1. OVERVIEW OF THE SCIENCE FRAMEWORK

Jeanne C. Chambers, Karen L. Prentice, and Michele R. Crist

Introduction

The Science Framework is part of an unprecedented conservation effort underway across 11 States in the western United States to address threats to sagebrush (*Artemisia* spp.) ecosystems and the species that depend on them. Sagebrush ecosystems provide a large diversity of habitats and support more than 350 species of vertebrates (Suring et al. 2005). These ecosystems currently make up only about 59 percent of their historical area, and the primary patterns, processes, and components of many sagebrush ecosystems have been significantly altered since Euro-American settlement in the mid-1800s (Knick et al. 2011; Miller et al. 2011). The primary threats to sagebrush ecosystems are well recognized and include large-scale wildfire, invasion of exotic annual grasses, conifer expansion, energy development, conversion to cropland, and urban and exurban development (Coates et al. 2016; Davies et al. 2011; Knick et al. 2011; USDOI FWS 2013). The continued loss and fragmentation of sagebrush habitats has placed many species at risk, including Greater sage-grouse (*Centrocercus urophasianus*; hereafter, GRSG), which has been considered for listing under the Endangered Species Act several times (USDOI FWS 2010, 2015) and whose status will be reevaluated in 2020 (USDOI FWS 2015).

The Science Framework was developed to provide a transparent, ecologically defensible approach for making policy and management decisions to reduce threats to sagebrush ecosystems and GRSG across multiple scales. It is directly linked to U.S. Department of the Interior directives and ongoing multi-partner conservation efforts (table 1.1).

The Science Framework represents a paradigm shift for agencies and managers in sagebrush ecosystems. Recent research has provided the basis for characterizing sagebrush ecosystems according to their ecological resilience to disturbance and resistance to invasive annual grasses (Chambers et al. 2014a,b, 2017b; Maestas et al. 2016). This has enabled development of approaches that couple information on resilience and resistance with knowledge of GRSG habitat and threats to sagebrush ecosystems in order to prioritize conservation actions based not only on species habitat requirements but also on the likely response of that habitat to disturbances and management actions (Chambers et al. 2014c, 2016, 2017a; Ricca et al. 2018). New geospatial data and analytical approaches provide the capacity to prioritize management actions to conserve and restore sagebrush ecosystems at much larger scales than in the past. Managing multiple resources across scales and surface land management jurisdictions in an integrated and collaborative manner is becoming common practice for agencies managing sagebrush ecosystems.

Top left: Mule deer walking through sagebrush (photo: USDOI National Park Service). Top right: Badger near its burrow (photo: USDOI Fish and Wildlife Service). Middle left: Burrowing owls near their burrow (photo: USDOI Fish and Wildlife Service). Middle right: Common sagebrush lizard on a rock (photo: commons.wikimedia.org). Bottom left: Pygmy rabbit hiding underneath sagebrush in snow (photo: USDOI Fish and Wildlife Service). Bottom middle: Sagebrush sparrow on a sagebrush plant (photo: S. Richards). Bottom right: Male Hera buckmoth on a sagebrush plant (photo: USDA Forest Service).

Table 1.1—Key directives, science information, and conservation and restoration strategies for the sagebrush biome.

Title	Description	Cooperators
An Integrated Rangeland Fire Management Strategy: Final Report to the Secretary of the Interior (IRFMS)	Longer-term actions to implement policies and strategies for preventing and suppressing rangeland fire and restoring rangeland landscapes affected by fire in the Western United States. Section 7b(iv) called for development of a Conservation and Restoration Strategy for sagebrush ecosystems that considered emerging science and included a baseline assessment, conceptual models, and other components necessary to provide an overarching strategy for "on the ground" restoration actions and provide a foundation for adaptive management and budget prioritization.	U.S. Department of the Interior (DOI) (USDOI 2015)
Science Framework for Conservation and Restoration of the Sagebrush Biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to Long-Term Strategic Conservation Actions Part 1. Science Basis and Applications	Scientific information and decision-support tools to: (1) facilitate prioritization of areas for conservation and restoration management actions; (2) inform budget prioritization of management actions; and (3) inform management strategies across scales and ownerships. Developed per IRFMS, Section 7b (iv). Builds on prior interagency work that developed a strategic, multi-scale approach to manage threats to sagebrush ecosystems and sage-grouse using resilience and resistance concepts (Chambers et al. 2014a, 2016).	State and Federal agencies (Chambers et al. 2017a)
Science Framework for Conservation and Restoration of the Sagebrush Biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to Long-Term Strategic Conservation Actions Part 2. Management Applications	Guidance for applying the scientific information and decision-support tools in Part 1 of the Science Framework in order to: (1) implement resource management priorities at large, landscape scales; and (2) use management strategies that increase ecosystem resilience to disturbance and resistance to nonnative invasive plant species across scales. Developed per IRFMS, Section 7b (iv).	State and Federal agencies (Crist et al. this volume)
Sagebrush Science Initiative	A collaborative effort to identify and fill the highest priority gaps in scientific knowledge needed to effectively conserve sagebrush dependent species and the sagebrush habitats they depend on.	Fish and Wildlife Service, Western Association of Fish and Wildlife Agencies (WAFWA), Bureau of Land Management (WAFWA lead; in progress)
Sagebrush Conservation Strategy Developed to meet the requirements of IRFMS, Section 7b (iv) in collaboration with the Sagebrush Science Initiative	A comprehensive, collaborative strategy to conserve sagebrush, sagebrush dependent species, and human uses of sagebrush ecosystems that builds on the resilience and resistance concepts, threat assessments, and habitat prioritization methods described in the Science Framework. This broad strategy will provide for voluntary conservation measures for managing and conserving sagebrush ecosystems, and is intended to provide an inclusive "all-hands, all-lands" approach.	State and Federal agencies, nongovernmental organizations, universities (WAFWA lead; in progress)
Secretarial Order 3362: Improving Habitat Quality in Western Big-Game Winter Range and Migration Corridors	Guidance to conserve and restore priority winter range and migration corridors for elk, mule deer, and pronghorn, as identified by State and tribal wildlife agency partners. DOI agencies will work with State, tribal, and other Federal partners such as USDA Forest Service to restore habitats, minimize disturbance, and use other site-specific management to conserve these areas. Much of the habitat for these three species is within the sagebrush biome.	DOI agencies, State agencies, WAFWA, USDA Forest Service (USDOI 2018)

The Science Framework uses a multi-scale approach to inform management decisions and actions. It applies the best available information on resilience and resistance to invasive annual grasses, GRSG habitat, and threats to sagebrush ecosystems to: (1) inform strategic management and conservation investments at broad scales (ecoregion or GRSG Management Zone to sagebrush biome), and (2) determine appropriate management strategies at local (field office or district) scales. An integrated monitoring and adaptive management approach is recommended to reduce the uncertainty in the effectiveness of management actions over time by improving both management objectives and strategies (Allen et al. 2011; Thompson et al. 2013). Syntheses of the best available science and considerations of the tradeoffs involved in making decisions facilitate development of appropriate management objectives and strategies in planning processes as well as alternatives for National Environmental Policy Act (NEPA) analyses.

Part 1 of the "Science Framework for Conservation and Restoration of the Sagebrush Biome: Linking the Department of the Interior's Integrated Rangeland Fire Management Strategy to Long-Term Strategic Conservation Actions" focuses on the **science basis and applications** for protecting, conserving, and restoring sagebrush ecosystems and GRSG habitat (Chambers et al. 2017a; hereafter, Part 1). Scientific information and decision-support tools are provided to: (1) assist in prioritizing areas for conservation and restoration management actions, (2) inform budget prioritization of management actions, and (3) inform management strategies across scales and ownerships.

Part 2 focuses on **management considerations and tradeoffs** for Part 1 and emphasizes adaptive management. The information in this volume can be used to apply the scientific information and decision-support tools in Part 1 in order to: (1) implement resource management priorities at large, landscape scales; and (2) use management strategies that increase ecosystem resilience to disturbance and resistance to nonnative invasive plant species across spatial scales. The concepts and approaches that form the basis for Parts 1 and 2 of the Science Framework are briefly reviewed in this section. The applications of these concepts and approaches are described in sections 2 through 8 and focus on key resource management topics, including adaptive management and monitoring, climate adaptation, wildfire and vegetation management, nonnative invasive plant management, application of National Seed Strategy concepts, livestock grazing management, and wild horse and burro considerations. Section 9 discusses integration of the management strategies for the different topics, and the associated tradeoffs involved in managing for diverse resources across large landscapes.

The Science Framework was developed to be used by resource specialists and practitioners at field and regional management levels, while providing a broader context for regional and national-level managers. Although the focus is largely on the sagebrush biome and GRSG, the information and tools provided allow managers to address other resource values and at-risk species as the necessary geospatial data are developed.

Concepts and Approaches Used in the Science Framework

The Science Framework provides the information and tools to address the primary threats to sagebrush ecosystems at geographical scales relevant to management. The threats addressed in the Science Framework were identified in the Sage-Grouse Conservation Objectives Team Final Report (USDOI FWS 2013) and reflect the threats to sagebrush ecosystems in general. These threats are consistent with those included in the Greater Sage-Grouse Monitoring Framework developed by the Interagency Greater Sage-Grouse Disturbance and Monitoring Subteam (IGSDMS 2014) and the State Wildlife Action Plans, which were prepared for the purpose of maintaining the health and diversity of wildlife within the State and reducing the need for future listings under the Endangered Species Act. In addition to these previously identified threats, climate adaptation is addressed in the Science Framework and climate adaptation strategies are provided.

The Science Framework includes three scales that inform different aspects of planning and implementation: (1) the sagebrush biome scale, where consistent data for the range of sagebrush and GRSG can inform budget prioritization; (2) the mid-scale (ecoregions and Management Zones), where assessments are typically conducted to inform budget prioritization and develop priority planning areas; and (3) the local scale, where local data and expertise are used to select project sites and determine appropriate management strategies and treatments within priority planning areas (table 1.2). At the mid-scale, a crosswalk is provided between U.S. Environmental Protection Agency ecoregions (USEPA 2016) and sage-grouse Management Zones (Stiver et al. 2006) (fig. 1.1). This approach aligns with the Sage-grouse Habitat Assessment Framework (Johnson 1980; Stiver et al. 2015).

Table 1.2—Scales and areas included in the strategic approach for managing threats to sagebrush ecosystems, sage-grouse, and other sagebrush obligate species as well as the data, tools, models, and processes considered at each scale or area.

Area	Geographic scale	Map extent	Data, tools, models	Process
Sagebrush biome and multiple Management Zones (MZs)	Broad	West-wide	Habitat Soils Population data and models Priority resource data Fire and other threat data Climate change projections	Budget prioritization for rangewide consistency
Sage-grouse MZs and ecoregions	Mid	State or national forest	Above, plus: Assessments and planning documents Regional data and models Regional tools	Assessments at ecoregion or MZ scale for prioritization of management actions
Local planning areas	Local	District, field office, or project area	Above, plus: Local data and information	Selection of treatment types within prioritized project areas

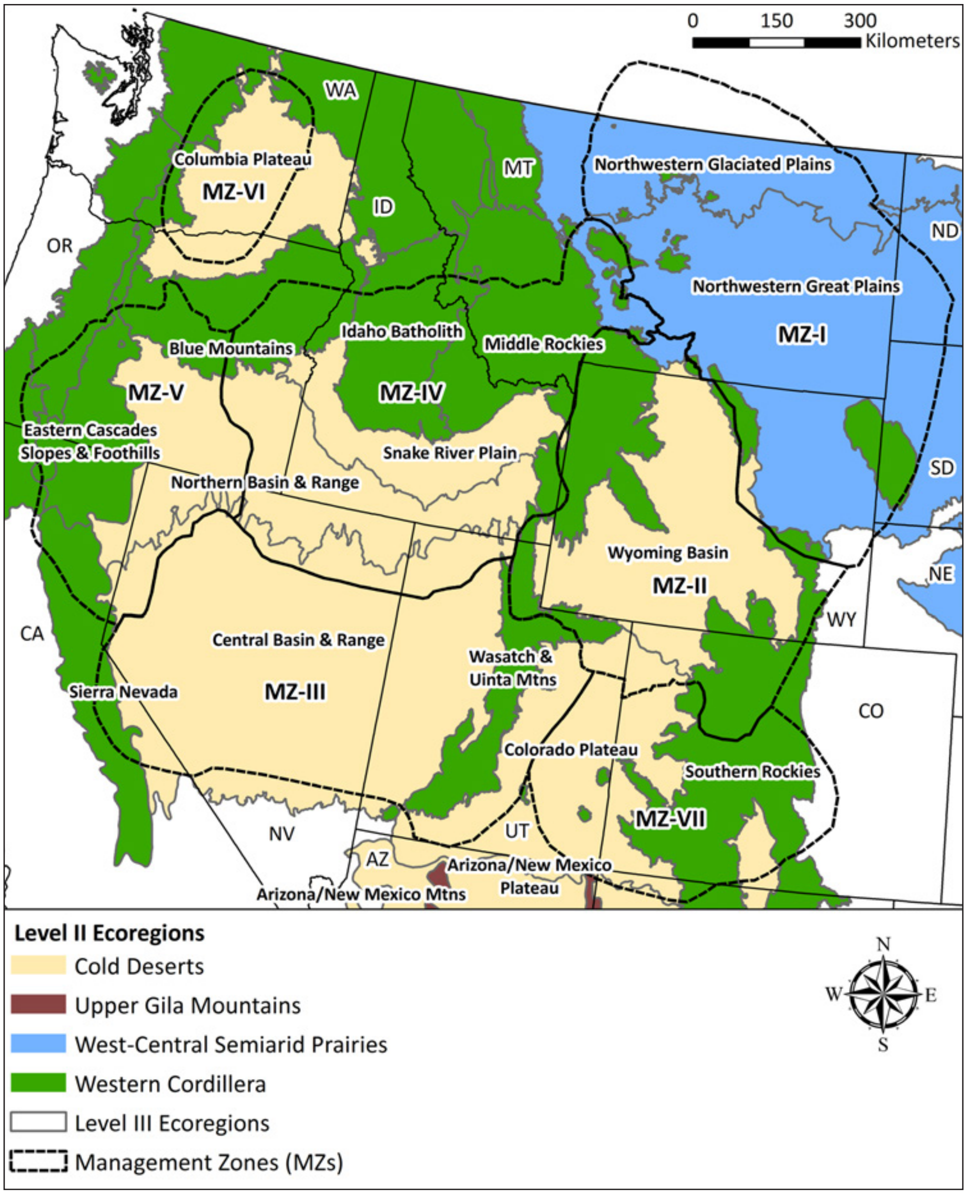

Figure 1.1—A crosswalk between level II and level III ecoregions (USEPA 2016) and sage-grouse Management Zones (MZs; Stiver et al. 2006) (Chambers et al. 2017a, fig. 1).

The Science Framework uses an approach that is based on current understanding of ecosystem resilience to disturbance and resistance to nonnative invasive plants in sagebrush ecosystems. Resilient ecosystems have the capacity to **reorganize and regain** their basic characteristics when altered by stressors such as invasive plants and disturbances such as improper livestock grazing and altered fire regimes (Angler and Allen 2016; Holling 1973). Species resilience refers to the ability of a species to recover from stressors and disturbances (USDOI FWS 2013), and is closely linked to ecosystem resilience. Resistant ecosystems have the capacity to ***retain*** their fundamental structure, processes, and functioning when exposed to stresses, disturbances, or invasive species (Angeler and Allen 2016; Folke et al. 2004). Resistance to invasion by nonnative plants is increasingly important in sagebrush ecosystems; it is a function of the abiotic and biotic attributes and ecological processes of an ecosystem that limits the population growth of an invading species (D'Antonio and Thomsen 2004). A detailed explanation of the factors that influence resilience and resistance in sagebrush ecosystems is found in Chambers et al. (2014a). Definitions of the terms used in this document are in Appendix 1.

Management focused on ecosystem resilience and resistance can help sustain local communities by ensuring that ecosystem services, such as water for human consumption and agricultural use, forage for livestock, and recreational opportunities, are maintained or improved over time. The resilience of socioeconomic systems, threats to those systems, and current capacities to implement management actions to address those threats are a separate aspect of developing an approach for conservation and restoration of the sagebrush biome and are addressed elsewhere.

The approach used in the Science Framework is intended to help prioritize areas for management and determine the most appropriate management strategies. The Science Framework is based on: (1) the likely response of an area to disturbance or stress due to threats, management actions, or a combination thereof (i.e., resilience to disturbance and resistance to invasion by nonnative plants); (2) the capacity of an area to support target species or resources; and (3) the predominant threats. It uses a mid-scale approach and has six steps.

- Identify focal species or resources and key habitat indicators for the assessment area, and then delineate their distribution or area using the best information available. For GRSG, this currently includes the modeled breeding habitat probabilities and the population index (Doherty et al. 2016). Information and tools are provided to allow managers to address other resource values and at-risk species as geospatial data for those values and species become available.
- Develop an understanding of ecosystem resilience to disturbance and resistance to nonnative invasive plants for the assessment area. At landscape scales, resilience and resistance to invasive annual grasses, which are a primary cause of altered fire regimes and habitat degradation in sagebrush ecosystems, are closely linked to soil temperature and moisture regimes (Chambers et al. 2014a,b; 2017b). Thus, soil temperature and moisture regimes are used to quantify and map resilience and resistance to invasive annual grasses (Maestas et al. 2016). More detailed information on soil characteristics and ecological site descriptions help managers to step-down generalized vegetation dynamics, including resilience and resistance concepts, to local scales.
- Integrate ecosystem resilience to disturbance and resistance to invasive annual grasses with species or resource habitat requirements and develop a decision matrix that can be used to spatially link ecosystem resilience and resistance, habitat requirements, and management strategies (table 1.3).
- Assess the key threats in the assessment area using geospatial data and maps.
- Prioritize areas for management in the assessment area using geospatial data and maps of species or resource habitat requirements, such as the breeding habitat probabilities for GRSG, resilience to disturbance and resistance to invasive annual grasses, and the key threats (fig. 1.2).
- Determine the most appropriate management strategies for areas prioritized for targeted conservation and restoration management actions based on habitat characteristics, relative resilience to disturbance and resistance to invasive annual grasses, and the predominant threats. The management strategies are developed in collaboration with stakeholders and are reconciled with socioeconomic and budgetary considerations. Other priority resources are considered such as special status plant species.

Table 1.3—Sage-grouse habitat, resilience and resistance matrix based on resilience and resistance concepts from Chambers et al. (2014a,b) and GRSG breeding habitat probabilities from Doherty et al. (2016). Rows show the ecosystem's relative resilience to disturbance and resistance to invasive annual grasses (1 = high resilience and resistance, 2 = moderate resilience and resistance, 3 = low resilience and resistance). Resilience and resistance categories were derived from soil temperature and moisture regimes (Chambers et al. 2017a [Part1], Appendix 2; Maestas et al. 2016) and relate to the sagebrush ecological types in Part 1, table 6. Columns show the landscape-scale GRSG breeding habitat probability based on Part 1, table 7 (A = 0.25 to <0.5 probability; B = 0.5 to <0.75 probability; C = ≥0.75 probability). Use of the matrix is explained in Part 1, section 7.4. Potential management strategies for persistent ecosystem threats, anthropogenic threats, and climate change are in table 1.4.

<table>
<tr><th rowspan="2">Ecosystem Resilience to Disturbance and Resistance to Invasion</th><th colspan="3">Landscape-Scale Sage-Grouse Breeding Habitat Probability</th></tr>
<tr><th>Low
(0.25 to <0.5 probability)

Landscape context is likely to be limiting habitat suitability. If limiting factors are within management control, significant restoration may be needed. These landscapes may still be important for other seasonal habitat needs or connectivity.</th><th>Moderate
(0.5 to <0.75 probability)

Landscape context may be affecting habitat suitability and could be aided by restoration. These landscapes may be at higher risk of becoming unsuitable with additional disturbances that degrade habitat.</th><th>High
(≥0.75 probability)

Landscape context is highly suitable to support breeding habitat. Management strategies to maintain and enhance these landscapes have a high likelihood of benefiting sage-grouse.</th></tr>
<tr><td rowspan="2">High</td><td>1A</td><td>1B</td><td>1C</td></tr>
<tr><td colspan="3">Potential for favorable perennial herbaceous species recovery after disturbance without seeding is typically high.

Risk of invasive annual grasses becoming dominant is relatively low. EDRR can be used to address problematic invasive plants.

Tree removal can increase habitat availability and connectivity in expansion areas.

Seeding/transplanting success is typically high.</td></tr>
<tr><td rowspan="2">Moderate</td><td>2A</td><td>2B</td><td>2C</td></tr>
<tr><td colspan="3">Potential for favorable perennial herbaceous species recovery after disturbance without seeding is usually moderately high, especially on cooler and moister sites.

Risk of invasive annual grasses becoming dominant is moderate, especially on warmer sites. EDRR can be used to address problematic invasive plants in many areas.

Tree removal can increase habitat availability and connectivity in expansion areas.

Seeding/transplanting success depends on site characteristics, and more than one intervention may be required, especially on warmer and drier sites.

Recovery following inappropriate livestock use depends on site characteristics and management.</td></tr>
<tr><td rowspan="2">Low</td><td>3A</td><td>3B</td><td>3C</td></tr>
<tr><td colspan="3">Potential for favorable perennial herbaceous species recovery after disturbance without seeding is usually low.

Risk of invasive annual grasses becoming dominant is high. EDRR can be used to address problematic invasive plants in relatively intact areas.

Seeding/transplanting success depends on site characteristics, extent of annual invasive plants, and post-treatment precipitation, but is often low. More than one intervention likely will be required.

Recovery following inappropriate livestock use is unlikely without active restoration.</td></tr>
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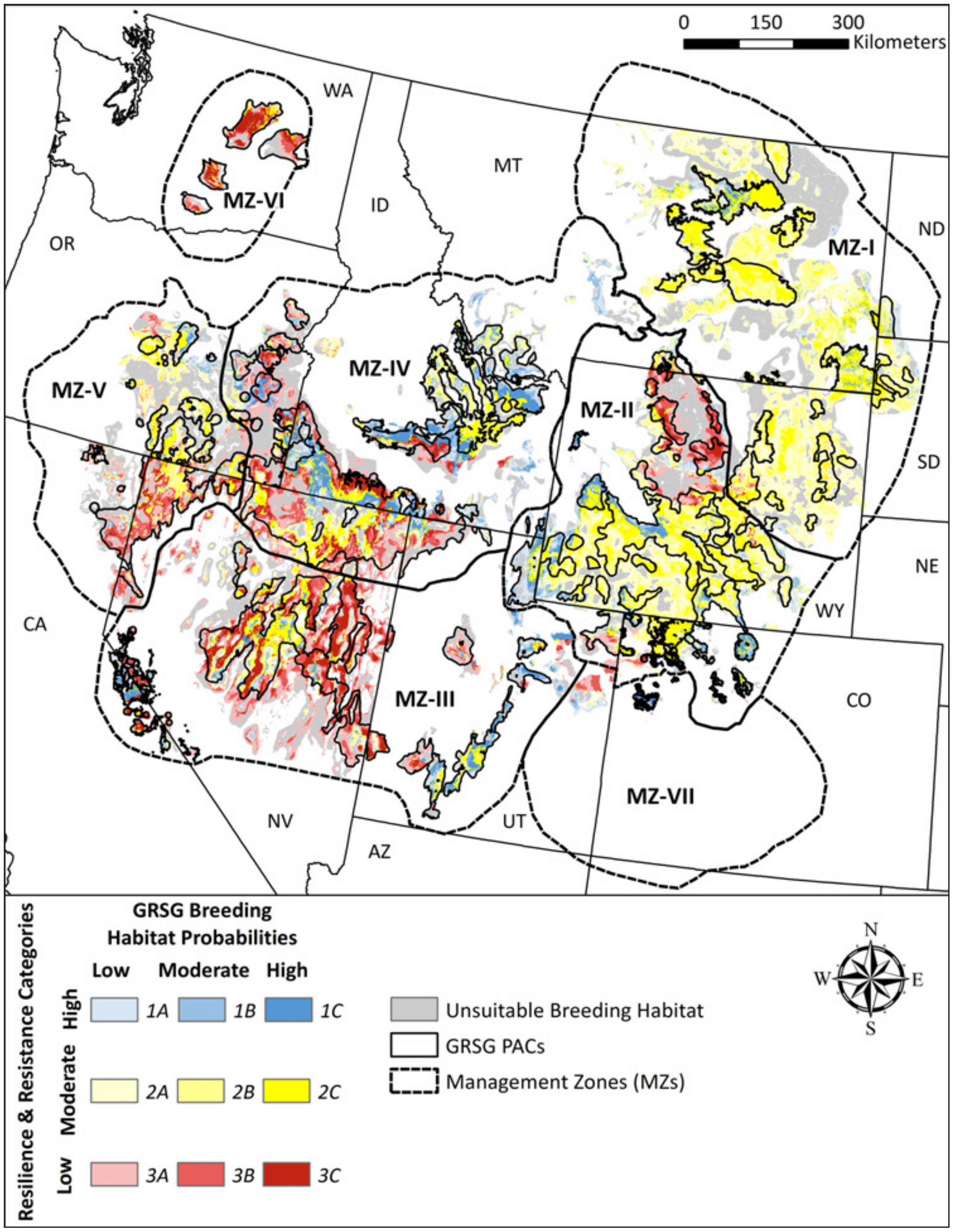

Figure 1.2—Greater sage-grouse (GRSG) breeding habitat probabilities based on 2010–2014 lek data (Doherty et al. 2016) intersected with resilience and resistance categories developed from soil temperature and moisture regimes (Chambers et al. 2017a). This map provides a spatial depiction of the sage-grouse habitat, resilience and resistance matrix (Chambers et al. 2017a, fig. 38).

These six steps help identify priority areas for management and overarching management strategies for the assessment area. Key aspects of the approach are the sage-grouse habitat resilience and resistance matrix (table 1.3) and linked management strategies for addressing threats to sagebrush ecosystems (table 1.4). To step down ecoregion or Management Zone priorities to the local scale, managers and stakeholders are engaged to: (1) refine priorities and management strategies based on higher resolution geospatial products, additional species information, and local knowledge, including traditional ecological knowledge; (2) select specific project areas; and (3) identify opportunities to leverage partner resources.

Table 1.4—Management strategies for persistent ecosystem threats, climate change, and land use and development threats. Recommendations are provided for prioritizing and targeting strategies based on cells in the sage-grouse habitat, resilience and resistance matrix (table 1.3). Threats and strategies are cross-cutting and affect multiple program areas. While many of the strategies fall under the broad umbrella of vegetation management, a coordinated and integrated approach is likely to be used in addressing threats. For example, it is expected that many agency program areas, such as nonnative invasive plant management, fuel management, range management, and wildlife, will contribute to strategies that use vegetation manipulation to address persistent ecosystem and anthropogenic threats.

Threat—Nonnative Plant Invasive Species

Management strategies

- Apply integrated vegetation management practices to manage nonnative invasive plant species, using an interdisciplinary and coordinated approach in designing and implementing projects and treatments.
    - Prioritize areas where management resources are likely to be available to ensure successful management in the long term.
- Use resilience and resistance categories and knowledge of invasive plant distributions to select appropriate management approaches.
    - Protect high quality (relatively weed-free) sagebrush communities with moderate to high sage-grouse habitat probabilities (cells 1B, 1C, 2B, 2C, 3B, 3C):
        - Focus on preventing introduction and establishment of invasive plant species, especially in low resistance areas with high susceptibility to annual grass invasion (in and adjacent to cells 3B, 3C);
        - Avoid seeding introduced forage species (e.g., crested wheatgrass, smooth brome) in postfire rehabilitation or restoration in moderate to high resilience and resistance areas because these species can dominate sagebrush communities; and
        - Practice Early Detection and Rapid Response (EDRR) approaches for emerging invasive species of concern (in and adjacent to cells 1B, 1C, 2B, 2C, 3B, 3C).
    - Where weed populations already exist, seek opportunities to maximize treatment effectiveness by prioritizing restoration within relatively intact sagebrush communities (cells 1B, 1C, 2B, 2C, 3B, 3C). Restoration is likely to be easier at locations in cooler and moister ecological types with higher resilience and resistance.
        - Prioritize sites with sufficient native perennial herbaceous species to respond to release from invasive plant competition;
        - Manage grazing to reduce invasive species and promote native perennial grasses. In the West-Central Semiarid Prairies and other cool and moist areas, manage grazing to reduce crested wheatgrass, Kentucky bluegrass, smooth brome, and other introduced forage species and to promote native cool season perennial grasses (see grazing strategies).
    - Restrict spread of large weed infestations located in lower breeding habitat probability areas (cells 1A, 2A, 3A) to prevent compromising adjacent higher quality habitats (cells 1B, 1C, 2B, 2C, 3B, 3C).

Threat—Conifer Expansion

Management strategies

- Addressing localized conifer expansion requires an interdisciplinary approach and necessarily involves multiple program areas.
    - Apply integrated vegetation management practices to treat conifer expansion, using an interdisciplinary approach in designing projects and treatments.
    - Focus tree removal on early to mid-phase (e.g., Phases I, II) conifer expansion into sagebrush ecological sites to maintain shrub/herbaceous cover.
    - Use prescribed burning cautiously and selectively in moderate to high resilience/resistance (cells 1A, 1B, 2A, 2B) to control conifer expansion.
    - Prioritize for treatment:
        - Areas with habitat characteristics that can support sage-grouse with moderate to high resilience and resistance (cells 1B, 1C, 2B, 2C), especially near leks. (Note: Cells 3B and 3C are generally too warm and dry to support conifers.)
        - Areas where conifer removal will provide connectivity between sagebrush habitats.
        - Areas where sufficient native perennial grasses and forbs exist to promote recovery and limit increases in invasive plant species.

Threat—Wildfire

Management strategies

The wildfire threat is generally addressed through fire operations, fuel management (mechanical treatments, prescribed burning, chemical and seeding treatments), and postfire rehabilitation.

Fire Operations: Protection of areas supporting sagebrush is important for maintaining sagebrush habitat. The types and locations of GRSG habitats have been incorporated into decision support, dispatch, and initial attack procedures, and represent key considerations for fire managers.

(Continued)

Table 1.4—(Continued).

If resources become limiting, consider the following prioritization:

- Fire suppression—typically shifts from low to moderate priority when resilience and resistance categories shift from high to moderate, but varies with large fire risk and landscape condition (cells 1B, 1C, 2B, 2C). In low resilience and resistance areas, the priority shifts from moderate to high as sage-grouse habitat probability increases (cells 3B, 3C). Scenarios requiring high priority may include:
  - Areas of sagebrush that bridge large, contiguous expanses of sagebrush and that are important for providing habitat connectivity;
  - Areas where sagebrush communities have been successfully reestablished through seedings or other rehabilitation investments; and
  - All areas during critical fire weather conditions, where fire growth may move into valued sagebrush communities. These conditions may be identified by a number of products including, but not limited to: Predictive Services National 7-Day Significant Fire Potential products; National Weather Service Fire Weather Watches and Red Flag Warnings; and fire behavior analyses and local fire environment observations.

Fuel Management: Fuel management is a subset of vegetation management. Fuel management activities include treatments that mitigate wildfire risk, modify fire behavior, improve resilience to disturbance and resistance to invasive annual grasses, and protect and restore habitat. Mechanical treatments are typically applied to reduce fuel loading, modify fire behavior, augment fire suppression efforts, or alter species composition consistent with land use plan objectives. Roadside fuel breaks are applied most commonly in MZ III, IV, and V. Prescribed burning is one form of fuel management that may be used to improve habitat conditions or create fuel conditions that limit future fire spread in areas with moderate to high resilience and resistance, but should be considered only after consultation with local biologists and land managers. Chemical and seeding treatments are conducted to reduce invasive plants and change species composition to native, more fire resistant species, or a combination thereof, where native perennial grasses and forbs are depleted. When setting priorities for fuel management, consider the following.

<u>Mechanical Treatments—Conifer Removal</u>

- Conifer removal conducted to decrease woody fuels and reduce the loss of large, contiguous sagebrush stands are high priority in areas with high GRSG breeding habitat probabilities and moderate to high resilience and resistance (cells 1B, 1C, 2B, 2C), and shift to low in areas with low breeding habitat probabilities (cells 1A, 2A). In these areas, the focus is primarily on conifer expansion areas with sufficient native perennial understory species for recovery.
- Management activities may include:
  - Tree removal in early to mid-phase (Phases I, II) postsettlement conifer stands to maintain shrub/herbaceous cover and reduce fuel loads;
  - Tree removal in later phase (Phase III) postsettlement conifer stands to reduce risks of large or high severity fires; and
  - Herbicide, seeding associated with mechanical treatments, or both, to reduce invasive species and restore native perennial herbaceous species where native perennial species are depleted.

<u>Mechanical Treatments—Fuel Breaks</u>

Fuel breaks are strategically placed treatments where vegetation is modified in order to change fire behavior, making fire control efforts safer or more effective. Common types of fuel breaks include road maintenance/roadside disking (brown strips), mowed fuel breaks, and vegetative fuel breaks (green strips).

- In areas of low resilience and resistance, fuel breaks may increase in priority as sage-grouse habitat probability increases (cells 3B, 3C). Repeated treatments may be necessary to maintain functional fuel breaks.
- Key management considerations for the design and placement of fuel breaks:
  - Implement where fire managers believe they will benefit suppression efforts;
  - Design at large landscape scales, providing multiple options for fire managers;
  - Design collaboratively with interdisciplinary specialists, private landowners, fire response partners, and other agencies;
  - Include plans for long-term monitoring and maintenance;
  - Design to minimize habitat impacts, including nonnative invasive species introduction and spread, while maximizing potential fire management benefits.
- Key ecological considerations for the design and placement of fuel breaks:
  - Design fuel breaks in an interdisciplinary setting which addresses the need, cumulative effects, alternative treatments, and possible undesired results;
  - Consider ecosystem resilience and resistance and place fuel breaks to minimize catastrophic ecological state changes;
  - Include conservation buffers around sagebrush leks, habitat fragmentation thresholds, and minimum habitat patch sizes;
  - Include the influence on habitat connectivity between seasonal sage-grouse habitats;
  - Follow technical guidance related to recommended design features (see Maestas et al. 2016a).

(Continued)

Table 1.4—(Continued).

Prescribed Fire

Prescribed fire to address the threat of wildfire includes burning to reduce woody biomass resulting from treatments, to control conifer expansion, to reduce hazardous fuels, and to create fuel breaks which augment fire suppression efforts. When setting priorities for prescribed fire, consider the following:

- Consider alternatives to prescribed burning where other treatment alternatives may meet management objectives.
- In low resilience and resistance areas, consider prescribed fire only after consultation with local biologists and land managers and when:
  - Site information, such as state-and-transition models, affirm that the postburn trajectory will lead to functioning sagebrush communities. Most low resilience and resistance areas that receive <12 in/yr (30 cm/yr) of precipitation do not respond favorably to burning (see Miller et al. 2014).
  - Burning is part of multi-stage restoration projects where burning is required to remove biomass following chemical treatments for site preparation or for improved chemical applications.
  - Monitoring data validates that the preburn composition will lead to successful, native plant dominance post-burn
- Use prescribed fire cautiously and selectively in moderate to high resilience and resistance areas, after consulting with local biologists and land managers and assessing site recovery potential and other management options based on the following:
  - Preburn community composition;
  - Probability of invasive species establishment or spread;
  - Historical fire regime, and patch size/pattern to be created by burning;
  - Wildfire risk and desired fuel loading to protect intact sagebrush; and
  - Alternative treatments that may meet objectives.

Chemical Treatment of Nonnative Invasive Plant Species and Seeding

Chemical treatments and seedings are used to decrease invasive species composition and increase native species dominance in areas where native perennial grasses and forbs are insufficient for site recovery. Chemical and seeding treatments may be selectively applied in conjunction with prescribed fire or mechanical treatments. Typically, these treatments are in response to clear evidence of a nonnative invasive species threat. Areas of higher priority for chemical and seeding treatments:

- Lower resistance and resilience cells (2A, 2B, 3A, 3B) lacking the ability for natural recovery;
- Recently disturbed areas where recovery will not occur without chemical or seeding treatments;
- Areas where investments have been made and objectives cannot be attained without chemical or seeding treatments.

Postfire Rehabilitation: General considerations for prioritization of postfire rehabilitation efforts are:

- Priority generally increases as resilience and resistance decrease and habitat probability for sage-grouse increases. High priorities include areas of low to moderate resilience and resistance that (1) lack sufficient native perennial grasses and forbs to recover on their own and (2) have nearby areas still supporting sage-grouse habitat (cells 2B, 2C, 3B, 3C). Areas of low habitat probability for sage-grouse (cells 2A, 3A) are generally lower priority but may become higher priority in areas that support other resource values or that increase connectivity for GRSG populations.
- Areas of higher priority across all cells include:
  - Areas where prefire perennial herbaceous cover, density, and species composition is inadequate for recovery (see Miller et al. 2015);
  - Areas where seeding or transplanting sagebrush is needed to maintain habitat connectivity for sage-grouse;
  - Areas threatened by nonnative invasive plants; and
  - Steep slopes and soils with erosion potential.

Threat—Sagebrush Reduction

Management strategies

- Avoid intentional sagebrush removal (either prescribed fire or mechanical removal) across all areas in the West-Central Semiarid Prairies due to relatively limited sagebrush availability and extended periods of recovery in the region. Many areas are characterized by moderate to moderately low resilience and resistance, and many sagebrush species lack the capacity to resprout.
- Use caution when attempting to increase herbaceous perennials by reducing sagebrush dominance through mechanical or chemical treatments in general.
  - Lower resistance and resilience areas are prone to annual grass increases and potential dominance if invasive annual grasses exist in the area before treatment.
  - Pretreatment densities of 2 to 3 native perennial bunch grasses per square meter are often necessary for successful increases in perennial herbaceous plants and for suppression of invasive annual grasses after treatment in lower resistance and resilience areas (Miller et al. 2014, 2015).

(Continued)

Table 1.4—(Continued).

Threat—Climate Change

Management strategies

- Continue to use best management practices where effects of climate change and its interactions with stressors are expected to be relatively small and knowledge and management capacity are high.
- Consider proactive management actions to help ecosystems transition to new climatic regimes where climate change and stressor interactions are expected to be severe.
- Practice drought adaptation measures such as reduced grazing during droughts, conservation actions to facilitate species persistence, and seeding and transplanting techniques more likely to work during drought. Consider developing formal drought management plans for livestock grazing.
- Anticipate and respond to species declines such as may occur on the southern or warmer edges of their geographic range.
- Favor genotypes for seeding and out-planting that are better adapted to future conditions because of pest resistance, broad tolerances, or other characteristics.
- Increase diversity of plant materials for restoration activities to provide those species or genotypes likely to succeed.
- Protect future-adapted regeneration from inappropriate livestock grazing.
- Monitor transition zones between climatic regimes (the edges) to provide advanced warning of range shifts. Plant community shifts that affect management decisions often occur between Major Land Resource Areas or level III ecoregions.

Threat—Cropland Conversion

Management strategies

- Secure Conservation Easements to maintain existing sagebrush grasslands and sage-grouse habitat and prevent conversion to tillage agriculture. Prioritize all areas supporting moderate to high sage-grouse habitat probability (cells 1B, 1C, 2B, 2C, 3B, 3C) in locations where tillage risk is elevated (see Sage Grouse Initiative, Cultivation Risk layer).
- Secure term leases (e.g., 30 years) to maintain existing sagebrush grasslands and sage-grouse habitat and prevent conversion to tillage agriculture as a secondary strategy to Conservation Easements. Prioritize all areas supporting moderate to high sage-grouse habitat probability (cells 1B, 1C, 2B, 2C, 3B, 3C) especially in locations where tillage risk is elevated (see SGI Cultivation Risk layer).
- Offer alternatives to farming on expired USDA Conservation Reserve Program (CRP) lands through Federal and State programs. Prioritize lands in and around intact habitats (cells 1B, 1C, 2B, 2C, 3B, 3C).
- Encourage enrollment in the USDA CRP or similar programs to return tilled lands to perennial plant communities supporting mixtures of grasses, forbs, and sagebrush where there are benefits to sage-grouse. Prioritize lands in and around intact habitats (cells 1B, 1C, 2B, 2C, 3B, 3C).

Threat—Energy Development

Management strategies

- Avoid development, if feasible, in areas with high breeding habitat probability for sage-grouse and high sagebrush cover (cells 1C, 2C, 3C) and steer development in non-habitat areas (1A, 2A, 3A).
- Minimize habitat fragmentation in areas with moderate and high breeding habitat probabilities for sage-grouse (cells 1B, 2B, 3B, 1C, 2C, 3C).
- For disturbances that remove vegetation and cause soil disturbance, minimize and mitigate impacts (topsoil banking, certified weed-free [including annual bromes] seed mixes, appropriate seeding technologies, and monitoring). Plan for multiple restoration interventions in areas with low resilience and resistance (cells 3B, 3C).
- Minimize or co-locate energy transport corridors (e.g., roads, pipelines, transmission lines) and limit vehicle access, where feasible.
- Maintain resilience and resistance of existing patches of sagebrush habitat by aggressively managing weeds that may require the following management practices (especially important in low resilience and resistant areas—cells 3A, 3B, 3C):
    - Implement a weed management plan that addresses management actions specific to a project area;
    - Use certified weed-free (including annual bromes) gravel and fill material;
    - Assess and treat weed populations, if necessary, prior to surface disturbing activities;
    - Remove mud, dirt, and plant parts from construction equipment;
    - Address weed risk and spread factors in travel management plans;
    - Ensure timely establishment of desired native plant species on reclamation sites;
    - Use locally adapted native seed, whenever possible;
    - Intensively monitor reclamation sites to ensure seeding success, determine presence of weeds, and implement corrective actions as necessary;
    - Use mulch, soil amendments, or other practices to expedite reclamation success when necessary; and
    - Ensure weeds are controlled on stockpiled topsoil.

(Continued)

Table 1.4—(Continued).

Threat—Urban and Exurban Development

Management Strategies

- Secure conservation easements to maintain existing sagebrush stands and sage-grouse habitat. Prioritize areas with high habitat probability for sage-grouse and high sagebrush cover (cells 1C, 2C, 3C).
- Encourage the protection of existing sage-grouse habitat through appropriate land use planning and Federal land sale policies. Steer development toward non-habitat (cells 1A, 2A, 3A) where habitat is unlikely to become suitable through management.

Threat—Livestock Grazing

Management strategies

- Manage livestock grazing to maintain a balance of native perennial grasses (warm or cool season species, or a combination, as described in Ecological Site Descriptions for that area), forbs, and biological soil crusts to allow natural regeneration and to maintain resilience and resistance to invasive plants. Ensure strategies prevent degradation and loss of native cool-season grasses in particular. Areas with low to moderate resilience and resistance may be particularly vulnerable (cells 2A, 2B, 2C, 3A, 3B, 3C).
- Implement grazing strategies that incorporate periodic deferment from use during the critical growth period, especially for cool season grasses, to ensure maintenance of a mixture of native perennial grasses. This strategy is important across all sites, but particularly essential on areas with low to moderate resilience and resistance supporting sage-grouse habitat (cells 2B, 2C, 3B, 3C).
- Ensure grazing strategies are designed to promote native plant communities and decrease nonnative invasive plants. In ephemeral drainages and higher precipitation areas in the West-Central Semiarid Prairies that receive more summer moisture and have populations of nonnative invasive plant species, too much rest may inadvertently favor species such as field brome, Kentucky bluegrass, and smooth brome. Adjustments in timing, duration, and intensity of grazing may be needed to reduce these species.

To support use of the Science Framework, geospatial data, maps, and models are provided through the Bureau of Land Management's (BLM's) Landscape Approach Data Portal (https://landscape.blm.gov/geoportal/catalog/main/home.page) and U.S. Geological Survey's (USGS's) ScienceBase database (https://www.sciencebase.gov/catalog/). USGS is developing a visualization tool that supports use of this information and that when completed will be accessible through the Landscape Approach Data Portal and ScienceBase database.

Updates to the Science Framework

The Science Framework, both Part 1, **science basis and applications,** and Part 2, **management considerations,** is intended to be adaptive and will be updated to highlight potential management considerations as new science and information on focal species and habitats become available. The mechanism for providing updates is being developed and is likely to include Fact Sheets and webinars developed with partner research and management agencies and organizations. Updates will be linked to periodic updates of the Western Association of Fish and Wildlife Agencies' (WAFWA's) Sagebrush Science Initiative and Sagebrush Conservation Strategy (table 1.1). Updates will be numbered to show the relationship to Part 1, Part 2, and the broader Sagebrush Conservation Strategy and will be housed on the BLM's Landscape Approach Data Portal, the Great Basin Fire Science Exchange website (http://greatbasinfirescience.org/), and USGS's ScienceBase database.

Updates to the Science Framework are expected to address the sagebrush biome, mid-, and local scales and may include new information, science, and analyses that were not included in this version. Updates to the Science Framework could be informed by State Heritage databases and the results of new research conducted as part of implementation of the Actionable Science Plan (IRFMSASPT 2016) and other ongoing research efforts. The State Wildlife Action Plans provide a resource for more detailed information for the Science Framework at the State level, while the Science Framework provides a resource for Wildlife Action Plan revisions by the individual States. Science synthesized to support the WAFWA Sagebrush Conservation Strategy or during development of NEPA analyses to support management decisions could also be considered for inclusion.

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