	Revised Plan Geographic Area	Square Miles	Percentage Secure 2008	Percentage Secure 2018	Change
Boulder	Absaroka Beartooth Mountains	278	64.8	69.7	+4.9
Bozeman	Madison, Henrys Lake, and Gallatin Mountains	271	45.6	59.3	+13.7
Bridger	Bridger, Bangtail, and Crazy Mountains	236	28.3	38.4	+10.1
Cooke City	Absaroka Beartooth Mountains	69	99.6	99.6	0.0
Crazy	Bridger, Bangtail, and Crazy Mountains	255	57.2	67.9	+10.7
Gallatin	Madison, Henrys Lake, and Gallatin Mountains	415	52.3	59.6	+7.3
Mill Creek	Absaroka Beartooth Mountains	312	82.3	83.8	+1.5
Pryor Mountains	Pryor Mountains	122	38.8	38.8	0.0
Quake Lake	Madison, Henrys Lake, and Gallatin Mountains	66	85.0	92.1	+7.1
Rock Creek	Absaroka Beartooth Mountains	237	83.8	83.8	0.0
Stillwater	Absaroka Beartooth Mountains	405	85.3	85.5	+0.2
Total	**Montane Ecosystem**	**2,666**	**65.7**	**70.8**	**+5.1**

Prior to combining, both the Custer and Gallatin national forests went through comprehensive travel management planning processes that examined all forms of travel (public and administrative use) and included consideration of future needs for travel infrastructure. Roads and trails, both inside and outside of the recovery zone, are subject to direction contained in the 2006 Gallatin Forest Travel Management Plan and the 2008 Beartooth Ranger District Travel Management Plan. Increases in secure habitat over time, both within and outside the recovery zone (as shown in table 67 and table 68), are largely due to implementation of these travel management plans.

Bear management subunits and bear analysis units provide appropriate scales of analysis for project-level effects, and have informed the analysis of programmatic direction prescribed in the revised plan. Additionally, management plan geographic areas represent portions of the Custer Gallatin that have unique ecological characteristics, and are places with which visitors are familiar and can easily identify. Grizzly bears are present in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, and these geographic areas are basically coincident with the current distribution area for grizzly bears on the national forest. The Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas contain suitable habitat, are within the demographic monitoring area for Yellowstone grizzly bears, and contain portions of the recovery zone. The Bridger, Bangtail, and Crazy Mountains Geographic Area is not currently occupied by grizzlies, and is outside of the Greater Yellowstone Ecosystem grizzly bear distinct population segment (U.S. Department of the Interior 2016b). However, the Bridger, Bangtail, and Crazy Mountains Geographic Area has good potential to provide habitat connectivity for grizzly bears to move between the Greater Yellowstone Ecosystem and the Northern Continental Divide Ecosystem. Grizzly bears are present today in these three geographic areas, where they have the best opportunities for reproduction and survival in the future, and where they may find habitat connectivity suitable for movement between existing grizzly bear ecosystems to promote genetic diversity. Currently, these geographic areas average about 74 percent secure habitat. Table 70 and figure 28 show proportions and distribution of secure habitat for grizzly bears by geographic area.

Table 70. Secure habitat for grizzly bears in Custer Gallatin montane geographic areas

Geographic Area	**Size in Square Miles**	**Percentage Secure as of 2019**
Absaroka Beartooth Mountains	2,167	86.2
Madison, Henrys Lake, and Gallatin Mountains	1,488	62.2
Bridger, Bangtail, and Crazy Mountains	491	53.7
Total (geographic areas combined)	**4,146**	**73.8**

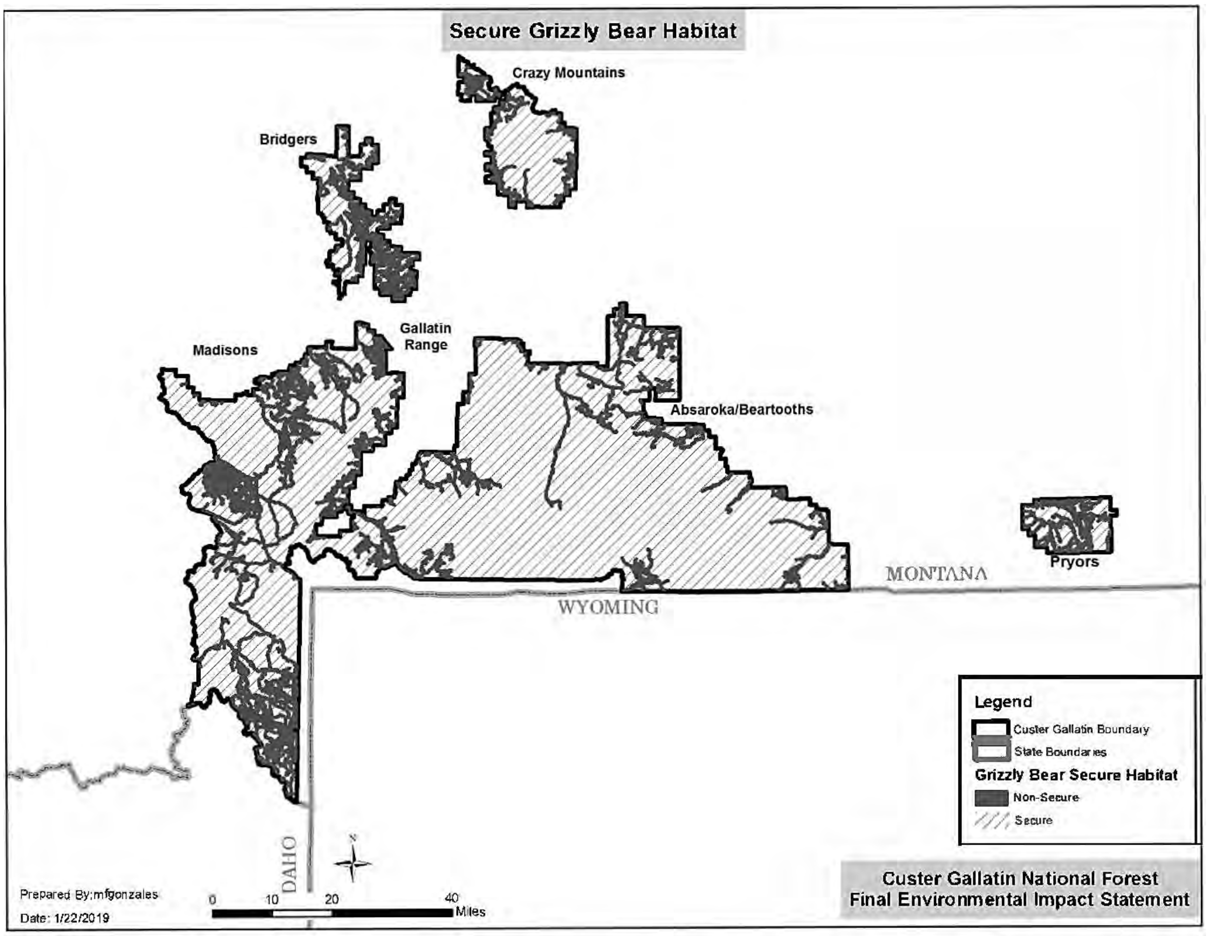

Figure 28. Grizzly bear secure habitat on the Custer Gallatin National Forest

In addition to secure habitat related to motorized human access, the other major human activities that affect grizzly bears and their habitat include permanent developments (aside from roads and trails) and domestic livestock grazing. These types of land uses have historically been associated with human-bear conflicts that result in grizzly bear mortalities, primarily due to the presence of attractants such as human food, pet food, livestock feed, garbage, animals or carcasses that draw bears into areas or situations where they are removed either through management actions or defense of life or property. All geographic areas within the montane ecosystem are under a special order that requires food and other human-related attractants to be stored so that they are unavailable to bears.

As with secure habitat, the year 1998 is used as a baseline for monitoring the number, distribution, and impacts associated with developed sites inside the recovery zone. Developed sites include areas on National Forest System lands that have permanent structures and facilities intended to accommodate public recreational use or administrative needs. Examples include, but are not limited to campgrounds, picnic areas, trailheads, recreational residences, and rental cabins. As mentioned previously, visitor use in the Greater Yellowstone Ecosystem (including areas of the Custer Gallatin) has increased dramatically since 1998, resulting in increased demand for developed site facilities and a subsequent request from the Yellowstone Ecosystem Subcommittee to re-evaluate how larger developed sites in the Greater Yellowstone Ecosystem are measured and tracked over time for changes relative to 1998 (Pederson et al. 2010). An Interagency Developed Sites Technical Team (Tech Team) was appointed by the Yellowstone

Ecosystem Subcommittee to examine the issue and make recommendations for changes back to the subcommittee. The processes employed by the Tech Team and resulting recommendations for changes were documented in a technical report (Landenburger 2019). Once the subcommittee approves the recommendations, the new approach for managing developed sites and monitoring associated impacts on grizzly bear habitat will be officially incorporated into the conservation strategy, with the technical report (Landenburger *in (van Manen et al. 2019)*) included as an appendix.

At the request of the Yellowstone Ecosystem Subcommittee, the Tech Team recommended using a "footprint approach" for delineating areas around larger developed sites inside the recovery zone, typically encapsulating all motorized access routes to, from, and within the developed areas, as well as other associated infrastructure (such as buildings, utilities, etc.). As described previously, the entire footprint was then buffered by 500 meters to capture the zone of influence associated with human use, and the entire acreage was detracted from secure habitat. Developed sites that warrant the footprint approach include extensively developed areas with permanent infrastructure designed to accommodate relatively high levels of concentrated public and/or administrative use, as well as areas identified by Greater Yellowstone Ecosystem managers as having the greatest need for added infrastructure to address the administrative difficulties resulting from increased, and often uncontrolled visitor use on public lands (Landenburger 2019). The Tech Team identified four different categories for prescribed footprints:

1. **Administrative** facilities used primarily by government employees and/or authorized agents (such as contractors, permittees), for the purpose of managing public lands and associated resources.
2. **Visitor Overnight** sights comprised of multiple building units to accommodate commercial overnight visitor use, as authorized under special use permit.
3. Front country, developed **Campgrounds**, with road access and associated infrastructure; such as paved parking pads, picnic areas, fire grates, restrooms, etc.
4. **Major Developments** characterized by expansive commercial, residential, administrative, and recreational development located on national park lands, designed to host a complex combination of administrative and public use.

Of these categories of developed sites, the Custer Gallatin currently hosts 17 administrative sites, 16 front-country developed campgrounds, and 2 visitor overnight lodges that operate under special use permit. All of these developments were in place in 1998, and most were operating in a similar capacity as currently. The two exceptions include the OTO administrative site and the Chief Joseph Campground (both in the Absaroka Beartooth Mountains Geographic Area). The Forest Service acquired the OTO Tract in 1991 as part of the Northern Yellowstone Winter Range Acquisition Project. Prior to that acquisition, the OTO was an historic, privately owned dude ranch dating back to the 1800s. From the time of Forest Service acquisition to the early 2000s, management activities at the OTO focused on historic preservation, but also provided administrative housing to agency personnel. Current use levels at the OTO are similar to those occurring during the preservation efforts, including approximately three weeks of overnight use and four weeks of day use in summer months, in addition to providing year-round housing for administrative personnel.

The Chief Joseph Campground was in place and operating at full capacity in 1998, but was closed in 2017, due in part to a grizzly bear mauling resulting in human fatality that occurred in the nearby Soda

Butte campground in 2010. Following this event, Custer Gallatin campgrounds in the vicinity were limited to hard-sided camping only. With this change, the campgrounds saw a decrease in use. The Chief Joseph campground was relatively small at just six sites, and costs associated with campground maintenance for this unit could no longer be justified. Finally, it should be noted that the Beaver Creek Campground (Madison 2) is almost entirely located outside the recovery zone, but a small part of the footprint and associated buffer now enter the recovery zone. Figure 29 shows locations of new footprints and primary roads on the Custer Gallatin National Forest inside the recovery zone.

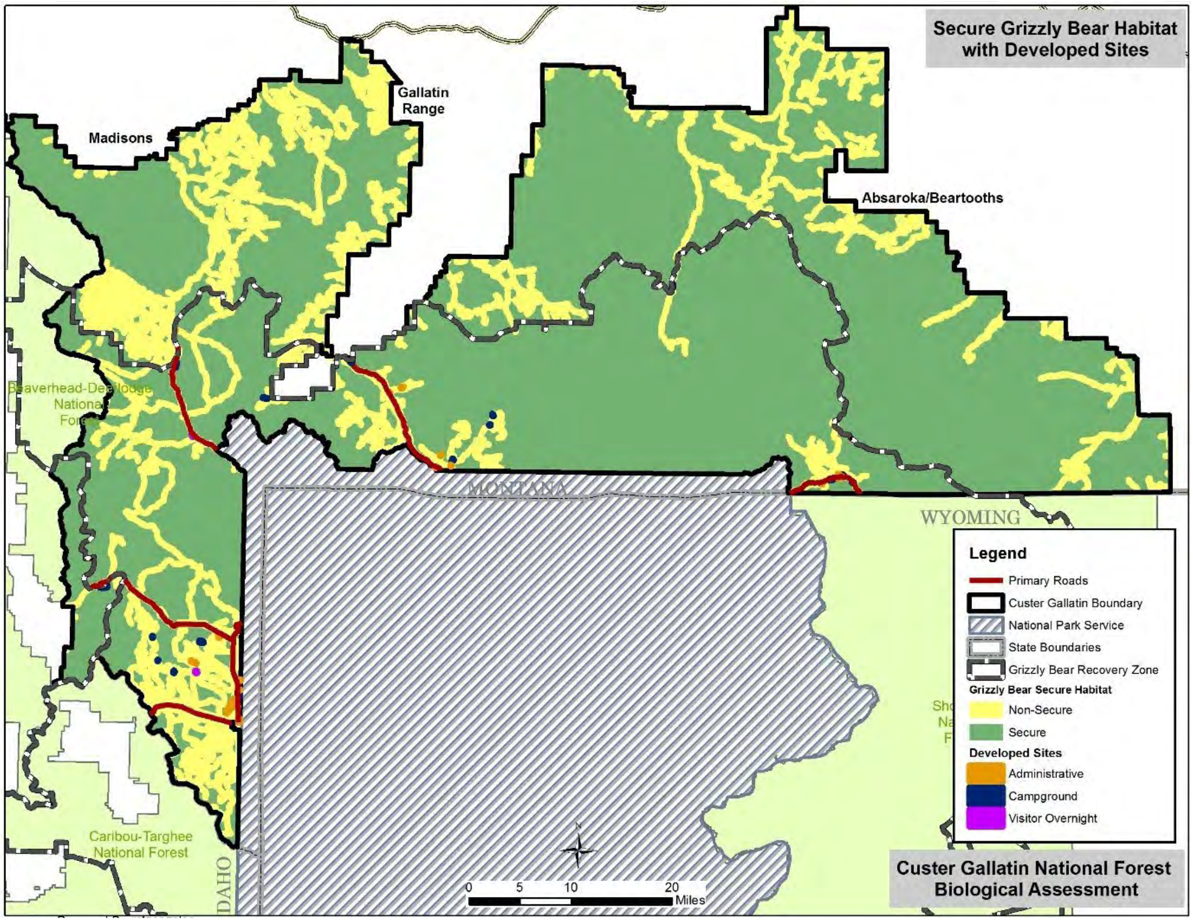

Figure 29. Secure habitat relative to motorized routes, developed site footprints, and primary roads

Smaller sites (for example, trailheads, backcountry cabins, etc.) are still treated as points rather than polygons, and do not detract from secure habitat other than the reduction associated with motorized access routes. The total number of developed sites, including both polygons (footprints) and points inside the recovery zone on the Custer Gallatin National Forest has dropped from 183 in 1998 to 177 in 2019 (van Manen et al. 2020). Developed sites were originally tracked at least in part, due to grizzly bear mortality risk associated with human foods and other attractants that can draw grizzly bears into conflict situations. There have been few human-caused grizzly bear mortalities associated with developed sites on the Custer Gallatin National Forest. The most recent occurred in 2010, when a food-conditioned female grizzly and three yearlings were removed after causing a human fatality and injuries at a developed campground. While mortalities are rare, a few bear-human conflicts (without injuries or fatalities to bears or humans) still occasionally occur at or near developed sites on the national forest. In

2021 a bear-human conflict on the Hebgen Lake District resulted in both a human fatality and bear removal.

Grazing of domestic livestock is another factor that can affect grizzly bears, in that grizzly bears are known to occasionally depredate on domestic grazing animals such as cattle or sheep. Such conflicts between grizzly bears and domestic livestock can result in the capture, relocation, injury, or removal of grizzly bears. Accordingly, the number and acreage of domestic livestock grazing allotments permitted within the grizzly bear recovery zone is tracked over time, as are grizzly bear conflicts with livestock on these allotments, including the outcome; such as, whether the conflict resulted in mortality of the bear (van Manen et al. 2020).

The Custer Gallatin National Forest contains 214 active livestock grazing allotments with an additional 19 vacant allotments. These allotments support approximately 36,200 head of cattle, 550 horses, and 400 domestic bison that are permitted to graze at various times throughout the year, for a total of 204,914 animal unit months on National Forest System lands. The majority of permitted livestock grazing (57 percent of permittees and 80 percent of animal unit months) occurs in the Ashland and Sioux Geographic Areas of the pine savanna ecosystem of the national forest, where grizzly bears are neither known, nor suspected to occur. In the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas combined, where grizzly bears are known to occur, there are currently 64 active and 18 vacant livestock grazing allotments. Of those, 14 active and 5 vacant allotments are located within the grizzly bear recovery zone.

The total number of domestic livestock allotments on the Custer Gallatin inside the recovery zone has declined from 39 in 1998 to 19 (14 active and 5 vacant) in 2019, and total acreage used by permitted livestock has declined by more than 70 percent. In 1998, active and vacant livestock allotments were present on more than 26 percent of the area inside the recovery zone. By contrast, active and vacant allotments currently occur on 7 percent of the area inside the recovery zone. This reduction included the permanent elimination of two active and four vacant sheep allotments. Outside the recovery zone, active and vacant livestock allotments are present on about 19 percent of the area within the current distribution of grizzly bears on the Custer Gallatin. There are currently no sheep grazing allotments on the Custer Gallatin National Forest, inside or outside the recovery zone. Table 71 shows numbers and acreage of permitted livestock grazing allotments in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, where grizzly bears are known to occur.

Table 71. Number, acreage, and types of permitted livestock grazing allotments

Allotment Type	**Inside Recovery Zone**[1] 1998 Number (Acres)	**Inside Recovery Zone**[1] 2019 Number (Acres)	**Outside Recovery Zone 2019 Number (Acres)**
Active Cattle and Horse	23 (91,157)	14 (57,252)	50 (221,991)
Vacant Cattle and Horse	10 (46,422)	5 (17,040)	13 (30,725)
Active Sheep	2 (91,570)	0 (0)	0 (0)
Vacant Sheep	4 (42,716)	0 (0)	0 (0)
Totals	**39 (271,865)**	**19 (74,292)**	**63 (252,716)**

1. Numbers inside recovery zone from van Manen et al. (2020) acres inside recovery zone calculated by Lisa Landenburger 2019.

There have been a few livestock (cattle) depredations attributed to grizzly bears on the Custer Gallatin in recent years. Depredations occurred in 2016 and 2017 on the Wigwam allotment located north of Yellowstone National Park. These were isolated incidents that neither led to recurring conflicts (defined as having occurred in three out of five preceding years), nor resulted in grizzly bear mortalities (van Manen et al. 2018). There were no grizzly bear-livestock conflicts reported on any Custer Gallatin grazing allotments in 2019 (van Manen et al. 2020).

A special order requiring the proper storage of food and attractants has been in place on the national forest within the recovery zone since the mid-1980s. The food storage order was expanded to cover the entire montane ecosystem of the forest in 2007, and now covers an area substantially beyond the current known grizzly bear distribution on the Custer Gallatin. Food and attractants include human food, pet food, livestock feed, scented personal hygiene products, and animal carcasses of domestic livestock or human-killed fish and wildlife. The food storage order requires that all such substances, when not attended, must be acceptably stored by a variety of means, so that they are made unavailable to bears. In the case of animal carcasses, such bear attractants must be an acceptable distance from camping and sleeping areas and National Forest System trails. This mechanism for improving human sanitation and reducing availability of unnatural foods for bears, combined with maintaining or increasing secure habitat and maintaining or reducing developed sites and livestock grazing allotments have worked collectively to allow for grizzly bear expansion into suitable habitats and reduced potential for human-caused grizzly bear mortality on the Custer Gallatin National Forest over time.

In the Montana portion of the Greater Yellowstone Ecosystem, which includes the Custer Gallatin, Frey and Smith (*in (van Manen et al. 2019)*) noted that sanitation efforts (including the food storage order) combined with information and education have helped reduce incidents of bears obtaining human-related foods, thereby reducing the need for management actions that result in relocation or removal of grizzly bears. Even so, these authors reported a 20 percent increase in grizzly bear-human conflicts in the Montana portion of the Greater Yellowstone Ecosystem during the most recent decade (2009–2018) compared to the previous decade (1999–2008), but attributed this increase to the growing grizzly bear population and expanding distribution combined with a growing human population and associated increase in human activity in the grizzly bear distribution area. Grizzly bear-human conflicts on the Custer Gallatin have followed similar trends.

While the number of grizzly bear-human conflicts in the Montana portion of the Greater Yellowstone Ecosystem has increased over time, the long-term grizzly bear mortality trend due to human causes has remained relatively stable, with an average (known or probable) loss of 5.4 grizzly bears per year. Although the numbers of human-caused grizzly bear deaths have remained fairly constant, the causes and locations of grizzly bear mortalities have changed over time. Grizzly bear mortalities during the first decade of the 21st century were primarily associated with bears seeking or obtaining unnatural foods from human sources on public and private lands. Human-caused grizzly bear mortalities in the past decade have been primarily related to front and backcountry surprise encounters, mainly on public lands, as well as livestock depredations occurring on private and public lands, many of which occurred outside the demographic monitoring area for Greater Yellowstone Ecosystem grizzly bears Frey and Smith cited in *(van Manen et al. 2019)*.

The number of known and probable human-caused grizzly bear mortalities on the Custer Gallatin has also remained fairly constant over time, averaging about two per year, which is roughly 37 percent of the average annual human-caused grizzly bear mortalities in the Montana portion of the Greater

Yellowstone Ecosystem demographic monitoring area. However, the Custer Gallatin administers nearly 62 percent of the land within that same area. As with other areas of the Greater Yellowstone Ecosystem, a change in cause of grizzly bear mortalities has been evident on the Custer Gallatin. Whereas human-caused mortalities early in the 21st century were primarily associated with grizzly bear attraction to anthropogenic food sources, within the past decade, grizzly bear mortalities on the Custer Gallatin have been primarily associated with backcountry encounters with hunters, either through mistaken identity by black bear hunters, or more frequently, by big game hunters defending themselves during encounters with grizzly bears.

The distinct population segment for the Greater Yellowstone Ecosystem grizzly population is all south of Interstate 90, and no grizzly bears from the Greater Yellowstone Ecosystem have been documented north of Interstate 90 in many years. DNA analyses have concluded that the Greater Yellowstone Ecosystem grizzly bear population is genetically isolated from other grizzly bears (U.S. Department of the Interior 2017b). However, the Greater Yellowstone Ecosystem population has been increasing, and has surpassed the estimated effective population size (500 animals) to avoid inbreeding depression, greatly reducing the concern for genetic health of the population (Kamath et al. 2015). Genetic interchange between the Greater Yellowstone Ecosystem and other grizzly populations is desirable as it would increase genetic diversity and be beneficial to long-term persistence of affected populations (U.S. Department of the Interior 2017b). The Greater Yellowstone Ecosystem is the southernmost, and one of the largest grizzly bear populations remaining in the continental United States. The other large grizzly bear population in the lower 48 states, and the closest to the Greater Yellowstone Ecosystem, is the Northern Continental Divide Ecosystem, the core of which is located in northwestern Montana. The Northern Continental Divide Ecosystem population is not only important because of its size and proximity to the Greater Yellowstone Ecosystem, but also because it is contiguous with grizzly bear populations in Canada, which enhances the genetic diversity of the population.

Since the Custer Gallatin covers much of the northern portion of the Greater Yellowstone Ecosystem for grizzly bears, it is important in terms of providing habitat connectivity to facilitate grizzly bear movement between the Greater Yellowstone Ecosystem and other grizzly bear ecosystems to the north, to promote genetic connectivity among grizzly bear populations in the continental United States. The Bridger, Bangtail, and Crazy Mountains Geographic Area, which is currently unoccupied by grizzly bears, has good potential to provide habitat connectivity for grizzly bear movement (Walker and Craighead 1997, Cushman et al. 2009, Peck et al. 2017). The Bridger and Bangtail mountain ranges are identified in the Northern Continental Divide Ecosystem Grizzly Bear Conservation Strategy (Northern Continental Divide Ecosystem Subcommittee 2018) as Management Zone 2, which indicates areas to be managed for opportunistic movement of grizzly bears between ecosystems. Notably, the Bridger and Bangtail Mountains are isolated ranges, separated from each other by Montana Highway 89, and separated from larger, contiguous mountainous and forested lands by Interstate 90, a number of state highways, and large areas of private land, which all affect connectivity. The Bridger Mountain range has generous patches of inventoried roadless areas, which provide secure habitat, as well as well as forage and cover options for bears. However, other than these inventoried roadless areas and a 3,300-acre special area in the Bangtails, there are currently no other designations or land use allocations in the Bridger and Bangtail range that restrict management actions. As a result, outside of inventoried roadless areas, there are a number of areas where road densities exceed 2 miles per square mile in the Bridger and Bangtail range. Like the rest of the montane ecosystem, the entire Bridger, Bangtail, and Crazy Mountains Geographic Area is under a special order for attractant storage.

The Pryor Mountains Geographic Area is within the distinct population segment for the Greater Yellowstone Ecosystem grizzly bear population, but is not identified as suitable habitat for grizzly bears, due to the isolated nature of the geographic area. The Custer Gallatin has no documented occurrences of grizzly bears in the Pryor Mountains. The U.S. Fish and Wildlife Service considered the Bighorn Mountains in Wyoming, just south of the Pryor Mountains, for habitat suitability. Since the range is separated from the current grizzly bear distribution by a distance greater than the average dispersal for both male and female grizzlies, immigration potential from occupied areas is limited. As such, isolated ranges such as the Bighorns are likely not capable of supporting a self-sustaining grizzly bear population, and were therefore excluded from suitable habitat within the Greater Yellowstone Ecosystem distinct population segment for grizzly bears (U.S. Department of the Interior 2017b). While the U.S. Fish and Wildlife Service did not specifically address the Pryor Mountains, the same logic applies; because the Pryor Mountains are separated by a greater distance, smaller in size, and have less total secure habitat than the Bridger Mountain range, the Pryor Mountains Geographic Area does not provide good potential habitat connectivity for grizzly bear dispersal.

Key Stressors

Interactions with people are by far the leading factors affecting the Greater Yellowstone Ecosystem grizzly bear populations (U.S. Department of Agriculture 2006b, Schwartz et al. 2010), including those bears that inhabit, or pass through the Custer Gallatin National Forest.

Motorized access routes (roads and trails) detract from secure habitat.

Permitted livestock grazing allotments contain live animals, livestock feed and supplements, and occasionally livestock carcasses that may attract grizzly bears into potential conflict situations with people.

Developed sites provide places for people to concentrate use, which can contribute disturbance factors that may displace wary bears, while at the same time often provide facilities for storing, preparing and eating food, or disposing of garbage, which may act as attractants for less wary bears.

Availability of secure habitat, key natural food sources, and human-related attractants, can influence grizzly bear survival, reproductive success, and distribution.

Environmental Consequences

Management Direction under the Current Plans

Both of the current plans contain goals to provide habitat that contributes to the recovery of threatened species.

The Gallatin Plan, which dictates management for the majority of grizzly bear habitat on the Custer Gallatin National Forest, was amended in 2015 (Amendment 51) to update management direction for grizzly bear habitat by formally adopting habitat management recommendations from the Greater Yellowstone Ecosystem Grizzly Bear Conservation Strategy, which are consistent with the habitat-based recovery criteria in the Grizzly Bear Recovery Plan (Servheen 2007, U.S. Department of the Interior 2013d) Accordingly, the Gallatin Plan includes direction for retaining secure habitat over the long term within the recovery zone or primary conservation area, including a measure that increased the baseline for secure habitat in three bear management subunits that were identified as needing improvement over the 1998 baseline. For these three subunits (Gallatin 3, Henrys Lake 2, and Madison 2), the new baseline for secure habitat became the level achieved with full implementation of the 2006 Gallatin Travel Management Plan. Implementation of the travel plan has resulted in notable increases in secure habitat for those subunits (table 67). Secure habitat is measured as a proportion of a bear management subunit (inside the recovery zone). Consistent with the conservation strategy, the current Gallatin Plan would allow for permanent changes in configuration of secure habitat inside the recovery zone, but losses of secure habitat due to new motorized routes must be replaced by restoring secure habitat (closing motorized routes) elsewhere in the same bear management subunit or in the nearest subunit possible. Temporary reductions in secure habitat below the appropriate baseline are allowed for administrative purposes, but are not to exceed 1 percent of the total acreage of the largest subunit within the affected bear management unit.

The Gallatin Plan requires management of developed sites and permitted livestock grazing within the grizzly bear recovery zone or primary conservation area at or below numbers and capacity available in 1998. No vacant or closed sheep grazing allotments would be reactivated, nor would existing cattle or horse allotments be converted to allow sheep. In addition, the Gallatin Plan (as amended 2015) adopted monitoring requirements from the Greater Yellowstone Ecosystem Grizzly Bear Conservation Strategy. There are currently no standards or guidelines that apply specifically to grizzly bear habitat management outside the recovery zone. However, the 2006 Gallatin Forest Travel Management Plan provides direction pertaining to access management, both within and outside the recovery zone, which affects secure habitat. In addition, the travel plan acknowledges the importance of travel corridors for wildlife by including forestwide and area-specific goals and objectives for managing access to provide habitat connectivity consistent with wildlife movement patterns.

The Custer Plan contains broad direction to coordinate land management uses with grizzly bear habitat needs to avoid conflicts. Most of the standards for managing land uses consistent with grizzly bear habitat conservation specify that activities are to follow direction contained in the publication "Guidelines for Managing Grizzly Bears in the Greater Yellowstone Area" and cite to a 1979 Forest Service publication. This document delineated grizzly habitat by "management situation" areas. Custer Plan direction applies to grizzly bear management situation 1 and 2, which is the same geographic area as the recovery zone. The Custer Plan was amended in 2006 (Amendment 42), to formally adopt the habitat standards from the Greater Yellowstone Ecosystem Grizzly Bear Conservation Strategy, anticipating delisting of the Greater Yellowstone Ecosystem grizzly bear population in 2007. However, the language in the amendment specified that the direction apply to a delisted population of grizzly bears. Amendment 42 remains in the Custer Plan since it was never removed, but since the Greater Yellowstone Ecosystem grizzly population returned to threatened status after a 2018 court ruling, Amendment 42 technically does not apply so long as the bear remains federally listed. Therefore, the Custer portion of the Custer Gallatin National Forest reverts to plan direction in place prior to Amendment 42. The Custer Plan does not contain direction specific to grizzly bear habitat management outside of the recovery zone, but like the Gallatin Plan, the 2008 Beartooth Ranger District Travel Management Plan provides direction pertaining to motorized access management, which affects secure habitat both within and outside the recovery zone.

The Gallatin Plan (as amended) emphasizes retention of mature and overmature (cone-producing) whitebark pine within the grizzly bear recovery zone; however, the Custer Plan contains no specific direction for whitebark pine. Both plans contain considerable direction for management of big game habitat, which is important for providing ungulate biomass for grizzly bears. Existing plan direction covers topics such as protection of big game winter ranges and calving areas, as well as providing hiding cover, security areas, and forage. Neither plan contains specific direction for management of bison, which are an important food source for grizzly bears in Yellowstone National Park, and may become more important on the Custer Gallatin as bison expand onto the national forest.

Effects of the Current Plans

Under the current plans, the Gallatin portion of the grizzly bear recovery zone would continue under plan direction that formally adopted habitat standards and monitoring items from the Greater Yellowstone Ecosystem Grizzly Bear Conservation Strategy regardless of the federal status of the bear. Since the Custer Plan amendment that incorporates habitat standards from the conservation strategy would not apply so long as the bear remains listed, the Custer portion of the national forest would remain under original plan language for grizzly bears. However, nearly all (more than 96 percent) of the Custer portion of the grizzly bear recovery zone is within the Absaroka-Beartooth Wilderness Area, and is managed under the mandates of the Wilderness Act. Therefore, under current plans, the portion of the Custer Gallatin National Forest inside the grizzly bear recovery zone would be managed in line with the intent of the grizzly bear conservation strategy to maintain secure habitat, developed sites, and domestic livestock grazing at or above the levels in place in 1998.

Under the current Gallatin Plan, secure habitat inside the recovery zone would be maintained at or above the proportions available in 1998 with new baselines adopted for the Gallatin 3, Henrys Lake 2 and Madison 2 bear management subunits. The new baselines reflect increases in secure habitat of 15, 6, and 1 percent for these subunits respectively (table 67). Aside from these three subunits, secure habitat has increased over 1998 baseline levels in nine other subunits on the Gallatin portion of the national forest (table 67). Under current plan direction, management actions could be implemented that would reduce secure habitat back to 1998 levels in these subunits, and it is likely that large, localized reductions in secure habitat could have negative impacts on individual bears living in those areas.

Under the current plans, the number and capacity of developed sites and livestock grazing allotments inside the recovery zone would remain at or below levels that occurred in 1998. Since there have been slight reductions in developed sites and grazing allotments, slight increases could occur under the current plan and still be within the constraints of plan direction. Increases in developed sites or livestock grazing allotments could have negative impacts on individual bears, but impacts would be mitigated by proper food and attractant storage measures. No new domestic sheep grazing allotments would be authorized inside the recovery zone under current plans. While habitat conditions could revert to 1998 baseline conditions where some improvements have been made, the current best science indicates that conditions in 1998 provided adequate conditions inside the recovery zone to support and conserve a healthy grizzly bear population (Servheen 2007, U.S. Department of the Interior 2017b). Therefore, remaining habitat on the Custer Gallatin would still contribute to grizzly bear recovery.

Outside the recovery zone, neither the Custer nor the Gallatin current plans contain specific direction for grizzly bear habitat. However, roughly 77 percent of the National Forest System lands outside the recovery zone but within the grizzly bear distribution area is within designated wilderness, the wilderness study area, or inventoried roadless areas, which come with land use restrictions that would maintain secure habitat to a large degree, and influence the potential for new developed sites and grazing allotments. Both the Custer and Gallatin portions of the grizzly bear distribution area (inside and outside the recovery zone) are under travel management plans that dictate how motorized routes (roads and trails) are managed, which influences secure habitat. Since these travel plans were completed, secure habitat outside the recovery zone has improved in nine of the eleven bear analysis units monitored, and has stayed constant in the other two. Given the substantial amounts of designated wilderness, wilderness study area, and inventoried roadless area outside the recovery zone, combined with motorized access restrictions contained in the travel management plans, secure habitat, developed sites and livestock allotments outside the recovery zone within the grizzly bear distribution area would stay relatively stable, but may see minor increases or decreases under the current plans.

Under current management direction for big game habitat, elk herds have fluctuated, but are currently largely within or over state population objectives, both in areas known to have grizzlies present as well as areas where grizzly bear dispersal is possible. Given this trend, it is expected that the Custer Gallatin would continue to provide ungulate biomass for grizzly bears under the current plans. Neither current plan specifically addresses habitat management for bison, but bison are expected to continue to migrate onto the national forest during severe winters consistent with current trends.

The Gallatin Plan (as amended) includes direction for vegetation management inside the recovery zone to retain over-mature forest structure, with whitebark pine emphasized. The Custer Plan contains no specific direction for whitebark pine management; however, management actions would have little or no effect on whitebark pine in designated wilderness, which corresponds with the recovery zone on the Custer part of the national forest. There is recent evidence to suggest that whitebark pine mortality may be declining in the Greater Yellowstone Ecosystem (Schwartz et al. 2014). Natural waning of the mountain pine beetle epidemic, coupled with the current direction for retaining mature whitebark pine and the underlying wilderness designations on the Custer Gallatin, would promote persistence of whitebark pine inside the recovery zone under the current plans. Therefore, whitebark pine would continue to provide a key food source for grizzly bears on the Custer Gallatin National Forest.

Consistent with grizzly bear recovery goals stated in both current plans, food storage orders were established in grizzly bear use areas on both forests in the mid-1980s. Over time, the food storage orders have expanded geographically in pace with grizzly bear distribution expansion on both national forests, and now cover all geographic areas in the montane ecosystem of the combined forests, which is substantially beyond current grizzly bear distribution. While there are no specific mechanisms in either current plan to ensure continued implementation of food storage orders, considerable effort has gone into developing, implementing, educating the public, and enforcing the current food storage regulations in a consistent manner across the Greater Yellowstone Ecosystem, so it is reasonable to expect that these efforts would continue under current plans.

Monitoring items were adopted from the conservation strategy into the Gallatin Plan (as amended). Within the recovery zone, the amount of secure habitat, motorized access route densities, number and capacity of developed sites, and livestock grazing allotments would continue to be monitored and reported annually. Outside the recovery zone, changes in secure habitat would be monitored and reported bi-annually. In addition, the Custer Gallatin would continue to track all grizzly bear-human conflicts within and outside the recovery zone, and evaluate livestock allotments for recurring conflicts with grizzly bears. Finally, the Custer Gallatin would assist with Greater Yellowstone Ecosystem monitoring of key grizzly bear food items as needed. Continuing these monitoring items would allow the Custer Gallatin National Forest employees to evaluate the effectiveness of plan direction, and if need be, respond to demonstrated issues in grizzly bear habitat in cooperation with other agencies.

In summary, direction for managing grizzly bear habitat in current plans has facilitated growth in both numbers and distribution of bears within and outside of the recovery zone since the original plans were established. Secure habitat has increased considerably, while the number of developed sites and livestock allotments has declined slightly inside the recovery zone. Sheep grazing allotments were eliminated from the recovery zone, and a special order for proper storage of food and attractants has been in place within the grizzly bear distribution area and beyond. All of these factors have improved conditions for grizzly bears compared to the 1980s, when these plans were established. Accordingly, while there could be negative effects to individual bears, the Custer Gallatin would continue to contribute to grizzly bear recovery under the current plan direction.

Management Direction under the Revised Plan Alternatives

All revised plan alternatives include coarse filter plan components for habitat that contributes to species recovery (FW-DC-WL-02), and provide direction pertaining to composition, structure, landscape pattern and connectivity of vegetation and watersheds, with the intent to achieve conditions that are within the natural range of variation, providing for ecological integrity, diversity, function and resiliency of wildlife habitat (FW-DC-WL-03, plus DC/STD/GDL WTR, RMZ, PRISK, VEGF, VEGNF, CARB All). Additional coarse filter components for wildlife include desired conditions for habitat security and refuge to allow wildlife to escape from stresses and threats (FW-DC-WL-04), and that human-related foods and attractants are unavailable to wildlife (FW-DC-WL-08, FW-STD-WL-01). All revised plan alternatives include forestwide plan components for big game species (FW-DC/GO/GDL-WLBG/WLBI), which would influence ungulate biomass as an important food source for grizzly bears. Plan components for domestic livestock grazing allotments (FW-DC/GO/STD/GDL GRAZ) would influence the probability of grizzly bear loss due to livestock depredations. Plan land allocations for land uses such as recommended wilderness areas (FW-DC/STD/GDL/SUIT RWA All), backcountry areas (FW-DC/STD/GDL/SUIT BCA All) and recreation emphasis areas (FW-DC/GDL/SUIT REA All) would influence the types of management actions and public uses that would be allowed in grizzly bear habitat, both within and outside the recovery zone. Revised plan alternatives B, C, D, and F adopt plan land allocation and associated plan components for key linkage areas (FW-DC-WL-07; FW-STD-WL-02; FW-GDL-WL-02-05) that promote habitat connectivity for wide-ranging species, including grizzly bears, to facilitate dispersal between ecosystems.

In addition to coarse filter plan components, all revised plan alternatives would adopt fine-filter plan components from the Conservation Strategy for Grizzly Bears in the Greater Yellowstone Ecosystem (FW-DC/GO/STD/GDL/SUIT-WLGB All). These fine-filter components would be the same as grizzly bear direction currently incorporated into the Gallatin Plan and amended to, but not currently effective in, the Custer Plan, for alternatives B, C, D, and E, with slight revisions to the developed site standards proposed for the conservation strategy (FW-STD-WLGB-04 and 05) adopted in alternative F.

Effects of the Revised Plan Alternatives

All revised plan alternatives include a desired condition for habitat that contributes to threatened and endangered species recovery, and for stable to increasing population trends for listed species (FW-DC-WL-02). Specifically, revised plan alternatives state that grizzly bears, including reproductive females, are present and well distributed within the recovery zone, and that grizzly bears occur where habitat is biologically suitable and their presence is socially acceptable outside the recovery zone (FW-DC-WLGB-01, 02). Further, revised plan alternatives contain a desired condition that secure habitat outside the recovery zone contributes to habitat connectivity and facilitates grizzly bear movement between ecosystems (FW-DC-WLGB-02), with a goal to ultimately achieve successful dispersal of grizzly bears between ecosystems (FW-GO-WLGB-01). In addition to grizzly bear-specific plan components, the revised plan alternatives contain desired conditions for vegetative patterns that are generally within the natural range of variation to provide habitat diversity for assorted life cycle needs, as well as general conditions that provide security and refuge for wildlife to escape from all manner of stresses and threats (FW-DC-WL-03, 04). In that regard, the revised plan alternatives contain a desired condition that human-related foods and attractants are unavailable to wildlife, and associated conflicts are avoided (FW-DC-WL-08). These specific and detailed desired conditions in all revised plan alternatives reflect changing attitudes, circumstances, and environmental conditions, as well as increased grizzly bear numbers and distribution on the national forest, relative to current plans.

Desired conditions spelled out in the revised plan alternatives affirm the intent to proactively manage habitat and human activities to support continued grizzly bear persistence and potential expansion on the Custer Gallatin National Forest, while also providing for human safety. Revised plan components would ensure consideration of potential impacts to grizzly bears from management proposals both within and outside the recovery zone, and create a more cohesive vision of grizzly bear habitat needs across the entire Forest by formally incorporating concepts previously practiced under interagency agreements to meet the intent of the conservation strategy. The desired condition to provide habitat connectivity for grizzly bear movement between ecosystems is not a new concept in science, but fills a void in revised plan alternatives where current plans lacked specific direction.

Under all revised plan alternatives, the portion of the national forest within the grizzly bear recovery zone would be managed using concepts outlined in the Greater Yellowstone Ecosystem grizzly bear conservation strategy (Yellowstone Ecosystem Subcommittee 2016a). Plan components would apply equally to both the Custer and Gallatin portions of the national forest, bringing greater consistency to management of habitat within the Custer Gallatin, as well as ensuring consistency with grizzly bear habitat management on other public lands in the Greater Yellowstone Ecosystem. Habitat recommendations in the conservation strategy are based upon the best available scientific information specific to grizzly bear habitat management in the Greater Yellowstone Ecosystem. The revised plan alternatives formally adopt habitat management recommendations from the conservation strategy, with the overall intent to maintain or improve grizzly bear habitat inside the recovery zone relative to 1998 conditions so that human-related disturbances and bear mortalities can be limited, while maintaining options for resource management activities both inside and outside the recovery zone. Incorporating grizzly bear habitat and conflict monitoring items (MON-WL-03) would allow the Custer Gallatin National Forest, in cooperation with other agencies (FW-GO-WLGB-03, 04), to respond to demonstrated issues with appropriate management actions. This strategy is consistent with the Grizzly Bear Recovery Plan revised 1993 (U.S. Department of the Interior 1993), amended 2007 (Servheen 2007), which acknowledges that lands outside the recovery zone will be managed with more consideration for human uses.

Management practices outlined in the conservation strategy have been implemented under current plan direction to some degree, as well as under interagency agreements, with demonstrated effectiveness in reducing bear-human conflicts and allowing for expansion of grizzly bear distribution across the Custer Gallatin National Forest, both inside and outside the recovery zone. The conservation strategy focuses habitat management recommendations on addressing three primary threats to grizzly bears: availability of secure habitat, presence of domestic livestock, and human use associated with developed sites, as well as establishes monitoring protocols for primary food sources.

Secure Habitat

Under all alternatives, grizzly bear habitat standards (FW-GB-STD01-03) would maintain proportions of secure habitat inside the recovery zone at or above levels present in 1998 as revised by the “footprint approach," with increased baselines for the Gallatin 3, Madison 2, and Henrys Lake 2 bear management subunits, which were identified as in need of improvement from 1998 conditions in the conservation strategy. The new baseline for secure habitat in these three subunits was achieved largely through implementation of the 2006 Gallatin Travel Management Plan. Aside from these three subunits, secure habitat has increased over 1998 baseline levels in additional subunits as well. Under all alternatives, management actions could be implemented that would temporarily or permanently reduce secure habitat in subunits that are currently above baseline levels (refer to table 67 for secure baseline levels using the footprint approach). In such cases, it is likely that large, localized reductions in secure habitat would have negative impacts on individual bears living in those areas. However, remaining secure habitat would continue to support grizzly bear recovery at the population level (Servheen 2007).

Consistent with the conservation strategy, all revised plan alternatives would allow for permanent changes in configuration of secure habitat inside the recovery zone, but losses of secure habitat below established baseline levels must be replaced with commensurate secure habitat elsewhere in the same bear management subunit or in the nearest subunit possible. The revised plan alternatives accomplish this by formally adopting the secure habitat standard and associated application rules from the conservation strategy (FW-STD-WLGB-01, 02 and 03). Resulting plan components include requirements for consideration of habitat quality and quantity when replacement secure habitat is needed (FW-STD-WLGB-02a). Further, replacement habitat must be in place before project implementation results in a reduction of secure habitat below baseline levels, and must be in place for a minimum of 10 years (FW-STD-WLGB-02b), which is the approximate generation time of a reproductive female grizzly, or the time it takes to replace herself in the population. This condition is intended to give affected grizzly bears time to adapt to changing conditions.

The modified developed site standard of alternative F (FW-STD-WLGB-04a) includes recommended changes to the conservation strategy, which acknowledge the need for occasional emergency repairs to existing infrastructure due to natural events such as landslides. Emergency repairs that require substantial relocation of facilities could impact secure habitat. Under alternative F, such repairs must be made in the nearest suitable location to damaged facilities when replacement within the existing alignment is not feasible. As with all alternatives, if emergency repairs result in a reduction of secure habitat below baseline levels, a commensurate level of secure habitat must be replaced elsewhere within the affected subunit or the nearest available subunit, to meet the intent of the secure habitat standard. Therefore, this addition in alternative F is more restrictive than the other alternatives. With 10 of the 14 subunits intersecting the Custer Gallatin currently above baseline levels for secure habitat, the added standard in alternative F further reduces the risk of dropping below baseline secure habitat levels due to emergency repairs of forest infrastructure.

Temporary reductions in secure habitat below the appropriate baseline would be allowed under all alternatives for administrative purposes, but such reductions would not exceed 1 percent of the total acreage of the largest subunit within the affected bear management unit (FW-STD-WLGB-03b). Additional restrictions would limit the number of projects so that only one project (regardless of administrative jurisdiction) could temporarily reduce secure habitat below baseline levels within any subunit at the same time (FW-STD-WLGB-03a). Further, plan components would restrict use of project roads that temporarily reduce secure habitat below baseline levels to administrative use, and limit the duration of associated reductions in secure habitat to no more than 4 years consecutively, including project implementation as well as decommissioning activities needed to close temporary roads upon project completion (FW-STD-WLGB-03c). Finally, management actions that result in temporary reductions in secure habitat below baseline would be concentrated in time and space to minimize disturbance effects on grizzly bears in the project vicinity (FW-GDL-WLGB-01).

Temporary reductions in secure habitat inside the recovery zone could potentially have adverse impacts on individual bears residing in the project vicinity, due to disturbance factors that could alter behavior patterns or result in displacement of bears from suitable habitat. However, the secure habitat plan components are derived from application rules in the conservation strategy that are intended to allow for some level of management flexibility, while simultaneously maintaining adequate proportions of secure habitat at the subunit level to allow options for bears disturbed or displaced by management actions to find refuge elsewhere within a bear management unit or subunit. Based on recent expansions in grizzly bear distribution, and slowing of grizzly bear population growth in recent years (van Manen et al. 2013b) have suggested that the Greater Yellowstone Ecosystem grizzly bear population may be nearing carrying capacity. If grizzly bear habitat on the Custer Gallatin is at or near carrying capacity, then individual bears displaced by management actions, even temporarily, could experience additional impacts due to conflicts with other bears in the vicinity.

Outside the recovery zone, secure habitat is measured by proximity to motorized routes and monitored for changes over time. There are no plan components specifically related to grizzly bears that would prevent reductions in secure habitat outside the recovery zone from future management actions on National Forest System lands. However, there are other factors that would limit secure habitat reductions outside the recovery zone. Forty-four percent of National Forest System lands in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas outside the recovery zone are within designated wilderness, where no further reductions in secure habitat could occur under established wilderness management laws. Another 33 percent of National Forest System lands in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas outside the recovery zone are currently within a wilderness study area or inventoried roadless areas designated by Congress, which also come with land use restrictions that limit road construction, and thus protect secure habitat. In addition to land use restrictions in areas designated by Congress, new land use allocations in the revised plan alternatives would establish long-term management direction in some portions of the wilderness study area and inventoried roadless areas, as well as some portions of the national forest with no existing Congressional designations. New land use allocations for recommended wilderness areas, backcountry areas and key linkage areas in the revised plan would limit further reductions in secure habitat outside the grizzly bear recovery zone. No new roads (permanent or temporary) would be constructed in recommended wilderness or backcountry areas in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, except temporary roads may be constructed in the South Cottonwood Backcountry Area (FW-STD-RWA-01, AB-STD-BCBCA-01, MG-STD-BHBCA-01, MG-STD-SCBCA-01, MG-STD-LHBCA-01, MG-STD-WPBCA-01). Permanent or temporary roads could be constructed within the key linkage area, but only for resource management, with duration limits applied for temporary roads (FW-GDL-WL-03-05).

There is considerable overlap of designations for wilderness study area and inventoried roadless areas with new plan land allocations for recommended wilderness, backcountry areas and key linkage areas. Inside the recovery zone, new plan land allocations would not notably influence the overall proportion secure habitat due to grizzly bear specific standards to maintain secure habitat at or above established baseline levels. Outside the recovery zone where there are no secure habitat standards for grizzly bears, plan land allocations of recommended wilderness and backcountry area would prohibit new permanent motorized routes (roads and trails) under all alternatives, whereas new motorized trails would be allowed in some areas under current designations of inventoried roadless. Therefore, plan land allocations outside of the recovery zone would protect secure habitat for grizzly bears to a greater degree than under current plans. Alternative D appreciably increases the amount of recommended wilderness that would remain secure outside the recovery zone, while alternatives B, C, and F have similar amounts, though different combinations of plan land allocations that would protect secure habitat outside the recovery zone. Alternative E includes no recommended wilderness, and would allow some additional motorized trail opportunity within a proposed backcountry area, so would not notably protect secure habitat for grizzly bears outside the recovery zone compared to current plans.

In addition to grizzly bear-specific direction and new plan land allocations, all revised plan alternatives include other plan components that would further limit impacts to secure habitat both inside and outside the recovery zone. These include direction to manage habitat for big game species (FW-GDL-WLBG-03) and direction for riparian management zones (FW-GDL-RMZ-03), which may preclude reductions in secure habitat in big game areas, or new roads within riparian management zone respectively.

Collectively, grizzly bear-specific direction plus direction for other resources, would maintain secure habitat inside the recovery zone at or above applicable baseline levels displayed in table 67. Again, there are no specific plan components that would preclude reductions in secure habitat outside the recovery zone. However, given the existing restrictions in designated wilderness areas, plus a variety of restrictions on new motorized transport for other resource reasons outside the recovery zone, it is reasonable to expect that future reductions in secure habitat outside the recovery zone over the life of the plan would be minor. All alternatives include monitoring requirements (MON-WL-10) in which secure habitat inside the recovery zone would continue to be measured and reported annually, with any new temporary or permanent motorized routes added to the motorized access database. Secure habitat would continue to be monitored and reported every two years outside the recovery zone, again by incorporating any new temporary and permanent motorized access routes on National Forest System lands (MON-WL-11).

The primary factor affecting secure habitat for grizzly bears is proximity to motorized access routes. Other indices useful for evaluating impacts from motorized access include measures of motorized access route densities. Route densities of particular concern with respect to grizzly bear habitat management are open motorized access route density greater than 1 mile per square mile and total motorized access route density greater than 2 miles per square mile (Mace and Manley 1993, U.S. Department of the Interior 1995), where open motorized access route density represents routes open to the general public and total motorized access route density includes routes open to the public as well as motorized routes restricted to administrative use. Route densities are correlated to secure habitat in that areas of higher route densities have lower proportions of secure habitat. In developing the conservation strategy, it was determined that maintaining habitat standards for all three access parameters (open motorized access route density, total motorized access route density and secure habitat) was unnecessary and somewhat redundant in meeting grizzly bear management objectives (U.S. Department of Agriculture 2006b). Revised plan alternatives follow suit with the conservation strategy by adopting standards for maintaining secure habitat inside the recovery zone, with no associated standards tied specifically to route densities. Constructing a new motorized route or reopening a previously closed motorized route would typically affect secure habitat, unless the new or reopened route is within 500 meters of an existing open route on both sides. In other words, for a new or reopened route to have no effect on secure habitat, it must be between existing motorized routes that are no more than 1,000 meters (0.6 mile) apart. Such an event would be rare, and would not likely have any notable effect on the proportion of area with open motorized access route density greater than 1 mile per square mile or total motorized access route density greater than 2 miles per square mile.

Schwartz et al. (2010) looked at hazards affecting grizzly bear survival in the Greater Yellowstone Ecosystem, and concluded that of all the covariates they examined, the amount of secure habitat within a bear's home range and density of roads outside of secure habitat were the most important predictors of grizzly bear survival. They found that measures of open rather than total motorized route density best depicted grizzly bear survival. Under all alternatives, secure habitat levels inside the recovery zone would be maintained at or above 1998 baseline levels, which have been documented to contribute to population growth for the Yellowstone grizzly bear. While there would be no formal mandate to maintain secure habitat levels outside the recovery zone, other plan components discussed above combined with direction in Custer and Gallatin National Forest Travel Management Plans, would effectively limit development of additional public motorized routes on National Forest System lands, which would moderate open route density levels outside the recovery zone. Based on field observations, enforcement issues, and professional opinion, Custer Gallatin staff is confident that the national forest is fulfilling its duty for managing motorized access as per the regulations associated with Travel Management Plans. Therefore, all alternatives would implement access management direction, which, combined with current travel plan direction, is expected to maintain high levels of grizzly bear survival within the recovery zone, and reasonable levels in the remainder of the plan area. Finally, the revised plan maintains monitoring requirements to track changes in open motorized access route density and total motorized access route density inside the recovery zone (MON-WL-10). Monitoring changes in open motorized access route density and total motorized access route density inside the recovery zone, as well as secure habitat inside and outside the recovery zone, will allow Custer Gallatin National Forest managers, in cooperation with other agencies, to respond to demonstrated issues with appropriate management actions.

Developed Sites

As with the importance of secure habitat for grizzly bears, the effects of human developments have long been recognized as having a notable influence on grizzly bear populations, particularly as such developments have been associated with grizzly bear displacement, and human-caused grizzly bear mortalities (Mattson et al. 1987, U.S. Department of the Interior 1993). Developed sites are those sites or facilities on National Forest System lands with features intended to accommodate administrative needs and public recreational use. Human use at developed sites can produce disturbance factors such as noise and human presence that may displace wary bears from otherwise suitable habitat (Coleman et al. 2013). In addition, developed sites often include facilities for preparing and eating food, and disposing of garbage, which can be an attractant for less wary bears. Bears drawn to human food sources can cause bear-human conflicts that may result in removal of the bears involved. Even if no immediate conflicts occur, bears that receive human-related food rewards may become food conditioned, reducing their natural wariness, which could lead to bear-human conflicts later, and possible management removal of the bears.

All revised plan alternatives contain desired conditions for human-related attractants to be unavailable to all wildlife, for natural foraging patterns to be the norm, and for food conditioning, habituation of animals and associated wildlife conflicts to be minimal (FW-DC-WL-08). Desired condition FW-DC-WLGB01, envisions developments inside the recovery zone to remain focused in areas where concentrated use was present in 1998. This reflects a desire to maintain consistency with the intent of the conservation strategy to manage distribution and general configuration of developed sites inside the recovery zone in a pattern similar to that which promoted grizzly bear recovery. In recent years, Greater Yellowstone Ecosystem land managers recognized the need to incorporate flexibility in a manner that strikes a balance between management needs and habitat protection to allow for grizzly bear and human co-existence. Alternative F provides guidance to accomplish this by incorporating pending changes to the conservation strategy that would allow greater management flexibility to increase the number and/or capacity of developed sites to address recent, unprecedented human population growth (in both permanent and seasonal residents) in the Greater Yellowstone Ecosystem, as well as dramatic increases in visitor use of public lands (Yellowstone Ecosystem Subcommittee 2016b, Developed Site Technical Team 2019).

All previous versions of the Greater Yellowstone Ecosystem conservation strategy have recommended that the number and capacity of developed sites inside the recovery zone be maintained at or below levels existing in 1998, under the premise that 1998 was reflective of a period of grizzly bear expansion, which led to the Greater Yellowstone Ecosystem grizzly population ultimately meeting established recovery criteria. However, previous methods of applying the developed site standards from the conservation strategy merely tallied the number of developed sites within the recovery zone, with little distinction between the sizes of development. For example, a one-tenth acre developed trailhead “counted” the same as the Grant Village complex in Yellowstone National Park. Nor did previous tracking methods clearly distinguish between the types of use at developed sites (such as administrative sites vs public recreation areas vs combined administrative and public use sites). Further, previous methods had no established protocol for measuring the capacity of existing developed sites relative to the 1998 baseline (Developed Site Technical Team 2019).

To address emerging management issues, a multi-agency technical team (Tech Team) convened by the Yellowstone Ecosystem Subcommittee of the Interagency Grizzly Bear Committee, proposed changes to conservation strategy habitat standards to address increasing demand for recreation opportunities associated with developed sites. The most significant recommendation to come from this effort is to apply the “footprint approach” to larger areas of concentrated human use associated with developed sites, as described previously. The rationale for adopting the footprint approach is that it 1) affords a more reliable, consistent, and accurate method of representing and tracking human development, 2) better accounts for impacts to secure habitat associated with concentrated human use and development, 3) delineates prescribed areas within which managers may authorize new or enhanced infrastructure without violating habitat standards, 4) concentrates new infrastructure in those areas already developed and rendered non-secure habitat incompatible with grizzly bear occupation, and 5) remains consistent with the intent of the original 1998 habitat standards baseline (Yellowstone Ecosystem Subcommittee 2016a). Not all developed sites warrant the footprint approach, and smaller developed sites (for example, trailheads, backcountry cabins) are still treated as single points on the landscape, as opposed to the polygons ascribed to footprints around larger developed sites.

Under current tracking measures, the number of developed sites on the Custer Gallatin had dropped from 183 in 1998 to 177 in 2019 (van Manen et al. 2020). Forest managers have attempted to remain true to the conservation strategy recommendation for no increase in capacity at developed sites, but due to lack of established protocols for measuring site capacity, this aspect of the conservation strategy has been difficult to assess for a variety of reasons. For one, the National Forest System does not place limits on the number of individuals that may occupy a developed site. For example, an individual campsite in a developed campground may be occupied by one or a dozen individuals on any given day, or not occupied at all. The same goes for smaller developed sites; a backcountry cabin may be occupied by one or a dozen individuals in one day, or not occupied at all. To meet the intent of the conservation strategy to not increase human capacity at developed sites, the Custer Gallatin National Forest has focused capital investments at existing sites to protect resources (such as adding food storage facilities and replacing toilets), rather than adding infrastructure such as new parking pads, tent sites, picnic tables, etc. for the purpose of increasing capacity at existing sites. While there are no specific limits placed on the number of individuals that may occupy a given developed site, once the site is occupied, it is unavailable to newcomers looking for a site-specific recreation opportunity such as such as a developed campsite, picnic area, or rental cabin.

Given the recent and dramatic increase in human use of public lands in the Greater Yellowstone Ecosystem, demands for recreation opportunities have increased accordingly on the Custer Gallatin National Forest. Since the national forest abuts Yellowstone National Park on two of four sides of the park, and adjoins three of the five entrances to the park, visitation to Yellowstone Park has an additive influence on recreation demands for opportunities presented on the Custer Gallatin National Forest. Most notably, when campgrounds, lodges, and resorts fill up and visitors cannot find overnight accommodations inside the park, they frequently look for opportunities on adjacent National Forest System lands, including those administered by the Custer Gallatin. Frequently, such visitors are not prepared to travel substantial distances from their vehicles to find camping opportunities, so they seek out developed sites accessible by vehicles on the national forest. Since the Custer Gallatin is a destination recreation area in its own right, most developed recreation sites are typically fully occupied during peak seasons. A domino effect can occur when developed sites on the national forest fill up, and the “spill-over” of visitors then becomes concentrated along nearby National Forest System roads, where visitors seek out suitable locations for dispersed camping accessible by vehicle. Most dispersed camping areas do not have infrastructure to accommodate the same types of use as developed sites. For example, dispersed sites often lack access roads, parking areas, toilets, contained fire pits, picnic tables, garbage receptacles, etc. Consequently, high levels of dispersed use sometimes result in resource damage.

In all versions of the conservation strategy, dispersed recreation sites have not been counted toward the developed site standard. However, previous versions (Interagency Conservation Strategy Team 2007, Yellowstone Ecosystem Subcommittee 2016a) of the conservation strategy acknowledged that consolidation and/or elimination of dispersed campsites is considered adequate mitigation for increasing capacity at existing developed sites, or for creation of new minor day-use sites. Proposed changes to the 2016 conservation strategy, including the footprint approach to managing larger developed sites in the recovery zone, would allow for increased capacity within authorized footprints without mitigation. As explained previously, part of the rationale for adopting the footprint approach is to better account for impacts on secure habitat imposed by concentrated human use areas. Using that same logic, the Tech Team also recommended that increased demands for services provided by developed sites could be accommodated within the non-secure buffers around primary roads inside the recovery zone. Primary roads include paved, two-lane, federal highways with high speed and high-volume traffic, which present high disturbance levels as well as high mortality risk to bears, and therefore already impact secure habitat to a high degree. Tech Team recommendations for additional developed sites along primary roads inside the recovery zone would allow new, day-use sites within 300 meters (1,000 feet) of the primary road (either side). Primary roads within the Custer Gallatin portion of the recovery zone include

Highway 20 south of Hebgen Lake, Highway 287 north of Hebgen Lake, Highway 191 in Gallatin Canyon, Highway 89 in the Yellowstone River Canyon and Highway 212 near Cooke City (figure 29).

Alternative F would adopt the recommendations of the Tech Team for revising the conservation strategy (FW-STD-WLGB-04, 05). Adjusting the developed site standards to allow for increased capacity at existing larger developed sites (within the footprint) and to allow for increased numbers of developed sites within the non-secure corridors along primary roads, would constitute a change in the way developed sites have traditionally been managed on the Custer Gallatin. Larger developed sites that would fall under the footprint approach are all located on the Gallatin portion of the recovery zone, as are all of the primary road corridors that would be open for additional developed sites.

Added management flexibility would be beneficial to Custer Gallatin land managers because overflow from existing developed sites is currently contributing to resource damage resulting from unmanaged dispersed use in some areas. Consequently, some additional development is reasonably expected to occur within Custer Gallatin campgrounds identified in the footprint approach, as well as some additional development within 300 meters of primary roads. The Forest currently has no detailed or specific plans for such development, as the proposed change to the conservation strategy has just been finalized, and has yet to be formally approved by the Yellowstone Ecosystem Subcommittee.

In alternative F, a total of approximately 582 acres would be within 16 campground footprints, where infrastructure could be added to accommodate increased demand for overnight capacity. This amount of acreage is infinitesimally small relative to the acreage of habitat inside the recovery zone on the Custer Gallatin National Forest (about six one-hundredths of one percent). While some added capacity in campgrounds is reasonably expected to occur, it could not permanently alter the entire 582 acres for a number of reasons. For one, topography and site suitability affect capacity for construction. Footprints were created by buffering existing infrastructure, and as a result, several of the campground footprints contain water bodies, roads, cliffs, and other features that would not accommodate construction of new sites. Also, open space, scenery, privacy, and esthetics are necessary features in developed campgrounds to satisfy visitor expectations. Further, construction of campground facilities is a costly proposition, and capital investment funds set aside for recreation and administrative facilities are very limited and highly competitive agency wide. Finally, the Beaver Creek Campground, which is the largest of the footprint campgrounds at 134 acres, is mainly (98 acres) outside of the recovery zone. All of the existing campsites in the Beaver Creek polygon are outside the recovery zone. It was only through adoption of the footprint approach that this campground was included as a developed site inside the recovery zone. Future added capacity in the Beaver Creek campground may not be inside the recovery zone at all. In summary, added overnight capacity at developed campgrounds under the footprint approach in alternative F is expected to have insignificant effects in terms of habitat alteration, but increased noise and disturbance associated with added capacity could affect individual bears near these sites.

Another category of developed sites that warranted the footprint approach includes administrative sites, of which there are seventeen that received a footprint on the Custer Gallatin, all of which are located on the Gallatin portion of the national forest. It is reasonable to assume that over the life of the plan, there will be needed maintenance, repairs, and additions at administrative sites in order to maintain or enhance public land management. Currently, the only identified need for any type of expansion or increased capacity within the administrative footprints specifically addressed in the revised plan is in the OTO administrative site in the Absaroka Beartooth Mountains Geographic Area. The OTO is an historic dude ranch, which was acquired by the Forest Service in 1991. The Forest Service, with a variety of partners, completed historic preservation of the OTO in the early 2000s. In addition to preservation-associated work, the OTO has provided housing for administrative personnel. Preservation work was conducted during the summer, and typically resulted in approximately three weeks of overnight use and four weeks of daytime use by volunteers working on preservation projects. Over time, there has been increased interest from the public to use the OTO facility for other purposes, most notably youth and environmental education. For several years now, the Custer Gallatin has welcomed youth education groups to the OTO within the same temporal frame as historic preservation activity to adhere to the developed site capacity limit. While there is no proposal or identified need to increase infrastructure within the administrative footprint, the national forest is proposing to increase the temporal aspect of use by the public.

All revised plan alternatives recognize the distinctive contributions of the OTO administrative site, to the cultural and historic characteristics of the Absaroka Beartooth Mountains Geographic Area. Accordingly, the revised plan alternatives include specific direction for the Forest Service to seek partnerships to provide a venue for conservation education, stewardship, and innovative opportunities, while preserving the historic significance and use of National Register listed OTO Homestead and Dude Ranch property (AB-GO-OTO-01). Under the revised plan alternatives, use of the OTO administrative site would not be opened to the public under a rental program (AB-STD-OTO-03). Non-administrative use of the facilities (such as buildings) would require authorization by special use permit or agreement (AB-STD-OTO- 01). Group size authorized would be limited to a maximum of 75 individual for overnight use, and 100 individuals for day use (AB-STD-OTO-02). Administrative use could occur year-round with no timing or group size restrictions. Non-administrative use may occur year-round, but would be limited during prime grizzly bear use seasons.

The OTO was acquired under the Northern Yellowstone Winter Range acquisition project, in which 31 acres of the property encompassing most of the guest ranch facilities were identified for administrative use, while the remaining 3,232 acres of OTO lands acquired were identified as important grizzly bear habitat and big game winter range. During the fall hyperphagia period, when bears are moving extensively with increased chances of encountering humans, use authorized by permit or agreement at the OTO would be limited to no more than one week of overnight use and no more than three weeks of day use from October 1 to December 1 (AB-GDL-OTO-01). During the spring den emergence season, when bears may visit the OTO site due to the potential presence of winter-killed ungulate carcasses on winter range in the area, permitted human use would be limited to no more than two weeks of overnight use and no more than two weeks of day use from March 1 to June 15 (AB-GDL-OTO-02). Similar to the current condition, the bulk of authorized public use is expected to occur during the summer months (June 16 to September 30), when grizzly bears have typically moved to higher elevation areas in search of natural foods. However, under the revised plan alternatives, the facilities would also be open to authorized public use (both overnight and day use events) during the winter denning season (December through February). Whereas public use of the administrative facilities (buildings) would be allowed only for authorized events, the public would be allowed to recreate within the administrative site (AB-SUIT-OTO-01). Compared to the current plans, the revised plan alternatives would increase the amount of time the OTO could be available for events authorized by permit. Otherwise, administrative use at the OTO would remain relatively unchanged.

Under alternative F, the proposed footprint approach for administrative sites would allow for additional infrastructure at existing administrative sites in the recovery zone, should needs arise to accommodate additional administrative workforce, changing technologies, and the need to upgrade or replace existing facilities due to wear and tear, as well as to ensure the health and safety of the Forest Service workforce and cooperators. The major difference between alternative F and all other alternatives is that alternative F adopts the pending revision to the conservation strategy for developed sites, in which any new construction at the larger administrative sites must be entirely within the authorized footprint. All other alternatives, including alternative A (current plans) adopt previous versions (2007, 2016) of the conservation strategy, which basically exempted administrative facilities from the “no added capacity” provision of the developed site standard altogether. The revised plan language would ensure that any future added capacity at administrative sites would be concentrated in the same general vicinity as existed in 1998, and prevent potential sprawl at larger administrative sites.

The third category of developed site that received a footprint in alternative F was termed “visitor overnight” sites by the Tech Team, which applies to visitor lodges and guest ranches operating under special use permit on National Forest System lands inside the recovery zone. There are two such sites on the Custer Gallatin—the Covered Wagon Ranch and the Madison Arm Resort—that are both located in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area. These developed recreation sites accommodate visitor overnight use in cabins and campsites suited for tent or RV use. By adopting recommended changes for the conservation strategy, alternative F would allow new infrastructure to be added at these sites, so long as it is fully encapsulated within the established footprints, and could accommodate no more than a ten percent increase over current visitor capacity. Special use permits for these sites have not set numeric limits for visitor use. However, these sites were both present in 1998, with no infrastructure added to accommodate additional overnight guests on National Forest System lands since that time. Therefore, the maximum visitor capacity at these sites today is the same as it was in 1998. Under the alternative F provision to allow expansion to accommodate up to ten percent more visitor use, the Covered Wagon Ranch could add infrastructure to accommodate approximately 2 to 3 additional overnight guests, while the Madison Arm resort could add infrastructure to accommodate up to thirty additional overnight visitors, within their respective footprints.

The final major change to management of developed sites within the recovery zone under alternative F is the addition of a provision to allow new developed sites to be constructed within a 300-meter (one-fifth mile) buffer of primary roads, without mitigation. There are five primary roads (paved Federal highways listed above) that intersect Custer Gallatin lands inside the recovery zone (figure 29). The rationale for adding this provision is that all motorized routes are already buffered by 500 meters (one-third mile) and the area within that buffer is subtracted from secure habitat. Primary roads receive the highest volume traffic and accommodate the highest traffic speeds, which results in the greatest disturbance effects to grizzly bears, and pose the highest mortality risk for bears that attempt to cross. Under alternative F, new developed sites along primary roads could have additive disturbance and mortality risk for bears, but these impacts would be minor relative to existing conditions near these roads. There is abundant literature demonstrating grizzly bear avoidance of roads (Interagency Grizzly Bear Committee 1987) including research specific to effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park (Mattson et al. 1987).

The primary road provision added to grizzly bear direction in alternative F is consistent with revised plan land use allocations, since two of the primary road segments (Highway 191 and Highway 89) are within recreation emphasis areas under all revised plan alternatives. The other three segments are within recreation emphasis areas in all revised plan alternatives except alternative D. Although alternative D includes no recreation emphasis area around the other primary roads, it has no provisions that would change management emphasis around these road segments. Accordingly, it is reasonable to expect some added development in these areas may be desirable to accommodate recreational use over time. However, there are currently no specific plans to add developed sites within primary road buffers on the Custer Gallatin National Forest, and there is no good way to estimate how many such developments might occur over the life of the plan, since conditions are so variable along the primary road segments.

Existing conditions provide a basis to consider potential effects of new plan language proposed in alternative F. Buffering primary roads inside the recovery zone by 300 meters on each side, produces an area of roughly 16,500 acres. Of this area, over one-third (over 5,700 acres) is located on non-National Forest System lands (generally private), over which the Forest Service has no control, and for which future development would not count against the developed site standard. National Forest System lands within this buffer account for just over one percent of the total Custer Gallatin lands inside the grizzly bear recovery zone. On the roughly 10,800 acres that are National Forest System lands, there are currently over 300 individual structures within the primary road buffers. This number accounts for smaller developed sites, such as trailheads or recreational residences, but also includes individual structures (for example, administrative buildings, individual campsites, bathrooms, picnic areas) within some of the larger developed site footprints on the national forest. Currently, twelve of the administrative site footprints, seven of the campground footprints (including Beaver Creek – the largest) and one of the visitor overnight footprints on the Custer Gallatin, overlap with the primary road buffers. This co-location of more than half of the developed site footprints on the national forest with the primary road buffer, would further concentrate potential future development that would be allowed without mitigation under alternative F. The resulting management scenario would be consistent with the intent of the conservation strategy to keep developed human uses in the same general location as were used in 1998.

While it is reasonable to expect some level of added recreation infrastructure within the primary road buffers in the recovery zone, there are also several factors in alternative F that would limit such development. For example, the application rules proposed for the revised direction in the conservation strategy (and related components in alternative F) require new developments within the primary road buffer to be for day-use only; non-commercial in nature; located outside of known grizzly bear or other wildlife crossing areas, riparian areas, ungulate calving and fawning grounds, and whitebark pine stands; and would occur on no more than 10 percent of the primary road buffer (FW-STD-WLGB-04c). Limiting new sites to day-use only would reduce the duration of human presence, thereby lowering the potential for grizzly bear-human conflicts, while restricting new sites to non-commercial uses would limit the demand for development that could be motivated by financial considerations. Habitat factors could rule out individual developments when considered on a case-by-case, site-specific basis. Most of the primary road segments are at least partially along river corridors or lakeshore, with potential limits to added development based on riparian habitat protections, while presence of whitebark pine could limit new development around Highway 212. Finally, any new roads associated with new development within 300 meters of a primary road would be buffered for impacts to secure habitat for grizzly bears as per the Greater Yellowstone Ecosystem Motorized Access Model. Alternative F mandates that any new roads and associated buffers will not reduce existing secure habitat below established baseline levels, further limiting potential new developments.

Alternatives A through E would adopt previous versions of the (Interagency Conservation Strategy Team 2007, Yellowstone Ecosystem Subcommittee 2016a) which allowed for consolidation and/or elimination of dispersed campsites to mitigate for expansion at existing developed campgrounds; for conversion of uncontrolled dispersed campsites to a new minor day-use site for human safety and benefits to bears;

and for modifications to dispersed campsites to reduce resource damage and reduce potential for grizzly bear-human conflicts. Adopting the footprint approach in alternative F would eliminate the need for the first allowance, since capacity could be added at developed campgrounds without consolidation or elimination of dispersed campsites. Alternative F incorporates the logic of previous strategies combined with recommended changes, to allow for minor modifications at dispersed recreation sites to address resource damage and reduce potential human-grizzly bear conflicts, but specifies that modifications must accommodate the same type and level of use occurring at existing dispersed sites (FW-STD-WLGB-05b). Alternative F also would allow for construction of up to four new campgrounds (one campground in each of the Gardiner Basin, Hebgen Basin, Taylor Fork, Cooke City) where the replacement of dispersed camping with a new campground would have a demonstrable benefit to grizzly bears and other resources. New campground development would be subject to effective closure and elimination of overnight dispersed recreation sites; the overnight dispersed sites must be restored and closed to the public for future vehicle access and overnight use, and not result in displacement of dispersed use to nearby areas. New campground development would be commensurate with the site capacity provided by the eliminated overnight dispersed sites (FW-STD-WLGB-05c). Further, overnight developed site expansion should occur in the area within the authorized footprint of a site that existed in 1998, unless expansion as outlined in FW-STD-WLGB-05(c) would have a greater benefit to grizzly bears and other resources (FW-GDL-WLGB-02c). These components of alternative F address ongoing and potential future resource issues associated with unmanaged dispersed recreation expected to occur as a result of rapidly increasing human populations and associated demand for recreation opportunities.

For years now, unmanaged recreation has been recognized as one of the main threats to the health of the Nation’s forests. The Rockies are identified as an area that has been notably impacted by human population growth, and an area where heavy pressure from increased recreation use is predicted to continue. Impacts from unmanaged recreation include soil erosion, spread of invasive species, disturbance of wildlife, destruction of wildlife habitat, and risks to public safety (Four Threats to the Health of the Nation's Forests and Grasslands). As noted previously, a major impetus to revise the application rules for developed sites in the conservation strategy is because existing direction for developed sites in the recovery zone has not kept pace with management challenges associated with increasing pressure on natural resources from growing human use. The Custer Gallatin has responded to resource damage by closing some areas to dispersed camping altogether, and by designating dispersed sites in others. Frequently, national forest visitors would prefer a developed recreation experience, but when developed sites are full, these visitors may opt to seek out dispersed opportunities or may find they have few other options available. When resource damage results from dispersed use, combining the sites contributing to resource impacts into one developed area serves to concentrate the use, and allows for better control over factors such as food storage, noise levels, and sanitation, all of which can impact bears.

Early versions of the conservation strategy (2003, 2007) acknowledged that developed sites could result in displacement of grizzly bears; in other words, developed sites affect secure habitat, which would be more accurately accounted for under the proposed footprint approach to track larger developed sites. However, early versions of the conservation strategy indicated that the primary concern related to developed sites is grizzly bear mortality related to human foods and other attractants connected to food conditioning and habituation of bears. A food storage order has been in place inside the recovery zone since the mid-1980s, and the order was expanded to cover the entire montane ecosystem of the Custer Gallatin in 2007. All revised plan alternatives include a standard (FW-STD-WL-01) to maintain and enforce the food storage order in areas where grizzly bears are currently present on Custer Gallatin National Forest, as well as areas where they are reasonably expected to move through or into during the life of the plan. Revised alternatives also acknowledge the importance of informing the public about proper behavior in bear country (FW-DC-WLGB03). Food storage regulations combined with information and education efforts, have been credited with reducing grizzly bear-human conflicts and subsequent need for management control of grizzly bears. As a result, bear-human conflicts have shifted away from developed sites, and are now more frequently associated with surprise encounters in back-country scenarios (Frey and Smith *in (van Manen et al. 2019)*).

Inside the recovery zone, developed site plan components in all alternatives would continue to concentrate human use in areas where higher levels of human presence occurred in 1998, whereas alternative F allow for management flexibility to address the emerging issues associated with largely unmanaged dispersed use. Relaxing the developed site standards to allow for some increased human presence at existing developed sites through expanded capacity, as well as possible increases in the numbers of developed sites within the primary road buffer and through consolidation of dispersed sites, could have added disturbance effects on bears in close proximity to expanded or new developments. However, bears that use habitats near high human use areas typically have a higher tolerance for human presence, whereas the more wary bears tend to avoid areas of concentrated human use. Allowing more management flexibility for developed sites in alternative F could reduce disturbance impacts from dispersed use in some areas. However, given the recent, current, and predicted growth of the human population in the Greater Yellowstone Ecosystem, dispersed use on the Custer Gallatin is also expected to continue to increase over the life of the plan, and reduced disturbance for bears is likely to occur only through the issuance of special orders to prohibit dispersed use in certain areas. Public education combined with food and attractant management at developed sites has proven effective at reducing bear-human conflict at developed sites, and is expected to continue to do so under all revised plan alternatives.

Developed sites are also a factor affecting grizzly bear use outside the recovery zone. The Grizzly Bear Recovery Plan revised 1993 (U.S. Department of the Interior 1993), amended 2007 (Servheen 2007) acknowledges that the area outside the recovery zone will be managed with more consideration for human uses. Consequently, there have been no plan limits on developed sites outside the recovery zone under current plans (alternative A), nor would there be any grizzly bear-specific restrictions on developed sites outside the recovery zone in any of the revised plan alternatives. However, as noted above for secure habitat, a variety of plan components associated with other resources would limit new developments outside the recovery zone as well. Designated wilderness areas account for 44 percent of National Forest System lands outside the recovery zone, in which no new developed sites would be allowed. Land use allocations in the revised plan alternatives for recommended wilderness areas, backcountry areas, and key linkage areas would also limit new developed recreation sites and other developments outside the recovery zone (FW-STD-RWA01-06; FW-STD-BCA01-07; FW-GDL-WL-03, 04). All revised plan alternatives include a desired condition that developed recreation corridors keep visitor use concentrated rather than shifting use to new areas (FW-DC-RECDEV06), and preclude new recreation residences both within and outside of the recovery zone (FW-STD-RECRES01). Additionally, the food storage order would continue to apply at all developed sites (as well as dispersed use areas) outside the recovery zone under all alternatives (FW-STD-WL-01).

Finally, the revised plan alternatives include goals to assist in interagency efforts to track, record, and report grizzly bear-human conflicts, and to identify potential relocation sites for grizzly bears involved in conflicts with humans (FW-GO-WLGB-02, 03). These goals reflect management intent to continue to participate in ongoing interagency efforts to monitor incidents in which grizzly bears and humans cross paths, evaluate conditions that may have led to conflicts or avoided conflicts, and if need be, respond to demonstrated issues in cooperation with other agencies. Having suitable relocation sites identified in advance can help streamline and expedite the process for dealing with grizzly bears involved in minor conflicts with humans, while allowing bears to learn from negative experiences yet remain in the ecosystem. Identification of relocation sites was included as an objective (FW-OBJ-WLGB-01) in alternatives B through E in the draft plan, but was changed to a goal (FW-GO-WLGB-02) for all revised plan alternatives in the final plan to emphasize the importance of interagency contributions to potential relocation site identification.

Domestic Livestock Grazing

The third major emphasis area in the conservation strategy (and reflected in the revised plan) is domestic livestock grazing management. Under all alternatives, the number and acres of domestic livestock grazing allotments inside the recovery zone would remain at or below levels that occurred in 1998 (table 71). In 1998, there were 39 grazing allotments (25 active and 14 vacant) inside the recovery zone covering a total of 271,865 acres. Twenty (20) of the allotments available for livestock grazing in 1998 have been permanently closed for a variety of resource reasons, including potential conflicts with grizzly bears. Since there has been a reduction in the number of grazing allotments since 1998, the number and acres of domestic livestock grazing allotments could increase compared to current levels inside the recovery zone, and still be within the constraints of plan direction and consistent with the conservation strategy. Currently, there are 14 active and 5 vacant allotments inside the recovery zone, for a total of 74,292 acres. The 1998 baseline would allow for a total of 25 active grazing allotments with a net acreage of 182,727 acres. Per standard FW-STD-GB 06c, acres not previously part of a grazing allotment could be added to an active or vacant allotment(s), and/or be used to create a new allotment inside the recovery zone (e.g., due to a land adjustment, or other acres are determined suitable), as long as the number and acres of domestic livestock grazing allotments inside the recovery zone do not exceed levels that occurred in 1998. The revised plan alternatives would allow for evaluating a variety of uses for current and future vacant grazing allotments, including but not limited to stocking or closing the allotments per Forest Service policy (FW-GO-GRAZ-02). The 5 allotments inside the recovery zone that are currently vacant could be restocked with permitted livestock (other than domestic sheep in alternatives B, C, D, and F), or used as forage reserves for permitted livestock, which would affect approximately 17,000 acres, and could support roughly 1,429 animal unit months. Alternatively, these 5 vacant allotments could be considered for closure in favor of natural resource conservation, including, but not limited to, minimizing risks to grizzly bears.

Grizzly bears occasionally kill cattle, but they often coexist with cattle without depredation, whereas domestic sheep are a known grizzly bear attractant, and bears that encounter domestic sheep are more likely to respond with depredation (U.S. Department of the Interior 2017b). Grizzly bear depredations on livestock can result in injury or removal of bears. While it is possible that the number and acreage of domestic livestock grazing allotments could increase inside the recovery zone compared to current levels, no new domestic sheep allotments would be authorized under any alternative, except for the express purpose of administrative use for noxious weed control in alternatives B, C, E, and F (FW-STD-GRAZ02). The use of domestic livestock (sheep or goats) for weed treatment is typically much more focused in time and space than grazing for livestock production, and can therefore be tightly restricted to minimize potential risk of conflict with grizzlies. This use would be allowed under current plans (alternative A) since it is not prohibited in the conservation strategy. Alternative D would prohibit the use of domestic sheep or goats for any purpose, including weed control, on the entire and Custer Gallatin National Forest.

Alternatives B, C, E, and F would require mitigation measures if domestic sheep or goats are used for weed treatment, including written instructions stipulating the timing, location, numbers of animals, retrieval of strays, disposition of livestock carcasses, or any other mitigation measures deemed necessary to minimize risk of conflict with grizzly bears (FW-STD-GRAZ-03, 04). Other mitigation measures might include such things as requirements for full-time supervision of weed-control livestock by humans or guard animals, use of electric fencing or other suitable measures to keep livestock in the target area while keeping predators out, or notification requirements if grizzly bears or signs of grizzly bears are seen in the area of livestock use. Under these alternatives, in the event of a grizzly bear conflict with domestic sheep or goats used for weed control inside the recovery zone, the management response would favor grizzly bears (FW-STD-WLGB-07), which means domestic sheep or goats would be removed from the area, with no adverse actions against the bear(s) involved unless additional circumstances indicate removal is warranted. Such circumstances may include, but are not limited to, bear-caused human injury or mortality, or the bear(s) involved are determined to be food-conditioned or in poor health and not expected to survive in the wild.

Outside of the recovery zone, permitted livestock grazing would be less restricted under the revised plan alternatives relative to inside the recovery zone, but revised plan alternatives would be more restricted than current plan direction. Outside the recovery zone, there are currently 50 active cattle and horse allotments and 16 vacant allotments in the Absaroka Beartooth and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, where grizzly bears are known to occur. The active allotments would likely remain stocked with cattle or horses, and the vacant allotments could be restocked for regular use, or used as needed (for example, to provide grass banks) for livestock. However, alternatives B and C would preclude new permits for grazing of domestic sheep and goats for livestock production in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas where bears currently reside on the Custer Gallatin National Forest. Alternative D would prohibit new sheep and goat permits anywhere on the national forest, and alternative E would allow new permits for sheep and goats outside the recovery zone, so long as it could be established that there would be no risk to bighorn sheep (FW-STD-GRAZ-02).

Alternative F would prohibit new grazing allotments for domestic sheep and goats in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas where bears currently reside, but would also prohibit domestic sheep and goat grazing for livestock production in the Bridger, Bangtail, and Crazy Mountains Geographic Area, which may be important areas for grizzly bear dispersal between ecosystems (FW-STD-GRAZ-02). While there are currently no active or vacant sheep or goat grazing allotments anywhere on the national forest, there are no restrictions under current plans that would prevent new permits for domestic sheep or goats outside the grizzly bear recovery zone. The addition of prohibitions on domestic sheep and goat permits for livestock production in the montane ecosystem geographic areas was added in alternatives B, C, D, and F not only to protect large predators such as grizzly bears, but also to protect wild sheep and goats that are susceptible to disease transmission from domestic livestock. These alternatives would eliminate the potential for future permitted grazing of domestic sheep and goats for livestock production in all areas of the Custer Gallatin National Forest currently known to be occupied by grizzly bears (Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas), whereas alternatives D and F would also eliminate potential conflicts in the Bridger, Bangtail, and Crazy Mountains Geographic Area that could potentially serve as a dispersal corridor for grizzly bears in the future.

Similar to inside the recovery zone, targeted use of domestic sheep and goats for weed treatment would be allowed outside the recovery zone under all alternatives except D, with appropriate mitigations (FW-STD-GRAZ-03, 04). Targeted grazing by domestic sheep or goats is an effective method of controlling the spread of invasive plants. Noxious weeds can out-compete native plant species, and subsequently overtake large areas of native habitat. Maintaining a variety of tools to manage invasive plants is expected to benefit a wide range of native wildlife species, including a number of herbivores that are potential prey species for grizzly bears. The primary difference in plan alternatives for use of domestic sheep or goats for weed control outside the recovery zone is that there would be no requirement for management actions to favor grizzly bears over livestock in the event of a conflict outside the recovery zone. In the event of a conflict between grizzly bears and weed-control livestock outside the recovery zone, additional factors would be considered in management actions, including but not limited to economic impacts on the livestock owners. After consideration of multiple factors, livestock could still be removed from a weed-treatment area, and there may be no adverse actions for the offending bear(s). However, grizzly bears could be relocated or removed if they are involved in depredation or conflicts with livestock operations authorized for weed control purposes outside the recovery zone. Since targeted weed control projects using domestic livestock are shorter in duration and can be tightly controlled, the risk to bears outside the recovery zone from this use would be lower than risk of conflict between bears and domestic sheep or goats on grazing allotments for livestock production.

Livestock can damage riparian resources (White et al. 2017). Riparian areas provide foraging opportunities, water, cover, and potential movement corridors for grizzly bears and their prey species (Peck et al. 2017). All revised plan alternatives contain a goal (FW-GO-GRAZ01) to work with livestock permittees to relocate existing infrastructure that attracts livestock use in or near riparian areas, as well as standards and guidelines for grazing practices that avoid, minimize or mitigate negative effects of livestock use in riparian areas (FW-STD-GRAZ01; FW-GDL-GRAZ01, 02, 04). Revised alternatives are more explicit, and would therefore be more restrictive for livestock management within or near riparian areas than under current plans, which would be beneficial to grizzly bears, both inside and outside of the recovery zone. In addition, all revised plan alternatives contain a guideline for livestock use levels that meet the forage needs of big game species on winter ranges (FW-GDL-GRAZ03). This component would help sustain the big game herds that contribute ungulate biomass as a key food source for grizzly bears.

Grizzly Bear Food Sources

The three major habitat standards for grizzly bears (secure habitat, developed sites, and livestock allotments) address factors linked to human land uses that can affect grizzly bear distribution through disturbance and/or displacement, and grizzly bear survival relative to human-caused grizzly bear mortality. In addition to these factors, all revised plan alternatives contain coarse filter plan components that could affect availability of key and alternate food sources for grizzly bears, vegetative cover requirements for security and thermoregulation, and habitat connectivity. The revised plan alternatives contain desired conditions for vegetation conditions that are generally within the natural (historical) range of variation, provide structural and functional diversity and are resilient to existing and predictable future stressors, thereby providing habitat for use by a diverse suite of species, and meeting a variety of life-cycle needs (FW-DC-WL-03, 06). As opportunistic omnivores, diversity is important to grizzly bears to provide a wide range of plant and animal food sources, as well as to meet needs for shelter, security, and thermoregulation.

The revised plan alternatives contain a suite of components designed to provide ecological integrity by managing vegetation within the natural range of variation, and for long-term resilience. Examples include desired conditions, standards and guidelines pertaining to composition, structure and landscape pattern of vegetation, with the intent to achieve conditions that are within the natural range of variation, thereby providing for ecological integrity, diversity, function and resiliency of wildlife habitat. Coarse filter plan components for terrestrial vegetation, water, and wildlife all influence grizzly bear habitat, as well as habitat for grizzly bear prey species (FW-DC/STD/GDL-VEGF; FW-DC/GDL-VEGNF; FW-DC/GDL-WTR; FW-DC/STD/GDL-RMZ; FW-DC/GDL-WLBG, FW-DC/GDL-WLBI). Revised alternatives include direction for management of whitebark pine (FW-DC/GO/OBJ/GDL-PRISK), old growth (FW-DC-VEGF-09; FW-GDL-VEGF01, 02), forest cover (FW-DC-VEGF04, 06), and riparian areas (FW-DC/STD/GDL-RMZ), all of which are important habitat elements for grizzly bears in that they provide foraging opportunities, cover for security and thermoregulation, and travel corridors for grizzly bears and their prey species (Thomas et al. 1988b, Naiman et al. 1993, Peck et al. 2017, U.S. Department of the Interior 2017b). Managing the habitat components within the natural range of variation would provide a level of plant and animal diversity that presents a wide variety of foraging opportunities and prey species for grizzly bears, including alternate food sources for bears to supplement their diet when key foods are less available.

Four key food groups have been identified for grizzly bears in the Greater Yellowstone Ecosystem. These include ungulate biomass, spawning cutthroat trout, whitebark pine seeds, and army cutworm moths (Schwartz et al. 2010, van Manen et al. 2015, Costello et al. 2016). Of these, ungulate biomass and whitebark pine are known to be important food sources for bears on the Custer Gallatin National Forest. All revised plan alternatives contain direction for management of big game habitat, including guidelines to provide cover, and protect winter range, reproductive areas, and secure habitat (FW-GDL-WLBG01-03). Combined with coarse-filter plan components to protect ecological integrity through management of key ecological characteristics as described above, these specific plan components for big game are expected continue to support large, thriving herds of elk, as well as moose and deer, which would contribute to ungulate prey and carrion availability for grizzly bears.

A notable change in the revised plan alternatives from current plans is recognition of the distinctive roles and contributions of bison on the Custer Gallatin, with the inclusion of fine filter direction aimed at expanding bison presence (spatially and temporally) on the national forest. All revised plan alternatives include desired conditions that would support year-round presence of bison on the Custer Gallatin National Forest (FW-DC-WLBI-01, 02). Alternatives D and F go a step further with desired conditions for a year-round, self-sustaining population of bison on the national forest and in alternative F, in conjunction with Yellowstone National Park bison herds (FW-DC-WLBI-04). Alternatives B, C, E, and F contain guidelines to limit management-related impediments to bison movement to purposes associated with interagency agreements, whereas alternative D would allow no human-made impediments to bison movement (FW-GDL-WLBI-03). All revised plan alternatives include direction for strategic management of habitat to focus on areas within and near existing bison management zones (FW-GDL-WLBI-02), which would encourage natural progression of bison distribution on the national forest. Alternatives B, C, D, and F contain direction to resolve ongoing or potential bison-livestock conflicts within the bison management zones in favor of bison (FW-GDL-WLBI-01), which would promote full use of these zones by bison. Revised alternative inclusion of positive plan components for bison could improve availability of ungulate biomass for grizzly bears on the Custer Gallatin.

Under alternative F, plan components limiting impediments to bison movement would be applied within the grizzly bear recovery zone (FW-GDL-WLBI03). While it is not likely that bison would expand to fully occupy all potentially suitable habitat within current grizzly bear distribution on the Custer Gallatin during the life expectancy (approximately 15 years) of the revised plan, it is desirable and conceivable under revised plan direction that bison could expand beyond the current bison management zones within that timeframe. The grizzly bear recovery zone was selected as the area to focus bison management because it encapsulates current bison management areas as well as most of the Custer Gallatin lands within the estimated pre-European settlement distribution of Yellowstone bison (White et al. 2015). Limits are already in place to curb potential for bison conflicts with livestock (FW-STD-WLGB06), and there is adequate habitat to support a year-round self-sustaining population of bison within the grizzly bear recovery zone. Expanded spatial and temporal presence of bison on the national forest is a desired condition under the revised plan alternatives (FW-DC-WLBI01, 02 and 04). Managing towards this condition would benefit grizzly bears by increasing the amount of bison biomass on the forest to provide a food source for grizzly bears, through either direct predation or scavenging bison carcasses or parts left behind through natural mortality or hunter harvest. Alternatives D and F contain the most pro-bison direction of the revised plan alternatives, and therefore have the most potential to provide more bison as a food source for grizzly bears.

All revised plan alternatives contain components specifically designed to protect, restore, and ultimately increase the presence of whitebark pine, which is a key food source for grizzly bears (FW-GO-PRISK-01, and FW-GDL-PRISK-02). Revised alternatives also include a desired condition that whitebark pine communities are diverse and stable, leading to increased cone production and decreased susceptibility to competition, insects and disease (FW-DC-PRISK-02), as well as an objective for periodic treatment for the purpose of sustaining or restoring whitebark pine (FW-OBJ-PRISK-02). These components in the revised plan alternatives provide detailed, clear, and specific management direction aimed at maintaining or increasing whitebark pine across the landscape, rather than just inside the recovery zone. Collectively, the plan components for whitebark pine would promote restoration of whitebark pine in areas hard hit by recent insect and disease outbreaks, increase presence and dominance of the species, and increase trees size class and patch size of larger trees, which would result in greater seed production. Therefore, the revised plan alternatives are more proactive and specific than language in current plans, and resulting management would contribute more toward long-term persistence of this key food source for grizzly bears, both within and outside the recovery zone. Detailed analyses relative to this important food source for grizzly bears can be found in the Terrestrial Vegetation section of the environmental impact statement, under at-risk plant species and forested vegetation.

Finally, all revised plan alternatives include a goal to encourage Forest Service participation in interagency monitoring of key grizzly bear foods (FW-GO-WLGB-04), as well as monitoring items to follow trends of natural food sources for grizzly bears. The revised plan alternatives provide mechanisms for tracking general habitat conditions for providing key foods as well as overall conditions for plant and animal diversity to provide alternate food sources for grizzly bears (MON-PRISK-02, MON-VEGF-01, MON-VEGNF-01, MON-WL-01, MON-WL-06, and MON-WL-07). Monitoring is intended to help Forest staff determine whether management actions are moving the Custer Gallatin National Forest landscape toward desired conditions, as well as to provide indicators of downward trends for important food sources, so that plan components can be amended and associated management actions implemented if needed.

Habitat Connectivity

All revised plan alternatives contain a suite of plan components to provide habitat connectivity specifically for grizzly bears (FW-DC-WLGB02), as well as for wildlife in general with an emphasis on wide-ranging species such as large carnivores and wild ungulates (FW-DC-WL-05-07; FW-GO-WL-02, 03, 05; FW-STD-WL-02; FW-GDL-WL-01-05). The Greater Yellowstone Ecosystem grizzly bear population has likely been geographically and genetically isolated from other grizzly bear populations for 100 years or more (U.S. Department of the Interior 2017b). Maintaining or restoring habitat connectivity would facilitate grizzly bear movement between the Greater Yellowstone Ecosystem and the Northern Continental Divide Ecosystem, which are the two largest grizzly populations in the continental United States. Grizzly bear movement between these ecosystems would enhance the genetic diversity and related long-term persistence of one or both populations, which is a long-term management goal in all revised plan alternatives (FW-GO-WLGB01). Dispersal of bears between the Greater Yellowstone Ecosystem and Northern Continental Divide Ecosystem could also contribute to genetic diversity in other smaller grizzly bear populations over time as bears expand their range. Alternatives B, C, D, and F identify key linkage areas, which are specific areas most likely to provide habitat connectivity between large blocks of contiguous wildlife habitat, due to their geographic proximity to other blocks of public land, presence of secure habitat, and orientation on the landscape.

Alternatives B, C, D, and F would allocate portions of the Gallatin and Bridger mountain ranges as key linkage areas. Since there has been no evidence of recent genetic exchange between Greater Yellowstone Ecosystem and Northern Continental Divide Ecosystem grizzly bears (Haroldson et al. 2010), there is limited empirical data upon which to identify potential movement corridors for grizzly bears. However, current best available scientific information supports the key linkage areas identified in the plan as likely travel routes for grizzly bears (Walker and Craighead 1997, Cushman et al. 2009, Peck et al. 2017). Most recently, Peck et al. (2017) noted that grizzly bears from both the Greater Yellowstone and Northern Continental Divide ecosystems are expanding in distribution, such that the current closest proximity between the two ecosystems has recently come within the maximum dispersal range for male grizzly bears in the continental United States, making it more likely that successful grizzly bear dispersal between the two ecosystems could occur in the future. Based on grizzly bear location data and known grizzly bear use patterns for the two ecosystems, Peck et al. (2017) identified potential corridors linking the two ecosystems for grizzly bears, in which, the key linkage areas identified in alternatives B, C, D, and F are shown to be of high importance. Plan components that would limit new developments, impose timing restrictions on major disturbance factors, and preclude new overnight recreation events (FW-STD-WL-02; FW-GDL-WL-02-05) within key linkage areas would serve to maintain the ecological integrity of potential movement corridors for grizzly bears. In addition, because cross country mountain bike use has the potential to increase levels of habitat alteration, chance for conflict with wildlife, and displacement of wildlife (Quinn and Chernoff 2010), within the key linkage areas mountain biking is only suitable occur on approved system routes (FW-SUIT-WL-01). Restricting suitability to approved system trails will concentrate potential impacts and minimize the proliferation of user created routes which increase the footprint of human use on the landscape.

The Bridger Mountains portion of the key linkage area is a relatively small, isolated mountain range, surrounded by private and other non-federal lands that are currently used for agricultural, residential, and commercial purposes. Due to its small size, proximity to human development, and high levels of recreational use, the Bridger portion of the key linkage area has limited potential to support long-term or residential use by grizzly bears (Frey 2020a). A primary purpose of the key linkage areas is to facilitate movement of wildlife across administrative boundaries, with an emphasis on providing natural conditions and limiting human disturbance factors to promote long-range dispersal for genetic interchange (FW-DC-WL-05-07). Dispersal routes for wildlife do not necessarily need to provide for all life cycle needs of each species (Ament et al. 2014). Not only is the Bridger range small relative to the size of a typical grizzly bear home range, but given the high levels of human occupation and use surrounding and within the Bridger range, the area has greater potential for grizzly bear-human conflict than other parts of the Custer Gallatin (Frey 2020a), particularly if bears are defending food sources or dependent young. Therefore, the northern portion of the key linkage areas identified in alternatives B, C, D, and F, is not likely capable of supporting long-term or residential use by grizzly bears, nor is long-term occupation of this area by grizzly bears desirable from a management aspect. Rather, providing a relatively secure movement corridor to facilitate successful grizzly bear dispersal between the Greater Yellowstone and other grizzly bear ecosystems is the goal (FW-GO-WLGB-01).

The Bridger and Bangtail ranges are identified in the Northern Continental Divide Ecosystem Grizzly Bear Conservation Strategy as Management Zone 2, which indicates areas to be managed for opportunistic movement of grizzly bears between ecosystems. Management emphasis for Zone 2 of the Northern Continental Divide Ecosystem is conflict prevention through appropriate storage of potential bear attractants (Northern Continental Divide Ecosystem Subcommittee 2018). Although the current Gallatin Plan (alternative A) does not include specific direction for attractant storage, all Custer Gallatin lands within Northern Continental Divide Ecosystem Zone 2 are currently under a special order that mandates appropriate storage of food and other attractants. All revised plan alternatives include components (FW-DC-WL-08; FW-STD-WL-01) that would ensure the food storage order would remain in place, effectively minimizing potential for dispersing grizzly bears to get into food-related conflicts with humans.

In addition to the Gallatin to Bridger connection, other potential movement corridors have been identified as likely routes for grizzly bears to move between ecosystems (Walker and Craighead 1997, Cushman et al. 2009, Peck et al. 2017). A considerable amount of National Forest System lands inside and outside the recovery zone on the Custer Gallatin is within designated wilderness. The revised plan alternatives all include plan land allocations for recommended wilderness and backcountry areas, which both contain land use restrictions that limit development (FW-STD-RWA/BCA All). Revised alternatives include plan land allocations of recommended wilderness and backcountry areas in juxtaposition with designated wilderness units and key linkage areas, thereby creating a well-connected system of low development areas within the Custer Gallatin to promote dispersal between the Greater Yellowstone Ecosystem grizzly bear recovery zone and other grizzly bear ecosystems. Furthermore, all revised plan alternatives include coarse filter plan components for managing vegetation toward conditions within the natural range of variation (FW-DC/STD/GDL-VEGF; FW-DC-VEGNF), including conditions related to patch size for forested habitats (FW-DC-VEGF06), which would contribute to maintenance or restoration of habitat connectivity, providing both foraging options and security cover for movement of grizzly bears.

The revised plan alternatives incorporate innovative and comprehensive measures to acknowledge, and proactively address the importance of wildlife habitat connectivity. However, regardless of management plan direction, there are still potential barriers to grizzly bear dispersal between ecosystems, including interstate and local highways, railways, agriculture and residential developments to name a few. These features are predominantly located outside the national forest boundary, and beyond the authority of the Custer Gallatin revised plan to manage. To address this factor, the revised plan alternatives include goals to work with Tribal, State, Federal, and other willing partners to continue to address the issue of linkage between grizzly bear ecosystems (FW-GO-WLGB-01; FW-GO-WL-02, 03; FW-GO-RT-03), which would include consideration of habitat connectivity outside the national forest boundary.

Consequences to Grizzly Bears from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Fire and Fuels Management

All revised plan alternatives contain desired conditions for the amount and severity of wildland fires to be within the natural range of variation to maintain resilient ecological conditions, and vegetation conditions that support natural fire regimes (FW-DC-FIRE-01, 02). Minimum impact suppression tactics are recommended to minimize natural resource damage (FW-GDL-FIRE-03). Grizzly bears evolved with and adapted to natural fire regimes in the Greater Yellowstone Ecosystem, and benefit from the habitat diversity created by fires burning within natural regimes. Hazardous fuel reduction projects may be designed to change the natural structure and function of vegetation over time (FW-GDL-FIRE-02), which could impact grizzly bears by reducing certain plant foods (such as berry-producing shrubs), and by reducing hiding cover used by grizzly bears and their prey species.

Generally, fuel reduction projects with long-lasting effects would be concentrated within or near areas that contain “values at risk,” which frequently include areas of high population densities such as residential areas and developed recreation sites. To minimize risk of grizzly bear-human conflicts, it is not desirable to manage habitat near areas of high human use to attract grizzly bears. Fuels reduction projects may occur in other areas as well, but would generally be designed to promote more natural fire behavior patterns in the long run, with more temporary effects on bears. Minimum impact suppression tactics could be used to protect important grizzly bear habitat elements such as whitebark pine and riparian areas. As with vegetation management, fire and fuels management under the revised plan alternatives would have a greater emphasis on fire as a natural ecological process than under the current plans (alternative A).

Effects from Timber Management

Timber management can affect grizzly bears by altering habitat as well as through disturbance effects that can cause displacement of bears from suitable habitat, or modify grizzly bear behavior patterns in ways that could affect foraging effectiveness, energy reserves, and risk of being killed. The primary factor related to timber harvest that would affect grizzly bears is the need for new road access, which could affect secure habitat for grizzly bears. As noted in the affected environment description, a number of bear management subunits on the Gallatin portion of the national forest are above established baselines for secure habitat. Road construction required for timber management would be allowed in those subunits, and timber harvest projects could result in relatively large, local reductions in secure habitat, which could negatively affect grizzly bears in the project area. The Gallatin Forest Travel Management Plan requires project roads such as those built for timber harvest, to be temporary, effectively gated to restrict public use, and decommissioned after the project is complete. The revised plan alternatives are consistent with direction that temporary roads should be located and constructed to facilitate removal and restoration following project use (FW-GDL-RT-02). Timber harvest and associated road building could also occur in bear management subunits that are at baseline levels, with temporary reductions in secure habitat, but impacts to secure habitat would be limited in size and duration (FW-STD-WLGB-03).

The 2012 Planning Rule requires identification of lands that are suited and not suited for timber production based on a variety of factors. Timber production is defined as the purposeful growing, tending, harvesting, and regeneration of regulated crops of trees to be cut into logs, bolts, or other round sections for industrial or consumer use. Therefore, on lands identified in the revised plan as suitable for timber production (also known as “the suitable base”), active vegetation management and some regular flow of timber products is expected to occur. Under all revised plan alternatives, the area suitable for timber production would decrease compared to current plans (alternative A). Within the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas where grizzly bears are currently known to occur, the revised plan would reduce the acreage that is suitable for timber production from approximately 14 percent under current plans (alternative A) to approximately 12 percent in alternatives B, E, and F; and to 11 percent in alternatives C and D. All alternatives leave the vast majority of the landscape in areas not suitable for timber production. Given the configuration of land use designations such as wilderness areas, the majority (roughly 65 percent) of the suitable timber base in the Absaroka Beartooth Mountains and the Madison, Henrys Lake, and Gallatin Mountains Geographic Areas is located outside the grizzly bear recovery zone in all alternatives.

Timber harvest for the purpose of timber production may use even-aged regeneration harvest in which all or nearly all of the trees are removed, or uneven aged regeneration harvest, which typically removes the majority of trees, but leaves groups or individual trees behind for seed source or other purposes. Timber harvest reduces forest cover for bears and prey species, but can also result in increased forage for bears and their prey species, when removal of forest canopy allows more sunlight to reach the ground, stimulating growth of grasses, forbs, and shrubs. Timber harvest may also occur outside the suitable base, but only for resource management needs other than timber production. Such purposes might include vegetation restoration, fuel reduction, wildlife habitat improvement, or other resource management. These types of projects often use prescriptions that generally remove smaller trees for purposes such as promoting individual tree growth, removing ladder fuels, or targeting improvement of particular tree species (such as aspen and whitebark pine). Timber harvest is not allowed in designated wilderness, and plan land allocations of recommended wilderness would not be suitable for timber harvest for any purpose. Other allocations such as the backcountry areas would allow vegetation management, including timber harvest, for purposes such as fuels reduction, restoration, or wildlife habitat enhancement.

Timber harvest, whether for timber production or for other resource management purposes, would have short-term disturbance impacts to grizzly bears, due to added noise and disturbance from road construction and use, as well as timber felling, collecting and transport. However, timber harvest can also result in short- and long-term benefits to bears, particularly when used for ecological restoration purposes. Timber harvest could be used to move vegetation structure and pattern toward desired conditions, which may benefit bears in the long term by providing conditions closer to those that bears have evolved with and adapted to over time. Timber harvest could also be used to maintain or restore aspen or create openings, to benefit grizzly bear prey species such as elk and bison, or to maintain or restore whitebark pine, which is a key food source for grizzly bears.

Effects from Plan Land Allocations

Designated areas such as wilderness, wilderness study areas, and inventoried roadless areas are created by authorities outside of the Forest Service and are not expected to change under the revised plan. However, the revised plan alternatives apply additional land use allocations within the existing wilderness study area and much of the existing inventoried roadless areas across the Custer Gallatin National Forest, thereby perpetuating generally protective land management strategies in these areas, and sometimes imposing added restrictions. For example, new energy and utility structures, commercial communication sites, recreation events, and extraction of saleable mineral materials, would not be allowed in plan land allocations of recommended wilderness or backcountry areas under any of the revised plan alternatives (FW-STD-RWA-02-06; FW-STD-BCA-01-04); whereas some or all of these activities could occur in inventoried roadless areas under current plans (alternative A), if they could be accomplished without the need for new road construction.

Under all revised plan alternatives, recommended wilderness areas would not be suitable for timber harvest for any purpose (FW-SUIT-RWA-01), whereas timber harvest would be allowed for fuel reduction or ecological restoration in backcountry areas (FW-SUIT-BCA-01), allowing more flexibility than recommended wilderness for restoration efforts to improve grizzly bear habitat, such as mechanical treatment to restore whitebark pine. Under current plans (alternative A), certain types of timber harvest are allowed for a variety of reasons in inventoried roadless areas, so long as no new road construction is required. In the revised plan alternatives, recommended wilderness areas would not be suitable for permitted livestock grazing in areas where it is not currently allowed (FW-SUIT-RWA-05), whereas new livestock allotments are not prohibited in backcountry areas, or inventoried roadless areas.

In alternatives C, D, and F, motorized and mechanized transport would no longer be suitable in recommended wilderness areas (FW-SUIT-RWA-02), but existing motorized and mechanized transport would continue to be suitable in alternative B. In all revised plan alternatives, summer or winter motorized transport would not be suitable in most backcountry areas in the grizzly bear distribution area (AB-SUIT-BCBCA-01, MG-SUIT-SCBCA-01, MG-SUIT-LHBCA-01, MG-SUIT-WPBCA-01). The exception would be in the Buffalo Horn Backcountry Area, where existing motorized transport would continue to be suitable (MG-SUIT-BHBCA-01).

Mechanized transport would be suitable in most backcountry areas in the grizzly bear distribution area in all revised plan alternatives, but mountain biking would be suitable only on approved system routes in alternative F (MG-SUIT-SCBCA-01, MG-SUIT-LHBCA-01, MG-SUIT-BHBCA-01, MG-SUIT-WPBCA-01). Recommended wilderness areas would generally not be suitable for rental cabins (FW-SUIT-RWA-06) and one such cabin, Windy Pass cabin, which is in the wilderness study area and inventoried roadless area, would come off the public rental program, and be available for administrative use only in alternatives B, D, and F. This cabin would stay open to the public in alternatives A and E since they do not allocate the area for recommended wilderness, and also in alternative C, which does include an allocation for recommended wilderness, but adds an exception for the Windy Pass Cabin. Of the revised plan alternatives, alternative D has by far the greatest amount of recommended wilderness in areas occupied by grizzly bears. Alternatives B, C, and F have similar amounts of recommended wilderness and backcountry areas, but in differing combinations. Alternative E has no recommended wilderness, but would allocate the wilderness study area and Lionhead area as backcountry areas. Collectively, added restrictions associated with plan land allocations of recommended wilderness and backcountry area, are generally more restrictive than existing land uses allowed in wilderness study areas and inventoried roadless areas, in ways that could benefit grizzly bears both within and outside the recovery zone, due to lower human disturbance effects to grizzly bears in these areas.

Effects from Recreation Management

Recreation emphasis areas are plan land allocations that typically offer a variety of recreation opportunities, including motorized and non-motorized uses. These areas may be regional, national, or international destinations, and are often close to human population centers. As such, recreation emphasis areas may have relatively high densities of roads, utilities, and trails, with associated high levels of human use. Under all alternatives, grizzly bear direction (FW-STD-WLGB-01-05) would limit the amount of new development added to recreation emphasis areas inside the recovery zone, except where they overlap with designated site footprints or primary road buffers in alternative F. However, outside the recovery zone, new roads, trails, and developed sites could be added in recreation emphasis areas, which could accommodate and perhaps attract higher levels of human use. Additional human use in recreation emphasis areas could increase human disturbance levels, which could displace some bears from otherwise suitable habitat. However, recreation emphasis areas are located in areas that already receive high levels of human use, and are likely already avoided by wary bears. Management focus on recreation in these areas would continue to concentrate human use, rather than encouraging recreationists to disperse over larger areas. Unmanaged dispersed use could increase the potential for grizzly bear-human conflicts over the broader landscape. As a result, effects of recreation emphasis area allocations are not expected to increase notably from existing conditions, and could help to manage potential grizzly bear-human conflicts by concentrating human use in areas and ways that are predictable to bears, and can therefore be avoided. Revised alternatives identify recreation emphasis areas both inside and outside of the grizzly bear recovery zone.

All revised plan alternatives except alternative D include recreation emphasis areas inside the recovery zone that emphasize winter use. These include the Hebgen Lake Basin, and area around Cooke City, which both receive high levels of recreation use year-round. However, these are destination areas for winter use on the Custer Gallatin, where snowmobile use has been popular for many years, facilities are already in place, and human use is already concentrated. While these areas receive no plan land allocation for recreation emphasis in alternative D, there are no provisions in alternative D that would change the levels or types of use, or make these areas less attractive for winter recreation. Winter use in recreation emphasis areas should have limited impacts to grizzly bears since most of the associated human use would occur when grizzly bears are denning.

Podruzny et al. (2002) looked specifically at potential conflicts between snowmobile use and grizzly bear den sites on the Gallatin portion of the national forest, which includes the winter recreation emphasis areas inside the recovery zone as well as other suitable denning habitat. They found that grizzly bear denning habitat is abundant, and due to the large proportion of wilderness and other areas where snowmobile use is either restricted or limited by terrain, a relatively small proportion of suitable denning habitat is vulnerable to impacts from snowmobile use. There is limited information regarding the effects of winter recreation on grizzly bears. However, there is evidence that human disturbance near an occupied grizzly bear den site may result in den abandonment, with potential adverse effects to the bear due to increased energy expenditures during a vulnerable time. This may be particularly stressful for females, since cubs are born in the winter dens, and den abandonment could result in loss of cubs (Fortin et al. 2016).

On the other hand, there is evidence of high tolerance to disturbance from snowmobile use at a den site occupied by a reproductive female grizzly bear in the Greater Yellowstone Ecosystem, with no obvious negative impacts to the sow or her cub (Hegg et al. 2010). Grizzly bears tend to select den sites in remote locations where human occupation and use is relatively low, but den site location may be more related to elevations and slopes that produce stable snow conditions for adequate insulation, rather than avoidance of humans (Linnell et al. 2000). This conclusion is supported by the selection of a den site by a reproductive female grizzly within 500 meters of a state highway in the Greater Yellowstone Ecosystem (Hegg et al. 2010). Winter logging operations could also potentially have disturbance impacts on denning grizzly bears (Linnell et al. 2000). This factor may be tempered by economic and safety reasons, as road plowing is costly and winter logging and hauling can be hazardous. Although winter recreation use or resource management near a grizzly bear den site could negatively affect bears at the site, human use near known grizzly bear den sites is monitored under the conservation strategy, with no evidence of den abandonment or grizzly bear-human conflict as yet on the Custer Gallatin National Forest (Montana Fish Wildlife and Parks 2013); (Haroldson 2019). In accordance with the conservation strategy, the revised plan alternatives stipulate that where otherwise allowed (for example, outside of designated wilderness), non-wheeled over-snow motorized use is suitable in otherwise secure habitat for grizzly bears during the winter denning season, unless such use results in grizzly bear den abandonment, bear-human conflicts shortly after den emergence, or new research identifies a threat (FW-SUIT-WLGB01). Therefore, while the revised plan alternatives would allow such use to continue, monitoring will also continue, and the plan would provide a mechanism for appropriate response should conflicts between denning bears and winter human use become an issue.

Ski areas can result in permanent habitat alterations, which could influence grizzly bear den site selection, as well as affect grizzly bear habitat use during the non-denning season. There are two alpine ski areas operating under special use permit on the Custer Gallatin National Forest. Both are located outside of the grizzly bear recovery zone, with one being outside the current known distribution area for grizzly bears. Under all revised plan alternatives, developed site plan components adopted from the grizzly bear conservation strategy would preclude development of new ski resorts within the grizzly bear recovery zone without appropriate mitigation (FW-STD-WLGB-04 and 05). Recreation plan components in the revised plan alternatives require that new downhill ski areas be considered only if existing ski areas could not be expanded to accommodate additional use (FW-STD-RECSKI-01), and that new activities associated with ski resorts be located at existing permitted areas unless those areas cannot be modified to accommodate such uses (FW-GDL-RECSKI-01). Collectively, these plan components would serve to concentrate habitat alterations and human activities associated with permitted ski areas outside the grizzly bear recovery zone, in areas already developed for skiing, which would minimize potential loss of suitable denning habitat for grizzly bears, and continue to concentrate potential disturbance impacts.

All revised plan alternatives include direction (FW-GDL-RECEVENT-02) that would prevent authorization of recreation events involving people traveling by foot, horse or non-motorized vehicle inside the recovery zone between sundown and sunrise. In addition, new nighttime recreation events would be prohibited in key linkage areas outside the recovery zone (FW-STD-WL-02). These provisions would minimize potential for surprise encounters with grizzly bears associated with humans moving quietly through core grizzly bear habitat at night, as well as to increase temporal options for grizzly bears to use secure dispersal routes.

Effects from Energy and Minerals Management

Energy and minerals management could affect grizzly bears through reductions in secure habitat due to additional road access, or through additions of developed sites with associated noise and human presence. Inside the grizzly bear recovery zone, grizzly bear plan components in all alternatives would limit the extent of these potential effects. Even where mineral access (such as locatable minerals) is guaranteed by law, grizzly bear plan components would require mitigation for effects from new access or developed sites related to mineral development inside the recovery zone (FW-STD-WLGB-02f).

Outside the recovery zone, new minerals and energy developments would not be restricted by grizzly bear-specific plan components. However, all revised plan alternatives contain desired conditions to restore site productivity following mineral activities (FW-DC-EMIN-01), and include standards for reclamation to achieve the desired condition (FW-STD-EMIN-01). These plan components indicate that energy and mineral management effects would be temporary, and eventually areas affected would be restored. However, minerals and energy development activities can last years or decades, which could have long-term impacts on grizzly bears, resulting in under use of otherwise suitable habitats. Much of the grizzly bear distribution area inside and outside the recovery zone is within designated wilderness, the wilderness study area, or inventoried roadless areas that restrict certain activities such as road building and construction of permanent facilities that would limit the amount of development associated with energy and minerals in areas suitable for grizzly bears.

The majority of minerals operations on the Custer Gallatin are located in the Stillwater complex, which is just outside the recovery zone in the Absaroka Beartooth Mountains Geographic Area. This area has shown high potential for continued mineral development. Alternatives B, C, E, and F contain a plan land allocation emphasizing minerals management in the Stillwater complex. Alternative D has no plan land allocation for mining emphasis, and instead would allocate some of the area surrounding the Stillwater complex as recommended wilderness, which would help conserve secure habitat for grizzly bears outside the recovery zone. However, in certain circumstances, access for mineral operations could still be allowed in recommended wilderness, although there could be additional mitigation measures, such as timing restrictions, road locations, or other considerations for resource protections under alternative D. Aside from added protections for secure habitat in alternative D, effects to grizzly bears from minerals management would be similar under all alternatives.

Effects from Roads and Trails, Facilities and Aircraft Management

Inside the grizzly bear recovery zone, the grizzly bear plan components in all alternatives dictate how roads, motorized trails, facilities, and aircraft use could affect grizzly bears (see previous discussion relative to secure habitat). Beyond the grizzly bear direction, the revised plan alternatives contain specific plan components for infrastructure including a desired condition that the Custer Gallatin National Forest transportation system has minimal impacts on threatened species (FW-DC-RT-01). The revised plan alternatives include guidelines for use of available technology to reduce resource impacts, and strategic location of infrastructure where possible (FW-GDL-RT -01, 02), as well as standards for avoidance or minimization of impacts to water quality and riparian and wetland habitats (FW-STD-RT-01-05). These plan components would ensure consideration for grizzly bears when new roads or other facilities are being considered outside of the recovery zone, and would protect riparian areas, which can provide forage, cover, and travel routes for bears.

The Forest manages hundreds of miles of system trails in areas occupied by grizzly bears. Human presence, including motorized and non-motorized use, may have disturbance impacts on grizzly bears, potentially causing bears to underutilize otherwise suitable habitats. Also, there is potential for bear-human conflicts that may result from encounters between bears and humans along trails. Such conflicts can result in direct mortality of grizzly bears through human defense of life, or indirect mortality if subsequent management actions result in removal of the offending bear(s) from the wild. Mountain bike use on National Forest System trails and potential for associated bear-human conflicts is an emerging concern. Compared with other forms of recreation, there is less understanding on the ecological effect of mountain biking. Effects are usually expected to be similar to other non-motorized uses such as hiking or horseback riding and focus on habitat alteration as a result of impact to soils and vegetation, as well as disturbance of daily or seasonal habitat use (Quinn and Chernoff 2010). The significance of the disturbance is related to the type, timing, intensity, duration, and spatial distribution of use (Quinn and Chernoff 2010). One key feature of mountain biking is the speed and relatively quiet nature of the activity. Research has shown that mountain bike use can impact wildlife, particularly since people on bikes can move more quickly than non-mechanized travel, and more quietly than motorized travel, resulting in higher potential for a surprise encounter with grizzly bears (Quinn and Chernoff 2010). Mountain bike use, like many other forms of recreation, is increasing in many parts of the Custer Gallatin, including areas currently occupied by grizzly bears. To date, there have been two reported incidents of surprise encounters between mountain bikers and grizzly bears on the Custer Gallatin that have resulted in minor injuries to the bikers, but with no known injuries or subsequent management actions for the bears involved (Frey 2020b). The revised plan encourages bear awareness information availability for forest users, resulting in reduced bear-human conflicts (FW-DC-WLGB03). Mountain bike use is not allowed in designated wilderness, and would not be suitable in recommended wilderness (FW-SUIT-RWA02) in alternatives C, D, and F, which would limit potential for bear-biker conflicts in the majority of the area where grizzly bears currently occur on the Custer Gallatin National Forest. In alternative F, mountain bike use would be suitable only on approved system routes in backcountry areas and key linkage areas (MG-SUIT-SCBCA-01, MG-SUIT-LHBCA-01, MG-SUIT-BHBCA-01, MG-SUIT-WPBCA-01, FW-SUIT-WL-01), which would limit mountain bike use of user-created routes in those areas. Key linkage areas have been designated with the purpose of maintain, restore, or enhance habitat connectivity (FW-GDL-WL-02). Cross country mountain bike use has the potential to increase levels of habitat alteration, chance for conflict with wildlife, and displacement of wildlife (Quinn and Chernoff 2010). These impacts may reduce the effectives of the key linkage area in facilitating connective across the landscape. Restricting suitability to approved system trails will concentrate potential impacts and minimize the proliferation of user created routes which increase the footprint of human use on the landscape.

Under all alternatives, the area within the recovery zone would not be suitable for new public airfields (FW-SUIT-AIRFIELDS-01), which would benefit grizzly bears by effectively limiting noise and disturbance associated with public aircraft landing or takeoff in areas that may otherwise be secure for grizzly bears. Grizzly bear plan components for all revised plan alternatives would allow landing and takeoff of aircraft (helicopters) inside the recovery zone for administrative use, but would limit such use for planned project implementation to no more than two days per project. Helicopter use for emergency response would be allowed as needed (FW-SUIT-WLGB-01b). Occasional helicopter use for administrative purposes could have negative impacts on individual bears, but such impacts would be limited by plan direction and therefore effects would be temporary. Outside the recovery zone, revised plan alternatives would restrict public recreational aircraft landing and take-off to designated sites, which would be constructed, maintained, and operated through partnerships (FW-STD-AIRFIELDS-01, 02). Public airfields could only be located in areas where such use would not be otherwise prohibited; in other words, such facilities would be located outside of designated wilderness, recommended wilderness and a number of other areas under all revised plan alternatives.

Cumulative Effects

Land management plans for areas adjacent to the Custer Gallatin National Forest could have cumulative effects with proposed direction for the Custer Gallatin National Forest. Greater Yellowstone Ecosystem national forests adjacent to the Custer Gallatin, including the Beaverhead-Deerlodge to the west, and the Shoshone National Forest to the southeast, have revised or amended their plans to incorporate habitat management direction from the Greater Yellowstone Ecosystem Grizzly Bear Conservation

Strategy, making plan direction for these national forests consistent with grizzly bear direction on the Custer Gallatin under all alternatives. The Caribou-Targhee National Forest to the southwest reverts to 1997 direction, which does not directly incorporate conservation strategy recommendations, but follows grizzly bear guidelines from the mid-1980s and access recommendations from the mid-1990s. It also adds specific plan components for maintaining secure habitat in certain areas, phasing out domestic sheep grazing allotments and requiring proper storage of food and attractants, which collectively, are consistent with language in the Custer Gallatin grizzly bear components and would result in similar protections for grizzly bear habitat and promote connectivity across the Greater Yellowstone Ecosystem.

Yellowstone National Park appended habitat standards to the Park Superintendent's Compendium, ensuring management consistent with the Greater Yellowstone Ecosystem Grizzly Bear Conservation Strategy, while the states of Montana, Idaho, and Wyoming also incorporated regulatory mechanisms for consistency with demographic recovery criteria (U.S. Department of the Interior 2017b). In addition to these Greater Yellowstone Ecosystem land managers, the Helena Lewis and Clark National Forest to the north is in the process of amending their plans to incorporate management direction from the Northern Continental Divide Ecosystem Grizzly Bear Conservation Strategy, which is also compatible with Custer Gallatin National Forest proposed grizzly bear direction under all alternatives. These protections may help contribute to connectivity of populations between ecosystems and genetic diversity in other smaller grizzly bear populations over time as bears expand their range.

The state of Montana has hunter education programs to inform big game hunters how to minimize potential conflicts with grizzly bears in the field, and to help black bear hunters distinguish between grizzly bears and black bears in order to minimize potential for grizzly bear mortality due to mistaken identity. State wildlife biologists and game wardens also help enforce food storage orders to minimize potential bear-human conflicts. State agency personnel also work directly with livestock producers to implement measures to reduce the risk of grizzly bear depredations on livestock and subsequent management related removals of grizzly bears. State personnel were also instrumental in working with some counties in southwestern Montana to establish proper food storage measures on private lands. Non-governmental organizations have also been involved in providing public education about living with grizzly bears, contributing to sanitation measures (for example, bear-proof dumpsters and food storage containers on public and private lands), and working with willing permittees to retire domestic livestock grazing allotments in grizzly bear habitat.

Montana Fish Wildlife and Parks manage a general hunt for bison, and a number of Tribes conduct bison hunts on public land. Since hunting is not allowed in the national parks for either indigenous peoples or the public, bison hunting that occurs in the Greater Yellowstone Ecosystem occurs primarily on the Custer Gallatin National Forest. Hunting of bison provides gut piles and carcass remnants, and to a lesser degree entire carcass in the even that an animal is shot and not retrieved. Bison remnants from hunting attract grizzlies, and if managed properly, could be an important food source for grizzly bears on the Custer Gallatin in the future. Currently, any plans to allow hunting of grizzly bears as a big game species in the states of Wyoming, Idaho, and Montana have been suspended with the relisting of the Greater Yellowstone Ecosystem grizzly population as a threatened species.

Forestry management on state and private lands can affect grizzly bears by altering habitat and causing noise disturbance, but primarily through reductions in secure habitat associated with new road construction for accessing timber. There is only one section of State Trust land inside the Custer Gallatin National Forest boundary that is managed for timber production, and it is located well outside the grizzly bear recovery zone. Inside the recovery zone, state-owned lands are in wildlife management areas, where species conservation is the highest management priority. The City of Bozeman owns several (5 plus) sections of land outside the recovery zone, but within grizzly bear distribution, and these lands are primarily managed for municipal water resources. Forestry management on city lands may also affect grizzly bears through habitat alteration, disturbance factors, and road construction.

Human population growth is increasing at a dramatic rate in the Greater Yellowstone Area, including communities within and near the Custer Gallatin National Forest. Large-scale permanent developments to accommodate human population growth could occur on non-Federal lands, with associated potential for adverse effects on grizzly bears and their habitats. All Montana Counties overlapping grizzly bear distribution in southwest Montana have growth policies in place, most of which contain goals to protect important wildlife habitats, while providing safety for residents and protecting economic interests. County growth policies are not regulatory, and therefore, would not preclude or restrict residential or commercial development on private lands, but may impose mitigation measures through subdivision review and approval processes.

Conclusion

In summary, the grizzly bear direction adopted from the Greater Yellowstone Ecosystem Grizzly Bear Conservation Strategy (Yellowstone Ecosystem Subcommittee 2016a) would ensure that the Custer Gallatin National Forest continues to contribute to grizzly bear recovery under all alternatives by limiting known stressors within the grizzly bear recovery zone. However, compared to current plans (alternative A), all revised plan alternatives would improve management for grizzly bears in a number of ways. All revised plan alternatives would provide clear, consistent grizzly bear direction and a coordinated monitoring plan for both the Custer and Gallatin portion of the recovery zone. To further emphasize the management commitment, all revised plan alternatives add a standard to maintain a special order for effective storage of food and other attractants, as well as a guideline to restrict nighttime special use recreation event activities inside the recovery zone, both of which would help to minimize grizzly bear-human conflicts, and thereby, reduce morality risk for bears.

In addition to grizzly bear-specific direction applied inside the recovery zone, all revised plan alternatives include plan components for other resources that would benefit grizzly bears inside and outside the recovery zone. Vegetation management components emphasize habitat composition, structure, and function within the natural range of variation to which grizzly bears have adapted over time, which would maintain habitat diversity and provide a variety of food items for grizzly bears. All revised plan alternatives would give more specific and affirmative direction for management of important grizzly bear habitat elements such as whitebark pine and riparian areas. All revised plan alternatives contain plan components for managing big game habitat, including specific direction for management of bison, which would maintain a supply of ungulate biomass as a food source for grizzly bears. Revised plan alternatives include grazing plan components that would influence how livestock are managed, which would reduce the risk of grizzly bear mortalities associated with livestock depredations. Importantly, all revised plan alternatives specifically and proactively address habitat connectivity for wildlife, including allocation and management of key linkage areas in alternatives B, C, D, and F, which would facilitate grizzly bear movement between ecosystems. Finally, the revised plan alternatives contain an array of plan land allocations that vary by alternative, but would add management restrictions in most cases that would benefit grizzly bears, particularly outside the recovery zone.

Northern Long-Eared Bat (*Myotis septrionalis*)

The northern long-eared bat ranges across eastern and north-central United States, to the eastern edge of Montana. If the northern long-eared bat occurs on the Custer Gallatin National Forest, it would be most likely in the Sioux and Ashland Geographic Areas. However, at the time this analysis was prepared, there were no verified occurrences of this species on the Custer Gallatin National Forest (Bachen 2019). Rangewide, the northern long-eared bat is typically found in coniferous and deciduous forested habitat during summer, and hibernating in caves, mines, and other structures during winter. This species has experienced recent dramatic population declines due to the spread of white-nose syndrome, a disease that primarily affects bats in their winter hibernacula. As a result, the U.S. Fish and Wildlife Service listed the northern long-eared bat as a threatened species in April 2015 (U.S. Department of the Interior 2015e).

In 2016, the U.S. Fish and Wildlife Service followed up with a final rule under section 4(d) of the Endangered Species Act. The 4(d) rule "prohibits purposeful take of northern long-eared bats throughout the species' range" with few exceptions for public safety. However, incidental (unintentional) take resulting from legal activities was not prohibited (exempted) in areas not yet affected by white-nose syndrome. Areas not yet affected include those areas that are at least 150 miles from a county where there is confirmed evidence of white-nose infection in bats. Areas within 150 miles of a county with confirmed detection are considered within the white-nose syndrome zone. Critical habitat has not been designated for the northern long-eared bat, because the U.S. Fish and Wildlife Service determined that identifying such areas (known hibernacula) could actually increase the likelihood of threat from disturbance, vandalism, or introduction of pathogens (U.S. Department of the Interior 2016d).

The 2015 Final Rule listing the northern long-eared bat as threatened was challenged in District Court. The court remanded, but did not vacate the U. S. Fish and Wildlife Service listing decision. Therefore, at the time this document was completed, the northern long-eared bat remains a threatened species that may be present on the Custer Gallatin National Forest, and the recent District Court ruling has no bearing on analyses for the northern long-eared bat.

Analysis Area

Northern long-eared bats have not been verified as present on the Custer Gallatin. As mentioned previously, the species may be present in the Sioux and Ashland Geographic Areas, but has not been positively identified in surveys conducted in those areas (Bachen 2019). These geographic areas are at the western edge of the species' range and also represent the extent of suitable summer habitat for the northern long-eared bat on the Custer Gallatin National Forest. Therefore, the Sioux and Ashland Geographic Areas were used as the analysis area for this species.

Notable Changes between the Draft and Final Environmental Impact Statements

In addition to minor clarifying language in plan components, a goal was added to all revised plan alternatives for Forest Service participation in the development, maintenance and implementation of bat monitoring protocols and white-nose syndrome prevention guides (FW-GO-WLBAT-01). A guideline was modified to allow vegetation management around a known bat hibernacula for purposes of improving bat habitat (FW-GDL-WLBAT-01). These changes and other modification to plan components were evaluated for all revised plan alternatives, including alternative F.

Affected Environment (Existing Conditions)

Although the northern long-eared bat has not yet been verified as present on the Custer Gallatin National Forest, it is relatively common in the Black Hills of South Dakota (U.S. Department of the Interior 2015e), which is roughly 50 air miles southeast of the Sioux Geographic Area. The species has also recently been confirmed in Dawson County, Montana, roughly 100 air miles north of the Sioux Geographic Area (Montana Natural Heritage Program). At the time this analysis was prepared, neither white-nose syndrome nor the fungus that causes it had yet been detected in bats on the Custer Gallatin National Forest. However, in 2018, the pathogen that causes the disease was detected in South Dakota and Wyoming, and a bat (though not a northern long-eared bat) with white-nose syndrome was found shortly thereafter in the Black Hills of South Dakota (Krake et al. 2018). While this confirmed infection was still some distance away from the Custer Gallatin, the Sioux Geographic Area is now within the white-nose syndrome zone (U.S. Department of the Interior 2018a), and therefore, the 4(d) rule exemptions for incidental take of northern long-eared bats no longer apply in the Sioux Geographic Area.

Northern long-eared bats spend summer in deciduous and coniferous forest. The Ashland and Sioux Geographic Areas are dominated by coniferous (ponderosa pine) forest. Deciduous tree species are limited to riparian areas and woody draws, which are minor habitat components in the analysis area. In summer, northern long-eared bats use forested areas where they can find suitable roosts in trees at least 3 inches in diameter, either singularly or in colonies, under loose bark, in crevices, or in cavities of both live and dead trees. Roost trees used by maternity colonies typically range from 4 to 10 inches in diameter. Males and non-reproductive females may also roost in cooler sites such as caves or mines if available, and the species will occasionally roost in barns or abandoned buildings if trees are not available (U.S. Department of the Interior 2015f). The majority of known roosts for this species have been found in hardwood tree species in eastern North America. Where roosts have been found in coniferous forest habitats, the majority of roost sites were found in snags rather than live trees (Perry and Thill 2007). In the Black Hills of South Dakota, this species has been documented to use ponderosa pine snags for roosting (Cryan et al. 2001). Most studies to date suggest that hardwood trees are most likely to provide the characteristics of roost sites preferred by maternity colonies and groups of female bats (U.S. Department of the Interior 2015f).

Large wildfires in 2012 produced an abundance of snags, most notably in the Ashland Geographic Area. There have been numerous small fires in these geographic areas since then, but they have not been as large or severe. Burned snags may provide roosting habitat for bats, but generally, some degree of live tree canopy is found near roost sites (U.S. Department of the Interior 2015f). In addition to green and burned ponderosa pine forest, there are smaller inclusions of deciduous trees, most notably cottonwood, aspen, and green ash found in riparian areas and woody draws. Rimrock cliffs in these areas are riddled with cracks, crevices, and small holes that may also provide suitable summer roosting habitat for northern long-eared bats.

Northern long-eared bats are a nocturnal, insectivorous species, feeding on moths, flies, beetles, and other insects by capturing insects in flight or picking them off vegetation. Most foraging occurs within forested areas below the forest canopy, but above understory vegetation. Northern long-eared bats will also forage within small forest openings, near water and along roads (U.S. Department of the Interior 2015f). Ponderosa pine forests, woody draws, and riparian areas likely provide the best foraging habitat for northern long-eared bats in the analysis area.

There are no known winter hibernacula for this species in the analysis area. Northern long-eared bats typically use large caves with large entrances and passages for hibernacula, and are often found in areas of highest humidity within the cave (U.S. Department of the Interior 2015f). Caves in the Ashland and Sioux Geographic Areas are primarily wind-formed. They typically do not contain extensive passageways, and are generally dry (they lack hydrologic features and maintain low humidity). Only two small caves are known in the Ashland Geographic Area. While there are numerous small caves in portions of the Sioux Geographic Area, there are no known large caves or active or abandoned underground mines present that might serve as winter hibernacula for bats within the analysis area.

While there are no known winter hibernacula used by northern long-eared bats in the analysis area, there are known hibernacula in the nearby Black Hills of South Dakota. Unfortunately, the fungus that causes white-nose syndrome was found in Badlands National Park in South Dakota and the Fort Laramie National Historic Site in eastern Wyoming in spring of 2018. Then, in early June 2018, a different species of bat in the Black Hills National Forest in South Dakota was confirmed to be infected with white-nose syndrome (Krake et al. 2018).

Key Stressors

The primary threat to the northern long-eared bat is from white-nose syndrome. The northern long-eared bat appears to be one of the most highly susceptible species to this disease. However, it also seems that the northern long-eared bat is less common, or even rare at the western edge of its range (U.S. Department of the Interior 2015f). The bat with white-nose syndrome recently found in South Dakota was not a northern long-eared bat. Rather, it was a long-legged bat (*Myotis volans*), which is a western bat species, whereas previously this disease had affected primarily eastern bat species (Krake et al. 2018). Bats are also susceptible to other diseases such as rabies. While northern long-eared bats have been reported with rabies infection, this disease (unlike white-nose syndrome) has not been shown to have notable effects to northern long-eared bats at the population level (U.S. Department of the Interior 2015f).

Human activities can affect bats, and although white-nose syndrome is transmitted primarily by bat-to-bat contact, there is some evidence that suggests that the fungal spores associated with white-nose syndrome can also be transmitted by humans. Humans are not only potential vectors of white-nose syndrome, but also can create noise and disturbance that may impact bats at summer roosts as well as in hibernacula. Such disturbance of bats infected with white-nose syndrome can often be fatal to the bats (U.S. Department of the Interior 2015f).

Forest management through timber harvest and prescribed burning can alter summer habitat for northern long-eared bats, and may even cause direct mortality of bats in some circumstances; however, population-level impacts generally are not expected except where the population is already affected by white-nose syndrome (U.S. Department of the Interior 2015f).

Environmental Consequences

Management Direction under the Current Plans

Management direction for the Ashland and Sioux Geographic Areas is contained in the Custer Plan. The current Custer Plan contains no management direction specific to northern long-eared bats. However, the plan calls for conservation of threatened and endangered species through coordination with the U.S. Fish and Wildlife Service. Under the current plan, a number of bat species (not including the northern long-eared) are identified as Forest Service or State-listed sensitive species, but with no specific plan direction for maintaining these species. Timber management direction is included to maintain a variety of tree age classes; design size, and shape of individual treatment units in consideration of other resource (including wildlife) objectives; limit the size of even-aged harvest units; manage insect- and disease-infected timber in coordination with other resources; and reserve snags (dead standing trees) for wildlife. The current plan allows for a variety of management responses to wildfire including control, contain, and confine. Prescribed fire is allowed where needed to improve wildlife habitat or for other resource needs. Finally, the current plan contains management direction to manage woody draws and riparian areas to provide for diverse vegetation and protect key wildlife habitat from conflicting uses.

Effects of the Current Plans

The primary threat to the northern long-eared bat is spread of white-nose syndrome, which primarily affects bats in winter hibernacula. Human disturbance of bats in hibernacula is also a potential threat, particularly when combined with effects of white-nose syndrome. White-nose syndrome was discovered in the United States after the current plan was developed, and there is no current plan direction to address this threat. However, there are no known winter hibernacula used by northern long-eared bats in the Ashland or Sioux Geographic Areas, and no known caves, abandoned mines, or other features that provide suitable habitat for bat hibernacula in the analysis area. Therefore, there would be no effect on hibernating northern long-eared bats under the proposed action.

Ponderosa pine forests, woody draws, riparian areas, and rock formations provide summer roosting and foraging habitats for northern long-eared bats. Timber harvest of live trees, as well as salvage of dead trees can reduce availability of suitable roost trees, alter foraging habitat, and potentially even result in direct mortality of bats if roost trees are removed when occupied by pups (young bats) that are not able to fly. Current plan direction somewhat addresses these impacts through requirements to coordinate timber management with other resource needs, as well as size limitations on clearcuts, and snag retention in harvest units. Intermediate timber management prescriptions designed to create or maintain a variety of tree age classes could create gaps in even-aged canopies that could improve foraging habitat for northern long-eared bats. Emphasis on managing insect and disease outbreaks in timber could impact bats by reducing potential insect prey availability and snags for roosting. Prescribed burning under current plan direction could affect summer roosting and foraging habitat in ways similar to timber harvest, except that more snags may be left behind after prescribed burning, which may provide some short-term suitable foraging habitat for bats, and may also increase suitable roost trees. Current plan direction for fire suppression is consistent with protecting important forested roosting and foraging habitats for northern long-eared bats.

Riparian habitats and woody draws would be managed under current plan direction in a manner that would maintain potential foraging areas for bats, although northern long-eared bats show a stronger foraging affinity to coniferous forest rather than riparian areas (U.S. Department of the Interior 2015f). Summer roosting habitat provided by cracks, crevices, and fissures in rock formations would be unaffected by management under current plan direction.

Management Direction under the Revised Plan Alternatives

All revised plan alternatives contain a desired condition for habitat that contributes to species recovery needs for federally listed species (FW-DC-WL-02). In addition, plan components specifically address the needs of bats, including the northern long-eared bat, as well as other species. All revised plan alternatives include a desired condition for maintaining bat species diversity and key bat habitats such as winter hibernacula and maternity roosts, to be free from disturbance and disease (FW-DC-WLBAT-01). A goal was added to revised plan alternatives for the Forest Service to engage with other agencies, Natural Heritage Programs, cavers, and other interested parties to develop, update, and implement bat monitoring protocols and white-nose syndrome prevention and response guides (FW-GO-WLBAT-01). All revised plan alternatives include a standard requiring agency-authorized personnel to use established decontamination procedures before entering and exiting any known winter bat hibernacula to prevent the spread of disease (FW-STD-WLBAT-01). An entire suite of guidelines was included in revised plan alternatives to maintain vegetation conditions that may contribute to microclimates within known bat hibernacula, protect maternal roost sites, avoid adding human disturbance in key habitats, avoid removal of facilities when bats are present, use bat-friendly methods when closing caves or mines for human safety, and protect bats and birds from mortality risk associated with new wind energy developments (FW-GDL-WLBAT-02-05; FW-GDL-WL-07).

Effects of the Revised Plan Alternatives

Transmission and spread of white-nose syndrome constitutes the greatest threat to bat populations on the Custer Gallatin National Forest including the northern long-eared bat. The revised plan alternatives specifically address the threat of white-nose syndrome by including desired conditions for winter hibernacula to be free from human disturbance and introduced diseased (FW-DC-WLBAT01). Revised plan alternatives would require all Forest Service employees and agency-authorized personnel such as contractors, researchers, permittees, and other cooperators to use established white-nose syndrome decontamination procedures before entering and exiting caves, abandoned mines, or other features known to be used as winter hibernacula by any bat species (FW-STD-WLBAT01). Even though there are no known winter hibernacula used by northern long-eared bats on the Custer Gallatin, there are known hibernacula used by other bat species outside the range of the northern long-eared bat. Bat species are often communal at winter hibernacula, with multiple species present in the same sites. Most bat species show some degree of fidelity to winter hibernacula (return to the same site each year), but may move to another hibernacula under certain conditions (Johnson and King 2018). Also, some bats can be carriers of the fungus that causes white-nose syndrome, but are not affected by the disease. Movement of bats between hibernacula may not be frequent, but could further the spread of white-nose syndrome. By minimizing potential for human introduction of disease into bat hibernacula, plan components in all revised plan alternatives would reduce the risk of white-nose syndrome spreading between hibernacula on the Custer Gallatin and hibernacula used by northern long-eared bats.

The revised plan alternatives all include a goal for Forest Service participation with other State and Federal agencies, Natural Heritage Program personnel, organized caving groups and other interested parties to develop, update and implement bat monitoring protocols and white-nose syndrome prevention and response guides (FW-GO-WLBAT01). This goal acknowledges ongoing work to survey for bat presence, detect the fungus responsible for white-nose syndrome, take measures to reduce the spread and eradicate this fungus, continue research, and educate national forest visitors about the importance of proper decontamination procedures. Many known caves on the Custer Gallatin with characteristics of bat roosts or hibernacula have been surveyed for bat presence. Additional cave inventory and survey work has been underway in recent years. The Montana Natural Heritage Program has been surveying and monitoring for bats on a statewide basis through an agreement with the Forest Service (Bachen 2019). Cooperative cave inventory and bat survey and monitoring efforts are expected to continue under all revised plan alternatives consistent with the monitoring plan (MON-WL-05).

Disturbance of bats infected with white-nose syndrome can be fatal (U.S. Department of the Interior 2015f). All revised plan alternatives include measures to minimize human disturbance of bats not only at winter hibernacula, but at maternity and general roost sites as well (FW-GDL-WLBAT02-05). These measures would reduce the risk of bat mortality associated with disturbance or removal of maternity roost sites when juvenile bats are present, and would reduce disturbance at other roost sites, which would avoid negative effects caused by increased energy demands for bats having to relocate and find another suitable roost site. Measures would mitigate for loss of potential roosting areas and hibernacula by encouraging replacement or bat-friendly closure devices that would allow continued use by bats.

Finally, all revised plan alternatives would address potential effects of wind energy development on northern long-eared bats and other bat species. Wind energy turbines can cause displacement, injury or fatality of bats through changes in air pressure as well as actual collisions with wind turbine blades. Construction of new wind energy facilities can alter habitat if located within or near forested habitats, if tree clearing is needed for placement of, or access to, wind energy facilities. All revised plan alternatives include a guideline to locate and design new wind energy developments to minimize impacts to bats (FW-GDL-WL-07).

Consequences to Northern Long-Eared Bats from Plan Components Associated with other Resource Programs or Management Activities

Effects from Water and Riparian Habitat Management

Northern long-eared bats typically seek prey in forested areas, but will also forage near open water (U.S. Department of the Interior 2015f). All revised plan alternatives include a comprehensive suite of plan components to protect watersheds and riparian ecosystems (FW-DC/GO/OBJ/STD/GDL-WTR/RMZ All). These plan components would help maintain high-quality water features and healthy riparian areas that may provide important foraging areas for northern long-eared and other species of bats.

Effects from Terrestrial Vegetation Management

All revised plan alternatives include forestwide desired conditions that the amount and distribution of forest cover types, woody draws, and riparian habitats, supports the natural diversity of forest seral stages, tree size classes, presence of snags and community composition (FW-DC-VEGF-01-08; FW-DC-VEGNF-01, 03, 04) to maintain healthy coniferous and deciduous forest conditions that may support use by northern long-eared bats. Desired conditions in the revised plan alternatives reflect the symbiotic relationship of healthy vegetation conditions and pollinators (FW-DC-VEGNF-03), which would help maintain a number of insect prey species for bats. Managing toward desired conditions would support natural diversity and distribution of native plant species, generally within the natural range of variation to which northern long-eared bats have adapted over time. Plan direction for vegetation management under the revised plan alternatives would contribute to the restoration and maintenance of ecological integrity, including a level of plant and animal diversity that would provide roosting and foraging opportunities for bats. Coarse filter vegetation plan components would contribute to the resilience and adaptive capacity of coniferous forest and deciduous habitats to respond to a range of disturbance processes, which would conserve habitat for a number of bat species on the Custer Gallatin, including potential habitat for northern long-eared bats.

Effects from Fire and Fuels Management

Prescribed burning can alter bat habitat by reducing live tree cover, but many snags are typically left behind, which may provide some suitable foraging and roosting habitat for bats. Bats have evolved with fire, and prescribed fire can benefit bats by creating snags, increasing insect forage base, and creating small openings in forest canopies. Depending on the timing of the burns, there is potential for negative impacts as well, particularly if burns occur when and where maternity colonies are present. Wildfires could have similar impacts to prescribed burns, although natural ignitions typically occur later in the summer, often after young bats are able to fly independently (U.S. Department of the Interior 2015f). All revised plan alternatives include desired conditions that support natural fire regimes allowing wildfires to burn within a natural range of severity, but with special consideration for sensitive habitats of at-risk species (FW-DC-FIRE01, 02). Both wildfire and prescribed burning would be used as tools to keep vegetation conditions within, or move them toward, the natural range of variation (FW-GDL-FIRE01), which would help to maintain habitat conditions to which bat species, including the northern long-eared bat, have evolved. Plan components for bats would preclude the use of prescribed fire near known occupied bat maternal roosts during the pup season (FW-GDL-WLBAT02).

Effects from Timber Management

Forest management through timber harvest can alter summer habitat for northern long-eared bats by removing suitable roost trees or snags, as well as changing forest structure and canopy cover, which may affect both roosting and foraging conditions for bats. In addition to habitat alteration, forest management can have disturbance impacts if bats are roosting in the vicinity, and although many bats could likely flee such disturbance and survive, there is potential for direct mortality of bats if an occupied roost tree is felled, particularly if there are young, flightless, or inexperienced bats present (U.S. Department of the Interior 2015f). All revised plan alternatives would prohibit the removal of occupied bat maternal roost trees during the pup season and limit disturbance nearby (FW-GDL-WLBAT02). Revised plan components would also limit mechanical tree removal within a prescribed distance of known winter hibernacula in order to maintain vegetative conditions that may be associated with microclimates important to bats inside hibernacula (FW-GDL-WLBAT01). Exceptions are allowed for hazard tree removal for public safety, or vegetation removal needed to improve bat habitat.

Under the revised plan alternatives, mechanical harvest for timber production would be allowed only on those National Forest System lands classified as suitable for timber production. All revised plan alternatives reduce the proportion of the Ashland and Sioux Geographic Areas classified as suitable for timber production relative to the current plans. For lands suitable for timber production, see table 26 under timber in chapter 3 of volume 2 of the final environmental impact statement. Reducing the suitable timber base would leave a greater proportion of forested areas in more natural conditions for bats. However, not all timber harvest is detrimental to bat habitat. High-density forest structure is not the norm in ponderosa pine ecosystems that may be occupied by northern long-eared bats on the Custer Gallatin National Forest. Intermediate timber management prescriptions used to create or maintain a variety of tree size and age classes with more open understory structure, could have short-term disturbance effects on bats in the project area, but may improve roosting and foraging conditions in the longer term by improving habitat resilience (Johnson and King 2018). While all alternatives include direction to retain snags in timber harvest units, the current plans have no specific requirements for retaining large live trees and require fewer snags than revised plan alternatives. All revised plan alternatives include vegetation management direction to retain snags and large live trees in timber harvest projects to maintain or move toward desired conditions that reflect a natural range of variation

(FW-GDL-VEGF03-05). Following these guidelines would provide snags and large live trees for roosting bats, with an emphasis on leaving the largest trees and snags, which are preferred roost sites for bats (U.S. Department of the Interior 2015f).

Effects from Permitted Livestock Grazing

Domestic livestock grazing practices typically do not directly affect northern long-eared bat's roosting habitat or winter hibernacula. However, livestock can alter vegetation conditions, which could affect foraging habitat for bats. The revised plan alternatives contain direction for livestock grazing practices to meet or move toward desired conditions to maintain or improve resiliency of riparian and upland ecosystems (FW-STD-GRAZ-01), which would maintain consistent habitat for bats. The presence of water features developed for livestock use (for example, stock tanks) could enhance habitat for bats. Northern long-eared bats are insectivorous and the concentration of insects around artificial livestock water features may provide foraging opportunities for bats, and may also contribute to bat hydration. The revised plan alternatives include direction for livestock water developments to include escape features for wildlife that inadvertently fall into the water (FW-GDL-GRAZ-08).

While developed water sources may benefit northern long-eared bat, it is also important to consider the heath of existing natural riparian and wetland systems. Livestock often congregate within wetland and riparian habitats during the grazing season. Over-use of these locations has the potential to degrade the vegetative community and structure and function of the system. Proper grazing management is necessary to retain healthy riparian and wetland systems for the benefit of species such as northern long-eared. The revised plan alternatives address potential impacts from livestock grazing that could affect natural water features and other potential foraging habitat for bats, with a collection of plan components to protect streambanks, water quality, riparian areas, and woody draws (FW-GDL-GRAZ-01, 02, 04, 05), which are all important foraging habitats for bats. Implementing this direction would prevent livestock grazing from resulting in the degradation of potential northern long-eared bat foraging habitat.

Effects from Cave Management

Management direction for cave and karst resources is located in the Energy, Minerals and Geologic Areas of Interest section of the plan. The reader may refer to the same section of this document for more details on cave and karst resources. All revised plan alternatives include desired conditions that cave resources are available for public enjoyment, but also provide wildlife habitat requirements of stress-free and disease-free conditions for vulnerable cave-associated species (FW-DC-EMIN-06), such as northern long-eared bats and other bat species. Plan components in the revised plan alternatives restrict management actions that could damage cave resources, such as logging, road construction, and other uses of heavy equipment above or near cave entrances (FW-STD-EMIN-04-07). These measures would protect cave microclimates that contribute to suitability as roost sites or hibernacula, and limit disturbance impacts near potential roost sites and hibernacula. If closures of underground features are needed to provide for public safety, revised plan alternatives require surveys for at-risk species (such as northern long-eared bats), and if such species are present, closures must accommodate their needs (FW-STD-EMIN-03). This measure would ensure that bats are neither trapped within nor blocked from entering suitable roost sites or hibernacula.

Effects from Plan Land Allocations for Recommended Wilderness Areas and Backcountry Areas

Plan land allocations have limited potential to impact suitable habitat for northern long-eared bats in the Ashland and Sioux Geographic Areas. The revised plan alternatives include recommended wilderness area and backcountry area allocations in these geographic areas.

Recommended wilderness areas allow for natural processes such as wildfire, disease, or natural succession to be the primary forces that shape the environment (FW-DC-RWA-03). Most new permanent infrastructure would be restricted from recommended wilderness areas (FW-STD-RWA-01-05). Backcountry areas would be managed as generally undeveloped or lightly developed areas that have none or few primitive roads. Natural processes would be allowed to play the larger role in shaping bat habitat, and human use would leave little permanent or long-lasting evidence (FW-DC-BCA-01), since most new permanent infrastructure would be restricted from these areas (FW-STD-BCA-01-04, SX-STD-CBBCA-01, AL-STD-ABCA-01 and 02).

The primary influence of recommended wilderness area and backcountry area allocations on habitat for northern long-eared bats would be from limits placed on vegetation management for timber production purposes. Neither timber production nor timber harvest would be suitable in recommended wilderness areas (FW-SUIT-RWA-01). While backcountry areas are not suitable for timber production (or timber harvest for the primary purpose of producing lumber), they are suitable for vegetation management, including timber harvest, to benefit other resources, such as fuel reduction, ecological restoration, or wildlife habitat enhancement (FW-SUIT-BCA-01). Therefore, smaller-scale intermediate harvest prescriptions or prescribed fires would be more likely vegetation treatment options in these areas than large-scale timber removal projects that would reduce suitable habitat for northern long-eared bats. One relatively small backcountry area is included in the Sioux Geographic Area under alternatives D and F that would affect management in less than 4 percent of the geographic area. Another three backcountry areas covering about 9 percent of the Ashland Geographic Area would be carried forward from current plans (alternative A) under alternatives B, C, and F. In alternative D, these three areas would be recommended wilderness areas. Alternatives D and F contain the largest proportion of plan land allocations that would limit land management practices and public recreation uses in the Sioux and Ashland Geographic Areas, where northern long-eared bats may be found.

Effects from Recreation Management

Most bat species including the northern long-eared bat, are highly nocturnal, and are therefore, less affected by daytime recreational use than other wildlife. The exception is recreational caving, which can disturb roosting or hibernating bats, with potentially serious impacts associated with increased energy demands when bats are roused from rest or hibernation. There are no known winter hibernacula or colonial roost sites used by northern long-eared bats in the analysis area, so effects from recreation would be minimal under all revised plan alternatives. However, should northern long-eared bats be found in the future, all revised plan alternatives include direction that new developed recreation sites, including roads, trails, campgrounds, and picnic areas, should not be located near known bat hibernacula or maternal roost sites (FW-GDL-WLBAT-03; FW-DC-RECDEV-09).

Cumulative Effects

The Black Hills National Forest in South Dakota is within the range of northern long-eared bats, and there has been documented occurrence of white-nose syndrome in a different species. The Black Hills Plan (as amended 1997) (U.S. Department of Agriculture 2006c) contains direction for bat-friendly cave and mine closures and management of roosts and hibernacula, which are consistent with plan components in the revised plan alternatives.

The Miles City and South Dakota Field Offices of the Bureau of Land Management also manage land within the range of the northern long-eared bat. While neither resource management plan contains specific management measures for the northern long-eared bat, the South Dakota plan contains general bat protection measures. The Miles City Field Office Resource Management Plan contains resource protection measures, best management practices, no surface occupancy, and controlled surface use stipulations designed to minimize disruption of habitat and limit disturbance within and near bat habitat.

The South Dakota State Wildlife Action Plan identifies the northern long-eared bat as a species of greatest conservation need. Although the State Wildlife Action Plan does not show Custer Gallatin lands in South Dakota as occupied by this species, it identifies conservation actions such as minimizing disturbance at roost sites and hibernacula, and use of bat-friendly devices for closing caves and abandoned mines, which are compatible with plan components contained in the revised plan alternatives.

The Montana Natural Heritage Program developed White-Nose Syndrome Surveillance Plan and Protocols (Maxell 2015), which then provided a basis for the Montana White-Nose Syndrome Prevention and Response Guide (Montana Fish Wildlife and Parks 2018a). These plans encourage collaborative efforts between Tribes, agencies, academia, landowners, and organizations to increase knowledge and awareness of white-nose syndrome impacts and prevention; conduct surveys in suitable habitats for bat use; and develop, maintain, implement, and enforce prevention and eradication measures to minimize human transport of the fungus that causes white-nose syndrome. The Custer Gallatin revised plan would encourage Forest Service participation in these efforts.

Conclusion

Northern long-eared bats have not yet been documented to occur on the Custer Gallatin National Forest, and only a small portion of the national forest is within the species' range. However, all revised plan alternatives include a suite of plan components to specifically address land management issues for all bat species known to occur here. These plan components address factors of most concern for northern long-eared bats such as disease transmission, and disturbance at roost sites and hibernacula. Therefore, the revised plan alternatives would help conserve multiple bat species, and contribute to the recovery of the northern long-eared bat.

3.10.3 Wildlife Species of Conservation Concern

Species of conservation concern are those "species other than federally recognized threatened, endangered, proposed, or candidate species, that are known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long term in the plan area" (36 CFR 219.9 (c)). The existing plans operate under a policy for sensitive species, which are "those plant and animal species identified by a regional forester for which population viability is of concern" (FSM 2670.22). Both categories were established in order to maintain persistent populations of species on National Forest System lands. The 2012 Planning Rule notes that regional forester sensitive species are similar to species of conservation concern, but concludes that the shift to species of conservation concern is more focused than the emphasis on sensitive species under the viability provisions of the 1982 rule. Sensitive species include all vertebrate species for which population viability is a concern, regardless of whether there is substantial concern for persistence of the species in the plan area. Species of conservation concern can include invertebrate species as well. Species of conservation concern must be native to, and known to occur in, the plan area, whereas sensitive species could include non-native species, as well as native species whose presence in the plan area is known or suspected to occur, sometimes based on limited information. Under the current plans, the Custer Gallatin would continue to operate under existing policy for regional forester sensitive species (FSM 2670.22), whereas if any of the other alternatives (B through F) are selected, Custer Gallatin would shift to policy prescribed for species of conservation concern. The revised Forest Service Manual policy regarding species of conservation concern is forthcoming and specific changes and impacts to species are unknown. However, the 2012 Planning Rule states that if plan components to maintain ecosystem integrity and diversity are insufficient to provide ecological conditions to maintain long-term persistence of each species of conservation concern within the plan area, then additional species-specific plan components are to be included to provide such ecological conditions (36 CFR 219.9 (2)(b)).

As mentioned above, unless and until a new plan is approved (under the current plans), the Custer Gallatin National Forest will continue to operate under the Forest Service policy for regional forester sensitive species. The regional forester's list of sensitive species may change over time. The current list of sensitive species known or suspected to occur on the Custer Gallatin National Forest can be found on the USDA Forest Service Northern Region website at: USDA Forest Service: Plants and Animals. If a new plan is approved (for example under alternatives B through F), the Custer Gallatin would follow policy for species of conservation concern. The Northern Region Regional Forester has identified two terrestrial wildlife species of conservation concern for the Custer Gallatin National Forest. The regional forester's list of species of conservation concern is dynamic and may be updated based on new information or changing conditions. The current list of species of conservation concern, along with the criteria and rationale for their selection, can be found on the Northern Region website at: USDA Forest Service: Species of Conservation Concern.

Greater Sage-Grouse (*Centrocercus urophasianus*)

The greater sage-grouse is on the regional forester's list of species of conservation concern for the Custer Gallatin National Forest. The greater sage-grouse, hereafter referred as sage-grouse, is North America's largest grouse, and is a sagebrush-steppe obligate species dependent upon the sagebrush and associated grasses, forbs, and invertebrates for nearly all components of its lifecycle. Sage-grouse remain year-round within the sagebrush-steppe ecosystem. Within an individual's home range there is variability in seasonal habitat needs and movement patterns. For example, hens in northwestern South Dakota moved up to 25 miles in late summer, eventually returning to nesting grounds (Kaczor 2008). Leks, or breeding grounds, are typified by more open ground with sparse vegetation relative to the surrounding area. Male sage-grouse are known for their flamboyant displays at leks during the breeding season. Lek locations are often driven by the proximity of suitable nesting habitat. Sage-grouse are a ground nesting species typically nesting under sagebrush. Other nesting habitat criteria includes a suitable amount and height of desirable grass and forb species, which provide hiding cover and forage. Brood-rearing habitat can be divided into two key periods, early and late. Early brood-rearing occurs post hatch within the surrounding sagebrush dominated uplands. As the uplands begin to dry out broods relocate to wet meadows, agricultural lands adjacent to sagebrush, and higher elevation sagebrush-steppe, where forage is primarily comprised of succulent forbs and invertebrates such as grasshoppers, beetles and ants. Sage-grouse winter exclusively in sagebrush communities, typically selecting flat areas with dense sagebrush cover that protrudes above the snow. During winter, sagebrush represents the primary food source and provides cover from harsh conditions. Sage-grouse have also been found wintering in wind-swept areas where sagebrush plants are exposed throughout the winter months (Marks et al. 2016).

Sage-grouse was petitioned for listing under the Endangered Species Act in 2010, at which time the U.S. Fish and Wildlife Service determined it to be “warranted but precluded” from listing. The primary drivers for the warranted determination were loss and fragmentation of habitat and the lack of regulatory mechanisms to address habitat loss. Range wide, sage-grouse currently occupy about 56 percent of their historical range (U.S. Department of the Interior 2015d). In 2015, after a review of the best available scientific and commercial information, the U.S. Fish and Wildlife Service determined that the greater sage-grouse did not warrant listing protections under the Endangered Species Act because the primary threats to populations had been ameliorated by conservation efforts implemented by Federal, State, and private land owners (U.S. Department of the Interior 2015d). The sage-grouse is identified as a species of greatest conservation need in state wildlife action plans for Montana and South Dakota (South Dakota Department of Game Fish and Parks 2014a, Montana Fish Wildlife and Parks 2015c).

Sage-grouse habitat within the planning area is categorized as either priority habitat (core areas) or general habitat. Priority habitat was designated because it likely contains approximately 75 percent of all known breeding sage-grouse and represents landscapes of greatest biological importance to the long-term persistence of the species. There are approximately 2,127 acres of priority habitat on National Forest System lands found on the lower elevation fringes of the Ashland and Sioux Geographic Areas. Given the importance of the number of displaying males in deriving population estimates, priority habitat includes those areas surrounding locations with the largest number of displaying males on leks. Approximately 122,401 acres of the Custer Gallatin are identified as general habitat. General habitat provides habitat for sage-grouse, but is not considered priority. On the Custer Gallatin, general sage-grouse habitat is characterized by mountain big sagebrush in the montane ecosystem and Wyoming big sagebrush in the pine savanna ecosystem (U.S. Department of the Interior 2013c); however silver sagebrush is also found in sage-grouse habitat in the South Dakota portion of the pine savanna ecosystem (Flake et al. 2010 *cited in (South Dakota Department of Game Fish and Parks 2014a)*.

Analysis Area

On the Custer Gallatin National Forest, sage-grouse habitat is found in the Pryor Mountains, Ashland, and Sioux Geographic Areas. These areas combined with adjacent lands containing occupied sage-grouse leks, were used as the analysis area.

Notable Changes between the Draft and Final Environmental Impact Statement

In addition to supplementing the final environmental impact statement with new information and citations, clarifying language, minor edits, and analysis of alternative F, notable changes in the plan include modifying FW-STD-WLSG-01 in order to maintain consistency with existing management plans by including a statement allowing vegetation management provided it result in either no net loss or a net conservation gain to sage-grouse. Draft revised plan guideline FW-GDL-WLSG-02 focused on reducing the probability of cheatgrass invasion during wildfire rehabilitation projects. The guideline has been updated to consider all undesirable grass species not just cheatgrass. Analyses have been added for effects from fire and fuels management and management of invasive species.

Affected Environment (Existing Conditions)

Sage-grouse are known to occur within the Custer Gallatin National Forest, with the vast majority of general and priority sage-grouse habitat located in three geographic areas. These geographic areas are split across two different management zones, as identified in a collaborative effort through the Western Association of Fish and Wildlife Agencies. Sage-grouse management zones were identified by floristic provinces and sage-grouse habitats (Connelly et al. 2004), and populations (Stiver et al. 2006). These management zones facilitate conservation efforts across expansive landscapes, including multiple states and management jurisdictions. The Ashland and Sioux Geographic Areas are in the Great Plains Management Zone, and the Pryor Mountains Geographic Area is in the Wyoming Basin Management Zone. Collectively, the U.S. Forest Service represents only 2 percent of the land ownership in each of these zones, and the Custer Gallatin accounts for a very small proportion of the National Forest System lands represented in each management zone. Perhaps because it is such a minor habitat component on the Custer Gallatin, occupied sage-grouse range has decreased only slightly across the Custer Gallatin over time relative to historical levels.

There are currently no confirmed active leks on the Custer Gallatin. There is documentation of three historical leks at least partially located on the Ashland Geographic Area. These historical leks have been surveyed sporadically in recent years, with no sage-grouse detected. Due to sporadic surveys, the status of these three leks remains unconfirmed but inactive. Within the national forest boundary there is a total of 2,127 acres of priority habitat divided between the Ashland (339 acres) and Sioux (1,788 acres) Geographic Areas. This priority habitat on National Forest System lands is associated with sage-grouse leks located on adjacent lands outside the national forest boundary (Devore, 2018 personal communication). Priority habitat is distributed on the periphery of Custer Gallatin managed land, making up only about 1 percent of the Sioux Geographic Area, and less than 1/10th of 1 percent of the Ashland Geographic Area. Establishment of new sage-grouse leks either within or adjacent to the national forest boundary could result in a potential increase in priority habitat on the Custer Gallatin. Any potential increase would be limited by the relatively small amount of suitable habitat available on the Custer Gallatin.

The vast majority of sage-grouse general habitat on the Custer Gallatin National Forest is found on the Pryor Mountains, Ashland, and Sioux Geographic Areas. This habitat typically occurs outside of timbered areas in lower elevation sagebrush dominated habitats. Roughly 35 percent of the Pryor Mountains Geographic Area is identified as general habitat (26,599 acres), and has had the most recent and highest numbers of sage-grouse observations on the Custer Gallatin. Observations have been restricted to hens and chicks utilizing the high meadows during the late brood-rearing season. Nest sites for these broods were located outside the national forest boundary, (Pratt and Dillon 2015). Ashland Geographic Area has the most acres of general sage-grouse habitat 85,089 acres, accounting for approximately 20 percent of the geographic area. The Sioux Geographic Area contains 8,058 acres of general habitat, which represents roughly 5 percent of the geographic area. All other geographic areas, including Absaroka Beartooth Mountains; Bridger, Bangtail, and Crazy Mountains; Madison, Henrys Lake, and Gallatin Mountains have only minute amounts of sage-grouse habitat, each well below 1 percent of the geographic area size. Sagebrush habitat composition, structure, and function are influenced by local environmental factors and climatic conditions. For example, Foster et al. (2015) showed that sage-grouse core areas (containing priority and general habitat) in eastern Montana produce smaller sagebrush plants at lower densities than elsewhere within the species range. These authors reported that sage-grouse in southeast Montana frequently used habitat with sparse (1 to 10 percent) canopy cover, yet the area supports stable sage-grouse populations with considerable areas of intact sagebrush steppe habitat. Figure 30 and figure 31 show distribution of priority and general sage-grouse habitat.

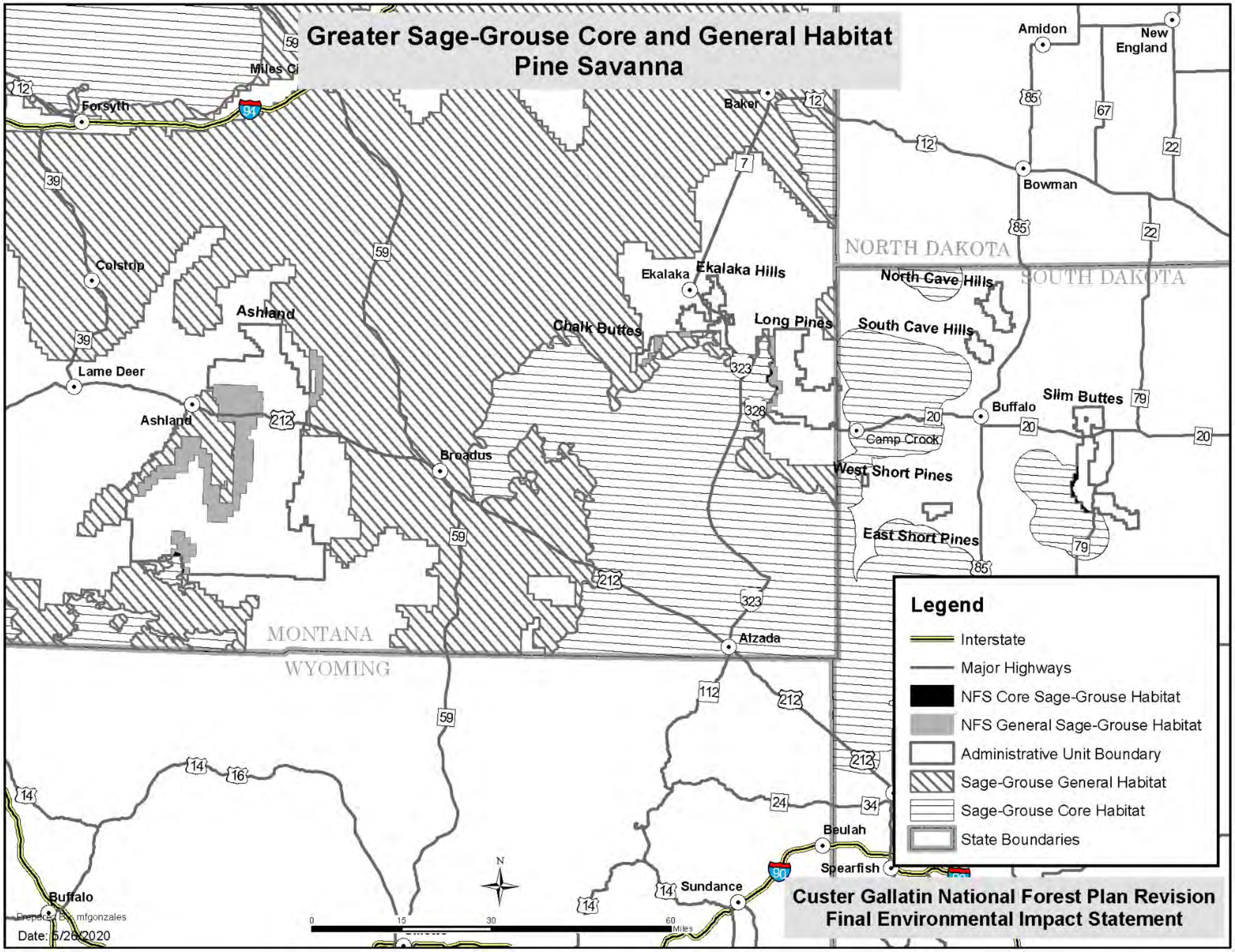

Figure 30. Distribution of priority and general sage-grouse habitat, pine savanna ecosystem

NFS = National Forest System

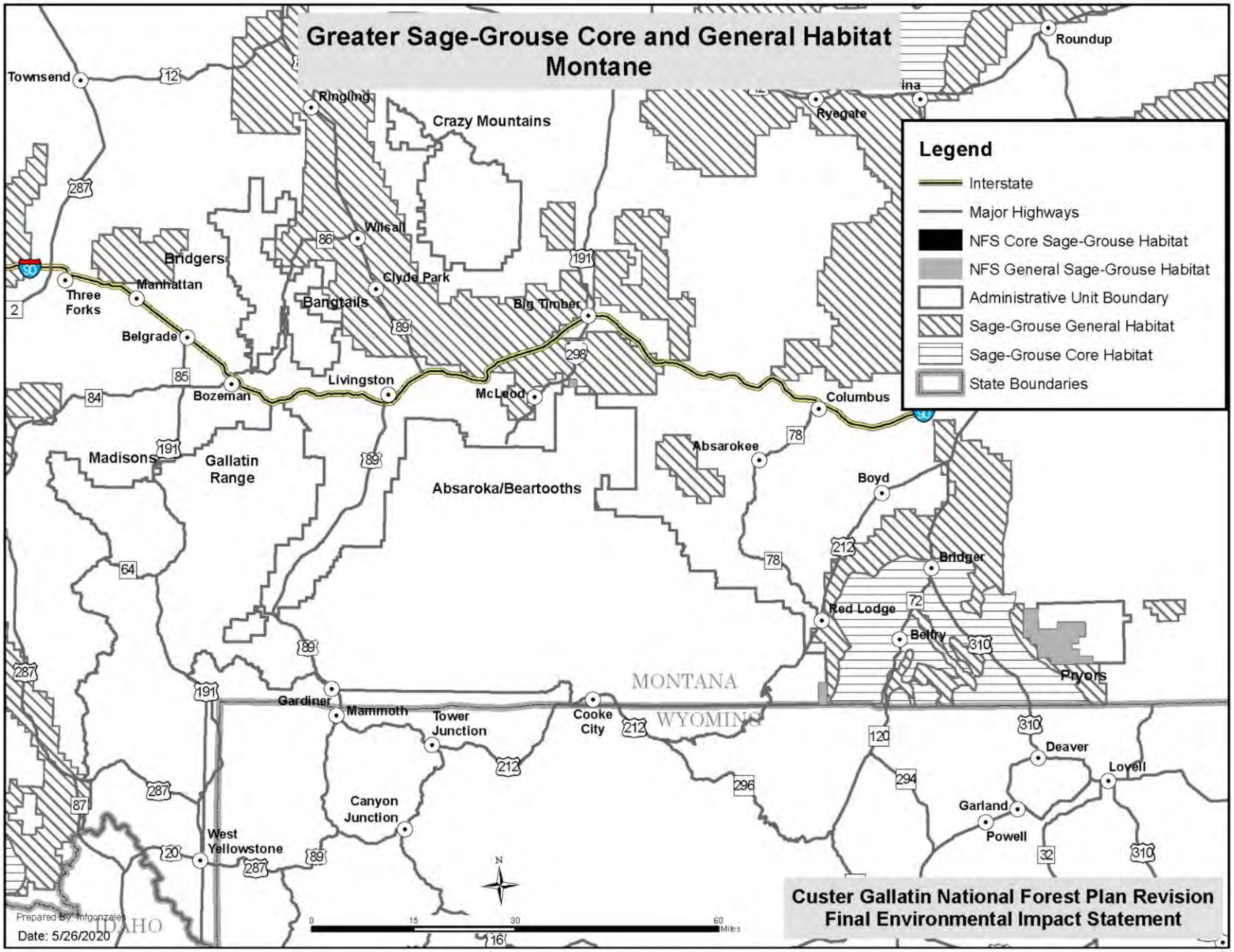

Figure 31. Distribution of priority and general sage-grouse habitat, montane ecosystem

NFS = National Forest System

Key Stressors

The U. S. Fish and Wildlife Service cited habitat loss, degradation, and fragmentation as primary causes for greater sage-grouse population declines and some areas of local extirpations in recent decades (U.S. Department of the Interior 2015d); (Stiver et al. 2015). At present, there is no primary threat to sage-grouse populations and habitats in northwestern South Dakota because there are multiple factors, including disease (South Dakota Game Fish and Parks pers. comm. Travis Runia 2018). Habitat impacts are caused by a variety of factors, but energy development, agricultural conversion, conifer encroachment, and wildfire and invasive species were listed by the U. S. Fish and Wildlife Service as primary concerns (U.S. Department of the Interior 2015d). Human land use can affect sage-grouse by physically altering habitat, which can result in permanent loss due to sagebrush conversion for agricultural, residential, or commercial purposes. Human use can also cause functional loss of habitat due to disturbance from noise and human presence (U.S. Department of the Interior 2013c). Ecosystem based habitat changes combined with human-caused impacts further complicates habitat impacts (Chambers et al. 2017). Bauman et al. (2018) stated that the loss of core (primary) sagebrush habitat in northwest South Dakota was minimal. However, new technologies, demands for various forms of energy, and increased exploration are rapidly growing (South Dakota Department of Game Fish and Parks 2014a) and could be realized within the life of the plan.

Fire, both natural and human caused, is a major factor associated with loss of sagebrush habitats and corresponding population declines for sage-grouse. Fire frequency and associated habitat loss has increased in the western portion of sage-grouse range in recent years, at least partly facilitated by the presence and spread of non-native grasses such as cheatgrass, Japanese brome, and timothy. Other invasive plants may also impact sage-grouse habitat. Climate change has the potential to influence the spread and distribution of non-native plants over time, as well as to increase the frequency and severity of fires. Conifer encroachment can result from changes in fire return intervals, which can in turn be influenced by fire suppression activities. Increased conifer presence may also be caused by overgrazing of domestic livestock. Climate change may facilitate conifer encroachment through increased carbon dioxide concentrations, but this theory has not been proven conclusively. Traditionally, fire and other vegetation management practices have been used to remove sagebrush in order to enhance grazing conditions for domestic livestock. Grazing pressure from livestock, as well as impacts from wild ungulates and free-roaming horses have all been identified as potential stressors for sage-grouse and their habitats (U.S. Department of the Interior 2013c). All the priority habitat, and most of the general sage-grouse habitat on the Custer Gallatin are within livestock grazing allotments. Wild (feral) horses are present in the Pryor Mountains Geographic Area, but their range does not overlap with sage-grouse habitat. Wild ungulates, primarily deer, but also pronghorn antelope and increasing numbers of elk, are present within portions of the Custer Gallatin that contain sage-grouse habitat.

Other factors that can affect sage-grouse populations include disease, parasites, predation, and weather events such as sever spring storms or periods of drought. These types of threats can vary in spatial and temporal impacts, but may impact populations locally. For example, in 2008, West Nile virus impacted the sage-grouse population in southwest North Dakota (U.S. Department of the Interior 2013c). In 2007, 44 percent of radio collared sage-grouse died from West Nile virus in northwestern South Dakota (K.C. Jensen as cited in (Flake et al. 2010)). West Nile virus was suspected as a major mortality factor of chicks in 2006 and 2007 in the same study areas (Kaczor 2008). These events occurred within proximity to the easternmost part of the Sioux Geographic Area, where both primary and general sage-grouse habitats are located and where sage-grouse gene flow occurs. Regarding predation, when visual obstruction by vegetation is sufficient around the nest (i.e. high-quality nesting habitat), predation may not be a major contributing factor to sage-grouse mortality in northwest South Dakota (Flake et al. 2010). Sage-grouse in northwest South Dakota are on the easterly fringe of their range (South Dakota Department of Game Fish and Parks 2014a) within a relatively small, isolated geographic area with fragmented habitats. For sage-grouse in northwest South Dakota, there is evidence that localized gene flow and movement among neighboring populations is adjacent states such as Montana exists (Oyler-McCance et al. 2005, U.S. Department of the Interior 2013c). This results in a positive correlation between genetic distance and geographical distance, suggesting an isolation-by-distance phenomenon. In order to sustain the long-term persistence of these isolated populations and genetic diversity, integrated management strategy that addresses bird use across multiple lands ownerships including national forest system lands is necessary within the pine savanna (Ashland Geographic Area and Sioux Geographic Area) and elsewhere on the Custer Gallatin National Forest.

Environmental Consequences

Management Direction under the Current Plans

Only the Custer Plan contains management direction for this species. The Custer Plan establishes spatial and temporal restrictions on disturbance actions relative to lek locations and sets a stubble height requirement within 1 mile of lek locations. The Custer Plan does not identify greater sage-grouse as a management indicator species. Sagebrush control activities are permitted to occur outside of designated big game and sage-grouse winter ranges.

Effects of the Current Plans

The spatial and temporal restrictions set forth in the Custer Plan are designed to reduce impacts to breeding and nesting grouse in the immediate vicinity of a lek. Some of the established disturbance offset distances may not be adequate, this includes the 0.25-mile restriction on ground-disturbing activity between March 1 and April 15. Connelly et al. (2011) identified a negative influence on lek persistence associated with the level of human footprint within 3 miles (5 kilometers) of the lek. U.S. Geologic Survey published a set of potential conservation buffer distances based on the category of disturbance type. The conservation buffer for surface disturbing activities ranged from 3 to 5 miles (5 to 8 kilometers) (Manier et al. 2014). Nest-to-lek distances may vary depending upon habitat condition and fragmentation and nearby disturbances (Connelly et al. 2011). Common nest-to-lek distances have been reported from 0.68 to 4 miles (Connelly et al. 2000, Stiver et al. 2010, South Dakota Department of Game Fish and Parks 2014a) with distances as high as 12 miles within South Dakota (South Dakota Department of Game Fish and Parks 2014a). Under the existing Custer Plan the protection of suitable habitat away from known lek locations is limited. The allowance for sagebrush control within sage-grouse winter range would enable the potential removal of suitable nesting and brood rearing habitat if located outside winter range. Holloran and Anderson (2005) found 64 percent of nests occurred within 3 miles (5 kilometers) from a lek within relatively contiguous sagebrush habitat. This suggests nesting hens could be impacted by actions within suitable habitat several miles from the breeding location. In addition, the Custer and Gallatin Plans do not incorporate recent general and priority habitat designations established by the states of Montana and South Dakota respective conservation plans. These habitats would not receive any additional protections or consideration under this alternative.

Management Direction under the Revised Plan Alternatives

Forestwide plan components with the potential to affect sage-grouse would be the same under all revised plan alternatives. These alternatives incorporate some existing direction, as well as new plan components. Alternatives B through F include a desired condition that sage-grouse habitat contains contiguous areas of native vegetation, including a variety of sagebrush-community compositions, little or no invasive species present, and variation in species composition, shrub cover, herbaceous cover and structure, to meet seasonal requirements for food, cover, and nesting (FW-DC-WLSG-01). Plan components include a standard that requires vegetation management Greater sage-grouse priority and general habitat, to result in no net loss of habitat or result in a net conservation gain for sage-grouse (FW-STD-WLSG-01). Additional guidelines address tactics and strategies to minimize the loss of existing habitat through fire management tactics, use of appropriate seed mixes in rehabilitation, infrastructure development restriction for transmission corridors and recreation facilities, control of non-native grasses and conifer encroachment, design of range management structures, and the location of energy and mineral development (FW-GDL-WLSG-01-07).

Effects of the Revised Plan Alternatives

Under the revised plan alternatives, the greater sage-grouse would no longer be managed as a Forest Service sensitive species. Compared with the current plans, the revised plan alternatives, B through F, would provide greater protection for sage-grouse and seasonal habitats. These alternatives incorporate the priority and general habitat designations within Montana and South Dakota. Individual vegetation projects within designated general and priority habitats shall be designed to result in no net loss of habitat or provide a net conservation gain to the species (FW-STD-WLSG-01). The concept of no net loss means that vegetation management projects would not purposely reduce or degrade general or priority sage-grouse habitat unless it could be demonstrated that effects could be mitigated elsewhere by restoring general or priority habitat, or that short term impacts to general or priority habitat would reasonably be expected to result in a net conservation gain for sage-grouse over time. Such impacts would be tracked over time through the revised plan monitoring implementation indicators (MON-WL-09). Examples of potential mitigation measures and restoration methods are provided in the management approaches section of the plan (appendix A).

Relative to the current plans, the standards and guidelines set forth in revised plan alternatives would provide protection across all seasonal habitats and address the key stressors to sage-grouse previously discussed. The plan components would reduce the probability of non-native or undesirable species introduction through wildfire rehabilitation and vegetation management projects (FW-GDL-WLSG-02. In addition, man-made facilities and structures would not be constructed in priority habitats, unless for the purpose of achieving a conservation gain for sage-grouse (FW-GDL-WLSG-03, 04, 06, 07). An example of a conservation gain would be consolidation of multiple dispersed recreation sites into one developed site to accommodate recreation while reducing the amount of priority habitat affected. Implementation of these plan components would help to minimize habitat loss, avoid disturbance of sage-grouse, and limit the risk of sage-grouse mortality from predation and collisions with infrastructure on breeding grounds, which would provide habitat protections at and near leks. As noted in the affected environment, establishment of new sage-grouse leks within or adjacent to the forest boundary could increase the amount of priority habitat relative to general habitat. It is assumed that sage-grouse that establish new leks near existing human uses are tolerant of the activity present when the lek was established. These plan components combined with the no net loss (FW-STD-WLSG-01) direction and ecosystem components for non-forest vegetation would help maintain ecological conditions and minimize potential habitat fragmentation impacts due to management actions on the Custer Gallatin National Forest.

Consequences to Greater Sage-Grouse from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Watershed, Riparian, and Aquatic Management

Revised plan alternatives forestwide plan components associated with watershed, aquatic and riparian ecosystems, as well as those associated with terrestrial vegetation set the coarse filter strategies that have the potential to help maintain or restore sage-grouse habitat. The revised plan alternatives provide more detailed guidance than the current plans for protection of watersheds, riparian areas and aquatic habitats. The revised plan alternatives include the adoption of riparian management zones, which are greater in size from the riparian zones currently identified for streams east of the Continental Divide. Specifically, the riparian management zone direction restricts management activities with few exceptions, to allow only those intended to restore, maintain composition and structural diversity of native plant communities within aquatic and riparian habitats (FW-DC-RMZ-01). These zones are not suitable for timber production (FW-SUIT-RMZ-01). Vegetation management should only occur for the purpose of restoration or enhancement of riparian resource condition (FW-STD-RMZ-02). These components would protect or improve habitat conditions in areas representative of sage-grouse late summer brood-rearing seasonal habitats.

Effects from Terrestrial Vegetation Management

The management of grassland, shrubland, woodland, and riparian vegetation could affect the condition of sage-grouse habitats in beneficial, neutral, or harmful ways. As discussed previously sage-grouse seasonal habitats extend across a variety of landscapes and ecosystems and therefore require a diversity of vegetation types to meet their seasonal habitat needs. Plan components under revised plan alternatives may provide for this diversity through the targeted development or maintenance of resilient communities that are comprised of diverse native plant assemblages with limited encroachment by conifers (FW-DC-VEGNF-01). Sagebrush and perennial grass and forb communities should contain sufficient diversity and structure to provide a variety of wildlife habitats including suitable seasonal habitat for sage-grouse (FW-DC-VEGNF-04). Vegetation management actions within designated priority and general habitat shall result in no net loss or result in a net conservation gain to greater sage-grouse (FW-STD-WLSG-01). Projects within general or priority habitat should be designed to remove or reduce the encroachment of conifers and other species such as invasive annual grasses that have potential to reduce habitat suitability for sage-grouse (FW-GDL-WLSG-05).

Effects from Fire and Fuels Management

Wildfire is a factor contributing to habitat fragmentation for sage-grouse (U.S. Department of the Interior 2015d). The revised plan alternatives contain desired conditions for the amount and severity of wildland fire to be within the natural range of variation to maintain resilient ecological conditions, and vegetation conditions that support natural fire regimes, with minimal impacts to values at risk (FW-DC-FIRE01 through 03). Objectives for prescribed fire as well as natural and unplanned wildfire are higher under revised plan alternatives than levels that have occurred under existing plans (FW-OBJ-FIRE01 and 02). Revised plan alternatives direct that management response to wildfires consider risk to human life and safety, while also considering impacts to resources and values at risk (FW-STD-FIRE01), with further direction to minimize resource damage through use of minimum impact suppression tactics (FW-GDL-FIRE01). Proposed direction for fire management could result in more fire on the landscape within sage-grouse habitat, which is also predicted to occur under future climate and fire regimes. Prescribed fire projects in general and priority sage-grouse habitat would be subject to the no net loss requirement of sage-grouse plan components (FW-STD-WLSG01). Since prescribed fire is vegetation management, it could only be used in sage-grouse habitat if habitat losses could be mitigated elsewhere, or for purposes that would achieve a net conservation gain to sage-grouse. For example, prescribed fire could be used to stimulate forb production in areas where existing sagebrush cover would not be reduced.

Wildfire that results from natural (lightning) or unintentional man-caused ignitions, is a potential driver of sage-grouse habitat conditions. Revised plan alternatives direction for fire and sage-grouse habitat would result in wildfire management tactics that would minimize loss of sagebrush cover in general and priority sage-grouse habitat, to the extent possible given human safety considerations (FW-GDL-FIRE-01 and FW-GDL-WLSG-02).

Effects from Invasive Species Management

Invasive plant species, such as non-native annual grasses and noxious weeds, have also been identified as a factor that may impact sage-grouse habitat (U.S. Department of the Interior 2015d). The revised plan alternatives include desired conditions for native plant species to dominate the landscape, with minimal intrusion from non-native species (FW-DC-VEGNF02), that non-infested areas remain free of invasive species, and where invasive species do occur, their range is reduced, or at least does not expand (FW-DC-INV01). To achieve these conditions, the revised plan alternatives include multiple goals for collaborative efforts to prevent new infestations and control the spread of existing infestations (FW-GO-INV01 through 04), as well as objectives for targeted weed management across the Custer Gallatin (FW-OBJ-INV01). In addition, revised plan alternatives contain direction that would help prevent spread of invasive species due to management actions (FW-STD-INV03 and 04, FW-GDL-INV01). Sage-grouse plan components further emphasize procedures to prevent spread of invasive plant species in sage-grouse habitat (FW-GDL-WLSG02 and 05). Collectively, the revised plan alternatives acknowledge potential impacts of invasive plant species in sage-grouse habitat, and provide clearer direction to prevent the spread of invasive species compared to existing plans.

Effects from Plan Land Allocations for Recommended Wilderness and Backcountry Areas

Aside from forestwide plan components, the alternatives differ in their proportion of backcountry area and recommended wilderness area designations. The backcountry area designation is designed to allow for natural processes with little evidence of long-lasting human use (FW-DC-BCA-01). The recommended wilderness area designation allows natural processes such as wildfire, disease, or natural succession to be the primary forces that shape the environment (FW-DC-RWA-03). These land use designations come with a series of land use restrictions that prohibit certain types of human use. In the case of backcountry areas prohibitions include the construction of new permanent roads, developed recreation sites, energy and utility structures, commercial communication sites, and extraction of saleable mineral material (FW-STD-BCA- 01-05 and SX-STD-CBBCA-01, AL-STD-ABCA-01, PR-STD-PRBCA-01, PR-STD-PBBCA-01, AB-STD-BCBCA-01, BC-STD-BPBCA-01, BC-STD-CMBCA-01, MG-STD-BHBCA-01, MG-STD-SCBCA-01, MG-STD-LHBCA-01, MG-STD-WPBCA-01). All special uses must be compatible with backcountry character (FW-STD-BCA-05). Backcountry areas are not suitable for timber production, but they are suitable for vegetation management, including timber harvest for purposes such as fuels reduction, restoration, or wildlife habitat enhancement (FW-SUIT-BCA-01).

Recommended wilderness areas prohibit new roads, developed recreation sites, recreation events, energy and utility structures, commercial communication sites, and extraction of saleable mineral material (FW-STD-RWA-01-06). Neither timber production nor timber harvest would be suitable in recommended wilderness areas (FW-SUIT-RWA-01). Existing motorized and mechanized transport would continue to be suitable in alternative B, and no longer suitable in alternatives C, D, and F.

The restrictions on development and types of human use associated with backcountry areas and recommended wilderness areas may result in the protection and retention of sage-grouse habitat. The prohibition of these activities could have the beneficial effect of the prevention of habitat degradation associated with physical disturbances and increased anthropogenic noise. In addition, prevention of the installation of tall structures associated with energy corridors or communication sites will not increase predator perch opportunities on the landscape.

Within the Ashland Geographic Area, alternatives B, C, and F designate the same three backcountry areas two of which contain sage-grouse general habitat. Under alternative D, the proposed backcountry areas would be designated as recommended wilderness areas. The acreage of general habitat protected under alternative D would be slightly lower than alternatives B, C, and F, given the exclusion of existing road corridors from the recommended wilderness areas. The backcountry areas would not be suitable for motorized or mechanized transport except for game carts (AL-SUIT-ABCA-01). New permanent or temporary roads and trails would not be allowed within the backcountry area designation (AL-STD-ABCA-01, 02). Alternative E proposes fewer land use restrictions than the current plans in the Ashland Geographic Area because the current plans low development areas are very similar to the backcountry areas.

Under alternatives D and F, the Chalk Buttes unit in the Sioux Geographic Area would be managed as a backcountry area. The eastern side of the Chalk Buttes is within general habitat and would therefore receive the land use restriction protections described above. Within the Chalk Buttes the construction of new permanent roads or motorized trails would not be allowed (SX-STD-CBBCA-01, 02). The area would be considered suitable for motorized transport on existing routes (SX-SUIT-CBBCA-01) and temporary roads may be allowed (SX-STD-CBBCA-01). There are no other proposed land use designations within the remaining alternatives for the Sioux Geographic Area.

Within the Pryor Mountains Geographic Area two of the four proposed land use designation areas contain sage-grouse general habitat (Big Pryor and Bear Canyon). Alternatives vary between backcountry area and recommended wilderness area designations. Under alternatives B and C, Big Pryor and Bear Canyon would be managed as backcountry areas. Alternative F retains the backcountry area designation for Big Pryor; however, Bear Canyon would be designated as recommended wilderness area. The Big Pryor backcountry area would be suitable for motorized transport on existing system routes (PR-SUIT-PRBCA-01) and temporary roads may be allowed (PR-STD-PRBCA-01). There would be no new permanent roads or motorized trail construction, or designation allowed (PR-STD-PRBCA-01, 02). Alternative D designates both areas as recommended wilderness. The Big Pryor recommended wilderness area designation in alternative D would encompass more general habitat than backcountry areas proposed in alternatives B, C, and F.

The remaining national forest geographic areas contain a minute amount of general habitat. The Lionhead backcountry area in alternative F and recommended wilderness in alternative D overlap with a small portion of general habitat at the southwest tip of the designations. Likewise, the Line Creek Plateau recommended wilderness area in alternative D contains a small portion of general habitat.

Effects from Permitted Livestock Grazing

Much of the designated sage-grouse habitat on the Custer Gallatin is located within permitted livestock grazing allotments. Improper utilization by livestock has the potential for impacts across all seasonal habitats (U.S. Department of the Interior 2013c). Grazing can influence sagebrush communities through reduced productivity, changing plant composition, and herbaceous structure. Indirect effects include those associated with grazing infrastructure, including mortalities associated with water troughs and fence strikes (Boyd et al. 2014). Land managers should consider local ecological conditions, vegetation potential, precipitation levels, and soil types when developing grazing management strategies (U.S. Department of the Interior 2013c). To ensure that the ecological potential of sage-grouse habitat is met the revised plan alternatives contain a desired condition that grazing allotments supply livestock forage and contribute to local ranching operations, while staying within or moving toward desired ecological conditions (FW-DC-GRAZ01). A standard would require new or revised allotment management plans to design grazing practices to maintain or improve resiliency of riparian and upland ecosystems (FW-STD-GRAZ01). Grazing-specific guidelines contain measures to maintain or improve riparian habitat, including specific, quantifiable forage utilization measures within riparian areas (FW-GDL-GRAZ01-03, 05). Adaptative management strategies would be incorporated into new or revised allotment management plans in order to consider both needs and impacts of domestic livestock and wildlife and move towards desired conditions for vegetation and riparian resources (FW-GDL-GRAZ 10). Infrastructure associated with range management activities can have negative impacts on sage-grouse through the fragmentation of habitats (roads and fences) or a reduction in habitat quality (concentration of ungulate use) (U.S. Department of the Interior 2013c). To avoid or reduce the impact of range management structures on sage-grouse infrastructure such as fences and water developments should be designed and located to prevent barriers to wildlife and provide for escape (FW-GDL-GRAZ07, 08). New range management structures should be designed and located to be of neutral impact or beneficial to sage-grouse (FW-GDL-WLSG06). To avoid concentration or attraction of livestock to a single area, supplement placement should be distributed at least 0.25 miles away from special habitats for at-risk species (FW-GDL-GRAZ04).

Effects from Energy and Minerals Management

Energy and mineral development has the potential to greatly impact sage-grouse populations and habitat through the removal and fragmentation of habitat and anthropogenic noise disturbances (Holloran and Anderson 2005). Revised plan alternatives direct that new energy and mineral development be located outside of sage-grouse priority habitat, subject to valid and existing rights (FW-GDL-WLSG07). In addition, under all revised plan alternatives, mineral and energy development activities include provisions to reclaim disturbed areas and minimize adverse effects to riparian resources (FW-GDL-EMIN02). Plan components also include requirements for infrastructure such as roads, trails and other facilities to minimize impacts to riparian habitats and limit disturbance to associated wildlife species (FW-DC-RT01; FW-STD-RT01-05). Components address potential impacts from the location of facilities and the introduction of invasive species through ground-disturbing activities. Roads, trails, and facilities represent a potential vector for the spread of invasive species within sage-grouse habitats. Plan components set a desired condition that non-infested areas along forest roads, trails or around facilities remain free of invasive species; and where they occur, their range is reduced where possible, or they do not expand (FW-DC-RT03). Forest Service construction and maintenance equipment shall be free of invasive plant material prior to entering national forest lands (FW-STD-RT02). Collectively, these plan components would help to maintain the ecological integrity of priority sage-grouse habitat by minimizing potential for fragmentation and limiting activities that could disturb sage-grouse at or near lek sites.

Effects from Recreation Management

The installation, maintenance and use of recreation facilities including trails has the potential to affect sage-grouse through removal or fragmentation of habitat and displacement through avoidance of human use. Within the revised plan there are several forest wide components that address the addition of new, and maintenance of existing, recreation facilities such as trails, campgrounds, picnic areas, etc. (FW-GDL-WLSG-04; FW-DC-REC-05; FW-DC-RECDEV-09). There is an objective to remove or relocate some existing recreation facilities out of riparian areas (FW-DC-RECDEV-07, 09; FW-GDL-RECDEV-01). The revised plan alternatives include desired conditions for recreation facilities to have minimal impacts on ecological integrity and diversity, as well as overall compatibility with natural resources (FW-DC-REC-05; FW-DC-RECDEV-09). New developed sites would be designed to replace existing dispersed sites that are degrading riparian resources (FW-DC-RECDEV-07).

Cumulative Effects

In Montana and South Dakota, much of the existing sage-grouse habitat is located on non-federal land. In many cases, the habitat is distributed across a patchwork of ownership including private, State, and Federal. Bureau of Land Management lands host the greatest amount of sage-grouse habitat in federal ownership. Bureau of Land Management resource management plans for areas adjacent to the Custer Gallatin include extensive direction for sage-grouse habitat management. The Bureau of Land Management plan for the Billings Field Office covers lands adjacent to the Pryor Mountains Geographic Area, while the Miles City Field Office and South Dakota Field Office plans cover Bureau of Land Management lands adjacent to the Ashland and Sioux Geographic Areas. Sage-grouse priority and general habitat on the Custer Gallatin often occurs as an extension of sage-grouse habitat on adjacent lands. The states of Montana and South Dakota also have conservation strategies and management plans for greater sage-grouse. These plans all contribute to coordinated efforts to implement land management programs designed to conserve sage-grouse habitat. The U. S. Fish and Wildlife Service determined that the greater sage-grouse is not warranted for listing as a threatened or endangered species, partly due to the development of federal and state management plans that incorporate conservation principles to reduce the major threats to the species (U.S. Department of the Interior 2013c).

Conclusion

The amount of high-quality sage-grouse habitat is limited on the Custer Gallatin, with most mapped habitat occurring on the edges of what would be considered suitable habitat. There are currently no active leks on the Custer Gallatin. All revised plan alternatives contain plan components that are designed to protect or maintain sage-grouse populations and their habitat. Greater level of protections and more specific language is contained within the revised plan alternatives (B through F). These alternatives better address emerging issues and more thoroughly address issues and provide protections for all seasonal habitat needs compared to the current plans (alternative A). Forest wide plan components address the known causes of population declines and habitat loss including fragmentation, development, conversion, encroachment, fire, and invasive species. Across each alternative, the allocation of land use restrictions differs within each of the geographic areas. The greatest level of benefit from these land use restrictions is associated with alternatives B, C, D, and F. Given the limited amount of potentially suitable habitat, the difference in protections provided by the land use allocations between alternatives B, C, D and F is relatively small. The measures for managing permitted livestock grazing, vegetation management, mineral and energy development, as well as administrative and recreational facilities, could help protect, maintain, or restore seasonal habitats and minimize human disturbance. Combined with the forestwide, comprehensive, detailed and specific plan direction the revised plan would provide better protection for, and potential improvement of, sage-grouse populations and associated habitats.

Known sage-grouse use on the Custer Gallatin is currently limited to summer brood rearing by a few individuals, in other words, their presence on the national forest is currently seasonal. The nearest leks in South Dakota occur on priority habitats approximately 1-5 miles from the Sioux Geographic Area. Considering most of the nesting in South Dakota can occur within 4.3 miles of a lek (Kaczor 2008) and winter habitats can range beyond 5 miles of a lek (Schroeder et al. 1999), there is potential for birds to spend at least some of their time on the Sioux Geographic Area annually. To date, a lek has not been located within the Sioux Geographic Area boundary, but priority habitat management on the Sioux Geographic Area is within the radius-influence of leks and therefore, can impact the year-round life requirements of sage-grouse. The occurrence of past lek locations in the Ashland Geographic Area, combined with currently unoccupied priority and general habitat on the Custer Gallatin, indicates potential for expanded sage-grouse use. Most of the sage-grouse habitat on the Custer Gallatin is located near the edges of administrative units, occurring as an extension of suitable habitat from adjacent mixed land ownership. Given that sage-grouse could have a year-round presence within the associated geographic areas, there is potential for increasing sage-grouse numbers and distribution on the Custer Gallatin thereby supporting the species' long-term persistence in the plan area. However, due to the relatively limited amounts and isolated distribution of sage-grouse habitat, national forest lands would likely support only a small population, which would be vulnerable to ecological stressors from both within and outside the national forest boundary. Therefore, it is likely not within the inherent capability of the plan area to maintain or restore ecological conditions that would support long term persistence of sage-grouse within the national forest boundary. Species specific plan components are designed to maintain or enhance existing habitat in support of populations whose seasonal habitat requirements extend across both non-federal and National Forest System lands. Sage-grouse persistence across the species' range will require multiple geographically distributed populations to retain redundancy, representation, and resilience (U.S. Department of the Interior 2013c). Plan components in all revised plan alternatives would maintain or restore ecological conditions within the plan area to contribute toward maintaining long term persistence of the species within its range.

White-Tailed Prairie Dog (*Cynomys leucurus*)

The white-tailed prairie dog is identified as a regional forester's species of conservation concern for the Custer Gallatin National Forest. It is one of two species of prairie dog found on the Custer Gallatin. Prairie dogs create habitat conditions favorable for a number of species besides themselves. Prairie dogs influence vegetation composition and structure through their foraging habits, creating conditions favorable for a range of short-grass prairie species. A number of species prey directly on prairie dogs for food, and some species find shelter from weather and predators in prairie dog burrows (Montana Prairie Dog Working Group 2002). White-tailed prairie dogs in Montana are at the northern tip of the species' range, occurring just north of the Wyoming border, including a small portion of the Custer Gallatin National Forest in southern Carbon County (figure 32). The white-tailed prairie dog was petitioned for listing under the Endangered Species Act. After a review of the best available scientific information in 2010, the U.S. Fish and Wildlife Service determined the species did not warrant listing. This determination was confirmed in a 2017 status review, which found that white-tailed prairie dog populations are in moderate to high overall conditions across the species' range, with trends that are generally stable except for declines due to stochastic events followed by recovery (U.S. Department of the Interior 2010b, Mack et al. 2017).

White-tailed prairie dogs are squirrel-like rodents that dig burrows underground and live in loosely formed colonies. They remain active for five to seven months of the year, and hibernate during winter. White-tailed prairie dogs are typically found at higher elevations than black-tailed prairie dogs (*C. ludovicianus*), which are the other species known to occur on the Custer Gallatin. White-tailed prairie dogs prefer relatively open areas with low vegetation height, but often have dense sagebrush cover nearby to provide protection from predators. They feed primarily on plants such as grasses, forbs, and shrubs, but will also eat a variety of insects. Across their historical range, white-tailed prairie dog distribution has remained relatively constant, but population declines have occurred due to pest control efforts, habitat loss, and disease (such as plague).

Across their range, white-tailed prairie dogs occur in an elevation band between about 3,700 and 10,500 feet. Montana is at the northern extent of white-tailed prairie dog predicted range, with Custer Gallatin National Forest System lands at about mid-elevation for the species at 6,000 to 7,000 feet. Although white-tailed prairie dog distribution has been relatively consistent across the entire range, the notable exception has been in Montana, where white-tailed prairie dogs previously occupied areas to the north of their current distribution (U.S. Department of the Interior 2010b). According to monitoring reports for the Custer Plan, (Flath 1979, cited in (U.S. Department of Agriculture 2000)) mapped the distribution of white-tailed prairie dogs in Montana during the 1970s, and found 15 colonies totaling about 773 acres in Carbon County, located on public and private lands. These colonies were resurveyed in 1997, and only two remained occupied, one of which was located partially on National Forest System lands on the Beartooth Ranger District. Conversion of shrub and grassland to agricultural lands and apparent plague have been cited as the likely causes of decline for white-tailed prairie dogs in Montana (U.S. Department of the Interior 2010b). Habitat conversion for agricultural purposes occurred on private land.

Analysis Area

White-tailed prairie dog range is very limited on the Custer Gallatin National Forest, occurring only in very small areas at the easternmost edge of the Absaroka Beartooth Mountains and westernmost edge of the Pryor Mountains Geographic Areas (figure 32). The area used for this analysis includes the range extent for the species in Montana, including small amounts of National Forest System lands for indirect effects and adjacent lands of other ownership for cumulative effects.

Figure 32. Range map for white-tailed prairie dogs in Montana
(Source: Montana Field Guide November 2018 (http://fieldguide.mt.gov/species))

Notable Changes Between the Draft and Final Environmental Impact Statement

In addition to supplementing this document with clarifying language and an analysis of effects to prairie dogs from energy and minerals management, notable changes in the plan include modifying FW-DC WLPD-01 to focus on plant and animal diversity and long-term persistence of the species, and modifying FW-GO WLPD-01 to focus on mutual Custer Gallatin and State wildlife agency conservation goals.

Affected Environment (Existing Conditions)

Prairie dogs in Montana are managed under a state-wide conservation plan (Montana Prairie Dog Working Group 2002). White-tailed prairie dog range is very limited in Montana, occurring primarily in the rolling plains and valley bottoms between the Beartooth and Pryor Mountains Ranges. The portion of the species' range in Montana is only about 1 percent of the total predicted range for white-tailed prairie dogs. Of that small amount, roughly 2 percent of the predicted range for white-tailed prairie dogs in Montana is on National Forest System lands located on the Custer Gallatin National Forest (U.S. Department of the Interior 2010b). In other words, only about 0.02 percent of white-tailed prairie dog habitat in the United States is located on the Custer Gallatin National Forest. As of 2017, when last surveyed, the single active white-tailed prairie dog colony on the Custer Gallatin was estimated at approximately 40 acres in size, located near the national forest boundary in the Absaroka Beartooth Mountains Geographic Area. White-tailed prairie dogs are also found near the Pryor Mountains Geographic Area, but to date have all been found entirely on Bureau of Land Management and private lands outside the national forest boundary (Stewart, 2018 personal communication).

White-tailed prairie dogs are typically found in relatively dry habitats, within plant communities of mixed shrub and grass species. Their habitat is often dominated by sagebrush interspersed with grass and forb species (Flath and Paulick 1979, cited in Montana Field Guides). Habitat is typically found in flat or gently rolling terrain, with lower vegetation height to facilitate predator detection, but also with some dense shrub structure nearby to use as escape cover. Deep, well-drained soils are required for digging burrows (Mack et al. 2017). Generally, prairie dogs do not inhabit areas dominated by coniferous or deciduous trees (Montana Prairie Dog Working Group 2002). Habitat conditions are limited for prairie dogs on the Custer Gallatin National Forest, since most of the National Forest System land is inhospitable due to the presence of trees, greater topographic relief, and rocky soils. The area currently occupied by white-tailed prairie dogs is shrub-steppe habitat, dominated by xeric grass and forb species, with naturally sparse (no more than 5 percent) shrub cover. Grass-shrub habitats like this typically fall within a fire regime in which stand-replacing fires burn frequently (0 to 35 years). Fire has been a natural part of this ecosystem, with the most recent burn occurring in the early 1990s. Invasive plants are present, but currently at low levels with spotty coverage; cheatgrass has yet to firmly establish in the area. Conifer encroachment could become an issue if not managed.

There is substantial evidence that globally, climates are changing, and generally, temperatures are increasing within the range of white-tailed prairie dog. Temperatures are predicted to continue to rise, with possible increases in fire size, severity, and frequency. Such changes may affect availability of suitable habitat, and could potentially result in a range shift for white-tailed prairie dogs (U.S. Department of the Interior 2010b).

Public use is relatively light in the portion of the Custer Gallatin currently occupied by white-tailed prairie dogs. Recreation on existing roads and trails is the primary use, but occurs at low levels relative to other parts of the national forest. The small size and remote location of the white-tailed prairie dog colony has not attracted recreational shooting of this species on the Custer Gallatin. There are currently no active livestock grazing allotments on National Forest System lands in this area; however, there is some residual fencing left from past livestock operations. One oil well was established in the general vicinity in the early 1990s, but did not produce as anticipated and has since been capped. Agricultural conversion has not occurred within the national forest boundary in white-tailed prairie dog habitat, but some agricultural conversion and residential development outside the national forest boundary have reduced the total colony size of white-tailed prairie dogs living within the boundary. This includes the recent construction of two private residences just outside the national forest boundary, in an area previously, and perhaps currently, occupied by white-tailed prairie dogs (Stewart, 2018 personal communication).

Key Stressors

Disease (such as plague) and habitat loss through conversion for agriculture are the most probable causes for population declines of white-tailed prairie dogs in Montana (U.S. Department of Agriculture 2000, Montana Prairie Dog Working Group 2002, U.S. Department of the Interior 2010b).

Agricultural conversion occurs when native plant communities are replaced with exotic species for purposes of producing croplands, pasturelands, or other agricultural products. Such conversion at a large scale represents permanent habitat loss for prairie dogs. In some cases, prairie dogs can coexist with agricultural operations, and may even benefit from highly nutritious forage produced on agricultural lands. However, where prairie dogs are considered a nuisance or threat to agricultural operations, pest control efforts can have negative effects on prairie dog populations (Mack et al. 2017).

Drought is another potential stressor for white-tailed prairie dogs and their habitats. Drought can affect forage production and quality, which in turn can affect prairie dog body condition, reproductive capability, and survival. Drought may also influence plague dynamics in prairie dog colonies, but this relationship is poorly understood. On the one hand, drought can affect prairie dog health, making them more vulnerable to plague infection; while on the other hand, good precipitation benefits primary productivity, which can increase abundance of fleas carrying the plague bacterium (Mack et al. 2017).

Shooting of prairie dogs has been used historically for population control, and is still a popular sport in some areas (U.S. Department of the Interior 2010b).

Poisoning has been widely used as a method of pest control to reduce or eliminate prairie dog colonies, primarily to address perceived conflicts between prairie dogs and livestock. Historical prairie dog control programs reduced the amount of area occupied by prairie dogs, including local extirpations in some areas, resulting in isolation of some colonies (Mack et al. 2017).

Invasive plant species such as non-native annual grasses and a variety of noxious weeds, can out-compete, and may eventually replace native plant species, thereby altering habitat suitability for prairie dogs by changing vegetative structure as well as forage quantity and quality. In addition to non-native grasses and forbs, native species such as juniper can also invade shrub-steppe habitats occupied by white-tailed prairie dogs, adding tall structure that is avoided by prairie dogs (Mack et al. 2017).

Fire occurrence and suppression are additional factors that may affect prairie dog habitat. Shrub-steppe habitat favored by white-tailed prairie dogs evolved with fire as a natural disturbance process that occurred at relatively low frequency intervals (Mack et al. 2017).

Climate change has been identified as a factor that could potentially affect white-tailed prairie dogs (U.S. Department of the Interior 2010b). Climate change is expected to affect precipitation, potentially increasing in this area, which could benefit white-tailed prairie dogs through increased forage production. Plague ecology could also be influenced by climate change, but impacts are difficult to predict since plague transmission is positively correlated with rainfall, but negatively associated with overall temperature increases. Warmer winter temperatures could affect plague transmission through reduced periods of prairie dog hibernation and better over-winter survival of plague-carrying fleas (U.S. Department of the Interior 2010b). In the Greater Yellowstone Area, which is where white-tailed prairie dogs occur on the Custer Gallatin, climate projections indicate that both precipitation and temperature will increase, but that increases in precipitation likely will not offset increases in drying caused by increasing average temperatures (Hansen et al. 2018). Hansen et al. (2018) also presented habitat suitability models that project potential replacement of lower elevation Douglas-fir forest by sagebrush/juniper communities, which could possibly increase the amount of suitable habitat for white-tailed prairie dogs on the Custer Gallatin. There is a considerable degree of uncertainty in climate change modeling, and these projections are speculative, with low to moderate probability of presenting over the expected life of the plan.

Environmental Consequences

Management Direction under the Current Plans

Prairie dogs are known to occur only on the Custer part of the Custer Gallatin National Forest. The existing Custer Plan addresses prairie dogs without distinguishing between white-tailed prairie dogs and black-tailed prairie dogs, which both occur on the national forest. The current Custer Plan indicates that prairie dogs are to be managed in coordination with other resources, and that prairie dog control measures will be considered to address resource issues. The current plan identifies a maximum of 50 acres of primary suitable range for livestock to be occupied by prairie dogs on the Beartooth Ranger

District, which is where white-tailed prairie dogs occur. Before control programs may be approved, the agency must consider factors such as the presence of any threatened or endangered species that could be negatively impacted, environmental implications of control methods proposed, and economic feasibility. The plan also requires considering whether proposed control measures would maintain a suitable number of prairie dog towns to provide a reasonable gene pool and adequate distribution of colonies. The plan contains a standard that new roads and facilities will be located at least 100 feet from the edge of prairie dog towns. Finally, the plan calls for monitoring of prairie dog management through surveys. An increase or decrease of 10 percent in the number of prairie dog towns, or a 10 percent increase in acres of prairie dog colonies within domestic livestock grazing allotments are indicated as the level of variation that would initiate evaluation of the need for control.

The Custer Plan identifies sensitive species as those that are susceptible or vulnerable to activity impacts or habitat alterations. In 1993, the plan was amended (Amendment 27) to add both white-tailed and black-tailed prairie dogs as sensitive species known to occur on the Custer National Forest. The Custer Plan defines a biological evaluation as the tool used to review programs and activities for possible effects on sensitive species. Prairie dogs are not known to occur on the Gallatin portion of the national forest, and the Gallatin Plan contains no direction for managing prairie dogs or their habitat.

Effects of the Current Plans

The existing (1986) (as amended) Custer Plan contains measures that apply to prairie dog towns, but do not differentiate between white-tailed and black-tailed species. The plan contains direction to provide habitat for prairie dogs in a manner that does not significantly affect the grazing of livestock, with an emphasis on controlling new prairie dog towns at a small size. There are currently no permitted livestock grazing allotments in the area white-tailed prairie dogs occupy on the Custer Gallatin, and no control measures targeting white-tailed prairie dogs have been implemented under the existing plan. There is no existing plan direction that would prohibit lethal control of white-tailed prairie dogs; however, under the current plans, the species would continue to be addressed as a regional forester’s sensitive species, so control measures would need to comply with Forest Service Manual direction for maintenance of sensitive species (FSM 2670). The current plan requires that new roads or other facilities be located at least 100 feet from the edge of existing prairie dog towns. This limit was imposed to minimize disturbance of prairie dogs and other species associated with prairie dog colonies.

Recreational shooting, which is more popular at black-tailed prairie dog colonies, may also be a factor limiting the expansion of white-tailed prairie dogs. Recreational shooting of prairie dogs tends to occur within a short distance of occupied burrows. The plan limit on new roads and trails within 100 feet of prairie dog towns may limit the amount of prairie dog mortality associated with recreational shooting. Further, the limit on new structures of any kind within 100 feet of an active colony, reduces the number of artificial perches that may be used by aerial predators of prairie dogs, which also reduces the amount of direct mortality of prairie dogs associated with management actions.

Management Direction under the Revised Plan Alternatives

Under all revised plan alternatives, the plan contains a desired condition that acknowledges the unique contributions of prairie dogs (both species) to habitat conditions required by a variety of prairie-associated plants and animals (FW-DC-WLPD-01). Habitat for both white-tailed and black-tailed prairie dogs allows for colony expansion, but black-tailed prairie dog colony expansion does not result in unwanted encroachment onto adjacent non-Federal lands (FW-DC-WLPD-02). All revised plan alternatives include a goal to engage with State wildlife agencies to coordinate management of prairie dog towns (FW-GO-WLPD-01). The revised plan alternatives contain standards that would preclude the use of toxicants (such as rodenticides) for control of white-tailed prairie dog colonies, and like the existing plan, would also prohibit construction of new permanent roads, trails or other facilities and structures within 100 feet of white-tailed prairie dog colonies (FW-STD-WLPD-01 and 02).

Effects of the Revised Plan Alternatives

Under the revised plan alternatives, desired conditions acknowledge the important ecological contributions of prairie dogs (FW-DC-WLPD-01). Accordingly, the Custer Gallatin may take a more proactive role in managing white-tailed prairie dog habitat to facilitate colony expansion. However, the amount of habitat suitable for white-tailed prairie dogs is somewhat limited on the Custer Gallatin. All revised plan alternatives contain objectives for implementation of projects to benefit at-risk species, which could promote habitat restoration or improvement projects for white-tailed prairie dogs (FW-DC-WLPD-01). For example, the targeted removal of conifers encroaching into otherwise suitable prairie dog habitat, or noxious weed treatment to reduce competition for native plant species, could be used to benefit white-tailed prairie dogs. All revised plan alternatives would prohibit the use of toxicants (such as rodenticides) to control the spread of white-tailed prairie dog colonies, and also prohibit the construction of new permanent facilities or structures near white-tailed prairie dog colonies, which combined would limit the amount of prairie dog mortality associated with management actions (FW-STD-WLPD-01, 02). The revised plan alternatives include a goal to engage with State wildlife agencies to coordinate management of prairie dog towns (FW-GO-WLPD-01). Such coordinated efforts could result in increased size or number of prairie dog colonies, as well as improved health and resilience to disease for white-tailed prairie dogs on the Custer Gallatin National Forest.

Sylvatic plague is an exotic disease that is caused by a bacterium carried by fleas and subsequently transmitted to host animals (such as prairie dogs) through flea bites. Prairie dogs live in colonies and are highly social, so they are more likely to transmit disease among themselves than are other rodents. However, white-tailed prairie dog colonies are more loosely organized, less densely populated, and exhibit less social behavior (such as grooming one another) than other species of prairie dogs, and therefore, appear to be less susceptible to plague dynamics (Montana Prairie Dog Working Group 2002, Nistler 2009, U.S. Department of the Interior 2010b). Forest management actions have little influence on disease spread among prairie dogs. However, the revised plan alternatives all contain a goal to engage with State wildlife agencies to coordinate management of prairie dogs, which could result in cooperative efforts to manage plague outbreaks on the Custer Gallatin and adjacent lands (FW-GO-WLPD01).

Consequences to White-Tailed Prairie Dog from Plan Components Associated with other Resource Programs or Management Activities

Effects from Terrestrial Vegetation Management

All revised plan alternatives contain desired conditions for grassland and shrubland habitats, including native plant communities that are self-sustaining, non-native species are in check (not increasing) and plant communities support biodiversity (FW-DC-VEGNF-01, 02). In addition, detailed descriptions are included for plant species composition, structure, and conditions that result in healthy, resilient habitats that support prairie dogs (FW-DC-VEGNF-04). Refer to the terrestrial vegetation, grasslands, and shrublands section of this document for a more detailed description of existing conditions and environmental consequences of the revised plan alternatives. These desired conditions reflect knowledge of the natural range of variation for grassland and shrubland communities. Achieving desired conditions for grass and shrub habitats would provide over time a range of conditions to which prairie dogs have adapted on the Custer Gallatin. The revised plan alternatives include guidelines to promote habitat heterogeneity and minimize habitat fragmentation, which would benefit prairie dogs (FW-GDL-VEGNF-01, 03). In summary, the revised plan alternatives contain much more detailed, community-specific and ecologically based direction for managing grass and shrub habitats, which would be more favorable for prairie dog habitat than under existing plan direction.

Effects from Fire and Fuels Management

Fire can reduce vegetation height, thereby increasing visibility for prairie dogs to detect predators. Fire also contributes to nutrient cycling, which is important for plant productivity and forage production. However, intense fire can kill sagebrush, and often favors invasive species, which may perpetuate a more frequent fire cycle. White-tailed prairie dogs use shrubs as forage, as well as escape cover from predators, and severe reductions in shrub cover may have negative impacts on habitat. Fire in late summer or autumn can reduce forage needed by prairie dogs to build fat reserves for winter hibernation (Mack et al. 2017). The revised plan alternatives include desired conditions for the amount and severity of wildland fires to be within the natural range of variation to maintain resilient ecological conditions, which would promote a more natural fire regime that produces conditions favorable to prairie dogs (FW-DC-FIRE01, 02). Fire and fuels direction under all revised plan alternatives include plan components aimed at hazardous fuels mitigation to protect values at risk, particularly in the wildland-urban interface (FW-STD-FIRE01; FW-GDL-FIRE02, 03). Location of the white-tailed prairie dog colony near the national forest boundary adjacent to private homes lends it to consideration for hazardous fuels mitigation. Common fuel-reduction practices such as removal of conifers encroaching into the area, or removal of tall, dense grasses that present flashy fuels, could benefit prairie dog habitat, and timing could be used to minimize negative impacts to prairie dogs.

Over time, fire suppression can result in an increase in tree and shrub species in sage-steppe habitats, at the expense of native grass and forb species that provide important forage components for prairie dogs. On the other hand, fire suppression can prevent severe fires from removing important escape cover in white-tailed prairie dog habitat (Mack et al. 2017). Due to the location of the white-tailed prairie dog colony near the national forest boundary and adjacent to private homes, suppression of wildfire would be a high priority if homes were threatened. All revised plan alternatives include a guideline to minimize natural resource damage through use of minimum impact suppression tactics, including habitat for at-risk species such as the white-tailed prairie dog (FW-GDL-FIRE03). Given the colony proximity to private homes, increased presence of trees and shrubs would likely be a target for hazardous fuels mitigation under all alternatives.

Effects from Permitted Livestock Grazing Management

Properly managed livestock grazing can benefit white-tailed prairie dogs by reducing vegetation height to enhance visibility and predator detection by prairie dogs. However, overgrazing by livestock can alter vegetation and soils, resulting in negative impacts to prairie dogs. Infrastructure associated with livestock production such as roads, fences, and water developments can fragment habitat, and attract prairie dog predators. Livestock may also compete directly with prairie dogs for preferred forage species, leaving less desirable or unpalatable plant species to flourish, including potential colonization by invasive plant species such as cheatgrass. Overstocking of livestock can result in soil compaction, reducing soil suitability for prairie dog burrows (Mack et al. 2017). No livestock grazing is currently permitted in the area white-tailed prairie dogs occupy on the Custer Gallatin. However, short-term use of domestic livestock could be an appropriate tool to reduce existing vegetation height, or to treat noxious weeds competing with native plants that provide forage for prairie dogs. This tool would be available under all alternatives. All revised plan alternatives contain a standard that new or revised allotment management plans include grazing practices that avoid, minimize, or mitigate adverse livestock-related effects in both riparian and upland habitats, which would result in proper grazing levels, and minimize impacts from invasive plants and soil compaction in a manner that would benefit white-tailed prairie dogs (FW-STD-GRAZ01).

Effects from Recreation Management

The area occupied by white-tailed prairie dogs has road and trail access, with a semi-primitive motorized recreation opportunity class under all alternatives. However, it is immediately adjacent to semi-primitive non-motorized areas, and overall recreational use occurs at low levels and is highly dispersed, relative to other parts of the Custer Gallatin National Forest. The primary concern from recreation management would be potential for recreational shooting of white-tailed prairie dogs. Shooting of nongame species such as prairie dogs falls under State jurisdiction, and is largely unregulated in areas occupied by prairie dogs on the Custer Gallatin National Forest. White-tailed prairie dogs are susceptible to unrestricted recreational shooting, but the effects have not been well studied for this species. Lower population density and less social structure of white-tailed prairie dog colonies may discourage recreational shooting (U.S. Department of the Interior 2010b). Further, the small size and isolated location of the white-tailed prairie dog colony is unlikely to attract recreational shooting on the Custer Gallatin.

Effects from Energy and Minerals Management

Energy and mineral development has potential to result in negative impacts to prairie dogs through destruction or adverse modification of habitat and displacement of individuals or colonies. These impacts could be particularly acute to small, isolated colonies such as the existing white-tailed prairie dog colony on the Custer Gallatin. If full and unrestricted energy development were to occur within or near the current colony, the impacts may result in extirpation.

The effects of oil and gas activities and development of lease stipulations are determined in a site-specific analysis at the leasing decision stage. Conservation measures would be developed to meet protections afforded through multiple plan components. Given that a desired condition states that a complete suite of native species is present and adaptable to changing conditions (FW-DC-WL-01), the Custer Gallatin would take actions to ensure maintenance of the white-tailed prairie dog colony. Roads and other permanent facilities would not be constructed within 100 feet of both white- and black-tailed prairie dog colonies (FW-STD-WLPD-02; FW-GDL-WLPD-02). Per infrastructure desired condition (FW-DC-RT-01), the transportation system has minimal impact on species of conservation concern including white-tailed prairie dogs. Disturbed areas would be reclaimed to pre-operational site conditions (FW-STD-EMIN-01). These restrictions apply to infrastructure associated with energy development. Therefore, actions associated with energy development would minimize impact to white-tailed prairie dogs and their habitat.

Cumulative Effects

Hunting of wildlife falls under jurisdiction of the states. White-tailed prairie dogs are managed under a conservation plan for prairie dogs in Montana (Montana Prairie Dog Working Group 2002), and are identified as species of concern by the state of Montana. For regulatory purposes, prairie dogs have dual designation of "nongame" status by the Montana Fish Wildlife and parks, as well as "vertebrate pests" by the Montana Department of Agriculture. As such, recreational shooting of prairie dogs is largely unregulated (Montana Fish Wildlife and Parks 2007, Nistler 2009). Although white-tailed prairie dogs are identified as a "species of greatest conservation need" by the state of Montana, they are currently unregulated as a nongame species, and shooting is allowed on public lands, unless covered under a special area closure (Montana Fish Wildlife and Parks 2015c). The revised plan alternatives plan components for prairie dogs are consistent with the conservation plan for prairie dogs in Montana (Montana Prairie Dog Working Group 2002).

The Bureau of Land Management Resource Management Plan for the Billings Field Office considers white-tailed prairie dogs a special status species. In Montana, prairie dog management actions on Bureau of Land Management lands are subject to the conservation plan for prairie dogs (Montana Prairie Dog Working Group 2002), under which white-tailed prairie dogs will be considered a priority for management due to limited and declining populations. The Bureau of Land Management plan prohibits surface occupancy and use for oil and gas exploration and development within ¼ mile of prairie dog colonies active within the past 10 years.

Conclusion

In summary, the revised plan alternatives acknowledge the ecological importance of prairie dog communities, and subsequently provide more specific and protective measures for white-tailed prairie dogs than the current plans, including a proactive desired condition to allow for natural colony expansion where suitable, rather than placing limits on allowable acreage of occupation. Under the current plans, the white-tailed prairie dog would remain on the regional forester's list of sensitive species. Direction for Forest Service sensitive species management is found in the Forest Service Manual (FSM 2672.32), which mandates that agency decisions must not result in loss of species viability or create significant trends toward Federal listing. The U.S. Fish and Wildlife Service has determined that the white-tailed prairie dog is not warranted for Federal listing (U.S. Department of the Interior 2010b) (Mack et al. 2017).

The 2012 Planning Rule requires that plan components must provide the ecological conditions necessary to maintain long term persistence of each species of conservation concern within the plan area. The Custer Gallatin National Forest (plan area) is at the very northern tip of the established range for white-tailed prairie dogs (http://fieldguide.mt.gov/species). The white-tailed prairie dog population on the Custer Gallatin National Forest is small, but has remained persistent over time. Due to the small size of the population and limited habitat available on the Custer Gallatin for expansion, the white-tailed prairie dog is vulnerable to stressors beyond the authority of the Forest Service to manage; most notably the risk of plague spread by fleas from source populations outside the forest boundary. In this case, the plan must provide direction that will contribute to maintaining long term persistence of the species within its range. The U.S. Fish and Wildlife Service recently found that white-tailed prairie dog populations are in moderate to high overall conditions across the species' range, with trends that are generally stable except for declines due to stochastic events followed by recovery (Mack et al. 2017). Under all revised plan alternatives, plan components provide proactive measures to manage conditions within the authority of the Forest Service to maintain the existing population of white-tailed prairie dogs, and allow for colony expansion within the inherent capability of the habitat on the Custer Gallatin National Forest. Therefore, the revised plan would maintain conditions that would contribute to the long-term persistence of the species within its range.

3.10.4 General Wildlife

Notable Changes between the Draft and Final Environmental Impact Statements

The discussion and analysis of wolverine has been moved from the Federally Listed Wildlife Species section and placed in the General Wildlife section due to the 2020 FWS decision to not list wolverine under the Endangered Species Act.

Bighorn Sheep (*Ovis canadensis*)

Bighorn sheep occur in the mountainous regions of the western United States, including both Montana and South Dakota. They are currently present only in the Montana portion of the Custer Gallatin National Forest. Some have suggested that bighorn sheep historically present in the badlands of eastern Montana and northwestern South Dakota, may have been a subspecies called Audubon sheep (*O. c. auduboni*). However, since few specimens from the area were available to study, it was difficult to prove distinction to the subspecies level, and debate as to whether a true subspecies existed continues today (Montana Fish Wildlife and Parks 2010).

European settlement of the western United States led to serious declines in bighorn sheep populations at the turn of the 20th century. By 1930, wild sheep were limited to a number of small, remnant bands across their range, and the bighorns were extirpated from eastern Montana and South Dakota (Montana Fish Wildlife and Parks 2010, South Dakota Department of Game Fish and Parks 2014b). Causes cited for population declines include competition with domestic livestock for space and forage, introduced disease, and overharvest from hunting. Other contributing factors included poor range condition, extreme weather events, and native disease outbreaks. Alarm over rapidly declining sheep populations spurred restoration efforts in the 20th century. The distribution of bighorn sheep has improved since then because of improved range management, reduced competition from livestock and other native herbivores, reductions in the presence of domestic sheep and goats, regulated hunting, and implementation of a bighorn sheep transplanting program (Montana Fish Wildlife and Parks 2010). Disease-related die-offs and lowered lamb recruitment periodically affect individual herds throughout the west, including some on the Custer Gallatin (Montana Fish Wildlife and Parks 2010, Garrott et al. 2015).

Bighorn sheep use a variety of vegetation, elevations, and other conditions that can vary by individual herd, season, and between sex and age cohorts. While variation is common for bighorn sheep, there are habitat components that are particularly important, and consistently used across bighorn sheep range. Escape terrain is a key element in all seasonal bighorn sheep ranges. Escape terrain typically includes steep, rocky slopes that are used by bighorn sheep to escape predation. Most bighorn sheep, but particularly ewes and lambs, are generally found within 100 meters (109 yards), and rarely found more than 300 meters (328 yards) from escape terrain. High visibility is another characteristic of great importance to bighorn sheep, as it is necessary for the detection and avoidance of predators, as well as for locating and accessing suitable foraging areas. Winter range for bighorn sheep is typically found at lower elevations, on southerly aspects with escape terrain available near foraging areas. However, some bighorn sheep find suitable winter range at higher elevations where windswept slopes provide access to both forage and escape terrain (DeCesare and Pletscher 2006, Montana Fish Wildlife and Parks 2010). Bighorn lambs are born in spring, generally near or at lower elevations than, winter ranges. Lambing areas typically provide warmer slopes (such as southerly exposure), accessible escape terrain, good visibility, and proximity to good quality drinking water and forage (Montana Fish Wildlife and Parks 2010).

Bighorn sheep are opportunistic foragers, using a wide variety of vegetation types as foraging areas. A key attribute of foraging habitat is proximity to escape terrain and high visibility. Heavily forested areas are typically avoided. Forbs are predominant in spring diets of bighorn sheep, and grasses become more important during summer and fall when forbs dry out and become less available and palatable. Browse species (such as shrubs and trees) may become important in fall and winter with decreasing availability of grasses and forbs (Montana Fish Wildlife and Parks 2010). Recently burned areas may provide new foraging opportunities for bighorn sheep, particularly where pre-fire conditions supported dense tree or tall shrub cover (DeCesare and Pletscher 2006).

Bighorn sheep often persist as a metapopulation, which is several subpopulations (or relatively distinct herds) distributed across habitat such that they are connected to some degree by dispersal of individuals between subpopulations. Some degree of habitat connectivity between subpopulations is required to promote dispersal. Metapopulation systems facilitate gene flow to maintain or increase genetic diversity, which generally improves fitness of individuals and populations. However, metapopulation structure can also influence the rate of disease spread between subpopulations (Montana Fish Wildlife and Parks 2010).

Analysis Area

The stronghold for bighorn sheep on the Custer Gallatin is currently, and always has been, the large, relatively contiguous block of habitat contained in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas. Therefore, these geographic areas will be the focal area for the analysis. However, bighorns occasionally wander into the Pryor Mountains Geographic Area, and there is suitable, but unoccupied habitat for the species in the Bridger, Bangtail, and Crazy Mountains; Ashland; and Sioux Geographic Areas, so these areas will be considered for indirect and cumulative effects as well.

Notable Changes between the Draft and Final Environmental Impact Statement

In addition to supplementing the analyses with new information and citations, clarifying language, minor edits, and analysis of alternative F, this section was revised to include a more quantitative analysis of potential impacts on currently occupied bighorn sheep habitat, as well as to expand the analysis regarding potential for transmission of disease-causing pathogens from domestic animals to bighorn sheep. The section on effects from recreation management was revised to reflect differences in management between domestic herd animals (sheep and goats) permitted on the national forest for livestock production or weed treatment, versus domestic species used by recreationists as pack animals. A notable change to the plan is the addition of a goal for the Forest Service to cooperate with Tribes, state wildlife management agencies, and other stakeholders to support bighorn sheep establishment in suitable areas not currently occupied by wild sheep (FW- GO-WLBHS-02).

In response to objections, the maximum limit on the number of allowable pack goats per individual in FW-STD-RECOG-01 (h) and FW-SUIT-REC-02 (h) was raised from four to six. The Custer Gallatin found no scientific literature recommending a number of pack goats per individual threshold. The limit of six per individual was selected following consultation with pack goat operators on the maximum number of goats an individual could be reasonably expected to manage in accordance with required standards. Allowing six goats per individual provides efficiencies in the removal of harvested big game such as elk by minimizing the number of visits to accomplish the task thereby reducing the probability of conflict with predators and contact with bighorn sheep.

Affected Environment (Existing Conditions)

Bighorn sheep are currently present in the Madison, Henrys Lake, and Gallatin Mountains, Absaroka Beartooth Mountains, and Pryor Mountains Geographic Areas of the montane ecosystem on the Custer Gallatin National Forest; with multiple herds using the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, and a single herd occasionally using the Pryor Mountains Geographic Area. Bighorn sheep presence on the Custer Gallatin is a result of both long-term persistence of native sheep herds, as well as more recent transplants in some areas. Bighorns in the Madison, Henrys Lake, and Gallatin Mountains and Absaroka Beartooth Mountains Geographic Areas are mostly native herds, but there has been some augmentation with transplants. It is likely that individual sheep disperse between herds and interbreeding occurs in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas. The Pryor Mountains bighorn sheep herd is primarily found outside the Custer Gallatin on lands managed by the National Park Service (Bighorn Canyon National Recreation Area) and Bureau of Land Management, but bighorns occasionally venture onto the national forest in the Pryor Mountains Geographic Area. The Pryor Mountains herd was established through transplants of bighorn sheep from Montana and Wyoming. Wild (feral) horses are present in the Pryor Mountains Geographic Area; however, only a few bighorns, primarily rams, are occasionally found within the wild horse territory on the Custer Gallatin. In the late 1800s, bighorn sheep were likely present in the Crazy Mountains of the Bridger, Bangtail, and Crazy Mountains Geographic Area, but were historically absent from the Bridger and Bangtail Ranges (Montana Fish Wildlife and Parks 2010).

Bighorn sheep are not known historically from the Ashland Geographic Area, but a few individuals have been documented there in the early 2000s (Montana Natural Heritage Program). These sheep were likely from the Blue Hills herd, which was established north of the Ashland Geographic Area by transplant in the late 1950s (Montana Fish Wildlife and Parks 2010). Recent sightings of sheep on the Ashland Geographic Area occurred during extreme fire seasons, possibly due to smoke and fire causing the sheep to roam further than usual (Montana Natural Heritage Program); however, wild sheep are not known to reside in the Ashland Geographic Area. Bighorn sheep were historically present in the prairies and badland formations of the Sioux Geographic Area, but were extirpated by the early 1900s. In 1961, bighorn sheep from Canada were released into the Slim Buttes of the Sioux Geographic Area (South Dakota Department of Game Fish and Parks 2018b). Some of the transplanted bighorn rams mingled with domestic sheep and as a result, were likely shot by ranchers. The remaining wild sheep in the Sioux Geographic Area died of disease, and no further reintroductions occurred (Deisch, 2019b personal communication). No bighorn sheep have been documented in the Sioux Geographic Area since the 1960s. The Sioux Geographic Area, and to a lesser extent the Ashland Geographic Area, are near domestic sheep allotments on Bureau of Land Management land (Montana Fish Wildlife and Parks 2010).

Individual herd size can vary considerably year to year. While some of the bighorn sheep herds utilizing the Custer Gallatin are robust and frequently number well over 100 animals, others are much smaller. Generally smaller herd sizes and isolation can affect bighorn sheep population health and recruitment. However, higher population growth has been observed for smaller bighorn herds in the Greater Yellowstone Area (including some on the Custer Gallatin), which could be due to density-dependent factors (competition for resources) limiting growth rates of larger herds (Flesch and Garrott 2012). Loveless (2016) noted strong evidence that disease risk increases at higher bighorn sheep densities in areas of the Custer Gallatin Forest, indicating that smaller herd size and isolation can actually limit potential for disease transmission through greater dispersion of individuals, and limited movement between established herds. Although mixing of herds can benefit genetic diversity of the larger bighorn population, such movement, either through natural dispersal or animal transplants, can also introduce disease, or augment herds with more susceptible individuals (Loveless 2016).

Bighorn sheep habitat in the montane ecosystem of the Custer Gallatin ranges in elevation from about 5,500 feet to over 12,000 feet, and can generally be described as a mosaic of rolling montane foothills, grass, forb, and shrub meadows, open-canopied forested slopes, alpine ridges and basins, steep canyons, and sheer cliffs. Lower elevation badlands in the pine savanna ecosystem may provide suitable habitat, but are currently not occupied by bighorn sheep. Winter range currently occupied by bighorn sheep is a mix of high and low elevation habitats. Some sheep winter on open, wind-swept slopes at higher elevations, while others move to lower elevations where thermal conditions expose more forage. Some herds intermingle on summer range, and move to separate winter ranges. Roughly 47 percent of the Absaroka Beartooth Mountains Geographic Area provides potential bighorn sheep habitat, including 25 percent in grass and forb meadows that provide foraging habitat for summer and winter range, 2 percent in shrublands that provide cover for possible lambing areas, and 20 percent in rock or other sparsely vegetated types that provide potential escape terrain. About 24 percent of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area is potential bighorn sheep habitat, with 14 percent grass and forb cover, 4 percent shrub cover, and 6 percent rock or other non-vegetated areas. The Pryor Mountains bighorn sheep herd is mainly found on lands managed by the Bureau of Land Management and Bighorn Canyon National Recreation Area, but bighorns occasionally venture onto the Forest Service in the Pryor Mountains Geographic Area. The Pryor Mountains Geographic Area is much smaller than the others, but roughly 36 percent of the area is grass and forb habitat, with 2 percent shrub cover, and only 1 percent rock or cliff component. The lack of adequate escape terrain in the Pryor Mountains Geographic Area likely explains why bighorn sheep presence there is limited.

Bighorn sheep general and winter range distribution information for the Custer Gallatin National Forest was obtained from Montana Fish Wildlife and Parks (http://gis-mtfwp.opendata.arcgis/com). According to these data, bighorn sheep use over a million acres of National Forest System lands in the Absaroka Beartooth; Madison, Henrys Lake, and Gallatin; and Pryor Mountain Geographic Areas of the national forest. General range is typically where bighorn sheep may be found in spring, summer, and fall. Winter range is primarily where bighorn sheep winter, but sheep may also use winter range during spring, summer, and fall. Bighorn sheep general and winter range in the Absaroka Beartooth Geographic Area correspond with potential suitable habitat as described above, covering approximately 46 percent of the geographic area. In the Madison, Henrys Lake, and Gallatin Geographic Area, bighorn sheep distribution (general and winter range) covers roughly 53 percent of the geographic area, whereas only about 24 percent of the area is dominated by grass, forbs, shrubs, sparse vegetation, and rock, indicating that bighorns make considerable use of some forested habitats in this geographic area. Nearly 40 percent of the Pryor Mountains Geographic Area contain open habitats that may be suitable for bighorn sheep use, but as noted previously, wild sheep occur there sporadically, using less than 1 percent of this geographic area as general range.

Perhaps due to their affinity for rugged (escape) terrain, roughly 56 percent of current bighorn use areas (general and winter range) are within designated wilderness areas, with an additional 27 percent located in wilderness study areas or inventoried roadless areas. In other words, approximately 83 percent of the bighorn sheep use areas on the Custer Gallatin are within designated areas managed with land use restrictions that limit permanent developments that can fragment bighorn sheep habitat. Also, with limited human access, which provides greater security from human disturbance. While such areas provide some protections for bighorn sheep habitat, land use restrictions in these designated areas do not preclude the presence of domestic livestock. The most important influence on bighorn sheep populations in Montana appears to be disease-related die-off. An extensive review of scientific literature and available data on bighorn sheep populations in the western United States concluded that contact with domestic sheep and goats was the source of most of the disease resulting in major die-offs of bighorn sheep (Western Association of Fish and Wildlife Agencies (WAFWA) 2012). Bighorn sheep are susceptible to a lung disease called pneumonia. Pneumonia is caused by the interaction of several pathogens such as bacteria, lungworms and viruses. One bacterium in particular, Mycoplasma ovipneumoniae (M.ovi), is currently thought to be most important to the initiation of pneumonia in bighorn sheep. Many of these pathogens, including M. ovi, can be introduced to bighorn sheep through contact with their close relatives, domestic sheep and goats (Besser et al. 2013, Cassirer et al. 2017).

Most studies have focused on domestic sheep as carriers of infectious pathogens to bighorn sheep, likely because domestic sheep have historically been more common than domestic goats in bighorn sheep habitat. In the limited research, where domestic goats were intentionally comingled with bighorn sheep, only sporadic occurrence of fatal pneumonia has been reported (Besser et al. 2013). However, phylogenetic analysis of an M. ovi strain that recently caused 33 percent mortality in adult bighorn sheep within the Hells Canyon region indicated this strain was most likely of domestic goat origin (Besser et al. 2013). This suggests that some domestic goats may carry more serious strains of M. ovi than captive comingling studies have indicated to date.

Domestic sheep and goats may be authorized by special use permit on National Forest System lands for livestock production, use as bio-control agents to manage infestations of noxious weeds, or use as recreational pack animals. However, there are currently no permits issued for grazing allotments stocked with domestic sheep or goats, and no permits issued for outfitter or guide use of pack goats on the Custer Gallatin National Forest. Targeted grazing of domestic sheep and goats has been used for weed treatment in some areas of the Custer Gallatin; however, such use has been deliberately restricted to sites not currently occupied by bighorn sheep. Trespass of domestic sheep and goats may occasionally occur from adjacent lands, but is not known to have been a major issue on the Custer Gallatin. A few individuals have used domestic pack goats for personal recreational purposes, but to date, such use has been very limited on the Custer Gallatin National Forest.

Mountain goats are not native to the Custer Gallatin National Forest, but rather were introduced here in the 1940s and 1950s, some in areas of native bighorn sheep habitat. The two species occupy similar habitats, and where they overlap there could be competition for forage and other resources, as well as potential for disease transmission between these species (Flesch and Garrott 2012, Garrott 2016, Wolff et al. 2016) (Garrot, 2016 personal communication). To date, studies conducted on the Custer Gallatin have shown differences in habitat selection and foraging behavior between the species, with little direct competition noted. From 1995 to 2009, bighorn sheep populations on the Custer Gallatin, which are all sympatric with mountain goats, showed stable to increasing populations (Montana Fish Wildlife and Parks 2010, Garrott et al. 2012).

Key Stressors

The presence of domestic sheep and goats that carry disease-related pathogens near bighorn sheep is a key stressor for bighorn sheep. Respiratory disease, likely originally transmitted to bighorns from domestic sheep and perhaps goats, was identified as a primary cause of mortality in bighorn sheep in the 20th century (Montana Fish Wildlife and Parks 2010, Western Association of Fish and Wildlife Agencies (WAFWA) 2010, Garrott et al. 2019). Consequently, comingling of bighorns with domestic sheep and goats continues to be a major concern today (Garrott et al. 2012).

Conifer establishment in previously open areas limits visibility, which reduces suitability for bighorn sheep, can fragment bighorn sheep habitat, and may disrupt traditional migration patterns (Montana Fish Wildlife and Parks 2010).

Noxious weed invasion can alter plant community composition and impact forage availability for bighorn sheep (Montana Fish Wildlife and Parks 2010).

Livestock grazing operations for cattle, horses, or other species not considered a risk for disease transmission can impact bighorn sheep habitat (Montana Fish Wildlife and Parks 2010).

Human disturbance can be a key stressor on bighorn sheep winter range or lambing areas, as such disturbance can cause displacement of sheep, or other behavioral modifications that can deplete energy reserves at crucial times (Montana Fish Wildlife and Parks 2010).

Permanent developments such as residential areas or resorts, recreation facilities, paved roads and highways, dams, large mining operations, and energy developments, can affect bighorn sheep through loss or fragmentation of habitat, disruption of migratory corridors, mortality from vehicle collisions, harassment by domestic pets, and displacement to less suitable habitats (Montana Fish Wildlife and Parks 2010).

Environmental Consequences

Management Direction under the Current Plans

The Custer Plan directs that special consideration be given for bighorn sheep, indicating that activities may be restricted during key timing periods for herds using the Custer Gallatin National Forest. The Custer Plan specifies that vegetation manipulation will be used to increase the abundance and vigor of bighorn sheep forage species, but that mechanical methods resulting in surface disturbance are not allowed for such projects on bighorn sheep winter range. The existing plan resulted in closure of the only domestic sheep allotment that was in the Custer portion of the Absaroka-Beartooth Wilderness, which is an area that has been a stronghold for bighorn sheep on the Custer Gallatin.

The Gallatin Plan acknowledges the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area as home to an important population of bighorn sheep, with an associated goal to maintain and enhance bighorn sheep habitat and a standard to manage the lambing area. The Gallatin Plan also incorporates by reference management direction from the 1982 “Absaroka-Beartooth Wilderness Management Plan,” which requires monitoring of bighorn sheep populations, and coordination of land uses that could negatively impact bighorn sheep in the wilderness area. Finally, the Gallatin Plan prohibits stocking of domestic sheep in grazing allotments within the grizzly bear recovery zone/primary conservation area. This restriction applies to roughly 44 percent of the Madison, Henrys Lake, and Gallatin Mountains and the Absaroka Beartooth Mountains Geographic Areas, which contain bighorn sheep.

Bighorn sheep are currently identified as a regional forester's sensitive species known to be present on both the Custer and Gallatin portions of the Custer Gallatin National Forest. Under both current plans, habitat management for sensitive species is subject to special management considerations, as outlined in the Forest Service Manual (FSM 2670).

Effects of the Current Plans

Respiratory disease epidemics are perhaps the primary limiting factor for bighorn sheep populations, and research has confirmed that domestic sheep and goats can carry some of the same strains of pathogens, which can be transmitted to bighorn sheep in the wild, potentially causing disease in wild sheep herds. Separation between domestic and wild sheep is considered an effective way to reduce the risk of disease transmission between domestic and wild species (Montana Fish Wildlife and Parks 2010) (Western Association of Fish and Wildlife Agencies (WAFWA) 2012). Under the current plans, there have been no permits issued for livestock grazing allotments stocked with domestic sheep or goats on the Custer or Gallatin for over 20 years. Bighorn sheep on the Custer Gallatin still carry known disease pathogens, and have experienced respiratory disease epidemics. Some, but not all herds found on the Custer Gallatin have experienced disease-related die-offs, but affected herds generally have recovered either naturally or through population augmentation (Montana Fish Wildlife and Parks 2010, Garrott et al. 2015).

Under current plans, domestic sheep and goats could be permitted on grazing allotments in some areas where disease transmission between domestics and wild sheep could occur. The Gallatin Plan prohibits stocking of domestic sheep in livestock allotments inside the grizzly bear recovery zone/primary conservation area. This restriction prevents stocking of domestic sheep in approximately 44 percent of the total bighorn sheep range on the national forest, including about 49 percent of the general range and roughly 23 percent of the winter range used by bighorns. There is currently no such prohibition elsewhere, leaving approximately 56 percent of bighorn sheep range open to consideration for domestic sheep grazing permits. Improper grazing of cattle and horses can result in overutilization, which can affect forage availability for wild sheep, and livestock fences can affect bighorn sheep movement patterns (Montana Fish Wildlife and Parks 2010). Grazing utilization standards in current plans have minimized areas where improper livestock grazing has affected bighorn sheep forage. In fact, a livestock grazing system was established on bighorn sheep winter range in one area of the Custer Gallatin for the purpose of improving bighorn sheep winter forage (Montana Fish Wildlife and Parks 2010). While standards in current plans have been largely compatible with bighorn sheep habitat management strategies, current plans do not directly address the primary threat of disease transmission from domestic sheep and goats to bighorn sheep.

Although there is no existing direction specifically addressing disease transmission between domestic sheep and goats and bighorn sheep, both plans contain management direction to maintain or enhance bighorn sheep habitat. Further, both plans contain language for management of sensitive species, and the bighorn sheep is currently on the regional forester's list of sensitive species for both the Custer and Gallatin Forests. Although the plans themselves may not specifically prohibit stocking of domestic sheep on permitted grazing allotments in some areas where bighorn sheep may be present, manual direction for Forest Service sensitive species would likely preclude authorization of domestic sheep or goat grazing permits where such activity would present a high risk of disease transmission to bighorn sheep. Current plans do not specifically address the primary threat of disease transmission from domestic sheep or goats to bighorn sheep. However, other directives are in place that would minimize risk of disease transmission from livestock to bighorn sheep under the current plans.

Management Direction under the Revised Plan Alternatives

All revised plan alternatives include components for general wildlife to maintain a complete suite of native species, provide habitat conditions within a natural range of variation, provide habitat security, maintain habitat connectivity, provide structural and functional diversity, limit disturbances, and maintain low risk of disease transmission (FW-DC-WL-01, 03, 04, 05, 06, 07, 09). In addition to general wildlife components, the revised plan alternatives include desired conditions for habitat that supports robust bighorn sheep populations that can, if necessary, serve as source populations for augmentation elsewhere (FW-DC-WLBHS-01), and that bighorn sheep do not intermingle with, or contract contagious disease from, domestic livestock (FW-DC-WLBHS-02). With these conditions in mind, the revised plan alternatives include a goal for cooperation and collaboration with Tribal governments, state wildlife management and livestock health agencies, livestock permittees, and other interested parties to develop livestock management protocols and habitat management strategies to minimize risk of disease transmission between domestic sheep and goats and bighorn sheep (FW-GO-WLBHS-01). In order to prevent disease transmission from domestic animals to wild sheep, the revised plan alternatives include a suite of plan components that address permitted grazing of domestic sheep and goats on National Forest System lands for livestock production, outfitter and guide use (pack animals), recreational use and biocontrol of invasive plants. These plan components vary by alternative as follows.

Under alternatives B and C, special use permits would not be authorized for grazing allotments stocked with domestic sheep or goats (draft plan FW-STD-GRAZ-02) or for outfitter use of domestic goats as pack animals (draft plan FW-STD-RECOG-01) in the Absaroka Beartooth Mountains; Madison, Henrys Lake, and Gallatin Mountains; or Pryor Mountains Geographic Areas; nor would these geographic areas be suitable for recreational packing of domestic goats by the general public (draft plan FW-SUIT-REC-01). Permits could be issued for sheep and goat grazing allotments (draft plan FW-STD-GRAZ-02), or for pack goat use by outfitters and guides (draft plan FW-STD-RECOG-01) in the Bridger, Bangtail, and Crazy Mountains; Ashland; and Sioux Geographic Areas if the risk of disease transmission could be effectively mitigated. Targeted grazing by domestic sheep or goats for weed control could be used anywhere on the Custer Gallatin, so long as mitigation measures could effectively minimize risk of disease transmission from domestic animals to wild sheep (draft plan FW-STD-GRAZ-03).

Under alternative D, stocking of permitted grazing allotments with domestic sheep or goats for livestock production (draft plan FW-STD-GRAZ-02) or packing of domestic goats by outfitters and guides (draft plan FW-STD-RECOG-01) would not be allowed anywhere on the Custer Gallatin, and the entire national forest would not be suitable for recreational packing of domestic goats by the general public (draft plan FW-SUIT-REC-01). Targeted grazing of domestic sheep or goats for weed control would not be allowed anywhere on the Custer Gallatin in alternative D (draft plan FW-STD-GRAZ-03).

Under alternative E, stocking of permitted grazing allotments with domestic sheep or goats for livestock production, recreational packing, or biological control of invasive plants, could occur anywhere on the national forest (outside the grizzly bear recovery zone), but only if mitigation measures could effectively minimize potential for disease transmission between domestic livestock and wild sheep (draft plan FW-STD-GRAZ-02, draft plan FW-STD-RECOG-01). Recreational use of domestic goats as pack animals by the general public would not be restricted under alternative E (draft plan FW-SUIT-REC-01).

Under alternative F, permits would not be issued for grazing of domestic sheep or goats for livestock production (meat or dairy products) in the Absaroka Beartooth; Madison, Henrys Lake, and Gallatin; Pryor Mountains; or the Bridger, Bangtail, and Crazy Mountains geographic Areas. However, domestic sheep and goat grazing permits could be authorized on the Ashland and Sioux Geographic Areas if it can be shown that there is low risk of disease transmission between domestic sheep and goats and bighorn sheep (FW-STD-GRAZ-02). Under this alternative, permits could be issued for use of domestic goats as pack animals by outfitters and guides in the Absaroka Beartooth; Madison, Henrys Lake, and Gallatin; Pryor Mountains Geographic Areas, with certain conditions for care and supervision of livestock written into the special use permits (FW-STD-RECOG-02). While remaining unoccupied by bighorn sheep permits could be authorized for outfitters and guides to use domestic pack goats in the Bridger, Bangtail and Crazy Mountains; Ashland; and Sioux Geographic Areas so long as effective separation or other mitigation measures can be achieved (FW-STD-RECOG-01). Once occupied by bighorn sheep new special use permits in the Bridger, Bangtail and Crazy Mountains; Ashland; and Sioux Geographic Areas would be required to follow conditions outlined in FW-STD-RECOG -02 (FW-STD-RECOG-01). Finally, under alternative F the use of domestic pack goats by the general public would be suitable in the Absaroka Beartooth; Madison, Henrys Lake, and Gallatin; and Pryor Mountains Geographic Areas, with certain conditions for care and supervision of livestock required (FW-SUIT-REC-02). While remaining unoccupied by bighorn sheep, recreational use of pack goats would be suitable for the remaining geographic areas. Once occupied by bighorn sheep, then use would adhere to the conditions outlined in FW-SUIT-REC-02 (FW-SUIT-REC-01).

Under all revised plan alternatives, permitted grazing of domestic sheep would be precluded inside the recovery zone/primary conservation area for grizzly bears, except for the targeted use of domestic sheep for the express purpose of weed control in the current plans and alternatives B, C, E and F (FW-STD-WLGB-07). The grizzly bear recovery zone/primary conservation area covers roughly 44 percent of the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas.

The presence of domestic sheep and goats could occur on the national forest for a variety of reasons as described above. Table 72 shows what uses would be allowed in the various geographic areas under each alternative considered.

Table 72. Plan components for domestic sheep and goat use by alternative

Domestic Sheep and Goat Use	Alternatives A and E	Alternatives B and C	Alternative D	Alternative F
Livestock Production	Allowed in all geographic areas Draft Plan FW-STD-GRAZ-02 – Alternative E Not allowed inside Grizzly Bear RZ/PCA (Draft Plan FW-SUIT-WLGB-01)	Allowed in BBC, Ashland, and Sioux Geographic Areas Not allowed in AB, MHG, and PR geographic areas (Draft Plan FW-STD-GRAZ-02) Not allowed inside Grizzly Bear RZ/PCA (Draft Plan FW-SUIT-WLGB-01)	Not allowed in all geographic areas Draft Plan FW-STD GRAZ-02	Allowed in Ashland and Sioux Geographic Areas Not allowed in AB, BBC, MHG and PR geographic areas FW-STD-GRAZ-02, 04

Domestic Sheep and Goat Use	Alternatives A and E	Alternatives B and C	Alternative D	Alternative F
Weed Treatment	Allowed in all geographic areas with mitigation Draft Plan FW-STD-GRAZ-03-04	Allowed in all geographic areas with mitigation Draft Plan FW-STD-GRAZ-03-04	Not allowed in all geographic areas Draft Plan FW-STD-GRAZ-03	Allowed in all geographic areas with mitigation FW-STD-GRAZ-03-04
Goat Packing Special Use Permit – Outfitters and Guides	Allowed in all geographic areas with risk assessment Draft Plan FW-STD-RECOG-01-04 Alternative E	Allowed in BBC, Ashland, and Sioux Geographic Areas with mitigation Not allowed in AB, MHG, and PR geographic areas Draft Plan FW-STD-RECOG-01-04	Not allowed in all geographic areas Draft Plan FW-STD-RECOG-01	Allowed in BBC, Ashland, and Sioux Geographic Areas with mitigation. Once occupied allowed with restrictions FW-STD-RECOG-02 (a-h) Allowed in AB, MHG, and PR geographic areas with restrictions FW-STD-RECOG 02 (a-h)
Goat Packing General Public	Allowed in all geographic areas, no restrictions Draft Plan FW-SUIT-REC-01 Alternative E	Suitable in BBC, Ashland, Sioux Geographic Areas, no restrictions; Not Suitable in AB, MHG, PR geographic areas Draft Plan FW-SUIT-REC-01	Not suitable in all geographic areas Draft Plan FW-SUIT-REC-01	Suitable without restrictions in BBC, Ashland, and Sioux Geographic Areas until occupied by bighorn. Once occupied, suitable with restrictions FW-SUIT-REC-01 Suitable in AB, MHG, PR geographic areas with restrictions FW-SUIT-REC-02

GA = geographic area; AB = Absaroka Beartooth; MHG = Madison, Henrys Lake, and Gallatin; PR = Pryor Mountains; BBC = Bridger, Bangtail, and Crazy Mountains.

Effects of the Revised Plan Alternatives

All revised plan alternatives include a suite of plan components to directly, specifically, and clearly address the threat of disease transmission from domestic livestock to bighorn sheep. All revised plan alternatives include desired conditions for habitat that supports healthy bighorn sheep populations that do not intermingle with, or contract disease from, domestic livestock (FW-DC-WLBHS-01, 02). These alternatives also contain goals to support establishment of bighorn sheep in suitable habitats not currently occupied, and collaborate with partners to develop cooperative management protocols and strategies to minimize risk of disease transmission between livestock and wildlife (FW-GO-WLBHS-01, 02). Forestwide desired conditions and goals would support expanded distribution of bighorn sheep, potential increases in genetic diversity, and innovative strategies to reduce vulnerability of bighorn sheep to pathogens carried by domestic livestock. All revised alternatives include a range of standards that require mitigation based on risk assessment to effectively minimize potential for disease transmission between domestic sheep and goats and bighorn sheep, whether it be for permitted grazing of domestic sheep or goats for livestock production, outfitter use as pack animals, or targeted use for weed control (FW-STD-GRAZ-02-06 for alternatives B through E; FW-STD-GRAZ-02-04 for alternative F). Application of these plan components would help achieve effective separation of domestic and wild animals, and reduce risk of disease transmission to bighorn sheep populations.

Alternatives B and C would minimize risk of disease transmission from domestic livestock to existing bighorn sheep populations, because stocking of permitted grazing allotments with domestic sheep or goats for livestock production (FW-STD-GRAZ-02) or outfitted pack trips (FW-STD-RECOG-01) would not be allowed in the Absaroka Beartooth Mountains, Madison, Henrys Lake, and Gallatin Mountains or Pryor Mountains Geographic Areas where wild bighorn herds are currently located. Use of pack goats by the general public would also be restricted in the Absaroka Beartooth Mountains; Madison, Henrys Lake, and Gallatin Mountains; and Pryor Mountains Geographic Areas, since these geographic areas would not be suitable (FW-SUIT-REC-01) for this use under alternatives B and C. Under these same two alternatives, domestic sheep and goats could be permitted on grazing allotments for livestock production as well as pack goats for recreational outfitting or guiding in the Bridger, Bangtail, and Crazy Mountains, Ashland, and Sioux Geographic Areas (FW-STD-GRAZ-02), but only if a risk assessment indicates that physical separation or other mitigation can effectively minimize the risk of disease transmission between domestic sheep and goats and bighorn sheep.

Under alternatives B, C, E, and F, targeted grazing by domestic sheep and goats could be used anywhere on the Custer Gallatin for purposes of weed control, but only if a risk assessment indicates that mitigation could effectively minimize disease transmission between domestic sheep and goats and bighorn sheep (FW-STD-GRAZ-03). These alternatives would require written instructions included in permits, contracts, or agreements for weed control to address the management, retrieval and disposition of stray or deceased domestic animals (FW-STD-GRAZ-04). This allowance was made to acknowledge that invasive weeds are a potential threat to habitat for bighorn sheep, as well as other wildlife and plant communities, and targeted grazing by domestic sheep and goats has proven to be an effective means of controlling weed spread. Use of domestic livestock grazing for targeted weed control lends itself well to tight restrictions on timing, number of animals, location of use, and oversight requirements, so risk of contact with bighorn sheep could be effectively minimized.

Alternative D would not allow any Forest Service authorized use of domestic sheep or goats for any purpose across the entire forest (FW-STD-GRAZ-03, FW-STD-RECOG-01), and the entire national forest would not be suitable for recreational goat packing by the public (FW-SUIT-REC-01). This alternative expands the prohibition on domestic sheep and goats to recognize that bighorn sheep were historically present across most of the Custer Gallatin. Bighorn sheep are capable of long-distance dispersal movements, and the Bridger, Bangtail, and Crazy Mountains, Ashland, and Sioux Geographic Areas are all within possible dispersal distance of existing bighorn sheep herds. Restricting domestic sheep and goat presence on National Forest System lands where bighorns are not currently established, would serve to better maintain the suitability of these areas for possible future recolonization by bighorn sheep, whether by natural dispersal or through deliberate transplants. However, alternative D would not allow the use of domestic sheep or goats for weed control, which precludes an effective management tool, and has potential for impacts to bighorn sheep habitat from noxious weed infestations and/or spread.

Alternative E would allow pack animal use and stocking of permitted grazing allotments with domestic sheep or goats anywhere outside the grizzly bear recovery zone/primary conservation area on the Custer Gallatin, so long as a risk assessment indicates that spatial or temporal separation or other mitigation can effectively minimize risk of disease transmission between domestic sheep and goats and bighorn sheep (FW-STD-GRAZ-02, 03; FW-STD-RECOG-01; FW-SUIT-REC-01). This alternative allows more flexibility for domestic livestock grazing and recreational use of pack animals, but increases risk of disease transmission to bighorn sheep, given that bighorn sheep are capable of long-range movement, and could come into contact with domestic livestock in areas otherwise considered to be very low risk.

Alternative F implements protection measures that limit the presence of domestic sheep or goats on the national forest, while still allowing responsible land uses in a manner that minimizes risk of disease transmission from domestic livestock to bighorn sheep. Under this alternative, areas where bighorn sheep are currently established (Madison Henrys Lake and Gallatin Mountains, Absaroka-Beartooth, and Pryor Mountains Geographic Areas) would not see new permits issued for domestic sheep and goat grazing for livestock production (FW-STD-GRAZ-02). Targeted use of domestic sheep or goats for weed control, outfitter and guide use of pack goats, and public use of pack goats could occur in geographic areas where bighorn sheep are currently established, but these uses would be tightly regulated through mandatory permit stipulations and/or future special orders that require strict control of domestic animals (FW-STD-GRAZ-03, 04; FW-STD-RECOG-01, 02; FW-SUIT-REC-01, 02). Under this alternative, the Bridger, Bangtails and Crazy Mountain Geographic Area, which contains suitable habitat, but currently has no resident bighorn sheep, would remain free of large herds of domestic sheep or goats grazing on public lands. However, alternative F would allow targeted use of domestic sheep and goats for weed control under certain conditions (FW-STD-GRAZ-03, 04), and would also allow the use of domestic goats as pack animals by outfitters as well as the general public, unless or until the area becomes occupied by bighorn sheep (FW-STD-RECOG-01; FW-SUIT-REC-01). Once occupied, use would be dependent upon conditions for the care and supervision of livestock outlined in FW-STD-RECOG-02 and FW-SUIT-REC-02. Goal FW-GO-WLBHS-02 which supports expansion of bighorn sheep into currently unoccupied areas with suitable habitat would be factored future authorizations for domestic sheep and goats. Requests for permits to stock domestic sheep or goats on grazing allotments for livestock production, weed control, or outfitted use of pack goats, would be considered in the Ashland and Sioux Geographic Areas, but authorized only if there is no or low risk of contact with bighorn sheep (FW-STD-GRAZ-03, 04). Recreational use of pack goats would not be restricted in these geographic areas provided they remain unoccupied by bighorn (FW-STD-RECOG-01; FW-SUIT-REC-01), but there is a reasonable expectation that best management practices would be employed to protect the goats from harm, which would also reduce risk of contact with wildlife.

Alternative F provides measures to minimize risk of contact between domestic sheep or goats and bighorn sheep, with most restrictions where that risk is greatest. Any use of domestic sheep or goats authorized by the Forest Service would first be evaluated for potential risk to bighorn sheep, adding mitigation measures as necessary. While this alternative takes a proactive stance to minimize risk of contact between domestic animals and bighorn sheep, there is still some level of risk associated with certain uses. Alternative F addresses the risk by requiring prior consideration for bighorn sheep before authorizing permits, identifying appropriate mitigation measures, and requiring report of contact between domestic animals and bighorn sheep in areas where it is most likely to occur. There is no way to guarantee zero risk to bighorn sheep from human associated under any alternative.

South American camelid species such as llamas and alpacas are popular recreational pack animals that can have lower impacts on fragile environments than other species of pack animals. There is some question as to whether llamas and alpacas pose a threat of disease transmission to wild bighorn sheep. Centre for Coastal Health (2017) examined the risk for disease transmission from llamas and alpacas to bighorn sheep and other wild ungulates in British Columbia, Canada. This research found no peer-reviewed publications verifying disease transmission from llamas or alpacas to wild bighorn sheep or mountain goats, but cautioned that lack of documentation does not prove that transmission has not, or could not occur. The authors concluded there is a high degree of uncertainty regarding the probability of disease transmission from llamas and alpacas to bighorn sheep. Llamas and alpacas are used at low levels for recreational packing on the Custer Gallatin, with no known or suspected disease transmission to wild sheep or goats. Until more definitive science verifies disease transmission from llamas and alpacas to bighorn sheep in the wild, the Custer Gallatin would track this issue relative to the forestwide desired condition for low or no disease transmission between domestic livestock and wildlife, under all revised plan alternatives.

Consequences to Bighorn Sheep from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Terrestrial Vegetation Management

All revised plan alternatives contain desired conditions for grassland and shrubland habitats, including native plant communities that are self-sustaining and diverse, while non-native species are not increasing (FW-DC-VEGNF-01). Compared to the current plans, desired conditions under the revised plan alternatives include greater detail about vegetation conditions, including plant species composition, structure, and function. Such details provide better information for management of grassland and shrubland communities to contribute to plant diversity and ecological integrity of these habitats, and to maintain, restore, or improve resilience to environmental stressors. A more detailed analysis of effects to grasslands and shrublands can be found in the Terrestrial Vegetation section of the draft environmental impact statement.

Conifer encroachment into grasslands, shrub-steppe, or alpine areas limits visibility, and reduces habitat suitability for bighorn sheep (Montana Fish Wildlife and Parks 2010). Conifer encroachment can result from natural succession, but may also be facilitated by fire suppression efforts. All revised plan alternatives include a desired condition that encroachment of conifers is limited, and grasslands are maintained by high-frequency, low-severity fire regime (FW-DC-VEGNF04). However, a guideline is included that existing vegetation (including, but not limited to conifers) should be retained to provide for other big game species such as elk, moose, and deer when it's determined that existing condition is limiting habitat functionality (FW-GDL-WLBG01). At face value, this guideline may seem contrary to best science for managing range conditions for bighorn sheep. However, the guideline acknowledges that existing vegetative cover can be important to big game species for a variety of reasons, and certain types of vegetative cover, such as sage brush, can provide important forage on bighorn sheep winter range (Montana Fish Wildlife and Parks 2010).

Invasive plant species such as non-native annual grasses and noxious weeds can have negative effects on bighorn sheep habitat by altering forage quantity and quality and influencing fire behavior patterns. All revised plan alternatives include desired conditions for low or no invasive plant species on a landscape dominated by native plant species (FW-DC-INV-01), with a suite of standards (FW-STD-INV-01-04) and guidelines (FW-GDL-INV-01) that include measures to minimize risk of noxious weed introduction or spread. While the revised plan alternatives contain more specificity about desired plant species composition and specific mitigation for reducing risk of new noxious weed infestations or spread of existing sites, current plans also encompass best management practices, and the revised plan alternatives provide similar guidance for management of invasive species (see invasive species section of the environmental impact statement for more detailed analyses of invasive plants). Under similar direction, the effects from non-native plant invasion in bighorn sheep habitat would be similar under all alternatives; however, alternative E contains a lower weed treatment objective (FW-OBJ-INV-01) than other alternatives. Targeted grazing by domestic sheep or goats has proven an effective way to reduce the spread of noxious weeds; however, these domestic species pose some level of risk to bighorn sheep through possible transmission of pathogens that can cause disease in bighorn sheep. A range of alternatives was considered for use of this potential tool for managing invasive species, and the potential impacts to bighorn sheep were addressed above.

Effects from Fire and Fuels Management

All revised plan alternatives include desired conditions in which the amount and severity of wildland fires is within the natural range of variation to maintain resilient ecological conditions (FW-DC-FIRE-01). Bighorn sheep on the Custer Gallatin have adapted to habitat conditions largely shaped by wildfire over time. Under all alternatives, wildland fires would continue to support the diversity of vegetation on the Custer Gallatin, and would retard conifer encroachment into grassland, meadows and park-like habitats that support bighorn sheep in all seasons. All revised plan alternatives include objectives for wildfire to occur at a larger scale than has been the case under current plans (FW-OBJ-FIRE-02), which could benefit bighorn sheep habitat by reducing conifer encroachment into grasslands, maintaining or restoring forage conditions, and maintaining open views for bighorns to detect predators. To support this objective, all revised plan alternatives include a guideline that wildland fire should be used to meet desired conditions for vegetation and other resources where conditions permit (FW-GDL-FIRE-01).

Fire suppression has been cited as a possible cause of conifer encroachment into bighorn sheep habitat (Montana Fish Wildlife and Parks 2010). All revised plan alternatives acknowledge the important ecological role of fire and accordingly set the stage for more and better use of wildland fire as tools to move vegetation towards desired conditions compared to the current plans. Increased fire on the landscape would promote plant and animal diversity and ecological integrity, potentially increasing resilience of bighorn sheep habitat to environmental stressors such as conifer encroachment, drought and habitat fragmentation. All revised plan alternatives include a guideline for use of minimum impact fire suppression tactics in sensitive areas (FW-GDL-FIRE03), which may include alpine habitats that support bighorn sheep.

Invasive species such as cheatgrass may alter fire behavior patterns in grasslands and shrublands that comprise bighorn sheep habitat. Wildfires would continue to be a major habitat driver under all alternatives, although there is considerable uncertainty as to the extent and distribution of wildfire events. Effects of wildfire on spread of invasive plant species is a concern for bighorn sheep habitat, and these effects would likely be the same across all alternatives.

Effects from Plan Land Allocations

Human disturbance can be a stressor for bighorn sheep on winter ranges or lambing areas, since it may cause displacement of sheep, or other behavioral modifications that can deplete energy reserves at crucial times. Permanent developments such as residential areas, resorts, recreation facilities, paved roads, large mining or energy developments, etc. can affect bighorn sheep through habitat loss or fragmentation, disruption of migratory corridors, mortality from vehicle collisions, and displacement due to human disturbance (Montana Fish Wildlife and Parks 2010). Plan land allocations have associated plan components that can affect human access and types of uses allowed, which would influence levels of human disturbance and degree of permanent habitat modifications. In all alternatives, plan land allocations do not overlap with designated wilderness areas, and therefore the 56 percent of bighorn sheep use areas (general and winter range combined) inside designated wilderness areas would have similar, and low impacts from management-related habitat alterations or disturbance associated with human presence. As noted in the affected environment section, wilderness study areas and inventoried roadless areas also include land use restrictions that place limits on management actions and provide some protection for bighorn sheep and their habitats. Although plan land allocations do not change the underlying regulatory mechanisms associated with wilderness study areas or inventoried roadless areas, they may overlap with these designations, and in some cases additional plan restrictions would apply in areas of overlap.

Plan land allocations of recommended wilderness and backcountry areas generally promote low impact human uses with more limited access than areas without associated restrictions. New permanent developments would generally not be allowed in recommended wilderness areas (FW-STD-RWA-01-04) or backcountry areas (FW-STD-BCA-01-04 and STD-BCA-01 for each backcountry area) where they overlap with bighorn sheep use areas. New recreation events authorized by special use permit and extraction of saleable minerals would not be allowed in recommended wilderness (FW-STD-RWA-05, 06) and new special uses in backcountry areas would be compatible with the backcountry characteristics (FW-STD-BCA-05). In the Montane ecosystem where bighorn sheep occur, alternatives A and D have recommended wilderness, but no backcountry areas, whereas alternative E has only backcountry areas and no recommended wilderness. Alternatives B, C, and F each have different combinations of recommended wilderness and backcountry areas.

Recommended wilderness carries the strongest land use restrictions of the plan land allocations. Recommended wilderness areas would not be suitable for timber harvest for any purpose (FW-SUIT-RWA-01), whereas in backcountry areas timber harvest would be suitable as a vegetation management tool for purposes of restoration or wildlife habitat improvement (FW-SUIT-BCA-01), such as conifer removal from bighorn sheep range. Other tools, such as prescribed fire, would be allowed in recommended wilderness for restoration purposes (FW-SUIT-RWA-03), but in some cases (for example in areas with high fuel loads, or near communities) prescribed fire would not be an appropriate tool to use unless mechanical pre-treatment could be used to reduce fuel loads prior to burning. Plan land allocations of recommended wilderness or backcountry areas are likely to result in similar, low levels of human disturbance for bighorn sheep on winter ranges and lambing areas, because these allocations carry similar restrictions on administrative and public uses where they overlap bighorn sheep habitat. The primary difference is that mountain biking would be suitable in most backcountry areas (BCA-SUIT for each backcountry area)), whereas mechanized transport would not be suitable in recommended wilderness areas (FW-SUIT-RWA-02). Mechanized human transport can be more disruptive to wildlife than non-mechanized transport, since people can move quickly and quietly, which can result in more surprise encounters with wildlife, potentially causing animals to flee and expend energy. In alternative F, mountain bike use would be restricted to approved system routes within all backcountry areas where this use is suitable, which would further limit disturbance effects to sheep, by minimizing the area affected, and allowing bighorn sheep to better anticipate where such use would occur. Table 73 shows the percentage of bighorn sheep general range in recommended wilderness and backcountry area plan land allocations for each alternative. Table 74 shows the percentage of bighorn sheep winter range in recommended wilderness and backcountry area plan land allocations for each alternative. Table 75 shows the total combined percentage of bighorn sheep general and winter range in plan land allocations for each alternative.

Table 73. Percentage of bighorn sheep general range in recommended wilderness and backcountry area plan land allocations for each alternative

Allocation Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended Wilderness	1	10	12	22	0	10
Backcountry Area	0	2	3	0	12	4
Total	1	12	15	22	12	14

Table 74. Percentage of bighorn sheep winter range in recommended wilderness and backcountry area plan land allocations for each alternative

Allocation Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended Wilderness	1	9	13	28	0	7
Backcountry Area	0	0	4	0	11	6
Total	1	9	17	28	11	13

Table 75. Total combined percentage of bighorn sheep general and winter range in plan land allocations for each alternative

Allocation Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recommended Wilderness and Backcountry Area – Combined General and Winter Range Total	2	11	15	24	12	14

It is important to keep in mind that figures shown in the tables above are in addition to protections for bighorn sheep habitat already established in designated wilderness areas, which accounts for approximately 56 percent of the current bighorn sheep range on the Custer Gallatin. Alternative D has the greatest overlap between restrictive land use allocations and current bighorn sheep use areas (both general and winter range), all of which is in recommended wilderness. Alternative D then, would have the greatest potential for limiting the amount of human disturbance due to motorized or mechanized transport, and would also have the greatest limits on habitat alteration through permanent human development and vegetation management. However, alternative D would limit the tools available for habitat improvement projects on bighorn sheep ranges, and could also limit opportunities for research, or to augment sheep populations, since aircraft typically used to capture and relocate sheep may be subject to additional conditions in recommended wilderness. Alternatives B and C combine protective plan land allocations in bighorn sheep habitat, with most of the overlap in recommended wilderness. Alternative E contains only backcountry area allocations, which allow for mechanized transport and some limited motorized transport in bighorn sheep range. Alternative F has similar levels of bighorn sheep range in protective allocations as alternative C, but with more even proportions of recommended wilderness and backcountry areas. The tradeoff for bighorn sheep is that in backcountry areas in big horn sheep habitat, mechanized and limited existing motorized transport would continue to be suitable with associated disturbance effects, but also allow more flexibility for management of sheep and their habitats.

The Buffalo Horn Backcountry Area is the only backcountry area overlapping bighorn sheep habitat where existing motorized transport would continue to be suitable (MG-SUIT-BHBCA-01). There are slightly different sizes and configurations of this backcountry area between Alternatives B, C, and F, but all would allow the Big Sky Snowmobile Trail and Play Area to remain open for winter use. The snowmobile play area is within bighorn sheep general range, but would not affect winter range, while the snowmobile trail is outside of bighorn sheep range altogether. Existing summer and winter motorized use would continue to be suitable under these three alternatives in the area between Portal Creek, Levinski Creek and Highway 191, affecting small amounts (< 1 percent) of both general and winter bighorn sheep range. The Buffalo Horn Backcountry Area is much larger in alternative E than in other alternatives, covering the entire existing Hyalite-Porcupine-Buffalo Horn Wilderness Study Area. Like alternatives B, C, and F, in alternative E mechanized transport and existing motorized transport to would continue to be suitable uses. In addition, alternative E would potentially allow new summer and winter motorized opportunities in bighorn sheep general range that could draw more human use to the area. Additional motorized opportunities in alternative E could add human disturbance factors in bighorn sheep general range where sheep have become accustomed to lower levels of quiet recreational use. Such disturbance could cause displacement of sheep into unsuitable habitats, expose them to predators, increase stress and energy expenditure and possibly other negative impacts. It should be noted that potential new motorized opportunities in alternative E are in the wilderness study area, and therefore could only be implemented if Congress were to withdraw the wilderness study area designation. Under alternative D, all configurations of the Buffalo Horn Backcountry Area in other alternatives, would become recommended wilderness.

Key linkage areas are a new form of plan land allocation in alternatives B, C, D, and F. In these alternatives, key linkage areas are identified along the west slope of the Bridger Mountain Range and at the north end of the Gallatin Mountain Range. Key linkage areas and associated plan components were primarily designed to promote long-range movements of animals in a northerly or southerly direction between the Gallatin and Bridger Mountain Ranges, in order to facilitate broader distribution of some species. Bighorn sheep currently do not reside in the Bridger, Bangtail, and Crazy Mountains Geographic Area, although there is suitable habitat for wild sheep in these areas. In key linkage areas, new recreation developments would generally not be allowed (FW-GDL-WL-03) and new permanent facilities or structures needed for administrative use would be designed so as not to disrupt wildlife movement patterns (FW-GDL-WL-04). These plan components would limit new permanent developments that could disrupt bighorn sheep movements through National Forest System lands. There is more flexibility for vegetation management in key linkage areas compared to recommended wilderness and backcountry areas, but plan components with timing restrictions (FW-GDL-WL-05) would allow periods of low management activities when animals could move more freely through the key linkage areas. The boundary of the key linkage area in the Gallatin Range was extended to the south in alternative F, making this the only alternative in which key linkage areas overlap with current bighorn sheep range. In alternative F, about 1,400 acres of bighorn sheep general range (less than one percent of general bighorn range on the national forest) falls within the key linkage area in the Gallatin Mountain Range. Also, in alternative F, like backcountry areas, mountain bike use would be restricted to approved system routes within key linkage areas, allowing bighorn sheep to learn and anticipate where and when such use is likely to occur. The juxtaposition of key linkage areas could potentially facilitate natural movement of bighorn sheep from currently occupied areas of the national forest, to currently unoccupied but potentially suitable habitat in the Bridger, Bangtail, and Crazy Mountains Geographic Area to the north, consistent with the stated goal to support establishment of bighorn sheep in currently unoccupied habitat (FW-GO-WLBHS-02).

Whereas plan land allocations of recommended wilderness, backcountry area, and key linkage areas all tend to restrict management actions and new developments, plan land allocations of recreation emphasis areas and the Stillwater Complex identify places where human developments and associated use are likely to be concentrated (FW-SUIT-REA-01, AB-DC-SWC-01). Configuration of recreation emphasis areas differs by alternative. Table 76 shows the percentage of bighorn sheep general range overlapping with recreation emphasis areas and the Stillwater Complex mining emphasis allocation. Table 77 shows the percentage of bighorn sheep winter range overlapping with recreation emphasis areas and the Stillwater Complex mining emphasis allocation.

Table 76. Percentage of bighorn sheep general range in recreation emphasis areas and Stillwater complex for each alternative

Allocation Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recreation Emphasis Year-round	0	3	2	1	4	5
Recreation Emphasis Winter	0	6	6	0	6	6
Stillwater Complex	0	1	1	0	1	1
Total	0	10	9	1	11	12

Table 77. Percentage of bighorn sheep winter range in recreation emphasis areas and Stillwater complex for each alternative

Allocation Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recreation Emphasis Year-round	0	6	6	5	5	7
Recreation Emphasis Winter	0	<1	<1	0	<1	<1
Stillwater Complex	0	5	5	0	5	5
Total	0	11	11	5	10	12

Plan land allocations can overlap with Congressionally designated wilderness study area and/or inventoried roadless areas. These underlying designations primarily restrict the number of new roads that can be constructed, which essentially limits new access to land within recreation emphasis areas. Table 78 shows the total combined percentage of plan land allocations in bighorn sheep range that are also in inventoried roadless areas. For example, in alternative B, roughly 10 percent of the combined (general and winter) bighorn sheep habitat is within a plan land allocation, but of that, 42 percent is still within inventoried roadless designation, where new road access would be limited.

Table 78. Total combined percentage of bighorn sheep in general and winter range in recreation emphasis areas and Stillwater complex for each alternative

Allocation Type	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E	Alternative F
Recreation Emphasis Areas and Stillwater Complex – Combined General and Winter Range Total	0	10 (42% IRA)	9 (35% IRA)	2 (25% IRA)	11 (30% IRA)	12 (36% IRA)

IRA = inventoried roadless area.

The revised plan alternatives identify year-round recreation emphasis areas as well as winter recreation areas; however, year-round use may occur in any recreation emphasis area. Alternative F has the highest proportion of combined (general and winter) bighorn sheep range in recreation emphasis areas, and therefore would have the highest level of associated human disturbance in bighorn sheep ranges. Across all revised plan alternatives, most of the overlap between recreation emphasis areas and bighorn sheep range would affect general habitat. There is little overlap between winter recreation emphasis areas and bighorn sheep winter range, because wild sheep typically winter on areas with little or no snow (Montana Fish Wildlife and Parks 2010), and winter recreation emphasis areas are in places with deep snow accumulations to accommodate winter activities such as skiing and snowmobiling. Effects to bighorn sheep winter ranges would be from human use in year-round recreation emphasis areas. Winter recreation is not restricted by plan components in year-round recreation emphasis areas, but winter access for recreation may be more limited in some year-round recreation emphasis areas than in recreation emphasis areas specifically managed for winter human use.

All revised plan alternatives include year-round recreation emphasis areas along state highways within river corridors that bisect important bighorn sheep winter ranges. This scenario involves the Gallatin River, Yellowstone River, and Main Fork Rock Creek Recreation Emphasis Areas. The primary recreation use associated with these corridors involves summertime river-related recreational pursuits such as fishing, rafting, kayaking, hiking and sight-seeing. There is not much winter recreation within these narrow recreation emphasis areas, but the highways through them (Montana Highway 191, 89 and 212 respectively) provide major access routes for winter recreation opportunities on the national forest, in Yellowstone National Park, and at private resorts such as Big Sky, Lone Mountain, and Moonlight Basin alpine and Nordic Ski Areas. The major issue for wintering bighorn sheep associated with these river corridor recreation emphasis areas is not from recreation per se, but rather from collisions with vehicles associated with travel on the highways. The designation of these corridors as recreation emphasis areas would likely have little additional effect on bighorn sheep since use levels are already established, but sheep mortality from vehicle collisions along these corridor remains an issue under all alternatives. All revised plan alternatives include a goal (FW-GO-RT-03) for Forest Service cooperation with Tribes, highway managers, State agencies, and landowners to create wildlife crossing features that reduce vehicle collisions with wildlife, which could potentially reduce bighorn sheep mortality within the river corridor recreation emphasis areas.

Since recreation emphasis areas are areas where human developments and associated high levels of human use can be expected, these areas could fragment sheep habitat, disrupt movement patterns, and disturb sheep, which may result in displacement of bighorn sheep from otherwise suitable habitats. However, recreation emphasis areas in the revised alternatives were identified based on current and projected human use patterns, so sheep have already adapted to high levels of human use in some portions of their range. While alternative D has the lowest amount of bighorn sheep habitat in recreation emphasis areas, with few exceptions, alternative D includes no plan land allocations that would notably change the nature of recreation already occurring in recreation emphasis areas identified in other alternatives.

The Stillwater Complex is a plan land allocation identified in alternatives B, C, E, and F as a mining emphasis area. The effects of mining on bighorn sheep are addressed under “Effects from Energy and Minerals Management,” but the emphasis area is noted here as an area where human developments, management actions, and human presence are expected to be concentrated. The size of the mining emphasis area, and amount of bighorn sheep range affected is the same in alternatives B, C, E and F, as shown in table 76 and table 77 above. While there is no mining emphasis area with the same configuration identified in alternative A or any mining emphasis area identified in alternative D, mining operations would be expected to continue at existing, if not increased levels in the Stillwater area in these alternatives. Therefore, effects to bighorn sheep from this plan land allocation are expected to be similar for revised plan alternatives, except for possible added mitigation measures to protect bighorn sheep from mining impacts that could occur under alternative D.

Effects from Permitted Livestock Grazing

Effects from permitted livestock grazing related to potential disease transmission to bighorn sheep from domestic sheep and goats were addressed above. Improper grazing of cattle and horses can result in overutilization, which can affect forage availability for wild sheep, and livestock infrastructure such as fencing, can affect bighorn sheep movement patterns (Montana Fish Wildlife and Parks 2010). All revised plan alternatives (B, C, D, E, and F) incorporate plan components for permitted grazing allotment use that maintains vegetation within, or moves vegetation toward desired ecological conditions (FW-DC-GRAZ01, FW-GDL-GRAZ03, 10), which would benefit bighorn sheep by limiting livestock grazing impacts on wild sheep forage. The revised plan alternatives contain plan components for grazing practices to minimize negative impacts on both riparian and upland habitats (FW-STD-GRAZ01, FW-GDL-GRAZ01, 02, 04, 05), meet big game forage needs (FW-GDL-GRAZ03), and locate fences to minimize collision hazards and prevent barriers to wildlife movement (FW-GDL-GRAZ07). These plan components in the revised plan alternatives address factors relevant to bighorn sheep that are not directly addressed in current plans. In addition, plan components adopted for grizzly bears under all alternatives limit the number and acreage of livestock (including cattle and horse) grazing allotments within the grizzly bear recovery zone/primary conservation area (FW-STD-WLGB-06). This standard would ensure that livestock grazing levels would be maintained at or below levels present in the grizzly bear recovery zone in 1998, which could prevent new livestock grazing allotments (including cattle and horse) from being established within bighorn sheep ranges inside the grizzly bear recovery zone/primary conservation area.

Effects from Energy and Minerals Management

Industrial developments such as hard rock mining, oil and gas exploration and leasing, and power transmission lines, can result in direct loss of bighorn sheep habitat, displacement of sheep due to activity-related disturbance factors, and habitat fragmentation of existing habitats (Montana Fish Wildlife and Parks 2010).

While energy and minerals development on National Forest System lands can have negative impacts on bighorn sheep and their habitats, certain activities such as the right to prospect and explore public lands open to mineral entry, are guaranteed under the Mining Law of 1872. Leasable commodities such as oil and gas, have greater management flexibility for imposing design criteria favorable to wildlife habitat and other resource needs. All revised plan alternatives contain plan components that require resource considerations for energy and mineral development (FW-DC-EMIN01), including a requirement for reclamation plans with provisions to return disturbed areas to stability and land use comparable to adjacent lands and pre-operational site conditions (FW-STD-EMIN01). Reclamation measures can notably improve bighorn sheep habitat impacted by mining operations, as evidenced by bighorn sheep abandonment of traditional native ranges to instead winter on reclamation sites in the Stillwater mining complex area. Reclamation sites can provide suitable, if temporary, habitat for bighorn sheep. However, reclamation sites that are small can result in concentrated sheep use, which can increase the risk of density-related disease transmission among the sheep (Montana Fish Wildlife and Parks 2010).

The Stillwater mining complex is the only major minerals management area currently overlapping occupied bighorn sheep range on the Custer Gallatin. This area has shown high potential for mineral development, and would receive a plan land allocation to recognize such use in alternatives B, C, E, and F. The area is used primarily for mineral development under the existing Custer and Gallatin Plans as well (alternative A). Under all alternatives, mineral development would be expected to continue and perhaps expand as a recognized land use in the Stillwater mining complex area, with associated impacts to bighorn sheep habitat. Under alternative D, there would be no plan land allocation for mining purposes, but mining operations would be expected to continue at existing levels. Under alternative D, some of the area with minerals emphasis under alternatives B, C, E, and F, would be allocated as recommended wilderness. Under certain circumstances, access for mineral operations would still be allowed under existing laws in recommended wilderness (mineral encumbrances section of the environmental impact statement provides further details). However, additional mitigation measures to protect resources, such as location of facilities and timing of use, may be imposed on any new proposals for minerals or energy development within the recommended wilderness. Generally small herd size and isolation from other bighorns can affect reproductive recruitment, genetic diversity, and population dynamics (Montana Fish Wildlife and Parks 2010, Garrott et al. 2015). The Stillwater bighorn sheep herd has some evidence of inbreeding, likely due to the small herd size, limited exchange with neighboring herds, and possibly impacts from establishment of the Stillwater mine (Garrott, 2016 personal communication). While smaller herds may suffer from genetic isolation, there may be benefits in terms of less competition for resources and reduced potential for disease transmission. Alternative D would have the least potential for impacts associated with mineral development that could further isolate the Stillwater bighorn sheep herd.

Effects from Recreation Management

Domestic goats can carry pathogens that, if transmitted to bighorn sheep, can develop into diseases that are harmful to wild sheep. Therefore, disease transmission from recreational use of domestic pack goats is a potential threat to bighorn sheep. Besser et al. (2017) found that while domestic goats carry disease that can be transmitted to bighorn sheep, the severity of disease that developed after exposure to domestic goats was milder than impacts to bighorn sheep resulting from disease transmitted by domestic sheep. This being the case, these authors cautioned that there is still uncertainty as to whether there are more virulent strains of disease present in domestic goats, or other factors yet to be considered. Domestic goats are used for meat and dairy products, weed control, and recreational pack animals. Goats used for food production and weed control are typically managed as herd animals, put out to graze in certain areas. They are typically allowed to move about freely, so long as they stay within the general area they are intended to graze. Grazing animals may be supervised by herders and/or guard animals, but supervision is focused on keeping the animals within the allotted grazing area, and protecting them from predators. Grazing goats may include animals of both sexes and a wide range of age groups.

Domestic goats used as pack animals include many of the same breeds as herd goats used for food products or weed control but are managed differently. Importantly, goats used for recreational packing are generally present in lower numbers (typically two to ten animals), compared to herd goats used for food or weed control, which may number from dozens to thousands. Pack goats imprint on and bond with humans. This bonding and subsequent training create a strong desire in pack goats to stay close to their human handlers, and as a result, they are less apt to wander than are herd goats. Wethers, or neutered males, are preferred as pack animals because they are large, and capable of carrying more weight than females, but more docile and less likely to roam than intact bucks. Pack goats are generally well cared for by their owners, with high veterinary standards, including vaccination. Adult animals are typically used as pack animals, since their training can take two to four years, and adults are larger, stronger and thus more suited to carry weight. Results from pack goats tested at the Washington Animal Disease Laboratory showed that detection of pathogens known to cause respiratory disease in bighorn sheep occurred in 8.2 percent of all pack goats tested, and only 3.3 percent of adult pack goats tested positive (NAPgA website: Packgoats and Mycoplasma ovipneumoniae Prevalence Study 2016). The best available scientific information indicates that disease transmission from domestic goats to bighorn sheep may be less likely, and less lethal if it does occur, than is the case with disease transmission from domestic sheep to bighorns (Besser et al. 2017). In addition, recreational pack goats can be managed in a way that further reduces the risk of contact between domestic goats and bighorn sheep. However, while the risk of disease transmission between domestic pack goats and bighorn sheep may be low, it is not zero.

The revised plan alternatives address this potential threat, whereas the current plans do not. Alternatives B and C would not allow special use permits for outfitter and guide use of pack goats in the Absaroka Beartooth Mountains, Madison, Henrys Lake, and Gallatin Mountains or Pryor Mountains Geographic Areas where bighorn sheep currently reside (FW-STD-RECOG-01). These geographic areas would also be unsuitable for pack goat use by the public under alternatives B and C (FW-SUIT-REC-01). Alternative D would prohibit use of recreational pack goats by outfitters, guides and the public across the entire forest. These alternatives would all ensure that there is extremely low risk of disease transmission to bighorn sheep from Forest Service authorized use of domestic pack goats on the Custer Gallatin. Alternative D would ensure that all areas of the Custer Gallatin National Forest are essentially free from potential disease vectors in pack goats so that recolonization by bighorn sheep could occur with minimal risk of domestic disease sources. While these alternatives would minimize risk of disease transmission, it cannot be eliminated entirely since implementation would rely on enforcement, which realistically cannot be made 100 percent effective, given the size of the Custer Gallatin National Forest. Alternative E would allow issuance of special use permits for pack goat use by outfitters and guides, so long as the risk of disease transmission to bighorn sheep could be minimized through appropriate mitigation measures. Alternative E would allow recreational use of pack goats, which would carry a higher risk of disease transmission to bighorn sheep than other revised alternatives.

Recreational pack goat users formed the North American Pack Goat Association (NAPgA), which established a set of best management practices for pack goat users, both to protect the goats and their handlers, as well as to protect natural resources, including measure to minimize the risk of contact with bighorn sheep in the wild (Best Management Practices https://www.napga.org/w p-content/uploads/2018/10/BMP-2018.8.30.pdf). Many of these practices, along with recommendations in Montana Bighorn Sheep Conservation Strategy (Montana Fish Wildlife and Parks 2010), informed the development of alternative F for recreational use of pack goats on the Custer Gallatin. Under alternative F, unregulated recreational use of pack goats by the general public would be allowed in the Bridger, Bangtail, and Crazy Mountains as well as the Ashland and Sioux Geographic Areas, but only until these areas become occupied by bighorn sheep (FW-SUIT-REC01). Once occupied, use would be dependent upon conditions for the care and supervision of livestock outlined in FW-SUIT-REC02 and detailed below. There is a reasonable expectation that pack goat users would voluntarily follow best management practices established by the North American Pack Goat Association. In areas currently occupied by bighorn sheep, recreational use of pack goats by the general public in the Madison, Henrys Lake, and Gallatin Mountains; Absaroka Beartooth; and Pryor Mountain Geographic Areas would be suitable under conditions that are consistent with Best Management Practices established by the North American Pack Goat Association. These conditions include individual identification (such as collars, tags, micro-chips, or tattoos), direct human supervision, leads attached, nighttime control measures, timing restrictions, reporting requirements, health certificates, and limited numbers of goats (FW-SUIT-REC02). Since plan components guide and constrain Forest Service personnel and authorized agents, not the general public (FSH 1909.12, section 22.1), the conditions imposed by the plan suitability statement could only be enforced through issuance of a closure order, which would follow the plan final record of decision. Regulations established for public recreational use of pack goats would help to maintain effective separation of domestic pack goats and bighorn sheep, by limiting numbers of domestic animals, controlling wandering, restricting pack goat presence on National Forest System lands to avoid bighorn sheep lambing and rutting seasons, ensuring high health standards for domestic animals, and establishing protocols for dealing with sick or lost pack goats. These measures would effectively reduce the risk of bighorn sheep exposure to disease-causing pathogens that can be carried by domestic livestock, while still allowing for responsible recreational pursuits on public lands.

The Forest Service has discretion in authorizing use of domestic pack goats by outfitters and guides operating under special use permit. Under alternative F, permits could be issued for outfitters and guides to use pack goats in areas not currently occupied by bighorn sheep, including the Bridger, Bangtail, and Crazy Mountains; Ashland; and Sioux Geographic Areas, so long as it can be demonstrated that spatial or temporal separation or other measures could effectively minimize disease transmission from domestic pack goats to bighorn sheep (FW-STD-RECOG-01). Future requests for special use permits in these areas would be evaluated to determine potential risk of disease transmission by considering such factors as whether bighorns have naturally recolonized these areas, bighorns have been sighted in these areas but did not stay, or whether the areas are suitable and desirable for near future translocations to establish bighorn sheep in the area. Once occupied by bighorn sheep new special use permits in the Bridger, Bangtail and Crazy Mountains; Ashland; and Sioux Geographic Areas would be required to follow conditions outlined in FW-STD-RECOG-02 (FW-STD-RECOG-01). In geographic areas where bighorns are already established (Madison, Henrys Lake, and Gallatin Mountains; Absaroka Beartooth; and Pryor Mountains), special use permits for outfitters and guides to use domestic goats as pack animals would require measures to identify and supervise pack goats, ensure good health, limit numbers of goats and duration of use on the national forest, and minimize potential for contact with bighorn sheep if encountered in the wild (FW-STD-RECOG-02). These measures would effectively reduce the risk of bighorn sheep exposure to disease-causing pathogens that can be carried by domestic livestock, while still allowing for responsible recreational and commercial pursuits on public lands.

Recreational and resort developments can result in permanent loss or fragmentation of bighorn sheep habitat, and associated human use can cause displacement of wild sheep into less suitable habitats. Human disturbance on important seasonal ranges such as winter range and lambing areas can have negative impacts on bighorn sheep populations (Montana Fish Wildlife and Parks 2010). Roughly 53 percent of the bighorn sheep winter ranges on the Custer Gallatin National Forest are in designated wilderness, where there are no major developments, and recreational use is limited to non-motorized activities. Winter access is limited in these areas, and non-motorized activities generally have a relatively small footprint on bighorn sheep winter range in wilderness areas. There are a number of developed campgrounds and administrative sites within bighorn sheep general range that may fragment bighorn sheep habitat, but at a small-scale relative to the size of landscapes used by wild sheep. There are currently no major developments under special use permit that operate winter activities in bighorn sheep winter range. All revised plan alternatives include standards that no new recreation residences will be allowed, and existing recreation residences will be limited in size (FW-STD-RECRES-01, 02). Neither of the alpine ski resorts (Red Lodge Mountain or Bridger Bowl) operating under special use permit are located within general or winter bighorn sheep range. All revised plan alternatives include components requiring that new downhill ski areas would be considered only if existing ski areas cannot be expanded to accommodate additional use (FW-STD-RECSKI-01) and that new activities such as zip lines, alpine slides, and downhill mountain bike trails with infrastructure, should be located at existing downhill ski areas (FW-GDL-RECSKI-01). These provisions would ensure that future developments associated with downhill sports would be accommodated at existing developed sites before any new developments could occur that might impact bighorn sheep habitat. Finally, all revised alternatives include plan components that limit new major developments within the grizzly bear recovery zone/primary conservation area (FW-STD-WLGB-04, 05). Since approximately 44 percent of current bighorn sheep range is located inside the grizzly bear recovery zone, these plan components would benefit sheep as well by restricting the amounts and locations of new human developments that could affect bighorn sheep.

Cumulative Effects

The Montana Department of Transportation (Montana Department of Transportation 2017) plan includes a goal for a transportation system that protects the natural environment. This plan shows that wildlife crossings and barriers are top priorities, and also indicates that winter roadway maintenance is a major part of the department’s program. There is little information to suggest that two-lane gravel roads with low traffic volume and speed have major impacts on bighorn sheep or their habitats. These secondary roads make up the vast majority of roads on National Forest System lands. On the other hand, highways can have major impacts on bighorn sheep, primarily as a result of direct mortality caused by vehicle collisions with sheep, but also due to habitat fragmentation and barriers to movement between wild sheep populations. Highways tend to be in close proximity to bighorn winter range on the Custer Gallatin, and winter maintenance such as salting the road surface to reduce snow and ice, can increase the impact on bighorns, as sheep may be attracted to the salt, increasing the risk of vehicle collisions with sheep.

Big Sky and Moonlight Basin are private ski areas within bighorn sheep range. Resort and residential development associated with these areas has resulted in direct loss of bighorn sheep habitat including winter range. These areas attract thousands of visitors for year-round activities, a draw that results in high density traffic on U.S. Highway 191 through Gallatin River Canyon, which travels through bighorn sheep winter range. Vehicle collision with bighorn sheep along this highway is a major mortality factor for native bighorn sheep in the Spanish Peaks Range (Montana Fish Wildlife and Parks 2010).

Montana Fish Wildlife and Parks developed a Bighorn Sheep Conservation Strategy in 2010. This document contains recommendations for domestic sheep and goat management in wild sheep habitat, many of which were adopted by all revised plan alternatives for the Custer Gallatin National Forest.

The Beaverhead-Deerlodge and Shoshone national forests are adjacent to areas occupied by bighorn sheep on the Custer Gallatin. There are no domestic sheep allotments in either of these forests in areas adjacent to the Custer Gallatin, but some domestic sheep grazing is still authorized in the plans. The Beaverhead-Deerlodge plan (2009a) includes a standard to close domestic sheep allotments that become vacant in the Gravelly Range, or issue use to existing permittees, which would maintain or possibly reduce numbers of domestic sheep on this forest. The Shoshone plan (2015c) does not allow domestic sheep or goats in areas of core bighorn sheep habitat, which is compatible with proposed plan components in the Custer Gallatin revised plan alternatives.

Bureau of Land Management policy is to achieve effective separation of authorized domestic sheep or goats from wild sheep on Bureau of Land Management lands and to minimize the risk of contact between the species, which is consistent with direction proposed in the revised plan under all revised plan alternatives. However, existing presence of domestic sheep on Bureau of Land Management lands adjacent to the Custer Gallatin could preclude reintroduction of wild bighorn sheep into historical range on the Sioux Geographic Area.

The general management plan for Yellowstone National Park calls for preserving natural resources, including natural vegetation, landscapes and disturbance processes. Grazing of domestic livestock and use of domestic goats as pack animals are prohibited in Yellowstone Park, which is consistent with management direction for adjacent Custer Gallatin lands under all alternatives for grizzly bear habitat, and alternatives B, C, and D for bighorn sheep.

Conclusion

The primary factor related to Forest Service management that may influence bighorn sheep and their habitats is the presence of domestic sheep or goats that may carry pathogens, which if transmitted to wild sheep, can cause disease with potential to result in major bighorn sheep die offs. This factor was addressed by all revised plan alternatives, whereas it is not specifically addressed in current plans. Alternative D has the very lowest possible risk of disease transmission from domestic livestock to bighorn sheep, and alternative E has the greatest risk for potential disease transmission. Alternatives B, C, and F fall between these alternatives relative to potential for disease transmission. These alternatives all contain restrictions to maintain effective separation of bighorn sheep from domestic sheep and goats and thereby manage for low risk of disease transmission. Alternative F would limit potential contact between bighorn sheep and domestic sheep and goats using the best available scientific information, and implementing best management practices. These provisions would promote healthy bighorn sheep populations while simultaneously allowing for responsible, legitimate uses of domestic livestock on public lands.

The other major factors affecting bighorn sheep populations include habitat fragmentation due to permanent human developments and disturbance due to human presence during energy-crucial times for bighorn sheep. The majority (56 percent) of existing bighorn sheep range is in designated wilderness, which would not change under any plan alternative. The primary difference between plan alternatives for that could influence habitat fragmentation and human disturbance, is the various types and configurations of plan land allocations. Alternative D would provide the highest degree of added protection for bighorn sheep from habitat loss associated with permanent human developments, as well as the most security from disturbance associated with human presence and types of activities. However, with the most recommended wilderness, alternative D would limit management flexibility for implementing bighorn sheep habitat improvement projects, research, and translocation efforts. At the other end of the spectrum, alternative E would provide the lowest level of protections against permanent habitat loss due to human development, and would also have the lowest level of security for bighorn sheep to avoid disturbance associated with certain types of use and high levels of human presence. Alternatives B, C, and F fall between these alternatives.

Alternative F would create long-term land use allocations of recommended wilderness and backcountry areas that would maintain additional bighorn sheep habitat with low or no permanent development and limited access that would moderate human use levels over time. Of alternatives B, C and F have the highest ratio of backcountry area to recommended wilderness. While in this configuration mechanized transport would be a suitable use and its associated impacts would occur over a greater proportion of bighorn sheep range, alternative F would restrict mountain bike use to approved system routes, which would limit a possible proliferation of user-created routes that could accommodate mechanized transport in bighorn sheep ranges. Finally, the higher proportion of backcountry area in alternative F would allow greater management flexibility for beneficial projects in bighorn sheep use areas. All revised plan alternatives include direction specifically aimed at reducing risk of disease caused by contact with domestic livestock, which is the primary threat to bighorn sheep populations, and was not specifically addressed in current plans. Therefore, all revised plan alternatives would help to ensure continued long-term persistence of bighorn sheep on the Custer Gallatin National Forest.

Big Game (Elk, Moose, and Deer)

Big game species have a key ecological role on the Custer Gallatin National Forest. Large ungulates can influence vegetation structure, composition, and distribution through effects of hoof action, horning, and herbivory. Big game species contribute to nutrient cycling through deposition of waste materials and decomposition of large carcasses. They provide an important prey base for predators as well as large carcasses that can feed many scavengers. In addition to these important ecological functions, big game species provide hunting opportunities that contribute to local, regional, and national economies. Big game populations and associated hunting regulations are managed by Montana Fish Wildlife and Parks, and South Dakota Game Fish and Parks. The Custer Gallatin National Forest supports a wide range of big game species including elk, moose, mule deer, white-tailed deer, pronghorn antelope, bison, bighorn sheep, mountain goat, wild turkey (*Meleagris gallopavo*), black bear (*Ursus americanus*), and mountain lion. Of these, elk, deer, and moose are the primary hunted species on the Custer Gallatin and will be the focus of this analysis. Most big game species on the Custer Gallatin tend to be habitat generalists. An assumption was made that by addressing the needs of elk, moose, and deer, which are habitat generalists with traits and needs that both overlap and differ from each other, the needs of big game species across the Custer Gallatin would be largely addressed. Exceptions include bison and bighorn sheep, which are addressed separately in this analysis.

The 2012 Planning Rule requires development of plan components that provide ecological conditions to sustain ecosystems that maintain the diversity of plant and animal communities and the persistence of native species in the plan area (36 CFR 219.9). For most wildlife, including most big game species, a coarse-filter approach that maintains or restores key ecological characteristics, such as species composition, structure, function, and connectivity of vegetation communities, provides habitat conditions required to support most wildlife needs. The 2012 Planning Rule requires fine-filter, or additional, species-specific plan components, only if needed to provide the ecological conditions necessary to address specific needs of at-risk species. None of the big game species that are hunted on the Custer Gallatin is an at-risk species, so no additional plan components are required. However, there is a great deal of public and agency interest in big game species, and a considerable body of science relative to habitat management for these species. Coarse-filter habitat components associated with water and terrestrial vegetation management provide for most habitat needs of big game species, but fine-filter plan components were added to address more site-specific needs associated with habitat security, winter range, and reproductive habitat.

Analysis Area

This analysis was conducted at the forestwide scale, as big game species occur across the entire national forest. Habitat connectivity between Custer Gallatin administrative units is addressed separately in this analysis; therefore, big game habitat was analyzed primarily within the national forest boundary. However, for habitat issues such as security that can be affected by factors outside the boundary, a buffer of roughly one-half mile outside the boundary was examined. Information was presented by geographic area where differences were notable, or where breaking down information was informative.

Notable Changes Between Draft and Final Environmental Impact Statement

In addition to supplementing this document with clarifying language and an analysis of effects to big game species in response to issues raised in public comment, several notable changes were made to big game-specific plan components. FW-GDL-WLBG-01 was modified to focus on the retention of forest cover where current levels are limiting to maintain functionality of key habitats such as winter range. Several exceptions associated with FW-GDL-WLBG-01 were deemed redundant and removed from the final plan. The goal to engage in cooperative collaboration with other agencies was clarified to allow for sustainable harvest rather than high-quality hunter experiences (FW-GO-WLBG-01). Finally, FW-GDL-WLBG-03 was clarified to state that current conditions of secure habitat would determine if any reeducation is allowable in the area of interest.

Affected Environment (Existing Conditions)

Unless otherwise noted, the affected environment described herein focuses on conditions for elk, moose, and deer.

Populations

With the exception of moose, these big game populations on the Custer Gallatin National Forest have generally increased in number and distribution since the original forest management plans were finalized in the mid-1980s. According to the State wildlife management agencies, big game population trends are generally strong near the Custer Gallatin National Forest. Elk populations are currently (as of 2018) above state management objectives in 11 of the 15 units reported in Montana that fall within the Custer Gallatin National Forest. Another three of the units are within state population objectives, and only one (Hunting District 310) is currently below the state objective level. Elk numbers in Hunting District 310, which is in the upper Gallatin River drainage, began declining early in the 21st century, when a portion of the herd began leaving the Gallatin Valley to occupy private lands in the Madison Valley during winter (Cunningham 2014). Herd numbers in this district have not recovered, but are increasing. The largest proportional growth for elk herds has occurred in the pine savanna ecosystem, where elk numbers are currently 3 to 4 times over state population objectives for the Ashland and Sioux Geographic Areas (in Montana). Elk numbers in the South Dakota portion of the Custer Gallatin National Forest have also been generally increasing over the past decade. It is difficult to track specific numbers or population trends for the relatively small acreage and disconnected pine escarpments of the Custer Gallatin National Forest in South Dakota, but herd estimates are approximately 150 animals within the entire northwest section of Harding County, which includes Custer Gallatin administrative units in the Sioux Geographic Area (Deisch, 2019a personal communication).

Mule deer population estimates for 2018 were above the decadal average (2008 to 2017) for Montana Fish Wildlife and Parks Regions 3, 5, and 7, which cover the Montana portion of the Custer Gallatin National Forest. White-tailed deer generally occur in lower-elevation habitats on the Custer Gallatin, and therefore, are not as widely distributed as elk and mule deer. White-tailed deer population estimates for 2018 were above the 10-year average in Montana Fish Wildlife and Parks Regions 5 and 7, but were slightly (about 1 percent) below average in Region 3 in Montana (Montana Fish, Wildlife and Parks: Deer Management).

Deer populations are monitored at a broad scale in South Dakota, with no specific estimates for the relatively small acreage of Custer Gallatin National Forest that occurs in that state. South Dakota Game Fish and Parks recognizes the unique habitat of Custer Gallatin lands in northwestern South Dakota and manages a hunting season for mule deer accordingly. White-tailed deer occur in low numbers in the South Dakota portion of the Custer Gallatin, and are not separately managed for hunting on the national forest. White-tailed deer are abundant in South Dakota outside the Custer Gallatin Forest boundary (Deisch, 2019a personal communication).

Moose can be difficult to monitor because they are more solitary, and thus, more widely dispersed than other large ungulates. However, moose populations in Montana appear to have been declining since the 1990s, based on aerial counts and hunter harvest statistics. As a result, Montana Fish, Wildlife, and Parks implemented a study to monitor statewide moose population trends and identify possible factors limiting population growth (DeCesare and Newby 2018). Although the study areas do not include portions of the Custer Gallatin National Forest, nearby moose populations are stable to increasing in two of the study areas, and potentially declining in another (DeCesare and Newby 2018). Moose occur at fairly low densities across most of the montane ecosystem (DeCesare et al. 2014), although their presence in the Pryor Mountains Geographic Area is infrequent. Attempts to survey moose have been sporadic in the montane geographic areas, but aerial surveys in the Hebgen Basin of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area have averaged about 5 moose annually in recent years, compared to counts in the same area that averaged 47 moose during the period from 1965 to 1971 (Cunningham 2015). Similar declines have been reported from the Beartooth Face, Stillwater, and Rosebud drainages of the Absaroka Beartooth Mountains Geographic Area. The pine savanna ecosystem is at the periphery of moose historical range, but moose have been sighted with increasing frequency in the Ashland and Sioux Geographic Areas in recent years. Moose appear to be colonizing or recolonizing the Pryor Mountains, Ashland, and Sioux Geographic Areas, and may be expanding their range in eastern Montana (DeCesare et al. 2014, Nadeau et al. 2017). Possible explanations for moose population declines include hunter harvest, increased predation, vegetation changes due to large-scale disturbances and natural succession, disease, parasite loads, and climate change (DeCesare et al. 2014). Moose are not known to occur on the Custer Gallatin in South Dakota.

Habitats

Elk, moose, and deer are habitat generalists, and although their habitats may frequently overlap, their daily, seasonal, and life-cycle needs can vary tremendously within and between species (Ranglack et al. 2017). For example, big game herds in the montane geographic areas are often migratory, with some making long-distance movements between summer and winter range. Conversely, there is no definable winter range for most big game species in the pine savanna geographic areas, where herd distribution does not vary notably by season (Devore, 2017 personal communication).

Elk use a wide variety of habitat types, typically wintering in lower-elevation, warmer, drier types in the montane geographic areas and moving upslope to spend summers in higher-elevation, cooler forest types. Elk often forage in the open grasslands, shrublands, and parklike openings in timbered areas, moving into more densely forested areas to find shelter from weather, extreme temperatures, predators, insects, and human disturbance. Elk are generally grazers, selecting from a wide variety of forbs and grasses, but will also use some woody browse species. In summer, nutritional value of forage is particularly important for elk, especially for females with young under the high nutritional demands associated with lactation. The nutritional value of summer forage typically wanes through late summer and fall as plants progress through the growing season and become more desiccated (Ranglack et al. 2016).

Nutritional value of vegetation can be estimated at the landscape scale using remotely sensed data (such as satellite imagery). Ranglack et al. (2016) estimated the nutritional value of forage for elk in southwestern Montana, including multiple herds that use portions of the Custer Gallatin National Forest. In this study, summer forage value for elk was derived from the normalized difference vegetation index based on greenness of reflected vegetation images. Using this particular measure, areas of highest summer nutrition values for elk on the Custer Gallatin are generally associated with northerly aspects and higher elevations. Optimal summer nutrition areas for elk are relatively rare on the Custer Gallatin, and generally include wetlands, moist meadows, mesic shrublands, deciduous forest types, and recently burned or transitional forests. Most conifer forest types produce lower nutritional forage values, with the exception of spruce pockets, that occur in wetter areas. Using normalized difference vegetation index as a measure, tree size class is generally not a good indicator of nutritional value within coniferous forests, until trees reach the larger size classes. Optimal nutrition areas are associated with forested stands in the 15-inch and larger size classes. Canopy cover also influences nutritional value in coniferous stands, with lower values associated with higher (more than 60 percent) canopy cover.

Elk winter range in the montane ecosystem is characterized by lower elevations, south- and west-facing slopes where thermal conditions result in lower snowpack and warmer temperatures, although some elk, particularly bulls, may occasionally winter at higher elevations on wind-swept slopes. In many areas of the Custer Gallatin, elk winter range is a limited extension of primary winter range in the valley bottoms, the majority of which is often on private land. Forage and cover are key attributes of winter range quality, where a typical scenario has elk foraging in open grasslands and seeking shelter in adjacent forest stands. Cook (2014) found that elk benefit more from forage quality and quantity than from cover in terms of optimal fat metabolism throughout the winter period. They concluded that thermal cover may be important under certain conditions, but its value is relational to other habitat attributes that contribute to the productivity of elk. Forested cover on winter range may have multiple functions including snow interception, thermal regulation, wind buffering and hiding cover to escape predators or human disturbance. Ideal winter range on the Custer Gallatin is likely a mosaic of non-forest and forest habitats that provide optimal juxtaposition of both forage and cover.

There is no definable winter range in the pine savanna ecosystem, and elk distribution does not vary notably by season. Snow intercept and winter thermal cover may not be as important to elk habitat selection as it is in the montane ecosystem. However, summer thermal cover may be vitally important in the warmer temperatures of the pine savanna ecosystem. Dense stands of coniferous and deciduous tree species provide high-quality hiding and thermal cover for elk in the pine savanna ecosystem (Devore, 2017 personal communication). Research has been conducted in the southern Black Hills of South Dakota, which have ponderosa pine habitats and summer weather patterns similar to Custer Gallatin Forest units in northwestern South Dakota. The South Dakota Game, Fish and Parks Elk Management Plan (2015) suggests that elk may select summer thermal cover for diurnal (daytime) bedding sites in the form of higher overstory canopy closure, increased tree basal area, north-facing slopes, and lower microsite temperature (Millspaugh et al. 1998, cited in the (South Dakota Department of Game Fish and Parks 2015) Elk Management Plan). In the southern Black Hills of South Dakota, elk exhibited high use of pine stands in the summer, likely for thermoregulation and avoidance of human disturbances (Millspaugh 1995, cited in the (South Dakota Department of Game Fish and Parks 2015) Elk Management Plan). Elevation, forage availability and quality, availability of aspen stands, and proximity to motorized trails and roads were cited as additional factors that influenced elk summer range in the ponderosa pine forests of the central Black Hills (Stubblefield 2006, cited in the (South Dakota Department of Game Fish and Parks 2015) Elk Management Plan), and may also influence elk habitat use in the Custer Gallatin National Forest units in South Dakota. There is no definable winter range in the pine savanna ecosystem, and elk distribution does not vary notably by season. Snow intercept and winter thermal cover may not be as important to elk habitat selection as it is in the montane ecosystem. However, summer thermal cover may be vitally important in the warmer temperatures of the pine savanna ecosystem. Dense stands of coniferous and deciduous tree species provide high-quality hiding and thermal cover for elk in the pine savanna ecosystem (Devore, 2017 personal communication). Research has been conducted in the southern Black Hills of South Dakota, which have ponderosa pine habitats and summer weather patterns similar to Custer Gallatin Forest units in northwestern South Dakota. The South Dakota Game, Fish and Parks Elk Management Plan (2015) suggests that elk may select summer thermal cover for diurnal (daytime) bedding sites in the form of higher overstory canopy closure, increased tree basal area, north-facing slopes, and lower microsite temperature (Millspaugh et al. 1998, cited in the (South Dakota Department of Game Fish and Parks 2015) Elk Management Plan). In the southern Black Hills of South Dakota, elk exhibited high use of pine stands in the summer, likely for thermoregulation and avoidance of human disturbances (Millspaugh 1995, cited in the (South Dakota Department of Game Fish and Parks 2015) Elk Management Plan). Elevation, forage availability and quality, availability of aspen stands, and proximity to motorized trails and roads were cited as additional factors that influenced elk summer range in the ponderosa pine forests of the central Black Hills (Stubblefield 2006, cited in the (South Dakota Department of Game Fish and Parks 2015) Elk Management Plan), and may also influence elk habitat use in the Custer Gallatin National Forest units in South Dakota.

Moose are closely associated with boreal forest conditions prominent in northern environments such as Canada and Alaska. They are typically found in cool, moist, mature forest habitat, but some of their preferred forage species such as aspen and other deciduous trees or shrubs, are typically common in recently disturbed areas. Moose also select for riparian habitats, where they feed on willows, forbs, and aquatic vegetation (Foresman 2012).

Unlike other big game species that migrate to lower elevation with lower snow accumulation, moose may remain at higher elevations with greater snow depths, making winter a critical time for moose because forage quality and availability is low, and energetic demands of moving through deep snow while maintaining body heat in cold temperatures are high. Winter habitat for moose is variable across their range, but always includes concentrations of accessible browse. Willow and aspen are among the most palatable browse species to moose, and are often heavily used if available in winter. At higher snow depths, moose will shift away from open browse fields and move into dense stands of conifers where canopy cover ameliorates snow depth and tree shading reduces snow crusting. On the northern winter range located in the Absaroka Beartooth Mountains Geographic Area where the Custer Gallatin abuts the northern boundary of Yellowstone National Park, older lodgepole pine forests with subalpine fir understory were heavily used by moose under deep snow conditions. Subalpine fir is a preferred winter browse species for moose in this area (Tyers 2003). Diet analysis in the Hebgen Basin of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area (unpublished data) indicated that for most moose in the basin, willow makes up a high proportion of the diet. However, conifer needles also make up a substantial portion of some moose diets, even when willow and other browse species appeared readily available. Based on moose pellet samples, in the Hebgen Basin, lodgepole pine comprises a larger portion of moose winter diet than other conifer species.

Moose response to habitat disturbance varies substantially across their range. In many areas, early successional conditions created by fire or logging are beneficial because they result in vigorous regeneration of palatable browse species. However, the relationship of moose to ecological disturbances in parts of the Greater Yellowstone Area appears to be different. In the northern winter range, older lodgepole pine stands are among the most important wintering areas for moose. When subject to disturbance, lodgepole-dominated forests typically regenerate with high density of lodgepole pine seedlings, rather than the more palatable woody shrubs that often appear soon after disturbance in mixed conifer forests. Tyers (2003) found little or no use by moose of lodgepole pine stands less than 100 years old, and highest use of lodgepole pine stands more than 300 years old on the northern winter range of the Custer Gallatin Forest. He also reported a precipitous decline in the moose population following the 1988 fires, which burned a substantial portion of his study area on the northern winter range, and attributed this decline at least in part to the loss of subalpine fir browse in the understory, and loss of canopy cover to intercept snow (Tyers 2003). Individual moose and populations within the Greater Yellowstone Area are susceptible to various types of diseases and parasites (Courtemanch 2015). These include chronic wasting disease, winter ticks, keratoconjunctivitis, filaroid nematodes, liver flukes, and meningeal worms. Moose are a temperature-sensitive species, requiring expenditure of additional energy to maintain suitable body temperatures when winter temperatures rise above 23 degrees Fahrenheit. General warming trends associated with climate change represent a potential threat to the moose population by increasing the potential for heat stress and result in higher parasite and disease loads (DeCesare and Newby 2013).

Deer, like moose and elk, use a wide variety of habitat types making them habitat generalists, but with various habitat conditions sometimes providing very different needs. While mule deer and white-tailed deer often overlap in range, mule deer typically occur at higher elevations, in more rugged terrain. Within the montane ecosystem, mule deer are typically associated with more open habitats, but spend time in the subalpine coniferous forest types as well. In the pine savanna ecosystem, mule deer use ponderosa pine forests, sagebrush slopes, woody draws, and badlands. Like other big game species in the montane ecosystem, mule deer typically migrate between higher-elevation summer and lower-elevation winter ranges with seasonal movements largely driven by the availability of suitable forage. Mule deer are browsers with a highly adaptable diet that varies between seasons and includes woody plant species as well as herbaceous forbs and grasses (Foresman 2012).

Following the onset of winter in the montane ecosystem, populations shift to lower elevations to escape greater snow depths. Winter habitats are often characterized by more open grassland or shrub-steppe landscapes. Mule deer will seek out south-facing or wind-swept areas to access forage. With the return of spring and associated recession of snowpack, mule deer begin to track the emergence of vegetation and "green up" in their return to higher-elevation, more productive summer range (Merkle et al. 2016, Aikens et al. 2017). During the day, mule deer seek areas of more rugged terrain that provide escape routes from predators as well as human disturbance. In the montane ecosystem, escape terrain is associated with steep, rocky areas, whereas badlands, coulees, and canyons often provide escape terrain for mule deer in the pine savanna ecosystem.

White-tailed deer generally occur at lower elevations across the Custer Gallatin. In the montane ecosystem, they typically occur near the national forest boundary in riparian areas, and adjacent private lands. White-tailed deer are widespread in the pine savanna ecosystem, where they are found in riparian areas, woody draws, and dense, young ponderosa pine stands, as well as adjacent agricultural fields. Cover, including dense ground cover and higher canopy cover, seems to be more important for white-tailed deer than mule deer, and they are often found near hiding cover. Recent large wildfires within and near the Ashland Geographic Area have notably impacted the availability of hiding cover for white-tailed deer, whereas increased shrub production following the fires has likely benefitted mule deer in the Ashland Geographic Area (Devore, 2017 personal communication).

In the pine savanna ecosystem, big game herds, including elk, mule deer, and white-tailed deer, do not migrate between seasonal ranges (Devore, 2017 personal communication). Elevation does not vary enough to result in differential snow depths in the pine savanna ecosystem. Winter snow depths on the Ashland and Sioux Geographic Areas are low relative to winter conditions in the montane geographic areas, resulting in better access to forage and easier travel conditions for wintering big game. Therefore, the tree canopy required for winter thermal cover and snow intercept may be less of a limiting factor for big game in the pine savanna ecosystem than in the montane ecosystem (U.S. Department of Agriculture and Montana Fish Wildlife and Parks 2013).

Cover

As discussed in previous paragraphs, cover is important for big game species for a number of reasons. Before beginning the plan revision, Forest Service biologists engaged with biologists from Montana Fish Wildlife and Parks to generate a basis to inform and guide plan revision efforts as they relate to big game species. The result was an interagency overview and set of recommendations for habitat management for big game species (U.S. Department of Agriculture and Montana Fish Wildlife and Parks 2013). As that effort was underway, big game populations were expanding, and in some cases colonizing or recolonizing habitats in the pine savanna ecosystem of eastern Montana and northwestern South Dakota. Since the ecology of increasing big game herds is not well understood for these areas, ongoing collaboration between the states and the Forest Service may result in changing management approaches for big game species over time. The recommendation for providing cover for big game species during spring, summer, and fall is to manage coniferous forest within the ecological context of the natural range of variation. Agency biologists concurred that canopy cover is a reasonable surrogate for evaluating coniferous forest cover conditions for big game species at the landscape scale, and that generally, coniferous canopy cover of 40 percent or higher provides functional hiding and thermal cover for big game under most conditions. Across the Custer Gallatin, the proportion of coniferous canopy cover of at least 40 percent varies by broad potential vegetation type relative to the natural range of variation. In most vegetation types, while proportions of canopy cover class are not all within the natural range, the total proportion at or above 40 percent canopy cover generally is within the natural range of variation (see the terrestrial vegetation section for more detail on canopy cover within forested habitats).

Secure Habitat

Secure habitat is important for reducing big game vulnerability during hunting seasons, and providing animals the opportunity to meet their biological needs throughout the year without being displaced to potentially lower-quality habitats. A shared goal for the Custer Gallatin and associated State wildlife management agencies is to provide habitat conditions that support year-round presence of big game species on National Forest System lands accessible to the public. In some areas of the Custer Gallatin, big game (most notably elk) distribution has become a management concern, as elk are spending significant amounts of time on private lands. The reasons for this changing distribution pattern are varied, and may be due to multiple, and different factors in different areas, including hunting pressure or lack of security on public land, attraction of high-value forage found on agricultural lands, low or no hunting pressure on private lands, and higher densities of natural predators on National Forest System lands compared to private lands. Providing secure habitat on National Forest System lands is considered a potential tool to manage elk distribution (U.S. Department of Agriculture and Montana Fish Wildlife and Parks 2013).

Secure habitat has been measured in varying ways, in many different geographic areas, and at various times. To further complicate matters, different species, different individuals within the same species, and even the same individuals under different circumstances, respond differently to human-caused disturbance factors. A widely accepted measure of secure habitat is distance from roads (Lyon 1983, Hillis et al. 1991, Ranglack et al. 2017). However, there is no universally agreed-upon distance at which all individuals of all big game species in all areas under all circumstances will feel secure. Based on research on elk habitat use in Montana (Lyon 1983, Hillis et al. 1991, Ranglack et al. 2017), the Custer Gallatin has traditionally used a standard distance of one-half mile from a motorized route, including all public and private roads and trails open to administrative, public, and private motorized use, to calculate proportions of secure habitat for big game species. Using this measure, roughly 62 percent of the entire Custer Gallatin land base provides secure habitat for big game. By geographic area, this figure breaks down to 83 percent secure for the Absaroka Beartooth Mountains Geographic Area; 58 percent secure for the Madison, Henrys Lake, and Gallatin Mountains Geographic Area; 49 percent secure for the Bridger, Bangtail, and Crazy Mountains Geographic Area; 34 percent secure for the Pryor Mountains Geographic Area; 33 percent secure for the Ashland Geographic Area; and 29 percent secure for the Sioux Geographic Area.

Key Stressors

- Hunting pressure, motorized access, and other human disturbance can affect big game security and distribution.
- Forage quality and quantity can be affected by livestock grazing, noxious weeds, fire, timber harvest and climate change.
- Loss of forested cover due to wildfire, insects, disease, and timber harvest, can increase big game vulnerability to predation, weather, and hunter harvest.

- Reduced fitness and reproductive success associated with communicable diseases and parasitic infections such as brucellosis, chronic wasting disease, arterial worm, and epizootic hemorrhagic disease.

Environmental Consequences

The analysis in this section is limited to those effects of the proposed alternatives on moose, elk, mule deer, and white-tailed deer. Unless otherwise noted, all subsequent references to big game species in this section refer to these four.

Management Direction under the Current Plans

Under the current plans, the existing separate Custer and Gallatin Forest Plans would remain in effect. The Custer Plan identifies elk, mule deer, and white-tailed deer as major interest species. White-tailed deer are classified as habitat indicator species for dog hair ponderosa pine. Winter range forage is considered the most significant limiting factor for deer and elk populations within the Custer Plan area. The plan allows restrictions on certain types of activities within big game winter ranges and calving areas where deemed necessary. Livestock grazing and associated range improvements would be implemented in accordance with implementation plans for fish and wildlife management. In certain management areas, timber harvest proposals would be analyzed for wildlife values and potential impacts.

The Gallatin Plan emphasizes forage and cover needs on big game summer and winter range, to be coordinated with other uses. Timber management, prescribed fire, and improved range management practices will be used to improve forage conditions for big game, including the use of prescribed fire to improve winter range condition. The plan contains specific cover retention requirements for big game. Livestock allotments are to be coordinated with wildlife habitat needs. Elk are identified in the Gallatin Plan as an indicator for big game species. Specific management area protections for big game include restrictions on certain types of recreation and maintenance, or may allow for improvement of forage quality, general habitat improvements, and prioritization of forage needs.

Effects of the Current Plans

The restrictions set forth in the current plans focus on cover and forage needs of big game with emphasis on winter habitats as the most critical. Cover requirements would be assessed and retention would be prescriptive, rather than striving to manage within the natural range of variation. Temporal and spatial restrictions on the types of projects that can occur within key habitats are intended to minimize the impact of human presence and disturbance on the landscape. Wildlife respond to human presence and noise disturbance in a variety of ways, including movement away from disturbance (flight response), which can result in increased energy demand as well as disruption of other activities, such as foraging or resting (Wisdom et al. 2018).

Some big game species, or individual herds, exhibit migratory behavior, particularly in the montane ecosystem geographic areas. Migration between seasonal habitats represents an important life history strategy that can allow wild ungulates to maximize energy intake by coordinating movements with the emergence of forage (Rolandsen et al. 2017). Migration paths and distance may vary between individual animals even within a single herd or population (Morelli et al. 2016). This may result in individuals experiencing different levels of risk and impacts across migratory paths. The current plans do not provide specific habitat connectivity language for big game species outside of the Gallatin Plan’s requirement of Management Area 19 to provide for natural elk migration patterns. In addition, the continued use of separate plans with differing direction would not allow for consistent management objectives to be established forestwide for widespread species such as big game.

Management Direction under the Revised Plan Alternatives

As with most wildlife species, the revised plan alternatives use a coarse-filter/fine-filter approach. Coarse-filter components include a comprehensive suite of plan components for riparian and terrestrial vegetation resources, designed to maintain or restore ecological conditions and processes to support diverse plant and animal communities (FW-DC-VEGF-02, 03; FW-DC-VEGNF-01, 04; FW-DC-RMZ-01). Fine-filter, forestwide plan components were added for big game species to address general habitat, as well as species-specific needs. Species-specific needs were identified for bison and bighorn sheep, which are addressed separately in this document. Fine-filter plan components for big game species in general would be the same under all revised plan alternatives (alternatives B through F). These alternatives address similar issues as current plans, but with new plan components. Alternatives B through F include a desired condition that wildlife resources contribute to social and economic benefits, including diverse and sustainable opportunities for research, wildlife viewing, photography, hunting, and trapping. Wildlife abundance and distribution supports State wildlife harvest and population objectives (FW-DC-WLBG-01). Several goals are included to highlight the importance of interagency coordination and other partnerships (FW-GO-WLBG-01 and FW-GO-WL-01-05). Guidelines address retaining forest cover where analysis demonstrates current levels are limiting functionality of key habitats such as winter range (FW-GDL-WLBG-01). Additional guidelines address avoidance of stressing big game with high energy demands; such as on winter range and reproductive areas (FW-GDL-WLBG-02). Finally, a guideline also addresses the maintenance of secure habitat during the hunting seasonal to minimize pressure on big game (FW-GDL-WLBG-03).

In addition to plan components for big game, the revised plan alternatives highlight the importance of habitat connectivity, which is important for big game species to meet daily, seasonal, and long-term life-cycle needs. All revised plan alternatives include desired conditions for landscape patterns that provide habitat connectivity, including structural and functional diversity to support natural movement patterns (FW-DC-WL-05, 06). Guidelines would prevent management actions that would create barriers to movement of big game (and other) species (FW-GDL-WL-01). Finally, alternatives B, C, D, and F adopt key linkage area plan land allocations with added habitat protection measures in certain areas that may be important for big game movement (FW, DC-WL-07, FW-GDL-WL-02, 03, 04, and 05, FW-SUIT-WL-01). Key linkage areas were identified in the far north end of the Gallatin Mountain Range and the west side of the Bridger Mountain Range.

Effects of the Revised Plan Alternatives

Compared with the current plans, the revised plan alternatives B through F would provide greater protection for big game seasonal habitats, address habitat connectivity, and standardize big game habitat management forestwide. Plan components would enable big game to contribute to social and economic benefits and support State wildlife harvest and population objectives (FW-DC-WLBG-01). Similar to the current plans, winter and reproductive seasonal habitats have been identified as vital for species population health and management actions would be located, timed, or otherwise mitigated to avoid stressing individuals and populations during those seasons (FW-GDL-WLBG-02). Vegetation management projects would be designed to retain conifer cover on big game key habitats where snow intercept, hiding, or thermal cover is limiting habitat functionality (FW-GDL-WLBG-01). Security habitat would be maintained during the hunting season where there is potential for game animals to experience added pressure from hunter use on public lands (FW-GDL-WLBG-03).

Plan components for key linkage areas in alternatives B, C, D, and F would minimize construction of permanent facilities and structures, and limit management activities in an effort to concentrate disturbance in space and time to allow for periods of low disturbance to for wide-ranging species. The key linkage areas and associated plan components were primarily designed to promote long-range movements of animals in a northerly or southerly direction across Custer Gallatin lands, potentially connecting landscapes at a scale beyond the national forest boundary. However, land use restrictions in the key linkage areas would restrict permanent habitat alterations, and limit large-scale disturbances in areas that are also important for big game daily and seasonal movements. For example, the west side of the Bridger Range is transitional habitat between summer and winter ranges for elk and mule deer.

Consequences to Big Game from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Watershed, Riparian, and Aquatic Management

All revised plan alternatives contain forestwide plan components associated with watershed, aquatic, and riparian ecosystems that set the coarse filter strategies that would protect, maintain, or restore water quality and riparian habitat (FW-DC-WTR-01, 03-06, 09, 10; FW-DC-RMZ-01). Specifically, the riparian management zone direction restricts management activities with few exceptions, to allow only those intended to restore, maintain, or improve aquatic and riparian habitats (FW-STD-RMZ-01). Desired conditions include support for self-sustaining populations of riparian-associated plant and animal species (FW-DC-RMZ-01). These components would protect or improve habitat conditions in areas important for seasonal forage, notably in the summer and fall seasons when succulent plants and browse species become more important in big game diets. Moose, in particular, would benefit from this direction given their year-round reliance upon riparian habitats for cover and forage. In addition to providing important water and food sources, riparian areas are often used as travel corridors by big game (and other) species. Riparian management zone direction under the revised plan alternatives would provide a higher degree of protection for a key habitat used by all big game species than the current plans.

Effects from Terrestrial Vegetation Management

The Custer Gallatin supports a diversity of plant communities distributed in a mosaic across the national forest landscape. Communities such as woodlands, grassland, shrubland, montane and subalpine forests, meadows, and riparian areas have potential to provide important habitat elements for big game. Plan components within the revised plan alternatives address composition, structure, and function of vegetation communities, which provide a coarse filter strategy designed to support disturbance regimes that will maintain and reinforce ecological integrity as well as plant and animal diversity. Revised plan alternatives include plan components to maintain vegetation within the natural range of variation when possible. All revised plan alternatives contain desired conditions for grassland and shrubland habitats, with native plant communities that are self-sustaining and support plant diversity with few non-native species present (FW-DC-VEGNF-01, 02 and 04). These plan components would provide for a wide diversity of foraging options for big game species.

Forested habitats provide cover, shelter, and security for big game from both environmental conditions and human use such as hunting. Forage can also be found in forested areas characterized by canopies that are more open. Revised plan alternatives contain coarse filter components to maintain forested habitats within the natural range of variation, including measurable desired conditions for tree size class and forest density across a range of broad potential vegetation types (FW-DC-VEGF01, 03, 04, and 05). To achieve desired conditions in forested habitats, management actions would strive to increase tree size class, with specific guidelines to increase the abundance of trees 15 inches or greater in diameter, which could improve nutritional value of forage within forested areas (Ranglack et al. 2016) (FW-GDL-VEGF05). Coniferous forest provides hiding cover for big game animals to escape from predators, contributes to thermoregulatory needs, and provides access to winter forage. Desired conditions to maintain forest structure within the natural range of variation for tree density as measured by canopy cover would provide a range of forest cover conditions to meet these needs of big game. The plan also supports a diversity of successional stages that are ecologically resilient and sustainable. Retention of a diverse landscape and mix of structural stages could allow for more effective response to changes in climate or natural disturbance, such a fire or disease. The amount and distribution of big game (elk, deer, and moose) security can be a primary factor determining whether big game will use or remain on National Forest System lands during the big game archery and rifle hunting seasons.

Compared to the current plans, the revised plan alternatives plan components include greater detail about vegetation conditions, including plant species composition, structure, and function. Such details provide better information for managing grassland, shrubland, and forest environments, which would contribute to biodiversity and ecological integrity of these habitats, and better meet the forage and cover needs for big game species. Collectively, these coarse filter components would contribute to the suitability of seasonal big game ranges and provide connecting corridors between seasonal habitats over time.

Effects from Fire and Fuels Management

Wildfire and prescribed burns are landscape processes that can affect big game habitat. Fire can reduce or remove vegetative cover that may be important for big game security and thermoregulation, but can simultaneously improve forage conditions for big game by increasing herbaceous species and shrubs, while reducing plant litter that is not palatable (Lyon and Christensen 2002). Where forage is a more limiting factor than cover, fire is likely to benefit big game species. However, depending on the timing and intensity of the event, wild and prescribed fire can either increase or decrease the nutritional value of forage resources for big game (Ranglack et al. 2016). The revised plan includes desired conditions for the amount and severity of wildland fire to be within the natural range of variation to maintain resilient ecological conditions, with vegetation conditions that generally support natural fire regimes (FW-DC-FIRE01 and 02). Managing towards these conditions would provide a range of habitat conditions to which big game species have adapted over time. Prescribed fire could be a valuable tool for increasing forage quantity and quality, and removing conifer encroachment to maintain natural ecotones in important big game habitats such as winter ranges and aspen stands (U.S. Department of Agriculture and Montana Fish Wildlife and Parks 2013).

Fire suppression can also affect big game habitat over time, by influencing the ratio of cover to forage, altering nutrient cycling processes, and preventing natural fire to play a role in maintaining openings. Non-forested areas and recently burned forest can provide not only foraging options, but also potential travel corridors where visibility for detection of predators may be an important factor for big game movement. Past fire suppression has likely resulted in more forested cover than would be supported under natural fire regimes in some parts of the Custer Gallatin (U.S. Department of Agriculture and Montana Fish Wildlife and Parks 2013). The revised plan includes objectives for increased prescribed burning and wildfire acres burned compared to existing plans (FW-OBJ-FIRE01, 02). Increased fire on the landscape could benefit big game species in some cases by improving foraging conditions, but could also have negative effects if important cover is removed, or if high intensity fire results in low nutritional value of regenerating vegetative communities. Revised plan alternatives' emphasis on ecological integrity would allow fire to play a more natural role in the montane and pine-savanna ecosystems, which is expected to benefit big game species to a greater degree than existing plans.

Effects from Timber Management

Like fire, timber harvest can alter big game habitat by removing overstory and horizontal cover, which typically stimulates subsequent grass, forb, and shrub production. Where forage is more limiting than cover, timber harvest can improve habitat conditions for big game by increasing the quantity and quality of forage (U.S. Department of Agriculture and Montana Fish Wildlife and Parks 2013). However, where cover is a limiting factor, timber harvest can have negative effects on big game by removing trees that provide hiding cover to protect big game from predators, thermal cover to ameliorate effects of temperature extremes, and snow intercept to maintain forage availability and movement corridors in winter. Disturbance from road construction and mechanical equipment needed for timber harvest can reduce habitat security for big game, potentially causing displacement of wildlife from otherwise suitable habitats.

Under revised plan alternatives, timber harvest projects must be consistent with plan direction for forested vegetation management (VEGF) as described above, which would generally result in forested habitat conditions within the natural range of variation for species composition, tree size class, forest density, and patch sizes. These requirements would help maintain or move toward habitat conditions to which big game species have evolved. Timber harvest for timber production may occur only on those lands classified as suitable for timber production (FW-STD-TIM-01). The amount of Custer Gallatin National Forest lands classified as suitable for timber production is lower under all revised plan alternatives compared to existing plans. Revised plan components for wildlife would limit potential negative effects of timber management on habitat connectivity in key linkage areas (FW-GDL-WL-02 and 05), cover functionality, winter ranges, reproductive areas, and secure habitat for big game (FW-GDL-WLBG-01 through 03).

On lands outside of the suitable base for timber production, timber harvest may be used as a tool for other resource benefits, including for purposes of wildlife habitat improvement. Timber harvest could be a useful tool for increasing forage quantity and quality where needed, removing conifer encroachment to maintain natural ecotones, and removing overly dense live or dead trees that may be restricting big game movement (U.S. Department of Agriculture and Montana Fish Wildlife and Parks 2013). Whether used for timber production or other resource benefits, new roads needed for timber harvest would generally be temporary roads located and constructed to facilitate removal and restoration following the intended use (FW-GDL-RT01), which would help maintain habitat security for big game over time.

Effects of Plan Land Allocations

The revised plan alternatives differ in their proportion of backcountry area and recommended wilderness area allocations. These allocations can influence the management of big game habitat throughout the Custer Gallatin. The backcountry area allocation is designed to allow for natural processes with little evidence of long-lasting human use (FW-DC-BCA-01). The recommended wilderness area allocation allows natural processes such as wildland fire, disease, or natural succession to be the primary forces that shape the environment (FW-DC RWA-01, 03). These plan land allocations come with a series of land use restrictions that prohibit certain types of human use. In backcountry areas, prohibitions include the construction of new permanent roads, new energy or utility structures, new commercial communication sites, new developed recreation sites, and removal of new saleable mineral material (FS-STD-BCA-01-05, see also plan components for individual backcountry areas by geographic area in the plan). All special uses must be compatible with backcountry character (FW-STD-BCA-06).

Recommended wilderness areas prohibit new roads, developed recreation sites, recreation events, energy and utility structures, commercial communication sites, and extraction of saleable mineral material (FW-STD-RWA-01-06). Neither timber production nor timber harvest would be suitable in recommended wilderness areas (FW-SUIT-RWA-01). New mechanized or motorized transport would not be suitable; existing motorized and mechanized transport would continue to be suitable in alternative B, and no longer suitable in alternatives C, D, and F.

The restrictions on development and types of human use associated with backcountry areas and recommended wilderness areas may result in the protection and retention of big game habitat. The limitations on land use activities would have the beneficial effect of preventing habitat degradation and displacement of individuals and populations associated with physical and anthropogenic disturbance. The recommended wilderness area allocation could potentially limit the opportunity for implementation of habitat improvement projects within big game seasonal habitats. Encroachment of conifers into aspen, meadows, or other habitats can reduce the quality, productivity, and diversity of important forage habitats. Removal of the encroaching species can be an important tool in maintain and enhancing existing habitat conditions for big game species.

The majority of recommended wilderness area and backcountry area allocations across the alternatives tend to fall within higher-elevation portions of the Custer Gallatin. Big game tend to use higher elevations during the warmer summer seasons and transition to lower elevations during the winter. Therefore, the plan land allocations would primarily affect the condition of summer and transitional habitat. This is especially true within the montane ecosystem geographic areas, which include Madison, Henrys Lake, and Gallatin Mountains; Bridger, Bangtails, Crazy Mountains; and Absaroka Beartooth Mountains. Proposed land use destinations within the Ashland and Sioux Geographic Areas would likely encompass year-round seasonal habitats.

The plan land allocations proposed in alternatives B through F would work in conjunction with existing designated wilderness and inventoried roadless areas to create a series of protected corridors that would maintain habitat connectivity within and between Custer Gallatin administrative units. In the montane ecosystem, Montana Fish Wildlife and Parks personnel have identified the area from Yellowstone National Park to Paradise Valley as a priority big-game winter range and migration corridor (Montana Fish Wildlife and Parks 2018b). This area includes much of the Absaroka Beartooth Mountains Geographic Area, and parts of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area as well. The majority of the Absaroka Beartooth Mountains Geographic Area is within designated wilderness, which provides the highest degree of wildlife habitat protection from land management practices under all alternatives. The revised plan alternatives propose varying combinations of land use allocations for recommended wilderness area and backcountry area within the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas that would support state priorities to improve the habitat quality of western big game winter range and migration corridors (Montana Fish Wildlife and Parks 2018b). Alternative D would add the most acreage of recommended wilderness area, which would extend the land use restrictions well beyond the existing wilderness area. While alternative D with recommended wilderness areas would provide the greatest protection from human disturbance due to land uses, it would also limit the management tools available for habitat enhancement to maintain or restore habitat connectivity if needed.

In the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, additional allocations of recommended wilderness area, backcountry area, and key linkage areas, would also contribute to protection of habitat connectivity for wildlife, in a manner that would be complementary to the State priorities for improving big game winter ranges and migration corridors. In the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, Montana Fish Wildlife and Parks personnel have identified the top research priority to improve understanding of the seasonal habitat use and migration corridors for pronghorn antelope in the Madison Valley (Montana Fish Wildlife and Parks 2018b). The Madison Valley sits just west of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area on the Custer Gallatin, and supports one of largest wintering populations of pronghorn in southwestern Montana. Evidence suggests that a substantial portion of this population migrates to different summer range, with some perhaps moving into and across the southern portion of the Custer Gallatin, and possibly into Yellowstone National Park (Montana Fish Wildlife and Parks 2018b). This hypothesis raises questions about the importance of the area around Hebgen Lake as a possible connection for pronghorns between the Madison Valley and Yellowstone Park. All alternatives include plan components for coordination with State wildlife management agencies, and the revised plan alternatives contain specific goals to work across boundaries to promote wildlife habitat connectivity, improve knowledge bases, and raise public awareness that would support this top Montana research priority for wildlife movement.

Effects from Permitted Livestock Grazing

Direct interaction between livestock and big game is likely to occur, especially within the eastern geographic areas (Ashland and Sioux) where the majority of permitted livestock use occurs. Effects of livestock grazing on big game species can include direct competition for resources and degradation of habitat conditions. Grazing can influence vegetation communities through reduced productivity, changing plant composition, and herbaceous structure (Svejar et al. 2014). Coe et al. (2001) suggest competition for resources has the potential to occur between cattle and elk to a higher degree than between mule deer and cattle. Elk demonstrated a higher degree of displacement and avoidance from cattle compared to mule deer; this is likely due to resource partitioning and associated spatial displacement (Coe et al. 2001, Stewart et al. 2002). It is important to note that temporal niche partitioning of resources has the potential to break down under changing climatic and environmental conditions, which could result in more direct competition for resources between species (Herfindal et al. 2017). This highlights the importance of maintaining a balance and diversity of forage species on the landscape to benefit big game as they transition between seasonal ranges. Increased vegetative vigor and production could retain a greater proportion of digestible biomass for big game species to use. Indirect effects include those associated with grazing infrastructure, including mortalities associated with fence entanglements.

Under the revised plan alternatives, all new or revised allotment management plans would design grazing practices (such as stocking levels, duration, timing) and allotment infrastructure to avoid, minimize, or mitigate adverse livestock-related effects to maintain or improve resiliency of riparian and upland ecosystems, and associated flora and fauna (FW-STD-GRAZ-01). The revised plan alternatives contain a desired condition that grazing allotments supply livestock forage and contribute to local ranching operations, while staying within or moving toward desired ecological conditions (FW-DC-GRAZ-01). Grazing-specific guidelines contain measures to maintain or improve riparian habitat, including specific, quantifiable forage utilization measures within riparian areas (FW-GDL-GRAZ-01). Infrastructure such as fences and water developments should be designed and located to prevent barriers and reduce the probability for injury or mortality to wildlife (FW-GDL-GRAZ-07). New and revised allotment management plans should incorporate adaptive strategies to maintain functionality of winter range and forage needs in coordination with other uses (FW-GDL-GRAZ-03).

Effects from Minerals Management

Industrial development has the potential to greatly impact big game populations through the removal and fragmentation of suitable habitats and the avoidance of development on the landscape. Behavioral changes including avoidance and displacement can be long lasting with limited evidence of acclimation by individuals or herds (Sawyer et al. 2017). In addition, energy development could influence harvest efficiency and probability for sportsman by increasing access potential or displacement of individuals (Dorning et al. 2017). Under all revised plan alternatives, mineral and energy development activities include provisions to reclaim disturbed areas (FW-STD-EMIN-01) and minimize adverse effects to riparian resources (FW-GDL-EMIN02).

Effects from Infrastructure and Recreation Management

The installation, maintenance, and use of recreation facilities including trails has the potential to affect big game through removal or fragmentation of habitat and displacement through avoidance of human use. The revised plan alternatives include several forestwide components that address the addition of new and maintenance of existing recreation facilities such as trails, campgrounds, picnic areas, etc. (FW-DC-REC-05; FW-DC-RECDEV-09; FW-GDL-RECDEV-02). The revised plan alternatives include desired conditions for recreation facilities to have minimal impacts on ecological integrity and diversity, as well as overall compatibility with natural resources (FW-DC-REC-05). Plan components include requirements for infrastructure such as roads, trails, and other facilities to minimize impacts to riparian habitats and limit disturbance to associated wildlife species (FW-DC-REVDEV 09; FW-GDL-RECDEV-01). There is an objective to remove or relocate some existing recreation facilities out of riparian areas (FW-OBJ-REC-01). New developed sites would be designed to replace existing dispersed sites that are degrading riparian resources. Components address potential impacts from the location of facilities and the introduction of invasive species through ground-disturbing activities (FW-GDL-INV-01).

Cumulative Effects

The framework for big game population management is determined by the applicable State wildlife management agency, Montana Fish Wildlife and Parks and South Dakota Game and Fish. The State agencies use a variety of data sources to compile population estimates, trends, and habitat condition across different seasonal ranges and big game populations. This information is used in establishing harvest limits and hunting seasons. The State of Montana recently instituted an action plan designed to improve the quality of big game winter ranges and migration corridors (Montana Fish Wildlife and Parks 2018b).

Given the wide distribution of big game species across the Custer Gallatin and throughout the region, management of these species involves multiple agencies and plans. Neighboring forests such as the Beaverhead-Deerlodge, Helena-Lewis and Clark, Targhee, and Shoshone national forests have goals for wildlife habitat that are compatible with those outlined in the Custer Gallatin revised plan alternatives.

The Beaverhead-Deerlodge seeks to provide a mosaic of species and age classes that provide cover and forage for wildlife, along with secure areas and seasonal habitat connectivity for ungulates. The Helena-Lewis and Clark is proposing ungulate winter range be relatively free of human disturbance during seasonally active time periods. The Shoshone applies seasonal restriction on motorized use of travelways within big game crucial winter ranges. Other Federal land management agencies such as the Bureau of Land Management Miles City Field Office require that surface-disturbing and disruptive activities have design features that maintain the functionality of crucial winter range habitat. This does not represent a complete list of management requirements, but highlights the compatible nature of direction focusing on many of the same issues addressed in the Custer Gallatin proposed plan components and alternatives.

Conclusion

The big game species discussed in this section occur throughout much of the Custer Gallatin National Forest. These species are wide-ranging, and as such, require a diversity of habitat types distributed across the landscape. All revised plan alternatives contain plan components that are designed to develop or maintain a diversity within vegetative communities and age-class structure. The retention and maintenance of suitable hiding and thermal cover, and the diversity of vegetation types and structure could benefit forage quality and abundance. Greater levels of protection and more specific language is contained within the revised plan alternatives, than the current plans. The revised plan alternatives better address emerging issues and more thoroughly address issues and provide protections for all seasonal habitat needs, compared to the current plans.

Each alternative differs in the plan land allocations within each of the geographic areas. Alternative D provides the greatest amount of proposed recommended wilderness area acreage and likely represents the greatest level of management restrictions. However, this would include a reduced opportunity for habitat enhancement or maintenance projects within crucial wildlife habitats. Alternatives B and C represent intermediate levels of restriction relative to the other alternatives and include both recommended wilderness area and backcountry area allocations within big game habitats. Alternative E proposes no recommended wilderness area, but proposes two backcountry areas. Alternatives B, C, and D also delineate a key linkage area designed to minimize impediments to the movement of wide-ranging species, such as big game. The plan components for managing permitted livestock grazing, vegetation management, mineral and energy development, and administrative and recreational facilities would help maintain or enhance big game habitat conditions and minimize human disturbance within critical habitat areas. The revised plan alternatives would provide better protection for, and potential improvement of, big game populations, seasonal habitat condition, and habitat connectivity than the current plans.

Bison (*Bison Bison*)

The American bison is an iconic symbol of Yellowstone National Park, and was recently officially designated as the United States' national mammal (The National Academies of Sciences 2017). The Custer Gallatin is unique within the National Forest System in that it borders Yellowstone Park on the north and west sides, where bison naturally tend to migrate to lower elevation habitats on National Forest System lands when winter snows become too deep in the Park. The Yellowstone bison population is unique in that it is genetically pure due to isolation from domestic bovines (such as cattle), and it contains thousands of individuals that exhibit wild behavior, roaming relatively free over large landscapes (White et al. 2015). As such, this bison population is of great social, economic, and spiritual importance to Tribes, and local, regional, national, and international visitors to the Greater Yellowstone

Area, including the Custer Gallatin National Forest. Bison have a key ecological role in the Greater Yellowstone Ecosystem, and are managed largely under the auspices of an Interagency Bison Management Plan, developed in partnership between Yellowstone National Park, the state of Montana, USDA Forest Service and Animal and Plant Health Inspection Service (U.S. Department of the Interior 2000b).

Enabling legislation for State and Federal agencies mandates coordinated conservation of wildlife and habitat. Consequently, responsibility for management of Yellowstone bison and their habitat is jointly held by State and Federal agencies. Inside Yellowstone National Park, the secretary of interior has exclusive jurisdiction to manage Yellowstone National Park's resources, including bison and their habitats. Outside Yellowstone National Park, the primary role of the Custer Gallatin National Forest is management of habitat, whereas state agencies (Montana Fish Wildlife and Parks, Montana Department of Livestock) have the lead role in managing bison populations.

Bison are the largest terrestrial mammal in North America, although considerable size variation occurs between subspecies, as well as sex and age cohorts. Historically, two subspecies of bison occurred in North America; the woods (or mountain) bison (*B. b. athabascae*) which is the larger of the two, and the plains bison (*B. b. bison*), which is slightly smaller, although still quite massive (Adams and Dood 2011). Yellowstone bison are descended from the plains bison (White et al. 2015). The original remnant herd that survived in Yellowstone National Park in the late 1800s consisted of a small number of individuals, and the herd was later augmented with bison from other areas. As suggested by their name, plains bison are adapted to short-grass prairie habitats found in the Great Plains. They feed primarily on grasses, but will also eat forbs and woody browse species when grasses are limited (Meagher 1973).

Historically, bison were present throughout most of North America, numbering in the millions (Adams and Dood 2011). Currently they are found in isolated units throughout their historical range (http://exporer.natureserve.org). Pre-European settlement of the American west, Yellowstone bison occupied approximately 20,000 kilometers^2 (7,722 miles^2) in the northern Greater Yellowstone Area, whereas they presently occur primarily within an area of about 3,175 kilometers^2 (1,225 miles^2), or roughly 16 percent of their historical range (U.S. Department of the Interior 2015g). Bison population size is strongly correlated with age and sex structure of the herd, as well as habitat quality and forage availability. Herd sizes are generally smaller in mountainous or forested habitat than in large open prairie habitats (Adams and Dood 2011).

As mammals of large body size, Yellowstone bison are relatively long-lived, with the oldest individuals aged at over 20 years (White et al. 2015). Survival rates are high for prime age adults at roughly 95 percent. Mortality rates are highest for calves and older bison. Breeding occurs during summer and early fall, and most bison calves are born in April or May, although there is evidence that calving season may be influenced by forage availability; such as earlier after a mild winter or later after a particularly hard winter. Calves born later in the season may have a lower survival rate. Availability of vegetative cover may influence whether cow bison give birth in isolation, or stay closer to the herd. Typically, cow bison have only one calf each year, although on rare occasions, twins may be produced (Adams and Dood 2011).

Partly because of their size, but also due to behavioral characteristics, bison have a key ecological role, and are considered a "keystone species" in prairie/grassland ecosystems. They provide food for a variety of large predators and a whole suite of scavengers. They influence vegetation composition and structure through grazing, hoof action, and seed dispersal. They contribute to nutrient cycling through deposition of urine and feces, as well as decomposition of bison carcasses. They create wallows by rolling in the dirt to remove parasites and shedding fur, add dust for thermal regulation, and promote pheromone exchange during the breeding season (or rut). Wallows are depressions in compacted soil, which collect rainwater and runoff, creating microsites that can produce lush vegetation that may otherwise be limited in a short-grass prairie environment. These traits give bison considerable influence on the plant and animal communities around them (Adams and Dood 2011).

Yellowstone bison can carry a bacterium-caused disease called brucellosis, which was originally transmitted to wild bison and elk in the Greater Yellowstone Area by domestic cattle in the early 1900s. The only remaining source of brucellosis left in the United States is in wild bison and elk in the Greater Yellowstone Area (Aune et al. 2011). Brucellosis causes pregnant ungulates to abort, with potential impacts at the population level. The disease has since been eradicated from domestic livestock for the most part, except for isolated incidents in recent years. Just as the disease can be transmitted from domestic livestock to wild animals, it can also be transmitted from wildlife to domestic livestock. However, there has never been a confirmed case of brucellosis transmission from bison to cattle in the wild, largely due to management-controlled separation of the two species. To date, all known cases of brucellosis transmission from wild ungulates to domestic livestock have come from infected elk (Rhyan et al. 2013, White et al. 2015, Kamath et al. 2016, The National Academies of Sciences 2017). While there are no known cases of brucellosis transmission form bison to cattle in the wild, because such transmission is possible, the state of Montana designated bison management zones, or areas where bison presence would be tolerated (Montana Fish Wildlife and Parks 2015a). These zones fall primarily on National Forest System lands within the Custer Gallatin National Forest.

Analysis Area

Bison presence is currently limited to relatively small areas on the Custer Gallatin, primarily located within state-identified bison management zones west of Yellowstone Park in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area and north of the park in the Madison, Henrys Lake, and Gallatin Mountains and Absaroka Beartooth Mountains Geographic Areas. There is suitable habitat for bison outside these management zones, and bison occasionally wander, but not far, outside the zones. Bison are native to the Custer Gallatin, and their presence as wildlife in suitable habitat on National Forest System lands is a desired condition. Therefore, the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas were used as the spatial bounds for effects analysis. Given the current social constraints on bison tolerance in rural, residential, and agricultural lands in Montana, it is unlikely bison would successfully migrate beyond these geographic areas to other areas of the Custer Gallatin during the life of the plan.

Notable Changes between the Draft and Final Environmental Impact Statement

The discussion about genetic differences between the two herds of Yellowstone bison that move onto the Custer Gallatin National Forest was expanded. Changes were made to better explain terminology such as “potential” versus “suitable” bison habitat, and “connecting corridors” for bison, and to better describe the intent and possible implications of plan components for strategic placement of habitat improvement projects relative to bison management zones (FW-GDL-WLBI-02). Finally, the effects analyses for plan land allocations and effects from recreation management were modified to better explain the complexity of overlapping designations and allocations, and habitats, and eliminate redundancies between the two sections. The environmental consequences section was supplemented with new information for alternative F. A notable change to the plan was identification of the primary conservation area for grizzly bears as an area where bison expansion is expected to occur over the life of the plan, where bison habitat improvements would have the most benefit, and consequently, where certain plan components apply (FW-GDL-WLBI-03).

Language was added to FW-DC-WLBI-04 stating that year-round bison presence on the Custer Gallatin National Forest with sufficient numbers and distribution to provide a self-sustaining bison population would occur in conjunction with bison herds in Yellowstone National Park. Current use of the national forest by bison is the result of seasonal migrations out of the Yellowstone National Park. Therefore, establishment of any year-round, self-sustaining population on the national forest would most likely originate from Yellowstone bison. These herds require cooperative and collaborative management across multiple agencies, States and interested partners. The revised plan continues the Custer Gallatin's commitment to work cooperatively in development of adaptive strategies to manage bison and their habitats to facilitate natural movement or translocation of bison into and between suitable habitats (FW-GO-WLBI-01).

Affected Environment (Existing Conditions)

Bison were historically present across the Custer Gallatin with highest densities in the Absaroka Beartooth Mountains; Ashland; and Sioux Geographic Areas. Pre-European settlement distribution of Yellowstone bison founders covered portions of the Absaroka Beartooth and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas on the Custer Gallatin (White et al. 2015). Due to a combination of factors including hunting, poaching, drought, disease transmission and competition from domestic livestock, bison were extirpated from the Custer Gallatin by the turn of the 20th century. However, a small, remnant herd remained within the confines of Yellowstone National Park. The Yellowstone bison population was heavily managed and artificially maintained within Yellowstone National Park boundaries until the late 1960s, when natural regulation through predation, weather, and forage availability was allowed a more prominent role. The population quickly responded with increasing bison numbers, resulting in large-scale bison migration outside the Park during winters in the late 1980s (Adams and Dood 2011, White et al. 2015). This recent development initiated the return of bison to seasonal use of habitat within the Custer Gallatin.

Bison are migratory, and capable of long-distance movements between seasonal ranges. Meagher (1973) reported that Yellowstone bison winter in lower elevation valleys, moving in spring to summer ranges at higher elevations, and then reversing the migration pattern again in fall. Following this pattern, Yellowstone bison spend most of the year inside Yellowstone National Park, migrating to lower elevation winter range, including some areas on the Custer Gallatin National Forest, when snow levels restrict access to forage at higher elevations.

The Yellowstone bison population consists of two genetically distinguishable groups, the northern and central herds, which spend most of their time inside Yellowstone National Park. However, during winter, some bison from the northern herd migrate onto the Custer Gallatin National Forest in the Gardiner Basin area north of the park boundary, while some bison from the central herd migrate west of the park boundary and onto the Custer Gallatin in the Hebgen Basin Area near the town of West Yellowstone, Montana. The genetic distinction of the two herds and recent declines in number of bison in the central herd were issues of concern often cited in public comments on the Custer Gallatin National Forest Plan revision draft final environmental impact statement. However, annual reports for the Interagency Bison Management Plan show that since 2005, bison have been dispersing from the central herd to join the northern herd, resulting in sharp declines in the central herd, but with commensurate increases in bison numbers in the northern herd, for an overall steady population trend (Interagency Bison Management Plan 2018b). Most recently, while the total summer bison count dropped from 4,816 in 2017 to 4,527 in 2018, largely due to culling operations, the number of bison in the central herd increased from 847 to 1,190 during this time (Interagency Bison Management Plan 2018a;2019a).

The genetic distinction between the Yellowstone bison herds can be traced back to the turn of the 20th century, when native bison were nearly extirpated from the Yellowstone Ecosystem in the late 1800s, except for 23 individuals that survived in central Yellowstone National Park. The northern herd was established by importing unrelated bison from northern Montana and Texas. These two herds were intentionally mixed in the early 1900s by introducing animals from the central to the northern herd and vice versa. Bison emigration from the central to the northern herd in recent times has likely been in response to density dependent dynamics as the Yellowstone bison population reached up to 5,000 animals. High bison numbers combined with severe winters with deep snow accumulations that limited forage availability likely triggered emigration out of the central herd (White and Wallen 2012). Recent emigration between the herds may be influenced by anthropogenic factors, since plowed roads and groomed snowmobile routes in Yellowstone Park have been used as travel routes by bison (Meagher et al. 2002). However, some authors have reported that plowed and groomed routes, while used by bison, have minor influence on bison distribution in Yellowstone Park (Bjornlie and Garrott 2001, White and Wallen 2012).

In Montana, the Department of Livestock manages livestock disease control programs. Because bison leaving Yellowstone Park can transmit brucellosis to cattle in Montana, the state veterinarian has the authority and discretion to remove bison that pose a threat to livestock (White et al. 2015). Removal of bison for such purposes can influence the numbers and distribution of bison on the Custer Gallatin. In December 2015, Montana Governor Steve Bullock signed a decision notice that expanded management zones for bison. This decision was based on new information and changed conditions including new scientific information indicating negligible risk of transmission of brucellosis from bull bison to cattle, and closure of several livestock grazing allotments on the Custer Gallatin National Forest (Montana Fish Wildlife and Parks 2015a). The expansion nearly tripled the size of the western management zone, and increased the northern management zone to roughly eight times its previous size. As a result, bison may persist year-round in these parts of the Custer Gallatin, without being hazed back into Yellowstone Park (**Error! Reference source not found.** provides the location of bison management zones).

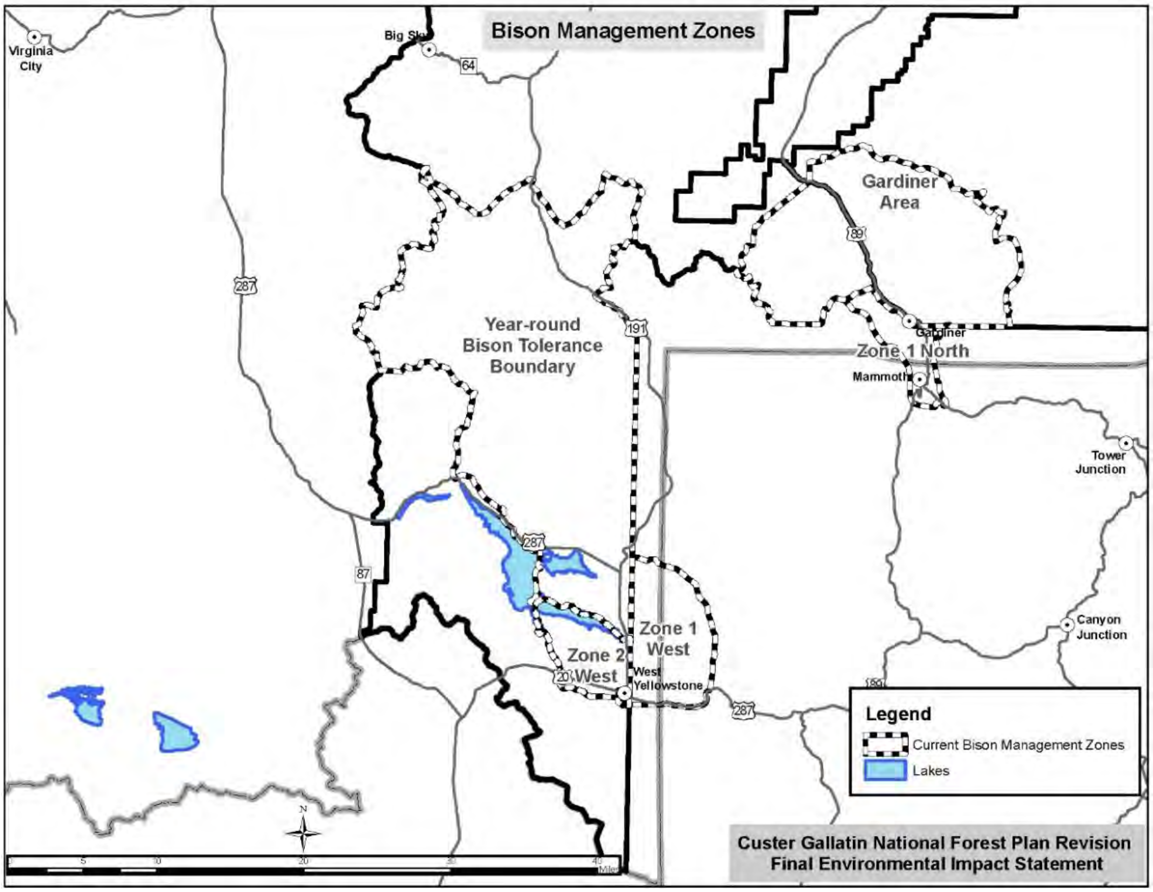

Figure 33. Bison management zones

Cattle are permitted on Forest Service grazing allotments within the bison management zones, although the number of cattle allotments in areas where bison migrate onto the Custer Gallatin National Forest have been reduced in recent years through willing participation with grazing permittees, as well as partnerships with state and federal agencies along with contributions from private organizations. Currently, there are no active cattle allotments inside the western management zones. However, outside the western management zones, two active cattle allotments running cow and calf pairs and one vacant allotment previously ran yearling cattle. In addition, there are six active grazing allotments for horses inside the western management zones. Horses have not been identified as a potential threat for disease transmission to or from wild bison. There are two active cattle allotments running cow and calf pairs, and three vacant allotments that previously ran cow and calf pairs, inside the northern bison management zone. In addition, there are three active livestock grazing allotments outside but near the northern bison management zone. These allotments currently run cow and calf pairs, yearling cattle, and horses. There have been no incidents of bison and cattle comingling on these allotments due to spatial and temporal separation.

Since the Interagency Bison Management Plan was first signed in 2000, several livestock allotments have been permanently closed within and near the bison management zones on the Custer Gallatin. Most of the closed allotments ran cattle, including six allotments inside and one allotment outside the western management zone, plus two allotments inside and one allotment outside the northern management zone. Cattle or other classes of livestock would not be re-stocked on these allotments without appropriate environmental analysis. **Error! Reference source not found.** and **Error! Reference source not found.** show the history of livestock allotments relative to bison management zones on the Custer Gallatin.

Wallen (2012; cited in ((Montana Fish Wildlife and Parks and Montana Department of Livestock 2013)) mapped potential habitat for bison in Yellowstone Park as well as the bison management zones on the Custer Gallatin. Potential habitat is habitat that is suitable for bison, but not all of which is currently used by bison. Using similar parameters (Wallen, 2016 personal communication), a query of existing vegetation (using Northern Region VMap data) was used to estimate potential bison habitat for the entire Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas. Potential bison habitat includes grass, forb, and shrub fields as general range, and open (less than 25 percent canopy cover) forest areas as spring range. Roughly 11 percent of the Absaroka Beartooth Mountains GA provides potential habitat for bison, along with about 15 percent of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area. This relatively simple GIS exercise estimated over 223,000 acres of general bison habitat, plus roughly 69,000 acres of spring range, for a total of approximately 292,000 acres of potential bison habitat on the Custer Gallatin in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas combined. Connecting corridors between suitable habitats for bison would require areas with no barriers and minimal impediments to bison movement.

Bison leave Yellowstone Park and move onto the Custer Gallatin National Forest when winter conditions become too extreme to support the entire bison population in the park. Bison first began leaving Yellowstone Park to winter on the Custer Gallatin in the 1980s (Meagher et al. 2002). Since then, bison numbers using the Custer Gallatin have been rising. According to the most current data, over 400 bison were observed in the northern management zone in March of 2019 and over 600 bison were observed in the western management zone in May of 2019 (Interagency Bison Management Plan 2019a). Bison that leave Yellowstone Park and move onto the national forest are hunted by Tribal members as well as the general public. Hunter harvest, which largely only occurs on National Forest System lands, has also been increasing over the years, from a low of one bison harvested in 2009 to a high of 468 taken in 2016–2017. Bison harvest on the Custer Gallatin went down for the first time in 2017–2018 to 375 (Geremia et al. 2018)(Geremia et al. 2018), and declined again to 107 animals harvested by state-licensed and Tribal hunters in 2018–2019 (Interagency Bison Management Plan 2019a).

Table 79. Active or vacant domestic livestock allotments within or near bison management zones

Allotment Name	Location	Status	Class of Livestock	Permitted Season
Moose	Western Zone 2	Active	Horses	7/1–9/1
Grayling Creek	Western Zone 2	Active	Horses	7/1–10/31
Sage Creek	Western Yearlong	Active	Horses	6/15–10/15
North Cinnamon	Western Yearlong	Active	Horses	7/1–9/18
South Cinnamon	Western Yearlong	Active	Horses	6/20–10/20
Taylor Fork	Western Yearlong	Active	Horses	6/15–10/15
Watkins Creek	Outside Western Zone	Active	Cow/calf pairs	7/1–9/30
South Fork	Outside Western Zone	Active	Cow/calf pairs	7/1–9/30

Allotment Name	Location	Status	Class of Livestock	Permitted Season
Sheep Mile	Outside Western Zone	Vacant	Yearlings	Not applicable
Slip and Slide	Northern Zone	Active	Cow/calf pairs	6/16–10/15
Green Lake	Northern Zone	Active	Cow/calf pairs	6/16–10/15
Cottonwood	Northern Zone	Vacant	Cow/calf pairs	Not applicable
Lion Creek	Northern Zone	Vacant	Cow/calf pairs	Not applicable
Mill Creek and Section 22	Northern Zone	Vacant	Cow/calf pairs	Not applicable
Tom Miner and Ramshorn	Outside Northern Zone	Active	Cow/calf pairs	7/1–10/15
Horse Creek and Reeder Creek	Outside Northern Zone	Active	Cow/calf pairs, yearlings, horses	7/1–9/30
Wigwam	Outside Northern Zone	Active	Cow/calf pairs	6/16–9/30

Table 80. Closed domestic livestock allotments within or near bison management zones

Allotment Name	Location	Previous Livestock Class	Year Closed
Horse Butte	Western Zone 2	Cow/calf pairs	2009
Duck Creek	Western Zone 2	Cow/calf pairs	2008
Dry Gulch	Western Zone 2	Cow/calf pairs	2008
Wapiti	Western Yearlong	Cow/calf pairs	2015
Cache-Eldridge	Western Yearlong	Cow/calf pairs	2015
University	Western Yearlong	Sheep	2008
Red Canyon	Western Yearlong	Cow/calf pairs	2015
Basin	Outside Western Zone	Cow/calf pairs	2015 – West Unit1
Sulphur Springs	Outside Western Zone	Horses	2015
Lionhead	Outside Western Zone	Sheep	2008
Two Top	Outside Western Zone	Sheep	2008
Park	Northern Zone	Cow/calf pairs	2007
Sentinel Butte	Northern Zone	Cow/calf pairs	2007
Canyon	Outside Northern Zone	Cow/calf pairs	2007

Note: East Unit added to Basin Admin Site for periodic government stock use (horse/mule).

Climate influences these migration patterns (Adams and Dood 2011). There is strong scientific evidence that climate is changing. Climate projections for the Greater Yellowstone Area predict increasing temperatures and precipitation in coming years (Halofsky et al. 2018a). Warming temperatures could mean milder winters in Yellowstone Park, with reduced pressure for bison to move to lower elevations (and onto the national forest). On the other hand, warmer winter temperatures could result in more freeze-thaw events, creating more ice, or denser crust on snowpack, making it more difficult for bison to expose forage, causing animals to move to lower elevations. Climate projections also indicate more extreme seasonal events, which could result in periodic episodes of harsh winters with deeper snow and colder temperatures (Halofsky et al. 2018b), which may also pressure bison to move out of Yellowstone Park onto the Custer Gallatin.

Forage availability for bison could be affected by changing climates; fire frequency, severity and size; and competition for forage by wild and domestic ungulates. Vegetation baseline data gathered from National Forest System lands in the Gardiner and Hebgen Basins were used to calculate forage availability for general bison habitat by management plan geographic areas as well as for logical bison management areas. Using a fairly conservative allocation for bison given the forage needs for other wild ungulates and domestic livestock, it is estimated that the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas have a combined grazing capacity to support roughly 1,991 bison year-round, or perhaps twice that many bison for only seasonal (winter or spring) use. However, based on numerous factors including the Forest Service multiple use mandate, presence of domestic livestock on public and private lands, concerns over potential bison damage to infrastructure and livestock on private lands, Interagency Bison Management Plan protocols for bison expansion, and resource limits for bison habitat improvement projects, it is unlikely that bison would become fully distributed throughout all potentially suitable habitat in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Geographic Areas during the life expectance (approximately 15 years) for the revised plan. Given the interagency coordination that has resulted in delineation (and subsequent expansion) of bison management zones, bison could become fully distributed throughout these zones on the forest within the life of the revised plan. Based on the same parameters, it is estimated that the North Zone bison management area could support up to 248 bison per year, and the West Zone could support up to 106 bison per year.

Bison presence on the national forest as a native wildlife species with free-ranging capabilities beyond the current bison management zones is potentially obtainable within the expected life of the revised plan. As such, estimates were also calculated for bison carrying capacity within the grizzly bear primary conservation area, which represents an area larger than the two current bison management zones but smaller than the entire Absaroka Beartooth and Madison, Henrys Lake, and Gallatin Geographic Areas combined. Using the same conservative forage production and allocation parameters, it is estimated that potential bison habitat within the grizzly bear primary conservation area could support approximately 1,308 bison per year. The grizzly bear primary conservation area was evaluated as a potential bison use area over the life of the plan for reasons described in the effects analysis for revised plan alternatives.

Key Stressors

Bison are large animals that compete directly with humans and domestic livestock for space and resources. As such, the primary limiting factor is social tolerance for bison on the landscape. Within the Greater Yellowstone Area, large portions of historical bison range are now occupied by agricultural, residential and recreational developments. Social and political concerns over bison expanding outside the park include human safety, property damage, competition with livestock and big game species for forage, and disease transmission between bison and cattle (White et al. 2015).

It has long been argued that Yellowstone bison pose a serious threat of disease transmission to cattle. However, there has never been a confirmed case of brucellosis transmission from bison to cattle in the wild, and to date, all known cases of brucellosis transmission from wild ungulates to domestic livestock have come from infected elk (White et al. 2015).

Climate can influence bison survival rates, as harsher winters with deeper snow, and longer freezing periods affecting forage availability and body condition, which can increase winter mortality rates. Climate may also impact reproductive rates, with lower birth rates or reduced calf survival associated with severe weather conditions the previous winter (Adams and Dood 2011).

Population density can affect bison survival rates, particularly when combined with climate effects resulting in more severe winters. Geremia et al. (2009 cited in (Adams and Dood 2011)) found that female bison survival decreased significantly in the central Yellowstone herd when the herd size exceeded 2,000 animals, an effect that was notably intensified during winters with deeper snowpack.

Environmental Consequences

Management Direction under the Current Plans

There is no existing direction in either the Gallatin or Custer Plans specific to bison or bison habitat management, but bison presence has been limited to seasonal (winter or spring) use on small spatial areas on the Gallatin, and management has occurred in a cooperative manner under the Interagency Bison Management Plan.

Effects of the Current Plans

Under the current plans, bison would continue to be treated as a native species whose presence is accepted and desirable on the Custer Gallatin. Specific actions would continue to be driven by the recommendations and priorities set forth in the Interagency Bison Management Plan. Even though the current plans have no specific direction for bison management, positive steps have been taken under these plans, particularly in the reduction of livestock allotments within the bison management areas. Some closure of livestock grazing allotments has been consistent with existing plan direction for grizzly bear habitat management as well, but some closures have been with a specific focus on reducing potential conflicts between bison and livestock. Under the current plans, bison habitat management would likely be focused within bison management zones, which would support continued persistence of the species on the Custer Gallatin, but would be less pro-active than the revised plan alternatives.

Management Direction under the Revised Plan Alternatives

The revised plan alternatives all contain a desired condition for a complete suite of native species presence on the Custer Gallatin, with enough numbers and distribution for long-term persistence (FW-DC-WL-01). All revised plan alternatives recognize the key ecological role of bison as a native species, with desired conditions for bison access to forage, security and movement corridors to facilitate distribution of the species to suitable habitats on the Custer Gallatin (FW-DC-WLBI-01). Revised alternatives all contain desired conditions for habitat that accommodates bison migration out of Yellowstone National Park in winter, and year-round bison presence on the Custer Gallatin (FW-DC-WLBI-02). Alternatives D and F go a step further than the other alternatives by including a desired condition for bison presence on the Custer Gallatin National Forest year-round with sufficient numbers and distribution to provide a self-sustaining bison population and in alternative F, in conjunction with bison herd in Yellowstone National Park (FW-DC-WLBI-04). All revised plan alternatives acknowledge the need to provide educational materials to help national forest users understand wild bison behavior and act accordingly to avoid conflicts (FW-DC-WLBI-03).

The revised plan alternatives recognize the importance of ongoing interagency efforts focused on bison management, with a goal for Forest Service engagement with State, Federal and other willing partners to expand the science of bison ecology, foster awareness of the important biological, ecological and cultural roles of bison on the landscape, reduce conflict with livestock and private property, and cooperatively develop adaptive strategies to manage bison and their habitats to facilitate natural movement or translocation of bison into suitable habitat (FW-GO-WLBI-01).

Revised plan alternatives include desired conditions for habitat connectivity that facilitates daily and seasonal movement as well as long-range dispersal of wildlife, particularly for wide-ranging species (such as bison) (FW-DC-WL-05). An associated goal for all revised alternatives includes Forest Service coordination with Tribes, other agencies, and adjacent landowners to achieve habitat connectivity across administrative boundaries (FW-GO-WL-02). All revised plan alternatives include desired conditions for adequate connecting corridors between suitable habitats to facilitate bison on the landscape with enough distribution to be resilient to stressors, adaptable to changing conditions and contributing to stable or increasing genetic diversity (FW-DC-WLBI-02). Alternatives B, C, D, and F contain objectives to undertake bison habitat improvement projects within, or for the purpose of creating or connecting, suitable habitat for bison on the Custer Gallatin. Alternative E has no such objective (draft plan FW-OBJ-WLBI-01 for alternatives B through E, final plan FW-OBJ-WLBI-01 for alternative F).

Alternatives B, C, D, and F include a guideline that vegetation treatment and management actions taken to resolve bison-livestock conflicts should favor bison within the bison management zones on the Custer Gallatin (FW-GDL-WLBI-01), whereas alternative E contains a guideline that such actions should favor livestock within the bison management zones (draft plan FW-GDL-WLBI-01 for alternative E).

All revised plan alternatives include guidelines to facilitate the progressive expansion of bison management zones over time (FW-GDL-WLBI-02).

Alternatives B, C, and E, state that, except where needed to achieve interagency bison population and distribution objectives, management actions should not limit bison expansion into unoccupied suitable habitat on the Custer Gallatin (draft plan FW-GDL-WLBI-03). Alternative F applies this guideline to the area that coincides with the Grizzly Bear Primary Conservation Area (FW-GDL-WLBI-03).

Alternative D states that management actions should not impede bison expansion into unoccupied suitable habitat (draft plan FW-GDL-WLBI-03).

Effects of the Revised Plan Alternatives

Currently, bison management on the Custer Gallatin is conducted through cooperation with Tribes, State and Federal Agencies, under the adaptive management approach of the Interagency Bison Management Plan. Under this strategy, the Yellowstone bison population has been on an upward trend, stabilizing in recent years with the use of hunting and culling operations to manage population levels. Consequently, bison numbers on the Custer Gallatin have increased as well, as bison numbers exceed the carrying capacity of winter range in Yellowstone Park. Although current plans have no specific direction for bison management, the Custer Gallatin has taken positive actions, such as closure of livestock grazing allotments, to make conditions on the Custer Gallatin more conducive to bison presence year-round over a larger area. All revised plan alternatives incorporate plan components emphasizing bison as a native wildlife species, whose presence and long-term persistence on the Custer Gallatin is desired. The revised plan alternatives address bison needs such as access to forage, security and movement corridors to facilitate distribution of the species in suitable habitats on the Custer Gallatin, and specifically state that habitat on the Custer Gallatin accommodates bison migrating out of Yellowstone Park in winter, as well as supporting year-round presence on the Custer Gallatin National Forest (FW-DC-WLBI-01, 02).

Alternatives D and F go furthest toward accommodating bison spatial and temporal expansion on the Custer Gallatin with a desired condition for bison presence year-round with enough numbers and adequate distribution to maintain a self-sustaining population on the Custer Gallatin and in alternative F, in conjunction with herds in Yellowstone National Park (FW-DC-WLBI-04). These alternatives would fully support proactive measures within and outside the bison management zones to maintain or improve existing habitat conditions such that bison can move freely between suitable habitats within the management zones, but also so that habitat conditions outside the existing zones are suitable for increases in bison numbers, distribution, and time spent on the Custer Gallatin. The desired condition in alternatives D and F for a self-sustaining population of bison on the Custer Gallatin is most consistent with the desired condition for a complete suite of native wildlife species on the national forest (FW-DC-WL-01). However, the desired condition for a self-sustaining population of bison on the Custer Gallatin may be difficult to achieve, since social bonds among bison are very strong, as are their instincts to aggregate. Bison are constantly on the move, and their movements are often initiated to maintain social bonds. Therefore, the potential for wide-range bison expansion on the Custer Gallatin could be constrained by the bison's desire to aggregate and maintain traditional use patterns (Meagher, 2017 personal communication).

The revised plan alternatives would continue the commitment to cooperate with Tribes, State and Federal Agencies, and other willing partners with a goal to expand the science of bison ecology, foster awareness of the important biological, ecological and cultural roles of bison on the landscape, and cooperatively develop adaptive strategies to manage bison and their habitats to facilitate natural movement or translocation of bison into and between suitable habitats (FW-GO-WLBI-01). Alternative F adds a provision to reduce conflict with livestock and private property to this plan component. This goal would encourage new research, monitoring and educational efforts to increase the existing knowledge base, develop strategies to address potential conflicts between bison and private property owners, and disseminate information about bison biology, ecology and habitat management to a broad base of stakeholders, as well as provide forest managers with better information regarding bison habitat management.

Under alternatives B, C, D, and F, vegetation treatment projects within bison management zones should result in favorable conditions for bison, and management actions taken to resolve bison-livestock conflicts within bison management zones should favor bison over livestock (FW-GDL-WLBI-01). Examples of beneficial vegetation treatments include timber harvest or prescribed fire that remove conifer encroachment from otherwise suitable winter range, increase forage production, or reduce tree density to facilitate bison movement between suitable foraging areas. Examples of management actions favoring bison over livestock could include closure of livestock allotments, altered livestock turn-on dates, change in class of livestock from cows and calves to bulls, steers, horses, or mules that do not have the same brucellosis concerns, or relocating livestock to other areas where there is lower risk of conflict with bison. These proactive measures would create conditions that are more conducive to bison expansion into currently unoccupied, but suitable habitats within the bison management zones.

All revised alternatives contain a plan component to strategically locate bison habitat improvement projects within or near existing bison management zone boundaries (FW-GDL-WLBI-02). This guideline would make efficient use of resources by focusing efforts to benefit the species in areas where bison have already demonstrated a natural tendency to move onto National Forest System lands, while progressively creating conditions to facilitate bison movement into areas deemed most suitable for their long-term persistence. This guideline would also help to prioritize proactive habitat management for bison in a manner that would facilitate future expansion of bison management zones. Objectives for bison habitat improvement projects (FW-OBJ-WLBI-01) could result in better habitat connectivity for bison to move between suitable habitats, improved forage conditions within suitable habitats, or both. Alternatives D and F have the highest objective for bison habitat improvement projects.

Alternative E would improve upon the existing condition by incorporating the same desired conditions for bison presence, distribution, and long-term persistence on the Custer Gallatin (FW-DC-WLBI-01, 02), but would not support a self-sustaining bison population on the Custer Gallatin. Compared to the other revised plan alternatives, alternative E gives more emphasis to livestock operations within bison management zones and beyond (draft plan FW-GDL-WLBI-01). Alternative E has no objectives to implement bison habitat improvement projects on the Custer Gallatin. Vegetation treatment projects would be designed with livestock needs in mind, which may also benefit bison but not necessarily so. Should bison presence within or outside the management zones be deemed a threat to livestock on National Forest System or private lands, the bison could be removed through hazing, hunting, capture, or culling, rather than altering the livestock operations. Alternative E would therefore support long-term bison persistence on the Custer Gallatin similar to current plans, but at a reduced spatial and temporal scale compared to the other revised plan alternatives.

In contrast to current plans, all revised plan alternatives contain plan components that specifically and affirmatively address habitat connectivity for wildlife (FW-DC-WL-05, 06, FW-GDL-WL-01), with a focus on wide-ranging species such as bison. Revised plan alternatives include a complementary guideline for bison that management actions should not create barriers that would impede bison movement into suitable habitats, unless specifically needed to achieve interagency targets for bison population size and distribution (FW-GDL-WLBI-03). The general wildlife plan components would encourage a holistic approach to managing habitat to provide connectivity for a wide range of species with diverse habitat requirements. Adding specialized components for bison would support efforts to maintain or restore habitat connectivity for bison while preserving consistency with interagency efforts.

Alternative F includes reference to the grizzly bear primary conservation area as the portion of the national forest to which certain plan components apply (FW-GDL-WLBI-03) for several reasons. It is not likely that bison distribution would expand to fully occupy all potentially suitable habitat on the Custer Gallatin during the life expectancy (approximately 15 years) of the revised plan, but it is conceivable that bison could expand beyond the current bison management zones within that timeframe. The grizzly bear primary conservation area is an established boundary based on recognizable characteristics such as topographic and hydrologic features as well as administrative boundaries. Restrictions are already in place within the grizzly bear primary conservation area for factors that could affect bison, including limits on permanent human developments and the acreage of permitted livestock grazing allotments (FW-STD-WLGB-04, 05, 06). The grizzly bear primary conservation area encapsulates existing bison tolerance zones as well as most of the Custer Gallatin lands within the estimated pre-European settlement distribution of Yellowstone bison (White et al. 2015), and much of the inferred late prehistoric/early historic higher bison density areas (Adams and Dood 2011). Finally, the grizzly bear primary conservation area contains enough potentially suitable habitat to support over a thousand bison per year, which would contribute to meeting the desired condition for a year-round, self-sustaining population of bison on the national forest in conjunction with bison herds in Yellowstone National Park (FW-DC-WLBI-04). Therefore, establishing the grizzly bear primary conservation area as the portion of the Custer Gallatin to which certain bison plan components apply would serve to improve conditions for bison, while maintaining management flexibility in portions of the national forest where bison are unlikely to occur within the expected life of the revised plan. See also discussion in section 3.10.2, Grizzly Bear Environmental Consequences, Effects of the Revised Plan Alternatives, Grizzly Bear Food Sources.

In response to future climate, all revised plan alternatives include multiple ecosystem desired condition components to maintain or restore habitat resilience (FW-DC-RMZ-01; FW-DC-VEGF-03, 04 and 09; FW-

DC-VEGNF-04; FW-DC-FIRE-01; FW-DC-CARB-01; and FW-DC-WL-06), which would help maintain or restore habitat conditions for bison. In addition, species-specific plan components (FW-DC-WLBI-01, 02 and 04; FW-GO-WLBI-01; FW-OBJ-WLBI-01; and FW-GDL-WLBI-01 through 03) promote bison expansion into currently unoccupied but suitable habitat on the Custer Gallatin, which would accommodate regular or periodic migrations of bison out of Yellowstone Park.

Consequences to Bison from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Water, Aquatic, and Riparian Management

As with most wildlife, access to water is crucial for bison. Sedges are primary forage species for bison during all seasons. Wetlands, creek banks and pond edges support dense production of sedges and other important forage species for bison (Meagher 1973). All revised plan alternatives contain a suite of forestwide plan components that provide more detail and clarity regarding the conditions and management of water quality and riparian habitats (FW-DC/GO/OBJ/STD/GDL-WTR/RMZ All), which would contribute to the ecological integrity and resilience of watersheds on the Custer Gallatin to a greater degree than the current plans. Compared to the current plans, all revised plan alternatives include more rigorous restrictions on what types of management actions may or may not occur within riparian management zones, which would benefit bison through maintenance, improvement or restoration of wetlands, riparian areas, and water sources that provide crucial resources for bison.

Effects from Terrestrial Vegetation Management

The Custer Gallatin supports a diversity of plant communities in a mosaic of woodland, shrubland and grasslands, montane to subalpine forests, open parklands, and riparian areas, all of which may provide different habitat elements for bison. Broadly speaking, bison use open meadows and parklands for foraging, woodlands and forested areas for shelter, and riparian habitats for forage, cover and access to water (Meagher 1973). All revised plan alternatives include plan components to maintain vegetation within the natural range of variation to the extent possible (FW-DC-VEGF-01-04, FW-DC-VEGNF-01, FW-DC-WL-03). To that end the revised plan alternatives contain plan components that address composition, structure, and function of vegetation communities, which provide a coarse filter strategy designed to support disturbance regimes that will maintain and reinforce ecological integrity and plant and animal diversity (FW-DC-FIRE-01, 02). These coarse filter components provide the basis to maintain or restore habitat conditions to which Yellowstone bison have adapted over time. A detailed analysis of vegetation conditions on the Custer Gallatin and anticipated effects of plan components can be found in the terrestrial vegetation section of the environmental impact statement. All revised plan alternatives contain desired conditions for grassland and shrubland habitats, with native plant communities that are self-sustaining, where non-native species are in check (not increasing) and plant communities are diverse, including a complementary suite of pollinators to sustain native plant communities (FW-DC-VEGNF-01-04). These coarse filter components would contribute to suitable foraging habitat for bison over time, and help to maintain or restore habitats on the Custer Gallatin National Forest to conditions like those in which bison evolved in the Yellowstone area.

Forested habitats provide shelter for bison from environmental conditions such as temperature extremes and biting insects (Adams and Dood 2011). Forests with more open canopies provide shelter as well as limited forage. All revised plan alternatives contain coarse filter components to maintain forested habitats within the natural range of variation (FW-DC-VEGF-02), including measurable desired conditions for tree size class (FW-DC-VEGF-03) and forest density (FW-DC-VEGF-04). Broadly speaking, to achieve desired conditions in forested habitats, management actions would strive to increase tree size class and decrease forest density class in the montane and subalpine forest types most likely to be used by bison (FW-DC-VEGF-06). This strategy would maintain or improve bison habitat in forested areas by creating more open, park-like conditions in some areas, which would provide shelter and some forage for bison, and could improve permeability for bison to move through forested habitats between suitable foraging areas.

Compared to the current plans, plan components in the revised plan alternatives include greater detail about vegetation conditions, including plant species composition, structure, and function. Such details provide better information for management of grassland, shrubland, and forest environments, which would contribute to plant diversity and ecological integrity of these habitats, and serve to maintain, restore, or improve resilience to environmental stressors over time. These factors would provide greater habitat benefits to bison than the current plans.

Effects from Timber Management

All revised plan alternatives identify areas that are suitable for timber production, which includes areas where growing, tending, harvesting, and regenerating crops of trees for commercial purposes may be emphasized. Timber harvest would generally benefit bison, as removal of standing trees could make more nutrients available for, and stimulate production of, grasses, forbs and shrubs that provide forage for bison. However, such benefits would be temporary, as trees grow back. Different methods of timber management would result in a variety of structural and functional vegetation conditions. Regeneration harvest would create openings that would provide greater volume of forage and remove impediments to bison travel through such areas. Size and shape of openings created through regeneration harvest in the revised plan alternatives would be designed to mimic openings created by natural processes (FW-STD-TIM-05). All revised plan alternatives specify that clearcutting and other methods of regeneration harvest are to be used only where deemed appropriate for multiple resource needs, including wildlife habitat (FW-STD-TIM-04). Reforestation through natural regeneration or planting of seedlings would occur, reducing suitability of these areas for bison over time (FW-STD-TIM-10). Precommercial thinning and intermediate harvest treatments in forested habitats would reduce tree density, improving bison mobility through these areas, and also allowing more sunlight to penetrate to the ground, thereby stimulating production of grasses, forbs, and shrubs in the understory, providing some forage for bison as they move through treated areas.

In concert with bison habitat guidelines (FW-GDL-WLBI-02), timber management actions could be strategically located and timed within or near bison management zones to facilitate expansion of the zones, and increased distribution of bison on the Custer Gallatin. Alternative D would treat the most acres with timber harvest, which could include projects designed to enhance habitat for bison. Alternative E would result in the most regeneration harvest, creating larger openings that would benefit bison where it occurs in proximity to Yellowstone Park.

Effects from Fire and Fuels Management

Under all revised plan alternatives, fire would play a major role in creating landscape mosaics that support vegetation diversity that benefits bison (FW-DC-FIRE-01). Fires contribute to nutrient cycling, which can increase grassland productivity and associated forage conditions for bison. Fire also plays a valuable role in reducing conifer encroachment into grasslands, aspen groves and riparian areas that support bison. All revised plan alternatives include increased objectives for wildfires and prescribed burning (FW-OBJ-FIRE-01, 02) relative to the current plans. As with timber harvest, wildland fire could be used in concert with bison management guidelines to increase habitat suitability within and near bison management zones, strategically creating conditions conducive to expansion of bison zones over time. Alternative D would likely result in the most acreage of prescribed fire use for fuel reduction purposes on the Custer Gallatin, which would benefit bison where it occurs within or near bison management zones. However, prescribed fire would have minor influence on bison habitat conditions compared to wildfires resulting from natural ignitions, which would be similar under all alternatives.

Under all revised plan alternatives, fuels management would be emphasized within the wildland urban interface and adjacent to infrastructure to protect values at risk from wildfire (FW-GDL-FIRE-02). Fuel reduction projects often result in habitat improvement for bison, by removing trees and other woody materials that can impede growth of grasses and other forage species for bison. Bison may be attracted to areas treated for fuel reduction by a flush of high-quality forage, which could result in increased incidents of bison-human conflict if bison move into residential, recreation, or other areas with higher densities of humans, where fuel reduction projects may be more common.

Fire suppression can result in over-dense forest conditions and conifer encroachment into grasslands, which can affect the availability of movement corridors as well as forage quality and quantity for bison. The revised plan alternatives support the important ecological role of fire to a greater degree than the current plans, as evidenced by higher objectives for wildfire on the landscape (FW-OBJ-FIRE-02).

Effects from Invasive Species Management

Invasive plant species can out-compete native plants for resources, which can result in community dominance by non-native plants. While bison may eat non-native plant species, and can digest lower protein, poor quality forage (Adams and Dood 2011), native plant communities provide better quality forage for bison and other grazing mammals. All alternatives include plan components designed to ensure that management actions minimize spread and prevent establishment of invasive plant species on National Forest System lands and adjacent areas, to provide for healthy, resilient plant communities (FW-DC-INV-01, FW-STD-INV-01-04, FW-GDL-INV-01). Of the revised plan alternatives, alternative D has the highest objective for noxious weed treatment, which would have the greatest potential to maintain or improve habitat for bison. The alternative E weed treatment objective is substantially lower than traditional levels of treatment which could impact native habitats. Alternatives B, C, and F contain mid-range objectives for noxious weed treatment that would help keep existing infestations in check and reduce potential weed establishment in new areas, which would help to maintain suitable habitats for bison, but with limited expected contributions to improve potential bison habitat (FW-OBJ-INV). Invasive species management direction could be used in concert with bison habitat management guidelines to focus treatment in bison management zones and adjacent areas, to create conditions conducive to expansion of bison management zones over time.

Effects from Plan Land Allocations

All revised plan alternatives contain plan land allocations for recommended wilderness areas, backcountry areas, and/or recreation emphasis areas. Plan land allocations dictate what types of management actions and recreation use may occur in certain areas. Bison may react defensively to human presence, which can cause severe injury or death to humans that approach bison. Bison injuries to humans are quite rare, but typically result from humans approaching the bison at unsafe distances. All revised plan alternatives include plan components to provide educational materials to help national forest visitors understand wild bison behavior and act accordingly to avoid conflicts (FW-GO-WL-05, FW-DC-WLBI-03). Most instances where bison have posed a threat to human safety or property have occurred at developed sites such as campgrounds. In such cases, bison may be harassed (hazed), or in rare instances, lethally removed (Interagency Bison Management Plan 2017a). Plan land allocations can dictate the types of facilities (such as developed sites) that may be in different areas.

Recommended wilderness areas prohibit new developments such as campgrounds, picnic areas, resorts, etc., where people often congregate (FW-STD-RWA-04). Fewer facilities generally result in lower densities of human use, with associated lower probability of bison-human interaction, as well as lower human disturbance factors that could affect bison use patterns. Backcountry areas are generally low development as well, with fewer facilities than other areas of the national forest, resulting in dispersed human use rather than concentrated use. Like recommended wilderness, new recreation developments would not be allowed in backcountry areas (FW-STD-BCA-03). In addition to plan land allocations for recommended wilderness and backcountry areas, plan components for grizzly bears would further restrict new road construction and permanent developments (FW-STD-WLGB-01-05) in areas where bison occur now, and where they may reasonably be expected to expand. In the Absaroka Beartooth Mountains and Madison, Henry Lakes, and Gallatin Mountains Geographic Areas where bison occur, alternatives B, C, and F have slightly different combinations of recommended wilderness and backcountry areas, whereas alternative D has only recommended wilderness areas, and alternative E has only backcountry areas. Therefore, alternative D would likely have the lowest human disturbance potential that might influence bison behavior, whereas alternative E would have the greatest. However, since recommended wilderness and backcountry areas both restrict new permanent developments, and grizzly bear plan components further restrict new human developments under all alternatives, effects of revised alternatives would be similar for potential bison-human conflicts and human disturbance factors due to plan land allocations.

Plan land allocations of recommended wilderness and backcountry areas also dictate what types of management actions are allowed. Recommended wilderness areas are not suitable for timber harvest for any purpose (FW-SUIT-RWA-01), whereas in backcountry areas timber harvest is suitable as a vegetation management tool for purposes of restoration or wildlife habitat improvement (FW-SUIT-BCA-01). Therefore, backcountry areas would allow more flexibility and variety of tools available for bison habitat improvement projects, such as forest thinning to create travel corridors for bison to move more freely between suitable habitats. Other tools, such as prescribed fire would be allowed in recommended wilderness for restoration purposes (FW-SUIT-RWA-03), but in some cases (for example in areas with high fuel loads, and/or near communities) prescribed fire would not be an appropriate tool to use unless mechanical pre-treatment could be used to reduce fuel loads prior to burning. Further, burning leaves a legacy of dead trees behind, which eventually fall, creating more obstacles for bison to maneuver through or around. Alternative D has the most recommended wilderness area, which could limit options for bison habitat improvement projects. Alternative E, with the most backcountry area, provides the most options for habitat improvement in plan land allocations, while still maintaining low levels of development throughout much of the current and potential future habitat that may be occupied by bison. Alternatives B, C, and F have similar amounts and configuration of recommended wilderness and backcountry area, each offering potential for future habitat improvement projects in backcountry areas and increasing management restrictions in recommended wilderness areas.

Recreation emphasis areas are plan land allocations located in places with higher levels of development, and expected higher densities of human use where there may be more opportunities for bison to encounter people. Under all revised plan alternatives, recreation emphasis areas are proposed along the Gallatin River, a segment of which is within the western year-round bison management zone, and along the Yellowstone River, most of which is in the northern bison management zone. These are year-round recreation emphasis areas, but most recreation use associated with these corridors involves summertime river-related recreational pursuits such as fishing, rafting, kayaking, hiking and sight-seeing. Currently, bison presence in these corridors occurs most frequently in winter and spring (Interagency Bison Management Plan 2018a;2019a). There is not much winter or spring recreation within these linear recreation emphasis areas, but the highways through them (Montana Highway 191 and 89 respectively) provide major year-round access routes for recreation and other human uses. The major issue for bison associated with these linear recreation emphasis areas are not from recreation use per se, but rather from collisions with vehicles associated with travel on the highways. See more about this topic under effects from Infrastructure, below. Under alternatives B, C, E, and F, Zone 2 of the western bison management area would also overlap with a recreation emphasis area. Most of Zone 2 overlaps with the Hebgen winter recreation emphasis area. Concentrated recreation use occurs in this area year-round, but the management emphasis in the plan land allocation would focus on winter recreation pursuits such as snowmobiling and skiing. Peak bison use in Zone 2 occurs in May (Interagency Bison Management Plan 2017a;2018a;2019a), when winter recreation use has tapered off or ended, and before summer recreation use reaches its peak, so given current use patterns, bison are most likely to be in Zone 2 when human recreation uses are at relatively low levels.

Bison distribution on the Custer Gallatin has been extremely limited in recent years, providing little data upon which to base effects analyses. However, bison-human interactions in Yellowstone Park are generally associated with developed sites, and rarely occur in backcountry areas of the park (Interagency Bison Management Plan 2017a). Therefore, it is logical to assume similar conditions on the Custer Gallatin. Alternative D with the fewest recreation emphasis areas, would seem the least likely to impact bison. However, recreation emphasis areas identified in all alternatives were based upon already established concentrated human use areas, and alternative D makes no plan land allocation that would notably change the nature of concentrated uses already occurring in in potential bison habitat. In summary, the recreation emphasis areas are similar across potential bison habitat for all revised plan alternatives, giving the revised alternatives similar potential for bison expansion into concentrated human use areas, with associated higher risk of bison-human conflict that could have negative impacts on individual bison. This analysis was based on data from Yellowstone Park, where bison attacks on humans infrequently occur. Bison are not hunted in Yellowstone Park, and hunted populations of wildlife tend to behave differently than non-hunted populations, often with enhanced wariness and increased avoidance of humans (Montana Fish Wildlife and Parks 2015b). Since the bison population on the Custer Gallatin would be hunted, it is reasonable to assume that bison human conflicts would be rare and manageable. Therefore bison-human conflicts are not expected to be a major factor in national forest management under any alternative.

Effects from Permitted Livestock Grazing Management

When bison began migrating out of Yellowstone Park into Montana, there was concern that bison would transmit brucellosis to domestic cattle grazing on Forest Service allotments and private land. There has yet to be a confirmed case where bison have transmitted brucellosis to cattle in the wild, not because such transmission is not possible, but rather because the two species have been effectively separated, generally by moving bison off the national forest before livestock are turned onto grazing allotments. All revised plan alternatives emphasize bison as a native species of wildlife whose presence and long-term persistence on the Custer Gallatin is a desired condition (FW-DC-WLBI-02). As described above under effects of the revised plan alternatives, guidelines vary by alternative as to whether management actions would favor bison or livestock in the event of a conflict between the species (draft and final plan FW-GDL-WLBI-01). Alternative F includes the guideline that bison-livestock conflicts should be resolved in favor of bison within the bison management zones.

Alternatives B, C, E, and F include a goal for livestock allotments that become vacant to be evaluated for further livestock use as needed or for allotment closure to benefit other resources or economic considerations (FW-GO-GRAZ-02). This same goal for alternative D emphasizes allotment closure for other resource needs (draft plan FW-GO-GRAZ-02 Alternative D). Leaving vacant grazing allotments within or near bison management zones available for use by livestock would maintain a degree of risk that could weigh against future decisions about expanding bison management zones. However, all revised alternatives include a provision allowing managers to evaluate vacant allotments for closure for ecological or economic reasons. Such evaluation would not mandate closure of vacant allotments, but would allow for consideration of allotment closure where doing so would enhance bison distribution within management zones, and facilitate expansion of bison management zones to include larger areas of the Custer Gallatin National Forest. Management direction for grizzly bears in all revised alternatives includes limits on the number and acreage of livestock allotments within the grizzly bear recovery zone/primary conservation area (FW-STD-WLGB-06), which may factor into evaluations for management of vacant livestock allotments, and also limits the amount of livestock grazing that can occur in an area with potential for bison expansion on the Custer Gallatin.

Domestic livestock can compete with wild ungulates for available forage. Alternatives B, C, D, and F would restrict grazing of domestic sheep and goats in geographic areas where bison are expected to occur on the Custer Gallatin (FW-STD-GRAZ-02), which would leave more forage available for bison, and prevent bison-livestock conflicts with these domestic species. All revised alternatives require that livestock allotment management plans be designed to meet big game forage needs on winter ranges (FW-GDL-GRAZ-03), which could include forage allocations for bison wintering on the national forest. Further, all revised plan alternatives contain a guideline that new or reconstructed livestock fences should be located and designed to minimize collision hazards and barriers to wildlife movement (FW-GDL-GRAZ-07). Livestock fences on the Custer Gallatin typically do not present barriers to bison movement. Bison are large, powerful, and agile creatures, fully capable of breaking through or jumping over most types of fencing used to contain livestock on Forest Service allotments. However, livestock fencing can pose a hazard to bison, and injury may occur if bison intentionally or unintentionally collide with, or become entangled in fencing material. Fences can be strategically located, and designed so that they may be dropped during times when livestock are not present on allotments, reducing the hazard to bison moving through the area. Fences can be made to be more easily detected by wildlife by placing flagging or other moving parts on the fence to catch the attention of wildlife, or can be made with smooth, rather than barbed wire for the top and bottom strands so that bison and other wildlife can pass over or under the fence with less risk of injury. These and other possible measures for creating wildlife-friendly fences are addressed in the management approaches section of the plan (appendix A).

Other than plan components for bison that require conflict resolution to favor bison over livestock (alternatives B, C, D, and F) or livestock over bison (alternative E), grazing management under the revised plan would have similar impacts to bison under all alternatives.

Effects from Infrastructure (Roads and Trails) Management

All revised plan alternatives include the desired condition that the Custer Gallatin transportation system provides for safe and efficient travel and access to the national forest, with minimal impacts on natural resources, including wildlife (FW-DC-RT-01). Bison on roadways can be a traffic hazard for humans, and collisions with vehicles can result in bison mortalities. Most National Forest System roads are narrow, gravel surface routes that support generally low speed travel (less than 35 miles per hour), with low probability of vehicle collisions with bison. However, several state and federal highways travel through or between Custer Gallatin administrative units. A forestwide goal would encourage Forest Service cooperation with highway managers, state agencies and landowners to create highway crossings for wildlife that reduce risk of collision with vehicles (FW-GO-RT-03), which could lead to implementation of technology that would reduce the risk of bison mortality from vehicle collisions.

Meagher et al. (2002) reported that, beginning in the 1980s, winter human use (including plowing and grooming) of road systems in Yellowstone Park resulted in snow compaction that in certain circumstances, created travel corridors that eventually facilitated bison movement out of the park and onto the Custer Gallatin. After studying this possible phenomenon in Yellowstone Park, Bjornlie and Garrott (2001) found that while bison did travel on road systems in winter, they were more likely to travel off roads. Further, road travel by bison was negatively correlated with grooming of road systems, in that the highest winter use of roads by bison occurred outside the road-grooming periods. These authors concluded that groomed roads in Yellowstone Park had minor influence on bison distribution, and that because the bison population had reached or exceeded the winter carrying capacity in the park, bison migration onto adjacent National Forest System lands likely would have occurred regardless of road systems. Very few Forest System Roads are groomed or plowed in winter, and most that are maintained for winter use are in areas of the Custer Gallatin not occupied by bison in winter. Therefore, effects from forest infrastructure management would have low impact on bison, and would be the same under all revised plan alternatives.

Effects from Recreation Management

Effects from recreation management were largely addressed with effects from plan land allocations and infrastructure discussed above. As noted previously, bison-human conflicts occur most frequently in developed areas with concentrated human use. In addition to restrictions associated with plan land allocations, all revised alternatives include plan components that would preclude new recreation residence developments and limit the size of existing recreation residences on the Custer Gallatin (FW-STD-RECRES-01, 02). These provisions would further reduce potential for bison-human conflicts as bison expand into suitable habitats and/or spend more time on the national forest.

Bison in Yellowstone Park have demonstrated a high tolerance level for human presence, although they can be disturbed or displaced by human activities. Winter is a critical time of energy balance for wildlife, including bison, and therefore winter recreation has the greatest potential for impacts to bison. Trail grooming and snow compaction resulting from winter recreation use could influence bison distribution on the Custer Gallatin, but likely to a low degree based on studies conducted in Yellowstone Park. Borkowski and associates (Borkowski et al. 2006) studied behavioral responses of bison to snowmobile use in Yellowstone Park, and found that bison have lower response to snowmobile use than elk. Bison more frequently responded to snowmobiles by looking up briefly and then resuming previous behavior, than actively responding by moving away, and very seldom responded defensively; for example, by charging snowmobilers. Bison were more likely to respond actively (generally, move away) if snowmobiles encountered bison on the roadway, or if snowmobilers deliberately approached bison. Bison responses to snowmobiles declined as snowmobile use increased, suggesting some level of habituation to the activity. These authors found no evidence that snowmobile use in Yellowstone Park has had negative impacts on the bison population. However, snowmobile use in Yellowstone Park is limited to designated routes, whereas many areas of the Custer Gallatin are open to dispersed snowmobile use, the effects of which have not been directly studied for bison. The other notable difference is that bison are not hunted in Yellowstone Park, but can be hunted on the Custer Gallatin National Forest. Snowmobiles could provide access for bison hunters in some areas if winter bison distribution increases on the Custer Gallatin. In that case, alternative D, with the highest proportion of recommended wilderness in areas where bison expansion could be expected, would provide bison more options to avoid hunters, and would also provide hunters more quiet opportunities to hunt bison, compared to all other alternatives.

Cumulative Effects

The framework for management of Yellowstone bison is found in the Interagency Bison Management Plan, which was developed by the National Park Service, Forest Service, Animal and Plant Health Inspection Service, Montana Fish Wildlife and Parks, and the Montana Department of Livestock. The Interagency Bison Management Plan was formally adopted by these agencies in 2000. Three Tribal entities: the Confederated Salish and Kootenai Tribes, the Intertribal Buffalo Council, and the Nez Perce Tribe, joined as Interagency Bison Management Plan voting members in 2009 (Interagency Bison Management Plan). The Interagency Bison Management Plan is an adaptive management plan, in which operating procedures are periodically updated, including annual updates since 2012 (Interagency Bison Management Plan 2017b). Under the guidance of this plan, the Yellowstone bison population has been managed at a relatively stable level, allowing for increased numbers and distribution of bison on the Custer Gallatin National Forest over time. This cooperative management strategy is expected to continue in a manner that would be consistent with plan components under all alternatives.

Conclusion

The current plans (alternative A) are silent to bison habitat management, and under these plans the Custer Gallatin could take a less proactive role in facilitating bison expansion on the Custer Gallatin. All revised plan alternatives take an affirmative stance to acknowledge the key ecological role of bison in the Yellowstone ecosystem and on the Custer Gallatin National Forest. The revised plan alternatives all contain desired conditions for continued bison presence on the Custer Gallatin, allowing bison to pioneer and establish new migration routes, resulting in expanded distribution of bison on the Custer Gallatin. Alternatives B, C, D, and F would be more proactive, by setting objectives for bison habitat improvement projects, and favoring bison management over livestock management within the bison management zones. All revised plan alternatives would limit management actions that could impede bison expansion on the Custer Gallatin, and would promote strategic habitat management within and near existing bison management zones to produce conditions that would allow for progressive expansion of bison management zones and increased bison distribution over time.

Alternative D would be the most proactive for bison, with a desired condition for a year-round, self-sustaining population on the Custer Gallatin, higher objectives for habitat improvement projects, and no exceptions for management actions specifically designed to control bison movement. Of the revised plan alternatives, E would be the least proactive for bison, with desired conditions for bison presence on the Custer Gallatin, but no set objectives for habitat improvement projects, and a guideline that would emphasize livestock operations over bison presence. Alternative F carries forward the most proactive desired condition for a year-round self-sustaining population of bison on the Custer Gallatin, as well as higher objectives for bison habitat improvement projects than alternatives B, C, and E. The primary difference between alternative F and alternative D is that alternative F would retain management flexibility to allow for strategic limits on bison movement where bison presence is contrary to agreements made in the Interagency Bison Management Plan. Alternative F then establishes a proactive management approach to facilitate bison expansion on the Custer Gallatin while continuing to support a cooperative interagency management strategy. In summary, all revised alternatives would support and improve long-term persistence of bison on the Custer Gallatin National Forest, including added potential for increased bison numbers, distribution and time spent on the national forest. Supporting more bison on the Custer Gallatin could accommodate a moderate increase in the effective population size of Yellowstone bison, thereby contributing to genetic health of the species.

Wolverine (*Gulo gulo*)

The wolverine is the largest land-dwelling member of the weasel family (U.S. Department of the Interior 2013a). With large, flat feet, a compact body and a thick, insulated coat of fur, the species is well adapted to live in cold, snowy conditions. As such, the species occurs throughout arctic and subarctic regions, as well as boreal forests in Eurasia and North America (Copeland et al. 2010). In North America, they are found primarily in tundra, taiga, and subalpine habitats, which at southern latitudes, occur as extensions into the contiguous United States, and as such, these habitats are naturally more fragmented than core habitat farther north in Canada and Alaska. As a result of this habitat patchiness, wolverine populations occur at lower densities in the continental United States, (Ruggiero et al. 2007). Wolverine habitat in the lower 48 states is typically found at higher elevations, generally above 2,100 meters (6,800 feet). It is likely that wolverines select higher elevation habitats to avoid high temperatures in summer (U.S. Department of the Interior 2013b). Additionally, high elevations provide deep snow that persists well into spring months, a condition crucial to females selecting reproductive den sites (Ruggiero et al. 2007).

Female wolverines may be capable of giving birth at two years of age, but the average age at first reproduction is likely three years. Breeding typically takes place in late summer to early fall, but implantation of fertilized eggs is delayed until winter. Kits are born in February or March, with an average litter size of one or two (U.S. Department of the Interior 2013b). Once kits are weaned in late April or May, the natal den is usually abandoned (Copeland et al. 2010). Although most female wolverines are capable of annual reproduction, high energetic demands associated with pregnancy in a harsh, unproductive environment, result in loss of pregnancy for about half the reproductive population each year. Consequently, wolverines have one of the lowest reproductive rates of any mammal (U.S. Department of the Interior 2013b). The combination of naturally fragmented habitat, low productivity in the environment, and low reproductive rates, result in very sparse population densities for wolverines on the Custer Gallatin and elsewhere across their range (Inman et al. 2013).

Wolverines use the foraging strategy of an opportunistic omnivore, feeding on a variety of food sources based on availability. Wolverines are primarily scavengers, seeking out carrion from ungulates that died of natural causes, or carcasses left behind by other predators. While they are capable of taking live prey larger than themselves, wolverines typically prey on small mammals and birds. They will also consume insects, berries, and other fruity plants if available (U.S. Department of the Interior 2013b). This adaptive foraging strategy allows wolverines to persist in an otherwise hostile, unproductive environment (Inman et al. 2013).

Home range sizes for most mammals are associated with body size, and individuals living in less productive habitats typically have larger home ranges. This association holds true for wolverines, as inhabitants of harsh, relatively unproductive environments, their home range size is large relative to their body mass. Home range sizes for wolverines in the Greater Yellowstone Ecosystem, which includes the Custer Gallatin National Forest, average about 303 square kilometers (117 square miles) for independent females (without young), and about 797 square kilometers (308 square miles) for adult males. Females with dependent young still have fairly large annual home range size at roughly 100 square kilometers (39 square miles). Minimal overlap (typically less than 2 percent) between home ranges of adult wolverines of the same sex indicates territoriality. Finding adequate resources and maintaining large territories requires long-range movements. Males travel two to three times farther than females on average, but both sexes frequently move distances equivalent to the diameter of their home range in just a couple of days, often covering a distance equal to the perimeter of their home range in less than a week. Juveniles disperse from their mother's home range, starting at about 11 months of age. Genetic profiles of different wolverines indicate that dispersals of up to 500 kilometers (310 miles) are possible (Inman et al. 2012b).

Given the natural patchiness of wolverine habitat, coupled with the species' capacity for long-range movement, it is likely that wolverines in the lower 48 states exist as a metapopulation. A metapopulation is basically a network of subpopulations occupying isolated patches of suitable habitat, separated by sometimes vast expanses of unsuitable habitat, but that occasionally interbreed through dispersing or wandering individuals (U.S. Department of the Interior 2013b). Due to the wolverine's selection of remote, harsh environments and associated low density occurrence on the landscape, population demographics are difficult to monitor. However, what is clear is that their persistence in the naturally fragmented habitat found on the Custer Gallatin and elsewhere at the southern edge of their range, is vitally dependent upon regular, or at least intermittent, dispersal of individuals between habitat islands to facilitate gene flow between sub-populations (Ruggiero et al. 2007). Significant genetic diversity has been found in between subpopulations of wolverines, indicating low migration rates and at least some degree of geographic isolation between subpopulations (Aubry et al. 2007). Male-dominated dispersal and female tendencies to remain closer to their birth areas are thought to contribute to this genetic structuring of wolverine populations (Squires et al. 2007).

Until recently, wolverines were one of the least-studied carnivores in North America, particularly in the continental United States, which has very low-density populations that are difficult to monitor. The species was petitioned for listing at the turn of the 21st century, which prompted new research on wolverine distribution, ecology, and interactions with humans (Ruggiero et al. 2007). Even with this new research, there is no reliable historical or current population census for wolverines in the continental United States, so there is uncertainty in population trend estimates; however, it is widely accepted that wolverine densities are naturally low in the lower 48 states. The U.S. Fish and Wildlife Service reviewed potential threats to wolverines in the contiguous United States and found that the species met the criteria for a threatened species due to the likelihood of habitat loss caused by climate change, resulting in population decline and possible breakdown of metapopulation dynamics. They identified the wolverine in the contiguous United States as a distinct population segment, and proposed to list this distinct population segment of the North American wolverine as threatened under the Endangered Species Act (U.S. Department of the Interior 2013b). On October 13, 2020 the U.S. Fish and Wildlife

Service withdrew the proposed rule to list the North American wolverine occurring in the contiguous United States as the threatened species (U.S. Department of the Interior 2020b). This was in part due to the determination that the best available scientific information does not indicate abundance, reproductive success, and resiliency would be significantly affected by potential threats such as climate change. In addition, the popoulation of wolverines in the contiguous United States did not meet the criteria for te Distinct Population Segement (U.S. Department of the Interior 2020b).

Analysis Area

Wolverines occur in the montane ecosystem of the Custer Gallatin National Forest. This ecosystem, which includes the Madison, Henrys Lake, and Gallatin Mountains; Absaroka Beartooth Mountains; Bridger, Bangtail, and Crazy Mountains; and Pryor Geographic Areas, constitutes the analysis area used for indirect effects to wolverines. However, wolverines that occur on the Custer Gallatin are members of subpopulations of animals in which individuals may come from, or disperse to, areas outside the Custer Gallatin National Forest boundaries. Therefore, science considered in this section, and a cumulative effects analysis area expands beyond the national forest boundary to include the entire Greater Yellowstone Area.

Notable Changes Between Draft and Final Environmental Impact Statement

No plan components for wolverines were changed between draft and final environmental impact statement. The effects analysis was updated to include adjustment of other plan components, including but not limited to, configuration of plan land allocations, in alternative F. On October 13, 2020 the U.S. Fish and Wildlife Service withdrew the proposed rule to list the North American wolverine occurring in the contiguous United States as the threatened species (U.S. Department of the Interior 2020b).

Affected Environment (Existing Conditions)

On the Custer Gallatin, wolverines that occur in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas are part of the Greater Yellowstone subpopulation. These geographic areas contain large, contiguous blocks of high elevation habitat with persistent spring snow, and low levels of human disturbance. The Greater Yellowstone Ecosystem has been identified as one area in the continental United States that is predicted to experience less snow loss due to climate change than other areas at lower elevations, (McKelvey et al. 2011). Another area for wolverines has been coined the “Central Linkage Region” by Inman et al. (2013). This region includes the Bridger, Bangtail, and Crazy Mountains Geographic Area, which could be highly important for wolverine metapopulation persistence, because its position on the landscape may provide habitat connectivity and linkage between large contiguous blocks of suitable wolverine habitat to the north and south. Collectively, the Central Linkage Region is roughly the same scale as the Greater Yellowstone Region for wolverines, but habitat is much more patchily distributed, primarily on public lands at higher elevations within the mountainous areas, which are separated by intervening valley bottoms and lowlands, much of which are held in private ownership, (Inman et al. 2012b). The Pryor Mountains Geographic Area has some, albeit very marginal quality wolverine habitat. This is the only geographic area in the montane ecosystem for which wolverine presence has not been documented, and that does not contain adequate primary habitat for wolverines. However, Inman et al. (2013) noted that the Pryor Mountains Geographic Area may serve as dispersal habitat, primarily for male wolverines.

The U. S. Fish and Wildlife Service determined that wolverines in the continental United States represent a distinct population segment, and estimated the current wolverine population at somewhere between

250 to 300 individuals (U.S. Department of the Interior 2013b). The Greater Yellowstone and Central Linkage subpopulations are believed to contain a considerable proportion of wolverines found in this distinct population segment, with an estimated 63 individuals in the Greater Yellowstone Area, and about 50 animals in the Central Linkage Region (Inman et al. 2013). No estimate is available for the number of wolverines that occupy the Custer Gallatin portion of these areas. However, estimates at the larger landscape scale equate to roughly 3.5 wolverines per 1,000 square kilometers (386 square miles) of suitable habitat (Inman et al. 2013). Based on criteria developed by Inman et al. (2013), the Custer Gallatin contains roughly 2,731 square miles of habitat suitable for residential occupation (maternal and primary habitat combined). Accordingly, if suitable habitat on the Custer Gallatin were fully occupied, one would expect approximately 25 wolverines to occur in the plan area.

Genetic structuring among wolverine subpopulations supports a theory that higher elevations and associated snow cover is important for wolverine dispersal as well, indicating that successful dispersals were linked to paths within areas of persistent snow cover (Copeland et al. 2010, McKelvey et al. 2011). With large, flat feet, a compact body, and a thick, insulated coat of fur, the wolverine is well adapted to live in cold, snowy conditions, and accordingly, it is not surprising that snow conditions influence travel (Inman et al. 2012b). Parks et al. (2012) reported that wolverines from the Greater Yellowstone Area showed limited genetic connectivity to the rest of the continental United States distinct population segment. They suggested that geographic isolation of the Greater Yellowstone subpopulation is due to conditions associated with connecting corridors, which tend to be long, linear areas located at lower elevations, frequently crossing areas of human development. Potential dispersal routes for wolverines have been identified based on models that predict persistent spring snow cover (Schwartz et al. 2009b, McKelvey et al. 2011). Based on these projections, the most prominent potential wolverine dispersal paths on the Custer Gallatin include a route between Yellowstone Park and the Absaroka-Beartooth Wilderness, with fading importance up through the Crazy Mountains to the north. Another prominent path goes from the south end of the Gallatin Range, up through the north end of the Madison Range (McKelvey et al. 2011). In addition to these areas, Inman et al. (2013) modeled wolverine habitat selection based on known locations of radio-collared wolverines, and concluded the entire Central Linkage Region, which includes the Bridger and Bangtail ranges as well as the Crazy Mountains, is important for habitat connectivity and wolverine dispersal.

Wolverines are capable of long-distance movements, including travel through human developments and otherwise altered habitat, but appear to prefer to move across suitable habitat, and minimize travel through low-elevation habitats (U.S. Department of the Interior 2013a, Halofsky et al. 2018b). Inman et al. (2013) noted that there is no evidence that wolverine dispersal is currently being restricted by human development to a degree that negatively affects metapopulation functionality. However, they also cautioned that there may be a limit to the wolverine’s willingness and capability to travel through increasing human development.

Copeland et al. (2010) used satellite imagery to build a coarse filter map of potential wolverine habitat on a global scale, by indicating where snow was consistently present through the end of the reproductive denning season (approximately through May 15). Inman et al. (2013) then produced a more fine-scale resource selection model to predict habitat suitability for wolverine survival, reproduction and dispersal. Results from these two models were a good match to known wolverine distribution for the Custer Gallatin National Forest, so parameters from these two models were used to quantify, evaluate, and display potential wolverine habitat within the plan area (figure 34). Approximately 66 percent of the National Forest System lands in geographic areas that make up the montane ecosystem of the Custer Gallatin was modeled to have persistent snow coverage as defined by Copeland et al. (2010). Research indicates that a pattern of reduced spring snowpack in wolverine habitat has been in place since at least the 1950s (Halofsky et al. 2018b, McKelvey and Buotte 2018), but there is little information as to whether, or how this pattern has affected wolverine habitat on the Custer Gallatin. Winter use does not necessarily affect the amount or persistence of spring snow, but noise and human presence during winter can affect wolverine use of habitat. Large portions of wolverine habitat are within designated areas that restrict the type of human use allowed in summer and winter. In addition, the Gallatin Travel Management Plan imposed snowmobile closures in some areas of suitable wolverine habitat.

Ninety-four percent of wolverine habitat in the contiguous United States is in federal ownership, most of which is managed by the Forest Service. Of that, a considerable portion is found in protected areas, with roughly 33 percent in designated wilderness and 16 percent in inventoried roadless areas (U.S. Department of the Interior 2013b). On the Custer Gallatin, approximately 89 percent of the montane ecosystem that provides wolverine habitat is National Forest System lands. Similar to the national statistics, much of the wolverine habitat on the Custer Gallatin is within designated areas, including approximately 43 percent in designated wilderness and another 33 percent in inventoried roadless areas.

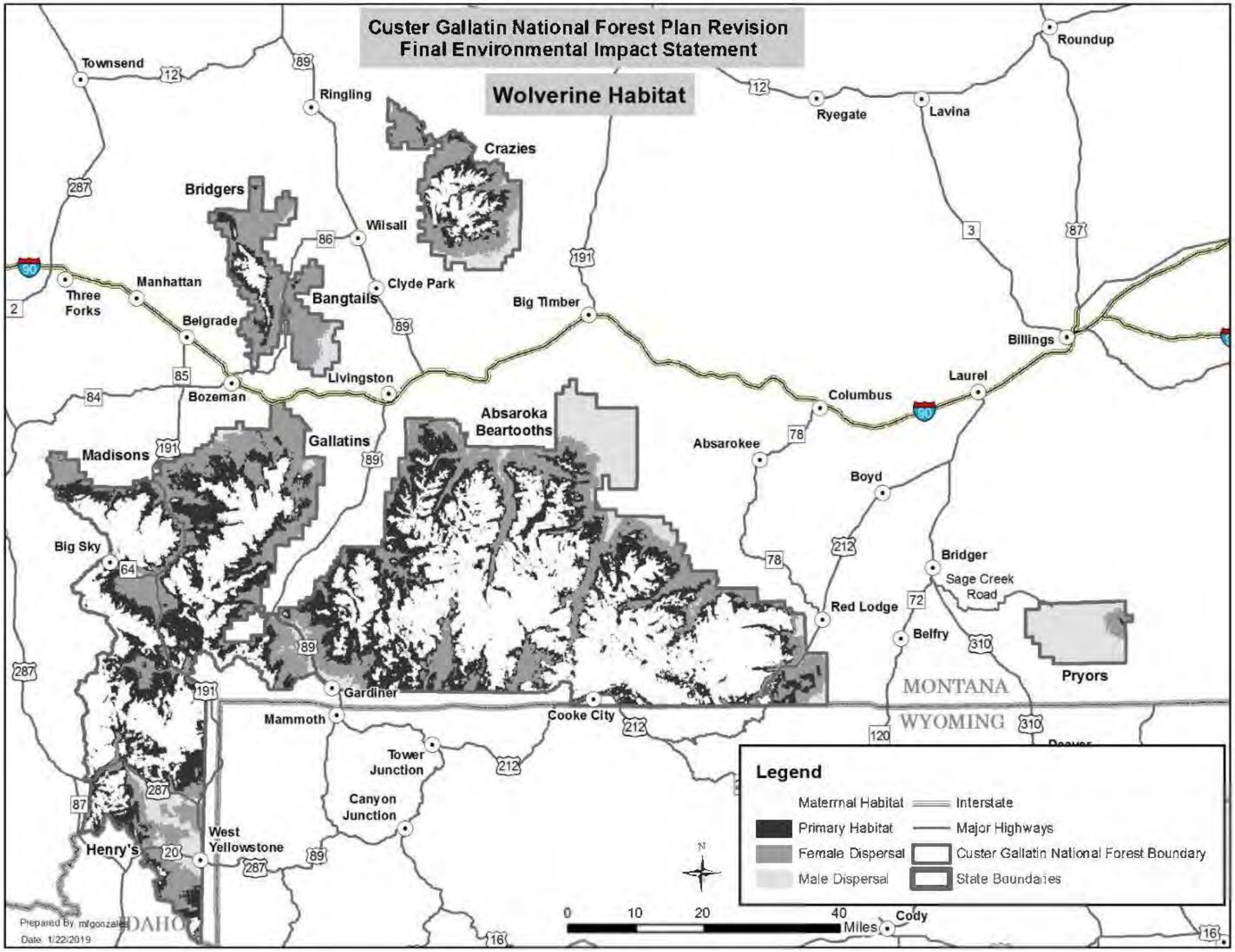

Figure 34. Custer Gallatin wolverine suitable habitat for residential occupation

Inman et al. (2013) used empirical data from wolverine studies in the vicinity of the Custer Gallatin National Forest to classify habitat into categories that are biologically meaningful to wolverines as well as pertinent to land management considerations. Generally, these categories included habitat that is suitable for wolverine reproduction, survival, and dispersal. Maternal habitat includes those areas that are suitable for use by reproductive females because they contain habitat components associated with known maternal den sites and kit-rearing rendezvous sites. Primary habitat includes maternal habitat, but expands farther, to include those areas suitable for long-term survival use by resident male and female wolverines. Primary habitat contains foraging opportunities as well as relatively secure habitat where wolverines can escape danger, shelter from weather elements, and avoid disturbance. Dispersal habitat includes both maternal and primary habitat, but also includes lower quality habitat that can be use by dispersing wolverines to move between patches of primary habitat. Since male wolverines tend to disperse farther than females, male dispersal habitat is generally inclusive of all other wolverine habitat components. Table 81 shows the proportions of various wolverine habitat components by geographic areas and wolverine subpopulations.

Table 81. Wolverine habitat proportions – National Forest Systems lands

Geographic Area (size)	Persistent Snow[1]	Maternal Habitat[2]	Primary Habitat[2]	Female Dispersal[2]	Male Dispersal[2]
Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains: Greater Yellowstone Region (2,165,156 acres)	69%	41%	73%	94%	100%
Bridger, Bangtail, and Crazy Mountains: Central Linkage Region (205,148 acres)	58%	14%	40%	90%	100%
Pryor Mountains (75,067 acres)	20%	0%	<1%	10%	100%
Total in Montane geographic areas (2,445,371 acres)	**66%**	**38%**	**68%**	**91%**	**100%**

Sources: 1. (Copeland et al. 2010, Inman et al. 2013)

Maternal and primary habitat are the most important areas for wolverines and are strongly tied to areas of persistent snow cover. These areas overlap to a considerable degree with designated wilderness and inventoried roadless areas, at least partly due to their locations in high-elevation, remote landscapes. Sixty-seven percent of maternal wolverine habitat on the Custer Gallatin is within designated wilderness, with an additional 28 percent in inventoried roadless area, for a total of 95 percent of maternal habitat in some form of protected area that is not expected to change. Primary wolverine habitat, which includes maternal habitat, is also well protected with existing designations, including 57 percent in designated wilderness, and an additional 32 percent in inventoried roadless areas, for a total of 89 percent of primary habitat.

Due to the wolverine's strong association with the amount, distribution, and persistence of snow cover, the potential for impacts to the species due to past, ongoing, and future changing climate is considerable (Copeland et al. 2010, McKelvey et al. 2011, Inman et al. 2013, U.S. Department of the Interior 2013b, McKelvey and Buotte 2018). Continuing impacts could result from loss of snowpack for reproductive den sites, warmer temperatures affecting the wolverine's capacity for thermoregulation, lack of snow and cold for preserving food caches, and loss of habitat connectivity for dispersal and subsequent impacts to genetic diversity (Copeland et al. 2010). McKelvey et al. (2011) used sophisticated modeling techniques to predict climate change impacts to wolverine habitat, resulting in expected shifts in wolverine distribution and connectivity by the end of the 21st century. This study identified the Greater Yellowstone Region, where the majority of suitable wolverine habitat on the Custer Gallatin National Forest is located, as an area likely to sustain persistent snow cover in coming decades. These authors also predicted that important corridors connecting the Greater Yellowstone wolverine subpopulation to other core areas in northwest Montana would shift to the east. If this prediction is correct, the Bridger, Bangtail, and Crazy Mountains Geographic Area on the Custer Gallatin may become even more important for wolverine habitat connectivity associated with the Central Linkage Region. There is convincing evidence that the climate is changing in ways that could affect snow accumulation, which may influence the distribution of wolverines. However, the precise nature of such impacts, including the degree of causality between climate change, habitat conditions, and wolverine response, are quite speculative (U.S. Department of the Interior 2014b).

Key Stressors

In the 20th century, wolverines were extirpated or nearly so, from the continental United States by the 1930s due to unregulated trapping and predator control (Aubry et al. 2007, U.S. Department of the Interior 2013b). As wolverines became reestablished around the mid-20th century (Aubry et al. 2007), Montana was the only state in the lower 48 to allow trapping of the species. In 2012, the legal harvest of wolverines in Montana was essentially halted, and the season has remained effectively closed with a harvest quota of zero (U.S. Department of the Interior 2013b).

In the 21st century, the U.S. Fish and Wildlife Service identified climate change as the primary threat to the distinct population segment of wolverines in the continental United States (U.S. Department of the Interior 2013b). Yet the U.S. Fish and Wildlife Service found that although reductions in spring snow cover have already been recorded in portions of the wolverine’s range, the best available scientific information shows no notable shrinkage of wolverine habitat thus far (U.S. Department of the Interior 2014b).

Other potential stressors identified for this analysis include resource extraction activities such as timber harvest and mining, roads and associated human access, and rural sprawl, all of which may have potential to impact wolverines and their habitat (Ruggiero et al. 2007, Inman et al. 2012b).

Given the strong association between wolverine habitat and snow cover, winter recreation uses such as skiing and snowmobiling may also be key stressors for this species.

Environmental Consequences

Management Direction under the Current Plans

Neither the Custer nor Gallatin current plans provide direction specifically addressing wolverines or their habitat. However, both plans contain general direction for maintaining wildlife habitat in coordination with other management actions. Under the current plans, management direction for lynx provides guidance that can restrict winter use that results in snow compaction. The wolverine is on the regional forester’s list of sensitive species and both plans contain generic language that habitat will be maintained in a suitable condition to support regionally designated sensitive species. Direction for management of sensitive species is contained in the Forest Service Manual and was therefore not repeated in the land management plans. The Gallatin Plan cites potential need for developed ski area expansion and states that existing ski areas will be given priority before any new proposals for downhill ski areas are considered. The Custer Plan indicates the need for possible expansion of the Red Lodge Mountain Ski Area, and refers to the approved master plan for direction specific to ski area management.

Effects of the Current Plans

Under the current plans, forest management would continue with no specific plan direction for wolverines, but new management actions would continue to address potential impacts to wolverine as a regional forester’s sensitive species, per direction to coordinate management actions with wildlife habitat needs. Vegetation management would continue at similar levels, with very minor impacts to wolverine habitats that generally occur at higher elevations where vegetation management is seldom targeted. Dispersed winter recreation would continue at similar or increasing levels, as the human population grows and associated visitor use increases. Use at existing permitted ski areas (including two alpine and two Nordic areas) could be expanded to cover larger areas. While such expansion could affect individual wolverines in those areas, expanding use near existing areas would have less impact on wolverines than adding new ski areas, thus concentrating use in areas that currently get relatively low levels of dispersed use. Under the current plans, there would be few restrictions on new winter use, except for those applied through Travel Management and direction for managing lynx habitat. The Northern Rockies Lynx Management Direction discourages expansion of snow-compacting activities, which would help maintain snow conditions important to wolverines as these two species are both dependent on persistent snow. The Gallatin National Forest Travel Management Plan includes areas of snowmobile closures in wolverine maternal and primary habitat that would continue to limit disturbance and snow compaction impacts in some areas. Most of the maternal and primary wolverine habitat on the Custer portion of the national forest is within designated wilderness, with few management actions and limited access for recreation use to minimize impacts on wolverines.

Management Direction under the Revised Plan Alternatives

All revised plan alternatives include desired conditions for native species presence, abundance, and distribution sufficient to provide for long-term persistence and adaptability to changing conditions; for habitat conditions within the natural range of variation to provide habitat for a variety of life-cycle needs; security and refuge for wildlife to escape from stresses and threats; landscape patterns that provide for habitat connectivity and support species movement within and across administrative boundaries; and natural foraging patterns (FW-DC-WL-01, 03, 04, 05, 08); and for habitats characterized by persistent snow cover and cooler temperatures to provide high-quality reproductive, denning, and foraging habitat for wolverines (FW-DC-WLWV-01). Standards and guidelines established under all revised plan alternatives to help meet these desired conditions include a mandate to apply a special order for proper storage of human food and attractants (FW-STD-WL-01), restrictions on management actions that could create barriers to movement for wide-ranging species (FW-GDL-WL-02), and no increase in winter special uses or designated winter routes in maternal wolverine habitat (FW-GDL-WLWV-01). As with current plans, all revised plan alternatives adopt plan components from the Northern Rockies Lynx Management Direction that discourage expansion of snow-compacting activities, and concentrate uses in existing developed areas (NRLMD Objective HU O1, HU O3, Guideline HU G4, HU G10, HU G11).

Alternatives B, C, D, and F introduce a new plan land allocation for key linkage areas for wildlife, with associated plan components to minimize permanent developments and limit human disturbance to facilitate movement of wildlife (FW-DC-WL-07, FW-GDL-WL-02-05).

Effects of the Revised Plan Alternatives

Coarse filter plan components for wildlife in the revised plan alternatives take a more holistic approach to managing for multiple species, by emphasizing habitat conditions within a natural range of variation to which native wildlife have evolved (FW-DC-WL-03, 08), and providing for habitat connectivity (FW-DC-WL-05, 06), while providing security and refuge (FW-DC-WL-04) by limiting human obstacles and disturbance (FW-GDL-WL-01, FW-STD-WL-01) and supporting landscapes that are resilient to natural and human-caused environmental disturbances and change (FW-DC-WL-01).

Wolverines are habitat generalists, other than a strong association with higher elevations, cooler temperatures, and persistent snowpack, including conditions at reproductive den sites. Wintertime human disturbance at or near wolverine reproductive den sites has been documented to result in den abandonment. Such incidents appear to be rare, and there are also reported incidents of human disturbance at den sites that were not abandoned (U.S. Department of the Interior 2013b). Plan components in the revised plan alternatives would reduce potential for human disturbance in maternal habitat by restricting new winter special uses and designated over-snow routes (FW-GDL-WLWV-01). Since wolverines and lynx are both well adapted for life in snowy environments, plan components adopted from the Northern Rockies Lynx Management Direction would also benefit wolverines by discouraging expansion of snow-compacting activities (NRLMD Objective HU O1, Guideline HU G11).

Wolverines on the Custer Gallatin are likely part of a metapopulation, or a network of subpopulations occupying isolated blocks of suitable habitat (U.S. Department of the Interior 2013b). As such, dispersal of individuals between subpopulations to facilitate genetic diversity may be needed to maintain the metapopulation structure (Ruggiero et al. 2007). The key linkage area concept could help facilitate wolverine dispersal between subpopulations on the Custer Gallatin. For example, wolverine dispersal through these areas could allow for genetic exchange between wolverines in the Greater Yellowstone and Central Linkage subpopulations. Key linkage areas established in alternatives B, C, D, and F include the north end of the Gallatin Range in the Madison Henrys Lake Gallatin Geographic Area and the west side of the Bridger Range in the Bridger, Bangtail, and Crazy Mountains Geographic Area. These areas of the national forest contain primary and dispersal habitat for wolverines (Inman et al. 2013), but are separated by agricultural, residential, commercial, and transportation developments, including Interstate 90, which all pose potential obstacles to wolverine movement. The key linkage areas encapsulate those portions of the Custer Gallatin that are nearest Interstate 90, and provide relatively narrow bands of mountainous habitat that create a natural ecological flow pattern funneling wildlife movement to a point where crossing the highway and associated development may be attempted by dispersing individuals.

Plan components for key linkage areas in alternatives B, C, D, and F would minimize habitat loss due to construction of permanent facilities (FW-GDL-03, 04), as well as limit habitat alteration and disturbance effects due to larger-scale management actions and recreational use (FW-DC-WL-07; FW-STD-WL-02; FW-GDL-02, 05; FW-SUIT-WL-01). The Bridger Range is part of the Central Linkage Region identified by Inman et al. (2013) as of high importance for habitat connectivity and gene flow between the larger contiguous blocks of high-quality wolverine habitat. The Bridger Range is identified as important connecting habitat for a wide range of wildlife, because of its proximity to larger contiguous blocks of relatively undisturbed habitat. The upper elevations within the key linkage area maintain persistent spring snow. Year-round limits on management effects within the key linkage area under alternatives B, C, D, and F would provide more protection for potential wolverine dispersal routes than would occur under either alternative A (current plans) or alternative E. Based on amounts and distribution of persistent snow cover, potential wolverine dispersal routes have also been identified through the Crazy

Mountains and the Madison Range (Schwartz et al. 2009b, McKelvey et al. 2011). These areas are not specifically identified as key linkage areas in any alternative, but habitat connectivity would be provided in revised plan alternatives through a variety of plan land allocations, which are described below under effects of land use allocations.

Consequences to Wolverine from Plan Components Associated with Other Resource Programs or Management Activities

Effects from Vegetation Management

All revised plan alternatives include forestwide desired conditions that the amount and distribution of forest cover types and alpine habitats supports the natural diversity of seral stages, habitats, and species composition across the landscape, allowing for appropriate recruitment and responses following disturbances (FW-DC-VEGF-01, 02, 03, 04, 07; FW-DC-VEGNF-01, 04). Managing toward these conditions would support natural diversity and distribution of native plant species, generally within the natural range of variation to which wolverines have adapted over time. Plan direction for vegetation management under the revised plan alternatives would contribute to the restoration and maintenance of ecological integrity, including a level of plant and animal diversity that would provide abundant foraging opportunities for wolverines. Coarse filter vegetation plan components would contribute to the resilience and adaptive capacity of forest and alpine habitats to respond to a range of disturbance processes, which would conserve wolverine habitat and support long-term persistence of the species on the Custer Gallatin.

In winter, both female and male wolverines select habitat with fir-associated conifer forest as well as forest and non-forest edges (Heinemeyer et al. 2019a). On the Custer Gallatin, these conditions are represented by spruce and subalpine fir cover types, often mixed with lodgepole pine and Douglas-fir at mid- to lower elevations. Predicted changes in climate indicate that some of these subalpine tree species, notably subalpine fir and lodgepole pine, could see shifts in suitable habitat to higher elevations over time (Hansen et al. 2018). However, these species are currently within the natural range of variation, and coarse filter plan components for forested vegetation would strive to maintain conditions within that desired range under all alternatives over the life of the plan. While high-elevation forest conditions would be maintained to a large degree under all alternatives, the revised plan alternatives provide substantially more detail pertaining to tree species composition forest structure, with more emphasis on key ecological characteristics of forests than direction contained in current plans (see the terrestrial vegetation section of this document for more detail).

Effects from At-Risk Plants Management

Whitebark pine is proposed for listing under the Endangered Species Act, and as such, is identified as an at-risk plant in all revised plan alternatives. This tree species grows at high elevations, and thrives in cold, harsh environments where wolverines are known to occur. All revised plan alternatives contain components specifically designed to protect, restore, and ultimately increase the presence of whitebark pine (FW-DC-PRISK-02, FW-GO-PRISK-01, and FW-GDL-PRISK-02), including objectives for periodic treatment for sustaining or restoring whitebark pine (FW-OBJ-PRISK-02). Although wolverines do not depend on whitebark pine for food or other functions, healthy whitebark pine ecosystems that are resilient to stressors would continue to provide suitable habitats for wolverines. Management plan objectives for projects that maintain or restore whitebark pine communities could benefit wolverines in the long term by promoting ecological resilience in high-elevation communities. However, vegetation management projects implemented to achieve objectives to maintain or restore whitebark pine, could have temporary disturbance impacts on wolverines due to noise and human presence associated with project activities.

Effects from Fire and Fuels Management

The revised plan alternatives contain desired conditions for the amount and severity of wildland fires to be within the natural range of variation to maintain resilient ecological conditions, with corresponding vegetation conditions that support natural fire regimes (FW-DC-FIRE-01). Guidelines for using minimum-impact fire suppression tactics are included in all alternatives to avoid resource damage, including negative impacts to habitat for at-risk species (FW-GDL-FIRE-02, 03). Predicted climate trends call for warmer temperatures and less precipitation than historical conditions, likely resulting in larger fires over longer burning seasons (see fire and fuels section of this document for more details).

The revised plan alternatives incorporate complementary desired conditions for fire, fuels, and vegetation management with an emphasis on forest conditions that are more resilient to predicted increases in disturbance patterns. Coordinated management of fire, fuels, and vegetation to mitigate negative effects of changing climate could benefit wolverine habitat by managing to strategically maintain vegetation conditions for maximum snow retention. An exception for desired fire and fuels conditions within natural fire regime patterns is identified for the wildland-urban interface and areas adjacent to infrastructure (FW-DC-FIRE-02). These areas would be managed to maintain vegetation conditions to support only low-intensity fires. The revised plan alternatives include objectives for hazardous fuel mitigation in wildland-urban interface areas as well as for ecological restoration and maintenance in other areas (FW-OBJ-FIRE-01; FW-DC-FIRE-02; FW-GDL-FIRE-03). Given the ecological niche occupied by wolverines at high elevations, in cold, rugged terrain with high levels of snow accumulation and persistence (Inman et al. 2012b, U.S. Department of the Interior 2013b), there is little overlap between wolverine primary range and wildland-urban interface, so fire and fuels management focused in these areas would have little effect on wolverines. On the other hand, management actions that reduce or remove vegetation cover, including fuel reduction and prescribed fire, can impact soil temperature, snow interception, and retention of snowpack (Luce 2018). Again, due to the wolverine’s preference for remote, high-elevation habitats, such management actions would be rare in habitats occupied by residential wolverines, and would likely occur at a very small-scale relative to a wolverine’s home range.

Effects from Carbon Storage and Sequestration Management

Wolverines are strongly associated with high-elevation habitats that maintain cool or cold temperatures and where snowpack persists well into spring months. Consequently, the U.S. Fish and Wildlife Service identified climate change as the primary threat to the distinct population segment of wolverines in the continental United States (U.S. Department of the Interior 2013b). National Forest System lands provide vegetation conditions that help mitigate greenhouse gas influence on climate change. Under all alternatives, land management actions that affect vegetation composition and function would occur at a very small-scale relative to the land base that supports natural ecosystem processes (see Carbon Storage and Sequestration section of this document for more detailed discussion of this topic). Therefore, land management actions are very unlikely to have a notable impact on climate change. However, all revised plan alternatives contain a desired condition for carbon storage and sequestration sustained by biologically diverse and resilient vegetation conditions that are adapted to natural disturbance processes and changing climates (FW-DC-CARB-01), as well as a goal to collaboratively engage with universities, research stations, and other entities to improve upon existing knowledge and develop management approaches to address the effects of climate change (FW-GO-CARB-01).

The Forest Service recognizes the vital role that our nation's forests play in carbon sequestration and associated impacts on climate regulation. Therefore, the revised plan alternatives also contain plan components that explicitly provide for ecosystem resiliency, and acknowledge carbon storage as an important function of National Forest System lands (FW-DC-SUS-03). All revised plan alternatives emphasize resilience in desired conditions for multiple resources (FW-DC: WTR-01; RMZ-01; VEGF-02, 03, 04, 09; VEGNF-04; FIRE-01; CARB-01; WL-06; RECSUP-04; RNA-02), and include standards and guidelines (FW-STD-GRAZ-01; FW-STD-TIM-08; FW-GDL-VEGF-01, 05) as proactive measures to improve ecosystem resilience relative to predicted changing climates. Collectively, these components in the revised plan alternatives would ensure that potential impacts of climate change are considerations for projects that could affect wolverine habitat, which would promote more proactive mitigation for possible impacts to wolverine habitat compared to the current plans.

Effects from Grazing Management

There is limited information relative to wolverine conflicts with domestic livestock in North America, with little evidence of economic losses to livestock producers from this species. However, wolverines are capable of taking prey much larger than themselves, and it is possible that young livestock could be vulnerable to wolverine depredation. The vast majority of livestock grazing on the Custer Gallatin occurs on the Ashland and Sioux Geographic Areas, in the pine savanna ecosystem where wolverines do not occur. Livestock on National Forest System lands in the montane ecosystem are typically cattle or horses, and there is limited overlap between livestock allotments and maternal or primary wolverine habitat on the national forest. Historical sheep allotments on the Custer Gallatin National Forest had considerable overlap with wolverine habitat, and were located at generally higher elevations than cattle allotments. There is little information on wolverine interactions with domestic sheep in the United States, but wolverines have been known to prey on domestic sheep in Norway (Landa et al. 1999). Under all revised plan alternatives, domestic sheep would not be established on grazing allotments inside the grizzly bear recovery zone, which overlaps a considerable amount of wolverine maternal and primary habitat in the Greater Yellowstone Area. Alternatives B and C would prohibit grazing allotments for domestic sheep production in the entire Absaroka Beartooth and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, more than doubling the amount of wolverine habitat where domestic sheep would not be allowed under alternatives A and E. Alternatives D and F would extend the prohibition on grazing allotments for domestic sheep production to include the Bridger, Bangtail, Crazy and Pryor Mountains Geographic Areas as well (FW-STD-GRAZ-02), thereby precluding the presence of unattended domestic sheep in all areas of the Custer Gallatin with wolverine habitat, which would minimize potential for conflicts between wolverines and domestic livestock.

Effects from Timber Management

Forest management actions that reduce or remove vegetation cover, such as timber harvest and associated road construction, can impact soil temperature, snow interception, and retention of snowpack (Luce 2018). Noise from equipment and human presence associated with timber harvest can also have disturbance effects on wolverines, possibly resulting in displacement from suitable habitat, or behavioral modifications that could affect a wolverine's energy reserves. However, timber harvest would occur at a very small-scale relative to suitable wolverine habitat on the Custer Gallatin, and even relative to the home range size of an individual wolverine. Also, the majority of wolverine use, including reproductive denning, occurs at elevations over 8,000 feet (Inman et al. 2012b) where vegetation removal for timber production is less likely to occur. Finally, a large proportion of maternal and primary wolverine habitat is in designated wilderness areas where timber harvest is not allowed, or in inventoried roadless areas, where timber harvest would be allowed under limited circumstances, including no road building.

Under all alternatives, timber harvest for timber production would be allowed only on those lands classified as suitable for timber production (FW-STD-TIM-01). The proportion of the montane ecosystem classified as suitable for timber production differs by alternative, ranging from 12 percent in alternatives C and D, to 13 percent in alternatives B and F, and 14 percent in alternative E, all of which are lower than the 17 percent classified as suitable in current plans (alternative A). The suitable timber base is generally located at lower elevations, where highly productive soils produce more and larger trees than the higher elevations typically occupied by wolverines. Therefore, timber harvest under all alternatives is unlikely to have a notable impact on vegetation that contributes to persistent spring snow cover in maternal or primary wolverine habitat, and is unlikely to occur in areas where disturbance-associated factors would have a notable impact on wolverines. Timber harvest could affect dispersal habitat for wolverines through habitat alterations and possible disturbance effects.

Effects from Minerals Management

The majority of mining activities on the Custer Gallatin have occurred in the Stillwater Complex along the northern margins of the Beartooth Plateau in the northeastern portion of the Absaroka Beartooth Mountains Geographic Area. As such, the Stillwater Complex is identified as a separate plan land allocation for specific management direction in alternatives B, C, E, and F due to the area's importance for mineral deposits. The Stillwater Complex allocation covers nearly 102,000 acres in these alternatives, including both primary and maternal wolverine habitat, as well as dispersal habitat. While about half of the Stillwater Complex area provides primary wolverine habitat, this plan land allocation would affect only about 2 percent of the maternal habitat and 3 percent of the primary wolverine habitat forestwide. The Stillwater Complex is adjacent to the Absaroka-Beartooth Wilderness to the south, which provides abundant primary and maternal habitat for wolverines. Substantial development associated with the Stillwater Complex, including both existing infrastructure and potential future development, could affect wolverine movement through dispersal habitat. However, alternate movement corridors would be available to the northwest, south, and southeast of the Stillwater Complex. Alternative D has no minerals allocation for the Stillwater area, and instead contains recommended wilderness allocations over roughly half of the area allocated for minerals management in other alternatives. While this allocation would not preclude new minerals activities, it would provide greater flexibility for imposing mitigation measures to minimize permanent developments and reduce potential snow compaction compared to other alternatives. Under all alternatives, plan components for wolverines and lynx (FW-GDL-WLWV-01; NRLMD Guidelines HU G5, G12) would support mitigation measures to minimize snow compaction, such as location of facilities and timing of use, which could be imposed on any future proposals for minerals or energy development within the Stillwater Complex area.

Effects from Plan Land Allocations

Under all alternatives, the majority of maternal and primary wolverine habitat is in designated wilderness, which would not change under any plan alternative. There is also considerable overlap between wolverine habitat (maternal and primary) and designated areas such as wilderness study area or inventoried roadless areas. Plan land allocations, such as recommended wilderness areas and backcountry areas, do not overlap with designated wilderness but often do overlap with wilderness study area or inventoried roadless areas in all alternatives. In such cases, plan land allocations often add restrictions that would not otherwise be applied in wilderness study or inventoried roadless areas. For example, no new energy or utility structures, commercial communication sites, developed recreation sites, or extraction of saleable minerals would be allowed in recommended wilderness or backcountry areas (FW-STD-RWA-02-06; FW-STD-BCA-01-04).

Addition of plan land allocations for recommended wilderness and backcountry areas would ensure that natural succession and disturbance processes continue as the primary change agents for wolverine habitat conditions over time. Of the plan land allocations, recommended wilderness areas have the highest level of restriction on management actions. Restrictions on use of both mechanized and motorized equipment in recommended wilderness would result in lower levels of disturbance due to noise and human presence. Alternative D has by far the highest amount of recommended wilderness area that overlaps primary and maternal wolverine habitat, followed by alternatives C, B, F, and A. Alternative E has no recommended wilderness in primary or maternal wolverine habitat. The major implication for wolverines would be that motorized over-snow recreation would no longer be a suitable use in primary or maternal wolverine habitat in recommended wilderness areas, except on about 4,500 acres where such use is currently suitable in alternative B. Alternative D would result in the greatest reduction of motorized over-snow use in maternal and residential wolverine habitat, followed by alternatives C and F, as compared to the existing condition. Motorized over-snow opportunity in alternatives B and E remain the same as alternative A.

Backcountry areas would be maintained as generally undeveloped or lightly developed, meaning they would typically have no roads, or few primitive roads. They may contain no trails, non-motorized use trails only, or a combination of motorized and non-motorized use trails, depending on the particular backcountry area. As with recommended wilderness, backcountry areas often spatially overlap with inventoried roadless areas, limiting certain types of use. With an emphasis on low development, the backcountry areas would have less noise and human disturbance than non-designated areas. However, land uses are less restricted in backcountry areas than in recommended wilderness areas. Existing motorized or mechanized transport would continue to be suitable in backcountry areas that overlap wolverine maternal and primary habitat, but it varies by alternative. In alternative F, mountain biking would be suitable only on approved system routes in backcountry areas. Backcountry areas are generally small relative to wolverine habitat in all alternatives, except for alternative E, which would allocate the entire Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (over 140,000 acres) as a backcountry area, whereas the Hyalite-Porcupine-Buffalo Horn would be entirely allocated recommended wilderness area in alternative D, and combinations of recommended wilderness area, backcountry area and other allocations in alternatives B, C, and F. Motorized over-snow opportunity would increase in the Buffalo Horn backcountry area in alterative E. In other backcountry areas, and in the Buffalo Horn backcountry area in other alternatives, motorized over-snow opportunity would not change from existing conditions within the montane geographic areas where wolverines occur.

The metapopulation structure of wolverines is dependent on dispersal of individuals to facilitate gene flow between subpopulations (Ruggiero et al. 2007). Wolverines are capable of long-distance movements, including travel through lower-elevation habitats and human developments, but appear to prefer areas with persistent spring snow as dispersal routes (McKelvey et al. 2011, U.S. Department of Agriculture 2012b, U.S. Department of the Interior 2013a). All revised plan alternatives include combinations of congressionally designated wilderness, wilderness study area, and inventoried roadless area, plus plan land allocations of recommended wilderness, backcountry areas or key linkage areas, that would limit permanent habitat modifications and high levels of human disturbance in a large proportion of the national forest that contains habitat for wolverines. All revised plan alternatives would maintain reasonably well-connected habitats within the forest boundary to facilitate wolverine movement within and across administrative boundaries, which would support wolverine dispersal to promote genetic exchange between subpopulations and conserve the species.

Effects from Recreation Management

Recreation emphasis areas are another form of plan land allocation that varies by revised plan alternative with potential to impact wolverines and their habitat. Recreation emphasis areas currently have, and are expected to continue to receive, relatively high levels of motorized and non-motorized recreation use, and may have a high density of recreation-related infrastructure relative to other parts of the Custer Gallatin. Recreation emphasis areas are generally small relative to the scale at which wolverines use the landscape. Only a small portion of wolverine maternal and primary habitat falls within recreation emphasis areas in all revised plan alternatives. The revised plan alternatives identified three winter recreation emphasis areas. The Cooke City winter recreation emphasis area in alternatives B, C, E, and F, is roughly 24,000 acres, and includes both maternal and primary wolverine habitat. This area currently receives high levels of both motorized and non-motorized winter use, and wolverines have likely become accustomed to high human use in this area. Although winter recreation in this area likely limits potential use by wolverines, the area is almost completely surrounded by the Absaroka-Beartooth Wilderness, giving wolverines abundant space to avoid high levels of winter recreation. The Hebgen winter recreation emphasis area in alternatives B, C, E, and F is roughly 72,000 acres, with a small amount of primary habitat, and very little maternal habitat. Most of the Hebgen recreation emphasis area is suitable for female and male wolverine dispersal.

Alternative E contains a winter recreation emphasis area of roughly 5,300 acres centered on the Bridger Bowl downhill ski area, which has been operating for decades. The Bridger winter recreation emphasis area in alternative E contains little maternal habitat and some primary habitat, but is mostly dispersal habitat for wolverines. In alternative F, the Bridger recreation emphasis area was expanded to the north to include the Fairy Lake area, which is also a very popular, primarily summer recreation area, but also receives considerable use by snowmobiles and backcountry skiers in winter. The Bridger recreation emphasis area in alternative F is nearly 13,000 acres, and includes some primary and maternal wolverine habitat, as well as dispersal habitat. Existing allowed uses would not change due to plan land allocation in this area, and the higher elevations containing most of the maternal habitat would remain closed to snowmobile use, but open to backcountry skiing in all alternatives. No winter recreation emphasis areas in maternal habitat or primary habitat are identified in alternative D. While alternative D would not emphasize recreation management in the Hebgen, Cooke City, or Bridger areas, it neither assigns more restrictive allocations nor provides plan components that would change the types of use already occurring in these areas.

Winter recreation likely has little effect on snow persistence at high elevations, but could have minor impacts in wolverine dispersal habitat, particularly in areas where roads are plowed to facilitate access for winter use. Very few Forest Service roads are plowed in winter. Winter use that results in snow compaction, such as snowmobiling, skiing, and grooming routes for these activities, may actually increase the length of time snow is present in compacted areas versus areas where snow is not compacted. However, under all alternatives, snow compacting activities would be limited by lynx management direction (NRLMD Guideline HU G11), and the scale at which snow-compacting activities is expected to occur is small relative to a wolverine's home range size.

Although winter use is not expected to have notable effects on snow persistence at high elevations, winter use, particularly backcountry use that overlaps with wolverine maternal or primary habitat, can have disturbance effects that may cause individual wolverines to alter normal behavior patterns, which can result in increased energy demand during a time when maintaining energy reserves is critical for wolverines. Heinemeyer et al. (2019b) studied effects of winter recreation on wolverines in the Greater Yellowstone Area, including parts of the Custer Gallatin National Forest. They found that wolverines responded to backcountry winter use in different ways, but given the extent of overlap between winter recreation and wolverine distribution, suggested that wolverines tolerate winter recreation to some degree. In this study, wolverines reacted negatively to higher levels of recreation use in winter, with stronger responses to dispersed use than to use on designated routes, indicating that wolverines may have a higher tolerance for more predictable patterns of winter recreation use. Female wolverines showed the strongest avoidance of off-route winter motorized recreation, but all wolverines reacted to both motorized and non-motorized winter recreation (Heinemeyer et al. 2019b). Since motorized equipment allows humans to travel farther and faster than non-motorized means of transport, motorized winter recreation could affect larger proportions of individual wolverine home ranges as well as overall wolverine habitat.

Many of the predicted effects of climate change on snow amount, distribution, and persistence, along with associated impacts on wolverines are uncertain (U.S. Department of the Interior 2013b). However, there is strong evidence that snowpack is already declining in many parts of the wolverine's range. At this time, the human population is growing rapidly in areas near the montane ecosystem that supports wolverines on the Custer Gallatin, with associated increased demand for winter recreation opportunity. The predicted decline in snowpack over the western United States (McKelvey et al. 2011) combined with ongoing human population growth could result in increased overlap between winter recreation use and wolverine distribution, as both humans and wolverines respond to continued decline in snow cover (Heinemeyer et al. 2019a). So, while parts of the Custer Gallatin are predicted to retain persistent snow better than other parts of the country, these areas could see increased use by winter recreation enthusiasts, which could have increased disturbance impacts on wolverines. Plan direction under all revised plan alternatives would limit new winter activities operating under special use permit or on designated winter routes in maternal wolverine habitat (FW-GDL-WLWV-01).

Developed ski areas on National Forest System lands are areas of concentrated winter recreation use that are likely avoided by wolverines since wolverines tend to respond more negatively as intensity of winter recreation increases (Heinemeyer et al. 2019a). The four existing ski areas under special use permit on the Custer Gallatin National Forest could potentially be expanded under all alternatives, which would further reduce suitable winter habitat for a small number of wolverines with home ranges that overlap the ski areas. However, under all revised plan alternatives, expansion of existing permitted ski areas would be favored over development of new areas (FW-STD-RECSKI-01, FW-GDL-RECSKI-01, NRLMD Guideline HU G1, G2). Concentrating use in areas already avoided by wolverines would have less impact than authorizing new development in areas that are relatively secure.

Winter access to National Forest System lands facilitates fur trapping. Montana's fur trapping season for wolverines has been effectively closed since 2012. However, as a dietary generalist with a winter foraging strategy focused on scavenging animal carcasses, wolverines may be attracted, and vulnerable to capture in traps set for other furbearers. Since the trapping season for wolverines was closed in 2012, there has been only one record of an incidental (unintended) trapping of a wolverine on the Custer Gallatin that resulted in a wolverine mortality (Inman, 2018 personal communication). Therefore, fur trapping in general would present a negligible indirect effect to wolverine populations in the plan area.

Effects from Infrastructure, Roads, Trails, and Airfield Management

Wolverine distribution is associated with remote locations, which has at times been correlated with avoidance of humans and human infrastructure. However, historical records of wolverines in the continental United States have all been associated with high elevation, alpine, subalpine, or relatively cold climatic conditions. Given the similarity between known historical and current distribution of wolverines, it is possible that the ecological niche occupied by wolverines, including high-elevation, cold, rugged terrain with substantial snow accumulation and persistence, naturally isolates them from the human developments typically located in more hospitable environs (Inman et al. 2012a, U.S. Department of the Interior 2013b).

All alternatives except D allow for potential construction and use of designated non-commercial recreational aircraft landing and take-off locations (airfields) in certain areas. Any future locations for public airfields would be authorized, constructed, and maintained through partnerships (FW-STD-AIRFIELDS-01, 02). Current plans are silent on airfields, although airfields are addressed in the Gallatin Forest Travel Plan, in a manner consistent with the revised plan alternatives. Under all revised plan alternatives, airfields for public recreation use would not be allowed in designated wilderness, wilderness study area, Cabin Creek Recreation and Wildlife Management Area, recommended wilderness, or within the grizzly bear recovery zone (FW-SUIT-AIRFIELDS-01), which collectively contain the vast majority of maternal and primary habitat for wolverines on the national forest. Therefore, any new airfields constructed for public recreation use under any alternative would typically be in wolverine dispersal habitat, which would have few notable impacts on wolverines. Finally, any future public airfields would be authorized through partnerships (FW-STD-AIRFIELDS-02), and all revised plan alternatives would preclude any such permits for winter use in maternal habitat (FW-GDL-WLWV-01).

Some research has indicated a negative relationship between roads and wolverine occurrence (Carroll et al. 2001, Rowland et al. 2003). While there may be a correlation, it could be because the remote, rugged terrain selected by wolverines is not conducive to road development. Wolverines have been shown to avoid major transportation routes (such as paved roads with high volume, high-speed vehicle traffic) in their daily movements. However, dispersing wolverines have been known to successfully cross major transportation routes, but there have also been documented wolverine mortalities due to vehicle collision along major routes. Major routes (paved highways) bisect the Custer Gallatin National Forest in a number of places, but only one, US Highway 212, is located at elevations most commonly known to be used by wolverines. All revised plan alternatives include goals to work with other agencies and landowners to cooperatively manage habitat and provide for connectivity across administrative boundaries, acquire non-Federal lands or seek conservation easements where needed to maintain or restore connectivity, and work with highway administrators to reduce vehicle collisions with wildlife (FW-GO-WL-02, 03, 05; FW-GO-LAND-01, FW-GO-RT-03). Most roads in high-quality wolverine habitat are low-speed, low traffic volume, dirt or gravel roads, that are not likely to cause wolverine avoidance (U.S. Department of the Interior 2013b). However, Scrafford et al. (2018a) documented wolverine avoidance of low traffic roads in Alberta, Canada, suggesting that wolverines may be wary of other predators travelling low-use roads. There have been no known mortalities of wolverines caused by vehicle collisions on Custer Gallatin National Forest System roads.

Under all revised plan alternatives, forestwide plan components include desired conditions to provide a safe, efficient transportation system for public and administrative use, with minimal impacts on other resources, including at-risk species (FW-DC-RT-02). To minimize impacts, the revised plan alternatives include plan components that encourage use of technologies that reduce impacts to other resources, and facilitate removal and restoration of roads and facilities no longer needed (FW-GDL-RT-01, 02). The forestwide plan components for infrastructure do not vary by alternative, therefore, effects to wolverine would be the same under all revised plan alternatives. However, all revised plan alternative components provide more detailed guidance, and more restrictions on construction of new roads and other facilities, than currently contained in current plans, so the revised plan alternatives would provide slightly higher protection for wolverine habitat.

Inman et al. (2012b) identified increasing human infrastructure and rural sprawl as potential stressors on wolverine habitat connectivity. However, the U.S. Fish and Wildlife Service concluded that current best science does not show that wolverines avoid human developments, nor is there any empirical evidence that wolverine dispersal is negatively affected by human infrastructure (U.S. Department of the Interior 2013b). Aside from the few roads and trails, there is little human infrastructure in primary wolverine habitat, and what is there is generally primitive, often low-use sites such as administrative facilities and rental cabins. Some limited infrastructure associated with developed ski areas occurs on National Forest System lands. Administrative sites at lower elevations include ranger stations, visitor centers, and work centers, which may contribute to human development impacts on wolverine dispersal. All revised plan alternatives contain plan components to protect water quality and quantity, and protect other natural resources through proper location, design, and maintenance of administrative and recreation developed sites (FW-GDL-FAC01-04; FW-DC-RECDEV02, 06, 07, 09).

Cumulative Effects

Adjacent national forest management plans contain some direction for managing wolverine habitat, most of which is focused on maintaining habitat connectivity and minimizing disturbance near reproductive den sites. The Beaverhead-Deerlodge plan (2009a) contains an objective to maintain habitat integrity for wolverines. The Helena Lewis and Clark Forest Plan (U. S. Department of Agriculture 2020) contains desired conditions for various geographic areas to provide habitat connectivity for wide-ranging species including the wolverine. The Targhee plan (1997) includes an objective to survey for wolverine den sites and document their presence, and a monitoring item to track wolverine population trends. The Shoshone plan (2015c) includes goals to conserve wolverines and maintain habitat connectivity. It states desired conditions for sensitive species (including wolverines) to have self-sustaining populations and habitat into which they can expand, as well as a standard for sensitive species (including wolverines) that management actions near denning sites be designed to avoid disrupting reproductive success. Wolverines are classified as a furbearer in Montana, although the trapping season for wolverine is effectively closed, with a quota of zero and no harvest allowed. If a wolverine is accidentally caught in a trap set for other furbearer species, the trapper must notify Montana Fish, Wildlife and Parks within 24 hours and inform appropriate personnel if the wolverine cannot be released from the trap uninjured. It is unlawful for any person to possess the pelt of a furbearer that is taken unintentionally (Montana Fish Wildlife and Parks 2018b). These management plans are compatible with Custer Gallatin proposed direction under all revised plan alternatives, and collectively would function to conserve wolverines.

Conclusion

Warming climates and impacts on persistent snow cover are the primary threats to wolverines. Forest management actions under all alternatives are unlikely to have a notable impact on climate or associated persistence of spring snow cover in primary wolverine habitat on the Custer Gallatin National Forest. Other than a strong reliance on snow cover, wolverines are habitat generalists with no strong dependence on particular vegetation composition, structure, or other habitat features. Forest land management actions occur on a small scale relative to the size of a wolverine’s home range, and the U.S. Fish and Wildlife Service found few negative effects to wolverines directly associated with land management actions such as timber harvest, livestock grazing, or mining (U.S. Department of the Interior 2013b). Therefore, the primary mechanism by which human use of National Forest System lands might affect wolverine persistence on the Custer Gallatin is through disturbance effects in winter, particularly those that may disrupt reproductive success of female wolverines.

All revised plan alternatives include plan components designed to increase vegetation resilience to climatic stressors, which may help mitigate negative impacts from climate change. All revised plan alternatives include a suite of plan components including land use allocations that would provide large areas of limited development, and restrict certain activities that alter habitat and impose disturbance effects on wintering wolverines. All revised plan alternatives contain an assortment of plan components to provide for habitat connectivity, with all but alternative E incorporating an extra measure with key linkage areas to improve connectivity to conserve the metapopulation structure of wolverines. All of the revised plan alternatives contain more proactive and specific direction for managing to conserve wolverines, as well as providing for ecological integrity in the face of climate change, making the revised plan alternatives more favorable for wolverines than the current plans. In summary, all alternatives would provide ecological conditions that would conserve habitat, and contribute to the long-term persistence of wolverines, through maintenance of habitat connectivity and protections that limit human disturbance in maternal and primary habitats.

3.10.5 Unique Wildlife Habitats

The Custer Gallatin National Forest administers more than 3 million acres of Federal land, including two different ecosystems—the montane ecosystem covering the west and central part of the Custer Gallatin National Forest and the pine savanna ecosystem to the east. The montane ecosystem includes the Absaroka Beartooth Mountains; Madison, Henrys Lake, and Gallatin Mountains; Bridger, Bangtail, and Crazy Mountains; and Pryor Mountains Geographic Areas. The pine savanna ecosystem includes the Ashland and Sioux Geographic Areas. This vast landscape provides an incredibly diverse range of habitats for wildlife. Detailed descriptions of ecosystem characteristics, structure, function, processes, existing conditions, and effects of the various plan alternatives are found in other sections of this document, as identified below. This section will tier to those analyses, and briefly describe some of the more unique habitats on the Custer Gallatin, with a synopsis of species associated with those habitats and conditions. Many of the species associated with these unique habitats, and therefore included in this section, are currently on the regional forester’s list of sensitive species (see the list in appendix C), but would remain so only under the current plans (alternative A).

Notable Changes between the Draft and Final Environmental Impact Statement

In this section, individual plan components are identified and a more detailed explanation is provided for coniferous forest habitats and associated wildlife species, particularly those species associated with mature, over-mature, or old-growth forest.

Aquatic and Riparian Habitats

Aquatic and riparian habitats are addressed in detail in the watershed, aquatics, and riparian section, as well as the terrestrial vegetation section of this document. These features include lakes, rivers, streams and ponds, and the vegetative communities such as willow and shrub riparian areas, wetlands, bogs, fens, and marshes that occur at the interface between water bodies and upland habitats. Riparian areas are typically saturated with water at least seasonally. Riparian areas support incredibly high diversity of plant and animal communities (Naiman et al. 1993), particularly given their relative rarity on the Custer Gallatin landscape. Riparian areas provide water, food, and shelter to many terrestrial wildlife species. Given their configuration on the landscape, riparian areas serve as transitional zones between aquatic and terrestrial ecosystems, which are often used as travel corridors, providing important habitat connectivity for wildlife. Nearly all terrestrial wildlife species use riparian areas or aquatic habitat for at least some part of their daily, seasonal or life cycle needs, and some species are very dependent upon aquatic or riparian habitats.

Species associated with aquatic or riparian habitat on the Custer Gallatin include the bald eagle (*Haliateeus leucocephalus*), harlequin duck (*Histrionicus histrionicus*), and trumpeter swan (*Cygnus buccinator*) to name just a few. Compared to when the current plans were written, bald eagle populations have been increasing in the conterminous United States (U.S. Department of the Interior 2016a), Montana (DuBois 2016a), and South Dakota (Deisch, 2018b personal communication), with higher numbers observed across the entire Custer Gallatin National Forest as well. Trumpeter swan populations have also increased in recent years in Montana (Marks et al. 2016) and South Dakota (Deisch, 2018b personal communication), with important winter habitat for this species located near Hebgen Lake in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area. The Rocky Mountain breeding population of harlequin ducks is relatively stable, with local declines noted for some areas in Montana (Marks et al. 2016). There is insufficient data to determine trends for this species on the Custer Gallatin.

All revised plan alternatives include an extensive set of plan components designed to maintain or restore the ecological integrity of aquatic and riparian habitats vital to native and desired non-native wildlife species on the Custer Gallatin (FW-DC/GO/OBJ/STD/GDL-WTR/RMZ All). The plan components for water, aquatic, and riparian resources in the revised plan alternatives are more detailed and generally more restrictive than comparable habitat direction in current plans. In addition to water and riparian resource-specific direction, the revised plan alternatives all include restrictions on a wide range of resource management areas designed to protect water quality and overall ecological integrity of aquatic and riparian-associated resources (FW-DC-VEGF-05; FW-DC-VEGNF-01, 04; FW-GO-VEGNF-02; FW-GDL-VEGNF-05; FW-STD-INV-01; FW-STD-WLGB-04, 05; FW-DC-SUS-01, 03; FW-DC-GRAZ-03; FW-GO-GRAZ-01; FW-STD-GRAZ-01; FW-GDL-GRAZ-01, 02, 04, 05, 10; FW-STD-TIM-02; FW-GDL-EMIN-02; FW-DC-RT-01, 02; FW-STD-RT-02, 03, 04, 05; FW-GDL-RT-03-11; FW-GDL-FAC-01-04; FW-SUIT-AIRFIELDS-01; FW-DC-DAM-01; FW-GO-DAM-01; FW-DC-REC-05; FW-OBJ-REC-01; FW-DC-RECDEV-07, 09; FW-GDL-RECSUP-01; FW-GDL-LANDUSE-03, 04; FW-SUIT-DWA-05; AB-SUIT-RNA-01, 02; MG-DC-WTR-01; MG-DC-BSSSA-01; MG-DC-GRREA-02; MG-DC-HLREA-02; MG-DC-YRREA-02). Given this compete and detailed set of plan components, aquatic and riparian habitats would be well protected, and associated species would be expected to persist on the Custer Gallatin under all revised plan alternatives.

Rock, Cliff, and Cave Habitats

Rock, cliff, and cave habitats are formed primarily by geologic processes, although some human activities, particularly those associated with mineral extraction, can create, or alter underground or surface structures that may provide unique habitats for wildlife. Caves are geologic features on the landscape that provide unique habitat elements for a number of wildlife species, most notably bats (refer to the caves and karst analysis under energy, mineral, and geologic areas section of this document for more detailed information on caves, and the northern long-eared bat section for additional information on bats). Cave environments used by bats would be protected under all revised plan alternatives, which include desired conditions for underground environments to remain unaltered to provide habitat for wildlife (FW-DC-EMIN-05, 06), goals for coordinated efforts to gain and exchange information about cave resources (FW-GO-EMIN-01), standards for bat-friendly cave closures where needed, and direction to protect the cave resources from a variety of management activities (FW-STD-EMIN-03-07).

A number of bat species occur on the Custer Gallatin National Forest, including but not limited to the fringed myotis (*Myotis thysanodes*), long-eared myotis (*M. evotis*), long-legged myotis (*M. volans*), pallid bat (*Antrozous pallidus*), spotted bat (*Euderma maculatum*), and Townsend's big-eared bat (*Corynorhinus townsendii*). These bat species occur at a variety of locations across the Custer Gallatin, and all have been detected in the Pryor Mountains Geographic Area. These bat species hibernate in winter, typically in caves, but occasionally in underground mines as well. Several bat species are vulnerable to white-nose syndrome, a fungal disease that affects hibernating bats. Some hibernating bats have experienced high mortality rates from white-nose syndrome in the eastern United States. This disease is a relatively new issue for bats, particularly in the western United States, and there are many uncertainties about how it might affect western bat populations, given the differences in species, environments, and roosting behavior. The fungus that causes white-nose syndrome has not yet been detected on the Custer Gallatin, but was recently confirmed nearby in South Dakota and Wyoming. The current forest plans do not address this issue. All revised plan alternatives contain plan components to directly address the potential human-caused spread of the fungus that leads to white-nose syndrome in bats (FW-DC-WLBAT-01; FW-GO-WLBAT-02; FW-STD-WLBAT-01; FW-GDL-WLBAT-01, 03, 05).

A number of bird species use cliffs as nesting habitat, including the peregrine falcon (*Falco peregrinus*) and the prairie falcon (*F. mexicanus*), the latter of which is a species of particular interest for South Dakota Game Fish and Parks associated with cliff and rock formations in the Sioux Geographic Area. The breeding population of peregrine falcons increased dramatically after a Federal ban on harmful pesticides and subsequent re-introduction effort, resulting in the species being removed from the endangered species list in 2000. Peregrine falcon breeding sites on the Custer Gallatin have been consistently occupied. Prairie falcons are not consistently monitored, but populations in Montana are believed to be stable (Marks et al. 2016). South Dakota is on the eastern fringe of the prairie falcon's breeding range, and the species is uncommon, but present in the Sioux Geographic Area. Surveys in the South Dakota units of the Sioux Geographic Area in 2011 found notably fewer prairie falcon nests compared to surveys in the same area in the 1970s (Deisch, 2018b personal communication). Other than limited recreational use, forest management actions generally do not target cliff habitats. The revised plan alternatives all include guidelines to limit management actions that may disturb nesting raptors (FW-GDL-WL-06), which would protect breeding sites for peregrine and prairie falcons. Since peregrine falcon nest sites are typically associated with wetlands and water bodies (Marks et al. 2016), the riparian management zone plan components (listed above) in the revised plan alternatives would provide additional protections for peregrine falcon breeding sites, compared to the current plans.

A number of reptile species are associated with rocky, sandy habitats typically found in warmer, drier portions of the Custer Gallatin. Examples include the greater short-horned lizard (*Phrynosoma hernandesi*), milksnake (*Lampropeltis triangulum*), and western hog-nosed snake (*Heterodon nasicus*). Where information exists, populations of these species appear relatively stable at the range-wide scale (Deisch, 2018b personal communication). However, there is very limited information on these species over much of the Custer Gallatin. These species may be associated with rocky, sandy beaches or dry riverbanks, which would generally be protected from disturbance with the increased restrictions for riparian management zones under the revised plan alternatives (FW-DC/STD/GDL-RMZ All). The revised plan alternatives all include a description of desired conditions for sparsely vegetated habitats that provide sandy, rocky conditions used by some reptiles (FW-DC-VEGNF04), and include a guideline to limit ground-disturbing activities near known reptile and amphibian reproductive areas and hibernacula during breeding and wintering seasons (FW-GDL-WL-08). Current plans do not specifically address habitats for reptiles and amphibians. Management actions typically do not target rocky, sandy areas that may be important for some species; however, specific guidelines in the revised plan alternatives would provide greater protection for known breeding and wintering areas than the current plans.

Recently Burned Forest Habitats

Fire is the primary ecological process that has influenced vegetation species composition, structure, and connectivity on the Custer Gallatin. Recently burned forests provide food and shelter for a variety of wildlife species, with some species having a strong association with recently burned areas. Woodpeckers are commonly associated with burn areas due to an abundance of prey species where insects feed on trees injured or killed by fires. The black-backed woodpecker (*Picoides arcticus*) is strongly associated with recently burned forests, using fire-killed trees for nesting and foraging sites (Bonn et al. 2007), as are a number of other woodpecker species. The revised plan alternatives all recognize the important ecological role of fire on the Custer Gallatin, including the contributions to a diversity of habitat conditions for fire-adapted wildlife species. The area burned by wildfires was reduced from the 1940s to the 1980s with a combination of fire exclusion, timber harvest, livestock grazing, and climate. During this time, fuel levels increased, resulting in larger fires on the Custer Gallatin starting about the time the current plans were written (see Affected Environment in the terrestrial vegetation section of this document for details). Consequently, post-burn habitat has been increasing, particularly in the pine savanna ecosystem, but with reasonable distribution across the Custer Gallatin. Black-backed woodpecker trends have been stable to increasing on the Custer Gallatin in recent years (IMBCR unpublished data).

The revised plan alternatives acknowledge the ecological benefits of allowing fires to burn under appropriate conditions and include an objective for greater wildfire acreage on the Custer Gallatin relative to existing conditions (FW-DC-FIRE-01, 02; FW-OBJ-FIRE-02). Recently burned forests are often targeted for salvage harvest to capture the economic value of burned timber. The revised plan alternatives contain requirements for retaining unburned patches, trees burned at low severity, and clusters of burned trees with a variety of sizes, including very large snags, in salvage harvest areas (FW-

GDL-TIM-01, 02). In addition, snag retention guidelines in the revised plan alternatives would require more, and larger snags be left in harvest areas than currently required (FW-DC-VEGF-05; FW-GDL-VEGF-03). Collectively, the revised plan alternatives would better support persistence of species associated with snags and recently burned habitat than the current plans.

Grassland Habitats

Grasslands habitats are addressed in detail in the terrestrial vegetation section of this document. Grasslands are a relatively minor habitat component in the montane ecosystem, compared to the pine savanna ecosystem. Notable grassland-associated species on the Custer Gallatin include bison, bighorn sheep, pronghorn antelope, and white-tailed prairie dogs, which are all addressed separately in this document. Other notable grassland associates include black-tailed prairie dogs (*Cynomys ludovicianus*), burrowing owls (*Athene cunicularia*), Baird's sparrows (*Ammodramus bairdii*), and long-billed curlews (*Numenius americanus*). Black-tailed prairie dogs occur in areas of relatively flat topography, with looser soils for digging burrows, and short-grass vegetation types devoid of sight-limiting trees and shrubs (Montana Prairie Dog Working Group 2002). These conditions are naturally limited on the Custer Gallatin, and are primarily found in the pine savanna ecosystem. Black-tailed prairie dogs are currently present only in the Ashland Geographic Area, where colony size is generally fewer than 100 animals, but has remained relatively stable over the life of the current plans. Black-tailed prairie dogs are more common, with much larger colonies, outside the national forest boundary. Livestock grazing is a prominent use in the pine savanna geographic areas, which contributes to the short grass structure favored by black-tailed prairie dogs. Burrowing owls are also associated with short-grass prairies, and are strongly associated with prairie dog towns, which provide both food and shelter for the owls. Burrowing owls were declining at a non-significant rate in Montana between the mid-1960s and early 2000s (Marks et al. 2016), with a similar trend (slight decline) in South Dakota (Deisch, 2018b personal communication). However, monitoring, and multi-species conservation efforts for prairie and grassland birds has improved the outlook, and recently resulted in a downgrading of the Montana rank for the burrowing owl from "at risk" to "potentially at risk".

Baird's sparrows are fairly common breeding residents in eastern Montana and populations appear stable in Montana while declining elsewhere (Marks et al. 2016). However, the species has only been detected once in regular bird surveys on the Custer Gallatin National Forest, providing insufficient evidence that the species is established or becoming established within the plan area. Long-billed curlews are shorebirds associated with short grass prairies. Range-wide surveys suggest increasing populations in recent years (Marks et al. 2016), with slight declines in South Dakota (Deisch, 2018b personal communication). Curlews and their habitats are relatively uncommon on the Custer Gallatin, with no trend information due to low density and limited survey effort.

The revised plan alternatives include specific plan components related to vegetation composition that would contribute to plant diversity and ecological integrity of grassland habitats (FW-DC-VEGNF-01-04; FW-GO-VEGNF-01-02; FW-OBJ-VEGNF-01; FW-VEGNF-GDL 01, 03). Compared to the current plans, the revised plan alternatives provide more detail regarding vegetation conditions and species composition to maintain or move toward desired conditions for grasslands. The revised plan alternatives also include direction to reduce invading conifers, control the spread of invasive annual grasses and noxious weeds, and minimize livestock grazing impacts (FW-DC-INV-01; FW-OBJ-INV-01; FW-DC-GRAZ-03; FW-STD-GRAZ-01), all of which would benefit grassland species. The revised plan alternatives include specific direction for prairie dogs (FW-DC/GO/STD/GDL-WLPD All), which would be more protective than current direction, benefitting both prairie dogs and associated species, such as the burrowing owl. Collectively, the revised plan alternatives would promote more proactive management of grassland habitats, thereby supporting long-term persistence of associated species to a greater degree than current plans.

Shrubland and Deciduous Woodland Habitats

Shrubland habitats are addressed in detail in the terrestrial vegetation section of this document. Many wildlife species on the Custer Gallatin use shrub habitats to meet daily, seasonal, or year-round needs. Shrublands are a minor habitat element on the Custer Gallatin, representing just about 4 percent of the land base, and often occurring as an extension of shrublands from adjacent lands outside the national forest boundary. As such, many wildlife species that are strongly associated with shrubland types are not year-round residents on the Custer Gallatin. In the pine savanna ecosystem, shrublands typically occur as irregular patches, in narrow bands or small, dense thickets. In the montane ecosystem, some shrublands may be found at higher elevations, but are present on a relatively small scale. Notable wildlife species that are shrub associates include the greater sage-grouse (a sagebrush obligate), and the white-tailed prairie dog (a grass and shrub-associated species). These two species are addressed in more detail under species of conservation concern in this document.

Other shrub-associated species on the Custer Gallatin include the regional forester's sensitive species blue-gray gnatcatcher (*Polioptila caerulea*) and loggerhead shrike (*Lanius ludovicianus*). These migratory songbird species breed in shrubby habitats on the Custer Gallatin. The blue-gray gnatcatcher is found in the Pryor Mountains Geographic Area, which is the only location where this tiny songbird is commonly found in the state of Montana (Marks et al. 2016). Breeding has also been confirmed for this species in the Sioux Geographic Area in South Dakota (Deisch, 2018b personal communication). This species' establishment on the Custer Gallatin indicates a fairly recent range expansion, as the historical range for the species is well south and east of the Custer Gallatin. Loggerhead shrikes are fairly uncommon breeding residents on the Custer Gallatin, with highest densities in the Ashland and Sioux Geographic Areas of the pine savanna ecosystem, where they may be found in woody draws and grassy areas with scattered trees and shrubs. Breeding bird surveys indicate insignificant declines for the species in Montana since the mid-1960s (Marks et al. 2016), with significant declines in South Dakota over roughly the same time period (Deisch, 2018b personal communication). However, local surveys do not show a notable population trend for this species on the Custer Gallatin, indicating relative stability at this time (IMBCR, unpublished data).

All revised plan alternatives contain a suite of plan components related to vegetation composition, structure, and function that would contribute to plant diversity and ecological integrity of shrublands on the Custer Gallatin (FW-DC-VEGNF-01, 03, 04; FW-OBJ-VEGNF-01). Compared to the current plans, the revised plan alternatives provide more detail regarding desired conditions, as well as specific restrictions on management actions such as new developments and livestock grazing to minimize impacts on shrublands and woody draws (FW-GDL-VEGNF-01,03, 05-08; FW-GO-GRAZ-01; FW-GDL-GRAZ-04, 05). Additional components for greater sage-grouse habitat in the revised plan alternatives (FW-DC/GO/STD/GDL-WLSG All) would also provide more protection for shrublands than current direction. Collectively, the revised plan alternatives provide more detailed, integrated, and ecologically based plan components that would support the long-term persistence of shrub-associated species to a greater degree than the revised plan alternatives.

Coniferous Forest Habitats

Coniferous forest habitats are addressed for a multitude of factors in the terrestrial vegetation section of this document. The Canada lynx and northern long-eared bat are two at risk species that are strongly associated with forest habitats, as addressed separately above. While many, perhaps even most, terrestrial species on the Custer Gallatin National Forest depend on coniferous forest habitats for at least some part of their life cycle, there are few true forest-obligates in the at-risk categories, or currently on the regional forester's list of sensitive species. Many of the bat species addressed previously that use cave habitats as roost sites and winter hibernacula, are known to forage and shelter in coniferous forests, but also use riparian areas and openings to a large degree. Large trees, late successional forest, and old growth provide a high degree of plant and animal diversity on the Custer Gallatin, including vital habitat elements for a wide range of terrestrial wildlife species. Mature forest habitat is abundant and widespread on the Custer Gallatin. Old-growth forest is defined by criteria established for the Northern Region of the Forest Service (Green et al. 2011) and the terrestrial vegetation section of this document contains a detailed analysis for this habitat component.

All forest successional stages are important for wildlife. Some native species select for recently disturbed forests (as described above). Young, regenerating forest is also strongly selected by some species, including (but not limited to) snowshoe hares, which are an important prey species for a variety of forest carnivores and birds of prey. Mature and old-growth forest are important not only because they typically provide a high level of plant and animal diversity, but also because it takes a long time to reach later successional stages of forest structure relative to the generational timeframe of most wildlife species. A number of wildlife species tend to use old-growth forest disproportionately to its availability (Thomas et al. 1988a, Hutto and Young 1999). Examples of such species known to occur on the Custer Gallatin include common species such as elk, mule deer, and moose, as well as less common species such as American (pine) marten (*Martes americana*), brown creeper (*Certhia americana*), and winter wren (*Troglodytes troglodytes*). While these wildlife species may show a preference for older forest conditions, they can be found in younger forest, as well as in non-forest types that may provide habitat components such as foraging opportunities not as readily available in older forest structure.

The northern goshawk (*Accipiter gentilis*) and pine marten are species with known affiliations for mature to over-mature forest conditions, including the presence of large trees, snags and logs, and relatively high canopy cover. While these individual habitat components are most abundant in mature and old growth forest, they can be found in earlier successional stages as well. Based on detection surveys, goshawks are present and well distributed across the Gallatin portion of the Custer Gallatin National Forest (U.S. Department of Agriculture 2016b), and occur on the Custer portion of the national forest as well. Pine martens are trapped for fur and consequently, market value can influence population trends. Martens are fairly common in forested habitats on the Gallatin portion of the national forest, but occur at lower densities in the isolated mountain ranges of the Bridger, Bangtail, and Crazy Mountains Geographic Area, where easy access for trappers may be a factor (U.S. Department of Agriculture 2016b).

Other species associated with forest habitats include the flammulated owl (*Otus flammeotus*), which is associated with open park-like structure typically found in ponderosa pine forests, as well as more generalist species such as the gray wolf (*Canis lupus*), which is associated with a wide variety of forest conditions, mostly as they relate to the availability of big game prey species. Flammulated owls have only been detected once on the Custer Gallatin. However, the detection was made by sound, and was not verified through observation or DNA. Subsequent surveys for flammulated owls failed to detect the species on the Custer Gallatin. Ponderosa pine habitat is limited to the pine savanna ecosystem, which is well outside the known range for this species. Gray wolves were reintroduced in Yellowstone National Park in the mid-1990s. Since then, wolves have expanded to occupy most of the suitable habitat in the montane ecosystem of the national forest.

Snags are another important wildlife habitat component found in forested environments. Snags are standing dead trees that provide nesting, roosting, denning, and foraging options for a number of wildlife species including a variety of birds, bats, martens, squirrels, and bears to name a few. Snags eventually fall, creating coarse, woody structure near the ground that is also important to wildlife as it provides security cover, denning habitat, and foraging substrate.

Management actions can alter forested habitats in many ways. The Custer Gallatin supports a wide range of native wildlife species that use an equally wide range of habitat types and structural conditions. Vegetation management then, may have negative impacts on some species, while benefitting others, and having little or no impact on others still. All revised plan alternatives contain a complete suite of plan components for forested vegetation conditions. These include desired conditions for maintaining the amount and distribution of forest cover types, individual tree species, successional stages (based on tree size class), forest density (based on tree canopy cover), forest patch size, presence of large trees and snags, natural disturbance processes, and the amount of old-growth forest, all within the estimated natural range of variation for these habitat components (FW-DC-VEGF-01-09). These plan components help maintain or move toward the desired condition for wildlife habitats generally within the natural range of variation (FW-DC-WL-03) found in all revised plan alternatives.

The revised plan alternatives also include a set of guidelines to achieve desired conditions for forested habitats, which would limit management impacts to old growth forest, help maintain snags for wildlife, and retain the large tree component that is currently limited across the Custer Gallatin (FW-GDL-VEGF-01-05). Additional guidelines specify the amount of coarse woody debris that should be left as ground cover after vegetation management projects (FW-DC-SOIL-03; FW-GDL-SOIL-07). Under all revised plan alternatives, these plan components would provide specific habitat elements required by species associated with mature to old-growth forest structure and snag-dependent species, as well as a wide range of conditions to provide the variety of habitat needs for more generalist species.

Conclusion

All revised plan alternatives contain a collection of coarse-filter vegetation components combined with fine-filter species-specific plan components designed to maintain or restore the ecological integrity of the habitats within the Custer Gallatin National Forest. Collectively, the plan components in the revised plan alternatives would maintain or move habitat conditions toward the natural range of variation to which wildlife have adapted, which would support long-term persistence of native species, including Regional Forest sensitive species and at-risk wildlife species, with greater certainty than current plans.

3.10.6 Connectivity

The 2012 Planning Rule requires that the plan must include components, such as standards or guidelines, to maintain or restore the ecological integrity of ecosystems on the Custer Gallatin National Forest, including plan components to maintain or restore connectivity. As it pertains to wildlife, connectivity is defined as the ecological conditions that exist at several spatial and temporal scales that provide landscape linkages that permit the daily and seasonal movements of animals within home ranges, the dispersal, and genetic interchange between populations, and the long-distance range shifts of species, such as in response to climate change (36 CFR 219.19).

Habitat connectivity is widely recognized as a crucial component for maintaining plant and animal diversity and managing for sustainable populations of native species (Western Governor's Association 2008, Hansen 2009, McIntyre and Ellis 2011, Cushman et al. 2012, Parks et al. 2012, Haber and Nelson 2015, Wade et al. 2015, McClure et al. 2016). While habitat connectivity is a prominent topic in the scientific literature, with specific focus on the Greater Yellowstone Area (the montane portion of the Custer Gallatin, excluding the Pryor Mountains), there is very limited information regarding terrestrial habitat connectivity in the pine savanna portion. There are two primary requirements for habitat connectivity. The first is that suitable habitats are present for species of interest, and the second is that landscapes are permeable to wildlife movement.

Conditions that present habitat suitability, as well as barriers to movement, vary widely between species. It follows logically that landscape connectivity also differs by individual species, based on daily, seasonal, and lifetime habitat needs. Corridors that facilitate movement by one species may not be suitable, and may even present barriers for movement of another species. Similarly, landscapes that facilitate dispersal out of the home range for a species may not provide habitat required to support long-term occupation by that same species (McClure et al. 2016). For example, large, unbroken tracts of mature forest cover are important to forest carnivore species such as Canada lynx and American marten. Yet for other species, including pronghorn antelope, bighorn sheep, and black-tailed prairie dog, dense forested habitat is not suitable, and conifer encroachment into grassland or shrub-steppe habitats can reduce habitat suitability and impede movement for these species. Forest cover can provide security cover to facilitate movement of big game species such as elk, deer, moose, and bear; however, these same species also rely on forest openings and grass and shrub habitats to find adequate forage. Similarly, Ruediger et al. (2000a) noted that dispersing lynx will move through large areas of limited forest cover, but such habitat is generally not considered suitable for residential (long-term) use by lynx.

Habitat connectivity is also influenced by the dispersal capability of species and individuals. For example, with the ability to fly, birds can move between habitat patches on a daily basis, making long-distance migratory movements between seasonal habitats more easily than ground-based terrestrial wildlife. Generally, large-bodied animals have greater dispersal capability than smaller animals. For example, while they occupy similar habitats, the wolverine, a mid-sized forest carnivore, has much greater dispersal capability than the fist-sized American pika (*Ochotona princeps*) (Parks et al. 2012). Connectivity corridors identified as high priority for conservation of plant and animal diversity are often identified from observed movement patterns of large-bodied, wide-ranging species. However, wide-ranging animals capable of long-distance movements are often habitat generalists, and therefore, may not adequately represent the habitat needs, or dispersal capabilities of other species (Cushman et al. 2012).

The reason for movement also plays a role in the functionality of habitat connectivity. For example, long-range dispersal movements may contribute to gene flow between populations, genetic rescue of small or isolated populations, and colonization of new areas (Parks et al. 2012). Habitats used to move within an individual's seasonal home range may be quite different from those used for movement between seasonal ranges, and can be dramatically different than areas used for dispersal to establish new home ranges. Not all movements undertaken by animals are beneficial. Movement to escape a possible predator or other threat can place an animal in unfamiliar territory. Likewise, exploratory movements outside of home ranges are often undertaken by inexperienced sub-adult animals, which may relocate that animal into less suitable or even unsuitable habitat (Wade et al. 2015).

Haber and Nelson (2015) defined structural connectivity as “the physical relationship between patches of habitat…” and functional connectivity as “the degree to which landscapes actually facilitate or impede the movement of organisms and processes of ecosystems.” They noted that fragmentation, which is the breaking-up of contiguous patches into smaller, disconnected patches, could introduce barriers to connectivity. While this notion is informative in the evaluating landscape connectivity, it is important to consider that habitat in the Rocky Mountains (including the montane ecosystem of the Custer Gallatin National Forest) is naturally more patchily distributed than in other parts of the United States, such as the North American prairie (Hansen 2006), which is more similar to parts of the pine savanna ecosystem.

Popular methods for modeling wildlife movement corridors include landscape resistance modeling, often referred to as “least cost path” or “least cost corridor” models, which operate under the concept that animals will choose to travel along routes with the least ecological cost (that is, the lowest cumulative resistance between their current and target locations on the landscape). Least cost movement models assume that all such paths or corridors contribute equally to connectivity on the landscape, that all animals have equal dispersal capability (Parks et al. 2012), that animals are goal-oriented and have the desire to move between their current and target locations, and that animals have absolute knowledge of their surrounding landscape (Wade et al. 2015, McClure et al. 2016). Circuit theory models provide an alternative to least cost models, by applying concepts related to flow of charged bits through an electrical circuit, to animal movement through the landscape. Circuit theory models assume that repeated use of routes between source and target locations infers better flow between points. In contrast to least cost models, circuit theory models assume that animals have no previous knowledge of the surrounding landscape. Therefore, one might expect least-cost models to be more representative of traditional movement patterns between seasonal ranges of herd animals (where there is collective knowledge of the landscape), whereas circuit models might be more useful for identifying exploratory or dispersal movements of animals out of known home range territories (McClure et al. 2016).

Habitat connectivity and movement corridor modeling has promising utility for identifying high-priority areas for protection or restoration, to sustain functional connectivity across the landscape. However, such models are generally based on many assumptions. Wade et al. (2015) examined a number of resistance-surface-based models (least cost models) and identified a considerable number of issues with such modeling efforts, such as failure to specify the temporal aspect of potential corridors (daily, seasonal or lifetime movement, for example), the purpose for modeled connector routes (such as foraging, breeding, and dispersal), or the biological rationale for selection of model-assigned resistance features. These authors stressed that process modeling (such as for wildlife movement) is often based on assumptions that are not supported by data.

Model validation with independent, empirical data is of course desirable, but not always possible. Further, while methods for validating connectivity models against empirical data exist, they have not been standardized (McClure et al. 2016). On the other hand, without any validation, the reliability of a model is basically unknown. In the absence of empirical data, expert opinion is a commonly used basis to derive model parameters. Many such connectivity models are based on general assumptions about habitat characteristics that are believed to have commonalities for a majority of species; for example, low level of human impacts, or a high degree of intact forest cover. While expert opinion has value, it is the least robust method of model validation. To illustrate the importance of model validation, Wade et al. (2015) gave an example where independent radio-tracked movement of animals was substantially different than the corridors predicted by a least cost model, and remarked that because animals are influenced by independent needs, such as seeking food or avoiding predators, strict adherence to a least cost path is not likely.

An alternative method to evaluate habitat connectivity as it relates to ecosystem integrity is to examine the amounts, distribution, and status of human development and access within the Custer Gallatin and surrounding landscape. Construction of roads, mines, administrative sites, and developed recreation areas results in relatively permanent habitat alteration that affects connectivity for wildlife. Certain land management allocations restrict the types and amounts of development and associated use allowed on National Forest System lands. Land use restrictions can add a degree of protection for important wildlife habitat components such as habitat security, which helps maintain habitat connectivity. This evaluation operates on the premise that designation of areas such as wilderness, wilderness study, and inventoried roadless, regulates the amount of habitat loss, degradation, and fragmentation that occurs due to human activities (Belote and Aplet 2014, Dietz et al. 2015), and that the resulting network of designated areas provide core habitats that facilitate conservation of habitat connectivity for wildlife movement (Montana Fish Wildlife and Parks 2011). Although designated areas typically provide a higher degree of overall habitat connectivity for wildlife by restricting the amount of permanent habitat alterations that humans may cause, all federally managed lands generally provide protection from permanent residential and urban development, yet allow for some level of resource utilization and associated transportation systems.

Analysis Area

Habitat connectivity is a key factor contributing to ecological integrity, and was therefore, examined across the entire forest. However, the montane and pine savanna ecosystems within the Custer Gallatin differ considerably in terms of ecological characteristics, habitat types, wildlife communities, and availability of specific research, so these ecosystems were also examined separately. Finally, the 2012 Planning Rule requires consideration of plan area contributions within the broader landscape, by taking into account existing conditions outside the national forest boundaries that may influence the plan area's ability to maintain or restore ecological integrity. Accordingly, connectivity was analyzed for a spatial extent encompassing all lands within 100 miles of any Custer Gallatin National Forest administrative unit (figure 35). The 100-mile radius was based upon the average and maximum dispersal distances of wide-ranging wildlife species. For example, grizzly bears have been known to disperse up to 175 kilometers (105 miles) (Haroldson et al. 2010), and wolverines up to 900 kilometers (540 miles) (Inman et al. 2009). These represent extremes for the species, but long-distance dispersals are common, and 100 kilometers (62 miles) captures the average to maximum dispersal distance known for most wide-ranging species that occupy the Custer Gallatin National Forest (excluding avian species).

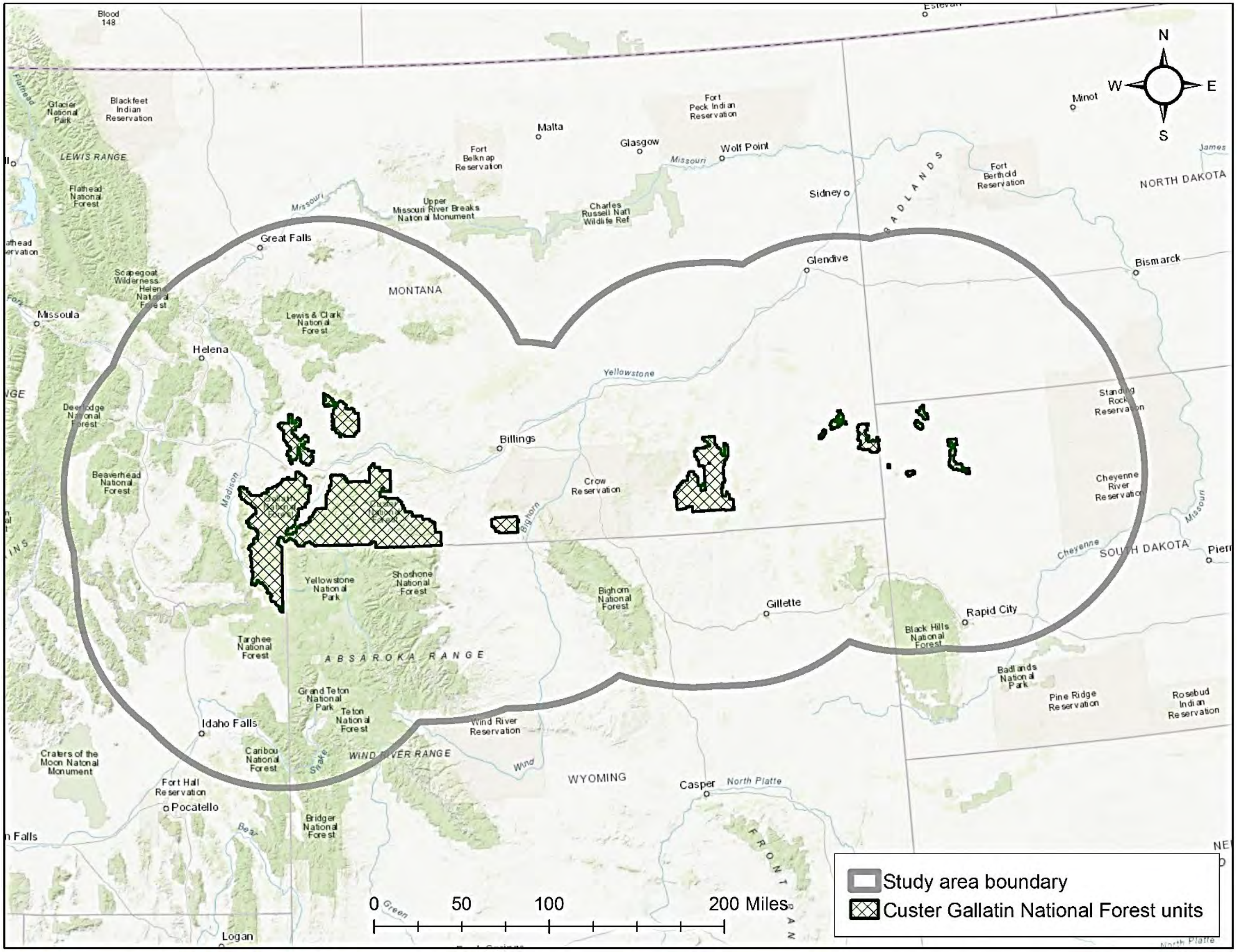

Figure 35. Habitat connectivity analysis area

Notable Changes between the Draft and Final Environmental Impact Statement

This section was revised to provide the scientific basis for the analysis area used in habitat connectivity modeling for the revised plan. Effects analyses were updated to reflect changes in plan components for key linkage areas (FW-DC-WL-07, FW-STD-WL-02, FW-GDL-WL-03, 04), provide a broader context for how integrated plan components could influence habitat connectivity for wildlife, and clarify how plan land allocations might affect habitat connectivity. More discussion was added relative to recreation impacts on habitat connectivity.

Affected Environment (Existing Conditions)

The montane ecosystem in the western portion of the Custer Gallatin includes the Madison, Henrys Lake, and Gallatin Mountains; Absaroka Beartooth Mountains; Bridger, Bangtail, and Crazy Mountains; and Pryor Mountains Geographic Areas. These areas are characterized by mountainous terrain with high topographic relief, ranging in elevation from just under 6,000 feet to well over 12,000 feet. Vegetation varies from semi-arid sage-steppe to moist meadows and riparian areas, montane and boreal forest, and alpine tundra. The Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas in the montane ecosystem represent the largest contiguous block of relatively undeveloped wildlife habitat on the Custer Gallatin. The pine savanna ecosystem in the eastern portion of the Custer Gallatin is characterized by rolling plains and tablelands of moderate relief. The Ashland and Sioux Geographic Areas stand out from the surrounding plains due to their elevation (roughly 3,000 to 4,000 feet) and the presence of ponderosa pine forest and woody draws amongst the rolling grassy plains. The Ashland Geographic Area is a moderately sized contiguous block of relatively undeveloped land, whereas eight small, distinct units comprise the Sioux Geographic Area. While there are some similarities in wildlife communities across the Custer Gallatin, due to the considerable ecological differences between these ecosystems, there are notable differences in wildlife habitats and species composition as well. Broadly speaking, species common to both the montane and pine savanna ecosystems tend to be more habitat generalists, whereas the more specialized species occur in one system or the other, but not both.

The Custer Gallatin National Forest is made up of a number of distinct administrative units, some of which are isolated from the rest by mostly private lands. This geographic separation is the most difficult factor to manage for in terms of habitat connectivity because the Forest Service has no authority over lands separating the distinct administrative units of the Custer Gallatin. Nonetheless, the geographic spread of the Custer Gallatin, which is over 400 miles from west to east, is a factor in habitat connectivity and associated movement of organisms. Given the spatial separation and dramatic ecological differences between the montane and pine savanna ecosystems, it is a logical assumption that wildlife movement between these ecosystems was historically low relative to movement within each ecosystem. Other than bird (and perhaps bat) species, there is likely a low level of wildlife interchange between the montane and pine savanna ecosystems currently as well.

The montane ecosystem of the Custer Gallatin is part of the Greater Yellowstone Area, which is perhaps the largest intact ecosystem in the continental Unites States (McIntyre and Ellis 2011), and one of the largest intact temperate zone ecosystems in the world (Ebinger et al. 2016). While the Greater Yellowstone Area is world renowned for its ecological contributions, it is geographically isolated from other intact and important ecosystems. For the Custer Gallatin portion of the Greater Yellowstone Area, the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas are contiguous with Yellowstone National Park to the south and east, respectively. The Absaroka

Beartooth Mountains Geographic Area is also adjacent to the Shoshone National Forest, with much of the shared boundary within the Absaroka-Beartooth wilderness. The Madison, Henrys Lake, and Gallatin Mountains Geographic Area also abuts the Beaverhead-Deerlodge National Forest to the west, with much of this shared boundary within the Lee Metcalf wilderness. The Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas of the Custer Gallatin provide a considerable amount of habitat connectivity between Yellowstone National Park, the Lee Metcalf, and the Absaroka-Beartooth Wilderness areas. The Bridger, Bangtail, and Crazy Mountains Geographic Area is separated from the rest of the montane ecosystem by Interstate 90, plus a two-lane frontage road, and a railroad, all of which run parallel to each other, as well as private land that is developed to varying degrees. This geographic area is mostly surrounded by private land, except where the Custer Gallatin Forest abuts the Helena Lewis and Clark National Forest at the north end of the Crazy Mountains. The Bridger, Bangtail, and Crazy Mountains Geographic Area has been identified as potentially important for connectivity between the Greater Yellowstone Area and the Northern Continental Divide Ecosystem to the north (Walker and Craighead 1997, Cushman et al. 2009, Peck et al. 2017). The Pryor Mountains Geographic Area is separated from the rest of the montane ecosystem by a mosaic of private and Bureau of Land Management land. While the Pryor Mountains Geographic Area is relatively isolated from the rest of the Custer Gallatin, it is contiguous with Bureau of Land Management land to the west, south, and east, and with the Crow Indian Reservation to the north, all of which are relatively undeveloped landscapes with few barriers to wildlife movement.

Much of the available scientific information on habitat connectivity embraces a concept of connecting core habitats, wherein core habitats are often identified as areas that have a high degree of “naturalness” and corresponding low level of human modification (Theobald 2013, Belote et al. 2016). Such areas typically have some degree of protection from permanent development and associated habitat loss (Western Governor's Association 2008, McIntyre and Ellis 2011, Montana Fish Wildlife and Parks 2011, Cushman et al. 2012, Theobald et al. 2012, Belote and Aplet 2014, Wade et al. 2015, McClure et al. 2016). As such, protected areas such as designated wilderness that impose restrictions on land uses, are often used as surrogates for “naturalness” of landscapes. Designated wilderness areas permanently bar most human-caused conversion of natural land cover. Natural disturbance events are generally allowed to occur without management interference (although wildfire is sometimes suppressed), and management activities and recreational pursuits are limited to primitive means. Other designated areas such as inventoried roadless areas, recommended wilderness, wilderness study areas, and research natural areas generally preclude permanent conversion of natural land cover, with a goal to maintain a mostly natural state, but some limited management activities, including low levels of resource utilization, are allowed. Parts of the Custer Gallatin outside of designated areas can be managed more intensely for uses such as timber harvest and mining, as well as recreational uses that may involve permanent developments such as roads, trails, and campgrounds, which may affect habitat connectivity for wildlife.

Roughly, 35 percent of the land base within the Custer Gallatin National Forest is in designated wilderness. These areas, which include parts of the Absaroka-Beartooth, and Lee Metcalf Wilderness Areas, are intended to preserve wilderness character on the landscape, thus providing large blocks of wildlife habitat relatively undisturbed by human development and by association, some of the best habitat connectivity for wildlife. The entire designated wilderness on the Custer Gallatin Forest is located in the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas. In addition to designated wilderness, another 28 percent of the Custer Gallatin falls within other designated areas, including inventoried roadless and wilderness study areas, which restrict the amount of road construction and associated activities, but still allow for some resource utilization and may contain permanent developments such as trail systems and occasional rustic cabins or other facilities. The only wilderness study area is located in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, whereas all geographic areas (except the Sioux) contain some inventoried roadless area (see the Inventoried Roadless Area section of the Designated Areas section of the environmental impact statement).

Less than half (37 percent) of the Custer Gallatin National Forest is not within a designated area, and is therefore, more readily available for higher levels of resource utilization and recreational development than are designated areas. In general, National Forest System lands regardless of land management allocations provide a higher degree of protection for wildlife habitat than do many areas outside of the national forest boundary, particularly private land, which may have little or no restrictions against permanent conversion of the landscape. Inside the national forest boundary, most non-Federal inholdings are small, isolated parcels, with management actions similar to multiple use activities on Federal lands outside of designation areas. However, there are large blocks of non-Federal lands, most notably in the Big Sky area in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, as well as the west side of the Bangtail Range in the Bridger, Bangtail, and Crazy Mountains Geographic Area, that are already developed to some degree and subject to further development.

The majority of permanent conversion of natural vegetation to a non-vegetative condition, hence resulting in a permanent loss of habitat on the Custer Gallatin, is attributable to the road and trail system, and associated parking areas. Other permanent developments such as campgrounds, picnic areas, administrative sites, etc., account for a relatively minor amount of permanent habitat conversion that contributes to habitat fragmentation, and at a small scale, impacts habitat connectivity. In addition to removing vegetation, forest roads and trails can affect hydrology, with associated impacts on water quality, wetlands, and riparian habitats (The Wilderness Society 2014), which can also affect habitat connectivity for wildlife. Roads and trails not only affect habitat connectivity for some species by permanently altering habitat, but human use on roads and trails creates disturbance that may cause avoidance by wary animals, reducing the effectiveness of otherwise suitable habitat surrounding the road or trail. Each individual road or trail can influence habitat connectivity at a small scale, and density of multiple roads and trails can affect suitability of habitat for wildlife at a larger scale. It is well documented that higher road densities can negatively affect the way some animals use habitat, including avoidance of otherwise suitable habitat, which can affect overall connectivity.

The Wilderness Society (2014) conducted a literature review for effects of transportation infrastructure (roads and trails) on wildlife, and cited several studies that found a broad-scale threshold for maintaining functional landscapes for large mammals required road densities below 1 mile per square mile. However, it should be noted that the scale at which road densities were calculated for the studies cited was not provided. Using a moving window analysis to calculate the proportion of motorized access route density classes across the Custer Gallatin provides a method for comparison. This analysis shows that 72 percent of the entire national forest has motorized access route density at or below 1 mile per square mile. This figure varies by geographic area, with the Absaroka Beartooth Mountains Geographic Area having the highest amount at 89 percent and Ashland and Sioux Geographic Areas at the lowest with 53 percent of each area, showing that all geographic areas currently have at least half the area in a condition that provides functional landscapes for large mammals to move through, and that the largest geographic areas have the greatest proportion of area with relatively low motorized access route densities. In addition to large mammals, the Wilderness Society review (2014) showed most reptiles, amphibians, and birds responded negatively to higher road densities; small mammals either responded positively or not at all to higher road densities; and mid-sized mammals showed negative or neutral effects to higher road densities. This supports the notion that habitat connectivity is different for different species, or guilds of animals.

Relative to road and trail impacts on habitat connectivity and wildlife movement, the 2006 Gallatin Forest Travel Management Plan incorporated an assessment of biological corridors and identified important linkage areas near the national forest boundary, where wildlife movement is desirable for genetic exchange between blocks of National Forest System lands, but likely to be restricted by permanent development such as highways, railroads, agricultural lands, and residential areas. As a result, the Gallatin Travel Plan includes a goal to provide for wildlife movement and genetic interaction, and an objective to provide habitat connectivity consistent with wildlife movement patterns between mountain ranges within the national forest boundary. Travel management plans for the Custer National Forest also considered wildlife corridors, but identified no specific areas for management constraints.

The Custer Gallatin includes parcels across all of southern Montana and into the northwestern corner of South Dakota. As such, it covers a broad range of ecological conditions, covering large, medium, and smaller land masses, each with unique capability to provide connectivity for ecological processes, as well as the large number of plant and animal species known to occur within the national forest boundary. Fine-filter connectivity models focus on individual species or populations, and are frequently based on detailed, site-specific, empirical data. A fine-filter connectivity assessment for each species and ecological element on the Custer Gallatin is not just infeasible, it is not necessarily the best approach, given the lack of empirical data to drive such analysis. To tackle the issue of evaluating habitat connectivity for many species simultaneously, the Forest Service partnered with the Center for Large Landscape Conservation and developed a modeling framework specific to the Custer Gallatin National Forest (Williamson et al. 2020). The model was based on a series of generic species, which are conceptual species whose ecological requirements are designed to reflect the needs of a group of real species, and to represent various combinations of preferred habitat type, perceptual range, and dispersal capability. This approach has been applied to other connectivity conservation modeling efforts (Watts et al. 2010, Foster et al. 2017, Lechner et al. 2017), and it attempts to strike an appropriate balance between fine-filter connectivity models designed for individual species and coarse filter models that are completely species neutral.

Core areas of high-quality habitat were mapped for each generic species, representing combinations of five habitat type preferences including coniferous forest, alpine, grassland and shrubland specialists, plus habitat generalists. Model parameters reflected two body sizes of large or small, under the assumption that an animal’s body size was positively correlated with its perceptual range as well as dispersal capability. Core areas contained relatively homogenous patches of preferred vegetation for specialist species and vegetation mosaics for habitat generalists. Patch size required for core habitat was based on the generic species’ body size and individual perceptual range, which is the distance at which an animal is sensitive to edge or difference in habitat condition. The model estimated landscape conductance representing an animal’s ease of movement across the landscape (Zeller et al. 2012), assuming that a preferred habitat type with minimal human modification was easiest to move through (Theobald et al. 2012). The model then generated a series of paths connecting core habitats using different assumptions about animal movement behavior. Predicting random movement along non-optimal paths assumed an animal has imperfect knowledge of its surroundings. This “random movement” model output is similar to circuit theory connectivity modeling, and is more reflective of dispersal movement to establish a new home range. Paths predicting deliberate movement between core habitats in an optimal fashion to minimize the total cost of movement assumed an animal has perfect knowledge of its surroundings. This “optimal movement” model output is similar to least-cost-patch connectivity modeling, and more representative of experienced individuals making daily movements or seasonal migrations within an established home range.

Not surprisingly, these modeling efforts showed markedly different spatial patterns of connectivity value for different generic species with more specialized habitat needs. For example, portions of the Custer Gallatin predicted to have the greatest connectivity value for large-bodied, coniferous forest specialists showed very little overlap with shrubland, grassland or alpine-associated species. Also not surprising is that the random movement simulations resulted in more diffuse patterns, and consequently, larger areas of high value for habitat connectivity than the optimal movement simulations, which showed more concentrated and linear movement patterns.

Model outputs for large-bodied species revealed areas of high connectivity value linking core habitats within, between, and beyond Custer Gallatin administrative units across the larger landscape covered by the connectivity analysis. These longer-distance connections resulted from the greater dispersal capacity for large-bodied species assumed in model parameters. In contrast, model outputs for smaller-bodied species tended to highlight connections over much smaller spatial scales within individual core habitat areas, with relatively little connectivity indicated between core habitat areas or between Custer Gallatin administrative units. Results for smaller-bodied species were highly sensitive to random locations of starting and ending points (model nodes), with alternative model runs suggesting different patterns of connectivity within core habitat areas. The connectivity variation for smaller-bodied species is attributed to computational limitations created by the large spatial extent of the broad landscape used as an analysis area, which encompassed an area roughly the size of the state of Montana. Better understanding of within-patch connectivity for smaller-bodied species would require additional analysis at a finer resolution, or more site-specific level, which is not the appropriate scale for this type of programmatic evaluation.

Habitat connectivity was greatest for alpine and coniferous forest species in the montane geographic areas and highest for grassland-associated species in the pine savanna geographic areas. Model outputs indicated that habitat connectivity for shrub-associated species is quite limited on the Custer Gallatin, but rather occurs at lower elevations between administrative units.

Both random walk and least cost path modeling results for the Custer Gallatin showed the highest value of connectivity habitat for alpine-associated species in the Beartooth Plateau area of the Absaroka Beartooth Mountains Geographic Area, and almost entirely within the Absaroka-Beartooth Wilderness. Moderately high values for alpine-associates were also indicated in the Crazy Mountains of the Bridger, Bangtail, and Crazy Mountains Geographic Area, as well as the Madison Range of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, with corresponding linkage paths between the geographic areas for large-bodied species. Alpine habitat of the Crazy Mountains is largely within checkerboard landownership. A considerable amount of private land and nearly all of the National Forest System lands with high value alpine habitat in the Crazy Mountains are inventoried roadless areas. Alpine habitat in the Madison Range is largely within the Lee Metcalf Wilderness.

The Absaroka Beartooth Mountains, Madison, Henrys Lake, and Gallatin Mountains and Bridger, Bangtail, and Crazy Mountains Geographic Areas all showed high value random walk habitat connectivity for coniferous forest associates, with least cost path concentrations in the Absaroka Mountains of the Absaroka Beartooth Mountains Geographic Area, the Gallatin Crest, Cowboy Heaven, and Taylor-Hilgard Peaks of the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, as well as the west flank of the Bridger and Crazy Mountains in the Bridger, Bangtail, and Crazy Mountains Geographic Area. In the Absaroka Beartooth Mountains and Madison, Henrys Lake, and Gallatin Mountains Geographic Areas, the least-cost paths for forest associates fell largely within the Absaroka-Beartooth Wilderness, Lee Metcalf Wilderness, or the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area. The west flank of the Bridger Range is largely inventoried roadless area, as is the national forest portion of the west Crazy Mountains, but with interspersions of private land.

The Ashland Geographic Area and Long Pines unit of the Sioux Geographic Area showed the highest random walk habitat connectivity for grassland associate species, and contained concentrations of least-cost-paths for grassland species in the southeastern corner of the Ashland Geographic Area and the southern portion of the Long Pines. These geographic areas have no designated wilderness. The Ashland Geographic Area contains three inventoried roadless areas that overlap with some of the high-quality random movement habitat connectivity values for grassland species. According to the model, the highest habitat connectivity values for grassland-associated species occur in multiple-use areas of the Ashland and Sioux Geographic Areas. While there are no designated areas with inherent land-use restrictions in these geographic areas, other than the three Ashland inventoried roadless areas, there are fewer permanent residents and visiting recreationists in the eastern portion of the Custer Gallatin, resulting in lower human demands on the landscape.

The model showed generally low habitat connectivity values for shrub-associated species on the Custer Gallatin. Shrub habitats on the national forest typically occur as small, dense thickets, narrow bands, or irregular patches. Shrublands are frequently found at lower elevations, near the national forest boundary as extensions from adjacent lands, but may also be found at higher elevations in relatively small patches. Mesic montane shrubs may occur in larger patches, but are frequently intermingled with coniferous forest. Riparian shrubs are associated with water sources. As a result, shrublands are naturally quite limited on the Custer Gallatin, accounting for just under 4 percent of the total land base, which supports model results showing low habitat connectivity for shrubland species on the Custer Gallatin.

Model outputs for habitat generalists produced large contiguous blocks of core habitat that included core areas for all habitat specialists, as well as mosaics of different vegetation types. Core areas for habitat generalists were separated only by major human modifications, such as highways passing through or near the national forest boundary. Consequently, nearly all of the Custer Gallatin National Forest provides core habitat for generalist species. Connectivity between core areas for habitat generalists is also predicted to be of highest quality in areas of low or no human modification.

Key Stressors

Land conversion resulting from human development for transportation, residential, commercial, recreational, or agricultural purpose, results in a permanent habitat loss, as well as major disturbance factors, and increased mortality risk for many wildlife species.

Habitat fragmentation occurs when a disturbance or development changes existing vegetation to a condition that is substantially different from adjacent or surrounding conditions. Habitat fragmentation can negatively affect individuals or species that are strongly associated with homogenous vegetation types, particularly those species requiring large, contiguous blocks of consistent vegetation types.

Conversely, habitat diversity resulting from fragmentation may benefit more generalist species, or may benefit more species by providing a variety of vegetative structure and function.

Environmental Consequences

Management Direction under the Current Plans

Habitat connectivity is not necessarily a new concept, but the science is emerging relative to other basic ecological principles. Neither the Custer nor Gallatin current plans contain specific direction for habitat connectivity, other than general references to migratory species. Both plans contain direction to protect a variety of key wildlife habitats, which collectively, have provided for good habitat connectivity over the life of the current plans. For example, both plans contain direction for riparian habitat management, forage emphasis areas, and security cover for wildlife, all of which are crucial elements that provide water, food, and shelter, and which collectively contribute to overall habitat connectivity. The Custer Plan was visionary in recognizing and anticipating the reintroduction of gray wolves into Yellowstone Park and subsequent expansion of the species onto the Custer Gallatin. The Gallatin Plan specifically acknowledged the importance of wildlife resources, including migratory species, not only as they relate to the Gallatin National Forest, but also in the larger context. In the preface, the plan recognizes the significance of the Greater Yellowstone Area and has been designed to complement the management of the entire Greater Yellowstone Ecosystem, and coordinate the use and management of the forest's resources with other national forests, national parks, and agencies involved. This plan contains a provision to maintain natural elk migration patterns in the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area.

Effects of the Current Plans

Management under direction of the current plans has resulted in good habitat quality and connectivity for wildlife within the national forest boundary, as evidenced by the fact that the Custer Gallatin currently supports the complete suite of native fauna that existed prior to development of the original plans, including renewed presence of some species, such as bison, and recovery of a number of previously listed species, including the peregrine falcon, bald eagle and gray wolf, which were all absent, or present at very low numbers when the current plans were written, and which are now all present on the Custer Gallatin with stable to increasing populations. The grizzly bear, another federally listed species, has also thrived under existing plan direction, with increased numbers and distribution within and outside of the recovery zone on the Custer Gallatin. New species have been listed since the plans were written, including the Canada lynx and northern long-eared bat, and subsequent direction was amended to the plans to address known risk factors for lynx. However, there is limited evidence that the Custer Gallatin was ever a stronghold for either species, and it is definitely on the edge of the historical range for the northern long-eared bat. The wolverine, a species that has been proposed for listing under the Endangered Species Act, is still present and well distributed on the Custer Gallatin and has received special emphasis under current plans as a regional forester's sensitive species.

National forest transportation systems (such as roads, trails, and associated use) have been identified as factors that can contribute to habitat fragmentation, cause disruption of normal wildlife behavior patterns, and increase direct mortality risk for a variety of wildlife species. Since the original forest plans were implemented, both the Custer and Gallatin national forests have completed travel management plans that are complementary to forest plan direction and specifically address wildlife habitat and connectivity issues related to location, design, type of use and density of transportation features. Travel plans have resulted in access management that has contributed to maintenance and restoration of habitat connectivity for wildlife across the Custer Gallatin.

Finally, habitat connectivity for wildlife is necessarily an issue that must be addressed not only within the national forest boundary, but also at the broader landscape, as wild animals do not recognize administrative boundaries, and many have life cycle requirements that cannot be wholly met within the national forest boundaries. This factor requires cross-boundary coordination and cooperation with other landowners and jurisdictions. The current forest plans acknowledge this need with broad direction for coordinating with state wildlife management agencies, the U.S. Fish and Wildlife Service, adjacent forests, and Yellowstone National Park. Under this direction, the Custer Gallatin (independently as separate national forests as well as unified since consolidation), has participated in interagency committees and working groups that facilitate communication and coordination across political and administrative boundaries, resulting in numerous habitat restoration projects for wildlife. Examples include, but are not limited to: implementation of a Greater Yellowstone Ecosystem-wide food storage order to minimize wildlife-human conflicts associated with improper storage of attractants; establishment of a whitebark pine seed orchard to produce genetically resistant seedlings for restoring whitebark pine habitat across the Greater Yellowstone Ecosystem; wildlife migration corridor summits; annual monitoring of a major raptor migration corridor; livestock allotment closures to reduce conflicts with native species such as grizzly bears, bison and bighorn sheep; beaver reintroductions to restore riparian habitats that provide important movement corridors for both terrestrial and aquatic species; and systematic inventories for bats. These are a few examples of coordinated, cooperative actions in which the Custer Gallatin has engaged with multiple entities to maintain or restore wildlife habitat and associated connectivity, even in the absence of specific plan direction to do so. Current plan direction has fostered cross-boundary coordination for wildlife habitat management, which would continue, but with a lack of specific direction based on emerging science.

Management Direction under the Revised Plan Alternatives

All revised plan alternatives contain plan components for multiple resource areas that either contribute to, or directly address habitat connectivity for wildlife. Ecosystem plan components for water and aquatic resources (FW-DC/GO/STD/GDL-WTR), riparian management zones (FW-DC/GO/STD/GDL-RMZ), forested vegetation (FW-DC/GO/STD/GDL-VEGF) and non-forested vegetation (FW-DC/GO/STD/GDL-VEGNF) all contain direction to maintain or restore ecological characteristics, which in turn provide habitat connectivity for wildlife. Plan components for all wildlife species (FW-DC/GO/OBJ/STD/GDL-WL) address multiple factors, such as species diversity, abundance, distribution, security, refuge, recovery, and habitat within the natural range of variation. These factors cannot be maintained without adequate habitat connectivity. All revised plan alternatives include specific desired conditions for habitat connectivity and wildlife movement (FW-DC-WL-05, 06). The revised plan alternatives contain multiple goals (FW-GO-WL-02, 03, 05) to work across administrative boundaries to maintain or restore habitat connectivity for wildlife, acknowledging that a broader landscape perspective is vitally important for animal movement and genetic interchange that contributes to biological diversity and ecological integrity. To achieve these desired conditions and goals, the revised plan alternatives include a guideline to minimize barriers to wildlife movement (FW-GDL-WL-01).

Alternatives B, C, D, and F introduce a new plan land allocation of key linkage areas for wildlife, along with associated plan components to limit habitat alterations and disturbance factors (FW-DC-WL-07, FW-STD-WL-02, FW-GDL-WL-02-05). In addition to key linkage areas that are specific to wildlife movement, the revised plan alternatives contain land use allocations for recommended wilderness areas and backcountry areas that are generally managed for low or no human development, leaving natural processes as the primary driver to maintain habitat connectivity. Like the key linkage areas, these plan land allocations differ by alternative in the amount, configuration, and juxtaposition of low development areas.

Finally, in addition to plan components that apply to all wildlife species forestwide, the revised plan alternatives all incorporate species-specific components for key species such as bison (FW-DC-WLBI-02, FW-OBJ-WLBI-01), greater sage-grouse (FW-DC-WLSG-01, FW-GO-WLSG-01), grizzly bear (FW-DC-WLGB-02, FW-GO-WLGB-01), wolverine (FW-DC-WLWV-01), and Canada lynx (FW-DC-WLLX-01), including components adopted from the Northern Rockies Lynx Management Direction (NRLMD: ALL O1; ALL S1; HU O2, O4, O6; HU G7). While the plan components address habitat connectivity for individual species, these species occur in all broad habitat types modeled for habitat connectivity on the Custer Gallatin National Forest. For example, bison are grassland-associated species, greater sage-grouse are shrub associates, wolverines are alpine associates, Canada lynx are forested habitat associates, and grizzly bears are habitat generalists. These are all wide-ranging species for which habitat connectivity is extremely important.

Effects of the Revised Plan Alternatives

Compared to current plans, the revised plan alternatives would all take a more affirmative, proactive approach to maintain or restore habitat connectivity for wildlife. The revised plan alternatives would accomplish this by incorporating specific, science-based desired conditions and goals for coordinated management, which are supported by a series of objectives and guidelines that promote habitat enhancement and limit management actions with potential for negative impacts on wildlife habitat connectivity. Alternatives B, C, D, and F would incorporate the key linkage area plan land allocation and associated land use restrictions for areas of known or intuitive importance for wildlife movement. Alternative E would not include the key linkage area plan land allocation, but rather would depend on protections afforded by existing designated areas, plan land allocations for multiple resources, and other collective plan components to maintain or restore habitat connectivity for wildlife.

All revised plan alternatives contain a desired condition for a complete suite of native species on the Custer Gallatin, with sufficient numbers and distribution to be adaptable to changing conditions for long-term persistence (FW-DC-WL-01). This desired condition adopts a more landscape-scale perspective, while acknowledging that the Custer Gallatin is one of the few areas where a nearly complete suite of native fauna known to be present prior to European settlement are still present today. The only known exception is the black-footed ferret (*Mustela nigripes*), which was historically present in the pine savanna geographic areas, but has long since been extirpated from the Custer Gallatin. This desired condition statement provides a framework that would support re-introduction efforts for species such as the black-footed ferret under the right conditions and reinforces the need for future management actions to maintain conditions that support long-term persistence of the many species that still exist, and even thrive on the Custer Gallatin. This same plan component also speaks to the desired condition for wildlife diversity that contributes to ecological processes such as predator-prey relationships, nutrient cycling, hydrologic function, vegetation composition and structure. It specifically recognizes the interrelationship of many elements that contribute to ecological integrity, and would foster a more integrated approach for future management actions with direction that is less prescriptive in favor of a more holistic and adaptive system compared to existing plan direction.

All revised plan alternatives state a desire for vegetation conditions that are generally within the natural range of variation, to provide wildlife habitat for a variety of life cycle needs, including year-round and seasonal use by a diverse array of species (FW-DC-WL-03). This plan component speaks to the commitment to engage in management practices that emulate natural disturbance patterns and facilitate ecological processes to provide habitat conditions comparable with those to which native wildlife have adapted over time. This plan component relative to wildlife habitat condition is supported by detailed, specific, and measurable plan components for terrestrial vegetation, as addressed below.

The revised plan alternatives share a desired condition for habitat that provides security and refuge for wildlife to escape from stresses and threats, whether they be from natural or man-caused disturbance factors (FW-DC-WL-04). Security is an important factor for habitat connectivity in that animals may resist moving through areas where they feel threatened. Likewise, refugia provide potential staging areas or steppingstones to facilitate wildlife movement through areas that may otherwise produce stressors that could influence natural behavior patterns. The presence of refugia that are relatively buffered from predicted environmental fluctuations may also help to support long distance range shifts of species, such as in response to climate change.

All revised plan alternatives specifically state desired conditions for landscape patterns throughout the Custer Gallatin that provide habitat connectivity for wildlife, particularly wide-ranging species such as medium to large carnivores and wild ungulates (FW-DC-WL-05). Resulting habitat connectivity would facilitate daily and seasonal movement, as well as long-range dispersal of wildlife to support genetic diversity, allowing animals to adapt to changing conditions over time. An assumption for this component is that by providing adequate conditions for large-bodied, wide-ranging species that require larger blocks of suitable habitat to move through, conditions will also be met for smaller-bodied species with shorter dispersal capabilities. This assumption is supported by connectivity modeling results in which locations of core habitat for smaller-bodied species exhibited strong overlap with high-value connectivity areas for larger-bodied species with similar habitat preferences. Since most connectivity for smaller-bodied animals likely occurs within these core areas due to their limited dispersal range, managing the landscape in a manner that protects the connectivity for larger-bodied species should simultaneously protect the highest quality habitat patches, and connections within these patches, for smaller-bodied species.

Another related plan component that applies to all revised plan alternatives states a desire for habitat conditions within the Custer Gallatin, but near the boundaries, to provide structural and functional diversity, and be resilient to existing and predictable future stressors, thereby supporting natural movement patterns for a wide variety of species across administrative boundaries (FW-DC-WL-06). This plan component recognizes the need to consider the broader landscape and provide a high degree of diversity, to accommodate needs of a wide range of species. While habitat diversity is desirable to support varied needs of many species, habitat diversity could also be perceived as habitat fragmentation by habitat specialists that require relatively large, unbroken patches of homogenous vegetation types. However, the purpose of this component is to provide for the many species inhabiting the Custer Gallatin, rather than the few more specialized species. The concept is to maintain conditions conducive to animal movement through an area, and not necessarily conditions that would support long-term or residential occupation of these areas. The intent is to promote wildlife movement across forest boundaries through adjacent areas, to facilitate long-range dispersals needed to maintain or improve genetic diversity.

All revised plan alternatives also contain a goal for cooperation and collaboration with other landowners and partners to expand knowledge and coordinate management across boundaries in order to maintain or improve habitat connectivity over a broader landscape (FW-GO-WL-02). Such coordination has, and would likely continue to occur under current plans, but the revised plan alternatives would formally address the need for such coordination in future land management activities. All revised plan alternatives contain a goal to work with willing landowners to acquire or otherwise conserve non-Federal lands within the national forest boundary where needed to maintain or restore habitat structure, function, and connectivity (FW-GO-WL-03). Existing plans contain similar goals, with wildlife habitat as one of many potential resources for consideration, rather than addressing this specific need to provide for habitat connectivity. Finally, all revised plan alternatives include a goal to work with partners to improve, exchange, and disseminate information to increase awareness of the value of habitat connectivity (FW-GO-WL-05). Better information and understanding may result in new or improved methods to protect and restore habitat connectivity, and maintain good compliance with use restrictions designed to promote habitat connectivity.

The desired conditions and goal statements that are common to all revised plan alternatives give more relevant and focused information specific to habitat connectivity across a highly diverse landscape compared to the broad and more generic desired future conditions and goals stated for wildlife in the current plans, which predict overall habitat improvements and greater diversity of forest structure. Desired condition plan components in the revised plan alternatives, combined with more detailed and specific goals would give national forest managers a more strategic and holistic conceptual process to help align land use programs with wildlife habitat needs across a varied landscape. In addition to desired conditions and goals, all alternatives include objectives for implementing wildlife habitat improvement projects (FW-OBJ-WL-01, 02) that could involve restoration of habitat connectivity. Alternative D has the highest objectives for wildlife habitat, whereas alternative E has the lowest. Alternatives B, C, and F all have the same objectives for wildlife habitat improvement, in a mid-range between alternatives D and E.

All revised plan alternatives include a guideline that management actions should not create movement barriers to wide-ranging species, except where necessary to provide for human or wildlife safety (FW-GDL-WL-01). While certain conditions on the ground may impede movement to some degree for certain species, there are few management actions in which the Forest Service engages that would create a true barrier to wildlife movement, particularly for large-bodied, wide-ranging species that have the ability to go over, under, through, across, or around most obstacles. However, large-scale developments or features strategically placed in concert with natural barriers such as a large reservoir or cliff wall, can notably affect permeability of the landscape for wildlife. This guideline would ensure that management actions that could alter the natural environment would be evaluated for possible impacts on movement patterns of wide-ranging species, and require mitigation or revision for those actions that would not maintain or restore habitat connectivity for wildlife. On the other hand, the guideline would allow for management actions specifically designed to restrict wildlife movement when needed to provide for human or wildlife safety. An example would be construction of a fence or other barrier deliberately designed to prevent wildlife from approaching and crossing a highway at an area where vehicle collisions with wildlife are an issue for both human and wildlife safety. Additional modifications could be made to funnel wildlife movement to an area of higher visibility, or even to a manufactured wildlife crossing structure. This guideline addresses an issue that is not covered under current plan direction.

Alternatives B, C, D, and F incorporate a plan land allocation for key linkage areas with associated plan components. The 2012 Planning Rule requires consideration of ecological connectivity at multiple scales to provide landscape linkages that facilitate the movement of species (FSH 1909.12). Many potential landscape linkages were identified in the Custer Gallatin habitat connectivity modeling exercise, but not all were identified as key linkage areas needing additional plant components. For example, some of the highest quality areas for habitat connectivity are already in designated areas, such as wilderness, in which major developments or construction of permanent structures that could present obstacles to wildlife movement would not be allowed. Land use restrictions mandated by law in designated wilderness provides the protection needed to maintain habitat connectivity, and therefore additional plan components were not necessary. Some parts of the Custer Gallatin identified as highly important for habitat connectivity were in habitat types where there are few known threats to habitat connectivity associated with likely Forest Service management actions (such as alpine areas). Accordingly, many areas of the Custer Gallatin identified as highly important for habitat connectivity are either already protected, or have few management-related threats, and were not singled out for plan land allocation as key linkage areas or additional plan components with added restrictions.

The locations identified as key linkage areas include the north end of the Gallatin Range in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area and the west side of the Bridger Range in the Bridger, Bangtail, and Crazy Mountains Geographic Area. Refer to the maps in appendix A. These areas were identified for fine-filter plan components for a number of reasons. They are within the top one percentile of habitat connectivity value for forest associates, and vegetation management actions have the greatest potential for impacts on forested habitats. Interstate 90 and nearby development presents a major impediment or barrier to north-south movement for most land-dwelling wildlife species that occur on the Custer Gallatin. Those capable of getting across the highway face high mortality risk to do so. The key linkage areas in alternatives B, C, D, and F encapsulate the portions of the Custer Gallatin that are nearest Interstate 90, and occur as relatively narrow bands that create a natural ecological flow pattern funneling wildlife movement to a point where crossing the Interstate may be attempted to reach a destination. The key linkage areas represent the shortest distance between Custer Gallatin administrative units that would involve a crossing of Interstate 90. Managing National Forest System lands nearest the highway for habitat connectivity would provide potential staging opportunities for wildlife on the move to remain relatively secure until a safe crossing of the highway can be executed. The path between the Gallatin and Bridger Mountain Ranges presents the shortest distance for wildlife to travel between isolated parcels of public lands in a north-south (or vice versa) fashion between larger contiguous blocks of relatively secure habitat. While other important linkage areas are present on the Custer Gallatin, none has the same unique ecological characteristics, social demands from proximity to population centers, or management concerns as those identified in the key linkage areas found in alternatives B, C, D, and F.

The key linkage area concept for alternatives B, C, D, and F focuses on providing landscape connectivity for long-range dispersals. The concept was developed under the assumption that managing for connectivity over a broader area to promote more random movement patterns of inexperienced individuals attempting long-range dispersal to establish a new home range, would also provide for more deliberate, often linear movement patterns of resident animals within a home range. This assumption was supported by connectivity modeling results for the Custer Gallatin, which showed all optimal movement corridors (such as those likely to be used for daily or seasonal movements by residents) to be within the more diffuse, broad areas that present many options for random movements of inexperienced animals.

Under alternatives B, C, D, and F, habitat with a key linkage area plan land allocation would be managed in accordance with guidelines allowing vegetation management with consideration to maintain or enhance habitat connectivity for wildlife (FW-GDL-WL-02). However, guidelines would also require “rest” periods with no major vegetation management projects for at least 4 out of every 10 years, including 2 consecutive years (FW-GDL-WL-05). Timing restrictions in key linkage areas would result in periods relatively free from large-scale disturbance that would allow wildlife to flow more freely through the area. This plan component was based at least partially on current forest plan timing and re-entry standards for grizzly bears and elk. Research has shown that large-bodied, wide-ranging animals such as elk and grizzly bears avoid areas of high disturbance, such as those associated with major vegetation management actions such as logging operations (Lyon et al. 1985, Waller 1992). This research showed that animals were frequently displaced when logging operations involved the use of heavy equipment during peak activity, but returned soon after logging operations were complete. These studies indicated that such disturbance over extended periods could permanently displace wildlife. Accordingly, duration limits for major activities, followed by periods of inactivity, were incorporated into current plan direction for grizzly bears and elk. However, the research cited and associated plan direction focused on habitat use by resident animals within home ranges. Dispersal movements, and even migratory movements between seasonal ranges, may occur at different rates (for example, animals may move more quickly), and may occur through suboptimal habitat conditions (Zeller et al. 2014, Abrahms et al. 2017, Brennan et al. 2018, Vanbianchi et al. 2018). Therefore, timing limits and rest periods for key linkage areas were developed to provide periods of low management activity, while allowing some management flexibility.

Under alternatives B, C, D, and F, habitat alteration effects from vegetation management in key linkage areas would be temporary, as succession and natural disturbance processes continue to change vegetation and disturbance effects would be temporary with requirements for “rest” periods. This would allow both experienced and inexperienced animals attempting to move through an area to find places and times free of major disturbances. The requirement for at least two consecutive years of no major vegetation projects would help facilitate multi-year dispersal events. Alternatives B, C, D, and F would also exclude authorization of new overnight recreation events in key linkage areas (FW-STD-WL-02), which would limit disturbance impacts on wildlife and allow more temporal options for animals attempting to move through key linkage areas.

Construction of new permanent facilities or structures such as roads, trails, or campgrounds to accommodate increased recreation use, would generally not be allowed within key linkage areas unless needed to address ongoing or imminent resource concerns within the key linkage areas (FW-GDL-WL-03). For example, a new hiking trail would not be constructed to accommodate increased demand for hiking opportunities, but an existing hiking trail could be relocated within the key linkage area if it is contributing unacceptable sediment levels to a stream in the current location. New permanent infrastructure for administrative purposes could be added within key linkage areas, but with location and design features to avoid impacts to wildlife habitat connectivity (FW-GDL-WL-04). Limiting new permanent structures and facilities within the key linkage area would limit habitat loss and fragmentation associated with human development, and would limit disturbance impacts associated with use of human facilities.

Because cross country mountain bike use has the potential to increase levels of habitat alteration, chance for conflict with wildlife, and displacement of wildlife (Quinn and Chernoff 2010), within the key linkage areas mountain biking is only suitable occur on approved system routes (FW-SUIT-WL-01).

Restricting suitability to approved system trails will concentrate potential impacts and minimize the proliferation of user created routes which increase the footprint of human use on the landscape.

Other plan land allocations may overlap with key linkage areas. In alternatives C and F, parts of the key linkage area would also be allocated as backcountry area. In areas of dual allocation, the more restrictive direction would apply, so new trails for hiking, horseback riding, or mountain biking that would otherwise be allowed in a backcountry area could be constructed in the key linkage area only if needed to address immediate resource concerns (FW-GDL-WL-03). Similarly, where salable mineral removal could otherwise occur within the key linkage area subject to timing restrictions, this activity would not be allowed with dual allocation as a backcountry area in alternative C or F (FW-STD-BCA-04). Alternative C has considerably more overlap between backcountry area and key linkage area, affecting both the north (Bridger Range) and south (Gallatin Range) key linkage areas, compared to alternative F, which only has overlap at the north end of the north (Bridger) key linkage area.

In alternative D, portions of both the north (Bridger Range) and south (Gallatin Range) key linkage areas would also have plan land allocations as recommended wilderness. Since the more restrictive direction would apply, some vegetation management actions that would otherwise be allowed in the key linkage areas would not be allowed in the recommended wilderness area portions. No new temporary or permanent roads would be allowed for any purpose, and no new energy or utility structures, communication sites, or extraction of saleable minerals would be allowed (FW-STD-RWA-01-03, 06). The recommended wilderness area portions of key linkage areas would no longer be suitable for mechanized (such as mountain bike) or motorized transport (FW-SUIT-RWA-02). Collectively, these restrictions would provide better security for wildlife movement within the recommended wilderness area portions of the key linkage area. However, because the recommended wilderness portions would also be unsuitable for timber harvest (FW-SUIT-RWA-01) restrictions could prohibit certain vegetation management activities to maintain or enhance wildlife habitat connectivity. For example, vegetation management projects designed to increase resilience to fire, insects and disease; to improve forage conditions; or to enhance visibility for wildlife might not be allowed in recommended wilderness area portions of the key linkage areas if mechanical timber harvest were required to implement the project. Likewise, mechanical removal of dense, down timber after a blowdown, fire or other natural disturbance to improve area permeability for wildlife may not be allowed in recommended wilderness area portions. Restrictions tied to recommended wilderness areas could also prohibit construction of features specifically designed to enhance wildlife habitat connectivity. On the other hand, new trails for hiking or horseback riding that would otherwise be allowed in a recommended wilderness area would not be constructed in the key linkage areas unless needed to address immediate resource issues (FW-GDL-WL-03).

Alternative E has no plan land allocation or associated plan components for key linkage areas. Permanent developments would be allowed to some degree; however, considerable portions of the key linkage areas are also inventoried roadless areas, so in those portions, future management actions would follow restrictions for inventoried roadless areas. Alternative E plan land allocations would be the same as the current plans, with no added land use restrictions to facilitate wildlife movement in a north-south direction across Interstate 90 and associated developed areas. Alternative E would have less potential than alternatives B, C, D, and F to promote wildlife movement, particularly long-range dispersal of individuals to increase genetic diversity of subpopulations of animals.

Consequences to Connectivity from Plan Components Associated with Other Resource Programs or Management Activities

Effects of Designated Areas and Plan Land Allocations of Recommended Wilderness Areas and Backcountry Areas

Designated areas are established by statute, regulation, or policy. Examples include wilderness areas, wilderness study areas, and inventoried roadless areas, all of which have prescribed purposes, conditions, or restrictions. Designated wilderness, wilderness study areas, and inventoried roadless areas are managed to provide and maintain a natural environment that is generally in a condition undisturbed by human activity. By contrast, land use allocations are developed in the forest planning process, and are not designated by statute, regulation, or policy. Aside from key linkage areas, plan land allocations of note for wildlife habitat connectivity include recommended wilderness and backcountry areas. Recommended wilderness areas would be managed to maintain wilderness characteristics, while backcountry areas would be largely undeveloped or lightly developed, and maintained in a generally natural condition. More detailed information can be found in the Designated Areas and the Plan Land Allocation sections of the final environmental impact statement.

Most of the high-value core habitat for alpine-associated species is located within the Absaroka-Beartooth and Lee Metcalf Wilderness Areas. Core habitat and associated connections within these designated wilderness areas would be maintained by land use restrictions mandated by the Wilderness Act. Some core areas and connecting habitats for alpine associates is also located in the high peaks of the Crazy Mountains, most of which is currently inventoried roadless area. In the revised plan alternatives, plan land allocations do not overlap with designated wilderness, but frequently overlap with inventoried roadless areas. As described above for key linkage areas, where plan land allocations overlap with designated areas such as inventoried roadless, the more restrictive direction applies. For alpine-associated species, alternatives B and E have no plan land allocations in the Crazy Mountains that would add more land use restrictions. Alternative C allocates backcountry area in the alpine habitat of the Crazy Peaks; alternative D allocates recommended wilderness that overlaps with core alpine habitat; and alternative F allocates both backcountry area and recommended wilderness that would overlap with core alpine habitats. For these alpine areas, plan land allocations of recommended wilderness would have the most restrictions on administrative and public use (FW-STD/GDL/SUIT-RWA-All). Backcountry areas have fewer restrictions than recommended wilderness, but still preclude some uses that would otherwise be allowed in inventoried roadless areas (FW-STD/GDL/SUIT-BCA-All and SX, AL, PR, AB, BC, MG-STD/GDL/SUIT-BCA-All). Therefore, alternative D contains the most restrictions that would maintain habitat connectivity for alpine-associated species, followed by alternatives C, F, B and E. Management actions generally are not targeted in alpine habitats, and would not notably affect habitat connectivity within major core areas under all alternatives. Individuals may attempt dispersal movements between large blocks of core alpine habitats in different geographic areas, but such dispersal would require movement through lower elevation suboptimal habitat for these species regardless of management actions.

Highest-value core areas and connecting habitats for forest-associated species are located in the Absaroka Beartooth Mountains; Madison, Henrys Lake, and Gallatin Mountains; and Bridger, Bangtail, and Crazy Mountains Geographic Areas of the montane ecosystem. The top one percentile of forested connectivity habitat is primarily located in designated areas, with roughly 90 percent of the best random movement habitat and 83 percent of the best optimal connecting paths found in designated wilderness, wilderness study, or inventoried roadless areas, which each have a specific set of land use restrictions.

Therefore, land management actions that could impact habitat connectivity for coniferous forest-associated species would be somewhat restricted under all alternatives. Additional restrictions apply to high-value forested habitats in the key linkage areas (described above) under alternatives B, C, D, and F.

Most of the core habitat and associated high-value connections for forested associates in the Absaroka-Beartooth Geographic Area are located within designated wilderness, where habitat connectivity would be maintained by land use restrictions dictated by law. Outside of designated wilderness, some additional core area and high- to moderate-value connections currently fall within inventoried roadless areas. Alternative D would add recommended wilderness in most of the high value core and connecting habitat outside of designated wilderness for forest-associated species in the Absaroka-Beartooth Geographic Area. None of the other alternatives contains plan land allocations in high-value connecting habitats in this geographic area.

In the Madison, Henrys Lake, and Gallatin Mountains Geographic Area, high value habitat for forest-associated species is well protected in the Lee Metcalf Wilderness Area. Outside of designated wilderness, high-value forested habitat is widespread in this geographic area, with particularly high values (least cost path for movement) along the Gallatin Crest, the Lionhead area, and Cowboy Heaven. Plan land allocations overlap with high-value forested habitat in the wilderness study area (Gallatin Crest) and inventoried roadless areas (Lionhead and Cowboy Heaven). Alternatives B, C, D, and F add recommended wilderness allocations in the Gallatin Crest area, whereas alternative E would allocate backcountry area along the Gallatin Crest. Alternatives B, C, and D allocate recommended wilderness in the Lionhead and southern Taylor Hilgard area; alternative F would allocate backcountry area for the Lionhead, and recommended wilderness for the Taylor Hilgard; and alternative E would allocate backcountry area for Lionhead, with no plan land allocation for the southern Taylor Hilgard unit. Alternatives C, D and F would allocate recommended wilderness in Cowboy Heaven; alternative B would allocate backcountry area, and alternative E would have no plan land allocation for Cowboy Heaven. Therefore, alternatives D and C would impose the most land use restrictions in high-value forested habitat outside of designated wilderness in the Madison, Henrys Lake, and Gallatin Mountains Geographic Area; followed by alternatives B and F, with alternative E having the least land use restrictions of the revised plan alternatives.

The Bridger, Bangtail, and Crazy Mountains Geographic Area also provides high-value core habitat and connectivity for random wildlife movement in forested habitats, with high-value corridors along the west slopes of the Bridger Range and Crazy Mountain Range. These areas are currently within inventoried roadless designations, and the west slope of the Bridger Range would receive plan land allocation as key linkage area in alternatives B, C, D, and F, as noted previously. Other than key linkage, alternative B has no plan land allocation for these areas. Alternative C would allocate backcountry area to both the Bridger and Crazy Mountain high-value forested connectivity habitat, whereas alternative D would allocate recommended wilderness in these areas. Alternative F contains a relatively small backcountry area allocation at the north end of the Bridger Range, which falls within the key linkage area. Alternative F would allocate a mix of backcountry area and recommended wilderness area in the Crazy Mountains. Alternative E has no plan land allocations that would restrict management actions or public access in the Bridger, Bangtail, and Crazy Mountains Geographic Areas.

In all geographic areas, recommended wilderness allocations and associated plan direction would provide the greatest protection from permanent habitat alterations and human disturbance in high-value forested habitats, but would also limit some tools and techniques that could be used to maintain or restore habitat connectivity in forested areas, relative to backcountry areas, key linkage areas, and areas with no plan land allocations. In addition to use restrictions that would maintain forest habitat connectivity within plan land allocations, all alternatives would carry forward direction from the Northern Rockies Lynx Management Direction, which directly addresses habitat connectivity for lynx (NRLMD Objectives ALL O1, HU O2, HU O4, HU O6; Standard ALL S1; and Guideline HU G7). Since Canada lynx are strongly associated with boreal forest habitats, these plan components would help to maintain habitat connectivity for other species that use boreal forest habitats, both within and outside of plan land allocation areas.

Grassland habitats are a minor component relative to alpine and forested habitats on the Custer Gallatin. Habitat connectivity for grassland-associated species is greatest in the pine savanna ecosystem, with highest quality values found in the southern part of the Ashland Geographic Area and a small amount in the Long Pines unit of the Sioux Geographic Area. Moderate levels of connecting habitat occur between these core areas. There are no designated areas (such as wilderness or inventoried roadless) in the high-value connectivity areas for grassland species in the Ashland or Sioux Geographic Areas, nor do any of the revised plan alternatives include plan land allocations that would add land use restrictions in the highest value areas for grassland connectivity. Livestock grazing and roads are the primary management actions with potential to affect habitat connectivity for grassland-associated species in the Ashland and Sioux Geographic Areas. Some grassland-associated species are increasing in these areas. For example, pronghorn antelope are grassland associates that have increased in both numbers and distribution in the pine savanna ecosystem geographic areas (Montana Fish Wildlife and Parks Pronghorn Data 2022, Deisch, 2019a personal communication), indicating good habitat connectivity in these areas for large-bodied, wide-ranging species. Therefore, no additional (fine-filter) components were included in the revised plan alternatives for grassland habitats.

Overall habitat connectivity is quite good for large- and smaller-bodied habitat generalists within the Custer Gallatin Forest boundaries, and has been well maintained under existing plan direction. All revised plan alternatives would incorporate desired conditions, goals, and guidelines to ensure that habitat connectivity is a consideration for future land management practices (FW-DC-WL-03, 05; FW-GO-WL-02, 03, 05; FW-GDL-WL-01). In addition, fine-filter components for individual wildlife species would protect important seasonal habitats and reproductive areas (FW-GDL-WL-06-08; FW-GDL-WLBG01-03), which would further contribute to habitat connectivity under all revised plan alternatives. Alternatives B, C, D, and F add specific plan components for key linkage areas (FW-DC-WL-07; FW-STD-WL-02; FW-GDL-WL-02-05). This would further protect potential corridors that have been identified in the scientific literature (Walker and Craighead 1997, Claar et al. 2003, Western Governor's Association 2008, Cushman et al. 2009, Wade et al. 2015), as well as Custer Gallatin connectivity modeling results (Williamson et al. 2020) as important for wildlife movement between intact ecosystems.

Effects of Aquatic and Riparian Habitat Management

The revised plan alternatives include substantially more detailed and restrictive plan components for watersheds and riparian management zones of the Custer Gallatin National Forest compared to the current plans (FW-DC/GO/OBJ/STD/GDL/SUIT-WTR/RMZ All). Access to water is crucial for wildlife, and animals on the move are no exception. Wildlife often follow watercourses and drainages when moving within home ranges, between seasonal ranges, and even during dispersal movements. All revised plan alternatives acknowledge that riparian habitats provide important travel corridors for a wide range of terrestrial species (FW-DC-WTR 10). Overall stronger riparian protections in the revised plan alternatives would serve to better maintain or restore habitat connectivity for wildlife associated with riparian areas, compared to the current plans.

Effects of Terrestrial Vegetation Management

All revised plan alternatives include a suite of plan components for terrestrial vegetation management designed to maintain or restore the ecological integrity of Custer Gallatin National Forest lands (FW-DC/GO/OBJ/STD/GDL-VEGF/VEGNF All). These components include desired conditions for vegetation that fall generally within the natural range of variation (FW-DC-VEGF-01, FW-DC-VEGNF-04), which would result in habitat connectivity and landscape patterns similar to those which native species have adapted to over time. The revised plan alternatives incorporate new scientific concepts reflective of more ecological thinking, and include considerably more detail regarding vegetation community composition, structure, function, and patch size, with a greater emphasis on providing for ecological integrity and resilience to disturbances under changing environmental conditions, compared to current plans. Collectively, these plan components would maintain or restore habitat connectivity for wildlife residing on or moving through the Custer Gallatin National Forest under all revised plan alternatives.

Effects of Fire and Fuels Management

Native wildlife on the Custer Gallatin are typically fire-adapted species. Wildfires are expected to be the most prominent disturbance factor influencing habitat connectivity during the life of the revised plan. Climate projections predict increases in fire size, frequency, and severity relative to fire regimes experienced under current plans. All revised plan alternatives include desired conditions for the amount and severity of wildland fires to be within the natural range of variation to maintain resilient ecological conditions (FW-DC-FIRE-01, 02). Management actions for fire and fuels would be focused on reducing risk to high value resources most commonly found in more developed areas, including the wildland urban interface (FW-DC-FIRE-02, 03). Therefore, under all alternatives, fire and fuels management actions would be focused in areas of relatively high human modification, which generally have lower habitat connectivity values for wildlife. Simultaneously, the revised plan alternatives recognize that wildland fire is a necessary and crucial ecological factor that plays an important role in shaping habitat for a wide array of wildlife species. To that end, the revised plan alternatives all include an objective for at least 375,000 acres of wildfire per decade on the Custer Gallatin (FW-OBJ-FIRE-02), based on predictions that wildfire-affected acres will at least double compared to what the landscape has experienced under current plans. Fire and fuels management actions would be designed to move toward the desired ecological conditions, which would generally be within the natural range of variation, resulting in conditions similar to those in which native species have evolved.

Effects of Timber Management

Under all alternatives, the effect of timber management on habitat connectivity would be small relative to effects from natural disturbance processes such as fire, insects or disease, and natural succession of vegetation communities. Regeneration harvest methods that remove all or most live trees, would alter habitat connectivity at a small scale for forest-associated species, but could temporarily improve habitat, and possibly increase habitat connectivity for grass and shrub-associated species, as well as some habitat generalists, again at a small-scale relative to natural disturbance processes. Under all alternatives, timber harvest for producing wood products would be allowed only on lands classified as suitable for timber production (FW-STD-TIM-01). The proportion of the Custer Gallatin land base classified as suitable for timber production is lower in all geographic areas under all revised plan alternatives compared to current plans (see table 26, under Timber in the Benefits to People section of the environmental impact statement), which would reduce potential for negative impacts to forest-associated species due to timber production under all revised plan alternatives.

Maximum opening size created by timber harvest would be limited (FW-STD-TIM-08), and shape of openings created would be designed to mimic the general shape of natural openings in the surrounding areas (FW-STD-TIM-05) in all revised plan alternatives. These plan components would limit habitat fragmentation in forested landscapes due to timber production, and create openings that may feel more familiar to wildlife by varying edge patterns. Timber management practices would be designed to facilitate conifer regeneration within a relatively short timeframe (FW-STD-TIM 10), so habitat fragmentation effects would be temporary.

Under all revised plan alternatives, timber harvest could occur outside of the suitable timber base, but only for purposes of achieving other resource objectives, such as reducing hazardous fuels to alter fire behavior, or restoring habitat conditions altered by insects, disease, or other natural disturbance processes. Timber harvest methods such as thinning and intermediate harvest would serve primarily to reduce existing tree density, which could be used to change tree species composition toward desired conditions, or could also be used to increase the average size of individual trees, thus increasing the large tree element in forested landscapes, and increasing structural diversity of some forested habitats. Timber management then could have negative impacts on habitat connectivity for some species, while benefitting or having neutral effects on others. However, under all the revised plan alternatives, the desired conditions for vegetation composition, structure, and function, (FW-DC-VEGF) would drive timber management toward achieving conditions within the natural range of variation, to which most native species have adapted.

Effects of Invasive Species Management

Invasive species, whether plant, animal, aquatic, or other organisms, often have potential to substantially outcompete native organisms, which can result in disruption of natural processes. The presence and spread of invasive species can alter vegetative conditions, which can result in habitat fragmentation for native species, particularly smaller species. The revised plan alternatives all contain desired conditions in which invasive species are absent or in low abundance, with no disruption of natural ecological function on the Custer Gallatin (FW-DC-INV-01). All revised plan alternatives contain multiple goals to coordinate with Tribes, other agencies, landowners, and organizations to prevent the spread of invasive species and to better inform the public on measures to prevent the spread of invasive species (FW-GO-INV-01-04). Reducing the spread of invasive species would promote better habitat connectivity for wildlife. Finally, the revised plan alternatives acknowledge that some non-native species are desirable. For example, mountain goats are not native to the Custer Gallatin, but provide prey species for predators, contribute to nutrient cycling in relatively harsh environments, and provide high-quality hunting and viewing opportunities for forest visitors. All revised plan alternatives support the presence of desired non-native species where they do not conflict with native species and contribute to healthy, functioning ecosystems (FW-DC-INV-01).

Effects of Permitted Livestock Management

Domestic livestock can alter grassland habitats through grazing, and can affect shrub habitats through browsing and trampling, which may have negative impacts to native species associated with these habitats, particularly smaller species. Domestic livestock generally have low impacts on coniferous forest habitats, but can delay forest regeneration after a disturbance such as fire or timber harvest, through trampling of conifer seedlings. Plan components adopted for lynx (NRLMD Guideline GRAZ G1) would prevent such impacts in many areas. The revised plan alternatives include desired conditions that grazing allotments contribute to ranching operations and local economies, while maintaining or moving toward desired ecological conditions (FW-DC-GRAZ-01), and add a desired condition for non-grazed areas to provide reference conditions for comparison purposes (FW-DC-GRAZ-03). To achieve these conditions, the revised plan alternatives include direction for new or revised allotment management plans to include grazing practices that will maintain or improve resiliency of riparian and upland ecosystems (FW-STD-GRAZ-01). These requirements would reduce potential livestock-related impacts to habitat connectivity for grassland and shrub-associated species. Revised plan alternatives include several components to specifically protect riparian and shrub habitats from livestock grazing pressure (FW-STD-GRAZ-01, FW-GDL-GRAZ-01, 02, 04, and 05). This direction would benefit habitat connectivity for a wide range of species, since riparian areas provide water, forage, and cover for many species on the move, and shrub/hardwood habitats provide for plant and animal diversity on the landscape. The revised plan alternatives also include direction for livestock grazing practices to meet big game forage needs on winter range (FW-GDL-GRAZ-03), which would maintain or improve habitat connectivity for large and smaller grassland species, by limiting livestock impacts to forage abundance, as well as plant species composition and structure that may be important for smaller grassland-associates.

Infrastructure associated with livestock grazing can also affect habitat connectivity for wildlife. All revised plan alternatives would help reduce negative impacts by requiring new or reconstructed livestock fencing to be designed or located to avoid potential wildlife collisions with or entanglement in fencing constructed on livestock allotments (FW-GDL-GRAZ-07). These considerations would allow free movement of wildlife, fewer wildlife injuries or mortalities related to livestock fencing, and ultimately better distribution of wildlife. Water features constructed for domestic livestock can benefit wildlife in arid environments, but can also pose a hazard for some native species, again with smaller-bodied wildlife facing the greatest risk of entrapment in livestock water features. All revised plan alternatives include direction to facilitate animal escape and prevent drowning hazards to wildlife associated with livestock water infrastructure (FW-GDL-GRAZ-08).

Effects of Infrastructure Management (Roads, Trails, Facilities, and Airfields)

Forest infrastructure such as roads, trails, and other permanent developments, can result in direct habitat loss at a relatively small scale associated with vegetation removal to create travel surfaces. Disturbance factors associated with human use of travel routes can also influence wildlife habitat use patterns. Human use of National Forest System roads and trails can result in wildlife mortalities due to vehicle collisions, or hunting. High speed and traffic volume are factors most frequently attributed to road impacts on wildlife movement patterns (Claar et al. 2003). Several studies have concluded that secondary, unpaved roads with lower speed and traffic volume have low impact on large-scale wildlife movement patterns (Forman 2003); however, different wildlife guilds, species, and individuals may have widely variable tolerance or avoidance tendencies relative to secondary roads (The Wilderness Society 2014). While some animals may avoid roads and underutilize habitat near roads, others actually use roads and trails to facilitate movement between habitats. Less than one percent of roads within the national forest boundary are paved routes that accommodate higher speeds and traffic volume. Over 90 percent of national forest roads are generally narrow (often single track) gravel or dirt surface that accommodate low levels of slow-moving traffic. Roughly half of the secondary roads within the national forest boundary are open to administrative use only, which means they are not open to motorized use by the general public.

Under all revised plan alternatives, forestwide plan components include desired conditions for a safe, efficient transportation system that poses minimal impacts on other resources (FW-DC-RT-01). Revised plan alternatives include plan components that encourage use of technologies that reduce impacts to other resources (FW-GDL-RT-01), and facilitate removal and restoration of roads and facilities no longer needed (FW-GDL-RT-02). These components would prompt location and design considerations for wildlife habitat connectivity, and limit temporal habitat alterations and associated disturbance impacts from project roads. All revised plan alternatives for infrastructure management emphasize protection of water and riparian resources (FW-STD-RT-01, 03, 04, 05; FW-GDL-RT-03 through 11; FW-GDL-FAC-01 through 05), which would limit permanent developments within or near water sources and riparian habitats, reducing potential impacts from habitat loss and water quality degradation in important connecting habitats for wildlife.

The revised plan alternatives include additional measures that place restrictions on road construction and administrative facilities in old-growth forest (FW-GDL-VEGF-02) and riparian areas (FW-RMZ-GDL 03), which would further reduce habitat fragmentation in important wildlife connectivity habitats. All revised plan alternatives include a goal to work with highway managers, state agencies, landowners, and other interested parties to facilitate safe highway crossings for wildlife (FW-GO-RT-03). This provision would support maintenance and restoration of habitat connectivity both within the forest boundary, as well as across the broader landscape. Airfields for public use would be unsuitable in a large portion of the Custer Gallatin (FW-SUIT-AIRFIELDS-01), which would limit potential habitat fragmentation and disturbance impacts from public aircraft landing and taking off on the national forest. Plan components for infrastructure, other than objectives, do not vary by alternative; therefore, effects to habitat connectivity would be the same under all revised plan alternatives. However, revised plan alternatives provide more detailed guidance, and more restrictions on construction of new roads and other facilities, than contained in current plans, so the revised plan alternatives would provide overall better protection for habitat connectivity; particularly with respect to riparian habitats that provide potential travel corridors for a wide variety of wildlife species.

Effects of Land Ownership and Use Management

Land status and ownership, along with associated uses can affect wildlife habitat and movement patterns. The revised plan alternatives support responsible land use for multiple uses such as mineral and energy production, and transportation systems that provide reasonable public access to the national forest (FW-DC-LAND-01 through 06; FW-DC-LAND USE-01, 02). Permanent human developments on the landscape can cause habitat fragmentation that can reduce connectivity for wildlife, and increased human access can have disturbance effects that may cause wildlife to alter normal behavior patterns. On the other hand, the revised plan alternatives also support consolidated land ownership (FW-DC-LAND-01), which could provide larger blocks of public lands with generally higher management restrictions on permanent development relative to private ownership. Land consolidation can serve to reduce wildlife-human conflicts and reduce potential for permanent habitat loss, which would facilitate maintenance or restoration of habitat connectivity for wildlife. Revised plan alternatives also include direction to minimize habitat alterations from land uses through colocation or other design features for new developments (FW-GO-LAND USE-01; FW-GDL-LAND USE-02 through 04). Such direction would ensure consideration of wildlife habitat needs, including habitat connectivity.

Effects of Recreation Management

The revised plan alternatives seek to accommodate a wide range of recreational uses, including meeting the needs for increasing recreation demand over time (FW-DC/GO/STD/GDL/SUIT-REC*All). Permanent recreation infrastructure such as roads, trails, campgrounds, ski resorts, etc., result in permanent habitat loss and potential habitat fragmentation at a variety of scales, which affects habitat connectivity for wildlife. Noise and disturbance associated with human presence and use can cause animals to change use patterns, which may result in underutilization of otherwise suitable habitats, further impacting habitat connectivity for wildlife. Forest management plans guide and constrain Forest Service actions; plans do not directly constrain public uses (FSH 1909.12 section 22.1). While plan components can influence the types of public use that may occur, they have little influence on levels of public use, other than through limitations on access to certain areas.

The revised plan alternatives place limits on addition of infrastructure to accommodate recreation use for multiple resources, as described throughout the Wildlife section of the environmental impact statement. By limiting infrastructure, the revised plan alternatives indirectly influence the amounts and types of public recreation use that can occur throughout the national forest. For example, plan land allocations such as recommended wilderness, backcountry areas, and key linkage areas limit the amount of new infrastructure for recreation use (FW-STD-RWA-01 through 04; FW-STD-BCA-01 through 03; FW-GDL-WL-03, 04).Plan land allocations can also limit certain types of recreation use that could be authorized under special use permit (FW-STD-RWA-05; FW-STD-BCA-05; FW-STD-WL-02; FW-GDL-RECEVENT-02), which collectively limit the amount and type of access for public recreation, and, in turn can limit disturbance impacts by influencing access. On the other hand, plan land allocations for recreation emphasis areas acknowledge existing popular and high-use recreation areas (FW-DC-REA-01 through 06). Recreation emphasis areas have existing high use by a variety of forest user groups. Locations are typically front-country, accessible by road, and often relatively close to human population centers. As a result, recreation emphasis areas may have a high density of infrastructure and associated human use. Concentrated human use areas can result in habitat fragmentation due to permanent developments, and high levels of noise and disturbance associated with human presence, which can reduce habitat connectivity for wildlife within and near recreation emphasis areas. However, concentrating human use in some areas can also limit disturbance impacts in more remote areas of the national forest, since recreation infrastructure facilitates certain types of use, attracting certain user groups to particular areas, rather than prompting users to go in search of recreation opportunities where infrastructure is not provided. While recreation emphasis areas would be managed with a recreation focus and continued concentrated use can be expected in these areas under all alternatives, additional recreation infrastructure could be added in areas outside of recreation emphasis areas where not otherwise restricted, which could result in habitat alteration and added disturbance effects to wildlife.

Recreation emphasis area allocations vary in number and acreage by alternative. Alternative D has the fewest, with corresponding least acreage in recreation emphasis area allocation, whereas alternative F has the most areas with the largest acreage in recreation emphasis area allocation. While alternative D has the least plan land allocation for recreation emphasis area, it makes no plan land allocation that would notably change the nature of concentrated uses already occurring in recreation emphasis areas identified in other alternatives. Therefore, effects of recreation emphasis area allocations on wildlife habitat connectivity would be similar among the revised plan alternatives. However, with the most recommended wilderness, alternative D would impose more restrictions that would limit added recreation infrastructure outside of recreation emphasis areas, thereby reducing potential for future recreation development that could impact habitat connectivity, compared to other alternatives.

The revised plan alternatives would cap the number and limit the size of recreation residences (FW-STD-RECRES-01, 02), limit development of ski areas to existing locations where possible (FW-STD-RECSKI-02; FW-GDL-RECSKI-02) and limit the number of individuals allowed for certain recreation events authorized under special use permit (FW-GDL-RECGROUP-01). Collectively, these plan components would further restrict the amount of permanent development that could have fragmentation impacts on habitat connectivity and limit the types, amounts, and locations of certain types of uses and associated disturbance impacts on wildlife habitat connectivity. With added plan components that guide and limit developments to accommodate recreation uses, the revised plan alternatives take a more affirmative, proactive approach to manage recreation use in a way that would help to maintain or restore habitat connectivity for wildlife, compared to current plans. Finally, desired conditions for wildlife in the revised plan alternatives (FW-DC-WL-01, 02, 04, 05) set the stage for possible future restrictions on recreation uses should emerging use patterns demonstrate impacts on habitat that warrant management changes.

Cumulative Effects

Very few land management plans for areas near the Custer Gallatin National Forest include direction specific to maintaining or restoring habitat connectivity across larger landscapes. However, in the montane ecosystem geographic areas, where genetic isolation of species has been cited as a stressor on individual populations and metapopulations (Haroldson et al. 2010, Proctor et al. 2012, Garrott et al. 2015), the Custer Gallatin is bordered on the south by Yellowstone National Park, which is primarily managed for conservation of natural resources. The Beaverhead-Deerlodge and Shoshone national forest portions adjacent to the Custer Gallatin are largely in designated wilderness areas, which provide a high degree of protection for wildlife habitat connectivity. The Helena-Lewis and Clark National Forest to the north of the Custer Gallatin is in the process of amending their land management plan to adopt direction consistent with 2012 Planning Rule requirements for habitat connectivity, as well as incorporating the Northern Continental Divide Ecosystem Grizzly Bear Conservation Strategy, which includes consideration for habitat connectivity between the Northern Continental Divide Ecosystem and Greater Yellowstone Ecosystem for wide-ranging species. State wildlife action plans for both Montana and South Dakota address the importance of habitat connectivity for conserving healthy, resilient wildlife populations (South Dakota Department of Game Fish and Parks 2014b, Montana Fish Wildlife and Parks 2015c), and the Western Governors Association developed a policy for states to work cooperatively with Federal land management agencies, non-governmental organizations, landowners, and local communities to identify and conserve wildlife habitats and corridors (Western Governor's Association 2019).

Conclusion

All revised plan alternatives specifically and thoroughly address habitat connectivity, stating the desire to maintain habitat connectivity for wildlife across the Custer Gallatin, as well as the broader landscape. The revised plan alternatives include goals to work with other agencies, landowners, and partners across jurisdictional boundaries to achieve habitat connectivity at a scale much larger than the Custer Gallatin National Forest. Whereas the current plans contain direction to protect important elements of wildlife habitat, which collectively contribute to habitat connectivity, the revised plan alternatives contain a more holistic, integrated, and ecological approach that would more effectively address the larger-scale issues associated with wildlife habitat connectivity.

Revised plan alternatives all contain many plan components that would directly or indirectly contribute to the maintenance or restoration of habitat connectivity for wildlife as required by the 2012 Planning Rule. The main difference between the revised plan alternatives lies in the various combinations of plan land allocations. Alternatives B, C, D, and F contain plan land allocations for key linkage areas, which would facilitate wildlife crossing of Interstate 90 and associated development in an area recognized as a bottleneck to long-distance wildlife dispersal that is possibly contributing to genetic isolation of wildlife subpopulations.

The montane ecosystem of the Custer Gallatin National Forest contains substantial amounts of designated wilderness, and is adjacent to designated wilderness in the Beaverhead-Deerlodge National Forest to the west, the Shoshone National Forest to the southeast, and Yellowstone National Park backcountry to the south. Additional plan land allocations of recommended wilderness, backcountry areas, and key linkage areas in juxtaposition with designated wilderness areas and Yellowstone National Park would provide well-connected landscapes in low development management regimes over the life of the plan in all revised plan alternatives. Fewer plan land allocations occur in the pine savanna ecosystems of the national forest, but existing low development areas in the Ashland Geographic Area would be maintained with plan or inventoried roadless area allocations in all revised plan alternatives. These allocations would help to maintain portions of the pine savanna ecosystem units in low development conditions to support wildlife movement. While there are few designated areas with associated land use restrictions in the pine savanna ecosystem, and few plan land allocations with added land use restrictions in any of the revised plan alternatives for the Ashland and Sioux Geographic Areas, the pine savanna ecosystem is farther from existing human population centers, with fewer human demands on the landscape that would require additional plan components for wildlife habitat connectivity in these units.

Index

276, 277, 280, 293, 294, 297, 298, 300, 302, 303, 309, 314, 315, 317, 323, 328, 334, 340, 341, 342, 343, 344, 345, 346, 347, 349, 350, 352, 372, 373, 376, 377, 378, 382, 383, 386, 391, 395, 396, 397, 418, 421, 424, 425, 429, 435, 436, 440, 441, 443, 444, 446, 451, 452, 453, 457, 461, 462, 464, 465, 473, 474, 476, 480, 484, 486, 489, 495, 497, 498, 499, 500, 502, 504, 506, 507, 508, 511, 513, 514, 520, 521, 522, 525, 526, 527, 528, 529, 530, 531, 537, 539, 540, 541, 542, 543, 545, 546, 547, 548, 557, 558, 559, 567, 569, 570, 571, 572, 574, 575, 576, 577, 578, 579, 581, 582, 583, 584, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 610, 616, 619, 620, 624, 625, 629, 632, 639, 642, 645, 653, 659, 660, 661, 663, 664, 665

References

Abatzoglou, J. T., and A. P. Williams. 2016. Impact of anthropogenic climate change on wildfire across western US forests. Proceedings of the National Academy of Sciences of the United States of America 113:11770-11775.

Abella, S. R., W. Wallace Covington, P. Z. Fule, L. B. Lentile, A. J. Sanchez Meador, and P. Morgan. 2007. Past, present, and future old growth in frequent-fire conifer forests ofthe western United States. Ecology and Society 12:16.

Abrahms, B., S. C. Sawyer, N. R. Jordan, J. W. McNutt, A. M. Wilson, J. S. Brashares, and M. Hayward. 2017. Does wildlife resource selection accurately inform corridor conservation? Journal of Applied Ecology 54:412-422.

Adams, G., J. Lott, W. Sayler, and M. Smith. 2016. Fisheries and aquatic resources 2016-2020 aquatic invasive species strategic management plan. South Dakota Game, Fish and Parks, Wildlife Division, Pierre, SD.

Adams, S. M., and A. R. Dood. 2011. Background information on issues of concern for Montana: Plains bison ecology, management and conservation. Montana Fish, Wildlife and Parks, Bozeman, MT.

Agee, J. K. 1993. Fire ecology of Pacific northwest forests. Island Press, Island Press Suite 300, 1718 Connecticut Avenue, NW, Washington, DC, 20009.

Agee, J. K., B. Bahro, M. A. Finney, P. N. Omi, D. B. Sapsis, C. N. Skinner, J. W. van Wagtendonk, and C. Phillip Weatherspoon. 2000. The use of shaded fuelbreaks in landscape fire management. Forest Ecology and Management 127:55-66.

Agee, J. K., and C. N. Skinner. 2005. Basic principles of forest fuel reduction treatments. Forest Ecology and Management 211:83-96.

Ager, A. A., M. A. Day, C. W. McHugh, K. Short, J. Gilbertson-Day, M. A. Finney, and D. E. Calkin. 2014. Wildfire exposure and fuel management on western US national forests. Journal of Environmental Management 145:54-70.

Aikens, E. O., M. J. Kauffman, J. A. Merkle, S. P. H. Dwinnell, G. L. Fralick, and K. L. Monteith. 2017. The greenscape shapes surfing of resource waves in a large migratory herbivore. Ecology Letters 20:741-750.

Al-Chokhachy, R., B. B. Roper, and E. K. Archer. 2010. Evaluating the status and trends of physical stream habitat in headwater streams within the interior Columbia River and upper

Missouri River basins using an index approach. Transactions of the American Fisheries Society 139:1041-1059.

Allen-Wardell, G., P. Bernhardt, R. Bitner, A. Burquez, S. Buchmann, J. Cane, P. A. Cox, V. Dalton, P. Feinsinger, M. Ingram, D. Inouye, C. E. Jones, K. Kennedy, P. Kevan, H. Koopowitz, R. Medellin, S. Medellin-Morales, and G. P. Nabhan. 1998. The potential consequences of pollinator declines on the conservation of biodiversity and stability of food crop yields. Conservation Biology 12:8-17.

Ament, R., R. Callahan, M. McClure, M. Reuling, and G. Tabor. 2014. Wildlife connectivity: Fundamentals for conservation action.

Amman, G. D., and L. J. A. 1998. Silvicultural control of mountain pine beetles: prescriptions and the influence of microclimate. American Entomologist:166-177.

Anderson, H. E. 1982. Aids to determining fuel models for estimating fire behavior. Gen. Tech. Rep. INT-GTR-122, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

Andreasen, J. K., R. V. O'Neill, R. Noss, and N. C. Slosser. 2001. Considerations for the development of a terrestrial index of ecological integrity. Ecological Indicators 1:21-35.

Andrus, R. A., B. J. Harvey, K. C. Rodman, S. J. Hart, and T. T. Veblen. 2018. Moisture availability limits subalpine tree establishment. Ecology 99:8.

Archer, E., and J. V. Ojala. 2016a. Stream habitat condition for sites in the Custer-Gallatin (east) National Forest. U.S. Department of Agriculture, Forest Service, InFish Biological Opinion (PIBO) Monitoring Program, Logan, UT.

_____. 2016b. Stream habitat condition for sites in the Custer-Gallatin (west) National Forest. U.S. Department of Agriculture, Forest Service, InFish Biological Opinion (PIBO) Monitoring Program, Logan, UT.

Archuleta, J. G., and E. S. Baxter. 2008. Subsoiling promotes native plant establishment on compacted forest sites. Native Plants Journal 9:117-122.

Arno, S. F. 1980. Forest fire history in the northern Rockies. Journal of Forestry 78:460-465.

Arno, S. F., and G. E. Gruell. 1983. Fire history at the forest-grassland eco-tone in southwestern Montana. Journal of Range Management 36:332-336.

Arno, S. F., and R. Hoff. 1990. Whitebark pine (*Pinus albicaulis Engelm.*). Pages 268-279 *in* R. M. Burns, and B. H. Honkala, editors. Silvics of North America. USDA Forest Service, Washington, DC.

Arno, S. F., and R. J. Hoff. 1989. Silvics of whitebark pine (*Pinus albicaulis*). Gen. Tech. Rep. INT-GTR-253, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Arno, S. F., D. J. Parsons, and R. E. Keane. 2000. Mixed-severity fire regimes in the northern Rocky Mountains: Consequences of fire exclusion and options for the future. Pages 225-232 *in* D. N. Cole, S. F. McCool, W. T. Borrie, and J. O'Loughlin, editors. Wilderness science in a time of change conference - volume 5: Wilderness ecosystems, threats, and management; 1999 May 23–27; Missoula, MT. Proceedings RMRS-P-15-vol-5. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Arno, S. F., D. G. Simmerman, and R. E. Keane. 1985. Forest succession on four habitat types in western Montana. Gen. Tech. Rep. INT-GTR-177, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

Artz, D. R., and K. D. Waddington. 2006. The effects of neighbouring tree islands on pollinator density and diversity, and on pollination of a wet prairie species, Asclepias lanceolata (Apocynaceae). Journal of Ecology 94:597-608.

Ashton, I. W. 2010. Observed and projected ecological response to climate change in the Rocky Mountains and Upper Columbia Basin; a synthesis of current scientific literature. Report Natural Resource Report NPS/ROMN/NRR—2010/220.

Auble, G. T., and M. L. Scott. 1998. Fluvial disturbance patches and cottonwood recruitment along the upper Missouri River, Montana. Wetlands 18:546-556.

Aubry, K. B., K. S. McKelvey, and J. P. Copeland. 2007. Distribution and broadscale habitat relations of the wolverine in the contiguous United States. Journal of Wildlife Management 71:2147-2158.

Aune, K. E., J. C. Rhyan, R. Russell, T. J. Roffe, and B. Corso. 2011. Environmental persistence of *Brucella abortus* in the Greater Yellowstone Area. Journal of Wildlife Management 9999:1-9.

Averett, J. P., B. McCune, C. G. Parks, B. J. Naylor, T. DelCurto, and R. Mata-Gonzalez. 2016. Non-native plant invasion along elevation and canopy closure gradients in a middle Rocky Mountain ecosystem. PLoS One 11:24.

Axelson, J. N., R. I. Alfaro, and B. C. Hawkes. 2009. Influence of fire and mountain pine beetle on the dynamics of lodgepole pine stands in British Columbia, Canada. Forest Ecology and Management 257:1874-1882.

Bachen, D. 2019. Assessment of presence, range, and status of the northern Myotis (Myotis septentrionalis) in the northern Great Plains of Montana. Montana Natural Heritage Program, Helena, MT.

Baker, W. L. 2006. Fire and restoration of sagebrush ecosystems. Wildlife Society Bulletin 34:177-185.

Baker, W. L., and D. Ehle. 2001. Uncertainty in surface-fire history: the case of ponderosa pine forests in the western United States. Canadian Journal of Forest Research 31:1205-1226.

Baker, W. L., and D. S. Ehle. 2003. Uncertainty in fire history and restoration of ponderosa pine forests in the western United States.

Balch, J. K., B. A. Bradley, C. M. D'Antonio, and J. Gomez-Dans. 2013. Introduced annual grass increases regional fire activity across the arid western USA (1980-2009). Global Change Biology 19:173-183.

Ballantine, D. J., D. E. Walling, A. L. Collins, and G. J. L. Leeks. 2008. The phosphorus content of fluvial suspended sediment in three lowland groundwater-dominated catchments. Journal of Hydrology 357:140-151.

Barber, J., R. Bush, and D. Berglund. 2011. The Region 1 existing vegetation classification system and its relationship to Region 1 inventory data and map products. Numbered Report 11-10, U.S. Department of Agriculture, Forest Service, Region 1, Missoula, MT.

Barbero, R., J. T. Abatzoglou, N. K. Larkin, C. A. Kolden, and B. Stocks. 2015. Climate change presents increased potential for very large fires in the contiguous United States. International Journal of Wildland Fire.

Barndt, S., K. Reid, and J. Chaffin. 2017. Assessment forest plan revision: Final aquatic and riparian ecosystems report. Custer Gallatin National Forest.

Baron, J. S., C. T. Driscoll, J. L. Stoddard, and E. E. Richer. 2011. Empirical Critical Loads of Atmospheric Nitrogen Deposition for Nutrient Enrichment and Acidification of Sensitive US Lakes. BioScience 61:602-613.

Baron, J. S., D. S. Ojima, E. A. Holland, and W. J. Parton. 1994. Analysis of nitrogen saturation potential in Rocky Mountain tundra and forest: implications for aquatic systems. Biogeochemistry 27:22.

Barrett, S. W. 1988. Fire regime classification for coniferous forests of the northwestern United States.

_____. 1993. Fire history of Tenderfoot Creek experimental forest, Lewis and Clark National Forest: Final report.

Barrett, S. W., S. F. Arno, and J. P. Menakis. 1997. Fire episodes in the inland northwest (1540-1940) based on fire history data. Gen. Tech. Rep. INT-GTR-370, U. S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Batchelor, J. L., W. J. Ripple, T. M. Wilson, and L. E. Painter. 2015. Restoration of riparian areas following the removal of cattle in the northwestern Great Basin. Environmental Management 55:930-942.

Bauman, P., B. Carlson, T. Butler, and B. Richardson. 2018. Quantifying Undisturbed (Native) Lands in Northwestern South Dakota: 2013.

Baumeister, D., and R. M. Callaway. 2006. Facilitation by Pinus flexilis during succession: A hierarchy of mechanisms benefits other plant species. Ecology 87:1816-1830.

Beechie, T. J., D. A. Sear, J. D. Olden, G. R. Pess, J. M. Buffington, H. Moir, P. Roni, and M. M. Pollock. 2010. Process-based principles for restoring river ecosystems. BioScience 60:209-222.

Behnke, R. J. 1992. Native trout of western North America. Volume 6.American Fisheries Society, Bethesda, MD.

Beier, P., and B. Brost. 2010. Use of land facets to plan for climate change: conserving the arenas, not the actors. Conservation Biology 24:701-710.

Bell, D. M., J. B. Bradford, and W. K. Lauenroth. 2014. Early indicators of change: Divergent climate envelopes between tree life stages imply range shifts in the western United States. Global Ecology and Biogeography 23:168-180.

Bell, H., K. Broderdorp, J. Cummings, B. Holt, M. McCollough, M. Parkin, T. Smith, and J. Zelenak. 2016. Canada lynx expert elicitation workshop - October 13-15, 2015 - Bloomington, Minnesota: Final report.

Belote, R. T., and G. H. Aplet. 2014. Land protection and timber harvesting along productivity and diversity gradients in the Northern Rocky Mountains. Ecosphere 5.

Belote, R. T., D. M. David-Chavez, M. S. Dietz, and G. H. Aplet. 2015. Whitebark pine in wilderness under a changing climate. Nutcracker Notes: Journal of the Whitebark Pine Ecosystem Foundation:3, 9-11, 31-32.

Belote, R. T., M. S. Dietz, B. H. McRae, D. M. Theobald, M. McClure, L., G. H. Irwin, P. S. McKinley, J. A. Gage, and G. H. Aplet. 2016. Identifying corridors among large protected areas in the United States. PLoS One 11.

Belsky, A. J., and D. M. Blumenthal. 1997. Effects of livestock grazing on stand dynamics and soils in upland forests of the Interior West. Conservation Biology 11:315-327.

Belsky, A. J., and J. L. Gelbard. 2000. Livestock grazing and weed invasions in the arid West.

Belsky, A. J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419-431.

Benda, L. E., N. L. Poff, C. Tague, M. A. Palmer, J. Pizzuto, S. Cooper, E. Stanley, and G. Moglen. 2002. How to avoid train wrecks when using science in environmental problem solving. BioScience 52:1127-1136.

Bengeyfield, P. 2006. Managing cows with streams in mind. Rangelands 28:3-6.

Bentz, B. J., J. P. Duncan, and J. A. Powell. 2016. Elevational shifts in thermal suitability for mountain pine beetle population growth in a changing climate. Forestry 89:271-283.

Bentz, B. J., C. J. Fettig, M. Hansen, J. L. Hayes, J. Hicke, R. Kelsey, J. Lundquist, J. F. Negron, R. Progar, J. Regniere, S. J. Seybold, and J. Vandygriff. 2009. Climate change and western U.S. bark beetles: Rapid threat assessment. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Bernays, E. A., and A. C. Lewis. 1986. The effect of wilting on palatability of plants to Schistocerca gregaria, the desert locust. Oecologia 70:132-135.

Beschta, R. L., and W. J. Ripple. 2005. Rapid assessment of riparian cottonwood recruitment: Middle Fork John Day River, northeastern Oregon. Ecological Restoration 23:150-156.

Besser, T. E., E. F. Cassirer, K. A. Potter, and W. J. Foreyt. 2017. Exposure of bighorn sheep to domestic goats colonized with Mycoplasma ovipneumoniae induces sub-lethal pneumonia. PLoS One 12:13.

Besser, T. E., E. Frances Cassirer, M. A. Highland, P. Wolff, A. Justice-Allen, K. Mansfield, M. A. Davis, and W. Foreyt. 2013. Bighorn sheep pneumonia: sorting out the cause of a polymicrobial disease. Preventive Veterinary Medicine 108:85-93.

Bethers Marchetti, S., J. J. Worrall, and T. Eager. 2011. Secondary insects and diseases contribute to sudden aspen decline in southwestern Colorado, USA. Canadian Journal of Forest Research 41:2315-2325.

Bingham, M. A., and S. Simard. 2012. Ectomycorrhizal Networks of Pseudotsuga menziesii var. glauca Trees Facilitate Establishment of Conspecific Seedlings Under Drought. Ecosystems 15:188-199.

Binkley, D. 1991. Connecting soils with forest productivity. Pages 66-69 *in* A. E. Harvey, and L. F. Neuenschwander, editors. Proceedings: Management and productivity of western-montane forest soils; 1990 April 10-12; Boise, ID. Gen. Tech. Rep. INT-280. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Birdsey, R., A. J. Dugan, S. Healey, K. Dante-Wood, F. Zhang, G. Mo, J. Chen, A. J. Hernandez, C. L. Raymond, and J. McCarter. 2019. Assessment of the influence of disturbance, management activities, and environmental factors on carbon stocks of United States National Forests. Gen. Tech. Rep. RMRS-GTR-402, U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Biswas, T., J. DiBenedetto, S. Brown, A. Yeager, R. Hamilton, and H. Fisk. 2012. Procedures for mapping rare vegetation types using mid-level vegetation maps. U.S. Department of Agriculture, Forest Service, Geospatial Management Office, Remote Sensing Applications Center, Salt Lake City, UT.

Bjornlie, D. D., and R. A. Garrott. 2001. Effects of Winter Road Grooming on Bison in Yellowstone National Park. Journal of Wildlife Management 65:560-572.

Boisvenue, C., and S. W. Running. 2010. Simulations show decreasing carbon stocks and potential for carbon emissions in Rocky Mountain forests over the next century. Ecological Applications 20:1302-1319.

Bollenbacher, B., R. Bush, B. Hahn, and R. Lundberg. 2008. Estimates of snag densities for eastside forests in the northern region. Numbered Report 08-07 v2.0, U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT.

Bonn, J., B. Dixon, E. Kennedy, and D. Pengeroth. 2007. Black-backed woodpecker northern region overview: Key findings and project considerations.

Booth, G. D., B. L. Welch, and T. L. C. Jacobson. 1990. Seedling growth rate of 3 subspecies of big sagebrush. Journal of Range Management 43:432-435.

Borkowski, J., P. J White, R. Garrott, T. Davis, A. Hardy, and D. Reinhart. 2006. Behavioral responses of bison and elk in Yellowstone to snowmobiles and snow coaches. Ecological Applications 16:1911-1925.

Bouwes, N., S. Bennett, and J. Wheaton. 2016. Adapting adaptive management for testing the effectiveness of stream restoration: An intensively monitored watershed example. Fisheries 41:84-91.

Boyd, C. S., J. L. Beck, and J. A. Tanaka. 2014. Livestock Grazing and Sage-Grouse Habitat: Impacts and Opportunities. Journal of Rangeland Applications 1:58-77.

Boyer, K. L., D. Rae Berg, and S. V. Gregory. 2003. Riparian management for wood in rivers. Pages 407-420 *in* S. V. Gregory, K. L. Boyer, and A. M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Bethesda, MD.

Bradley, A. F., W. C. Fischer, and N. V. Noste. 1992. Fire ecology of the forest habitat types of eastern Idaho and western Wyoming. Gen. Tech. Rep. INT-GTR-290, U. S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Bradley, B. A. 2009. Regional analysis of the impacts of climate change on cheatgrass invasion shows potential risk and opportunity. Global Change Biology 15:196-208.

Bradley, C. M., C. T. Hanson, and D. A. DellaSala. 2016. Does increased forest protection correspond to higher fire severity in frequent-fire forests of the western United States? Ecosphere 7.

Branson, D. H., A. Joern, and G. A. Sword. 2006. Sustainable management of insect herbivores in grassland ecosystems: New perspectives in grasshopper control. BioScience 56:743-755.

Brennan, A., E. M. Hanks, J. A. Merkle, E. K. Cole, S. R. Dewey, A. B. Courtemanch, and P. C. Cross. 2018. Examining speed versus selection in connectivity models using elk migration as an example. Landscape Ecology 33:955-968.

Bronstein, J. L., P.-H. Gouyon, C. Gliddon, F. Kjellberg, and G. Michaloud. 1990. The ecological consequences of flowering asynchrony in monoecious figs: A simulation study. Ecology 71:2145-2156.

Brown, J. K., E. D. Reinhardt, and K. A. Kramer. 2003. Coarse woody debris: Managing benefits and fire hazard in the recovering forest. Gen. Tech. Rep. RMRS-GTR-105, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Brown, P. M., and A. W. Schoettle. 2008. Fire and stand history in two limber pine (Pinus flexilis) and Rocky Mountain bristlecone pine (Pinus aristata) stands in Colorado. International Journal of Wildland Fire 17:339-347.

Brown, R., and R. Peet. 2003. Diversity and invasibility of Southern Appalachian plant communities. Ecology 84:32-39.

Brown, R. W. 1971. Distribution of plant communities in southeastern Montana badlands. American Midland Naturalist 85:458-477.

Brown, S. R., Jr. 2016. Custer Gallatin National Forest - VMap 2015 tree dominance type (DOM40), tree canopy cover, tree size class, and lifeform accuracy assessment. Region One Vegetation Classification, Mapping, Inventory and Analysis Report Numbered Report NRGG16-01, U.S. Department of Agriculture, Forest Service, Region One, Missoula, MT.

Bryant, L., W. Burkhardt, T. Burton, W. Clary, R. Henderson, D. Nelson, W. Ririe, K. Sanders, R. Wiley, J. Foster, and J. Palmer. 2004. University of Idaho stubble height study report. Report 986.

Bull, E. L., C. G. Parks, and T. R. Torgersen. 1997. Trees and logs important to wildlife in the interior Columbia River basin. Gen. Tech. Rep. PNW-GTR-391, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Bunting, S. C., B. M. Kilgore, and C. L. Bushey. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the northern great basin. Gen. Tech. Rep. INT-231., U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Buotte, P. C., J. A. Hicke, H. K. Preisler, J. T. Abatzoglou, K. F. Raffa, and J. A. Logan. 2016. Climate influences on whitebark pine mortality from mountain pine beetle in the Greater Yellowstone Ecosystem. Ecological Applications 26:2507-2524.

Burghardt Dowd, J. L. 2010. Coyote diet and movements in relation to winter recreation in northwestern Wyoming: Implications for lynx conservation. Master's thesis, Utah State University.

Burkle, L. A., and R. Alarcon. 2011. The future of plant-pollinator diversity: Understanding interaction networks across time, space, and global change. American Journal of Botany 98:528-538.

Burns, D. A. 2003. Atmospheric nitrogen deposition in the Rocky Mountains of Colorado and southern Wyoming—a review and new analysis of past study results. Atmospheric Environment 37:921-932.

Burns, R. M., and B. H. Honkala. 1990. Silvics of North America: Volume 1, Conifers. Agriculture handbook 654, U.S. Department of Agriculture, Forest Service, Washington, DC.

Bush, R. 2015. Mid-cycle remeasurement of FIA plots using IM protocols used on Custer-Gallatin, 2015. Region One Vegetation Classification, Mapping, Inventory and Analysis Report, U.S. Department of Agriculture, Forest Service, Region One, Missoula, MT.

Bush, R., and B. Reyes. 2015. Overview of FIA and intensified grid data. Region One Vegetation Classification, Mapping, Inventory and Analysis Report Numbered Report 15-12 v3.0, U.S. Department of Agriculture, Forest Service, Region One, Missoula, MT.

Bush, R., B. Reyes, and J. Zeiler. 2016. Summary database reports and utilities user’s guide. Region One Vegetation Classification, Mapping, Inventory and Analysis Report 16-2 v3.2, U.S. Department of Agriculture, Forest Service, Region One, Missoula, MT.

Calder, J. W., D. Parker, C. J. Stopka, G. Jimenez-Moreno, and B. N. Shuman. 2015. Medieval warming initiated exceptionally large wildfire outbreaks in the Rocky Mountains.

Proceedings of the National Academy of Sciences of the United States of America 112:13261-13266.

Cameron, S. A., J. D. Lozier, J. P. Strange, J. B. Koch, N. Cordes, L. F. Solter, and T. L. Griswold. 2011. Patterns of widespread decline in North American bumble bees. Proceedings of the National Academy of Sciences of the United States of America 108:662-667.

Canadian Wildlife Service and U.S. Fish and Wildlife Service. 2005. International recovery plan for the whooping crane (Grus americana): Third revision. U.S. Department of the Interior, Fish and Wildlife Service, Albuquerque, NM.

Cane, J. H. 2011. Specialist Osmia bees forage indiscriminately among hybridizing Balsamorhiza floral hosts. Oecologia 167:107-116.

Cane, J. H., R. L. Minckley, L. J. Kervin, T. a. H. Roulston, and N. M. Williams. 2006. Complex responses within a desert bee guild (Hymenoptera: Apiformes) to urban habitat fragmentation. Ecological Applications 16:632-644.

Canfield, J. 2016. Custer Gallatin National Forest: Updating the lynx habitat map layer using the latest corporate standardized data and state-of-the-art GIS technology. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Bozeman, MT.

Capinera, J. L., and D. R. Horton. 1989. Geographic variation in effects of weather on grasshopper infestation. Environmental Entomology 18:8-14.

Carroll, C., R. F. Noss, and P. C. Paquet. 2001. Carnivores as focal species for conservation planning in the Rocky Mountain region. Ecological Applications 11:961-980.

Carter, S. K., E. Fleishman, I. I. F. Leinwand, C. H. Flather, N. B. Carr, F. A. Fogarty, M. Leu, B. R. Noon, M. E. Wohlfeil, and D. J. A. Wood. 2019. Quantifying ecological integrity of terrestrial systems to inform management of multiple-use public lands in the United States. Environmental Management 64:1-19.

Cassirer, E. F., K. R. Manlove, R. K. Plowright, and T. E. Besser. 2017. Evidence for strain-specific immunity to pneumonia in bighorn sheep. Journal of Wildlife Management 81:133-143.

Centre for Coastal Health. 2017. Risk assessment on the use of South American camelids for back country trekking in British Columbia. Final Report, Centre for Coastal Health, Nanaimo, BC.

Chambers, J. C., C. R. Allen, and S. A. Cushman. 2019. Operationalizing ecological resilience concepts for managing species and ecosystems at risk. Frontiers in Ecology and Evolution 7:1-27.

Chambers, J. C., J. D. Maestas, D. A. Pyke, C. S. Boyd, M. Pellant, and A. Wuenschel. 2017. Using resilience and resistance concepts to manage persistent threats to sagebrush ecosystems and greater sage-grouse. Rangeland Ecology & Management 70:149-164.

Chambers, J. C., and M. Pellant. 2008. Climate change impacts on northwestern and intermountain United States rangelands. Rangelands 30:29-33.

Chambers, J. C., B. A. Roundy, R. R. Blank, S. E. Meyer, and A. Whittaker. 2007. What makes great basin sagebrush ecosystems invasible by Bromus tectorum? Ecological Monographs 77:117-145.

Chen, I.-C., J. K. Hill, R. Ohlemuller, D. B. Roy, and C. D. Thomas. 2011. Rapid range shifts of species associated with high levels of climate warming. Science 333:1024-1026.

Chew, J., B. Bollenbacher, C. J. Manning, Moeller, and C. Stalling. 2012a. Using SIMPPLLE to quantify the historic range of variability, current trends, and restoration opportunities for an ecological section. *in* F. S. U.S. Department of Agriculture, Rocky Mountain Research Station, editor.

Chew, J. D., K. Moeller, and C. Stalling. 2012b. SIMPPLLE Version 2.5 user's guide. Gen. Tech. Rep. RMRS-GTR-268WWW, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Chiarucci, A., M. B. Araujo, G. Decocq, C. Beierkuhnlein, and J. M. Fernandez-Palacios. 2010. The concept of potential natural vegetation: An epitaph? Journal of Vegetation Science 21:1172-1178.

Churchill, D. J., A. J. Larson, M. C. Dahlgreen, J. F. Franklin, P. F. Hessburg, and J. A. Lutz. 2013. Restoring forest resilience: from reference spatial patterns to silvicultural prescriptions and monitoring. Forest Ecology and Management 291:442-457.

Claar, J. J., T. Bertram, R. Naney, N. Warren, and W. Ruediger. 2003. Wildlife linkage areas: An integrated approach for Canada lynx. Pages 234-239 *in* C. L. Irwin, P. Garrett, and K. P. McDermott, editors. Proceedings of the 2003 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Coe, P. K., B. K. Johnson, J. W. Kern, S. L. Findholt, J. G. Kie, and M. J. Wisdom. 2001. Responses of elk and mule deer to cattle in summer. Journal of Range Management 54:A51-A76.

Cohen, J. D. 2000. Preventing disaster - Home ignitability in the wildland-urban interface. Journal of Forestry 98:15-21.

Coleman, T. H., C. C. Schwartz, K. A. Gunther, and S. Creel. 2013. Grizzly bear and human interaction in Yellowstone National Park: An evaluation of bear management areas. Journal of Wildlife Management 77:1311-1320.

Colla, S. R., and L. Packer. 2008. Evidence for decline in eastern North American bumblebees (Hymenoptera: Apidae), with special focus on Bombus affinis Cresson. Biodiversity and Conservation 17:1379-1391.

Connelly, J. W., S. T. Knick, C. E. Braun, W. L. Baker, E. A. Beever, T. Christiansen, K. E. Doherty, E. O. Garton, S. E. Hanser, D. H. Johnson, M. Leu, R. F. Miller, D. E. Naugle, S. J. Oyler-McCance, D. A. Pyke, K. P. Reese, M. A. Schroeder, S. J. Stiver, B. L. Walker, and M. J. Wisdom. 2011. Conservation of greater sage-grouse: A synthesis of current trends and future management. Pages 549-563 *in* S. T. Knick, and J. W. Connelly, editors. Greater sage-grouse: Ecology and conservation of a landscape species and habitats. University of California Press, Berkeley, CA.

Connelly, J. W., S. T. Knick, M. A. Schroeder, and S. J. Stiver. 2004. Conservation assessment of greater sage-grouse and sagebrush habitats. Western Association of Fish and Wildlife Agencies, Cheyenne, WY.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sage grouse populations and their habitats. Wildlife Society Bulletin 28:967-985.

Cook, R. C. 2014. Habitat-nutrition relations of elk during spring through autumn in the Blue Mountains of eastern Oregon and their implications for forest landscape management. U.S. Department of Agriculture, Forest Service, La Grande, OR.

Coop, J. D., and A. W. Schoettle. 2009. Regeneration of Rocky Mountain bristlecone pine (Pinus aristata) and limber pine (Pinus flexilis) three decades after stand-replacing fires. Forest Ecology and Management 257:893-903.

Coops, N. C., J. A. Timko, M. A. Wulder, J. C. White, and S. M. Ortlepp. 2008. Considering the effectiveness of mountain pine beetle mitigation strategies.

Copeland, J. P., K. S. Mckelvey, K. B. Aubry, A. Landra, J. Persson, R. M. Inman, J. Krebs, E. Lofroth, H. Golden, J. R. Squires, A. Magoun, M. K. Schwartz, J. Wilmot, C. L. Copeland, R. E. Yates, I. Kojola, and R. May. 2010. The bioclimatic envelope of the wolverine (Gulo gulo): do climatic constraints limit its geographic distribution? Canadian Journal of Zoology 88:233-246.

Costello, C. M., S. L. Cain, S. Pils, L. Frattaroli, M. A. Haroldson, and F. T. van Manen. 2016. Diet and Macronutrient Optimization in Wild Ursids: A Comparison of Grizzly Bears with Sympatric and Allopatric Black Bears. PLoS One 11:e0153702.

Costello, C. M., F. T. van Manen, M. A. Haroldson, M. R. Ebinger, S. L. Cain, K. A. Gunther, and D. D. Bjornlie. 2014. Influence of whitebark pine decline on fall habitat use and movements of grizzly bears in the Greater Yellowstone Ecosystem. Ecology and Evolution 4:2004-2018.

Courtemanch, A. B. 2015. Jackson moose herd unit population objective review.

Cross, M., and C. Servheen. 2010. Climate change impacts on wolverines and grizzly bears in the northern U.S. Rockies: Strategies for conservation, October 2-7, 2009. Final Workshop Summary Report, Wildlife Conservation Society & U.S. Fish and Wildlife Service, Department of the Interior, New York, NY.

Cryan, P. M., M. A. Bogan, and G. M. Yanega. 2001. Roosting habits of four bat species in the Black Hills of South Dakota. Acta Chiropterologica 3:43-52.

Cunningham, J. A. 2014. Pittman-Robertson federal aid in wildlife restoration report elk populations in Montana's Region 3. Montana Fish, Wildlife, and Parks, Bozeman, MT.

Cunningham, J. A. 2015. Moose monitoring in the Hebgen Basin 2013-2014 report.

Cushman, S. A., E. L. Landguth, and C. H. Flather. 2012. Evaluating the sufficiency of protected lands for maintaining wildlife population connectivity in the U.S. northern Rocky Mountains. Diversity and Distributions 18:873-884.

Cushman, S. A., K. S. McKelvey, and M. K. Schwartz. 2009. Use of empirically derived source-destination models to map regional conservation corridors. Conservation Biology 23:368-376.

D'antonio, C. M., and P. M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63-87.

Davis, K. T., S. Z. Dobrowski, P. E. Higuera, Z. A. Holden, T. T. Veblen, M. T. Rother, S. A. Parks, A. Sala, and M. P. Maneta. 2019. Wildfires and climate change push low-elevation forests across a critical climate threshold for tree regeneration. Proceedings of the National Academy of Sciences of the United States of America 116:6193-6198.

Davis, M. A., J. P. Grime, and K. Thompson. 2000. Fluctuating resources in plant communities: a general theory of invasibility. Journal of Ecology 88:528-534.

Davis, S. C., A. E. Hessl, C. J. Scott, M. B. Adams, and R. B. Thomas. 2009. Forest carbon sequestration changes in response to timber harvest. Forest Ecology and Management 258:2101-2109.

DeCesare, N., and J. Newby. 2018. Vital rates, limiting factors and monitoring methods for moose in Montana: Annual report, September 1, 2018. Federal aid in wildlife restoration grant W-157-R-6, Montana Fish, Wildlife & Parks, Helena, MT.

DeCesare, N. J., and J. Newby. 2013. Vital rates, limiting factors and monitoring methods for moose in Montana [Research Update July 1, 2013].

DeCesare, N. J., and D. H. Pletscher. 2006. Movements, connectivity, and resource selection of Rocky Mountain bighorn sheep. Journal of Mammalogy 87:531-538.

DeCesare, N. J., T. D. Smucker, R. A. Garrott, and J. A. Gude. 2014. Moose status and management in Montana. Alces: North American Moose Conference and Workshop Proceedings 50:35-51.

DellaSala, D. A., R. G. Anthony, M. L. Bond, E. S. Fernandez, C. A. Frissell, C. T. Hanson, and R. Spivak. 2013. Alternative views of a restoration framework for federal forests in the Pacific Northwest. Journal of Forestry 111:420-429.

DeLuca, T. H., and G. H. Aplet. 2008. Charcoal and carbon storage in forest soils of the Rocky Mountain west. Frontiers in Ecology and the Environment 6:18-24.

Developed Site Technical Team. 2019. Developed site footprints: Visuals and methods, developed site technical team, grizzly bear habitat monitoring 1998 baseline for developed sites: Proposed revisions to 2016 grizzly gear conservation strategy for the grizzly bear in the greater Yellowstone ecosystem (habitat standards, chapter 3). U.S. Department of the Interior, National Park Service, Yellowstone National Park, WY.

Dietz, M. S., R. T. Belote, G. H. Aplet, and J. L. Aycrigg. 2015. The world's largest wilderness protection network after 50 years: An assessment of ecological system representation in the U.S. National Wilderness Preservation System. Biological Conservation 184:431-438.

Dinkins, J. B., M. R. Conover, C. P. Kirol, J. L. Beck, and S. N. Frey. 2014. Greater sage-grouse (Centrocercus urophasianus) hen survival: Effects of raptors, anthropogenic and landscape features, and hen behavior. Canadian Journal of Zoology 92:319-330.

Dixon, G. E. 2008. Essential FVS: A user's guide to the forest vegetation simulator. U.S. Department of Agriculture, U.S. Forest Service, Forest Management Service Center, Fort Collins, CO.

Doak, D. F., and K. Cutler. 2014. Van Manenet al., doth protest too much: New analyses of the Yellowstone grizzly population confirm the need to reevaluate past population trends. Conservation Letters 7:332-333.

Dodds, W. K., K. Gido, M. R. Whiles, K. M. Fritz, and W. J. Matthews. 2004. Life on the edge: The ecology of Great Plains Prairie streams. BioScience 54:205-216.

Doerr, S. H., R. A. Shakesby, W. H. Blake, C. J. Chafer, G. S. Humphreys, and P. J. Wallbrink. 2006. Effects of differing wildfire severities on soil wettability and implications for hydrological response. Journal of Hydrology 319:295-311.

Domke, G. M., C. H. Perry, B. F. Walters, L. E. Nave, C. W. Woodall, and C. W. Swanston. 2017. Toward inventory- based estimates of soil organic carbon in forests of the United States. Ecological Applications 27:1223–1235.

Dorning, M. A., S. L. Garman, J. E. Diffendorfer, D. J. Semmens, T. J. Hawbaker, and K. J. Bagstad. 2017. Oil and gas development influences big-game hunting in Wyoming. Journal of Wildlife Management 81:379-392.

DuBois, K. 2016a. Bald eagle nesting populations and nest monitoring, 1980-2014: Final report.

_____. 2016b. Effectiveness of trail cameras and scat genetics for detecting northern bog lemmings in western Montana - 2015 progress report.

Dwire, K. A., K. E. Meyer, G. Riegel, and T. Burton. 2016. Riparian fuel treatments in the western USA: Challenges and considerations. Gen. Tech. Rep. RMRS-GTR-352, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Ebinger, M. R., M. A. Haroldson, F. T. van Manen, C. M. Costello, D. D. Bjornlie, D. J. Thompson, K. A. Gunther, J. K. Fortin, J. E. Teisberg, S. R. Pils, P. J. White, S. L. Cain, and P. C. Cross. 2016. Detecting grizzly bear use of ungulate carcasses using global positioning system telemetry and activity data. Oecologia 181:695-708.

Efta, J. A. 2014a. Evaluation of post-fire runoff response to two high-intensity, short-duration thunderstorm events, Sioux and Ashland Ranger Districts, Custer National Forest, Montana. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest.

_____. 2014b. Opeechee Sale strea/draw flow regime and SMZ applicability review. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Bozeman, MT.

Efta, J. A., and M. Layhee. 2016. An investigation into surface flow regime distribution, extent, and associated controls across the Ashland and Sioux Districts, Custer Gallatin National Forest, Montana/South Dakota. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Billings, MT.

Egan, J. M. 2014. Mountain pine beetle status and mortality trends from 2012 to 2013 in Montana and northern Idaho subwatersheds. R01-14-06, U.S. Department of Agriculture, Forest Service, Forest Health Protection, Missoula, MT.

Egan, J. M., J. Kaiden, J. Lestina, A. Stasey, and J. L. Jenne. 2019. Techniques to enhance assessment and reporting of pest damage estimated with aerial detection surveys. R1-19-09, U.S. Department of Agriculture, Forest Service, State & Private Forestry, Forest Health Protection, Missoula, MT.

Egan, J. M., S. Kegley, D. Blackford, and C. L. Jorgensen, (tech. eds.). 2014. Effectiveness of direct and indirect mountain pine beetle control treatments as implemented by the USDA Forest Service. Report 14-03, U.S. Department of Agriculture, Forest Service, Forest Health Protection, Missoula, MT.

Elliott, E. R. 2014. A floristic inventory of the northern Absaroka, Beartooth, and Gallatin Ranges, Wyoming and Montana, U.S.A., University of Wyoming, Laramie, WY.

Ellison, L., and E. J. Woolfolk. 1937. Effects of drought on vegetation near Miles City, Montana. Ecology 18:329-336.

Epstein, H. E., W. K. Lauenroth, I. C. Burke, and D. P. Coffin. 1997. Productivity patterns of C3 and C4 functional types in the U.S. Great Plains. Ecology 78:722-731.

Erdody, T. L., and G. Carnwath. 2018. Future fire assumptions for CGNF SIMPPLLE modeling: Estimating area burned, fire size distribution, fire severity/effects to vegetation and reburning. U.S. Department of Agriculture, Forest Service.

Esselman, P. C., D. M. Infante, L. Wang, D. Wu, A. R. Cooper, and W. W. Taylor. 2011. An index of cumulative disturbance to river fish habitats of the conterminous United States from landscape anthropogenic activities. Ecological Restoration 29:133-151.

Evans, E., R. Thorp, S. Jepsen, and S. Hoffman Black. 2008. Status review of three formerly common species of bumble bee in the subgenus Bombus. Xerces Society for Invertebrate Conservation, Portland, OR.

Farrow, R. A. 1979. Population dynamics of the Australian plague locust, Chortoicetes terminifera (Walker), in central western New South Wales I. Reproduction and migration in relation to weather. Australian Journal of Zoology 27:717-745.

Fenn, M. E., J. S. Baron, E. B. Allen, H. M. Rueth, K. R. Nydick, L. Geiser, W. D. Bowman, J. O. Sickman, T. Meixner, D. W. Johnson, and P. Neitlich. 2003. Ecological effects of nit. BioScience 53:17.

Fertig, W., and S. Markow. 2000. State species abstract: Wyoming natural diversity database: Salix barrattian barratt willow. University of Wyoming, Wyoming Natural Diversity Database, Laramie, WY.

Fiedler, C. E. 2000. Restoration treatments promote growth and reduce mortality of old-growth ponderosa pine (Montana). Ecological Restoration 18:117-119.

Fiedler, C. E. 2002. Natural process-based management of fire-adapted western forests. Pages 147-151 *in* D. M. Baumgartner, L. R. Johnson, and E. J. DePuit, editors. Small Diameter Timber: Resource Management Manufacturing, and Markets: Proceedings from Conference, February 25-27, 2002, Spokane, Washington. Washington State University Cooperative Extension, Pullman, WA.

Fiedler, C. E., P. Friederici, M. Petruncio, C. Denton, and W. D. Hacker. 2007. Managing for old growth in frequent-fire landscapes. Ecology and Society 12:12.

Finch, D. M. 2012. Climate change in grasslands, shrublands, and deserts of the interior American West: A review and needs assessment. Gen. Tech. Rep. RMRS-GTR-285, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Finch, D. M., R. L. Pendleton, M. C. Reeves, J. E. Ott, F. F. Kilkenny, J. L. Butler, J. P. Ott, J. R. Pinto, P. L. Ford, J. B. Runyon, M. A. Rumble, and S. G. Kitchen. 2016. Chapter 8: Rangeland drought: Effects, restoration, and adaptation. Pages 155-194 *in* J. M. Vose, J. S. Clark, C. H. Luce, and T. Patel-Weynard, editors. Effects of drought on forests and rangelands in the United States: A comprehensive science synthesis. U.S. Department of Agriculture, Forest Service, Washington Office, Washington, DC.

Finney, M. A., C. W. McHugh, and I. C. Grenfell. 2005. Stand- and landscape-level effects of prescribed burning on two Arizona wildfires. Canadian Journal of Forest Research 35:1714-1722.

Fischer, W. C., and B. D. Clayton. 1983. Fire ecology of Montana forest habitat types east of the Continental Divide. Gen. Tech. Rep. INT-GTR-141, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

Flake, L. D., J. W. Connelly, T. R. Kirschenmann, and A. J. Lindbloom. 2010. Grouse of plains and mountains: the south dakota story South Dakota Department of Game, Fish and Parks, Pierre, SD.

Flesch, E. P., and R. A. Garrott. 2012. Population trends of bighorn sheep and mountain goats in the greater Yellowstone area. Intermountain Journal of Sciences 18:1-28.

Foresman, K. R. 2012. Mammals of Montana. 2nd edition. Mountain Press Publishing Company.

Forest Ecosystem Management Assessment Team. 1993. Forest ecosystem management: An ecological, economic and social assessment. Forest Ecosystem Management Assessment Team, Washington, DC.

Forman, R. T. T. 2003. Changes in amount and quality of habitat. Pages 123-133 *in* Road Ecology: Science and solutions. Island Press.

Fortin, J. K., K. D. Rode, G. V. Hilderbrand, J. Wilder, S. Farley, C. Jorgensen, and B. G. Marcot. 2016. Impacts of human recreation on brown bears (*Ursus arctos*): A review and new management tool. PLoS One 11.

Foster, D. R., D. A. Orwig, and J. S. McLachlan. 1996. Ecological and conservation insights from reconstructive studies of temperate old-growth forests. Trends in Ecology & Evolution 11:419-424.

Foster, E., J. Love, R. Rader, N. Reid, and M. J. Drielsma. 2017. Integrating a generic focal species, metapopulation capacity, and connectivity to identify opportunities to link fragmented habitat. Landscape Ecology 32:1837-1847.

Foster, M. A., J. T. Ensign, W. N. Davis, and D. C. Tribby. 2015. Greater Sage-Grouse in the southeast Montana Sage-Grouse core area.

Fountain, A. G. 2011. Glaciers of Montana. *in* U.S. Department of the Interior, National Park Service, Glaciers of the American West, Fort Collins, CO.

Franklin, J. F., R. J. Mitchell, and B. J. Palik. 2007. Natural disturbance and stand development principles for ecological forestry. Gen. Tech. Rep. NRS-GTR-19, U.S. Department Agriculture, Forest Service, Northern Research Station, Newtown Square, PA.

Frankson, R., K. Kunkel, S. Champion, and D. Easterling. 2017. South Dakota State Climate Summary. NOAA Technical Report NESDIS 149-SD, National Oceanic and Atmospheric Administration, National Centers for Environmental Information, Asheville, NC.

Frey, B. R., V. J. Lieffers, E. H. Hogg, and S. M. Landhausser. 2004. Predicting landscape patterns of aspen dieback: mechanisms and knowledge gaps. Canadian Journal of Forest Research 34:1379-1390.

Frey, K. 2020a. Record of personal communication with Bev Dixon: Grizzly bear use Bridger Mountains. *in*, Bozeman, MT.

_____. 2020b. Record of personal communication with Bev Dixon: Grizzly bear vs mountain bikers. Pages 2 *in*, Bozeman, MT.

Fryer, J. L. 2019. Elliottia racemosa, Georgia plume. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, Fire Effects Information System, [Online].

Fule, P. Z., T. W. Swetnam, P. M. Brown, D. A. Falk, D. L. Peterson, C. D. Allen, G. H. Aplet, M. A. Battaglia, D. Binkley, C. Farris, R. E. Keane, E. Q. Margolis, H. Grissino-Mayer, C. Miller, C. H. Sieg, C. Skinner, S. L. Stephens, and A. Taylor. 2013. Unsupported inferences of high-severity fire in historical dry forests of the western United States: response to Williams and Baker. Global Ecology and Biogeography:1-6.

Gage, S. H., and M. K. Mukerji. 1977. A perspective of grasshopper population distribution in Saskatchewan and interrelationship with weather. Environmental Entomology 6:469-479.

Garrott, R. 2016. RE: BHS studies. Pages 4 *in* J. Canfield, editor. Montana State University, Bozeman, MT.

Garrott, R., J. Rotella, E. Flesch, C. Butler, E. Almberg, K. Proffitt, E. Lula, B. Lowerey, and T. Patterson. 2019. The role of disease, habitat, individual condition, and herd attributes on bighorn sheep recruitment and population dynamics in Montana: Annual report.

Federal Aid in Wildlife Restoration Grant W-159-R, Fish, Wildlife & Parks and Montana State University, Helena, MT.

Garrott, R., J. Rotella, M. O'Reilly, J. DeVoe, C. Butler, E. Flesch, and M. Sawaya. 2012. The greater Yellowstone area mountain ungulate project: 2011 annual report. Montana State University, Bozeman, MT.

Garrott, R. A., J. Rotella, K. Proffitt, and C. Butler. 2015. The role of disease, habitat, individual condition, and herd attributes on bighorn sheep recruitment and population dynamics in Montana. Federal Aid in Wildlife Restoration Grant W-159-R, Fish, Wildlife & Parks and Montana State University, Bozeman, MT.

Geiser, L. 2004. Manual for monitoring air quality using lichens on national forests of the Pacific northwest. R6-NR-ARM-TP-02-04, U. S. Department of Agriculture, Forest Service, Pacific Northwest Region, Air Resource Management, Portland, OR.

Geremia, C., R. Wallen, and P. J. White. 2018. Status report on the Yellowstone bison population, September 2018. U.S. Department of the Interior, National Park Service, Yellowstone National Park, Mammoth, WY.

Ghannoum, O. 2009. C4 photosynthesis and water stress. Annals of Botany 103:635-644.

Giersch, J. J., S. Hotaling, R. P. Kovach, L. A. Jones, and C. C. Muhlfeld. 2016. Climate-induced glacier and snow loss imperils alpine stream insects. Global Change Biology.

Giersch, J. J., S. Jordan, G. Luikart, L. A. Jones, F. R. Hauer, and C. C. Muhlfeld. 2015. Climate-induced range contraction of a rare alpine aquatic invertebrate. Freshwater Science 34:53-65.

Gilgert, W., and M. Vaughan. 2011. The value of pollinators and pollinator habitat to rangelands: Connections among pollinators, insects, plant communities, fish, and wildlife. Rangelands 33:14-19.

Golladay, S. W., K. L. Martin, J. M. Vose, D. N. Wear, A. P. Covich, R. J. Hobbs, K. D. Klepzig, G. E. Likens, R. J. Naiman, and A. W. Shearer. 2016. Achievable future conditions as a framework for guiding forest conservation and management. Forest Ecology and Management 360:80-96.

Gonzalez, P., R. P. Neilson, K. S. McKelvey, J. M. Lenihan, and R. J. Drapek. 2007. Potential impacts of climate change on habitat and conservation priority areas for *Lynx canadensis* (Canada lynx).

Goode, J. R., C. H. Luce, and J. M. Buffington. 2012. Enhanced sediment delivery in a changing climate in semi-arid mountain basins: Implications for water resource management and aquatic habitat in the northern Rocky Mountains. Geomorphology 139-140:1-15.

Goss, L. M., and B. B. Roper. 2018. The relationship between measures of annual livestock disturbance in western riparian areas and stream conditions important to trout, salmon, and char. Western North American Naturalist 78:76-91.

Graham, L., and R. L. Knight. 2004. Multi-scale comparisons of cliff vegetation in Colorado. Plant Ecology 170:223-234.

Graham, R. T. 2003. Hayman fire case study. Gen. Tech. Rep. RMRS-GTR-114, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Graham, R. T., A. E. Harvey, M. F. Jurgensen, T. B. Jain, J. R. Tonn, and D. S. Page-Dumroese. 1994. Managing coarse woody debris in forests of the Rocky Mountains. INT-RP-477, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Great West Engineering. 2016. Custer-Gallatin National Forest Beaver Habitat Suitability Modeling and Recommendations for Application to Watershed Condition.

Greater Yellowstone Coordinating Committee Whitebark Pine Subcommittee. 2011. Whitebark pine strategy for the greater Yellowstone.

Greater Yellowstone Whitebark Pine Subcommittee. 2015. Adaptive Action Plan Whitebark Pine in the Greater Yellowstone Area.

Green, P., J. Joy, D. Sirucek, W. Hann, A. Zack, and B. Naumann. 2011. Old-growth forest types of the Northern Region (1992, with errata through 2011).

Grenon, J., and M. Story. 2009. U.S. Forest Service Region 1 lake chemistry, NADP, and IMPROVE air quality data analysis. Gen. Tech. Rep. RMRS-GTR-230WWW, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Grenon, J., T. Svalberg, T. Porwoll, and M. Story. 2010. Lake and bulk sampling chemistry, NADP, and IMPROVE air quality data analysis on the Bridger-Teton National Forest (USFS region 4). Gen. Tech. Rep. RMRS-GTR-248WWW, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Grixti, J. C., L. T. Wong, S. A. Cameron, and C. Favret. 2009. Decline of bumble bees (Bombus) in the North American Midwest. Biological Conservation 142:75-84.

Gude, P., R. Rasker, and J. Van den Noort. 2008. Potential for future development on fire-prone lands. Journal of Forestry:198-205.

Gunther, K. A., R. R. Shoemaker, K. L. Frey, M. A. Haroldson, S. L. Cain, F. T. van Manen, and J. K. Fortin. 2014. Dietary breadth of grizzly bears in the Greater Yellowstone Ecosystem. Ursus 25:60-72.

Gustavsson, L., R. Madlener, H. F. Hoen, G. Jungmeier, T. Karjalainen, S. KlÖhn, K. Mahapatra, J. Pohjola, B. Solberg, and H. Spelter. 2006. The role of wood material for greenhouse gas mitigation. Mitigation and Adaptation Strategies for Global Change 11:1097-1127.

H Stout, D., and A. Sala. 2003. Xylem vulnerability to cavitation in Pseudotsuga menziesii and Pinus ponderosa from contrasting habitats. Tree Physiology 23:43-50.

Haber, J., and P. Nelson. 2015. Planning for connectivity: A guide to connecting and conserving wildlife within and beyond America's national forests.

Haglund, B. M. 1980. Proline and valine--cues which stimulate grasshopper herbivory during drought stress. Nature 288:697-698.

Hajek, A. E., and R. J. St Leger. 1994. Interactions between fungal pathogens and insect hosts. Annual Review of Entomology 39:293-322.

Hall, M. H. P., and D. B. Fagre. 2003. Modeled climate-induced glacier change in Glacier National Park, 1850-2100. BioScience 53:131-140.

Hallman, H. J. 2012. Final report to the United States Forest Service floristic inventory of Custer National Forest Ashland and Sioux Districts 2012. University of Wyoming, Department of Botany, Laramie, WY.

Halofsky, J., and D. Peterson. 2016. Climate change vulnerabilities and adaptation options for forest vegetation management in the Northwestern USA. Atmosphere 7.

Halofsky, J. E., D. L. Peterson, S. K. Dante-Wood, L. Hoang, J. J. Ho, and L. A. Joyce. 2018a. Climate change vulnerability and adaptation in the Northern Rocky Mountains: Part 1.

Gen. Tech. Rep. RMRS-GTR-374, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

_____. 2018b. Climate change vulnerability and adaptation in the Northern Rocky Mountains: Part 2. Gen. Tech. Rep. RMRS-GTR-374, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Hansen, A. 2006. Yellowstone bioregional assessment: Understanding the ecology and land use of greater Yellowstone. Technical Report 2, Montana State University, Landscape Biodiversity Lab, Bozeman, MT.

Hansen, A. J. 2009. Species and habitats most at risk in greater Yellowstone. Yellowstone Science 17:27-37.

Hansen, A. J., T. Olliff, G. Carnwath, B. W. Miller, L. Hoang, M. Cross, J. Dibenedetto, K. Emmett, R. Keane, V. Kelly, N. Korb, K. Legg, K. Renwick, R. D., D. Thoma, A. Adhikari, T. Belote, K. Dante-Wood, D. Delong, B. Dixon, T. Erdody, D. Laufenberg, and B. Soderquist. 2018. Vegetation climate adaptation planning in support of the Custer Gallatin National Forest Plan revision. Montana State University, Landscape Biodiversity Lab, Bozeman, MT.

Hansen, A. J., and L. B. Phillips. 2015. Which tree species and biome types are most vulnerable to climate change in the US Northern Rocky Mountains? Forest Ecology and Management 338:68-83.

Hansen, P. L., R. D. Pfister, K. Boggs, B. J. Cook, J. Joy, and D. K. Hinckley. 1995. Classification and management of Montana's riparian and wetland sites. Miscellaneous Publication 54, University of Montana, School of Forestry, Montana Forest and Conservation Experiment Station, Missoula, MT.

Harmon, M. E., W. K. Ferrell, and J. F. Franklin. 1990. Effects on carbon storage of conversion of old-growth forests to young forests. Science 247:699-702.

Haroldson, M. 2019. Custer Gallatin National Forest Grizzly bear den sites.

Haroldson, M. A., C. C. Schwartz, K. C. Kendall, K. A. Gunther, D. S. Moody, K. Frey, and D. Paetkau. 2010. Genetic analysis of individual origins supports isolation of grizzly bears in the greater Yellowstone ecosystem. Ursus 21:1-13.

Harrison, S., E. Damschen, and B. M. Going. 2009. Climate gradients, climate change, and special edaphic floras. Northeastern Naturalist 16:121-130.

Harsch, M. A., and J. H. Ris Lambers. 2015. Species distributions shift downward across western North America. Global Change Biology 21:1376.

Hart, S. C., T. H. DeLuca, G. S. Newman, M. D. MacKenzie, and S. I. Boyle. 2005. Post-fire vegetative dynamics as drivers of microbial community structure and function in forest soils. Forest Ecology and Management 220:166-184.

Hartman, R. L., and B. E. Nelson. 2010. Final report: Flora of the east pryor mountains, Montana. USFS-07-CS-11010800-011, UW-USDAFS45342, University of Washington, Department of Botany, Laramie, WY.

Hartsough, B. R., S. Abrams, R. J. Barbour, E. S. Drews, J. D. McIver, J. J. Moghaddas, D. W. Schwilk, and S. L. Stephens. 2008. The economics of alternative fuel reduction treatments in western United States dry forests: Financial and policy implications from the National Fire and Fire Surrogate Study. Forest Policy and Economics 10:344-354.

Harvey, B. J., D. C. Donato, and M. G. Turner. 2016a. Burn me twice, shame on who? Interactions between successive forest fires across a temperate mountain region. Ecology 97:2272-2282.

_____. 2016b. High and dry: post-fire tree seedling establishment in subalpine forests decreases with post-fire drought and large stand-replacing burn patches. Global Ecology and Biogeography 25:655-669.

Hatfield, R., S. Colla, S. Jepsen, L. Richardson, R. Thorp, and S. F. Jordan. 2015. IUCN assessments for North American Bombus spp., The Xerces Society for Invertebrate Conservation, Portland, OR.

Hatfield, R., S. Jepsen, E. Mader, S. Hoffman Black, and M. Shepherd. 2012. Conserving bumble bees: Guidelines for creating and managing habitat for America's declining pollinators. Entered by Ian Tedder on December 18, 2018, Portland, OR.

Hatfield, R. G., and G. LeBuhn. 2007. Patch and landscape factors shape community assemblage of bumble bees, Bombus spp. (Hymenoptera: Apidae), in montane meadows. Biological Conservation 39:150-158.

Hawe, A., and D. Delong. 1998. Partial cutting and controlled fire to restore old-growth forest conditions in the East Kootenay Trench. Pages 29-36 *in* Managing the dry Douglas-fir forests of the Southern Interior: Proc. workshop, Kamloops, April 29-30, 1997. B.C. Ministry of Forest Research.

Heath, L. S., J. E. Smith, C. W. Woodall, D. L. Azuma, and K. L. Waddell. 2011. Carbon stocks on forestland of the United States, with emphasis on USDA Forest Service ownership. Ecosphere 2.

Hegg, S. J., K. Murphy, and D. Bjornlie. 2010. Grizzly bears and snowmobile use: A summary of monitoring a grizzly den on Togwotee Pass. Yellowstone Science 18:23-28.

Heinemeyer, K., J. O'Keefe, and D. E. Mack. 2019a. Use of aerial surveys to monitor backcountry winter recreation and predict associated wolverine habitat use. Idaho Department of Fish and Game, Round River Conservation Studies, Boise, ID.

Heinemeyer, K., J. Squires, M. Hebblewhite, J. O'Keefe, J. D. Holbrook, and J. Copeland. 2019b. Wolverines in winter: Indirect habitat loss and functional responses to backcountry recreation. Ecosphere 10:1-23.

Henderson, T., A. Ray, P. Penoyer, A. Rodman, M. Levandowski, A. Yoder, S. Matolyak, M. B. Marks, and A. Coleman. 2018. Mine tailings reclamation project improves water quality in Yellowstone's Soda Butte Creek. Park Science 34:9-21.

Herfindal, I., U. S. Lande, E. J. Solberg, C. M. Rolandsen, O. Roer, and H. K. Wam. 2017. Weather affects temporal niche partitioning between moose and livestock. Wildlife Biology 2017:1-12.

Hessburg, P. F., and J. K. Agee. 2003. An environmental narrative of inland northwest United States forests, 1800–2000. Forest Ecology and Management 178:23-59.

Hessburg, P. F., J. K. Agee, and J. F. Franklin. 2005. Dry forests and wildland fires of the inland northwest USA : Contrasting the landscape ecology of the pre-settlement and modern eras. Forest Ecology and Management 211:117-139.

Hessburg, P. F., D. J. Churchill, A. J. Larson, R. D. Haugo, C. Miller, t. A. Spies, M. P. North, N. A. Povak, R. T. Belote, P. H. Singleton, W. L. Gaines, R. E. Keane, G. H. Aplet, S. L. Stephens, P.

Morgan, P. A. Bisson, B. E. Rieman, R. B. Salter, and G. H. Reeves. 2015. Restoring fire-prone inland Pacific landscapes: seven core principles. Landscape Ecology 30:1805-1835.

Hessburg, P. F., T. A. Spies, D. A. Perry, C. N. Skinner, A. H. Taylor, P. M. Brown, S. L. Stephens, A. J. Larson, D. J. Churchill, N. A. Povak, P. H. Singleton, B. McComb, W. J. Zielinski, B. M. Collins, R. B. Salter, J. J. Keane, J. F. Franklin, and G. Riegel. 2016. Tamm Review: Management of mixed-severity fire regime forests in Oregon, Washington, and Northern California. Forest Ecology and Management 366:221-250.

Hewitt, G. B., and J. Onsager. 1983. Control of grasshoppers in rangeland in the United States--a perspective. Journal of Range Management 36:202-207.

Heyerdahl, E. K., R. F. Miller, and R. A. Parsons. 2006. History of fire and Douglas-fir establishment in a savanna and sagebrush–grassland mosaic, southwestern Montana, USA. Forest Ecology and Management 230:107-118.

Higgins, K. F. 1984. Lightning fires in North Dakota grasslands and in pine-savanna lands of South Dakota and Montana. Journal of Range Management 37:100-103.

Hillis, J. M., M. J. Thompson, J. E. Canfield, L. J. Lyon, C. L. Marcum, P. M. Dolan, and D. W. McCleerey. Defining elk security: the Hillis paradigm. Montana State University, 10-12 April 1991, Bozeman, MT.

Hoff, R. J., D. E. Ferguson, G. I. McDonald, and R. E. Keane. 2001. Strategies for managing whitebark pine in the presence of white pine blister rust. Pages 346-366 *in* D. F. Tomback, S. F. Arno, and R. E. Keane, editors. Whitebark pine communities: Ecology and restoration. Island Press, Washington, DC.

Hoffman Black, S., M. Shepherd, and M. Vaughan. 2011. Rangeland management for pollinators. Rangelands 33:9-14.

Hogg, E. H., and P. A. Hurdle. 1995. The aspen parkland in western Canada: A dry-climate analogue for the future boreal forest? Water Air and Soil Pollution 82:391-400.

Holbrook, J. D., J. R. Squires, B. Bollenbacher, R. Graham, L. E. Olson, G. Hanvey, S. Jackson, and R. L. Lawrence. 2018. Spatio-temporal responses of Canada lynx (Lynx canadensis) to silvicultural treatments in the northern Rockies, U.S. Forest Ecology and Management 422:114-124.

Holbrook, J. D., J. R. Squires, B. Bollenbacher, R. Graham, L. E. Olson, G. Hanvey, S. Jackson, R. L. Lawrence, and S. L. Savage. 2019. Management of forests and forest carnivores: Relating landscape mosaics to habitat quality of Canada lynx at their range periphery. Forest Ecology and Management 437:411-425.

Holbrook, J. D., J. R. Squires, L. E. Olson, N. J. DeCesare, and R. L. Lawrence. 2017a. Understanding and predicting habitat for wildlife conservation: the case of Canada lynx at the range periphery. Ecosphere 8:1-25.

Holbrook, J. D., J. R. Squires, L. E. Olson, R. L. Lawrence, and S. L. Savage. 2017b. Multiscale habitat relationships of snowshoe hares (Lepus americanus) in the mixed conifer landscape of the Northern Rockies, USA: Cross-scale effects of horizontal cover with implications for forest management. Ecology and Evolution 7:125-144.

Holland, E. A., F. J. Dentener, B. H. Braswell, and J. M. Sulzman. 1999. Contemporary and pre-industrial global reactive nitrogen budgets. Biogeochemistry 46:38.

Holling, C. S. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics 4:1-23.

Holloran, M. J., and S. H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. TheCondor 107:742-752.

Hood, S. M., S. Baker, and A. Sala. 2016. Fortifying the forest: thinning and burning increase resistance to a bark beetle outbreak and promote forest resilience. Ecological Applications 26:1984-2000.

Hood, S. M., H. Y. Smith, D. K. Wright, and L. S. Glasgow. 2012. Management guide to ecosystem restoration treatments: Two-aged lodgepole pine forests of central Montana, USA. Gen. Tech. Rep. RMRS-GTR-294, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Hough-Snee, N. 2013. Riparian vegetation communities change rapidly following passive restoration at a northern Utah stream. Ecological Engineering 58:371-377.

Hovingh, P. 2004. Intermountain freshwater mollusks, USA (Margaritifera, Anodonta, Gonidea, Valvata, Ferrissia): Geography, conservation, and fish management implications. Monographs of the Western North American Naturalist 2:109-135.

Hungerford, R. D., M. G. Harrington, W. H. Frandsen, K. C. Ryan, and G. J. Niehoff. 1991. Influence of fire on factors that affect site productivity. Pages 32-50 *in* A. E. Harvey, and L. F. Neuenschwander, editors. Proceedings: Management and Productivity of Western-Montane Forest Soils; 1990 April 10-12, Boise, ID. Gen. Tech. Rep. INT-GTR-280. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Hunter, M. L., Jr., G. Jacobson, L., Jr., and T. Webb, lll. 1988. Paleoecology and the coarse-filter approach to maintaining biological diversity. Conservation Biology 2:375-385.

Huntington, C., W. Nehlsen, and J. Bowers. 1996. A survey of healthy native stocks of anadromous salmonids in the Pacific Northwest and California. Fisheries 21:6-14.

Hurteau, M. D., G. W. Koch, and B. A. Hungate. 2008. Carbon protection and fire risk reduction: toward a full accounting of forest carbon offsets. Frontiers in Ecology and the Environment 6:6.

Huston, M. A. 1994. Chapter 1: Introduction. Pages 1-11 *in* Biological Diversity: The Coexistence of Species on Changing Landscapes. Cambridge University Press, Cambridge, UK.

Hutson, S. S., N. L. Barber, J. F. Kenny, K. S. Linsey, D. S. Lumia, and M. A. Maupin. 2005. Estimated use of water in the United States in 2000. USGS Circular 1268, U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

Hutto, R. L. 1995. Composition of bird communities following stand-replacement fires in northern Rocky Mountain (U.S.A.) conifer forests. Conservation Biology 9:1041-1058.

_____. 2006. Toward meaningful snag-management guidelines for postfire salvage logging in North American conifer forests. Conservation Biology 20:984-993.

_____. 2008. The ecological importance of severe wildfires: Some like it hot. Ecological Applications 18:1827-1834.

Hutto, R. L., R. E. Keane, R. L. Sherriff, C. T. Rota, L. A. Eby, and V. A. Saab. 2016. Toward a more ecologically informed view of severe forest fires. Ecosphere 7.

Hutto, R. L., and J. S. Young. 1999. Habitat relationships of landbirds in the northern region, U.S. Department of Agriculture, Forest Service. Gen. Tech. Rep. RMRS-GTR-32, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Hynes, H. B. N. 1975. The stream and its valley. SIL Proceedings: 1922-2010 19:1-15.

Ingalsbee, T. 2004. Collateral damage: The environmental effects of firefighting: The 2002 Biscuit Fire suppression actions and impacts.

_____. 2017. Whither the paradigm shift? Large wildland fires and the wildfire paradox offer opportunities for a new paradigm of ecological fire management. International Journal of Wildland Fire 26.

Inman, R. M., B. L. Brock, K. H. Inman, S. S. Sartorius, B. C. Aber, B. Giddings, S. L. Cain, M. L. Orme, J. A. Fredrick, B. J. Oakleaf, K. L. Alt, E. Odell, and G. Chapron. 2013. Developing priorities for metapopulation conservation at the landscape scale: Wolverines in the Western United States. Biological Conservation 166:276-286.

Inman, R. M., A. J. Magoun, J. Persson, and J. Mattisson. 2012a. The wolverine's niche: linking reproductive chronology, caching, competition, and climate. Journal of Mammalogy 93:634-644.

Inman, R. M., M. L. Packila, I. K. H., A. J. McCue, G. C. White, J. Persson, B. C. Aber, M. L. Orme, K. L. Alt, S. L. Cain, J. A. Fredrick, B. J. Oakleaf, and S. S. Sartorius. 2012b. Spatial ecology of wolverines at the southern periphery of distribution. Journal of Wildlife Management 76:778-7925.

Inman, R. M., M. L. Packila, K. H. Inman, B. Aber, R. Spence, and D. McCauley. 2009. Greater Yellowstone Wolverine Program: Progress report, December 2009.

Interagency Bison Management Plan. 2017a. 2017 annual report of the Interagency Bison Management Plan. Interagency Bison Management Plan, Bozeman, MT.

_____. 2017b. Operating procedures for the Interagency Bison Management Plan (IBMP). Interagency Bison Management Plan, Bozeman, MT.

_____. 2018a. 2018 annual report of the interagency bison management plan, November 1, 2017 through October 31, 2018. Animal and Plant Health Inspection Service; Confederated Salish and Kootenai Tribes; Custer-Gallatin National Forest; InterTribal Buffalo Council; Montana Fish, Wildlife & Parks; Montana Department of Livestock; Nez Perce Tribe; and Yellowstone National Park, Washington, DC.

_____. 2018b. Yellowstone Bison Management Field Operations Summary Bison Management Operations Winter 2017-18. Interagency Bison Management Plan, Bozeman, MT.

_____. 2019a. 2019 annual report of the interagency bison management plan, November 1, 2018 through October 31, 2019. Animal and Plant Health Inspection Service; Confederated Salish and Kootenai Tribes; Custer-Gallatin National Forest; InterTribal Buffalo Council; Montana Fish, Wildlife & Parks; Montana Department of Livestock; Nez Perce Tribe; and Yellowstone National Park, Washington, DC.

_____. 2019b. Yellowstone Bison Management Field Operations Summary Bison Management Operations Winter 2018-19. Interagency Bison Management Plan, Bozeman, MT.

Interagency Conservation Strategy Team. 2007. Final conservation strategy for the grizzly bear in the greater Yellowstone area. Grizzly Bear Recovery Team.

Interagency Grizzly Bear Committee. 1987. Grizzly bear compendium.

Interagency Lynx Biology Team. 2013. Canada lynx conservation assessment and strategy (3rd ed.). 3rd edition. Forest Service Publication R1-13-19, U.S. Department of Agriculture,, Forest Service and U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Land Management, and National Park Service, Missoula, MT.

Intergovernmental Panel on Climate Change. 2007a. Climate change: 2007 synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

_____. 2007b. Climate change: Impacts, adaptation and vulnerability. Pages 976 *in* M. L. Parry, O. F. Canziani, and J. P. Palutikof, editors. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, U.K.; New York.

_____. 2014. Climate change 2014: Synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Ireland, K. B., A. J. Hansen, R. E. Keane, K. Legg, and R. L. Gump. 2018. Putting climate adaptation on the map: Developing spatial management strategies for whitebark pine in the greater Yellowstone ecosystem. Environmental Management 61:981-1001.

Ireland, K. B., M. M. Moore, P. Z. Fule, T. J. Zegler, and R. E. Keane. 2014. Slow lifelong growth predisposes Populus tremuloides trees to mortality. Oecologia 175:847-859.

Isaak, D. J., M. K. Young, D. E. Nagel, D. L. Horan, and M. C. Groce. 2015. The cold-water climate shield: delineating refugia for preserving salmonid fishes through the 21st century. Global Change Biology 21:2540-2553.

Jackson, M., A. Gannon, H. Kearns, and K. Kendall. 2010. Current status of limber pine in Montana. U.S. Department of Agriculture, Forest Service, Forest Health Protection. Report Numbered Report 10-06.

Jaeger, K. L., D. R. Montgomery, and S. M. Bolton. 2007. Channel and perennial flow initiation in headwater streams: management implications of variability in source-area size. Environmental Management 40:775-786.

Jaeger, K. L., J. D. Olden, and N. A. Pelland. 2014. Climate change poised to threaten hydrologic connectivity and endemic fishes in dryland streams. Proceedings of the National Academy of Sciences of the United States of America 111:13894-13899.

Janowiak, M., W. J. Connelly, K. Dante-Wood, G. M. Domke, C. Giardina, Z. Kayler, K. Marcinkowski, T. Ontl, C. Rodriguez-Franco, C. Swanston, C. W. Woodall, and M. Buford. 2017. Considering forest and grassland carbon in land management. Gen. Tech. Rep. WO-95, U.S. Department of Agriculture, Forest Service, Washington, DC.

Janowiak, M. K., C. W. Swanston, L. M. Nagel, L. A. Brandt, P. R. Butler, S. D. Handler, P. D. Shannon, L. R. Iverson, S. N. Matthews, A. Prasad, and M. P. Peters. 2014. A practical approach for translating climate change adaptation principles into forest management actions. Journal of Forestry 112:424-433.

Jennersten, O. 1988. Pollination in Dianthus deltoides (Caryophyllaceae): Effects of habitat fragmentation on visitation and seed set. Conservation Biology 2:359-366.

Joern, A., and S. Gaines. 1990. Chapter 14: Population dynamics and regulation in grasshoppers. Pages 415-477 *in* A. J. Chapman, and A. Joern, editors. Biology of Grasshoppers. John Wiley & Sons, Hoboken, NJ.

Johnson, C. M., and R. A. King. 2018. Beneficial forest management practices for WNS-affected bats: Voluntary guidance for land managers and woodland owners in the eastern United

States. U.S. Fish and Wildlife Service, Department of the Interior, White-nose Syndrome National Plan, White-nose Syndrome Conservation and Recovery Working Group.

Johnson, E. A., K. Miyanishi, and J. M. H. Weir. 1995. Old-growth, disturbance, and ecosystem management. Canadian Journal of Botany 73:918-926.

Johnston, C. A., and R. J. Naiman. 1990. Browse selection by beaver: Effects on riparian forest composition. Canadian Journal of Forest Research 20:1036-1043.

Jones, J. 2004. US Forest Service--Region One potential vegetation type (PVT) classification of western Montana and northern Idaho.

Jones, W. M. 2001. Ecologically significant wetlands in the upper Yellowstone River watershed including Boulder, Clarks Fork Yellowstone, Shields, and Stillwater River drainages. Montana Natural Heritage Program, Montana State Library, Helena, MT.

Jurgensen, M. F., A. E. Harvey, R. T. Graham, D. S. Page-Dumroses, J. R. Tonn, M. J. Larsen, and T. B. Jain. 1997. Impacts of timber harvesting on soil organic matter, nitrogen, productivity, and health of inland northwest forests. Forest Science 43:234-251.

Kaczor, N. W. 2008. Nesting and Brood-Rearing Success and Resource Selection of Greater Sage-Grouse in Northwestern South Dakota. South Dakota State University.

Kamath, P. L., J. T. Foster, K. P. Drees, G. Luikart, C. Quance, N. J. Anderson, P. R. Clarke, E. K. Cole, M. L. Drew, W. H. Edwards, J. C. Rhyan, J. J. Treanor, R. L. Wallen, P. J. White, S. Robbe-Austerman, and P. C. Cross. 2016. Genomics reveals historic and contemporary transmission dynamics of a bacterial disease among wildlife and livestock. Nature Communications 7:11448.

Kamath, P. L., M. A. Haroldson, G. Luikart, D. Paetkau, C. Whitman, and F. T. Van Manen. 2015. Multiple estimates of effective population size for monitoring a long-lived vertebrate: An application to Yellowstone grizzly bears. Molecular Ecology 24:5507-5521.

Keane, R. E. 2019. Record of personal communication with Gunnar Carnwath: Fire and Landscape Dynamics. Pages 1-3 *in* U.S. Department of Agriculture, Forest Service.

Keane, R. E., S. F. Arno, and C. A. Stewart. 2000. Ecosystem-based management in the whitebark pine zone. Pages 36-40 *in* H. Y. Smith, editor. The Bitterroot Ecosystem Management Research Project: What we have learned—symposium proceedings, 18-20 May 1999, Missoula, MT. Proceedings RMRS-P-17. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Keane, R. E., P. F. Hessburg, P. B. Landres, and F. J. Swanson. 2009. The use of historical range and variability (HRV) in landscape management. Forest Ecology and Management 258:1025-1037.

Keane, R. E., L. M. Holsinger, M. F. Mahalovich, and D. F. Tomback. 2017. Restoring whitebark pine ecosystems in the face of climate change. Gen. Tech. Rep. RMRS-GTR-361, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Keane, R. E., R. Loehman, J. Clark, E. A. H. Smithwick, and C. Miller. 2015. Chapter 8: Exploring interactions among multiple disturbance agents in forest landscapes: Simulating effects of fire, beetles, and disease under climate change. Pages 201-231 *in* A. H. Perera, B. R. Sturtevant, and L. J. Buse, editors. Simulation Modeling of Forest Landscape Disturbances. Springer International Publishing.

Keane, R. E., M. F. Mahalovich, B. L. Bollenbacher, M. E. Manning, R. A. Loehman, T. B. Jain, L. M. Holsinger, and A. J. Larson. 2018. Chapter 5: Effects of Climate Change on Forest Vegetation in the Northern Rockies. Pages 59-95 *in* J. E. Halofsky, and D. L. Peterson, editors. Climate Change and Rocky Mountain Ecosystems. Springer International Publishing, Switzerland AG.

Keane, R. E., K. C. Ryan, T. T. Veblen, C. D. Allen, J. Logan, and B. Hawkes. 2002. Cascading effects of fire exclusion in Rocky Mountain ecosystems: A literature review. Gen. Tech. Rep. RMRS-GTR-91, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Keane, R. E., D. F. Tomback, C. A. Aubry, A. D. Bower, E. M. Campbell, C. L. Cripps, M. B. Jenkins, M. F. Mahalovich, M. Manning, S. T. McKinney, M. P. Murray, D. L. Perkins, D. P. Reinhart, C. Ryan, A. W. Schoettle, and C. M. Smith. 2012. A range-wide restoration strategy for whitebark pine (*Pinus albicaulis*). Gen. Tech. Rep. RMRS-GTR-279, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Kearns, C. A., D. W. Inouye, and N. M. Waser. 1998. Endangered mutualisms: The conservation of plant-pollinator interactions. Annual Review of Ecology and Systematics 29:83-112.

Keck, T. J. 2012. Detrimental soil disturbance and revised best management practices for timber sales on the Gallatin National Forest.

Kemp, W. P., and M. M. Cigliano. 1994. Drought and rangeland grasshopper species diversity. Canadian Entomologist 126:1075-1092.

Kershner, J. L., C. M. Bischoff, and D. L. Horan. 1997. Population, habitat, and genetic characteristics of Colorado River cutthroat trout in wilderness and nonwilderness stream sections in the Uinta Mountains of Utah and Wyoming. North American Journal of Fisheries Management 17:1134-1143.

Kershner, J. L., B. B. Roper, N. Bouwes, R. Henderson, and E. Archer. 2004. An analysis of stream habitat conditions in reference and managed watersheds on some federal lands within the Columbia River basin. North American Journal of Fisheries Management 24:1363-1375.

Kessler, J., C. Bradley, J. Rhodes, and J. Wood. 2001. Imperiled western trout and the importance of roadless areas: A report by the Western Native Trout Campaign. Western Native Trout Campaign.

Kevan, P. G. 1977. Blueberry crops in Nova Scotia and New Brunswick - Pesticides and crop reductions. Canadian Journal of Agricultural Economics 25:61-64.

Keyes, C. R., T. E. Perry, E. K. Sutherland, D. K. Wright, and J. M. Egan. 2014. Variable-retention harvesting as a silvicultural option for lodgepole pine. Journal of Forestry 112:440-445.

Keyser, A., and A. LeRoy Westerling. 2017. Climate drives inter-annual variability in probability of high severity fire occurrence in the western United States. Environmental Research Letters 12.

Keyser, T. L., and S. J. Zarnoch. 2012. Thinning, age, and site quality influence live tree carbon stocks in upland hardwood forests of the southern Appalachians. Forest Science 58:407-418.

Kitzberger, T., P. M. Brown, E. K. Heyerdahl, T. W. Swetnam, and T. T. Veblen. 2007. Contingent Pacific-Atlantic Ocean influence on multicentury wildfire synchrony over western North

America. Proceedings of the National Academy of Sciences of the United States of America 104:6.

Knapp, A. K., J. M. Briggs, and J. K. Koelliker. 2001. Frequency and Extent of Water Limitation to Primary Production in a Mesic Temperate Grassland. Ecosystems 4:19-28.

Knick, S. T., A. L. Holmes, and R. F. Miller. 2005. The role of fire in structuring sagebrush habitats and bird communities. Studies in Avian Biology 30.

Koehler, G. M., and K. B. Aubry. 1994. Chapter 4: Lynx. Pages 74-98 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors. The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx, and Wolverine in the Western United States. Gen. Tech. Rep. RM-GTR-254. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Kohl, M. T., M. Hebblewhite, S. M. Cleveland, and R. M. Callaway. 2012. Forage value of invasive species to the diet of Rocky Mountain elk. Rangelands 34:24-28.

Kolb, T. E., J. K. Agee, P. Z. Fule, N. G. McDowell, K. Pearson, A. Sala, and R. H. Waring. 2007. Perpetuating old ponderosa pine. Forest Ecology and Management 249:141-157.

Kolbe, J. A., J. R. Squires, D. H. Pletscher, and L. F. Ruggiero. 2007. The effect of snowmobile trails on coyote movements within lynx home ranges. Journal of Wildlife Management 71:1409-1418.

Korb, J. E., N. C. Johnson, and W. W. Covington. 2004. Slash pile burning effects on soil biotic and chemical properties and plant establishment: recommendations for amelioration. Restoration Ecology 12:52-62.

Kosterman, M. K., J. R. Squires, J. D. Holbrook, D. H. Pletscher, and M. Hebblewhite. 2018. Forest structure provides the income for reproductive success in a southern population of Canada lynx. Ecological Applications.

Kovach, R. P., J. B. Armstrong, D. A. Schmetterling, R. Al-Chokhachy, and C. C. Muhlfeld. 2018. Long-term population dynamics and conservation risk of migratory bull trout in the upper Columbia River basin. Canadian Journal of Fisheries and Aquatic Sciences 75:1960-1968.

Krake, H., A. Picavet, C. Hibbard, E. Kiel, and I. Abernathy. 2018. Deadly white-nose syndrome confirmed in South Dakota; responsible bat protection efforts continue. U.S. Department of Agriculture, Forest service; U.S. Department of the Interior, National Park Service; U.S. Fish and Wildlife Service, South Dakota Game, Fish and Parks; University of Wyoming.

Kreutzweiser, D. P., P. K. Sibley, J. S. Richardson, and A. M. Gordon. 2012. Introduction and a theoretical basis for using disturbance by forest management activities to sustain aquatic ecosystems. Freshwater Science 31:224-231.

Kurz, W. A., C. C. Dymond, G. Stinson, G. J. Rampley, E. T. Neilson, A. L. Carroll, T. Ebata, and L. Safranyik. 2008. Mountain pine beetle and forest carbon feedback to climate change. Nature 452:987-990.

Kurzen, M. D., D. B. Tyers, J. L. Rossi, L. B. McNew, and B. F. Sowell. 2020. Snowshoe Hare use of Silviculturally Altered Conifer Forests inThe Greater Yellowstone Ecosystem. Intermountain Journal of Sciences 26:40-56.

Kuzara, S., E. Meredith, J. Wheaton, S. Bierbach, and D. Sasse. 2015. 2015 annual coalbed methane regional groundwater monitoring report: Powder Rover Basin, Montana.

Montana Bureau of Mines and Geology Open-File Report 679, Montana Bureau of Mines and Geology, Butte, MT.

Lacey, J. R., C. B. Marlow, and J. R. Lane. 1989. Influence of spotted knapweed (*Centaurea maculosa*) on surface runoff and sediment yield. Weed Technology 3:627-631.

Lackey, R. T. 2001. Values, policy, and ecosystem health. BioScience 51:437-443.

Ladyman, J. A. R. 2005. Salix barrattiana hooker (Barratt's willow): A technical conservation assessment. U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Fort Collins, CO.

Landa, A., K. Gudvangen, J. Swenson, and E. Røskaft. 1999. Factors associated with wolverine Gulo gulo predation on domestic sheep. Journal of Applied Ecology 36:963-973.

Landenburger, L. 2019. Error in 2018 annual report of the Interagency Grizzly Bear Study Team. *in* U.S. Department of the Interior, Geological Survey, Northern Rocky Mountain Science Center, Interagency Grizzly Bear Study Team, Bozeman, MT.

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9:1179-1188.

Langor, D. W. 2007. Status of the limber pine (Pinus flexilis) in Alberta. Alberta Wildlife Status Report No. 62, Alberta Conservation Association, Fish & Wildlife Division, Sherwood Park, AB.

Lanner, R. M., and S. B. Vander Wall. 1980. Dispersal of limber pine seed by Clark's nutcracker. Journal of Forestry 78:637-639.

Larmont, S., and K. Reid. 2017. Assessment forest plan revision: Final invasive plants report. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Billings, MT.

Larson, A. J., R. T. Belote, C. A. Cansler, S. A. Parks, and M. S. Dietz. 2013. Latent resilience in ponderosa pine forest: effects of resumed frequent fire. Ecological Applications 23:1243-1249.

Larson, A. J., and D. Churchill. 2012. Tree spatial patterns in fire-frequent forests of western North America, including mechanisms of pattern formation and implications for designing fuel reduction and restoration treatments. Forest Ecology and Management 267:74-92.

Lavin, M., T. J. Brummer, R. Quire, B. D. Maxwell, and L. J. Rew. 2013. Physical disturbance shapes vascular plant diversity more profoundly than fire in the sagebrush steppe of southeastern Idaho, U.S.A. Ecology and Evolution 3:1626-1641.

Lechner, A. M., D. Sprod, O. Carter, and E. C. Lefroy. 2017. Characterising landscape connectivity for conservation planning using a dispersal guild approach. Landscape Ecology 32:99-113.

Lehmkuhl, J. F., M. Kennedy, D. E. Ford, P. H. Singleton, W. L. Gaines, and R. L. Lind. 2007. Seeing the forest for the fuel: Integrating ecological values and fuels management. Forest Ecology and Management 246:73-80.

Lehnhoff, E. A., L. J. Rew, B. D. Maxwell, and M. L. Taper. 2008. Quantifying invasiveness of plants: A test case with yellow toadflax (Linaria vulgaris). Invasive Plant Science and Management 1:319-325.

Leonard, J. M., H. A. Magana, R. K. Bangert, D. G. Neary, and W. L. Montgomery. 2017. Fire and floods: The recovery of headwater stream systems following high-severity wildfire. Fire Ecology 13:62-84.

LeRoy Poff, N., J. D. Olden, and D. L. Strayer. 2012. Chapter 17: Climate change and freshwater fauna extinction risk. Pages 309-336 *in* L. Hannah, editor. Saving a Million Species: Extinction Risk from Climate Change. Island Press, Washington, DC.

Lesica, P. 1993. Vegetation and flora of the Line Creek Plateau Area, Carbon County, Montana. U.S. Department of Agriculture, Forest Service, Montana Natural Heritage Program, Helena, MT.

Lesica, P., and S. V. Cooper. 1997. Presettlement vegetation of southern Beaverhead County, Montana. U.S. Department of Agriculture, Forest Service, Beaverhead-Deerlodge National Forest; U.S. Department of the Interior, Bureau of Land Management, Helena, MT.

Lesica, P., S. V. Cooper, and G. Kudray. 2005. Big sagebrush shrub-steppe postfire succession in southwest Montana. Montana Natural Heritage Program, Helena, MT.

_____. 2007. Recovery of big sagebrush following fire in southwest Montana. Rangeland Ecology & Management 60:261-269.

Lesica, P., and E. E. Crone. 2017. Arctic and boreal plant species decline at their southern range limits in the Rocky Mountains. Ecology Letters 20:166-174.

Lesica, P., and C. Marlow. 2013. Green ash woodlands: A review. Research Bulletin 4601, Montana State University, Bozeman, MT.

Levine, J. M., M. Vilà, C. M. D'Antonio, J. S. Dukes, K. Grigulis, and S. Lavorel. 2003. Mechanisms underlying the impacts of exotic plant invasions. Proceedings of the Royal Society B: Biological Sciences 270:775-781.

Lewis, A. C. 1982. Leaf wilting alters a plant species ranking by the grasshopper Melanoplus differentialis. Ecological Entomology 7:391-395.

Linnell, J. D. C., J. E. Swenson, R. Anderson, and B. Barnes. 2000. How vulnerable are denning bears to disturbance? Wildlife Society Bulletin 28:400-413.

Lippke, B., E. Oneil, R. Harrison, K. Skog, L. Gustavsson, and R. Sathre. 2011. Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns. Carbon Management 2:303-333.

Lisle, T. E. 2002. How much dead wood in stream channels is enough? Pages 85-93 *in* W. F. Laudenslayer, Jr., P. J. Shea, B. E. Valentine, C. P. Weatherspoon, and T. E. Lisle, editors. Proceedings of the symposium on the ecology and management of dead wood in western forests; 1999 November 2-4; Reno, NV. Gen. Tech. Rep. PSW-GTR-181. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Littell, J. S., D. McKenzie, D. L. Peterson, and A. L. Westerling. 2009. Climate and wildfire area burned in western U.S. ecoprovinces, 1916–2003. Ecological Applications 19:1003-1021.

Lloyd, R. A., K. A. Lohse, and T. P. A. Ferre. 2013. Influence of road reclamation techniques on forest ecosystem recovery. Frontiers in Ecology and the Environment 11:75-81.

Loehman, R. A., J. A. Clark, and R. E. Keane. 2011. Modeling effects of climate change and fire management on western white pine (*Pinus monticola*) in the northern Rocky Mountains, USA. Forests 2:832-860.

Logan, J. A., W. W. Macfarlane, and L. Willcox. 2010. Whitebark pine vulnerability to climate-driven mountain pine beetle disturbance in the Greater Yellowstone Ecosystem. Ecological Applications 20:895-902.

Lorenz, T. J., C. Aubry, and R. Shoal. 2008. A review of the literature on seed fate in whitebark pine and the life history traits of Clark's nutcracker and pine squirrels. Gen. Tech. Rep. PNW-GTR-742, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Lotan, J. E., and D. A. Perry. 1983. Ecology and regeneration of lodgepole pine. Agriculture Handbook No. 606, U.S. Department of Agriculture, Washington, DC.

Loveless, K. 2016. Upper Yellowstone bighorn sheep survey 2016. Montana Fish, Wildlife & Parks, Helena, MT.

Lowrey, L., and G. Davis. 2018. Management and research goals for balsam woolly adelgid in the interior west. R01-18-07, U.S. Department of Agriculture, Forest Service, Forest Health Protection, Missoula, MT.

Luce, C. H. 2018. Chapter 3: Effects of climate change on snowpack, glaciers, and water resources in the Northern Rockies. Pages 25-36 *in* J. E. Halofsky, and D. L. Peterson, editors. Climate change and Rocky Mountain ecosystems. Springer, Cham, Switzerland.

Luyssaert, S., E. D. Schulze, A. Börner, A. Knohl, D. Hessenmoller, B. E. Law, P. Ciais, and J. Grace. 2008. Old-growth forests as global carbon sinks. Nature 455:213-215.

Lyman, J. C. 2005. Shoshonea pulvinata evert & constance (Shoshone carrot): A technical conservation assessment. U.S. Department of Agriculture, Forest Service, Rocky Mountain Region, Fort Collins, CO.

Lyon, J. L., and A. G. Christensen. 2002. Elk and land management. Pages 557-575 *in* D. E. Toweill, and J. W. Thomas, editors. North American elk: Ecology and management. Smithsonian Institution Scholarly Press, Washington, DC.

Lyon, L. J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81:592-613.

Lyon, L. J., T. N. Lonner, J. P. Weigand, C. L. Marcum, W. D. Edge, J. D. Jones, D. W. McCleerey, and L. L. Hicks. 1985. Coordinating elk and timber management: Final report of the Montana cooperative elk-logging study 1970-1985.

Mace, R. D., and T. L. Manley. 1993. South Fork Flathead River grizzly bear project: Progress report for 1992.

Macfarlane, W. W., J. A. Logan, and W. R. Kern. 2013. An innovative aerial assessment of greater Yellowstone ecosystem mountain pine beetle-caused whitebark pine mortality. Ecological Applications 23:421-437.

Mack, E., D. Keinath, J. Lindstrom, C. Hansen, J. Shoemaker, K. Newlon, K. Novak, A. Nicholas, and T. Abbott. 2017. Species status assessment report for the white-tailed prairie dog (Cynomys leucurus). U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Mahalovich, M. F., M. J. Kimsey, and S. Winward. Genetic refugia: A bottoms-up approach to identifying climate refugia for whitebark pine. U.S. Department of Agriculture, Forest Service, August 5-10 2018.

Malison, R. L., and C. V. Baxter. 2010a. Effects of wildfire of varying severity on benthic stream insect assemblages and emergence. Journal of the North American Benthological Society 29:1324-1338.

_____. 2010b. The fire pulse: wildfire stimulates flux of aquatic prey to terrestrial habitats driving increases in riparian consumers. Canadian Journal of Fisheries and Aquatic Sciences 67:570-579.

Manier, D. J., Z. H. Bowen, M. L. Brooks, M. L. Casazza, P. S. Coates, P. A. Deibert, S. E. Hanser, and D. H. Johnson. 2014. Conservation buffer distance estimates for Greater Sage-Grouse—A review. U.S. Geological Survey Open-File Report 2014–1239, U.S. Geological Survey, Fort Collins, CO.

Marks, J. S., P. Hendricks, and D. Casey. 2016. Birds of Montana. First edition. Buteo Books, Arrington, VA.

Marlin, J. C., and W. E. LaBerge. 2001. The native bee fauna of Carlinville, Illinois, revisited after 75 years: A case for persistence. Conservation Biology 5:1-19.

Marlon, J. R., P. J. Bartlein, D. G. Gavin, C. J. Long, R. S. Anderson, C. E. Briles, K. J. Brown, D. Colombaroli, D. J. Hallett, M. J. Power, E. A. Scharf, and M. K. Walsh. 2012. Long-term perspective on wildfires in the western USA. Proceedings of the National Academy of Sciences of the United States of America 109:E535-543.

Marten, L. M. 2016a. Clarification on lynx habitat mapping in R1. Pages 2 *in* R. L. Team, editor. U.S. Department of Agriculture, Forest Service, Region One, Northern Region, Missoula, MT.

Marten, L. M. 2016b. Letter from regional forester (Northern Region) to Michael Garrity, Alliance for the Wild Rockies. Pages 2 *in* M. Garrity, editor.

Martin, R. E., and D. B. Sapsis. 1991. Fires as agents of biodiversity: Pyrodiversity promotes biodiversity. U.S. Department of Agriculture, Forest Service, Forestry Sciences Lab, 1991, Santa Rosa, CA.

Marvin, R. 2000. Hydrogeologic assessment of the Soda Butte Spring for ground water under the direct influence of surface water. MBMG Open-file Report 401-H, Montana Bureau of Mines and Geology, Butte, MT.

Matthews, W. J. 1988. North American prairie streams as systems for ecological study. Journal of the North American Benthological Society 7:387-409.

Mattson, D. J., R. R. Knight, and B. M. Blanchard. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. Bears: Their biology and management 7:259-273.

Maupin, M. A., J. F. Kenny, S. S. Hutson, J. K. Lovelace, N. L. Barber, and K. S. Linsey. 2014. Estimated use of water in the United States in 2010. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

Maxell, B. A. 2009. Distribution, identification, status, and habitat use of Montana's amphibians and reptiles. *in* Montana Natural Heritage Program, Helena, MT.

_____. 2015. Montana bat and white-nose syndrome surveillance plan and protocols 2012-2016. Montana Natural Heritage Program, Helena, MT.

Maxell, B. A., P. Hendricks, M. T. Gates, and S. Lenard. 2009. Montana amphibian and reptile status assessment, literature review, and conservation plan. Montana Cooperative Wildlife Research Unit and Wildlife Biology Program, University of Montana, Missoula, MT.

McArthur, E. D., and B. L. Welch. 1982. Growth rate differences among big sagebrush [Artenisia tridentata] accessions and subspecies. Journal of Range Management 35:396-400.

McClure, M. L., A. J. Hansen, and R. M. Inman. 2016. Connecting models to movements: Testing connectivity model predictions against empirical migration and dispersal data. Landscape Ecology 31:1419-1432.

McHugh, C. W., and M. A. Finney. 2019. Historical Burning to Contemporary Fire Deficits on the Custer Gallatin National Forest. *in*.

McIntyre, C., and C. Ellis. 2011. Landscape dynamics in the greater Yellowstone area. NPS/GRYN/NRTR–2011/506 edition. Natural Resource Technical Report, U.S. Department of the Interior, National Park Service, Natural Resource Stewardship and Science, Fort Collins, CO.

McKelvey, K. S., and P. C. Buotte. 2018. Chapter 8: Effects of climate change on wildlife in the northern Rockies. Pages 143-167 *in* J. E. Halofsky, and D. L. Peterson, editors. Climate change and Rocky Mountain ecosystems. Springer International Publishing, Switzerland AG.

McKelvey, K. S., J. P. Copeland, M. K. Schwarts, J. S. Littell, K. B. Aubry, J. R. Squires, S. A. Parks, E. M. M., and G. S. Mauger. 2011. Climate change predicted to shift wolverine distributions, connectivity, and dispersal corridors. Ecological Applications 21:2882-2897.

McKenzie, D., and M. C. Kennedy. 2011. Scaling laws and complexity in fire regimes. Pages 27-49 *in* The Landscape Ecology of Fire.

McKinley, D. C., and J. M. Blair. 2008. Woody plant encroachment by Juniperus virginiana in a mesic native grassland promotes rapid carbon and nitrogen accrual. Ecosystems 11:454-468.

McKinley, D. C., M. G. Ryan, R. A. Birdsey, C. P. Giardina, M. E. Harmon, L. S. Heath, R. A. Houghton, R. B. Jackson, J. F. Morrison, B. C. Murray, D. E. Pataki, and K. E. Skog. 2011. A synthesis of current knowledge on forests and carbon storage in the United States. Ecological Applications 21:1902-1924.

McKinney, S. T., C. E. Fiedler, and D. F. Tomback. 2009. Invasive pathogen threatens bird–pine mutualism: implications for sustaining a high-elevation ecosystem. Ecological Applications 19:597-607.

McKinney, S. T., and D. F. Tomback. 2007. The influence of white pine blister rust on seed dispersal in whitebark pine. Canadian Journal of Forest Research 37.

McKinney, S. T., D. F. Tomback, and C. E. Fiedler. 2011. Altered species interactions and implications for natural regeneration in whitebark pine communities. Pages 56-60 *in* R. E. Keane, D. F. Tomback, M. P. Murray, and C. M. Smith, editors. The future of high-elevation, five-needle white pines in western North America: Proceedings of the High Five Symposium, 28-30 June 2010; Missoula, MT. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

McMurray, J. 2017. Assessment forest plan revision: Final air resources report. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Billings, MT.

McMurray, J., D. W. Roberts, M. Fenn, L. Geiser, and S. Jovan. 2013. Using Epiphytic Lichens to Monitor Nitrogen Deposition Near Natural Gas Drilling Operations in the Wind River Range, WY, USA. Water Air Soil Pollutution 224.

Meagher, M., M. L. Taper, and C. L. Jerde. 2002. Recent changes in population distribution: The pelican bison and the domino effect. Pages 135-147 *in* R. J. Anderson, and D. Harmon, editors. Yellowstone Lake: Hotbed of chaos or reservoir of resilience? Yellowstone Center for Resources; The George Wright Society, Hancock, MI.

Meagher, M. M. 1973. The bison of Yellowstone National Park. National Park Service Scientific Monograph Series 1, U.S. Department of the Interior, National Park Service.

Means, R. E. 2011. Synthesis of lower treeline limber pine (pinus flexilis) woodland knowledge, research needs, and management considerations. *in* R. E. Keane, D. F. Tomback, M. P. Murray, and C. M. Smith, editors. The future of high-elevation, five-needle white pines in western North America: Proceedings of the High Five Symposium. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Merkle, J., K. Monteith, E. O. Aikens, M. Hayes, K. R. Hersey, A. D. Middleton, B. Oates, H. Sawyer, B. Scurlock, and M. J. Kauffman. 2016. Large herbivores surf waves of green-up in spring. 283:8.

Metlen, K. L., and C. E. Fiedler. 2006. Restoration treatment effects on the understory of ponderosa pine/Douglas-fir forests in western Montana, USA. Forest Ecology and Management 222:355-369.

Meyer, J. L., D. L. Strayer, J. B. Wallace, S. L. Eggert, G. S. Helfman, and N. E. Leonard. 2007. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association 43:86-103.

Meyerson, L. A., and H. A. Mooney. 2007. Invasive alien species in an era of globalization. Frontiers in Ecology and the Environment 5:199-208.

Michels, A., K. R. Laird, S. E. Wilson, D. Thomson, P. R. Leavitt, R. J. Oglesby, and B. F. Cumming. 2007. Multidecadal to millennial-scale shifts in drought conditions on the Canadian prairies over the past six millennia: Implications for future drought assessment. Global Change Biology 13:1295-1307.

Mihuc, T. B., and G. W. Minshall. 2005. The trophic basis of reference and post-fire stream food webs 10 years after wildfire in Yellowstone National Park. Aquatic Sciences 67:541-548.

Milburn, A., B. Bollenbacher, M. Manning, and R. Bush. 2015. Region 1 existing and potential vegetation groupings used for broad-level analysis and monitoring. Numbered Report 15-4 v1.0, USDA Forest Service, Northern Region, Missoula, MT.

Milburn, A., G. Carnwath, S. Fox, E. Henderson, and R. Bush. 2019. Region 1 Large-tree Structure Classification Used for Broad-level Analysis and Monitoring. Numbererd Report 19-3 v1.0, U.S. Department of Agriculture, Forest Service, Region 1, Forest and Range Management, Missoula, MT.

Millar, C. I. 2014. Historic variability: Informing restoration strategies, not prescribing targets. Journal of Sustainable Forestry 33:S28-S42.

Millar, C. I., and N. L. Stephenson. 2015. Temperate forest health in an era of emerging megadisturbance. Pages 823-826 *in* Science.

Millar, C. I., N. L. Stephenson, and S. L. Stephens. 2007. Climate change and forests of the future: managing in the face of uncertainty. Ecological Applications 17:2145-2151.

Milner, K. S. 1992. Site index and height growth curves for ponderosa pine, western larch, lodgepole pine, and Douglas-fir in western Montana. Western Journal of Applied Forestry 7:9-14.

Mitchell, R. G., and P. E. Buffam. 2001. Patterns of long-term balsam woolly adelgid infestations and effects in Oregon and Washington. Western Journal of Applied Forestry 16:121-126.

Mitchell, R. G., and K. H. Wright. 1967. Foreign Predator Introductions for Control of the Balsam Woolly Aphid in the Pacific Northwest. Journal of Economic Entomology 60:140-147.

Montana Aquatic Nuisance Species (ANS) Steering Committee. 2002. Montana aquatic nuisance species (ANS) management plan.

Montana Department of Environmental Quality. 1999. Montana Source water protection program. Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Helena, MT.

______. 2010. Montana/Idaho Airshed Group operating guide.

______. 2018. State of Montana air quality monitoring network plan. Montana Department of Environmental Quality, Helena, MT.

Montana Department of Environmental Quality, Planning Prevention and Assistance Division - Water Quality Standards Section,. 2002. Circular WQB-7: Montana numeric water quality standards.

Montana Department of Natural Resources and Conservation. 2010. Final environmental impact statement for the Montana Department of Natural Resources and Conservation forested trust lands habitat conservation plan [Vol I & II].

______. 2020. Montana forest action plan. Montana Forest Action Advisory Council, Helena, MT.

Montana Department of Transportation. 2017. Transportation Management Plan.

Montana Fish Wildlife and Parks. 2007. Montana Fish, Wildlife & Parks legislative proposal form, 2007 legislature. Montana Fish, Wildlife & Parks, Helena, MT.

______. 2010. Montana bighorn sheep conservation strategy. Montana Fish Wildlife and Parks Wildlife Division, Helena, MT.

______. 2011. Montana connectivity project: A statewide analysis. National Fish and Wildlife Foundation; Montana Fish, Wildlife, & Parks; Wildlife Conservation Society, Helena, MT.

______. 2013. Grizzly bear management plan for southwestern Montana 2013: Final programmatic environmental impact statement.

______. 2014a. Montana state parks and recreation strategic plan 2015-2020, Charting a new tomorrow. Final Report edition., Montana Fish Wildlife and Parks, Helena, MT.

______. 2014b. Northcentral Montana westslope cutthroat trout restoration update. Montana Fish, Wildlife & parks, Region 4, Great Falls, MT.

______. 2015a. Decision Notice Year-round Habitat for Yellowstone Bison Environmental Assessment. Year-round Habitat for Yellowstone Bison Environmental Assessment, Montana Fish,, Wildlife and Parks.

______. 2015b. DRAFT Environmental Impact Statement Bison Conservation and Management in Montana.

______. 2015c. Montana’s state wildlife action plan.

______. 2016. AIS Species and Identification. *in* Montana Department of Fish, Wildlife, and Parks, Helena, MT.

______. 2018a. Montana's white-nose syndrome prevention and response guidelines. Montana Fish, Wildlife and Parks, Helena, MT.

______. 2018b. Montana trapping and hunting regulations. Montana Fish, Wildlife & Parks, Helena, MT.

______. 2019. Montana statewide fisheries management program and guide 2019-2027. Montana Fish Wildlife and Parks, Helena, MT.

Montana Fish Wildlife and Parks, and Montana Department of Livestock. 2013. Draft joint environmental assessment: Year-round habitat for Yellowstone bison. Montana Fish, Wildlife, and Parks and Montana Department of Livestock.

Montana Natural Heritage Program. 2018a. Barratt's willow - Salix barrattiana. *in* Montana Natural Heritage Program, Helena, MT.

_____. 2018b. Western pearlshell — Margaritifera falcata. Montana field guide. *in* Montana Natural Heritage Program, Helena, MT.

Montana Prairie Dog Working Group. 2002. Conservation plan for black-tailed and white-tailed prairie dogs in Montana.

Montgomery, M. E., and N. P. Havill. 2014. II Balsam Woolly Adelgid (Adelges piceae [Ratzeburg]) (Hemiptera: Adelgidae). Pages 9-19 *in* R. Van Driesche, and R. Reardon, editors. The Use of Classical Biological Control to Preserve Forests in North America. U.S. Department of Agriculture, Forest Service Forest Health Technology Enterprise Team, Morgantown, WV.

Morelli, T. L., C. Daly, S. Z. Dobrowski, D. M. Dulen, J. L. Ebersole, S. T. Jackson, J. D. Lundquist, C. I. Millar, S. P. Maher, W. B. Monahan, K. R. Nydick, K. T. Redmond, S. C. Sawyer, S. Stock, and S. R. Beissinger. 2016. Managing climate change refugia for climate adaptation. PLoS One 11.

Morgan, J. A., J. D. Derner, D. G. Milchunas, and E. Pendall. 2008. Management implications of global change for Great Plains rangelands. Rangelands 30:18-22.

Morgan, J. A., D. R. LeCain, E. Pendall, D. M. Blumenthal, B. A. Kimball, Y. Carrillo, D. G. Williams, J. Heisler-White, F. A. Dijkstra, and M. West. 2011. C4 grasses prosper as carbon dioxide eliminates desiccation in warmed semi-arid grassland. Nature 476:202-205.

Morgan, J. A., D. G. Milchunas, D. R. LeCain, M. West, and A. R. Mosier. 2007. Carbon dioxide enrichment alters plant community structure and accelerates shrub growth in the shortgrass steppe. Proceedings of the National Academy of Sciences of the United States of America 104:14724-14729.

Morgan, J. A., A. R. Mosier, D. G. Milchunas, D. R. LeCain, J. A. Nelson, and W. J. Parton. 2004. CO2 enhances productivity, alters species composition, and reduces digestibility of shortgrass steppe vegetation. Ecological Applications 14:208-219.

Morgan, P., C. C. Hardy, T. W. Swetnam, M. G. Rollins, and D. G. Long. 2001. Mapping fire regimes across time and space: Understanding coarse and fine-scale fire patterns. International Journal of Wildland Fire 10:329-342.

Muhlfeld, C. C., J. J. Giersch, F. R. Hauer, G. T. Pederson, G. Luikart, D. P. Peterson, C. C. Downs, and D. B. Fagre. 2011. Climate change links fate of glaciers and an endemic alpine invertebrate. Climatic Change 106:337-345.

Myers, T. 2009. Groundwater management and coal bed methane development in the Powder River Basin of Montana. Journal of Hydrology 368:178-193.

Myers, T. J., and S. Swanson. 1996. Temporal and geomorphic variations of stream stability and morphology: Mahogany Creek, Nevada. Water Resources Bulletin 32:253-265.

Nadeau, M. S., N. J. DeCesare, D. G. Brimeyer, E. J. Bergman, R. B. Harris, K. R. Hersey, K. K. Huebner, P. E. Matthews, and T. P. Thomas. 2017. Status and trends of moose populations and hunting opportunity in the western United States. Alces: North American Moose Conference and Workshop Proceedings 53:99-112.

Naiman, R. J., T. J. Beechie, L. E. Benda, D. R. Berg, P. A. Bison, L. H. MacDonald, Matthew D. O'Connor, P. L. Olson, and E. A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecoregion. Pages 127-188 *in* R. J. Naiman, editor. Watershed management: Balancing sustainability with environmental change. Springer-Verlag, New York, NY.

Naiman, R. J., and H. Decamps. 1997. The ecology of interfaces: Riparian zones. Annual Review of Ecology Evolution and Systematics 28:621-658.

Naiman, R. J., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3:209-212.

Naiman, R. J., C. A. Johnston, and J. C. Kelley. 1988. Alteration of North American streams by beaver. BioScience 38:753-754.

Naiman, R. J., G. Pinay, C. A. Johnston, and J. Pastor. 1994. Beaver influences on the long-term biogeochemical characteristics of boreal forest drainage networks. Ecology 75:905-921.

Nanus, L., J. McMurray, D. Clow, J. Saros, T. Blett, and J. Gurdak. 2017. Spatial variation of atmospheric nitrogen deposition and critical loads for aquatic ecosystems in the Greater Yellowstone Area. 223:644-656.

National Academies Press. 2007. Chapter 3: Causes of pollinator declines and potential threats. Pages 75-103 *in* Status of Pollinators in North America. The National Academic Press, Washington, DC.

National Interagency Fire Center. 2017. Interagency standards for fire and fire aviation operations. NFES 2724, National Interagency Fire Center,, Boise, ID.

National Wildfire Coordinating Group. 2018. National Wildfire Coordinating Group Memorandum No. 18-004 - Recent USFS data analysis on firefighter injuries and Recommendation to managers to emphasize hazard mitigations in identified areas.

Neary, D. G., K. C. Ryan, and L. F. E. DeBano. 2005. Wildland fire in ecosystems: Effects of fire on soil and water. Gen. Tech. Rep. RMRS-GTR-42-vol.4, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Newton, L. P., and F. P. Hain. 2005. Host interactions of the balsam woolly adelgid. Pages 11 *in* B. Onken, and R. Reardon, editors. Third Symposium on Hemlock Woolly Adelgid in the Eastern United States, February 1-3, 2005, Renaissance Asheville Hotel, Asheville, North Carolina (FHTET-2005-01). U.S. Department of Agriculture, Forest Service, Forest Health Technology Enterprise Team, Morgantown, WV.

Nguyen, D. 2018. Prism user manual 1.0. Prism, Inc., Reston, VA.

Nistler, C. M. 2009. A review of prarie dog population demographics and implications for management in Montana. Montana Department of Fish, Wildlife and Parks, Helena, MT.

North, M. P., and M. D. Hurteau. 2011. High-severity wildfire effects on carbon stocks and emissions in fuel treated and untreated forest. Forest Ecology and Management 261:1115-1120.

Northern Continental Divide Ecosystem Subcommittee. 2018. Conservation strategy for the grizzly bear in the northern continental divide ecosystem. U.S. Department of Agriculture, Forest Service, Interagency Grizzly Bear Committee, Norhern Continental Divide Ecosystem Subcommittee, Missoula, MT.

Obama, B. H. 2016. Executive Order 13751 of December 5, 2016: Safeguarding the nation from the impacts of invasive species. Federal Register 81:88609-88614.

Ohmann, J. L., and K. L. Waddell. 2002. Regional patterns of dead wood in forested habitats of Oregon and Washington. Pages 535-560 *in* W. F. Laudenslayer, Jr., P. J. Shea, B. E. Valentine, C. P. Weatherspoon, and T. E. Lisle, editors. Proceedings of the symposium on the ecology and management of dead wood in western forests; 1999 November 2-4; Reno, NV. Gen. Tech. Rep. PSW-GTR-181. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Olson, L. E., J. R. Squires, E. K. Roberts, J. S. Ivan, and M. Hebblewhite. 2018. Sharing the same slope: Behavioral responses of a threatened mesocarnivore to motorized and nonmotorized winter recreation. Ecology and Evolution 8:8555-8572.

Ortega, Y. K., and D. E. Pearson. 2005. Weak vs. strong invaders of natural plant communities: assessing invasibility and impact. Ecological Applications 15:651-661.

Ortega, Y. K., D. E. Pearson, L. P. Waller, N. J. Sturdevant, and J. L. Maron. 2012. Population-level compensation impedes biological control of an invasive forb and indirect release of a native grass. Ecology 93:783-792.

Ostovar, K. 2007. Montana Fish, Wildlife & Parks project performance report. Montana Fish, Wildlife & Parks, Helena, MT.

Oyler-McCance, S. J., S. E. Taylor, and T. W. Quinn. 2005. A multilocus population genetic survey of the greater sage-grouse across their range. Molecular Ecology 14:1293-1310.

Page-Dumroese, D. S., M. F. Jurgensen, M. P. Curran, and S. M. DeHart. 2010. Chapter 9: Cumulative effects of fuel treatments on soil productivity. Pages 164-174 *in* W. J. Elliot, I. S. Miller, and L. Audin, editors. Cumulative watershed effects of fuel management in the western United States. Gen. Tech. Rep. RMRS-GTR-231. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Pardo, L. H., M. E. Fenn, C. L. Goodale, L. H. Geiser, C. T. Driscoll, E. B. Allen, J. S. Baron, R. Bobbink, W. D. Bowman, C. M. Clark, B. Emmett, F. S. Gilliam, T. L. Greaver, S. J. Hall, E. A. Lilleskov, L. Liu, J. A. Lynch, K. J. Nadelhoffer, S. S. Perakis, M. J. Robin-Abbott, J. L. Stoddard, K. C. Weathers, and R. L. Dennis. 2011. Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States. Ecological Applications 21:3049-3082.

Parkinson, H., J. Mangold, J. Jacobs, J. Madsen, and J. Halpop. 2010. Biology, ecology, and management of Eurasian Watermilfoil (Myriophyllum spicatum L.). EB0193, Montana State University Extension, Bozeman, MT.

Parkinson, H., J. Mangold, and C. McLane. 2016. Biology, ecology, and management of curlyleaf pondweed (Potamogeton crispus). Montana State University, Bozeman, MT.

Parks, S. A., L. M. Holsinger, C. Miller, and C. R. Nelson. 2015a. Wildland fire as a self-regulating mechanism: the role of previous burns and weather in limiting fire progression. Ecological Applications 25:1478-1492.

Parks, S. A., K. S. McKelvey, and M. K. Schwartz. 2012. Effects of weighting schemes on the identification of wildlife corridors generated with least-cost methods. Conservation Biology 27:145-154.

Parks, S. A., C. Miller, J. T. Abatzoglou, L. M. Holsinger, M.-A. Parisien, and S. Z. Dobrowski. 2016a. How will climate change affect wildland fire severity in the western US? Environmental Research Letters 11.

Parks, S. A., C. Miller, L. M. Holsinger, L. S. Baggett, and B. J. Bird. 2016b. Wildland fire limits subsequent fire occurrence. International Journal of Wildland Fire 25.

Parks, S. A., C. Miller, C. R. Nelson, and Z. A. Holden. 2014. Previous fires moderate burn severity of subsequent wildland fires in two large western US wilderness areas. Ecosystems 17:29-42.

Parks, S. A., C. Miller, M.-A. Parisien, L. M. Holsinger, S. Z. Dobrowski, and J. Abatzoglou. 2015b. Wildland fire deficit and surplus in the western United States, 1984–2012. Ecosphere 6.

Parks, S. A., M.-A. Parisien, C. Miller, L. M. Holsinger, and L. S. Baggett. 2018. Fine-scale spatial climate variation and drought mediate the likelihood of reburning. Ecological Applications 0:14.

Parrett, C., and D. R. Johnson. 2004. Methods for estimating flood frequency in Montana based on data through water year 1998. Report Water-Resources Investigations Report 03-4308.

Pastor, J., and R. J. Naiman. 1992. Selective foraging and ecosystem processes in boreal forests. American Naturalist 139:690-705.

Pauchard, A., C. Kueffer, H. Dietz, C. C. Daehler, J. Alexander, P. J. Edwards, J. R. Arévalo, L. A. Cavieres, A. Guisan, S. Haider, G. Jakobs, K. McDougall, C. I. Millar, B. J. Naylor, C. G. Parks, L. J. Rew, and T. Seipel. 2009. Ain't no mountain high enough: plant invasions reaching new elevations. Frontiers in Ecology and the Environment 7:479-486.

Pearson, D., and Y. Ortega. 2009. Chapter 1: Managing invasive plants in natural areas: Moving beyond weed control. Pages 1-21 *in* R. V. Kingely, editor. Weeds: Management, economic impacts and biology. Nova Science Publishers, Inc., Hauppauge, NY.

Pearson, D. E., and R. M. Callaway. 2003. Indirect effects of host-specific biological control agents. Trends in Ecology & Evolution 18:456-461.

Pearson, D. E., Y. K. Ortega, O. Eren, and J. L. Hierro. 2016. Quantifying “apparent” impact and distinguishing impact from invasiveness in multispecies plant invasions. Ecological Applications 26:162-173.

Peck, C. P., F. T. Van Manen, C. M. Costello, M. A. Haroldson, L. A. Landenburger, L. L. Roberts, D. D. Bjornlie, and R. D. Mace. 2017. Potential paths for male-mediated gene flow to and from an isolated grizzly bear population. Ecosphere 8:1-19.

Pederson, L., D. Wulff, T. Eckberg, and N. Kittelson. 2010. 2009 North Idaho Douglas-fir tussock moth trapping system report. R01-10-04, U.S. Department of Agriculture, Forest Service, Forest Health Protection, Missoula, MT.

Pellant, M. 1990. The cheatgrass-wildfire cycle--are there any solutions? U.S. Department of Agriculture, U.S. Forest Service, Intermountain Research Station, 05-07 April 1989.

Perry, R. W., and R. E. Thill. 2007. Roost selection by male and female northern long-eared bats in a pine-dominated landscape. Forest Ecology and Management 247:220-226.

Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby. 1977. Forest habitat types of Montana. Gen. Tech. Rep. INT-GTR-34, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT.

Piekielek, N. B., A. J. Hansen, and T. Chang. 2015. Using custom scientific workflow software and GIS to inform protected area climate adaptation planning in the greater Yellowstone ecosystem. Ecological Informatics 30:40-48.

Platt, W. S. 1991. Livestock grazing. Pages 389-423 *in* W. R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Bethesda, MD.

Podruzny, S., S. Cherry, C. C. Schwartz, and L. Landenburger. 2002. Grizzly bear denning and potential conflict areas in the Greater Yellowstone Ecosystem. Ursus 13:19-28.

Pohl, K. 2018. Wildlife hazard & home development in western Montana. Headwaters Economics, Bozeman, MT.

Polley, H. W., D. D. Briske, J. A. Morgan, K. Wolter, D. W. Bailey, and J. R. Brown. 2013. Climate change and North American rangelands: Trends, projections, and implications. Rangeland Ecology & Management, 66:493-511.

Polley, H. W., H. B. Johnson, and J. D. Derner. 2003. Increasing CO2 from subambient to superambient concentrations alters species composition and increases above-ground biomass in a C3/C4 grassland. New Phytologist 160:319-327.

Pollock, M. M., G. Lewallen, K. Woodruff, C. E. Jordan, and J. M. Castro. 2015. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains, Version 1.0. Pages 189 *in* U.S. Department of Interior, Fish and Wildlife Service, Portland, OR.

Poore, R. E., C. A. Lamanna, J. J. Ebersole, and B. J. Enquist. 2009. Controls on radial growth of mountain big sagebrush and implications for climate change. Western North American Naturalist 69:556-562.

Potyondy, J. P., and T. W. Geier. 2011. Watershed condition classification technical guide. Report FS-978.

Pratt, A., and M. Dillon. 2015. Seasonal space use of greater sage-grouse in the Carbon Core area, Montana. Montana Bureau of Land Management, Billings, MT.

Pregitzer, K. S., and E. S. Euskirchen. 2004. Carbon cycling and storage in world forests: biome patterns related to forest age. Global Change Biology 10:2052–2077.

Price, M. F., A. C. Byers, D. A. Friend, T. Kohler, and L. W. Price, (Eds.). 2013. Mountain geography: Physical and human dimensions. University of California Press, Berkeley, CA.

Proctor, M. F., D. Paetkau, B. N. Mclellan, G. B. Stenhouse, K. C. Kendall, R. D. Mace, W. F. Kasworm, C. Servheen, C. L. Lausen, M. L. Gibeau, W. L. Wakkinen, M. A. Haroldson, G. Mowat, C. D. Apps, L. M. Ciarniello, R. M. R. Barclay, M. S. Boyce, C. C. Schwartz, and C. Strobeck. 2012. Population fragmentation and inter-ecosystem movements of grizzly bears in western Canada and the northern United States. Wildlife Monographs:1-46.

Progar, R. A., A. Eglitis, and J. E. Lundquist. 2007. Some ecological, economic, and social consequences of bark beetle infestations. Pages 71-83 *in* J. L. Hayes, and J. E. Lundquist, editors. The western bark beetle research group: A unique collaboration with forest health protection. Proceedings of a Symposium at the 2007 Society of American Foresters Conference, October 23-28, 2007, Portland, Oregon. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Quinn, M., and G. Chernoff. 2010. Mountain biking: A review of the ecological effects; A literature review for Parks Canada--National office (Visitor Experience Branch). Miistakis Institute, Faculty of Environmental Design, University of Calgary, Calgary, AB.

Radeloff, V. C., D. P. Helmers, H. A. Kramer, M. H. Mockrin, P. M. Alexandre, A. Bar-Massada, V. Butsic, T. J. Hawbaker, S. Martinuzzi, A. D. Syphard, and S. I. Stewart. 2018. Rapid growth of the US wildland-urban interface raises wildfire risk. Proceedings of the National Academy of Sciences of the United States of America 115:3314-3319.

Raffa, K. F., B. H. Aukema, B. J. Bentz, A. L. Carroll, J. A. Hicke, M. G. Turner, and W. H. Romme. 2008. Cross-scale drivers of natural disturbances prone to anthropogenic amplification: the dynamics of bark beetle eruptions. BioScience 58:501-517.

Raffa, K. F., E. N. Powell, and P. A. Townsend. 2013. Temperature-driven range expansion of an irruptive insect heightened by weakly coevolved plant defenses. Proceedings of the National Academy of Sciences of the United States of America 110:2193-2198.

Randall, C., B. Steed, and R. Bush. 2011. Revised R1 forest insect hazard rating system user guide for use with inventory data stored in FSVEG and/or analyzed with the forest vegetation simulator. 11-06, U.S. Department of Agriculture, Forest Service, Forest Health Protection, Missoula, MT.

Rangecroft, S., S. Harrison, and K. Anderson. 2015. Rock glaciers as water stores in the Bolivian Andes: An assessment of their hydrological importance. Arctic Antarctic and Alpine Research 47:89-98.

Ranglack, D., B. Garrott, J. Rotella, K. Proffitt, J. Gude, and J. Canfield. 2016. Evaluating elk summer resource selection and applications to summer range habitat management.

Ranglack, D. H., K. M. Proffitt, J. E. Canfield, J. A. Gude, J. Rotella, and R. A. Garrott. 2017. Security areas for elk during archery and rifle hunting seasons. Journal of Wildlife Management 81:778-791.

Reeves, G. H., L. E. Benda, K. M. Burnett, P. A. Bisson, and J. R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society, 1995.

Reeves, G. H., B. R. Pickard, and N. Johnson. 2016. An initial evaluation of potential options for managing riparian reserves of the aquatic conservation strategy of the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-937, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Reeves, M. C., A. L. Moreno, K. E. Bagne, and S. W. Running. 2014. Estimating climate change effects on net primary production of rangelands in the United States. Climatic Change 126:429-442.

Regier, H. A. 1993. The notion of natural and cultural integrity. Pages 3-18 *in* S. Woodley, J. Kay, and G. Francis, editors. Ecological Integrity and the Management of Ecosystems. St. Lucie Press, Delray Beach, FL.

Reich, P. B., D. Tilman, J. Craine, D. Ellsworth, M. G. Tjoelker, J. Knops, D. Wedin, S. Naeem, D. Bahauddin, J. Goth, W. Bengston, and T. D. Lee. 2001. Do species and functional groups differ in acquisition and use of C, N and water under varying atmospheric CO2 and N availability regimes? A field test with 16 grassland species. New Phytologist 150:435-448.

Reid, K. 2017a. Assessment forest plan revision: Final at risk and potential plant species of conservation concern report. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Bozeman, MT.

_____. 2017b. Assessment forest plan revision: Final nonforested terrestrial ecosystems report. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Bozeman, MT.

Reid, K., D. Sandbak, A. Efta, and M. Gonzales. 2018. Vegetation groupings for CGNF plan revision and metadata for adjustments made to VMAP. Region One Vegetation Classification, Mapping, Inventory and Analysis Report Updated 4/5/2016 Version, U.S. Department of Agriculture, Forest Service, Region One, Missoula, MT.

Reinhardt, E., and L. Holsinger. 2010. Effects of fuel treatments on carbon-disturbance relationships in forests of the northern Rocky Mountains. Forest Ecology and Management 259:1427-1435.

Reinhardt, E. D., R. E. Keane, D. E. Calkin, and J. D. Cohen. 2008. Objectives and considerations for wildland fuel treatment in forested ecosystems of the interior western United States. Forest and Ecology Management 256:1997-2006.

Rhoades, C. C., and P. J. Fornwalt. 2015. Pile burning creates a fifty-year legacy of openings in regenerating lodgepole pine forests in Colorado. Forest Ecology and Management 336:203-209.

Rhodes, J., D. A. McCullough, and F. A. Espinosa, Jr. 1994. A course screening process for evaluation of the effects of land management activities on salmon spawning and rearing habitat in ESA consultations. Technical Report 94-4, Columbia River Inter-Tribal Fish Commission, Portland, OR.

Rhyan, J. C., P. Nol, C. Quance, A. Gertonson, J. Belfrage, L. Harris, K. Straka, and S. Robbe-Austerman. 2013. Transmission of brucellosis from elk to cattle and bison, Greater Yellowstone area, U.S.A., 2002-2012. Emerging Infectious Diseases 19:1992-1995.

Rich, T. D., H. B. Beardmore, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Inigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenber, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in flight North American landbird conservation plan, part 2. Conservation issues.

Rieman, B. E., P. F. Hessburg, C. Luce, and M. R. Dare. 2010. Wildfire and management of forests and native fishes: Conflict or opportunity for convergent solutions? BioScience 60:460-468.

Robichaud, P. R. 2000. Forest fire effects on hillslope erosion: What we know. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Moscow, ID.

Robinson, S. B. 2011. Assessing visual disturbance conditions on the Custer National Forest. Michigan Technological University, Houghton, MI.

Rocca, M. E., P. M. Brown, L. H. MacDonald, and C. M. Carrico. 2014. Climate change impacts on fire regimes and key ecosystem services in Rocky Mountain forests. Forest Ecology and Management 327:290-305.

Rogers, P. C., C. Eisenberg, and S. B. St. Clair. 2013. Resilience in quaking aspen: Recent advances and future needs. Forest Ecology and Management 299:1-5.

Rolandsen, C. M., E. J. Solberg, B.-E. Saether, B. V. Moorter, I. Herfindal, and K. Bjørneraas. 2017. On fitness and partial migration in a large herbivore - migratory moose have higher reproductive performance than residents. Oikos 126:547-555.

Rollins, M. G., and C. K. Frame. 2006. The LANDFIRE Prototype Project: Nationally consistent and locally relevant geospatial data for wildland fire management. Gen. Tech. Rep. RMRS-GTR-175, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Rollins, M. G., P. Morgan, and T. Swetnam. 2002. Landscape-scale controls over 20th century fire occurrence in two large Rocky Mountain (USA) wilderness areas. Landscape Ecology 17:539-557.

Roper, B. 2016. Setting stubble height standards for riparian areas grazed by cattle in areas with Endangered Species Act listed or sensitive salmon and trout species. Pages 7 *in* National Stream and Aquatic Ecology Center, USDA Forest Service, Fort Collins, CO.

Roper, B. B., W. C. Saunders, and J. V. Ojala. 2019. Did changes in western federal land management policies improve salmonid habitat in streams on public lands within the Interior Columbia River Basin? Environmental Monitoring and Assessment 191:574.

Rosell, F., O. Bozser, P. Collen, and H. Parker. 2005. Ecological impact of beavers Castor fiber and Castor canadensis and their ability to modify ecosystems. Mammal Review 35:248-276.

Roulston, T. H., and K. Goodell. 2011. The role of resources and risks in regulating wild bee populations. Annual Review of Entomology 56:293-312.

Rowland, M. M., M. J. Wisdom, D. H. Johnson, B. C. Wales, J. P. Copeland, and F. B. Eldelmann. 2003. Evaluation of landscape models for wolverines in the interior northwest, United States of America. Journal of Mammalogy 84:91-105.

Ruddell, S., M. J. Walsh, and M. Kanakasabai. 2006. Forest carbon trading and marketing in the United States.

Ruediger, B., J. Claar, S. Gniadek, B. Holt, L. Lewis, S. Mighton, B. Naney, G. Patton, T. Rinaldi, J. Trick, A. Vandehey, F. Wahl, N. Warren, D. Wenger, and A. Williamson. 2000a. Canada lynx conservation assessment and strategy (2nd ed.). 2nd edition., U.S. Department of Agriculture,, Forest Service, and U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Land Management, and the National Park Service, Missoula, MT.

______. 2000b. Lynx geographic areas: Descriptions and risk factors. *in* Canada lynx conservation assessment and strategy (r1-00-53). U.S. Department of Agriculture, Forest Service and U.S. Department of Interior Fish and Wildlife Service, Bureau of Land Management, and National Park Service, Missoula, MT.

Rueth, H. M., and J. S. Baron. 2002. Differences in Englemann Spruce Forest Biogeochemistry East and West of the Continental Divide in Colorado, USA. Ecosystems 5:45-57.

Ruggiero, L. F., K. B. Aubry, S. W. Buskirk, G. M. Koehler, C. J. Krebs, K. S. McKelvey, and J. R. Squires. 1999. Chapter 16: The scientific basis for lynx conservation: qualified insights. Pages 443-454 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, G. M. Koehler, C. J. Krebs, K. S. McKelvey, and J. R. Squires, editors. Ecology and conservation of lynx in the United States. Gen. Tech. Rep. RMRS-GTR-30WWW. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Ruggiero, L. F., K. S. McKelvey, K. B. Aubry, J. P. Copeland, D. H. Pletscher, and M. G. Hornocker. 2007. Wolverine Conservation and Management. Journal of Wildlife Management 71:2145-2146.

Ryan, M. G., M. E. Harmon, R. A. Birdsey, C. P. Giardina, L. S. Heath, R. A. Houghton, R. B. Jackson, D. C. McKinley, J. F. Morrison, B. C. Murray, D. E. Pataki, and K. E. Skog. 2010. A synthesis of the science on forests and carbon for U.S. forests. Issues in Ecology 13:1-16.

Safranyik, L., R. Nevill, and D. Morrison. 1998. Effects of stand density management on forest insects and diseases. Technology Transfer Note 12, Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre., Victoria, BC.

Sala, A., and R. Callaway. 2004. Physiological responses of old growth ponderosa pine and western larch to restoration cutting and burning treatments. RMRS-99563-RJVA, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula, MT.

Sampson, F., and F. Knopf. 1994. Prairie conservation in North America. BioScience 44:418-421.

Sandbak, D. 2017. Assessment forest plan revision: Final forested terrestrial vegetation report. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Bozeman, MT.

Saros, J. E., D. W. Clow, T. Blett, and A. P. Wolfe. 2011. Critical Nitrogen Deposition Loads in High-elevation Lakes of the Western US Inferred from Paleolimnological Records. Water, Air, & Soil Pollution 216:193-202.

Saros, J. E., K. C. Rose, D. W. Clow, V. C. Stephens, A. B. Nurse, H. A. Arnett, J. R. Stone, C. E. Williamson, and A. P. Wolfe. 2010. Melting alpine glaciers enrich high-elevation lakes with reactive nitrogen. Environmental Science & Technology 44:6.

Saunders, W. C., and K. D. Fausch. 2007. Improved grazing management increases terrestrial invertebrate inputs that feed trout in Wyoming rangeland streams. Transactions of the American Fisheries Society 136:1216-1230.

Sawyer, H., N. M. Korfanta, R. M. Nielson, K. L. Monteith, and D. Strickland. 2017. Mule deer and energy development-Long-term trends of habituation and abundance. Global Change Biology 23:4521-4529.

Schaedel, M. S., A. J. Larson, D. L. R. Affleck, R. T. Belote, J. M. Goodburn, and D. S. Page-Dumroese. 2017. Early forest thinning changes aboveground carbon distribution among pools, but not total amount. Forest Ecology and Management 389:187-198.

Schaffers, A. P., I. P. Raemakers, and K. V. Sýkora. 2011. Successful overwintering of arthropods in roadside verges. Journal of Insect Conservation 16:511-522.

Schmechel, J. 2015. An environmental and hydrogeological investigation in the South Hebgen Basin, Montana. University of Montana, Missoula, MT.

Schoennagel, T., J. K. Balch, H. Brenkert-Smith, P. E. Dennison, B. J. Harvey, M. A. Krawchuk, N. Mietkiewicz, P. Morgan, M. A. Moritz, R. Rasker, M. G. Turner, and C. Whitlock. 2017. Adapt to more wildfire in western North American forests as climate changes. Proceedings of the National Academy of Sciences of the United States of America 114:4582-4590.

Schoennagel, T., T. T. Veblen, and W. H. Romme. 2004. The interaction of fire, fuels, and climate across Rocky Mountain forests. BioScience 54:661-676.

Schoettle, A. W., and R. A. Sniezko. 2007. Proactive intervention to sustain high-elevation pine ecosystems threatened by white pine blister rust. Journal of Forest Research 12:327-336.

Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Greater sage-grouse *Centrocercus urophasianus*: Distribution, migration and habitat. *in* Cornell Lab of Ornithology, Birds of North America, Ithaca, NY.

Schwartz, C. C., M. A. Haroldson, and K. West, editors. 2009a. Yellowstone grizzly bear investigations: Annual report of the Interagency Grizzly Bear Study Team, 2008. USDI U.S. Geological Survey, Bozeman, MT.

Schwartz, C. C., M. A. Haroldson, and G. C. White. 2010. Hazards affecting grizzly bear survival in the Greater Yellowstone ecosystem. Journal of Wildlife Management 74:654-667.

Schwartz, C. C., J. E. Teisberg, J. K. Fortin, M. A. Haroldson, C. Servheen, C. T. Robbins, and F. T. van Manen. 2014. Use of isotopic sulfur to determine whitebark pine consumption by Yellowstone bears: A reassessment. Wildlife Society Bulletin 38:664-670.

Schwartz, M. K., J. P. Copeland, N. J. Anderson, J. R. Squires, R. M. Inman, K. S. McKelvey, K. L. Pilgrim, L. P. Waits, and S. A. Cushman. 2009b. Wolverine gene flow across a narrow climatic niche. Ecology 90:3222-3232.

Schwilk, D. W., J. E. Keeley, E. E. Knapp, J. McIver, J. D. Bailey, C. J. Fettig, C. E. Fiedler, R. J. Harrod, J. J. Moghaddas, K. W. Outcalt, C. N. Skinner, S. L. Stephens, T. A. Waldrop, D. A. Yaussy, and A. Youngblood. 2009. The national Fire and Fire Surrogate study: effects of fuel reduction methods on forest vegetation structure and fuels. Ecological Applications 19:285-304.

Scrafford, M. A., T. Avgar, R. Heeres, and M. S. Boyce. 2018a. Roads elicit negative movement and habitat-selection responses by wolverines (Gulo gulo luscus). Behavioral Ecology 29:534-542.

Scrafford, M. A., D. B. Tyers, D. T. Patten, and B. F. Sowell. 2018b. Beaver Habitat Selection for 24 Yr Since Reintroduction North of Yellowstone National Park. Rangeland Ecology & Management 71:266-273.

Seligman, Z. M. 2009. Rock-glacier distribution, activity, and movement, northern Absaroka and Beartooth Ranges, MT, USA. University of Montana, Missoula, MT.

Sepulveda, A. J., M. Layhee, D. Stagliano, J. Chaffin, A. Begley, and B. Maxell. 2014. Invasion of American bullfrogs along the Yellowstone River. Aquatic Invasions 9.

Servheen, C. 2007. Grizzly bear recovery plan supplement: habitat-based recovery criteria for the Yellowstone ecosystem. U.S. Department of the Interior, Fish & Wildlife Service, Missoula, MT.

Shanahan, E., K. M. Irvine, D. Thoma, S. Wilmoth, A. Ray, K. Legg, and H. Shovic. 2016. Whitebark pine mortality related to white pine blister rust, mountain pine beetle outbreak, and water availability. Ecosphere 7:1-18.

Shanahan, E., K. Legg, and R. Daley. 2017. Status of whitebark pine in the greater Yellowstone ecosystem: A step-trend analysis with comparisons from 2004-2015. Natural Resource Report NPS/GRYN/NRR-2017/1445, U.S. Department of the Interior, National Park Service, Natural Resource Stewardship and Science, Fort Collins, CO.

Sheley, R. L., C. A. Duncan, M. B. Halstvedt, and J. S. Jacobs. 2000. Spotted knapweed and grass response to herbicide treatments. Journal of Range Management 53:176-182.

Sheley, R. L., J. J. James, M. J. Rinella, D. Blumenthal, and J. M. Ditomaso. 2011. Chapter 7: Invasive plant management on anticipated conservation benefits: A scientific assessment. Pages 291-336 *in* D. D. Briske, editor. Conservation benefits of rangeland practices: Assessment, recommendations, and knowledge gaps. U.S. Department of Agriculture, Natural Resources Conservation Science, Lawrence, KS.

Shelly, J. S., M. Mantas, A. Pipp, and J. Hahn. Metapopulation monitoring of *Howellia aquatilis*, a threatened aquatic plant species in northwestern Montana: Trends in relation to land management activities, disturbance and climate change, *in* Conference Metapopulation monitoring of *Howellia aquatilis*, a threatened aquatic plant species in northwestern Montana: Trends in relation to land management activities, disturbance and climate change. Oct. 18.

Shelly, T. E., E. M. Villalobos, S. L. Buchmann, and J. H. Cane. 1993. Temporal patterns of floral visitation for two bee species foraging on Solanum. Journal of the Kansas Entomological Society 66:319-327.

Shore, T. L., L. Safranyik, W. G. Riel, M. Ferguson, and J. Castonguay. 1999. Evaulation of factors affecting tree and stand susceptibility to the douglas-fir beetle (Coleoptera: Scolytidae). Canadian Entomologist 131:831-839.

Sievers, M., R. Hale, and J. R. Morrongiello. 2017. Do trout respond to riparian change? A meta-analysis with implications for restoration and management. Freshwater Biology 62:445-457.

Six, D., E. Biber, and E. Long. 2014. Management for mountain pine beetle outbreak suppression: Does relevant science support current policy? Forests 5:103-133.

Skinner, C. N. 2002. Influence of fire on the dynamics of dead woody material in forests of California and southwestern Oregon. Pages 445-454 *in* W. F. Laudenslayer, Jr., P. J. Shea, B. E. Valentine, C. P. Weatherspoon, and T. E. Lisle, editors. Proceedings of the symposium on the ecology and management of dead wood in western forests; 1999 November 2-4; Reno, NV. Gen. Tech. Rep. PSW-GTR-181. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Skog, K. E., D. C. McKinley, R. A. Birdsey, S. J. Hines, C. W. Woodall, E. D. Reinhardt, and J. M. Vose. 2014. Chapter 7: Managing carbon. Pages 151-182 *in* D. L. Peterson, J. M. Vose, and T. Patel-Weynand, editors. Climate change and United States forests, Advances in Global Change Research 57.

Smallidge, P. J., and D. J. Leopold. 1997. Vegetation management for the maintenance and conservation of butterfly habitats in temperate human-dominated landscapes. Landscape and Urban Planning 38:259-280.

Smith, C. M., D. W. Langor, C. Myrholm, J. Weber, C. Gillies, and J. Stuart-Smith. 2013. Changes in white pine blister rust infection and mortality in limber pine over time. Canadian Journal of Forest Research 43:919-928.

Smith, J. K., and W. C. Fischer. 1997. Fire ecology of the forest habitat types of northern Idaho. Gen. Tech. Rep. INT-GTR-363, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Somodi, I., Z. Molnar, and J. Ewald. 2012. Towards a more transparent use of the potential natural vegetation concept – an answer to Chiarucci et al. Journal of Vegetation Science 23:590-595.

Sorg, A., A. Kaab, A. Roesch, C. Bigler, and M. Stoffel. 2015. Contrasting responses of central Asian rock glaciers to global warming. Scientific Reports 5:1-6.

South Dakota Department of Agriculture, Resource Conservation & Forestry Division. 2020. South Dakota Forest Action Plan. South Dakota Department of Agriculture, Rapid City, SD.

South Dakota Department of Environment and Natural Resources. 2019. South Dakota Ambient Air Monitoring Annual Plan. South Dakota Department of Environment and Natural Resources, Air Quality Program, Pierre, SD.

South Dakota Department of Game Fish and Parks. 2014a. Sage-grouse management plan for South Dakota 2014-2018. Wildlife Division Report 2014-02, South Dakota Department of Game, Fish and Parks, Wildlife Division, Pierre, SD.

_____. 2014b. South Dakota wildlife action plan. South Dakota Department of Game Fish and Parks,, Pierre, SD.

_____. 2015. South Dakota elk management plan 2015-2019. Completion report 2015-01, South Dakota Department of Game, Fish and Parks, Pierre, SD.

_____. 2018a. Addendum 1. Modified components of South Dakota Wildlife Action Plan as part of minor revision of 2018 to add three species of greatest conservation need. South Dakota Game, Fish and Parks, Pierre, SD.

_____. 2018b. South Dakota bighorn sheep management plan, 2018-2027. Completion report 2018-02, South Dakota Department of Game, Fish and Parks, Pierre, SD.

_____. 2019. Fisheries and aquatic resources adaptive management system 2019-2023 statewide strategic plan components. South Dakota Department of Game Fish and Parks, Wildlife Division, Pierre, SD.

Spies, T. A., M. A. Hemstrom, A. Youngblood, and S. Hummel. 2006. Conserving old-growth forest diversity in disturbance-prone landscapes. Conservation Biology 20:351-362.

Spies, T. A., E. M. White, J. D. Kline, A. P. Fischer, A. Ager, J. Bailey, J. Bolte, J. Koch, E. Platt, C. S. Olsen, D. Jacobs, B. Shindler, M. M. Steen-Adams, and R. Hammer. 2014. Examining fire-prone forest landscapes as coupled human and natural systems. Ecology and Society 19:9.

Spittlehouse, D. L., and R. B. Stewart. 2003. Adaptation to climate change in forest management. Journal of Ecosystems and Management 4:1-11.

Spracklen, D. V., L. J. Mickley, J. A. Logan, R. C. Hudman, R. Yevich, M. D. Flannigan, and A. L. Westerling. 2009. Impacts of climate change from 2000 to 2050 on wildfire activity and carbonaceous aerosol concentrations in the western United States. Journal of Geophysical Research: Atmospheres 114.

Spranger, T., U. Lorenz, and H.-D. Gregor, (Eds.) 2004. Manual on methodologies and criteria for modelling and mapping critical loads & levels and air pollution effects, risks and trends. Federal Environmental Agency (Umweltbundesamt), Berlin, Germany.

Squires, J. R., J. P. Copeland, T. J. Ulizio, M. K. Schwartz, and L. F. Ruggiero. 2007. Sources and patterns of wolverine mortality in western Montana. Journal of Wildlife Management 71:2213-2220.

Squires, J. R., N. J. Decesare, J. A. Kolbe, and L. F. Ruggiero. 2010. Seasonal resource selection of Canada lynx in managed forests of the northern Rocky Mountains. Journal of Wildlife Management 74:1648-1660.

Squires, J. R., and T. Laurion. 1999. Chapter 11: Lynx home range and movements in Montana and Wyoming: Preliminary results. Pages 337-350 *in* L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, G. M. Koehler, C. J. Krebs, M. K. S., and J. R. Squires, editors. Ecology and conservation of lynx in the United States. Gen. Tech. Rep. RMRS-GTR-30WWW. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Squires, J. R., L. E. Olson, E. K. Roberts, J. S. Ivan, and M. Hebblewhite. 2019. Winter recreation and Canada lynx: reducing conflict through niche partitioning. Ecosphere 10.

Stagliano, D. 2010. A cumulative biological assessment of macroinvertebrate sites in the Custer National Forest Ashland Ranger District: A report to the Custer National Forest, Ashland Ranger District.

Stagliano, D. M. 2015. Re-evaluation and trend analysis of western pearlshell mussel (SWG tier 1) populations across watersheds of western Montana.

Stanford, J. A., M. S. Lorang, and F. R. Hauer. 2005. The shifting habitat mosaic of river ecosystems. Verhandlungen des Internationalen Verein Limnologie 29.

Starks, E., R. Cooper, P. R. Leavitt, and B. Wissel. 2014. Effects of drought and pluvial periods on fish and zooplankton communities in prairie lakes: systematic and asystematic responses. Global Change Biology 20:1032-1042.

Steeger, C., and H. Quesnel. 2003. Impacts of partial cutting on old-growth forests in the Rocky Mountain trench, British Columbia.

Steffan-Dewenter, I., and T. Tscharntke. 1999. Effects of habitat isolation on pollinator communities and seed set. Oecologia 121:432-440.

Steffan-Dewenter, I., and C. Westphal. 2008. The interplay of pollinator diversity, pollination services and landscape change. Journal of Applied Ecology 45:737-741.

Stephens, B. C., D. L. Scarnecchia, and D. N. Svingen. 2016. Fish assemblages, habitat conditions, and grazing effects in rolling prairie and badlands streams of the Northern Great Plains. Transactions of the Kansas Academy of Science 119:299-321.

Stephens, S. L., J. J. Moghaddas, C. Edminster, C. E. Fiedler, S. Haase, M. Harrington, J. E. Keeley, E. E. Knapp, J. D. McIver, K. Metlen, C. N. Skinner, and A. Youngblood. 2009. Fire treatment effects on vegetation structure, fuels, and potential fire severity in western U.S. forests. Ecological Applications 19:305-320.

Stevens-Rumann, C. S., K. B. Kemp, P. E. Higuera, B. J. Harvey, M. T. Rother, D. C. Donato, P. Morgan, and T. T. Veblen. 2018. Evidence for declining forest resilience to wildfires under climate change. Ecology Letters 21:243-252.

Steventon, J. D., K. L. MacKenzie, and T. E. Mahon. 1998. Response of small mammals and birds to partial cutting and clearcutting in northwest British Columbia. Forestry Chronicle 74:703-713.

Stewart, K. M., T. R. Bowyer, J. G. Kie, N. J. Cimon, and B. K. Johnson. 2002. Temporospatial distributions of elk, mule deer, and cattle: resource partitioning and competitive displacement. Journal of Mammalogy 83:229-244.

Stiver, S. J., A. D. Apa, J. Bohne, S. D. Bunnell, P. Deibert, S. Gardner, M. Hilliard, C. McCarthy, and M. A. Schroeder. 2006. Greater sage-grouse comprehensive conservation strategy. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming.

Stiver, S. J., E. T. Rinkes, and D. E. Naugle. 2010. Sage-grouse habitat assessment framework - Volume 3: Measurement techniques and data forms.

Stiver, S. J., E. T. Rinkes, D. E. Naugle, P. D. Makela, D. A. Nance, and J. W. Karl, (eds.). 2015. Sage-Grouse Habitat Assessment Framework: A Multiscale Assessment Tool. Technical Reference 6710-1, U.S. Department of the Interior, Bureau of Land Mangement, Denver, CO.

Story, M. 2007. R1 air quality monitoring program: Lake Sampling phase 3 chemistry sampling procedures. U.S. Department of Agriculture, Forest Service, Gallatin National Forest, Bozeman, MT.

Story, M., J. Shea, T. Svalberg, M. Hektner, G. Ingersoll, and D. Potter. 2005. Greater Yellowstone area air quality assessment update. Greater Yellowstone Clean Air Partnership.

Suding, K., E. Higgs, M. Palmer, J. B. Callicott, C. B. Anderson, M. Baker, J. J. Gutrich, K. L. Hondula, M. C. LaFevor, B. M. H. Larson, A. Randall, J. B. Ruhl, and Z. Z. S. Schwartz. 2015. Committing to ecological restoration. Science 348:638-640.

Svejar, T., C. S. Boyd, and et al. 2014. Western land managers will need all available tools for adapting to climate change, including grazing: A critique of Beschta et al. Environmental Management 53:1035-1038.

Sverdrup, H., T. C. McDonnell, T. J. Sullivan, B. Nihlgård, S. Belyazid, B. Rihm, E. Porter, W. D. Bowman, and L. Geiser. 2012. Testing the feasibility of using the ForSAFE-VEG model to map the critical load of nitrogen to protect plant biodiversity in the Rocky Mountains Region, USA. Water, Air, & Soil Pollution 223:371-387.

Swanson, S., S. Wyman, and C. Evans. 2015. Practical grazing management to maintain or restore riparian functions and values on rangelands. Journal of Rangeland Applications 2:1-28.

Switalski, T. A., J. A. Bissonette, T. H. DeLuca, C. H. Luce, and M. A. Madej. 2004. Benefits and impacts of road removal. Frontiers in Ecology and the Environment 2:21-28.

Syphard, A. D., V. C. Radeloff, J. E. Keeley, T. J. Hawbaker, M. K. Clayton, S. I. Stewart, and R. B. Hammer. 2007. Human influence on California fire regimes. Ecological Applications 17:15.

Taylor, K., T. Brummer, M. L. Taper, A. Wing, and L. J. Rew. 2012. Human-mediated long-distance dispersal: An empirical evaluation of seed dispersal by vehicles. Diversity and Distributions 18:942-951.

The National Academies of Sciences, Engineering, and Medicine. 2017. Revisiting Brucellosis in the Greater Yellowstone Area. The National Academies Press, Washington, DC.

The Wilderness Society. 2014. Transportation infrastructure and access on National Forests and grasslands: A literature review. The Wilderness Society, Washington, DC.

Theobald, D. M. 2013. A general model to quantify ecological integrity for landscape assessments and US application. Landscape Ecology 28:1859-1874.

Theobald, D. M., S. E. Reed, K. Fields, and M. Soule. 2012. Connecting natural landscapes using a landscape permeability model to prioritize conservation activities in the United States. Conservation Letters 5:123-133.

Thoma, D., E. Shanahan, and K. Irvine. 2019. Climatic Correlates of White Pine Blister Rust Infection in Whitebark Pine in the Greater Yellowstone Ecosystem. Forests 10.

Thomas, J. W., J. F. Franklin, J. Gordon, and K. N. Johnson. 2006. The Northwest Forest Plan: Origins, components, implementation experience, and suggestions for change. Conservation Biology 20:277-287.

Thomas, J. W., D. A. Leckenby, M. Henjum, R. J. Pedersen, and L. D. Bryant. 1988a. Habitat-effectiveness index for elk on Blue Mountain winter ranges. Gen. Tech. Rep. PNW-GTR-218, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Thomas, J. W., L. F. Ruggiero, R. W. Mannan, J. W. Schoen, and R. A. Lancia. 1988b. Management and conservation of old-growth forests in the United States. Wildlife Society Bulletin 16:252-262.

Thompson, J. M. 1979. Arsenic and fluoride in the upper madison river system: Firehole and gibbon rivers and their tributaries, yellowstone national park, wyoming, and southeast montana. Environmental Geology 3:13-21.

Thompson, M., P. Bowden, A. Brough, J. Scott, J. Gilbertson-Day, A. Taylor, J. Anderson, and J. Haas. 2016. Application of wildfire risk assessment results to wildfire response planning in the southern Sierra Nevada, California, USA. Forests 7:1-22.

Thompson, M. P., and D. E. Calkin. 2011. Uncertainty and risk in wildland fire management: A review. Journal of Environmental Management 92:1895-1909.

Thompson, M. P., N. M. Vaillant, J. R. Haas, K. M. Gebert, and K. D. Stockmann. 2013. Quantifying the potential impacts of fuel treatments on wildfire suppression costs. Journal of Forestry 111:49-58.

Thornburgh, D. 2017. Assessment forest plan revision: Final timber report. U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest, Bozeman, MT.

Thorpe, A. S., V. Archer, and T. H. DeLuca. 2006. The invasive forb, *Centaurea maculosa*, increases phosphorus availability in Montana grasslands. Applied Soil Ecology 32:118-122.

Tilman, D., and A. El Haddi. 1992. Drought and biodiversity in grasslands. Oecologia 89:257-264.

Tomback, D. F., and P. Achuff. 2010. Blister rust and western forest biodiversity: ecology, values and outlook for white pines. Forest Pathology 40:186-225.

Tomback, D. F., S. F. Arno, and R. E. Keane, (Eds.). 2001. Whitebark pine communities: Ecology and restoration. Inland Press, Washington, DC.

Trimble, S. W., and A. C. Mendel. 1995. The cow as a geomorphic agent - A critical review. Geomorphology 13:233-253.

Tucker Schulz, T., and W. C. Leininger. 1990. Differences in riparian vegetation structure between grazed areas and exclosures. Journal of Range Management 43:295-299.

Turner, I. M. 1996. Species loss in fragments of tropical rain forest: A review of the evidence. Journal of Applied Ecology 33:200-209.

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice: Pattern and process. Springer Science+Business Media, Inc., New York, NY.

Tyers, D. B. 2003. Winter ecology of moose on the northern Yellowstone winter range. Doctoral dissertation, Montana State University, Bozeman, MT.

U. S. Department of Agriculture, Forest Service. 2020. Land Management Plan, Helena - Lewis and Clark National Forest U. S. Department of Agriculture,, Forest Service, Northern Region (R1), Helena, MT.

U.S. Department of Agriculture, Animal and Plant Health Inspection Service. 2001. Future trends in agricultural trade. Miscellaneous publication no. 1579, Washington, DC.

U.S. Department of Agriculture, Forest Service. 1986. Custer National Forest management plan. U.S. Department of Agriculture, Forest Service, Custer National Forest, Bozeman, MT.

_____. 1991. Forest Service Manual, Title 5100: Fire Management. Washington, DC.

_____. 1997. Revised Forest Plan for the Targhee National Forest. U.S. Department of Agriculture, Forest Service, Targhee National Forest, St. Anthony, ID.

_____. 1998. Stemming the invasive tide: Forest Service strategy for noxious and nonnative invasive plant management. U.S. Department of Agriculture, Forest Service, Washington Office, Washington, DC.

_____. 2000. Wildlife Prarie Dog Managment - Monitoring Item C7 Custer National Forest. U.S. Department of Agriculture Forest Service.

_____. 2005. Noxious and invasive weed treatment project, Gallatin National Forest, Final Environmental Impact Statement. U.S. Department of Agriculture, Forest Service, Bozeman, MT.

_____. 2006a. Custer National Forest, Weed Management, Final Environmental Impact Statement. U. S. Department of Agriculture, Forest Service, Billings, MT.

_____. 2006b. Forest plan amendment for grizzly bear habitat conservation for the greater Yellowstone area National Forests: Final environmental impact statement Record of Decision. U.S. Department of Agriculture, Forest Service.

_____. 2006c. Land and Resource management plan for the Black Hills National Forest, Rocky Mountain Region. Phase II Amendment. U.S. Department of Agriculture, Forest Service, Black Hills National Forest, Custer, SD.

_____. 2007a. Biological assessment (revised) of the northern Rockies lynx amendment on threatened, endangered and proposed vertebrate and invertebrate species (revision of BA dated November 18. 2005).

_____. 2007b. Northern Rockies lynx management direction record of decision, national forests in Montana, and parts of Idaho, Wyoming, and Utah.

_____. 2009a. Beaverhead-Deerlodge National Forest Land and Resource Management Plan. U.S. Department of Agriculture, Forest Service, Beaverhead-Deerlodge National Forest, Dillon, MT.

_____. 2009b. Climate change considerations in project level NEPA analysis. U.S. Department of Agriculture, Forest Service, Washington D.C.

_____. 2011a. FSM 2900 - invasive species management chapter zero code. U.S. Department of Agriculture, Forest Service, Washington, DC.

_____. 2011b. Region 1; approach to soils NEPA analysis regarding detrimental soil disturbance in forested areas - a technical guide.

_____. 2011c. Sensitive species list: Forest Service, Region 1, February 2011.

_____. 2011d. Watershed condition framework: A framework for assessing and tracking changes to watershed condition. FS-977, Washington, DC.

_____. 2012a. Future of America's forests and rangelands - Forest Service. 2010 resources planning act assessment. Gen. Tech. Rep. WO-GTR-87, Washington, DC.

_____. 2012b. Interagency multi-species meso-carnivore (fisher, wolverine and lynx) surveys.

_____. 2013. Forest Service national strategic framework for invasive species management. FS-1017.

_____. 2014a. Ashland post fire landscape assessment. U.S. Department of Agriculture, Forest Service, Custer National Forest, Billings, MT.

_____. 2015a. Baseline estimates of carbon stocks in forests and harvested wood products for National Forest System units. (Two baselines: 1990-2013, 2005-2013). Northern Region. U.S. Department of Agriculture,Forest Service, Office of the Chief, Climate Change Advisor's Office, Washington, DC.

_____. 2015b. Gallatin Forest Plan. 1987 as amended through November 2015. U.S. Department of Agriculture,Forest Service, Northern Region (R1), Bozeman, MT.

_____. 2015c. Land Management Plan 2015 Revision, Shoshone National Forest. U.S. Department of Agriculture, Forest Service, Shoshone National Forest, Cody, WY.

_____. 2015d. Pollinator-friendly best management practices for federal lands. U.S. Department of Agriculture, Forest Service, Rangeland Management & Vegetation Ecology, Botany Program, Washington, DC.

_____. 2016a. Future of America's forests and rangelands: Update to the Forest Service 2010 resources planning act assessment. Gen. Tech. Rep. WO-94, U.S. Department of Agriculture, Forest Service, Research and Development, Washington, DC.

_____. 2017. Biological assessment for Canada lynx designated critical habitat: Northern Rockies lynx management direction. U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT.

_____. 2018. Volume 1-Final Environmental Impact Statement for the Land Management Plan Flathead National Forest. U.S. Department of Agriculture,, Forest Service, Kalispell MT.

U.S. Department of Agriculture, Forest Service, and Montana Fish Wildlife and Parks. 2013. Collaborative overview and recommendations for elk habitat management on the Custer, Gallatin, Helena, and Lewis and Clark National Forests.

U.S. Department of Agriculture, Forest Service, and U.S. Department of the Interior, Fish and Wildlife Service. 2006. Canada Lynx Conservation Agreement. U.S. Department of Agriculture, Forest Service, Washington, D.C.

U.S. Department of Agriculture, Forest Service, Custer Gallatin National Forest. 2016b. Gallatin Forest plan management indicator species assessment: Population and habitat trends 5 year monitoring document. U.S. Department of Agriculture, Forest Service, Bozeman, MT.

U.S. Department of Agriculture, Forest Service, National Interagency Fuels, Fire, & Vegetation Technology Transfer. 2010. Interagency fire regime condition class (FRCC) guidebook. 3.0 edition., U.S. Department of Agriculture, Boise, ID.

U.S. Department of Agriculture, Forest Service, Northern Region. 1990. The management of lodgepole pine in Region One. Committee report, September 1990. Missoula, MT.

_____. 2014b. FSM 2500 - Watershed and Air Management, chapter 2550 - Soil Management, Region 1 Soil Manual Supplement, FSM 2500-2014-1. U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2008. What are pollinators and why should you care? San Diego Fact Sheet 55, U.S. Department of Agriculture,, Natural Resources Conservation Science, Pierre, SD.

_____. 2015e. The Montana Natural Resources Conservation Service Soil Health Strategy. A plan to meet current and future challenges in agriculture.

U.S. Department of Agriculture, and U.S. Department of the Interior. 2011. A national cohesive wildland fire management strategy. WIldland Fire Leadership Council (WFLC).

U.S. Department of the Interior, Bureau of Indian Affairs. 2010a. Crow Agency Fire Management Plan 2010-2024. U.S. Department of the Interior, Bureau of Indian Affairs, Crow Agency, Fire and Aviation Management, Crow Agency, MT.

U.S. Department of the Interior, Bureau of Land Management. 2006. Record of Decision and approved Dillon Resource Management Plan. U.S. Department of the Interior, Bureau of Land Management, Dillon Field Office, Dillon, MT.

_____. 2009a. Butte Resource Management Plan. U.S. Department of the Interior, Bureau of Land Management, Butte Field Office, Butte, MT.

_____. 2015a. Billings Field Office approved Resource Management Plan. U.S. Department of the Interior, Bureau of Land Management, Billings Field Office, Billings, MT.

_____. 2015b. Miles City Field Office approved Resource Management Plan. U.S. Department of the Interior, Bureau of Land Management, Miles City Field Office, Miles City, MT.

_____. 2015c. South Dakota approved Resource Management Plan. U.S. Department of the Interior, Bureau of Land Management,South Dakota Field Office, Billings, MT.

U.S. Department of the Interior, Fish and Wildlife Service. 1993. Grizzly bear recovery plan.

_____. 1995. Biological opinion on the Gallatin National Forest plan [amended] to include an incidental take statement. U.S. Department of the Interior, Fish and Wildlife Service Ecological Services.

_____. 2000a. Endangered and threatened wildlife and plants, Determination of threatened status for the contiguous U.S. distinct population segment of the Canada lynx and related rule, final rule. Federal Register 65:16052-16086.

_____. 2005. Recovery outline: Contiguous United States distinct population segment of Canada lynx.

_____. 2007. Biological opinion on the effects of the Northern Rocky Mountains Lynx Amendment on the Distinct Population Segment (DPS) of Canada lynx (lynx) in the contiguous United States.

_____. 2009b. Endangered and threatened wildlife and plants; Revised designation of critical habitat for the contiguous United States distinct population segment of the Canada lynx; Final rule. Federal Register 74:8615-8702.

_____. 2010b. Endangered and threatened wildlife and plants; 12–month finding on a petition to list the white-tailed prairie dog as endangered or threatened. Federal Register 75:30338-30363.

_____. 2011a. Endangered and threatened wildlife and plants; 12-month finding on a petition to list *Pinus albicaulis* as endangered or threatened with critical habitat. Federal Register 76:42631-42654.

_____. 2013a. Endangered and threatened wildlife and plants; Threatened status for the distinct population segment of the North American wolverine in the contiguous United States. Federal Register 78:65248-65249.

_____. 2013b. Endangered and threatened wildlife and plants; Threatened status for the distinct population segment of the North American wolverine occurring in the contiguous United States; Establishment of a nonessential experimental population of the North American wolverine in Colorado, Wyoming, and New Mexico; Proposed rules. Federal Register 78:7864-7890.

_____. 2013c. Greater sage-grouse (*Centrocercus urophasianus*) conservation objectives: Final report.

_____. 2013d. Grizzly bear recovery plan, draft revised supplement: Revised demographic recovery criteria for the Yellowstone Ecosystem (approved February 19, 2013).

_____. 2014a. Endangered and threatened wildlife and plants; Revised designation of critical habitat for the contiguous United States distinct population segment of the Canada Lynx and revised distinct population segment boundary; Final rule. Federal Register 79:54782-54846.

_____. 2014b. Endangered and threatened wildlife and plants; threatened status for the distinct population segment of the North American wolverine occurring in the contiguous United States; establishment of a nonessential experimental population of the North American wolverine in Colorado, Wyoming, and New Mexico; Proposed rules; withdrawl. Federal Register 79:47522-47545.

_____. 2015d. Endangered and threatened wildlife and plants; 12-month finding on a petition to list greater sage-grouse (Centrocercus urophasianus) as an endangered or threatened species; proposed rule. Federal Register 80:59858-59942.

_____. 2015e. Endangered and threatened wildlife and plants; threatened species status for the northern long-eared bat with 4(d) rule; final rule and interim rule with request for comments. Federal Register 80:17974-18033.

_____. 2015f. Northern long-eared bat *Myotis septentrionalis*. U.S. Department of the Interior, Fish and Wildlife Service.

_____. 2016a. Bald and Golden Eagles Population demographics and estimation of sustainable take in the United States, 2016 update. U.S. Department of Interior,, Fish and Wildlife Service,Division of Migratory Bird Management, Washington D.C.

_____. 2016b. Endangered and threatened wildlife and plants; removing the Greater Yellowstone Ecosystem population of grizzly bears from the federal list of endangered and threatened wildlife. Federal Register 81:13174-13227.

_____. 2016c. Endangered and threatened wildlife and plants; Review of native species that are candidates for listing as endangered or threatened; Annual notification of findings on resubmitted petitions; Annual description of progress on listing actions. Federal Register 81:87246-87272.

_____. 2016d. Key to the northern long-eared bat 4(d) rule for federal actions that may affect northern long-eared bats.

_____. 2016e. National white-nose syndrome decontamination protocol - version 04.12.2016. U.S. Department of the Interior, Fish & Wildlife Service, Washington, DC.

_____. 2017a. Biological opinion on the effects of the northern rockies lynx management direction on designated critical habitat and Canada lynx. 06E11000-2017-F-0552 NRLMD - Lynx critical habitat, U.S. Department of Agriculture, Forest Service, Northern Region, Missoula, MT.

_____. 2017b. Endangered and threatened wildlife and plants; removing the Greater Yellowstone Ecosystem population of grizzly bears from the federal list of endangered and threatened wildlife. Federal Register 82:30502-30633.

_____. 2018a. Northern long-eared bat final 4(d) rule: White-nose syndrome zone around WNS/Pd positive counties/districts. *in* U.S. Department of the Interior, Fish & Wildlife Service.

_____. 2018b. Status review indicates Canada lynx recovery in the lower 48-states. Pages 2 *in* U.S. Department of the Interior, Fish and Wildlife Service, Lakewood, CO.

_____. 2019a. Endangered and threatened wildlife and plants: threatened species status for Meltwater Lednian stonefly and Western Glacier stonefly with a Section 4(d) Rule. Final Rule. Federal Register 84:64210-64227.

_____. 2019b. Threatened, endangered and candidate species for the Custer Gallatin National Forest, 12/12/2019. U.S. Department of the Interior, Fish & Wildlife Service, Ecological Services, Montana Field Office, Helena, MT.

_____. 2019c. Threatened, endangered and candidate species for the Custer Gallatin National Forest, Forest Plan Revision 10/22/2019. TAILS: 06E11000-2020-SL-0026 Custer Gallatin Forest Plan Revision Species List, U.S. Department of the Interior, Fish and Wildlife Service.

_____. 2020a. Endangered and threatened wildlife and plants; threatened species status for Pinus albicaulis (Whitebark pine) with section 4(d) rule. Proposed Rule. Federal Register 85:77408-77424.

_____. 2020b. Endangered and threatened wildlife and plants; Withdrawal of the proposed rule for the North American wolverine. Federal Register 85:64618-64648.

U.S. Department of the Interior, Fish and Wildlife Service, Ecological Services, Region 6. 2015g. 90-day finding on two petitions to list a distinct population segment of bison in its United States Yellowstone National Park range as threatened or endangered under the Endangered Species Act. Federal Docket No. FWS-R6-ES-2015-0123, Moline, IL.

U.S. Department of the Interior, Geological Survey. 2017c. Rocky Mountain Regional Snowpack Chemistry Monitoring Study. *in*.

U.S. Department of the Interior, National Park Service. 2014c. Foundation document: Yellowstone National Park. U.S. Department of the Interior, National Park Service, Yellowstone National Park, WY.

U.S. Department of the Interior, National Park Service, Yellowstone National Park. 2000b. Bison management plan for the state of Montana and Yellowstone National Park: Executive summary. U.S. Department of the Interior, National Park Service, Yellowstone National Park, Mammoth, WY.

U.S. Department of the Interior, National Park Service, Yellowstone National Park, Yellowstone Center for Resources. 2011b. Yellowstone National Park natural resource vital signs, 2011. YCR-2011-07, U.S. Department of the Interior, Mammoth Hot Springs, WY.

U.S. Environmental Protection Agency. 1998. Interim air quality policy on wildland and prescribed fires.

_____. 2015. Inventory of U.S. greenhouse gas emissions and sinks: 1990-2013.

_____. 2017. Information about Public Water Systems. *in*.

_____. 2021. Wildfire Smoke Guide for Public Health Officials - Revised 2019. Publication No. EPA-452/R-21-901, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Health and Environmental Impacts Division, Research Trianble Park, NC.

U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation. 1997. Climate Change and Colorado. EPA 230-F-97-008f, Washington, DC.

Vaillant, N. M., and E. D. Reinhardt. 2017. An Evaluation of the Forest Service Hazardous Fuels Treatment Program—Are We Treating Enough to Promote Resiliency or Reduce Hazard? Journal of Forestry 115:300-308.

van Manen, F. T., C. M. Costello, M. A. Haroldson, D. D. Bjornlie, M. R. Ebinger, K. A. Gunther, M. F. Mahalovich, D. J. Thompson, M. D. Higgs, K. M. Irvine, K. Legg, D. B. Tyers, L. A. Landenburger, S. L. Cain, K. L. Frey, B. C. Aber, and C. C. Schwartz. 2013a. Response of Yellowstone grizzly bears to changes in food resources: A synthesis. U.S. Geological

Survey, Northern Rocky Mountain Science Center, Interagency Grizzly Bear Study Team, Bozeman, MT.

van Manen, F. T., M. R. Ebinger, M. A. Haroldson, R. B. Harris, M. D. Higgs, S. Cherry, G. C. White, and C. C. Schwartz. 2014. Re-evaluation of Yellowstone grizzly bear population dynamics not supported by empirical data: Response to Doak & Cutler. Conservation Letters 7:323-331.

van Manen, F. T., M. A. Haroldson, and B. Karabensh. 2019. Yellowstone grizzly bear investigations 2018: Annual report of the Interagency Grizzly Bear Study Team 2018. U.S. Department of the Interior, U.S. Geological Survey, Bozeman, MT.

van Manen, F. T., M. A. Haroldson, and B. E. Karabensh, (eds.). 2016. Yellowstone grizzly bear investigations: Annual report of the interagency grizzly bear study team 2015. U.S. Department of the Interior, U.S. Geological Survey, Interagency Grizzly Bear Study Time, Bozeman, MT.

_____. 2018. Yellowstone grizzly bear investigations: Annual report of the interagency grizzly bear study team, 2017. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

_____. 2020. Yellowstone grizzly bear investigations: Annual report of the interagency grizzly bear study team, 2019. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA.

van Manen, F. T., M. A. Haroldson, and S. C. Soileau, (eds.). 2015. Yellowstone grizzly bear investigations: Annual report of the interagency grizzly bear study team 2014. U.S. Department of the Interior, U.S. Geological Survey.

van Manen, F. T., M. A. Haroldson, and K. West, (eds.),. 2013b. Yellowstone grizzly bear investigations: Annual report of the interagency grizzly bear study team 2012. U.S. Department of the Interior, U.S. Geological Survey.

Vanbianchi, C., W. L. Gaines, M. A. Murphy, and K. E. Hodges. 2018. Navigating fragmented landscapes: Canada lynx brave poor quality habitats while traveling. Ecology and Evolution 8:11293-11308.

Vandeberg, G. S., and J. A. VanLooy. 2016. Continental Glacier meltwater contributions to late summer stream flow and water quality in the northern Wind River Range, Wyoming, USA. Environmental Earth Sciences 75.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Veblen, T. T., T. Kitzenberger, and J. Donnegan. 2000. Climatic and human influences on fire regimes in ponderosa pine forests in the Colorado front range. Ecological Applications 10:1178-1195.

Vose, J. M., D. L. Peterson, G. M. Domke, C. J. Fettig, L. A. Joyce, R. E. Keane, C. H. Luce, J. P. Prestemon, L. E. Band, J. S. Clark, N. E. Cooley, A. D'Amato, and J. E. Halofsky. 2018. Chapter 6: Forests. Pages 232-267 *in* D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart, editors. Impacts, risks, and adaptation in the United States: Fourth national climate assessment, volume II. U.S. Global Change Research Program, Washington, DC.

Vose, J. M., D. L. Peterson, and T. Patel-Weynand. 2012. Effects of climatic variability and change on forest ecosystems: A comprehensive science synthesis for the U.S. forest sector. Gen.

Tech. Rep. PNW-GTR-870, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Vose, J. M., W. T. Swank, B. D. Clinton, R. L. Hendrick, and A. E. Major. 1995. Using fire to restore pine/hardwood ecosystems in the southern Appalachians of North Carolina. Pages 149-154 *in* J. M. Greenlee, editor. Proceedings: Fire Effects on Rare and Endangered Species and Habitats Conference, Nov. 13-16, 1995. Coeur d'Alene, ID. International Association of Wildland Fire.

Vuke, S. M. 2013. Geologic map of the Fan Mountain, Lone Mountain, and Gallatin Peak 7.5' Quadrangles, Madison Range Madison and Gallatin Counties, Montana. *in* Open-File Report. Montana Bureau of Mines and Geology, Butte, MT.

Wade, A. A., K. S. McKelvey, and M. K. Schwartz. 2015. Resistance-surface-based wildlife conservation connectivity modeling: Summary of efforts in the United States and guide for practitioners. Gen. Tech. Rep. RMRS-GTR-333, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Walker, R., and L. Craighead. 1997. Least-cost-path corridor analysis: Analyzing wildlife movement corridors in Montana using GIS.

Waller, J. S. 1992. Grizzly bear use of habitats modified by timber management. MS thesis, Montana State University, Bozeman, MT.

Ward, J. V. 1989. The four-dimensional nature of lotic ecosystems. Journal of the North American Benthological Society 8:2-8.

Warwell, M. V., G. E. Rehfeldt, and N. Crookston. 2007. Modeling contemporary climate profiles of whitebark pine (Pinus albicaulis) and predicting responses to global warming. Pages 139-142 *in* E. Michaels Goheen, and R. A. Sniezko, editors. Proceedings of the Conference, Whitebark pine: A Pacific Coast Perspective, August 27-31, 2006, Ashland, Oregon (R6-NR-FHP-2007-01). U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Portland, OR.

Washington-Allen, R. A., D. D. Briske, H. H. Shugart, and L. F. Salo. 2010. Introduction to special feature on catastrophic threshholds, perspectives, definitions, and applications. Ecology and Society 15:1-7.

Wasson, K., A. Woolfolk, and C. Fresquez. 2013. Ecotones as indicators of changing environmental conditions: Rapid migration of salt marsh-upland boundaries. Estuaries and Coasts 36:654-664.

Watanabe, M. E. 1994. Pollination worries rise as honey bees decline. Science 265:1170.

Watts, K., A. E. Eycott, P. Handley, D. Ray, J. W. Humphrey, and C. P. Quine. 2010. Targeting and evaluating biodiversity conservation action within fragmented landscapes: an approach based on generic focal species and least-cost networks. Landscape Ecology 25:1305-1318.

Weaver, J. E. 1968. Prairie plants and their environment: A fifty-year study in the midwest. University of Nebraska Press, Lincoln, NE.

Weldon, L. A. C. 2011. Follow up letter to Sensitive Species Designation for Whitebark Pine. *in* S. D. Forest and Grasslands Supervisors, editor. U.S. Department of Agriculture, Forest Service, Region One, Missoula, MT.

Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313:940-943.

Westerling, A. L., M. G. Turner, E. A. Smithwick, W. H. Romme, and M. G. Ryan. 2011. Continued warming could transform Greater Yellowstone fire regimes by mid-21st century. Proceedings of the National Academy of Sciences of the United States of America 108:13165-13170.

Western Association of Fish and Wildlife Agencies (WAFWA), Wild Sheep Working Group. 2010. Recommendations for domestic sheep and goat management in wild sheep habitat.

_____. 2012. Recommendations for domestic sheep and goat management in wild sheep habitat.

Western Governor's Association. 2008. Wildlife corridors initiative. Western Governer's Association, Jackson, WY.

_____. 2019. Policy Resolution 2019-08 wildlife migration corridors and habitat.

Wettstein, W., and B. Schmid. 1999. Conservation of arthopod diversity in montane wetlands: effect of altitude, habitat quality and habitat fragmentation on butterflies and grasshoppers. Journal of Applied Ecology 36:363-373.

White, P. J., K. A. Gunther, and F. T. van Manen, (Eds.). 2017. Yellowstone grizzly bears: Ecology and conservation of an icon of wildness. Yellowstone Forever, Yellowstone National Park and U.S. Department of the Interior, Geological Survey, Northern Rocky Mountain Science Center, Gariner, MT.

White, P. J., and R. L. Wallen. 2012. Yellowstone bison--Should we preserve artificial population substructure or rely on ecological processes? Journal of Heredity 103:751-753.

White, P. J., R. L. Wallen, and D. E. Hallac, Eds. 2015. Yellowstone bison: Conserving an American icon in modern society. Yellowstone Association, Yellowstone National Park, WY.

White, R. S., and P. O. Currie. 1983. The Effects of Prescribed Burning on Silver Sagebrush. Journal of Range Management 36:611-613.

White, T. C. R. 1976. Weather, food and plagues of locusts. Oecologia 22:119-134.

Whited, D. C., M. S. Lorang, M. J. Harner, F. R. Hauer, J. S. Kimball, and J. A. Stanford. 2007. Climate, hydrologic disturbance, and succession: Drivers of floodplain pattern. Ecology 88:940-953.

Whitehead, R. J., L. Safranyik, G. L. Russo, T. L. Shore, and A. L. Carroll. 2003. Silviculture to Reduce Landscape and Stand Susceptibility to the Mountain Pine Beetle. Pages 233-244 *in* T. L. Shore, J. E. Brooks, and J. E. Stone, editors. Mountain Pine Beetle Symposium: Challenges and solutions. October 30-31, 2003, Kelowna, British Columbia. Information Report BC-X-399. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Kelowna, British Columbia.

Whitlock, C., W. F. Cross, B. Maxwell, N. Silverman, and A. A. Wade. 2017. 2017 Montana climate assessment. Montana University System, Montana Institute on Ecosystems, Bozeman and Missoula, MT.

Whitlock, C., J. Marlon, C. Briles, A. Brunelle, C. Long, and P. Bartlein. 2008. Long-term relations among fire, fuel, and climate in the northwestern U.S. based on lake-sediment studies. International Journal of Wildland Fire 17:72-83.

Wiedinmyer, C., and M. D. Hurteau. 2010. Prescribed fire as a means of reducing forest carbon emissions in the western United States. Environmental Science & Technology 44:1926-1932.

Wiens, J. A., G. D. Hayward, H. D. Safford, and C. M. Giffen, (Eds.). 2012. Historical environmental variation in conservation and natural resource management. Wiley-Blackwell, Hoboken, NJ.

Wiensczyk, A. M., S. Gamiet, D. M. Durall, M. D. Jones, and S. W. Simard. 2002. Ectomycorrhizae and forestry in British Columbia: A summary of current research and conservation strategies [Special Issue]. Pages 20 *in* Journal of Ecosystems & Management.

Williams, H., S. Hood, C. Keyes, J. Egan, and J. Negrón. 2018. Subwatershed-Level Lodgepole Pine Attributes Associated with a Mountain Pine Beetle Outbreak. Forests 9:552.

Williams, M. W., and K. A. Tonnessen. 2000. Critical loads for inorganic nitrogen deposition in the Colorado front range, USA. Ecological Applications 10:18.

Williamson, M., and A. Fitter. 1996. The varying success of invaders. Ecology 77:1661-1666.

Williamson, M. A., T. G. Creech, G. Carnwath, B. Dixon, and V. Kelly. 2020. Incorporating wildlife connectivity into forest plan revision under the United States Forest Service's 2012 planning rule. Conservation Science and Practice 2:15.

Winslow, J. C., E. R. Hunt, and S. C. Piper. 2003. The influence of seasonal water availability on global C3 versus C4 grassland biomass and its implications for climate change research. Ecological Modelling 163:153-173.

Wipfli, M. S., and D. P. Gregovich. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: Implications for downstream salmonid production. Freshwater Biology 47:957-969.

Wisdom, M. J., and L. J. Bate. 2008. Snag density varies with intensity of timber harvest and human access. Forest Ecology and Management 255:2085-2093.

Wisdom, M. J., H. K. Preisler, L. M. Naylor, R. G. Anthony, B. K. Johnson, and M. M. Rowland. 2018. Elk responses to trail-based recreation on public forests. Forest Ecology and Management 411:223-233.

Wohl, E. 2005. Compromised rivers: Understanding historical human impacts on rivers in the context of restoration. Ecology and Society 10:2.

Wolff, P., M. Cox, C. McAdoo, and C. A. Anderson. 2016. Disease transmission between sympatric mountain goats and bighorn sheep. Northern Wild Sheep and Goat Council, Bozeman, MT.

Wood, F. L., A. L. Heathwaite, and P. M. Haygarth. 2005. Evaluating diffuse and point phosphorus contributions to river transfers at different scales in the Taw catchment, Devon, UK. Journal of Hydrology 304:118-138.

Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state-of-the-art review. Gen. Tech. Rep. INT-GTR-58, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Wright, J., C. Jones, and A. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia 132:96-101.

Wurtzebach, Z., and C. Schultz. 2016. Measuring ecological integrity: History, practical applications, and research opportunities. BioScience 66:446-457.

Yellowstone Ecosystem Subcommittee. 2016a. 2016 conservation strategy for the grizzly bear in the Greater Yellowstone Ecosystem. Interagency Grizzly Bear Committee, Yellowstone Ecosystem Subcommittee, Missoula, MT.

_____. 2016b. Appendix E. 1998 Baseline for Habitat Standards. Pages 36 *in* 2016 Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Ecosystem. U.S. Department of the Interior,, Fish and Wildlife Service, Missoula, MT.

Yue, X., L. J. Mickley, J. A. Logan, and J. O. Kaplan. 2013. Ensemble projections of wildfire activity and carbonaceous aerosol concentrations over the western United States in the mid-21st century. Atmospheric Environment 77:767-780.

Zeller, K. A., K. McGarigal, P. Beier, S. A. Cushman, T. W. Vickers, and W. M. Boyce. 2014. Sensitivity of landscape resistance estimates based on point selection functions to scale and behavioral state: pumas as a case study. Landscape Ecology 29:541-557.

Zeller, K. A., K. McGarigal, and A. R. Whiteley. 2012. Estimating landscape resistance to movement: A review. Landscape Ecology 27:777-797.

Ziesak, R. 2015. Montana forestry best management practices monitoring: 2014 forestry BMP field review report.

_____. 2016. Montana forestry best management practices monitoring: 2016 Forestry Best Management Practices field review results. Montana Department of Natural Resources & Conservation, Forestry Division.

_____. 2018. Montana forestry best management practices monitoring: 2018 Forestry BMP field review report.

Zimmer, J. P., D. B. Tyers, and L. R. Irby. 2008. Winter snowshoe hare habitat use within a silviculturally impacted area. Intermountain Journal of Sciences 14:40-49.

Ziska, L. H. 2010. Elevated carbon dioxide alters chemical management of Canada thistle in no-till soybean. Field Crops Research 119:299-303.

Ziska, L. H., and T. J. R. 2000. Sustained growth and increased tolerance to glyphosate observed in a C3 perennial weed, quackgrass (Elytrigia repens), grown at elevated carbon dioxide. Australian Jounral of Plant Physiology 27:159-166.

Ziska, L. H., J. B. Reeves, III., and B. Blank. 2005. The impact of recent increases in atmospheric CO2 on biomass production and vegetative retention of cheatgrass (Bromus tectorum): Implications for fire disturbance. Global Change Biology 11:1325-1332.

Zouhar, K., J. Kapler Smith, S. Sutherland, and M. L. Brooks. 2008. Wildland fire in ecosystems: Fire and nonnative invasive plants. Gen. Tech. Rep. RMRS-GTR-42-vol. 6, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.