

7. LIVESTOCK GRAZING MANAGEMENT

Michael G. “Sherm” Karl and Jeanne C. Chambers

Introduction

Part 1 of the Science Framework identifies livestock grazing as the most widespread land use in the sagebrush biome (Chambers et al. 2017a; hereafter, Part 1). In the Conservation Objectives Team Report (USDOI FWS 2013) improper livestock grazing is considered a present and widespread threat to Greater sage-grouse (*Centrocercus urophasianus*; hereafter, GRSG) for most GRSG populations. Livestock grazing affects the composition and structure of plant communities across the sagebrush biome and, consequently, the habitats of GRSG, other species at risk, and high value resources (Boyd et al. 2014). Livestock grazing can also affect habitat restoration efforts and thus the capacity to achieve broad-scale conservation and restoration goals.

The effects of livestock grazing on ecosystem composition, pattern, and function are well recognized (Beck and Mitchell 2000; Boyd et al. 2014; Cagney et al. 2010; Freilich et al. 2003; Fuhlendorf and Engle 2001; Knick et al. 2011). Major differences in plant responses to livestock grazing exist among ecoregions due to evolutionary adaptations to grazing and browsing, plant phenology relative to the timing of grazing, and selectivity of grazers for different plant species within the community (see Part 1, section 5.3.7). The effects of livestock grazing are strongly influenced by season of grazing relative to plant tolerance to grazing and the availability of water for plant regrowth after grazing. In the Cold Deserts water storage and plant growth depend on winter precipitation, and cool season plants (see definitions in Appendix 1) dominate plant communities (Part 1, sections 4.2 and 4.3). In the Cold Deserts both stocking rates (Briske et al. 2011) and grazing season affect plant responses to grazing (Briske and Richards 1995). Grazing of perennial grasses during inflorescence development (late spring) when moisture is becoming limited can negatively affect plant regrowth and recovery (Briske and Richards 1995). In contrast, in the West-Central Semiarid Prairies more moisture is available during summer and a mixture of cool season plants and warm season grasses, which have greater water use efficiency, dominate plant communities (Part 1, section 4.1). In both the West-Central Semiarid Prairies and Western Cordillera, precipitation during the growing season may increase tolerance to grazing, but cool season grasses can be eliminated by seasonal grazing that impacts them but not warm season plants.

Livestock grazing has the greatest potential to affect GRSG habitat by changing the composition, structure, and productivity of the herbaceous plants used by GRSG for nesting and early brood-rearing (Part 1, section 5.3.7; Beck and Mitchell 2000; Boyd et al. 2014; Cagney et al. 2010; Hockett 2002). The available research indicates that GRSG nest and early brood microhabitat selection and brood-rearing success are closely tied to areas with greater

Left: Utah rancher Bill Kennedy (photo: Jesse Bussard. USDA Forest Service). Top right: Livestock grazing in a sagebrush ecosystem (photo: Joe Smith, Sage Grouse Initiative/ University of Montana). Middle right: Placing fence markers to prevent sage-grouse strikes (photo: USDA Forest Service). Bottom right: Cattle and Greater sage-grouse in a sagebrush ecosystem (photo: USDA Forest Service).

sagebrush and grass canopy cover and height than are randomly available in sagebrush landscapes (Dinkins et al. 2016; Doherty et al. 2011, 2014; Hagen et al. 2007; Kirol et al. 2012; Thompson et al. 2006). However, the reported effects of grass-related variables on nest site selection and nest survival have been less consistent in the literature (Part 1, section 5.3.7; Coates et al. 2017; Smith 2016). Thus, it has been suggested that management prescriptions for livestock grazing within nesting habitats consider the potential regional variation in grass-related variables and the effects associated with plant phenology. Current vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, consider key plant community indicators such as sagebrush cover, sagebrush height, sagebrush shape, and perennial grass and perennial forb cover and height (Stiver et al. 2015). These vegetation habitat objectives also consider how plant community indicators vary between wetter and drier ecological sites (Stiver et al. 2015). Livestock grazing management is key to either maintaining or attaining these habitat objectives.

Livestock, primarily cattle and sheep, are grazed across the sagebrush biome on Federal, State, tribal, and private lands. Grazing practices and flexibility in those practices can vary according to the land manager or owner. Because many livestock grazing operations span multiple management jurisdictions, it is necessary to consider management opportunities and restrictions on each parcel that the operator uses.

Federal and State agencies are working together with private landowners to maintain or improve sagebrush habitat on rangelands in a manner appropriate for the site conditions and landowner interests. The Federal Land Policy and Management Act of 1976 stated that Federal land management agencies must “manage the public lands under principles of multiple use and sustained yield” (Public Law 94–579, Sec. 302). The Public Rangelands Improvement Act of 1978 (Public Law 95–514) further commits Federal land management agencies to providing regular updates on the condition and trend of rangelands. These legislative actions typically translate into management of livestock use in ways that sustain other land uses (e.g., wildlife conservation) and involve monitoring of livestock grazing effects.

This section begins by discussing the administration of livestock grazing on public and private lands and the ongoing review of grazing authorization (permits and leases) and processing in GRSG habitat. Then information is provided on the use of resilience and resistance concepts and the Science Framework to inform livestock grazing management. Considerations for the use of this information are presented for both the mid-scale (ecoregion or Management Zone) and local scale (field office or district), with an emphasis on grazing management practices to improve habitats of GRSG and other species and values at risk. Finally, select ecological types and state-and-transition models (STMs) (see Appendix 1 for definitions) are used as the basis for identifying livestock grazing management practices within the GRSG range that can be implemented to maintain or improve the resilience and resistance of sagebrush plant communities and the quality of GRSG nesting and early brood-rearing habitat.

Livestock Grazing Management on Public and Private Lands

The Bureau of Land Management (BLM) manages livestock grazing on 155 million acres (73 million hectares) of public land and administers nearly 18,000

permits and leases held by ranchers who graze their livestock at least part of the year on more than 21,000 allotments. A grazing permit is a document authorizing grazing use of the public lands within an established grazing district. A grazing lease is a document authorizing grazing use outside of an established grazing district. A grazing allotment is an area of land designated and managed for the grazing of livestock. Allotments may consist of BLM-administered lands as well as other Federally managed, State-owned, and private lands. Livestock numbers and periods of use are specified for each allotment. Permits and leases specify all authorized livestock grazing use including the total number of animal unit months (AUMS) and the area (allotment) authorized for grazing use.

Permits and leases generally cover a 10-year period and are renewable if the BLM determines that the terms and conditions of a permit or lease are being met. The terms and conditions for grazing on BLM-managed lands (such as stipulations on forage use and season of use) are set forth in the permits and leases issued by the BLM to public land ranchers. The amount of grazing that takes place each year on BLM-managed public lands can be affected by such factors as drought, wildfire, and market conditions.

The Forest Service manages livestock grazing on over 95 million acres (38 million hectares) of National Forest System lands on 7,275 allotments spread across 29 States. Grazing use is administered through a grazing permit system similar to that used by the BLM. Permits are issued for a 10-year period with the current permittee having the preference to reapply for the permit upon expiration provided that he or she has complied with the terms and conditions of the current permit. The Forest Service administers about 6,400 permits for 5,897 permittees. The majority (90 percent) of those permits are for cattle and sheep. The remaining 10 percent include bison, goat, donkey, burro, horse, and mule.

Potential livestock grazing management practices designed to improve sagebrush habitats can be incorporated into livestock grazing management alternatives during the grazing authorization (grazing permits and grazing leases) renewal process. When vegetation habitat objectives for GRSG and land health standards are not met because of current livestock grazing management, changes in livestock grazing management are needed to ensure significant progress toward achieving the vegetation habitat objectives for GRSG and land health standards. Current BLM livestock grazing regulations require that monitoring data or field observations, or both, be used to support decisions about stocking rates on allotments (43 CFR 4110.3) (text box 7.1).

Setting priorities for review and processing of grazing authorizations (permits and leases) is ongoing within the BLM (USDOI BLM 2017a) and other agencies. Priorities for review and processing of grazing authorizations are (1) areas where rangeland health standards have not been evaluated, and (2) areas that are not achieving rangeland health standards. In areas with GRSG habitat, BLM and its partners have developed specific vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, for GRSG in Montana (USDOI BLM 2015a, table 2.3-2; USDOI BLM 2015c, table 2-6; USDOI BLM 2015d, table 2-2), North Dakota (USDOI BLM 2015f, table 2-2), South Dakota (USDOI BLM 2015h, table 2-6), the Wyoming Basin Ecoregion and northeast Wyoming (USDOI BLM 2015j, tables 2-2 and 2-3), Oregon and Washington (USDOI BLM 2015g, table 2-2), Utah (USDOI BLM 2015i, table 2-2), Nevada and northeastern California (USDOI BLM 2015e, table 2-2), and Idaho and southwestern Montana (USDOI BLM 2015b, table 2-2). In areas with GRSG habitat, managers will need to evaluate vegetation habitat objectives for GRSG when conducting an evaluation of rangeland

Text Box 7.1—Monitoring Livestock Grazing

In 1995, through regulation in 43 CFR 4180, livestock grazing on BLM-administered lands was required to ensure the attainment of Fundamentals of Rangeland Health. The Fundamentals of Rangeland Health address minimum standards for ecosystem functioning including: (1) properly functioning watersheds; (2) ecological processes of the hydrologic cycle, nutrient cycle, and energy flow; (3) water quality; and (4) wildlife habitat quality (43 CFR 4180.1). The BLM was required to develop rangeland health standards that would conform to the Fundamentals of Rangeland Health within individual regions in consultation with local Resource Advisory Councils (43 CFR 4180.2). To evaluate land health, BLM field office personnel are required to perform individual, on-the-ground evaluations of these rangeland health standards in all grazing allotments. Current livestock grazing use is monitored within grazing allotments to ascertain whether current livestock grazing use is allowing for achievement of rangeland health standards. Collection of monitoring data on the effects of current livestock grazing use constitutes a major priority for livestock grazing management on BLM-administered lands.

health standards. If the BLM finds that vegetation habitat objectives for GRSG are not being achieved because of current livestock grazing, then the agency modifies the livestock grazing management practices to ensure that progress will be made toward achieving the vegetation habitat objectives for GRSG. It may be necessary to modify and update the vegetation habitat objectives over time as additional information on GRSG habitat requirements and ecological site potentials to support GRSG habitat become available and additional policy direction is provided (USDOI BLM 2017b).

Private landowners generally use range management principles and tools provided by entities such as the Agricultural Research Service, Natural Resources Conservation Service, and State and university extension programs. Use of proven range management principles and tools can ensure that private lands are managed in a manner that maintains or improves rangeland resilience and resistance to invasive annual grasses and provides the necessary resources for GRSG and other wildlife species. Tools for private lands include range management plans that are based on local ecological site information and rangeland plant inventories. It is recommended that range management plans incorporate flexibility in season of use and stocking rates to allow for implementing adaptive management of GRSG habitat. It is generally recognized that by promoting diverse and productive native perennial plant communities, private landowners can ensure that rangelands remain resilient to disturbance and resistant to invasive plants. As a result, drought, annual grass invasions, and wildfires are less likely to impact GRSG and other sagebrush dependent species.

Using Resilience and Resistance Concepts and the Science Framework Approach to Inform Livestock Grazing Management

Designing livestock grazing management practices to improve habitats of GRSG and other species and values at risk requires a consistent approach that can be applied across jurisdictions. In Part 1 of the Science Framework, an approach is identified for determining the suitability of an area for a management action and the most appropriate management action that can be applied to livestock grazing management. At the mid-scale, geospatial analyses can be used to evaluate: (1) the likely response of an area to disturbance or management actions

(i.e., resilience to disturbance and resistance to invasion by annual grasses), (2) the capacity of an area to support target species or resources, and (3) the predominant threats. Many of the data layers used in the mid-scale geospatial analyses for the Science Framework (see Part 1, sections 8.1 and 8.2) can be used to help inform livestock grazing administration and identify appropriate livestock grazing management practices. Key data layers include resilience and resistance to invasive annual grasses as indicated by soil temperature and moisture regimes (Maestas et al. 2016), GRSG breeding habitat probabilities (Doherty et al. 2016), and the primary threats within the assessment area.

At the local scale the Science Framework approach includes: (1) identifying the different ecological types or ecological sites that exist within the management area and determining their relative resilience to disturbance and resistance to invasive annual grasses; (2) evaluating the current ecological dynamics of the ecological types or ecological sites and, where possible, their restoration pathways; and (3) selecting livestock grazing management practices that have the potential to increase overall ecosystem functioning and habitat conditions. Ecological types or ecological site descriptions and STMs that explicitly consider ecosystem resilience to disturbance and resistance to invasive annual grasses provide the basis for selecting appropriate livestock grazing management practices (see Part 1, section 9). Consideration of habitat objectives for GRSG and other species and values at risk is used to assess whether the management area (e.g., grazing allotment) has the potential to attain the habitat objectives and, if so, the specific livestock grazing management practices needed to achieve the objectives (Beck and Mitchell 2000; Boyd et al. 2014; Hockett 2002).

In general, areas that support GRSG habitat or other important species or resources are high priorities for livestock grazing management that maintains or improves GRSG habitat values (tables 1.3, 1.4). Areas with moderate to high resilience and resistance to invasive annual grasses often have the potential to recover from disturbances through successional processes. These areas represent significant opportunities to use livestock grazing management and other management activities to direct plant succession to improve habitat. Areas with low resilience and resistance often lack the potential to recover from improper livestock grazing without significant intervention, and are among the highest priorities for improved livestock grazing management.

To step down to the local scale, ecological types or ecological site descriptions and their associated STMs can be used to evaluate current ecological dynamics and determine appropriate livestock grazing management practices (text box 7.2). In the Science Framework, generalized ecological types and STMs have been described for the range of environmental conditions in the eastern and western portions of the sagebrush biome. These ecological types and STMs are characterized according to their resilience to disturbance and resistance to invasive annual grasses based on soil temperature and moisture regimes and other biophysical characteristics (Part 1, Appendices 5 and 6). They provide information on the alternative states, ranges of variability within states, and processes that cause plant community shifts within states as well as transitions among states. Examples of how to use these resilience-based ecological types and STMs for managing ecosystem threats across the sagebrush biome are in Part 1, section 9.2. Information on using the ecological types and STMs in sagebrush and juniper (*Juniperus* spp.) and piñon (*Pinus* spp.) ecosystems of the Great Basin for selecting appropriate treatments is in Miller et al. (2014). Information on assessing postwildfire recovery potential and making restoration decisions is in Miller et al. (2015) and Pyke et al. (2017).

Text Box 7.2—Using Ecological Site Descriptions and State-and-Transition Models

Ecological site descriptions and their associated state-and-transition models (STMs) provide essential information for determining treatment feasibility and type of treatment. Ecological site descriptions are part of a land classification system that describes the potential of a set of climate, topographic, and soil characteristics and natural disturbances to support a dynamic set of plant communities (Bestelmeyer et al. 2009; Stringham et al. 2003). Ecological site descriptions have been developed by the Natural Resources Conservation Service and its partners to assist land management agencies and private landowners with making resource decisions. For a detailed description of ecological site descriptions and access to available ecological site descriptions see: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/desc/>.

STMs are a central component of ecological site descriptions that are widely used by managers to illustrate changes in plant communities and associated soil properties, causes of change, and effects of management interventions (Briske et al. 2005; USDA NRCS 2015; Stringham et al. 2003). STMs use the concepts of **states** (a relatively stable set of plant communities that are resilient to disturbance) and **transitions** (change among alternative states caused by disturbances or other drivers) to describe the range in composition and function of plant communities within ecological site descriptions (Stringham et al. 2003) (see Appendix 1 for definitions). The reference state is based on the natural range of conditions associated with the historical range of variation and often includes several plant communities (**phases**) that differ in dominant plant species relative to type and time since disturbance (Caudle et al. 2013). Alternative states describe new sets of communities that result from factors such as improper livestock use, invasion by nonnative species, or changes in fire regimes. Changes or transitions among states often are characterized by **thresholds** or conditions that may persist over time without active intervention, potentially causing irreversible changes in community composition, structure, and function. **Restoration pathways** are used to identify the environmental conditions and management actions that will facilitate return to a previous state.

Examples of Using Resilience-Based State-and-Transition Models to Identify Potential Livestock Grazing Management Practices

The dominant ecological types and STMs provide the basis for identifying livestock grazing management practices that can be implemented to maintain or improve the resilience and resistance of sagebrush plant communities and the quality of GRSG nesting and early brood-rearing habitat. Here, examples of ecological types and STMs are provided for different ecoregions and sage-grouse management zones (fig. 1.1). The examples were chosen to illustrate the differences in potential management strategies for ecological types that support GRSG populations and can often benefit from improved livestock grazing management. Some states within the STMs, and plant community phases within the states, do not provide the vegetation necessary for nesting and early brood-rearing habitat for GRSG as identified in vegetation habitat objectives for breeding and nesting seasonal habitat and brood-rearing and summer seasonal habitat (e.g., USDO I BLM 2015a, table 2.3-2; 2015b, table 2-2; 2015c, table 2-6; 2015d, table 2-2; 2015e, table 2-2; 2015f, table 2-2; 2015g, table 2-2; 2015h, table 2-6; 2015i, table 2-2; 2015j, tables 2-2 and 2-3). Potential livestock grazing management practices are presented that can be implemented to help improve ecological conditions and achieve the vegetation habitat objectives for nesting and early brood-rearing habitat for GRSG.

West Central Semi-Arid Prairies—Frigid Bordering on Cryic/ Ustic Bordering on Aridic, Grass Dominated with Silver Sagebrush (Management Zone I)

Potential Livestock Grazing Management Practices for the Reference State

There are two primary goals for livestock grazing management practices in the reference state of the silver sagebrush (*Artemisia cana*), 10–14 inch (25–36 centimeter) precipitation zone ecological type (fig. 7.1). The first is to maintain the reference state and prevent a transition to the unsustainable grazing state. The second is to facilitate achievement of vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, for GRSG in Montana (USDOI BLM 2015a, table 2.3-2; 2015c, table 2-6; 2015d, table 2-2), North Dakota (USDOI BLM 2015f, table 2-2), and South Dakota (USDOI BLM 2015h, table 2-6).

Plant communities in the reference state provide nesting and early brood-rearing habitat for GRSG. Plant communities in the reference state are dominated by perennial cool-season mid-grasses, with less abundance of perennial warm-season short grasses and silver sagebrush. Silver sagebrush is present within a matrix of perennial cool-season mid-grasses and perennial warm-season short grasses.

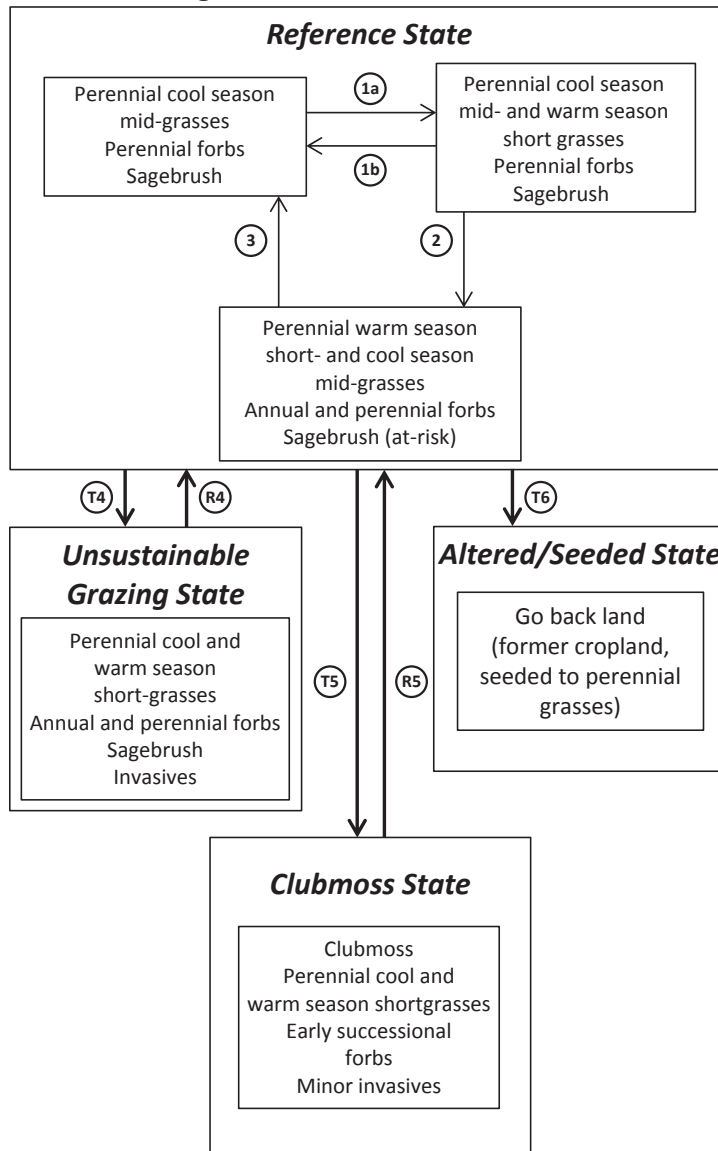
Consistent year to year, early spring use by livestock will reduce the abundance of perennial cool-season mid-grasses (Adams et al. 2004) and cause a transition to the unsustainable grazing state. Livestock grazing that is deferred to a late spring onset of grazing can improve plant vigor and productivity of the perennial cool-season mid-grasses and provide increased plant cover, reducing the potential conflict between livestock and GRSG during breeding and nesting (Adams et al. 2004). Managing for light grazing intensity of no more than about 25 to 40 percent annual utilization of the perennial grasses can maintain the productivity of the perennial grasses, provide cover to conceal GRSG nesting sites, and improve breeding and brood-rearing habitat (Adams et al. 2004).

Deferred rotation grazing systems can reduce the impacts of livestock to GRSG nesting sites by resting pastures from livestock grazing in the nesting and brood-rearing seasons and rotating early-season grazing among pastures (Adams et al. 2004). Rest-rotation grazing systems can increase perennial grass height in these plant communities compared with season-long grazing (Smith 2016).

In central Montana GRSG nesting habitat comprising mixed stands of silver sagebrush/Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) with perennial cool-season mid-grasses, the cover of silver sagebrush and Wyoming big sagebrush was comparatively more important than the cover and height of herbaceous vegetation, for GRSG nest site selection and nest survival (Smith 2016). Maintaining or increasing the cover of sagebrush in these plant communities is important to maintain breeding habitat for GRSG (Smith 2016). Grazing by livestock does not have direct effects on the cover of silver sagebrush. However, silver sagebrush is often low in stature and can be vulnerable to trampling by livestock, particularly if livestock congregate within silver sagebrush stands in winter (Adams et al. 2004).

To improve early brood-rearing habitat, large flood plain and overflow sites composed of western wheatgrass (*Pascopyrum smithii*)/silver sagebrush plant communities can be fenced off and managed separately as riparian pastures. Forb production can be stimulated with periodic light grazing in spring, at light stocking rates for a short duration, and then grazed again in late summer or fall after the brood-rearing season (Adams et al. 2004).

FRIGID BORDERING ON CRYIC/USTIC BORDERING ON ARIDIC
GRASS DOMINATED W/ SILVER SAGEBRUSH (10-14 IN PZ)
High Resilience and Resistance



- ①a Sagebrush increases and proportion of cool season mid-grass Functional/Structural Group decreases due to disturbances such as drought (3-5 years) and spring grazing.
- ①b Normal precipitation patterns favor herbaceous understory. Grazing intensity and/or duration is reduced to allow for herb recovery.
- ② Sagebrush increases and proportion of cool and warm season mid- and short-grass Functional/Structural Groups increases due to prolonged drought (5-7 years), increased grazing intensity and duration, and lack of fire. Plant community is at-risk of leaving reference state with extended drought and continued grazing pressure.
- ③ With favorable precipitation, disturbance such as fire, and a grazing system that provides rest and recovery of preferred species, cool season mid-grass Functional/Structural Groups increase.
- T4 Extended drought (>7 years) along with high intensity and long duration grazing result in transition to a state resistant to grazing that is dominated by cool and warm season short-grass Functional/Structural Groups. Silver sagebrush cover is at its highest, and early seral forbs are present. There is potential for invasive species such as field brome in high moisture years and/or due to removal of grazing, lack of fire, and other conditions causing accumulation of excessive litter.
- R4 Normal precipitation patterns, fire or fire surrogates (herbicides and/or mechanical treatments), and a grazing regime with proper timing and intensity that varies season of use can return the site to the reference state.
- T5 Extended drought (>7 years) may result in dense stands of clubmoss. However, no grazing, light grazing, and rotational grazing combined with drought can result in more rapid increase in clubmoss than drought alone. Lack of fire may contribute to this transition as well. Potential for invasives such as field brome is minor, and this transition occurs more often on older, more developed soils with an argillic horizon.
- R5 Extended periods of normal and above average precipitation, mechanical renovation, chemical treatment, fertilizer/manure application, seeding (if an adequate seedbank does not exist), fire, and/or periods of rest or light grazing can return the site to the reference state.
- T6 Former cropland seeded to introduced and/or native perennial grasses, largely funded by government programs. In the 1960-1970s seedings were primarily introduced species such as crested wheatgrass, intermediate wheatgrass, and smooth brome. From 1985 to present both introduced and native species were used, mainly under the Conservation Reserve Program. Sagebrush is largely absent from this state. There is potential for invasive species such as field brome in high moisture years and/or due to removal of grazing, lack of fire, and other conditions that would result in an accumulation of excessive litter.

Figure 7.1—State-and-transition model for a silver sagebrush, 10–14 inch precipitation zone ecological type applicable to the West Central Semi-arid Prairies in the eastern part of the sagebrush biome and GRSG range in Montana, North Dakota, and South Dakota (Management Zone I). Large boxes illustrate states that are made up of community phases (smaller boxes). Transitions among states are shown with arrows starting with T; restoration pathways are shown with arrows starting with R. The “at risk” community phase is most vulnerable to transition to an alternative state (figure source: Chambers et al. 2017a, Appendix 5).

Potential Livestock Grazing Management Practices for the Unsustainable Grazing State

Livestock grazing management practices in the unsustainable grazing state (fig. 7.1) have the goal of stimulating a transition of the unsustainable grazing state to a reference state. Plant communities in the reference state provide improved nesting and early brood-rearing habitat for GRSG. Livestock grazing management practices should facilitate achievement of vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, for GRSG in Montana (USDOI BLM 2015a, table 2.3-2; 2015c, table 2-6; 2015d, table 2-2), North Dakota (USDOI BLM 2015f, table 2-2), and South Dakota (USDOI BLM 2015h, table 2-6).

Grazing management practices that increase the amount of rest in a pasture can be useful in providing more cover for GRSG (Adams et al. 2004). Adams et al. (2004) recommend rest-rotation grazing systems to improve grass and silver sagebrush plant communities that are depauperate in perennial cool-season mid-grasses and aid regeneration of silver sagebrush plants if moisture is available to support resprouting.

Cold Deserts—Frigid/Ustic Bordering on Aridic Wyoming Big Sagebrush (Management Zones II and VII)

Potential Livestock Grazing Management Practices for the Reference State

Livestock grazing management practices in the reference state in the Wyoming big sagebrush, 10–14 inch precipitation zone ecological type (figs. 7.2, 7.3) have two primary goals. The first goal is to maintain the reference state and prevent a transition to the grazing resistant state. The grazing-resistant state results from continuous spring grazing with cattle during the critical growth period for cool season grasses and eventual dominance of grazing-tolerant species: perennial cool-season rhizomatous grasses, short or sod-forming warm-season grasses, and mat-forming forbs. The second goal is to facilitate achievement of vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, for GRSG in the Wyoming Basin ecoregion (USDOI BLM 2015j, tables 2-2 and 2-3). Plant communities in the reference state provide nesting and early brood-rearing habitat for GRSG.

A livestock grazing strategy that prevents grazing of the perennial cool-season bunchgrasses during the critical growing season (mid-May through mid-June) in at least two out of every three consecutive years is likely to maintain the reference state and prevent a transition to a grazing resistant state (Cagney et al. 2010).

Late season and winter grazing of the reference state may help promote the long-term persistence of perennial cool-season bunchgrasses, but can cause a reduction in the residual herbaceous material of these bunchgrasses that is needed for nesting cover for GRSG the next spring. Residual grasses remaining from the previous year provide the initial herbaceous cover available for nesting GRSG. Thus, late season and winter grazing is not always a grazing management practice that would allow for achieving nesting habitat objectives for GRSG (Cagney et al. 2010).

Potential Livestock Grazing Management Practices for the Grazing Resistant State

Livestock grazing management practices in the grazing resistant state (figs. 7.2, 7.4) have the goal of stimulating a transition of the grazing resistant state to a reference state. Plant communities in the reference state provide improved nesting and early brood-rearing habitat for GRSG. Livestock grazing management practices should help to achieve the vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, for GRSG in the Wyoming Basin ecoregion (USDOI BLM 2015j, tables 2-2 and 2-3).

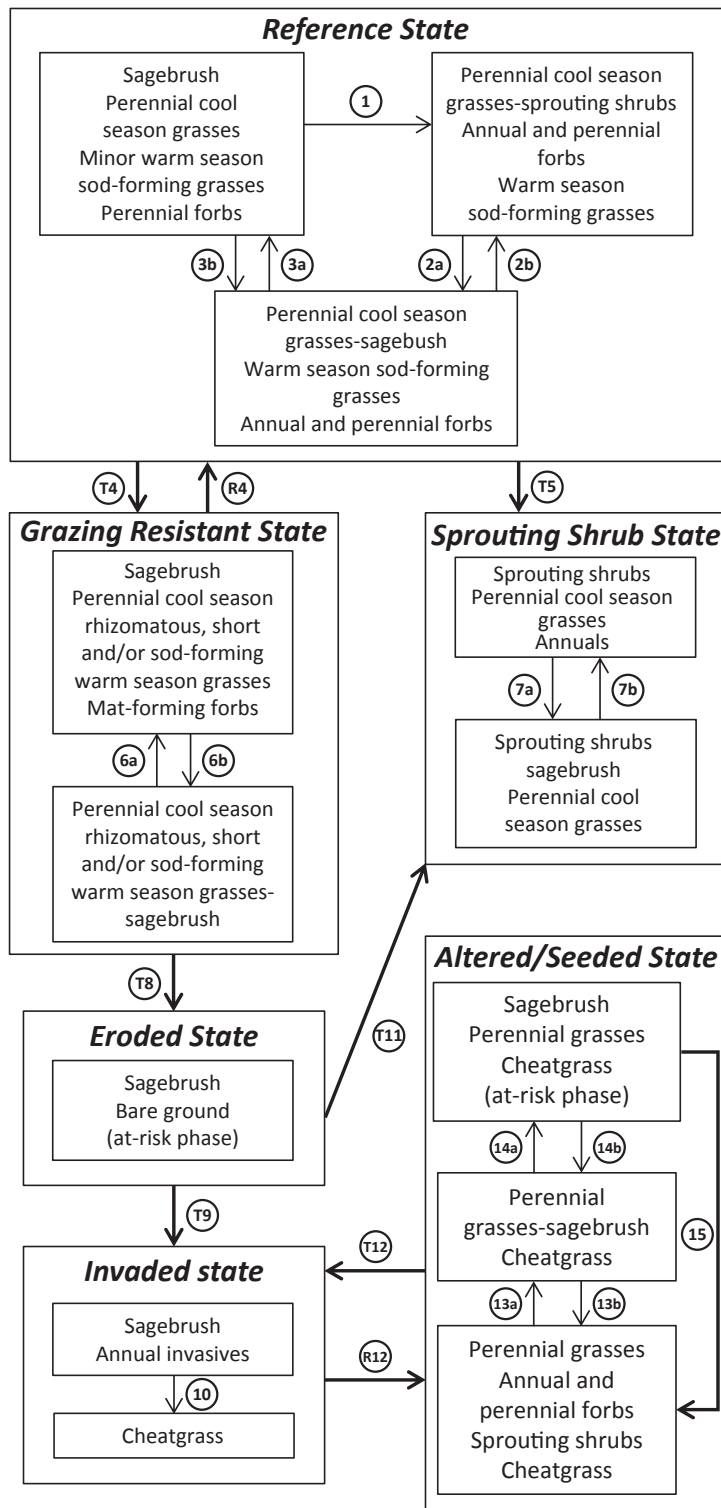
Grazing resistant grasses, specifically rhizomatous grasses and bluegrasses, are unlikely to decrease in abundance with changes in livestock grazing management alone (Cagney et al. 2010). Further, changing livestock grazing management, or eliminating grazing, is likely to have a limited effect on increasing the abundance of large bunchgrasses (Cagney et al. 2010). However, light to moderate grazing with periodic rest during critical growth periods along with fire, herbicides, mechanical treatments, or a combination thereof, may result in return to the reference state. If the grazing resistant state is burned or is treated with herbicides, causing a decrease in the canopy cover of sagebrush, it is advisable to defer livestock grazing during at least the first two growing seasons after fire or herbicide disturbance on these sites. Grazing deferment for two or more growing seasons will allow the remaining perennial, cool season bunchgrasses in this grazing resistant state to increase in abundance (Cagney et al. 2010). Heavy, continuous livestock grazing can cause a decrease in the herbaceous species and a more rapid increase in sagebrush, which will cause the site to progress back to the grazing resistant state (Cagney et al. 2010).

Targeted livestock grazing by domestic sheep in the grazing resistant state can cause browsing of sagebrush that decreases the canopy cover of sagebrush. It also opens up niches for establishment and increases in abundance of the grazing resistant rhizomatous grasses and bluegrasses as well as any remaining cool-season perennial bunchgrasses (Cagney et al. 2010). This treatment is applied in fall or winter when perennial cool-season bunchgrasses are not actively growing. Supplemental feeding of livestock in the winter on this grazing resistant state may be necessary to effectively implement this strategy. However, if these systems are grazed too intensely or too often, they can convert to a sprouting shrub state.

Potential Livestock Grazing Management Practices for the Eroded State

Changes in livestock grazing management alone are unlikely to cause an increase in perennial grasses on the eroded state (figs. 7.2, 7.5) (Cagney et al. 2010). Moreover, livestock grazing management practices alone cannot be used to achieve the vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, for GRSG on the eroded state in the Wyoming Basin ecoregion (USDOI BLM 2015j, tables 2-2 and 2-3). Interseeding with native perennial grasses and forbs may be needed to meet habitat objectives (Huber-Sannwald and Pyke 2005). Grazing deferment for two or more grazing seasons is recommended for seedling establishment.

WYOMING BIG SAGEBRUSH (10-14 IN PZ)
Moderate Resilience and Resistance



- 1 Perennial grass, sprouting shrubs, and forbs become dominant due to disturbances that decrease sagebrush like prolonged or severe drought, freezing, flooding, wildfire, insects, disease, and pathogens.
- 2a Sagebrush increases with time until co-dominant with the herbaceous understory.
- 2b Perennial grass, sprouting shrubs, and forbs become dominant due to disturbances that decrease sagebrush.
- 3a Sagebrush increases with time until dominant.
- 3b Perennial grass and forbs increase due to disturbances that decrease sagebrush.
- T4 Continuous spring grazing with cattle during the critical growth period of cool season grasses results in dominance of grazing tolerant species that may include warm season grasses (e.g., blue grama). As bare ground increases, surface erosion (e.g., rills, sheet erosion) and pedestalled plants (especially bunchgrasses) may result.
- R4 Light to moderate grazing with periodic rest during critical growth periods along with fire, herbicides, and/or mechanical treatments can result in return to reference state.
- T5 An increase in the disturbance cycle by fire, fire surrogates, mechanical types of disturbance, and/or high density/frequency grazing will favor sprouting shrubs such as rabbitbrush. Annual invasives can occur.
- 6a Sagebrush increases with time. Cheatgrass and other weeds can be present, but do not dominate.
- 6b Perennial cool season grasses increase due to disturbances that decrease sagebrush. A temporary flush of annual invaders is expected.
- 7a Sagebrush increases with time and removal of disturbances until co-dominant with herbaceous understory.
- 7b Perennial cool season grasses and sprouting shrubs increase due to disturbances that decrease sagebrush.
- T8 Perennial grasses and forbs are eliminated and sagebrush increases with high density/frequency grazing by cattle, resulting in altered biotic, hydrologic, and soil function. This state is at-risk to invasion by annuals such as cheatgrass, especially after a stand-replacing, sagebrush killing event.
- T9 If a cheatgrass seed source is introduced, and weather conditions are conducive to establishment (warm wet spring), it will invade, especially after a stand-replacing event that eliminates sagebrush.
- 10 Fire and fire surrogates that kill sagebrush will dramatically increase cheatgrass.
- T11 Multiple chemical and/or mechanical treatments or biological disturbances that reduce sagebrush will result in a shift toward sprouting shrub dominance with potential for cheatgrass to invade.
- T12 Catastrophic climatic events and/or fire can result in cheatgrass dominance, especially when in the sagebrush dominant phase of the altered state.
- R12 A restoration treatment, including chemical treatment for cheatgrass and seeding can restore a perennial grass community and eventually support an altered sagebrush community with invaders.
- 13a Sagebrush increases with time and no disturbances until co-dominant with the herbaceous understory, but cheatgrass will be present.
- 13b Perennial grass and forbs become dominant due to disturbances that decrease sagebrush.
- 14a Sagebrush increases with time and no disturbances until dominant, but cheatgrass may be present.
- 14b Perennial grass and forbs become dominant due to minor disturbances that decrease sagebrush.
- 15 Perennial grass and annual/perennial forbs become dominant due to disturbances that decrease sagebrush.

Figure 7.2—State-and-transition model for a Wyoming big sagebrush, 10–14 inch precipitation zone ecological type applicable to the Cold Deserts in the eastern part of the sagebrush biome and GRSG range in the Wyoming Basin in the western and central portions of Wyoming (Management Zones II and VII). Large boxes illustrate states that are made up of community phases (smaller boxes). Transitions among states are shown with arrows starting with T; restoration pathways are shown with arrows starting with R. The “at risk” community phase is most vulnerable to transition to an alternative state (figure source: Chambers et al. 2017a, Appendix 5).



Figure 7.3—Example of a plant community phase in the reference state in the Wyoming big sagebrush, 10–14 inch precipitation zone ecological type (fig. 7.2) in Wyoming. The site is dominated by Wyoming big sagebrush with an herbaceous understory dominated by cool-season perennial bunchgrasses. This plant community phase provides nesting and early brood-rearing habitat for GRSG (photo by Jim Cagney, used with permission).

Cold Deserts—Mesic/Aridic Bordering on Xeric Wyoming Big Sagebrush (Management Zones III, IV, and V)

Potential Livestock Grazing Management Practices for the Invaded State

Livestock grazing management practices in the invaded state (figs. 7.6, 7.7) can be used to promote an increase of perennial grasses to increase resistance to invasive annual grasses. Livestock grazing management practices can also help achieve the vegetation habitat objectives for nesting and brood-rearing seasonal habitat for GRSG in Oregon and Washington (USDOI BLM 2015g, table 2-2), Utah (USDOI BLM 2015i, table 2-2), Nevada and northeastern California (USDOI BLM 2015e, table 2-2), and Idaho and southwestern Montana (USDOI BLM 2015b, table 2-2).

Effects of grazing on the abundance of annual grasses such as cheatgrass (*Bromus tectorum*) depend on multiple factors including: (1) the relative resilience of the site as indicated by soil temperature and moisture regimes, (2) the relative resistance of the site as indicated by its climatic suitability for cheatgrass (fig. 7.8) (Strand et al. 2014), and (3) the relative abundance of competitive perennial grasses and forbs (Chambers et al. 2014a,b). If sufficient

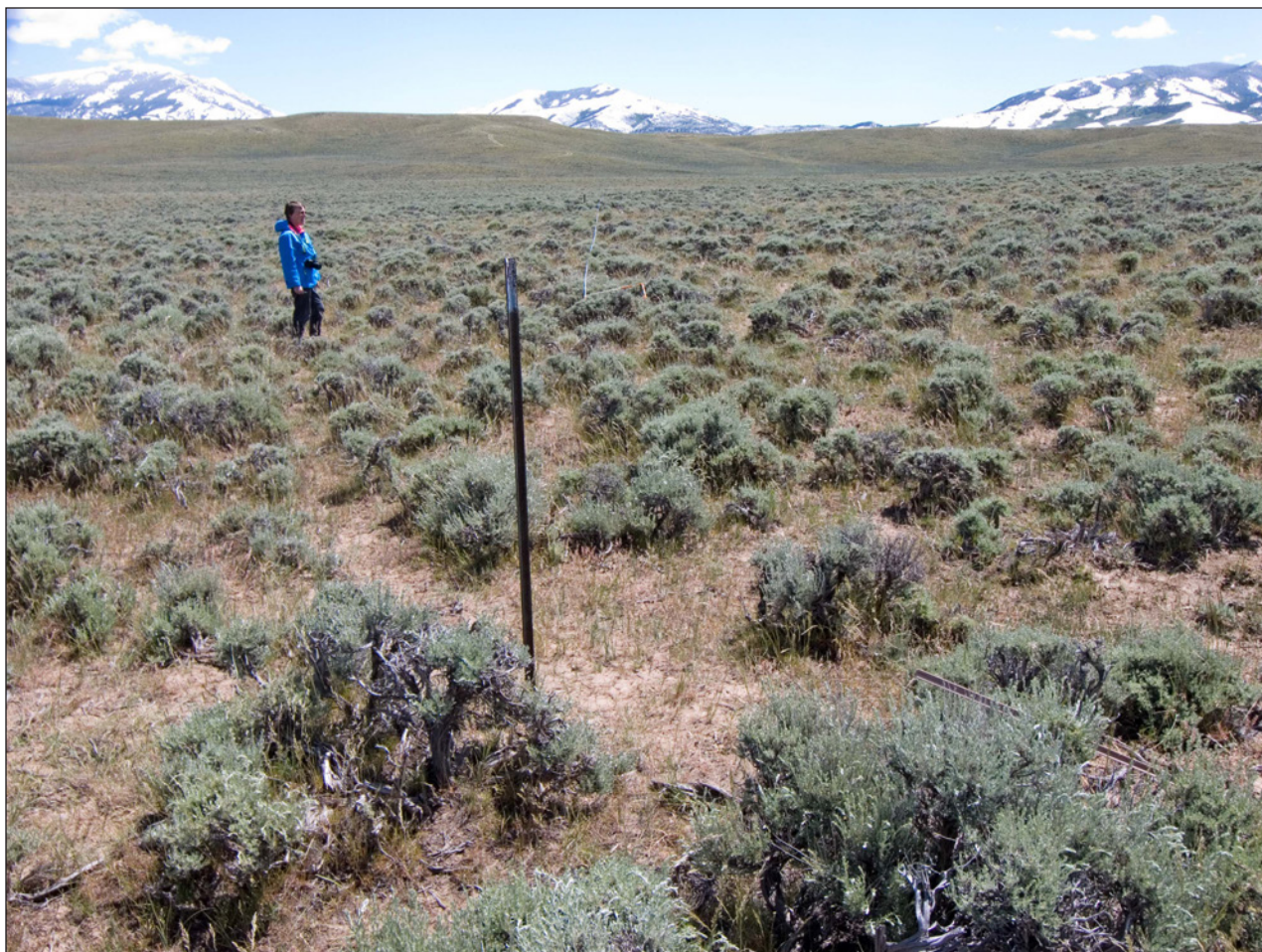


Figure 7.4—Example of a plant community phase in the grazing resistant state in the Wyoming big sagebrush, 10–14 inch precipitation zone ecological type (fig. 7.2) in Wyoming. The site is dominated by Wyoming big sagebrush with an herbaceous understory dominated by rhizomatous grasses and bluegrasses. If the herbaceous understory is not depleted, this plant community phase can provide nesting habitat for GRS. With a depleted herbaceous understory, this plant community phase does not provide nesting habitat for GRS (photo by Jim Cagney, used with permission).

perennial native grasses remain on the site, managed livestock grazing may result in an increase in perennial grasses and forbs and a decrease in invasive annual grasses, especially on relatively cool and moist sites. Grazing when perennial grasses are beginning to flower is likely to cause a decline in perennial grasses and an increase in cheatgrass (fig. 7.8) (Strand et al. 2014). Early spring grazing may suppress the abundance of cheatgrass and promote an increase of perennial grasses if grazing is applied when the annual grasses are starting to produce seeds but before the perennial grasses begin to bolt (fig. 7.8) (Strand et al. 2014). Livestock grazing persisting into the time when perennial grasses are beginning active growth can be detrimental to the perennial grasses (fig. 7.8) (Strand et al. 2014). Early spring grazing of cheatgrass can be difficult to plan for year after year and can be challenging to implement in a livestock grazing permit or lease on Federal land. This is because the amount of cheatgrass forage available in the early spring depends on the amount and timing of precipitation and varies considerably from year to year (Chambers et al. 2014b; West and Yorks 2002). Thus, the length of time that cheatgrass forage is available to be grazed in the early spring will vary from year to year, and permittees and lessees will have a difficult time planning ahead for how many animals will be required to consume the cheatgrass (Schmelzer et al. 2014).



Figure 7.5—Example of a plant community phase in the eroded state in the Wyoming big sagebrush, 10–14 inch precipitation zone ecological type (fig. 7.2) in Wyoming. The site is dominated by Wyoming big sagebrush and bare ground. Herbaceous vegetation is located primarily beneath shrubs or cactus. This plant community phase is not providing nesting or early brood-rearing habitat for GRSG (photo by Jim Cagney, used with permission).

Grazing with cattle during the fall at appropriate levels repeatedly over time may reduce the abundance of cheatgrass and will probably not decrease the abundance of the perennial grasses. But few longer-term data exist (Schmelzer et al. 2014; Strand et al. 2014) (see fig. 7.8).

Once the perennial native herbaceous species have been depleted, recovery of perennial native grasses is likely to be a slow process in this ecological type even with long-term rest from livestock grazing (e.g., West et al. 1984). Further, once the perennial native herbaceous species have been depleted, sagebrush and other shrubs may continue to increase in abundance for a decade or more even with removal of livestock (Chambers et al. 2017b; West et al. 1984). Thus, for areas within the invaded state with moderate cover of perennial native grasses, grazing practices to maintain or increase the cover of these species is a priority.

The effects of livestock grazing on wildfire potential in the invaded and other states depend on the relative proportion of sagebrush to herbaceous fuels combined with weather conditions. The potential for grazing to be effective in reducing the risk of fire initiation and spread is greatest when sagebrush cover is low and fire weather severity is low to moderate (fig. 7.9) (Strand et al. 2014). Long-term removal of grazing may increase the likelihood of wildfire-induced mortality of perennial bunchgrasses in some ecological sites because of fuel

COLD DESERTS – MESIC/ARIDIC BORDERING ON XERIC
 WYOMING BIG SAGEBRUSH (8-12 IN PZ)
Low to Moderate Resilience and Low Resistance

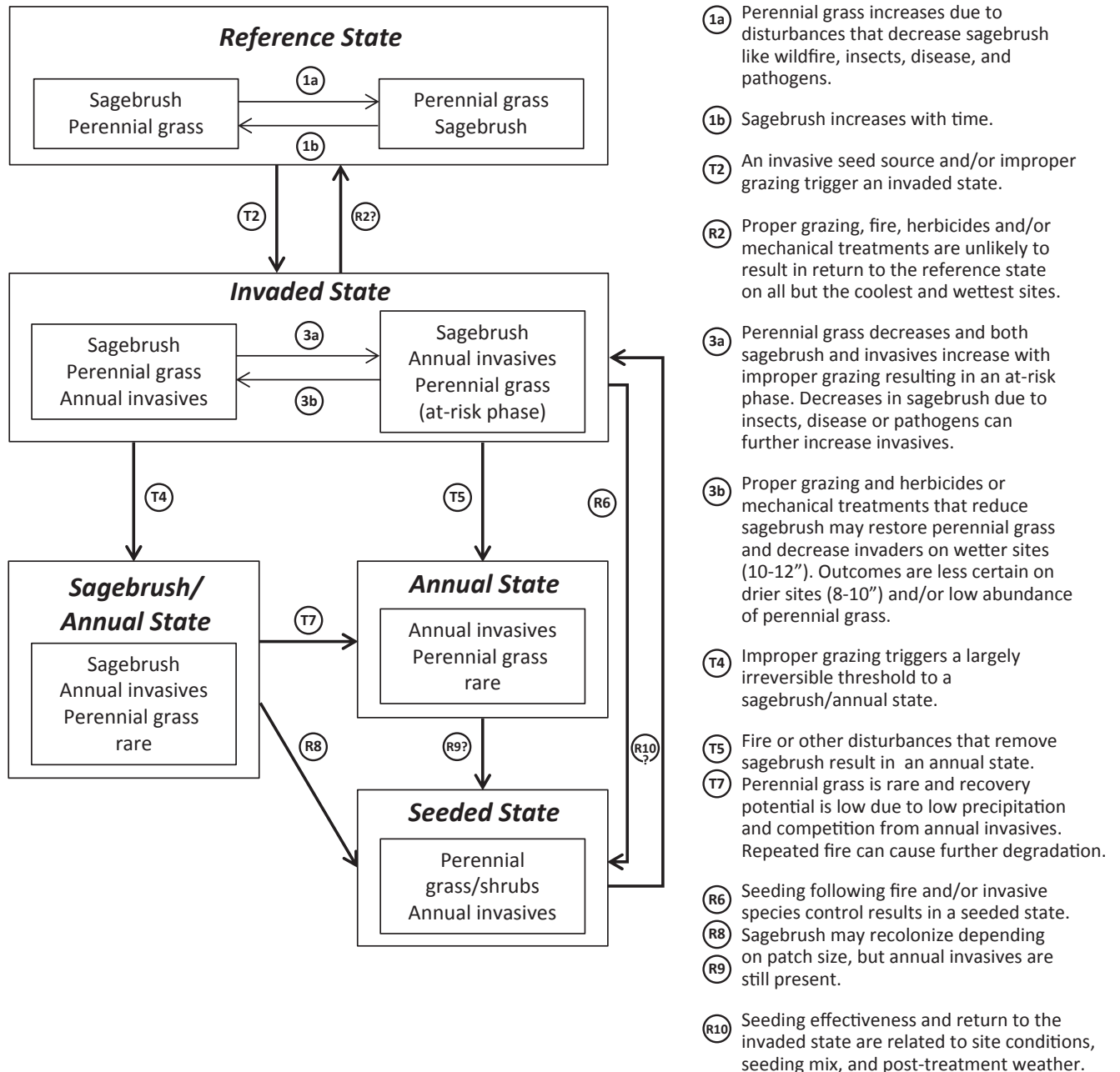


Figure 7.6—State-and-transition model for a Wyoming big sagebrush, 8–12 inch precipitation zone ecological type applicable in the Cold Deserts in the western part of the sagebrush biome and GRSG range in the Snake River Plain, Northern Basin and Range, and Central Basin and Range ecoregions (Management Zones III, IV, and V). Large boxes illustrate states that are made up of community phases (smaller boxes). Transitions among states are shown with arrows starting with T; restoration pathways are shown with arrows starting with R. The “at risk” community phase is most vulnerable to transition to an alternative state (figure source: Chambers et al. 2017a, Appendix 6).



Figure 7.7—Example of a plant community phase in the invaded state in the Wyoming big sagebrush, 8–12 inch precipitation zone ecological type (fig. 7.6) in Nevada. The plant community phase is dominated by Wyoming big sagebrush and cheatgrass with some perennial grasses. This site is not providing optimum nesting or early brood-rearing habitat for GRSB (photo by BLM).

buildup on the root crown of perennial bunchgrasses (Davies et al. 2009, 2010). While grazing may decrease fuels and reduce wildfire severity or extent in some cases (fig. 7.9), as weather conditions become extreme, the potential role of grazing in wildfire behavior decreases and may become meaningless (Strand et al. 2014).

Potential Livestock Grazing Management Practices for the Annual State

Shifts in plant communities in sagebrush ecosystems toward invasive annual grass dominance were caused in part by historical improper livestock grazing (Davies et al. 2014). However, changes in grazing practices in the annual state (figs. 7.6, 7.10) are not likely to aid conversion of annual grass-dominated plant communities back to native species-dominated communities (Davies et al. 2014; Strand et al. 2014). Similarly, changes in grazing practices in the annual state cannot be used to achieve vegetation habitat objectives for nesting and brood-rearing seasonal habitat for GRSB in Oregon and Washington (USDOI BLM 2015g, table 2-2), Utah (USDOI BLM 2015i, table 2-2), Nevada and northeastern California (USDOI BLM 2015e, table 2-2), and Idaho and southwestern Montana (USDOI BLM 2015b, table 2-2).

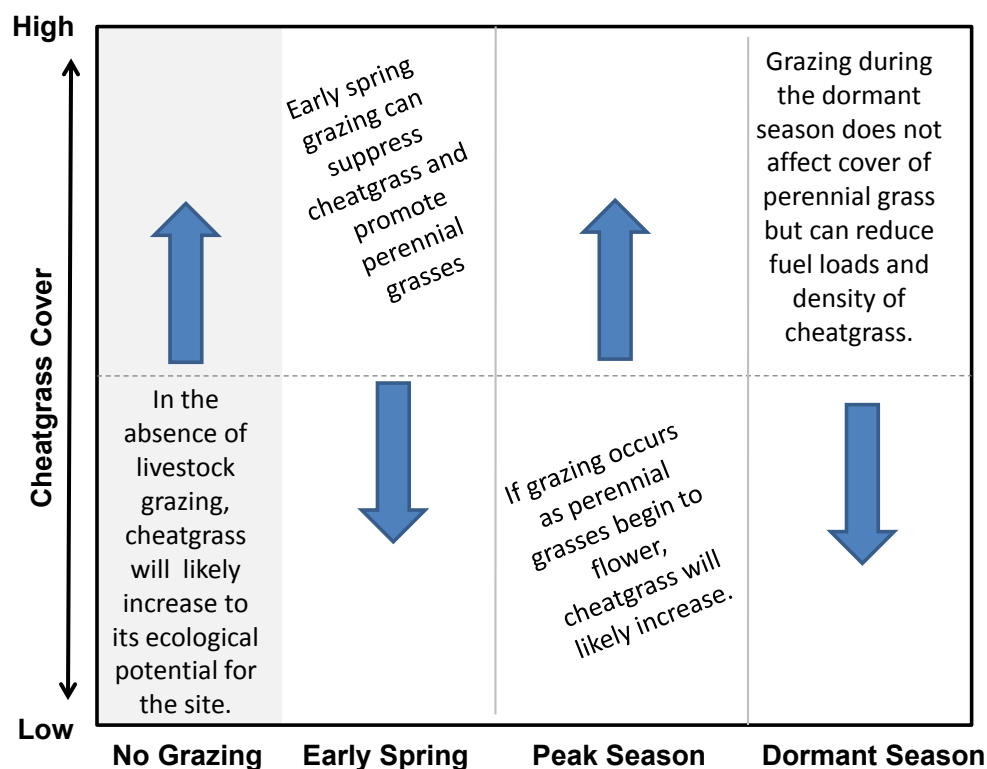


Figure 7.8—Conceptual depiction of how livestock grazing can influence cheatgrass abundance in sagebrush dominated ecosystems with a significant component of perennial grasses. Grazing can suppress or promote cheatgrass depending primarily on the season of grazing. Grazing suppresses cheatgrass when applied (1) in early spring when annuals begin to produce seeds and before native perennial grasses initiate bolting, and (2) during the dormant season (figure source: Strand et al. 2014, used with permission).

Grazing of the annual state can be effective in reducing the risk of fire initiation and spread (fig. 7.9). Targeted grazing, or the application of a specific kind of livestock at a determined season, duration, and intensity, can be used to achieve defined vegetation or broad-scale goals within annual states (Launchbaugh and Walker 2006; Mosley and Roselle 2006). For example, intense sheep grazing of cheatgrass dominated sites can effectively suppress or even eliminate cheatgrass stands in as little as 2 years, as was done in the urban interface above Carson City, Nevada (Mosley 1994). Managed grazing may also reduce the risk and extent of wildfire in cheatgrass dominated areas (Diamond et al. 2009, 2012; Walker 2006).

In sagebrush ecosystems, high intensity targeted grazing may best be used to create firebreaks by confining livestock to a strip of land with temporary fencing. This type of grazing may reduce the spread of wildfire by reducing herbaceous vegetation (fine fuels that carry fire) (Walker 2006). Further, because livestock tend to graze some areas more intensely than others, grazing may create patchy vegetation that reduces the continuity of fuel loads and the fires (Walker 2006). However, this reduction in fuel continuity is influenced strongly by multi-year precipitation patterns (Pilliod et al. 2017) and timing of grazing.

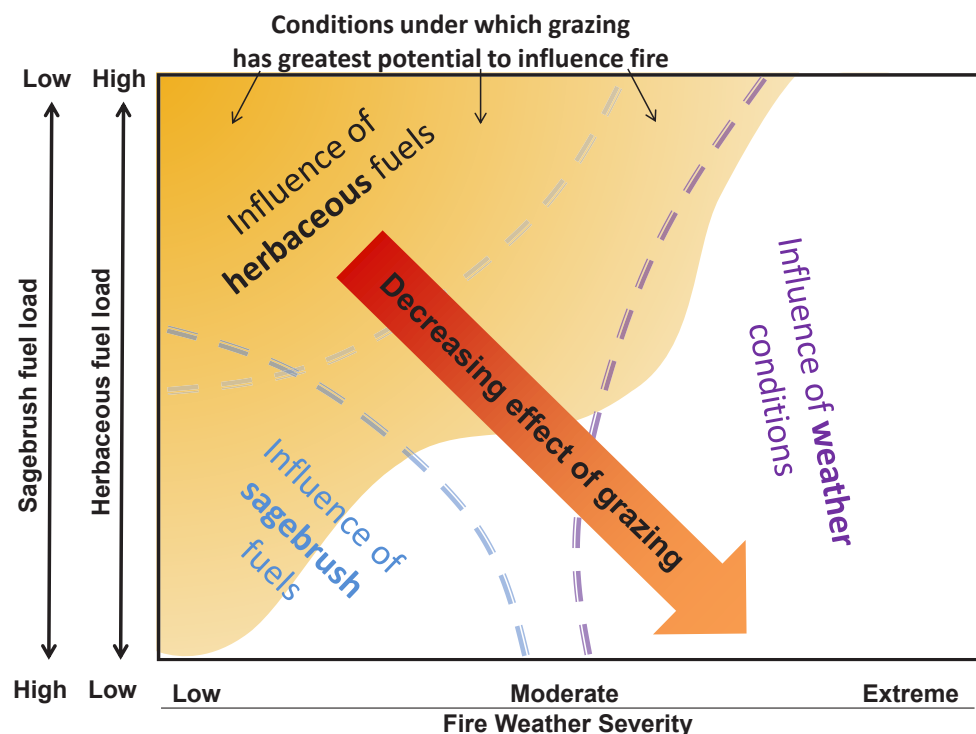


Figure 7.9—Conceptual model illustrating how the potential for grazing to influence fire behavior occurs along continuums of fuel and weather conditions. Fuel composition is displayed on the y-axis and fire weather condition is displayed on the x-axis. Low fire weather severity is characterized by high fuel moistures, high relative humidity, low temperature, and low wind speeds, whereas extreme fire weather is characterized by the opposite conditions. The potential for grazing to be effective in reducing the risk of fire initiation and spread is greatest when the sagebrush cover is low and the fire weather severity is low to moderate (figure source: Strand et al. 2014, used with permission).

Effective grazing programs for invasive plant control require a clear statement of the kind of animal and timing and rate of grazing necessary to suppress the invasive plant (Launchbaugh and Walker 2006). A successful targeted grazing prescription should: (1) cause significant reductions in the target plant(s), (2) limit effects to the surrounding vegetation, and (3) be integrated with other control methods as part of an overall management strategy. Because targeted grazing by livestock is typically focused on heavily invaded areas, follow-up management, such as seeding the target area with the desired perennial species, may be needed.

Potential Livestock Grazing Management Practices for the Seeded State

After wildfire, areas within the Wyoming big sagebrush, 8–12 inch (20–30 centimeter) precipitation zone that support GRSG are often a priority for seeding because residual perennial native grasses are typically insufficient to promote recovery (fig. 7.11). Seeding with a diverse mix of native shrubs, grasses, and forbs can increase resilience to disturbance as well as resistance to invasive annual grasses through increased competition with the invaders over the long term (see section 6).

Grazing rest and deferment schedules are needed to ensure establishment of the seeded species and recovery of the site after postwildfire rehabilitation (Pyke et al. 2017). Newly seeded and surviving plants are at risk of repeated defoliation due to animal preference for foraging in burned areas (Veblen et al. 2015). Thus,



Figure 7.10—Example of a plant community phase in the annual state in the Wyoming big sagebrush, 8–12 inch precipitation zone ecological type (fig. 7.6). The plant community phase is dominated by exotic annual grasses and forbs such as cheatgrass, medusahead (*Taeniatherum caput-medusae*), and tumblemustard (*Thelypodopsis* spp.). The site is located in the Jackies Butte allotment in the Jordan Resource Area of the BLM's Vale District in Oregon. This site is not providing nesting or early brood-rearing habitat for GRSB (photo by Jon Sadowski, used with permission).

grazing should be resumed only after perennial grasses have established and are producing viable seed at levels equal to grasses on unburned sites. Failure to implement a program of grazing rest or deferment may slow or prevent site recovery (Kerns et al. 2011) and promote invasive annual grasses and other undesirable plants.

Once postfire grazing resumes on a site, use should be deferred until after seed maturity or shatter to promote bunchgrass recovery (Bates et al. 2009; Bruce et al. 2007). In addition, postfire grazing after rest or during deferment periods will probably need to be lighter than grazing recommendations for unburned areas, which are no more than 50 percent utilization during active growth, and no more than 60 percent during dormancy (Guinn and Rouse 2009). Under certain conditions (e.g., in warm or dry areas, after high severity fires, or during low precipitation years), even lower utilization may be required to allow seeded species to establish and soils to recover. Options for mitigating livestock distribution problems in large grazing units include fencing, herding, and strategic placement of water, salt, and supplements.

Careful monitoring and assessment is an integral part of a grazing program to determine when grazing may be resumed, whether postfire grazing management has been effective, and whether changes in grazing management are needed.



Figure 7.11—Example of a plant community phase in the seeded state in the Wyoming big sagebrush, 8–12 inch precipitation zone ecological type (fig. 7.6). Plant community phase is a seeding dominated by Fairway crested wheatgrass. The site is located in the Jackies Butte allotment in the Jordan Resource Area of the BLM's Vale District in Oregon. This site is not providing nesting or early brood-rearing habitat for GRSB (photo by Jon Sadowski, used with permission).

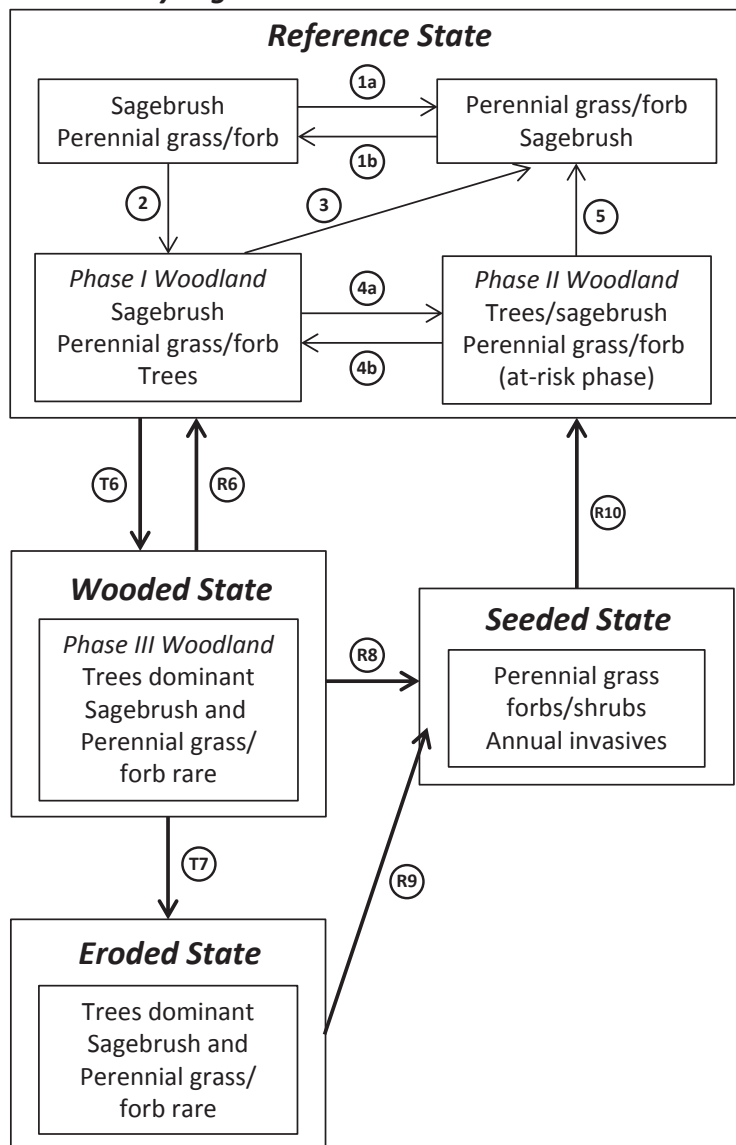
Cold Deserts—Frigid/Xeric-Typic Mountain Big Sagebrush with Piñon Pine and/or Juniper Potential (Management Zones III, IV, and V)

Potential Livestock Grazing Management Practices for the Reference State—Phase I and II Woodland

Managing livestock grazing in plant communities with phase I and II juniper and piñon in the reference state (figs. 7.12, 7.13) to maintain perennial grasses can decrease the rates of juniper and piñon expansion and infill into adjacent sagebrush ecosystems (Guenther et al. 2004; Madany and West 1983; Shinneman and Baker 2009; Soulé et al. 2004). Grazing management to maintain perennial grasses can increase the resilience of these plant communities and their capacity to recover after wildfire (Chambers et al. 2014a). It can also increase resistance to invasive annual grasses on warmer and drier sites (Chambers et al. 2014a,b).

In studies that compared adjacent grazed and historically ungrazed areas, juniper and piñon densities, canopy cover, or basal area were greater in the grazed than ungrazed pastures (Guenther et al. 2004; Madany and West 1983; Shinneman and Baker 2009; Soulé et al. 2004). Further, shrubs often act as nurse plants for juniper and piñon by modifying temperatures and increasing resource availability (Chambers 2001; Johnsen 1962; Miller and Rose 1995; Soulé and Knapp 2000, Soulé et al. 2004). Shrub abundance can increase after fire in

COLD DESERTS – FRIGID/XERIC-TYPIC
MOUNTAIN BIG SAGEBRUSH (12-22 IN PZ)
Piñon pine and/or juniper potential
Moderately High Resilience and Moderate Resistance



- 1a Disturbances such as wildfire, insects, disease, and pathogens result in less sagebrush and more perennial grass/forb.
- 1b Sagebrush increases with time.
- 2 Time combined with seed sources for piñon and/or juniper trigger a Phase I Woodland.
- 3 Fire and or fire surrogates (herbicides and/or mechanical treatments) that remove trees may restore perennial grass/forb and sagebrush dominance.
- 5 Fire surrogates (herbicides and/or mechanical treatments) that remove trees may restore perennial grass/forb and sagebrush dominance.
- 4a Increasing tree abundance results in a Phase II woodland with depleted perennial grass/forb and shrubs and an at-risk phase.
- 4b Fire surrogates (herbicides and/or mechanical treatments) that remove trees may restore perennial grass/forb and sagebrush dominance.
- T6 Infilling of trees and/or improper grazing can result in a biotic threshold crossing to a wooded state with increased risk of high severity crown fires.
- R6 Fire, herbicides and/or mechanical treatments that remove trees may restore perennial grass/forb and sagebrush dominance.
- T7 An irreversible abiotic threshold crossing to an eroded state can occur depending on soils, slope, and understory species.
- R8 Seeding after treatments or fire may be required on sites with depleted perennial grass/forb, but seeding with aggressive introduced species can decrease native perennial grass/forb. Annual invasives are typically rare. Seeded eroded states may have lower productivity.
- R9 Seeding after treatments or fire may be required on sites with depleted perennial grass/forb, but seeding with aggressive introduced species can decrease native perennial grass/forb. Annual invasives are typically rare. Seeded eroded states may have lower productivity.
- R10 Depending on seed mix and grazing, return to the reference state may be possible if an irreversible threshold has not been crossed.

Figure 7.12—State-and-transition model for a mountain big sagebrush, 12–22 inch precipitation zone ecological type applicable in the Cold Deserts in the western part of the sagebrush biome and GRSR range in the Snake River Plain, Northern Basin and Range, and Central Basin and Range ecoregions (Management Zones III, IV, and V). Large boxes illustrate states that are made up of community phases (smaller boxes). Transitions among states are shown with arrows starting with T; restoration pathways are shown with arrows starting with R. The “at risk” community phase is most vulnerable to transition to an alternative state (figure source: Chambers et al. 2017a, Appendix 6).



Figure 7.13—Example of a phase II woodland plant community in the reference state of the mountain big sagebrush, 12–22 inch precipitation zone ecological type (fig. 7.12) in Nevada. This woodland is dominated by piñon pine. Piñon pine is continuing to expand and increase in density and canopy cover, and mountain big sagebrush and bluebunch wheatgrass (*Pseudoroegneria spicata*) are declining in canopy cover. This plant community phase is not providing nesting or early brood-rearing habitat for GRSB (photo by Jeanne Chambers).

response to grazing that removes perennial grasses in mountain big sagebrush ecological types (Chambers et al. 2017b). A recent simulation model that evaluated woodland expansion across the Intermountain West identified grazing as the key factor leading to juniper expansion through reduction of perennial grass and shrub cover as well as decreases in fire occurrence (Caracciolo et al. 2017).

Areas with more than 2 percent conifer cover severely compromise GRSB habitat use and can result in greater bird mortality (Coates et al. 2017; Severson et al. 2016). Thus, changes in grazing management alone in phase I or phase II plant communities in the reference state (figs. 7.12, 7.13) cannot be used to achieve vegetation habitat objectives for nesting and brood-rearing seasonal habitat for GRSB in Oregon and Washington (USDOI BLM 2015g, table 2-2), Utah (USDOI BLM 2015i, table 2-2), Nevada and northeastern California (USDOI BLM 2015e, table 2-2), and Idaho and southwestern Montana (USDOI BLM 2015b, table 2-2). However, phase I and phase II expansion woodlands are often targeted for conifer removal treatments to improve GRSB habitat. Treatments may include cutting and leaving the trees, shredding or masticating the trees, and in some cases, prescribed fire. Bunchgrasses and other perennial vegetation may exhibit increases in cover, but may take several years to fully



Figure 7.14—Example of a plant community phase in the wooded state in the mountain big sagebrush, 12–22 inch precipitation zone ecological type (fig. 7.12) in Nevada. The site is a phase III woodland dominated by piñon pine that was dominated in the past by sagebrush and Thurber’s needlegrass (*Achnatherum thurberianum*). This plant community phase is not providing nesting or early brood-rearing habitat for GRSG (photo by Jeanne Chambers).

recover, especially on warmer and drier sites and following prescribed fire (Williams et al. 2017). During the recovery period, many of the same livestock grazing management practices as used after fire and rehabilitation seeding may be used, including rest and deferment, decreased levels of utilization, changes in the timing of livestock grazing, and increased emphasis on livestock distribution.

Potential Livestock Grazing Management Practices for the Wooded State—Phase III Woodland

Because GRSG do not use phase III woodland (fig. 7.14) (Severson et al. 2017), changes in grazing management alone cannot be used to achieve vegetation habitat objectives for nesting and brood-rearing seasonal habitat for GRSG in the wooded state in Oregon and Washington (USDOI BLM 2015g, table 2-2), Utah (USDOI BLM 2015i, table 2-2), Nevada and northeastern California (USDOI BLM 2015e, table 2-2), and Idaho and southwestern Montana (USDOI BLM 2015b, table 2-2). However, following wildfire and postfire rehabilitation seeding or tree removal in these areas to increase connectivity of sagebrush habitat, many of the same livestock grazing management practices as used after wildfire and postfire rehabilitation seeding may be used.

Conclusions

Livestock grazing management is a critical aspect of maintaining and improving resilience to disturbance and resistance to invasive annual grasses in sagebrush ecosystems and GRSG habitat. Livestock grazing has well-recognized effects on ecosystem structure and function that vary among ecoregions and GRSG Management Zones. Consideration of the potential regional variation in grass-related variables and the effects associated with plant phenology can help in the development of management prescriptions for livestock grazing to attain habitat objectives within nesting habitats. Potential livestock grazing management practices designed to improve sagebrush habitats can be incorporated into livestock grazing management alternatives during the grazing authorization (grazing permits and grazing leases) renewal process, which is ongoing within the BLM (USDOI BLM 2017a) and other agencies. Specific vegetation habitat objectives for breeding and nesting seasonal habitat, and brood-rearing and summer seasonal habitat, have been developed by BLM and its partners. But it may be necessary to modify and update these as additional information on GRSG habitat requirements and ecological site potentials to support GRSG habitat become available and additional policy direction is provided (USDOI BLM 2017b).

The Science Framework provides an approach for managing sagebrush ecosystems based on their relative resilience and resistance to invasive annual grasses. This approach can be used to evaluate the likely response of an area to disturbance or management actions and the capacity of an area to support target species or resources at the mid-scale. At the local scale, ecological types or ecological site descriptions and their associated STMs can be used to evaluate current ecological dynamics and determine appropriate livestock grazing management practices. In this section, examples of ecological types and STMs illustrate the use of these tools for identifying livestock grazing management practices that can be implemented to maintain or improve the resilience and resistance of sagebrush plant communities and the quality of GRSG nesting and early brood-rearing habitat.

References

- Adams, B.W.; Carlson, J.; Milner, D.; [et al.]. 2004. Beneficial grazing management practices for sage-grouse (*Centrocercus urophasianus*) and ecology of silver sagebrush (*Artemisia cana*) in southeastern Alberta. Tech. Rep. Publication No. T/049. Lethbridge, Alberta, Canada: Public Lands and Forests Division, Alberta Sustainable Resource Development. 60 p. https://albertawilderness.ca/wordpress/wp-content/uploads/20040101_rp_goa_BeneficialGrazingManagement-SageGrouse-SilverSagebrush.pdf. [Accessed May 23, 2018].
- Bates, J.D.; Rhodes, E.C.; Davies, K.W.; [et al.]. 2009. Postfire succession in big sagebrush steppe with livestock grazing. *Rangeland Ecology and Management*. 62: 98–110.
- Beck, J.L.; Mitchell, D.L. 2000. Influences of livestock grazing on sage grouse habitat. *Wildlife Society Bulletin*. 28: 993–1002.
- Bestelmeyer, B.T.; Tugel, A.J.; Peacock, G.L., Jr.; [et al.]. 2009. State-and-transition models for heterogeneous landscapes: A strategy for development and application. *Rangeland Ecology and Management*. 62: 1–15.

- Boyd, C.S.; Beck, J.L.; Tanaka, J.A. 2014. Livestock grazing and sage-grouse habitat: Impacts and opportunities. *Journal of Rangeland Applications*. 1: 58–77.
- Briske, D.D.; Fuhlendorf, S.D.; Smeins, F.E. 2005. State-and-transition models, thresholds, and rangeland health: A synthesis of ecological concepts and perspectives. *Rangeland Ecology and Management*. 58: 1–10.
- Briske, D.D.; Richards, J.H. 1995. Plant responses to defoliation: A physiological, morphological, and demographic evaluation of individual plants to grazing: Current status and ecological significance. In: Bedunah, D.J.; Sosebee, R.E., eds. *Wildland plants: Physiological ecology and developmental morphology*. Denver, CO: Society for Range Management: 635–710.
- Briske, D.D.; Sayre, N.F.; Huntsinger, L.; [et al.]. 2011. Origin, persistence, and resolution of the rotational grazing debate: Integrating human dimensions into rangeland research. *Rangeland Ecology and Management*. 64: 325–334.
- Bruce, L.B.; Perryman, B.; Conley, K.; [et al.]. 2007. Grazing management on seeded and unseeded post-fire public rangelands. *Professional Animal Scientist*. 23: 285–290.
- Cagney, J.; Bainter, E.; Budd, B.; [et al.]. 2010. Grazing influence, objective development, and management in Wyoming's Greater sage-grouse habitat, with emphasis on nesting and early brood rearing. Extension Bulletin B-1203. Laramie, WY: University of Wyoming, Cooperative Extension Service. 60 p.
- Caracciolo, D.; Istanbuluoglu, E.; Noto, L.V. 2017. An ecohydrological cellular automata model investigation of juniper tree encroachment in a western North America landscape. *Ecosystems*. 20: 1104–1123.
- Caudle, D.; DiBenedetto, J.; Karl, M.; [et al.]. 2013. Interagency ecological site handbook for rangelands. Washington, DC: U.S. Department of the Interior, Bureau of Land Management; U.S. Department of Agriculture, Forest Service and Natural Resources Conservation Service. <http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=33150>. [Accessed May 23, 2018].
- Chambers, J.C. 2001. *Pinus monophylla* establishment in an expanding pinon-juniper woodland: Environmental conditions, facilitation and interacting factors. *Journal of Vegetation Science*. 12: 27–40.
- Chambers, J.C.; Beck, J.L.; Bradford, J.B.; [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 1. Science basis and applications. RMRS-GTR-360. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 213 p.
- Chambers, J.C.; Board, D.I.; Roundy, B.A.; [et al.]. 2017b. Removal of perennial herbaceous species affects response of cold desert shrublands to fire. *Journal of Vegetation Science*. 28(5): 975–984.
- Chambers, J.C.; Bradley, B.A.; Brown, C.A.; [et al.]. 2014a. Resilience to stress and disturbance, and resistance to *Bromus tectorum* L. invasion in the cold desert shrublands of western North America. *Ecosystems*. 17: 360–375.
- Chambers, J.C.; Miller, R.F.; Board, D.I.; [et al.]. 2014b. Resilience and resistance of sagebrush ecosystems: Implications for state and transition models and management treatments. *Rangeland Ecology and Management*. 67: 440–454.

- Coates, P.S.; Prochazka, B.G.; Ricca, M.A.; [et al.]. 2017. Pinyon and juniper encroachment into sagebrush ecosystems impacts distribution and survival of Greater sage-grouse. *Rangeland Ecology and Management*. 70: 25–38.
- Davies, K.W.; Bates, J.D.; Svejcar, T.J.; [et al.]. 2010. Effects of long-term livestock grazing on fuel characteristics in rangelands: An example from the sagebrush steppe. *Rangeland Ecology and Management*. 63: 662–669.
- Davies, K.W.; Svejcar, T.J.; Bates, J.D. 2009. Interaction of historical and nonhistorical disturbances maintains native plant communities. *Ecological Applications*. 19: 1536–1545.
- Davies, K.W.; Vavra, M.; Schultz, B.W.; [et al.]. 2014. Implications of longer term rest from grazing in the sagebrush steppe. *Journal of Rangeland Applications*. 1: 14–34.
- Diamond, J.M.; Call, C.A.; Devoe, N. 2009. Effects of targeted cattle grazing on fire behavior of cheatgrass-dominated rangeland in the northern Great Basin, USA. *International Journal of Wildland Fire*. 18: 944–950.
- Diamond, J.M.; Call, C.A.; Devoe, N. 2012. Effects of targeted grazing and prescribed burning on community and seed dynamics of a downy brome (*Bromus tectorum*)-dominated landscape. *Invasive Plant Science and Management*. 5: 259–269.
- Dinkins, J.B.; Smith, K.T.; Beck, J.L.; [et al.]. 2016. Microhabitat conditions in Wyoming's sage-grouse core areas: Effects on nest site selection and success. *PLoS ONE* 11: e0150798.
- Doherty, K.E.; Beck, J.L.; Naugle, D.E. 2011. Comparing ecological site descriptions to habitat characteristics influencing greater sage-grouse nest site occurrence and success. *Rangeland Ecology and Management*. 64: 344–351.
- Doherty, K.E.; Evans, J.S.; Coates, P.S.; [et al.]. 2016. Importance of regional variation in conservation planning: A range-wide example of the Greater sage-grouse. *Ecosphere*. 7: e01462.
- Doherty, K.E.; Naugle, D.E.; Tack, J.D.; [et al.]. 2014. Linking conservation actions to demography: Grass height explains variation in greater sage-grouse nest survival. *Wildlife Biology*. 20: 320–325.
- Federal Register [FR]. 2005. 43 CFR 4180.2. Standards and guidelines for grazing administration [68 FR 33804. June 5, 2003.]. <https://www.gpo.gov/fdsys/granule/CFR-2005-title43-vol2/pdf/CFR/2005-title43-vol2-sec4180-2.pdf>. [Accessed Oct. 30, 2018].
- Federal Register [FR]. 2012. 43 CFR 4110.3. Implementing changes in active use. <https://www.gpo.gov/fdsys/granule/CFR-2012-title43-vol2/pdf/CFR/2012-title43-vol2-sec4110-3-2.pdf>. [Accessed Oct. 25, 2018].
- Freilich, J.E.; Emlen, J.M.; Duda, J.J.; [et al.]. 2003. Ecological effects of ranching: A six-point critique. *BioScience*. 53(8): 759–765.
- Fuhlendorf, S.D.; Engle, D.M. 2001. Restoring heterogeneity on rangelands: Ecosystem management based on evolutionary grazing patterns. *BioScience*. 51(8): 625–632.

- Guenther, D.; Stohlgren, T.J.; Evangelista, P. 2004. A comparison of a near-relict site and a grazed site in a pinyon-juniper community in the Grand Staircase-Escalante National Monument, Utah. In: Van Riper, C.; Cole, K.L., eds. The Colorado Plateau: Cultural, biological and physical research. Tucson, AZ: University of Arizona Press: 153–162.
- Guinn, K.; Rouse, G. 2009. Grazing management guidelines. Range Tech. Note-34, revised. Spokane, WA: U.S. Department of Agriculture, Natural Resources Conservation Service. 10 p.
- Hagen, C.A.; Connelly, J.W.; Schroeder, M.A. 2007. Meta-analysis of Greater sage-grouse *Centrocercus urophasianus* nesting and brood-rearing habitats. Wildlife Biology. 13: 42–50.
- Hockett, G.A. 2002. Livestock impacts on the herbaceous components of sage grouse habitat: A review. Intermountain Journal of Sciences. 8: 105–114.
- Huber-Sannwald, E.; Pyke, D.A. 2005. Establishing native grasses in a big sagebrush-dominated site: An intermediate restoration step. Restoration Ecology. 13: 292–301.
- Johnsen, T.N., Jr. 1962. One-seed juniper invasion of northern Arizona grasslands. Ecological Monographs. 32: 187–207.
- Kerns, B.K.; Buonopane, M.; Thies, W.G.; [et al.]. 2011. Reintroducing fire into a ponderosa pine forest with and without cattle grazing: Understory vegetation response. Ecosphere. 2: 59.
- Kirol, C.P.; Beck, J.L.; Dinkins, J.B.; [et al.]. 2012. Microhabitat selection for nesting and brood-rearing by the Greater sage-grouse in xeric big sagebrush. The Condor. 114: 75–89.
- Knick, S.T.; Hanser, S.E.; Miller, R.F.; [et al.]. 2011. Ecological influence and pathways of land use in sagebrush. In: Knick, S.T.; Connelly, J.W., eds. Greater sage-grouse—Ecology and conservation of a landscape species and its habitats. Studies in Avian Biology 38. Berkeley, CA: University of California Press: 203–251.
- Launchbaugh, K.; Walker, J. 2006. Chapter 1. Targeted grazing—A new paradigm for livestock management. In: Launchbaugh, K.; Walker, J., eds. Targeted grazing: A natural approach to vegetation management and landscape enhancement. Englewood, CO: American Sheep Industry Association: 2–8.
- Madany, M.H.; West, N.E. 1983. Livestock grazing-fire regime interactions within montane forests of Zion National Park, Utah. Ecology. 64: 661–667.
- Maestas, J.D.; Campbell, S.B.; Chambers, J.C.; [et al.]. 2016. Tapping soil survey information for rapid assessment of sagebrush ecosystem resilience and resistance. Rangelands. 38: 120–128.
- Miller, R.F.; Chambers, J.C.; Pellant, M. 2014. A field guide to selecting the most appropriate treatments in sagebrush and pinyon-juniper ecosystems in the Great Basin: Evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response. Gen. Tech. Rep. RMRS-GTR-322-rev. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 68 p.

- Miller, R.F.; Chambers, J.C.; Pellant, M. 2015. A field guide for rapid assessment of post-wildfire recovery potential in sagebrush and piñon-juniper ecosystems in the Great Basin: Evaluating resilience to disturbance and resistance to invasive annual grasses and predicting vegetation response. Gen. Tech. Rep. RMRS-GTR-338. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 70 p.
- Miller, R.F.; Rose, J.A. 1995. Historic expansion of *Juniperus occidentalis* (western juniper) in southeastern Oregon. Great Basin Naturalist. 55: 37–45.
- Mosley, J.C. 1994. Prescribed sheep grazing to suppress cheatgrass: A review. Sheep Research Journal. 12: 79-91.
- Mosley, J.C.; Roselle, L. 2006. Chapter 8. Targeted livestock grazing to suppress invasive annual grasses. In: Launchbaugh, K.; Walker, J., ed. Targeted grazing: A natural approach to vegetation management and landscape enhancement. Denver, CO: American Sheep Association: 67–72.
- Pilliod, D.S.; Welty, J.L.; Arkle, R.S. 2017. Refining the cheatgrass-fire cycle in the Great Basin: Precipitation timing and fine fuel composition predict wildfire trends. Ecology and Evolution. 7: 8126–8151.
- Pyke, D.A.; Chambers, J.C.; Pellant, M.; [et al.]. 2017. Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat—Part 3. Site level restoration decisions. Circular 1426. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey. 62 p. <https://www.treesearch.fs.fed.us/pubs/53743>. [Accessed Sept. 20, 2017].
- Schmelzer, L.; Perryman, B.; Bruce, B.; [et al.]. 2014. Case study: Reducing cheatgrass (*Bromus tectorum* L.) fuel loads using fall cattle grazing. The Professional Animal Scientist. 30: 270–278.
- Severson, J.P.; Hagen, C.A.; Maestas, J.D.; [et al.]. 2016. Effects of conifer expansion on Greater sage-grouse nesting habitat selection. Journal of Wildlife Management. 81: 86–95.
- Severson, J.P.; Hagen, C.A.; Maestas, J.D.; [et al.]. 2017. Short-term response of sage-grouse nesting to conifer removal in the northern Great Basin. Rangeland Ecology and Management. 70: 50–58.
- Shinneman, D.J.; Baker, W.J. 2009. Environmental and climatic variables as potential drivers of post-fire cover of cheatgrass (*Bromus tectorum*) in seeded and unseeded semiarid ecosystems. International Journal of Wildland Fire. 18: 191–202.
- Smith, J.T. 2016. Landscape to local: A multi-scale evaluation of voluntary efforts to reduce fragmentation and enhance management of rangelands for sage-grouse. Dissertation. Missoula, MT: University of Montana. 140 p. <http://scholarworks.umt.edu/etd/10902>. [Accessed May 23, 2018].
- Soulé, P.T.; Knapp, A.K. 2000. *Juniperus occidentalis* (western juniper) establishment history on two minimally disturbed research natural areas in central Oregon. Western North American Naturalist. 60: 26–33.
- Soulé, P.T.; Knapp, P.A.; Grissino-Mayer, H.D. 2004. Human agency, environmental drivers, and western juniper establishment during the late Holocene. Ecological Applications. 14: 96–112.

- Stiver, S.J.; Rinkes, E.T.; Naugle, D.E.; [et al.], eds. 2015. Sage-grouse habitat assessment framework: A multiscale assessment tool. Technical Reference 6710-1. Denver, CO: U.S. Department of the Interior, Bureau of Land Management and Western Association of Fish and Wildlife Agencies.
- Strand, E.K.; Launchbaugh, K.L.; Limb, R.; [et al.]. 2014. Livestock grazing effects on fuel loads for wildland fire in sagebrush dominated ecosystems. *Journal of Rangeland Applications*. 1: 35–57.
- Stringham, T.K.; Krueger, W.C.; Shaver, P.L. 2003. State and transition modeling: An ecological process approach. *Journal of Range Management*. 56: 106–113.
- Thompson, K.M.; Holloran, M.J.; Slater, S.J.; [et al.]. 2006. Early brood-rearing habitat use and productivity of Greater sage-grouse in Wyoming. *Western North American Naturalist*. 66: 332–342.
- U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. 2015. Ecological site descriptions. Washington, DC: U.S. Department of Agriculture, Natural Resources Conservation Service. <https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/ecoscience/desc/>. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015a. HiLine District Office Greater sage-grouse approved resource management plan. BLM/MT/PL-15/012+1610. Washington, DC: U.S. Department of the Interior, Bureau of Land Management, HiLine District Office. https://eplanning.blm.gov/epl-front-office/projects/lup/68346/88890/106398/HiLine_ARMP_2015.pdf. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015b. Idaho and southwestern Montana greater sage-grouse approved resource management plan amendment. BLM/ID/SG/EIS-15+1610. Boise, ID: U.S. Department of the Interior, Bureau of Land Management, Idaho State Office. https://eplanning.blm.gov/epl-front-office/projects/lup/31652/63337/68679/IDMT_ARMPA_print.pdf. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015c. Miles City Field Office approved resource management plan. BLM/MT/PL-15/010+1610. Miles City, MT: U.S. Department of the Interior, Bureau of Land Management, Miles City Field Office. [https://eplanning.blm.gov/epl-front-office/projects/lup/59042/86804/104007/Miles_City_Field_Office_Approved_Resource_Management_Plan_\(2015\).pdf](https://eplanning.blm.gov/epl-front-office/projects/lup/59042/86804/104007/Miles_City_Field_Office_Approved_Resource_Management_Plan_(2015).pdf). [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015d. Lewistown Field Office greater sage-grouse approved resource management plan amendment. BLM/MT/PL-15/009+1610. Billings, MT: U.S. Department of the Interior, Bureau of Land Management, Montana State Office. https://eplanning.blm.gov/epl-front-office/projects/lup/36877/63212/68461/LFO_ARMPA_camera-508.pdf. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI, BLM]. 2015e. Nevada and northeastern California greater sage-grouse approved resource management plan amendment. BLM/NV/NV/PL/15-14+1600. Reno, NV: U.S. Department of the Interior, Bureau of Land Management, Nevada State Office. https://eplanning.blm.gov/epl-front-office/projects/lup/21152/63235/68484/NVCA_Approved_RMP_Amendment.pdf. [Accessed May 23, 2018].

- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015f. North Dakota greater sage-grouse approved resource management plan amendment. BLM/MT/PL-15/008+1610. Dickinson, ND: U.S. Department of the Interior, Bureau of Land Management, North Dakota Field Office. https://eplanning.blm.gov/epl-front-office/projects/lup/36811/63113/68356/NDFO_ARMPA_camera_508.pdf. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015g. Oregon greater sage-grouse approved resource management plan amendment. BLM/OR/WA/PL-15/051+1792. Portland, OR: U.S. Department of the Interior, Bureau of Land Management, Oregon/Washington State Office. https://www.blm.gov/or/energy/opportunity/files/or_armpa.pdf. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015h. South Dakota approved resource management plan. BLM/MT/PL-15/013+1610. Belle Fourche, SD: U.S. Department of the Interior, Bureau of Land Management, South Dakota Field Office. <https://www.blm.gov/sites/blm.gov/files/South%20Dakota%20Approved%20RMP.pdf>. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015i. Utah greater sage-grouse approved resource management plan amendment. DOI-BLM-UT-9100-2013-0002-EIS. Salt Lake City, UT: U.S. Department of the Interior, Bureau of Land Management, Utah State Office. https://eplanning.blm.gov/epl-front-office/projects/lup/68351/87600/104856/Utah_ARMPA.pdf. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2015j. Bureau of Land Management Casper, Kemmerer, Newcastle, Pinedale, Rawlins, and Rock Springs Field Offices approved resource management plan amendment for greater sage-grouse. Cheyenne, WY: U.S. Department of the Interior, Bureau of Land Management, Wyoming State Office. https://eplanning.blm.gov/epl-front-office/projects/lup/9153/63189/68431/002_Wyoming_ARMPA_Main-Body.pdf. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management, Washington Office [USDOI BLM]. 2017a. Instruction Memorandum No. 2018-024. Setting priorities for review and processing of grazing authorizations and related livestock grazing monitoring. Washington, DC: U.S. Department of the Interior, Bureau of Land Management. <https://www.blm.gov/policy/im-2018-024>. [Accessed May 23, 2018].
- U.S. Department of the Interior, Bureau of Land Management [USDOI BLM]. 2017b. Instruction Memorandum No. 2018-025. Implementation of the habitat objectives table from the 2015 Greater Sage-Grouse Approved Resource Management Plans and Amendments. Washington, DC: U.S. Department of the Interior, Bureau of Land Management. <https://www.blm.gov/policy/im-2018-025>. [Accessed May 23, 2018].
- U.S. Department of the Interior, Fish and Wildlife Service [USDOI FWS]. 2013. Greater sage-grouse (*Centrocercus urophasianus*) Conservation Objectives: Final Report. Denver, CO: U.S. Department of the Interior, Fish and Wildlife Service. 91 p. <https://www.fws.gov/greatersagegrouse/documents/COT-Report-with-Dear-Interested-Reader-Letter.pdf>. [Accessed May 23, 2018].

- Veblen, K.E.; Newingham, B.A.; Bates, J.; [et al.]. 2015. Post-fire grazing management in the Great Basin. Great Basin Factsheet Series. Number 7. Reno, NV: Great Basin Fire Science Exchange.
- Walker, J. 2006. Chapter 12. Targeted grazing to manage fire risk. In: Launchbaugh, K.; Walker, J., eds. Targeted grazing: A natural approach to vegetation management and landscape enhancement. Englewood, CO: American Sheep Industry Association: 107–113.
- West, N.E.; Provenza, F.D.; Johnson, P.S.; [et al.]. 1984. Vegetation change after 13 years of livestock grazing exclusion on sagebrush semidesert in west central Utah. *Journal of Range Management*. 37: 262–264.
- West, N.E.; Yorks, T.P. 2002. Vegetation responses following wildfire on grazed and ungrazed sagebrush semi-desert. *Rangeland Ecology and Management*. 55: 171–181.
- Williams, R.E.; Roundy, B.; Hulet, A.; [et al.]. 2017. Pretreatment tree dominance and conifer removal treatments affect plant succession in sagebrush communities. *Rangeland Ecology and Management*. 70: 759–773.

