Grasslands/Sagebrush Habitats
14. Sagebrush Conservation and Restoration

DEFINITION

Sagebrush habitats exist across the western United States in areas with hot, dry summers and cool, moist winters. They are dominated by big sagebrush (*Artemisia tridentata*) vegetation and perennial grasses (Pyke et al. 2015). Almost half of historic sagebrush habitat has been lost to land use conversion and invasive plants. Remaining sagebrush areas are increasingly invaded by nonnative annual grasses, fragmenting patches of big sagebrush and making the ecosystem less suitable for dependent wildlife, most notably the greater sage-grouse. Fire suppression, grazing, and invasive plants in sagebrush habitats have also altered the historic fire regime, leading to increased tree cover and higher potential for severe wildfires. Sagebrush restoration aims to restore sagebrush vegetation communities to their original state by promoting growth of a mix of big sagebrush and perennial forbs and grasses while eliminating invasive plant species.

TECHNICAL APPROACH

The US Geological Survey (USGS) and Department of the Interior (DOI) Restoration Handbook for Sagebrush Steppe Ecosystems with Emphasis on Greater Sage-Grouse Habitat describes two main approaches for sagebrush restoration, summarized as follows (Pyke et al. 2015, 2017):

- **Passive restoration:** Passive restoration facilitates the growth of desirable plant species by changing management to facilitate natural processes that shift plant species composition. This is likely to be successful in less-degraded habitats where native perennial grasses still exist; if annual grasses already dominate, active restoration is likely needed. Passive restoration usually changes the grazing regime by adjusting the level and season of use for grazing, depending on the initial vegetation community and desired outcomes. This may require the use of herding, fencing, or adjusting water availability to spread grazing pressure across a larger area or rotate animals between different parts of the habitat.
    - **Grazing—start of growing season:** Grazing in the early growing season and resting pastures (eliminating grazing) during the fastest growth and reproductive season of perennial grasses and forbs supports their growth and population and can increase their competitiveness against invasive species, including cheatgrass. Specific growing seasons vary by geography and climate.
    - **Grazing—after flowering:** Grazing cattle in sagebrush after herbaceous plants have flowered tends to benefit the sagebrush vegetation because cattle preferentially graze herbaceous plants and avoid sagebrush. This can be helpful for promoting sagebrush growth, but repeated grazing can result in overly dense sagebrush that prevents herbaceous plant growth.

- **Grazing—end of growing season:** Resting pastures at the end of the growing season allows vegetation to reach its full height to provide cover and nesting habitat for wildlife, including the greater sage-grouse. It may take several years for the full effects of this strategy to occur.
- **Grazing—dormant season:** Grazing during the dormant season minimizes adverse impacts on perennial grasses and forbs and may benefit herbaceous plants by focusing grazing pressure on sagebrush, but also removes cover used by the greater sage-grouse during its nesting season. It is important to consider potential adverse habitat impacts and proceed with caution if using this approach.

  Passive restoration may also restrict recreational access to restoration areas to avoid transporting invasive seeds into the area. Alternatively, vehicle cleaning can be required before access to the restoration area to remove invasive seeds.

- **Active restoration:** Active restoration directly modifies the plant community by removing undesirable species or adding desired species. This active approach is required when desired native plant species have been degraded to the point that they are not likely to recover under passive restoration or when invasive or other undesirable species already dominate the site. The general process for active restoration is as follows:

  1. **Controlling undesirable plant species**: Active restoration is frequently done in areas dominated by invasive or other undesirable species that must be controlled before desired species can be planted. There are multiple approaches to control undesirable plant species:

     - **Prescribed fire:** Prescribed fire can be used to remove fire-sensitive species and to temporarily reduce woody plant cover, which is helpful for equipment access for other plant control techniques or seeding. See the prescribed fire strategy summary for more information about this strategy. Fire in sage-grouse areas can reduce habitat suitability for decades (an exception is sage-grouse habitats at high elevations with mountain big sagebrush, which is more resilient to fire and can recover more quickly), so caution is advised when considering the use of prescribed fire in sage-grouse habitat. In areas without sage-grouse, fire can reduce woody plant dominance and reduce annual grass populations for a few years. This depends on fire intensity and duration sufficient to kill seeds in the soil, which can be difficult to achieve under safe burning conditions.
     - **Mechanical treatments:** These range from harvesting individual trees (often done by hand in areas where sagebrush exists) to mowing or pulling pipes or chains between tractors to remove plants and disturb the soil. Many of these techniques have high potential for soil disturbance (which facilitates erosion) and damage to desirable plants as well as target plants, so positive and negative impacts should be considered when selecting a mechanical treatment.

- **Chemical treatment (herbicides):** Herbicides can also be used to control undesirable plants. Many herbicides used for annual grasses are nonselective (kill all plants), but the rate and timing of applications can be used to target certain types of plants. There are some selective herbicides for woody plants and shrubs that can be used to reduce sagebrush growth. Use caution when selecting and applying herbicides, considering the potential for adverse effects on desired plant species and subsequent impacts on sage-grouse habitat.
- **Biological control:** This includes the use of insects, microbes, or livestock to target undesirable plants. Insects or microbes usually require permitting because they are often imported from the same country the invasive plant originated from. Certain woody plants can be controlled with insects (e.g., saltcedar, leafy spurge); no microbial pathogens are currently approved for use to control invasive grasses, but research is ongoing. Targeted grazing using livestock does not require permits, but trained livestock may be required to ensure only target species are grazed.

2. **Soil rehabilitation:** This step may be needed to remedy unconsolidated surface soils or compacted subsurface soils. Firm surface soils are needed to optimize germination; soil firming (using packer equipment) is required in loose, unconsolidated soils. Conversely, compacted subsurface soils restrict water movement and root penetration within the soil and may require plowing prior to planting.
3. **Control erosion and stabilize soils in areas with high erosion potential:** This can be done by planting fast-growing, sterile annual grasses. Annual grasses like wheat grow faster than perennial grasses and thus provide soil stabilization more quickly; they can also help to compete with invasive annual grasses. This technique is often followed by seeding perennial grasses in the next growing season. Mulching with straw or other organic materials also helps to control erosion but is less effective in areas with high rain or wind intensity. It is important to select mulch materials that do not contain invasive species seeds (for example, rice straw is often used since it contains wetland seeds that are not likely to survive in sagebrush habitat).
4. **Revegetation of desired native species:** This may include sagebrush, perennial herbaceous plants, or both, depending on the initial state of the site. Revegetation is usually done by seeding, but transplanting can be a useful alternative in certain contexts.
    - **Seeding:** There are a variety of tools used for seeding. Rangeland seed drills are used to bury seeds, which increases germination success for many perennial grasses. Species with smaller seeds often do better when applied to the surface and pressed in to increase contact with soil. Seeds can also be broadcast from ground-based equipment or aerially (via planes or helicopters), but this increases the potential for seeds to be blown or washed away before they germinate (Figure 1). Mulching seeds with soil or plant litter after aerial seeding can help to prevent this. Seeding should occur just before the rainy season, which varies by location.

Figure 14.1 Aerial seeding of a sagebrush restoration project in Utah

Photo courtesy US Fish and Wildlife Service Mountain Prairie

- **Transplanting:** Where soil stabilization or quick recovery of vegetative structure are required (e.g., for wildlife habitat goals, windbreaks, or aesthetics), transplanting can be a useful alternative to seeding (Figure 2). Certain species also do better from transplants than seeding; there is evidence that after wildfire, sagebrush seedlings have higher survival rates when transplanted than seeded (Grant-Hoffman and Plank 2021). It can take additional time to obtain the plants required for transplanting, which should occur just before the growing season on cool, overcast, windless days.

5. **Rehabilitation:** Technically, active restoration is only possible when site soil and hydrologic characteristics are still capable of supporting original native plant communities. Extensive soil loss, which frequently occurs after fires, can prevent this and requires the use of different plant species (including introduced species) to provide similar structure and function and prevent further degradation. The USGS and DOI Restoration Handbook refers to this as *rehabilitation*, rather than restoration of the original habitat (Pyke et al. 2015). The rehabilitation process follows a similar process to that for active restoration, except revegetation includes different species.

Figure 14.2 Growing sagebrush seedlings for transplant

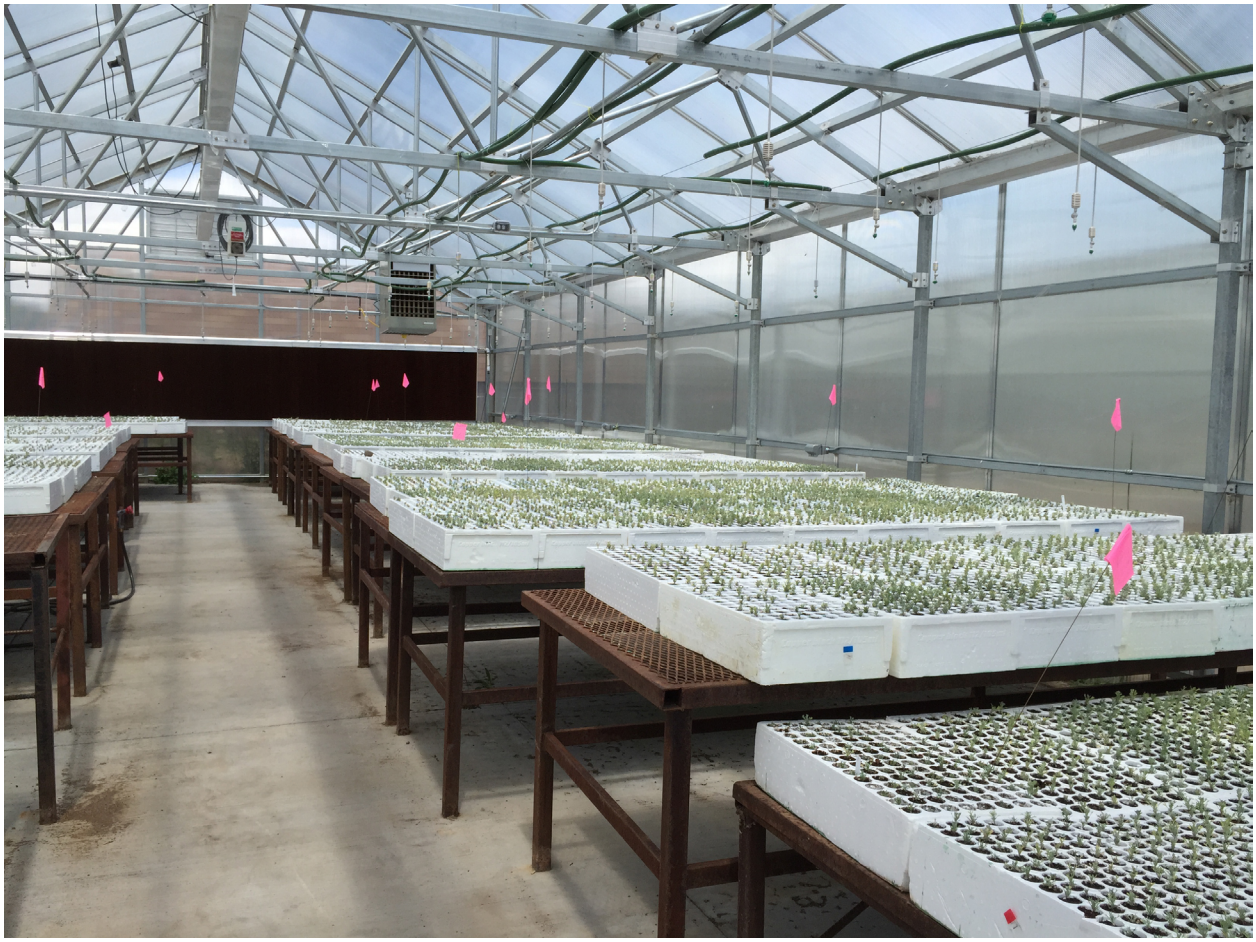

Photo courtesy Bureau of Land Management

OPERATIONS AND MAINTENANCE

Preventing livestock grazing after restoration is often required to allow vegetation to reach desired density and size before introducing grazing disturbance (Pyke et al. 2017). The length of time required varies by vegetation species and climate (vegetation recovers more quickly in wetter climates), but generally ranges between two and four growing seasons, with additional time required for sites that were burned and broadcast seeded, sites with remaining invasive grasses, and sites with erosive soils.

FACTORS INFLUENCING SITE SUITABILITY

- ✓ **Cool moist climates:** Sagebrush ecosystems in cool, moist climates are likely to respond well to passive restoration because they are more resistant to invasive annual grasses than hotter, drier areas (Pyke et al. 2017).

- ✓ **Mean annual precipitation of at least 13 in.:** Higher annual precipitation has been found to increase seeding success for perennial grasses (Pyke et al. 2017).
- × **Steep slopes:** Equipment used for seeding cannot operate on steep slopes (greater than 30%) (Pyke et al. 2017). Aerial seeding methods can be used instead.
- × **Stony soil (more than 15% stone cover):** Stones can damage equipment and increase fire risk from sparks created when metal equipment strikes stones (Pyke et al. 2017). Aerial treatment methods can be used in these areas instead of ground-based equipment.
- × **High erosion potential:** Extra care should be taken not to disturb soil in areas with high erosion potential to avoid additional soil loss (Pyke et al. 2017).

TOOLS, TRAINING, AND RESOURCES FOR PLANNING AND IMPLEMENTATION

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes: Design/Construction Guidance?	Resource Includes: Site Selection?	Resource Includes: Monitoring Guidance?	Resource Includes: Example Projects?
Restoration Handbook for Sagebrush Steppe Ecosystems with Emphasis on Greater Sage-Grouse Habitat— Part 1: Concepts for Understanding and Applying Restoration, Part 2: Landscape Level Restoration Decisions, and Part 3: Site Level Restoration Decisions	Guidebook	2015 (Parts 1 and 2), 2017 (Part 3)	USGS	National	Introduction to sagebrush ecosystem structure and function, and in-depth information about planning and implementing passive and active restoration approaches. Includes plant lists.	✓	✓	✓	—
Erosion Risk Management Tool	Online tool	2014	US Department of Agriculture, Forest Service (USFS)	National	Tool to assess the probability of erosion after a prescribed burn in sagebrush ecosystems, based on climate, soil, vegetation, slope, and fire characteristics.	—	✓	—	—
Reseeding Big Sagebrush: Techniques and Issues	Report	2005	USFS	National	Details on seeding big sagebrush, including site evaluation, pretreatment, seed testing and storage, germination, seeding techniques, and postseeding management and monitoring.	✓	✓	✓	—
Prioritizing Restoration of Sagebrush Ecosystems (PReSET)	Software	2021	USGS	National (has been run for Wyoming and work is ongoing to provide applications in other areas)	Decision-support map tool to identify priority sites for sagebrush management based on management priorities for restored or conserved habitats.	—	✓	—	—

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes: Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
Climate-Smart Restoration Tool	Online Tool	2019	USFS	Western United States	Identifies geographic areas within which seeds and native plants can be transferred based on current and future climate data.	✓	✓	—	—
Restoration of Sagebrush Ecosystems Class	Training	Offered annually	Bureau of Land Management (BLM), Great Basin Fire Science Exchange	Great Basin	In-person class on sagebrush restoration, including planning, techniques, and monitoring.	✓	✓	✓	—
Bipartisan Infrastructure Law Funding through the Sage-Steppe Ecosystem Restoration Program	Online tool	Covers fiscal years 2022 through 2024	US Fish and Wildlife Service (USFWS)	Western United States	Identifies sagebrush restoration projects by USFWS funded through the Bipartisan Infrastructure Law	—	—	—	✓
Grassland and Sagebrush Conservation Portal	Online tool	Not provided	USFWS	Western United States	Compilation of resources for grassland and sagebrush restoration practitioners, including a web map for priority sagebrush areas, links to existing projects, and data synthesis on invasive annual grasses.	✓	✓	✓	✓
A Sagebrush Conservation Design to Proactively Restore America's Sagebrush Biome	Guidebook	2022	USGS	Western United States	Spatially explicit sagebrush conservation plan to identify priority areas for collaborative conservation.	—	✓	X	X
Sagebrush Conservation Strategy—Challenges to Sagebrush Conservation	Guidebook	2021	USGS	Western United States	Overview of sagebrush ecosystem and dependent wildlife species, plus extensive discussion of causes of sagebrush degradation and strategies to address them. Also includes a chapter on adaptive management and monitoring.	✓	—	✓	—

LIKELY BENEFITS AND OUTCOMES

Primary objectives for each strategy are highlighted.

Climate Threat Reduction

- **Reduced wildfire risk:** Invasive annual grasses that often dominate degraded sagebrush ecosystems are very susceptible to fire and fuel large wildfires. Restoring native plants and removing these invasives reduces wildfire risk (Pyke et al. 2015).
- **Carbon storage and sequestration:** Soil carbon stocks are significantly higher under native sagebrush than under cheatgrass (an invasive annual grass), so sagebrush restoration can increase carbon storage (Austreng et al. 2011).

Social and Economic

- **Jobs:** Active sagebrush restoration supports local jobs. Reducing wildfire risk on sagebrush habitats also reduces risks to nearby land-based jobs such as ranching.
- **Cultural values:** Healthy sagebrush habitat supports traditional livelihoods such as grazing, as well as connection to the land through recreational opportunities.
- **Recreational opportunities:** Sagebrush habitats are used for a variety of recreational activities including camping, off-highway vehicle use, and hunting (ECONorthwest 2014).

Ecological

- **Supports wildlife:** Sagebrush restoration is frequently driven by sage-grouse habitat needs. Research shows that other wildlife species, including mule deer and songbirds (e.g., Brewer's sparrow, green-tailed towhee) also benefit from sagebrush restoration (Stemler 2015).
- **Invasive and nuisance species management:** Removing invasive species (primarily annual grasses such as cheatgrass) and nuisance woody vegetation is a key part of sagebrush restoration.
- **Supports native plants:** Sagebrush restoration aims to enhance native sagebrush and perennial herbaceous plants.

BARRIERS AND SOLUTIONS FOR PRACTITIONERS

Common Barriers

Several barriers are common across many of the nature-based solutions strategies; these are described in more detail in Section 1 of the Roadmap. Additional notes about the barriers specific to sagebrush conservation and restoration are included here.

- **Expense:** Uncertainty about future funding levels for sagebrush management impedes long-term planning and projects (Calzado-Martinez et al. 2023).

- **Capacity:** The geographic scale of sagebrush degradation, particularly invasive grass dominance, overwhelms agency capacity to address the issue (Calzado-Martinez et al. 2023).
- **Public opinion**
- **Conflict with other land uses:** Sagebrush habitats are used for grazing, recreation, and mining and energy; these uses may be temporarily or permanently excluded during restoration (Pyke et al. 2015; Remington et al. 2021).
- **Regulation:** This is especially true for newer techniques, like transplanting, that are required to go through the entire National Environmental Policy Act process rather than a faster categorical exclusion (Calzado-Martinez et al. 2023).
- **Lack of effectiveness data:** Particularly, data identifying which sites are most suitable for restoration (Calzado-Martinez et al. 2023).

Ecological

- **Invasive species:** Invasive plant species including annual grasses dominate degraded sagebrush habitats and are extremely difficult to eradicate (Pyke et al. 2015).
- **Altered fire regimes:** Fire regimes that influence sagebrush habitats are not well-understood and have been altered by human interference, invasives, and climate change. This has caused large-scale conversion from native sagebrush plant communities to fire-prone invasive annual plants (Remington et al. 2021).
- **Climate change:** Rising temperatures and modest increases in precipitation are expected to change drought and moisture availability patterns in sagebrush areas, which could cause additional loss of sagebrush habitats (Remington et al. 2021).
- **Free-roaming equids:** Without active management to reduce population growth, wild horse and burro populations could more than double in four years, exceeding the carrying capacity of rangelands including sagebrush and causing additional ecosystem degradation (Remington et al. 2021).

EXAMPLE PROJECTS

Name and Link	Location	Leading Organizations	Techniques Used	Size, acres	Cost, $	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Five Creeks Rangelands Restoration	Oregon	**BLM,** Harney County Soil and Water District	Mechanical removal of juniper trees, controlled burns, aerial reseeding	~75,000	>2 million	At least 10 years	Heavy grazing in the 1800s changed the plant community, allowing juniper to encroach and dominate. This also changed the fire regime, with many fewer fires in a juniper -dominated system. The project aimed to restore historical sagebrush habitat that would provide forage and habitat for important species, reduce erosion, enhance stream flows, and allow for easier animal movement.	No	Monitoring is underway
Anthro Mountain Greater Sage Grouse Habitat Restoration	Ashley National Forest, UT	USFS	Mechanical removal of pinyon and juniper trees using the "lop and scatter" method to remove the pinyon-juniper overstory without removing sagebrush and other understory species	1573	43,000 (for tree removal only)	1 year	Sage grouse seasonal habitat was being degraded through encroachment of pinyon-juniper. The project was completed to provide winter habitats for the greater sage grouse.	No	This project was a local test of the "lop and scatter" tree removal method, and results helped inform other restoration efforts

Name and Link	Location	Leading Organizations	Techniques Used	Size, acres	Cost, $	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Kelly Hayfields Sagebrush Habitat Restoration	Grand Teton National Park, WY	**National Park Service,** Grand Teton National Park Foundation, Teton Conservation District, **USFWS,** University of Wyoming	Removal of nonnative hay crop, collection and propagation of native seeds on- and off-site, replanting native species, ongoing removal of invasives	4500	400,000 annually (since 2007)	Ongoing (began 2007)	The project was meant to restore historical sagebrush habitat that had been converted to hay fields in the 1800s. The sagebrush areas are important habitat that benefit bison, elk, pronghorn, sage grouse, and songbirds.	No	Various restoration methods have been tested using adaptive management strategies.

Bolding indicates DOI affiliates.

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