Grasslands/Sagebrush Habitats
13. Grassland Conservation and Restoration

DEFINITION

Grasslands, often called *prairies* in the United States, are habitats where the dominant vegetation type is grass. Though trees may be present, there is often not enough precipitation to support a forest ecosystem. Grassland habitats are typically maintained through a combination of limited precipitation, fire, and grazing animals (National Geographic Society n.d., Buisson et al. 2022). Intact grasslands support high levels of biodiversity and have high conservation value from the numerous benefits they provide, including pasture forage, water regulation, erosion control, support for pollinators, and carbon storage and sequestration. However, grassland habitats have been severely degraded in many areas of the world and continue to be threatened by land cover conversion to agriculture, woody encroachment, altered fire and grazing regimes, urbanization, invasive species, and climate change (Buisson et al. 2022; Török et al. 2021). In the US Great Plains region, more than half the original grasslands have been lost (Buisson et al. 2022). Grassland restoration is important given the amount of these habitats that have been lost and the immense value they provide. Despite their value, there is relatively little focus on grassland restoration research compared to that for forests, wetlands, and rivers (Buisson et al. 2022; Török et al. 2021).

TECHNICAL APPROACH

Grassland restoration may seem simple. However, reestablishing "old-growth" grasslands (akin to old-growth forests) takes a lot of time and effort, and restored grasslands do not typically deliver all the same (or the same level of) functions as pristine grasslands (Buisson et al. 2022). Grassland restoration techniques vary depending on the beginning state of the target site; however, they typically involve three main steps: site preparation, plant/ seed selection, and revegetation (Gornish and Shaw 2017).

1. **Site preparation**: Site preparation involves management to create conditions conducive to native grassland vegetation. This typically involves addressing and mitigating key negative disturbances to the site (Gornish and Shaw 2017). Preparation of the site depends on findings of an initial site assessment that examines previous use of the site, soil moisture, slope, and existing vegetation (Phillips-Mao 2017a, b). Site preparation activities may include:

   • **Invasive species/weed management:** Native plants often will not establish on a site where invasive plants dominate. Therefore, invasive plants need to be removed from a site before revegetation can occur. Invasive removal can be done through use of prescribed burns, herbicides, mowing, or managed grazing. It is not unusual for multiple invasive control techniques to be required for a single site, and repeated treatments may be necessary. Additionally, timing invasive control techniques can be important to target invasive plants at particular life stages

(Gornish and Shaw 2017). If possible, spending two growing seasons on weed/invasive control at the beginning of a project can help prevent the invasives from returning to the site (Phillips-Mao 2017a, b).

- **Addressing compaction:** Soil compaction is often an issue at sites where intensive grazing has occurred or vehicles/farm equipment have repeatedly driven over the soil. Compaction can prevent root growth and water infiltration, which makes revegetation with native plants difficult. Compaction can be reversed by subsoiling or ripping the soil using a field cultivator or a ripper (Benson et al. 2011). Tilling the soil has been linked to changes in soil carbon, so decisions to till should be made with this in mind (Young et al. 2021).

- **Managing elevated nutrients:** In some cases, grasslands may be restored on sites where excessive nutrients were applied to the soil. To reduce nutrients in eutrophic soils, a variety of techniques can be used, including topsoil removal, high-yield crop cultivation to deplete nutrients, mulching, controlled burns, grazing, mowing, and haying (Lyons et al. 2023).

- **Addressing overgrazing:** Sites that have been overgrazed may require reduced grazing access or grazing exclusion, especially during early stages of a project (Dicks et al. 2020).

- **Hydrological restoration:** In some cases, the natural hydrology of a site may have been altered during historic land use and will need to be restored. This may involve removing water diversion structures such as ditches or drainage tiles (Phillips-Mao 2017a, b).

2. **Plant selection**: Choosing plants that will thrive at the restoration site is very important. Species should be selected based on site conditions (soil type, slope, aspect, elevation, presence of grazing, climate, and so on) as well as restoration goals. Look for local guidance regarding species mixes well-suited to the region and conditions of a particular site. For example, Appendix A of the Restoration Manual for Annual Grassland Systems in California contains detailed decision support for selecting plant mixes based on existing site conditions. Many state natural resource agencies have similar guidance. Using a nearby healthy grassland reference site can also be helpful in selecting a good plant mix. Selecting a diversity of species for planting is important to help provide a diversity of functional traits that enhance plant community stability as well as contribute to a variety of ecosystem services (Gornish and Shaw 2017). Plant selection can also be influenced by particular restoration goals. To support pollinators, selecting a mix of plants that flower at different times during the growing season can provide more consistent pollinator resources. To help control erosion, species that grow rapidly and provide fast ground coverage can be selected. For grazing support, plant mixes that have low toxicity, rapid establishment, high growth rates, and high protein content are best. To support carbon storage, seed mixes with a majority of perennial grasses combined with sufficient fertilization will help enhance carbon sequestration (Gornish and Shaw 2017).

3. **Revegetation**: After plants have been selected, they need to be seeded at the site. Timing of planting is important and local guidance about planting times should be

followed. It is possible to seed an entire restoration site, but also to seed a subset of site patches and allow natural regeneration across the entire site in following seasons (also called *strip seeding* or *spatially patterned seeding*). Seeds can be applied to the site in multiple ways, including broadcast seeding by vehicle or by hand, aerial seeding by aircraft, hydroseeding (spraying a slurry mixture of seed, mulch, and fertilizer), and drill seeding (dispensing seeds from a seed hopper on a tractor). Typically, grassland revegetation is accomplished using seeds because of cost constraints, but introducing established plants can help enhance restoration in some cases by providing erosion control, shade, landscape heterogeneity, and reducing the chances of exotic/ invasive reestablishment (Gornish and Shaw 2017).

OPERATIONS AND MAINTENANCE

Weed management is a key maintenance activity at restored grassland sites because early stage native plants are susceptible to competition by invasives. Weed management can be accomplished in a variety of ways, including selective herbicide use, burning, and mowing. Managing weeds will be most important in the first few years after revegetation (Gornish and Shaw 2017; Phillips-Mao 2017a, b).

FACTORS INFLUENCING SITE SUITABILITY

- ✓ **Historic grassland sites:** Typically, grassland restoration is successful on sites that historically have been grassland and have been either degraded or converted

- ✓ **Disturbance:** Grasslands are maintained through a disturbance regime that limits woody encroachment (e.g., limited precipitation, grazing, fire, and so on). The site should have either expected natural disturbance or sufficient funds to introduce disturbance that will maintain the restored grassland

- ✘ **Nearby herbicide use:** It can be difficult to establish native grasslands in areas with herbicide drift from neighboring crop fields.

TOOLS, TRAINING, AND RESOURCES FOR PLANNING AND IMPLEMENTATION

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
Restoration Manual for Annual Grassland Systems in California	Guidebook	2017	University of California, Division of Agriculture and Natural Resources	Designed for California but most of the information is more broadly applicable	This guide helps users select grassland restoration goals and implement those goals with technical guidance on grassland restoration activities. It also contains a guide to help with native plant selection for California sites.	✓	—	—	—
Shrub-Steppe and Grassland Restoration Manual for the Columbia River Basin and accompanying Case History Library	Guide-book, document	2011	Bonneville Power Administration, Washington Department of Fish and Wildlife, Bureau of Land Management	Designed for the Columbia River Basin, WA, but most of the information is more broadly applicable	This manual contains information useful for planning, implementing, and maintaining grassland restoration projects. The case history library documents learnings from case studies from the target region.	✓	—	✓	✓
Restoring Your Degraded Grassland to Conservation Prairie	Guidebook	2017	The Nature Conservancy	Designed for Minnesota but most of the information is more broadly applicable	This guide is targeted at landowners who want to transform their degraded grasslands into conservation prairies. It gives high-level guidance and helps set expectations for what such a project might entail.	✓	—	✓	—

LIKELY BENEFITS AND OUTCOMES

Primary objectives for each strategy are highlighted.

Climate Threat Reduction

- **Carbon storage and sequestration:** Most carbon storage in grassland systems takes place belowground—90% of carbon in these systems is stored as root biomass or soil organic carbon (Ontl and Janowiak 2017, Bai and Cotrufo 2022). Though intact grasslands typically store more carbon than restored grasslands, it has been found that management practices, including conversion of cultivated areas to grasslands, increasing plant diversity, sowing legumes and grasses, and fertilization can help enhance carbon storage and sequestration in restored grassland systems (Bai and Cotrufo 2022).

Social and Economic

- **Reduced erosion:** Grassland vegetation helps stabilize soil and reduce erosion, especially as compared to croplands (which is often an alternative land use for grassland sites) (Bengtsston et al. 2019).

- **Recreational opportunities:** Many popular recreational activities like birdwatching, hiking, and hunting take place in grassland systems (Bengtsston et al. 2019).

- **Agriculture and timber yields:** Where managed grazing is allowed on grassland systems, these habitats can provide important fodder to grazing livestock (Bengtsston et al. 2019).

- **Cultural services:** Grassland systems have been known to be associated with cultural heritage, containing certain sacred places and linkages to traditional livelihoods (Bengtsston et al. 2019).

Ecological

- **Enhanced biodiversity:** Healthy grasslands can host extremely high numbers of species, many of which are grassland specialists and endemics. High numbers of plant species can exist within a relatively small area, supporting high biodiversity and multiple ecosystem functions (Petermann and Buzhdygan 2021).

- **Supports wildlife:** Healthy grasslands host a species-rich wildlife community both below- and aboveground, with especially high numbers of insect species, including pollinators. Grasslands also host some of the last remaining populations of large mammalian herbivores as well as a wide variety of birds (Petermann and Buzhdygan 2021).

- **Enhanced soil health:** Grassland systems help maintain and improve soil health; the breakdown of grassland plants and roots after each growing season helps establish rich organic matter in the soil (Ontl and Janowiak 2017; Bai and Cotrufo 2022).

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 grassland conservation and restoration are included here.

- **Expense**

- **Capacity:** There has been relatively little research on grassland restoration, as opposed to restoration of other habitats like forests, wetlands, and rivers. Limited research restricts knowledge of how to effectively restore these habitats (Török et al. 2021).

- **Public opinion:** In some cases, it has been found there is relatively little public support for grassland restoration because grassland restoration benefits are not widely recognized (Lyons et al. 2023).

- **Conflict with other land uses**

- **Regulation**

- **Lack of effectiveness data**

Ecological

- **Establishment and disturbance:** Grassland restoration challenges include difficulty establishing native seeds successfully and difficulty establishing an appropriate disturbance regime for restored sites (Török et al. 2021).

- **Seed availability:** In some cases, a lack of availability of suitable native plant seeds has been reported as a challenge (Lyons et al. 2023).

- **Invasive species:** Removing and continuing to prevent intrusion by invasive species is a constantly cited challenge to grassland restoration (Lyons et al. 2023).

EXAMPLE PROJECTS

Name and Link	Location	Leading Organizations	Techniques Used	Size, acres	Cost	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Duralde Cajun Prairie Restoration	Evangeline Parish, LA	**US Fish and Wildlife Service (USFWS)**	Mechanical clearing of invasive trees, removal of levees, reintroduction of native plants through transplantation and seeding	334	Not provided	Not provided	Restoration of coastal tallgrass prairie that had been degraded from agricultural activity and livestock use	No	It was discovered that transplanted native plants survived better than seeded ones and that seeded areas took up to 10 years to recover.
Rotational Cattle Grazing to Restore Degraded Chihuahuan Desert Grasslands and Promote Watershed Health	Marfa, TX	Dixon Water Foundation, Rio Grande Joint Venture, Bird Conservancy of the Rockies, Borderlands Research Institute, Natural Resources Conservation Service	Introducing rotational grazing that mimics natural bison movement to prevent overgrazing and conversion of grasslands to bare ground	11,000	Not provided	Not provided	This restoration effort restored grasslands that had been degraded through many years of overgrazing by cattle. Rotational grazing restored the grassland habitat and prevented runoff and accelerated flows throughout the watershed.	No	Monitoring is ongoing to help with adaptive management.
Prescribed Burns for Grassland Management at the Sevilleta National Wildlife Refuge	Sevilleta National Wildlife Refuge, La Joya, NM	US Department of Agriculture—Forest Service, **USFWS,** University of New Mexico, Sevilleta Long Term Ecological Research	Prescribed burns to increase native grass cover in existing grasslands	>20,000	Not provided	Not provided	This grassland management activity (prescribed burning) has the primary goals of contributing to new knowledge on fire, increasing native grass cover, and identifying the most effective burn treatments to promote native plant communities	No	Various burn treatments are applied to contribute to knowledge about how to apply prescribed fire for effective native plant recovery

Bolding indicates DOI affiliates.

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