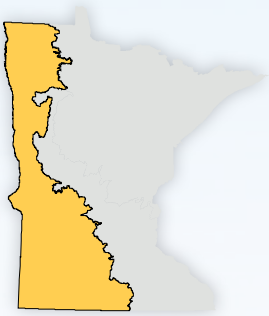
PRAIRIE PARKLAND AND TALLGRASS ASPEN PARKLANDS

PRAIRIES OF MINNESOTA
LANDOWNER
HANDBOOK



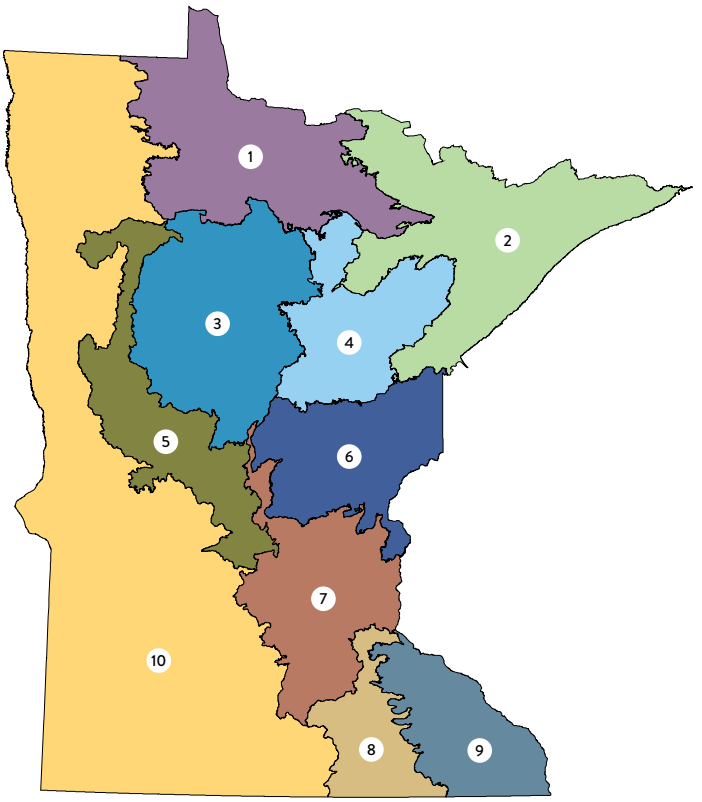
MINNESOTA DEPARTMENT OF NATURAL RESOURCES

About Prairies of Minnesota

This handbook is for people who own and/or manage prairie parcels in the prairie region of Minnesota which includes the Prairie Parkland and Tallgrass Aspen Parklands provinces (see map below, area 10) and throughout the rest of the state. It is an extension of the popular *Woodlands of Minnesota* Handbook Series, all of which are available at **mndnr.gov/woodlands**.

Areas Covered by Handbook Series

1. Agassiz Lowlands and Littlefork–Vermilion Uplands
2. Northern Superior Uplands
3. Chippewa Plains and Pine Moraines–Outwash Plains
4. St. Louis Moraines and Tamarack Lowlands
5. Hardwood Hills
6. Mille Lacs Uplands and Glacial Lake Superior Plains
7. Anoka Sand Plain, Big Woods, and St. Paul–Baldwin Plains and Moraines
8. Oak Savanna
9. Rochester Plateau and Blufflands
10. Tallgrass Aspen Parklands and Prairie Parkland



Cover photo credit: Fred Harris

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Introduction

Private landowners in Minnesota collectively own about 131,000 acres of the state's native prairie land, about 560,000 acres of the state's restored Conservation Reserve Program (CRP) grassland (USDA FSA, 2020) and thousands of acres of other grassland and wetland habitat. Private prairies and grasslands provide important benefits such as clean air and water, wildlife habitat, carbon sequestration, scenic beauty, recreation, and income. You, as a landowner, help enhance these benefits for yourself and for all Minnesotans through active involvement in caring for the health of your prairie.

The prairie landowner community is supported by conservation professionals from many private and public entities across the state. This book is a compilation of input from many conservation professionals as well as private landowners, it aims to provide resources to help you care for your land. Though it is not a comprehensive treatment of all subjects, this handbook contains pertinent background information, on-the-ground management strategies, and information on additional resources.

How to Use This Handbook

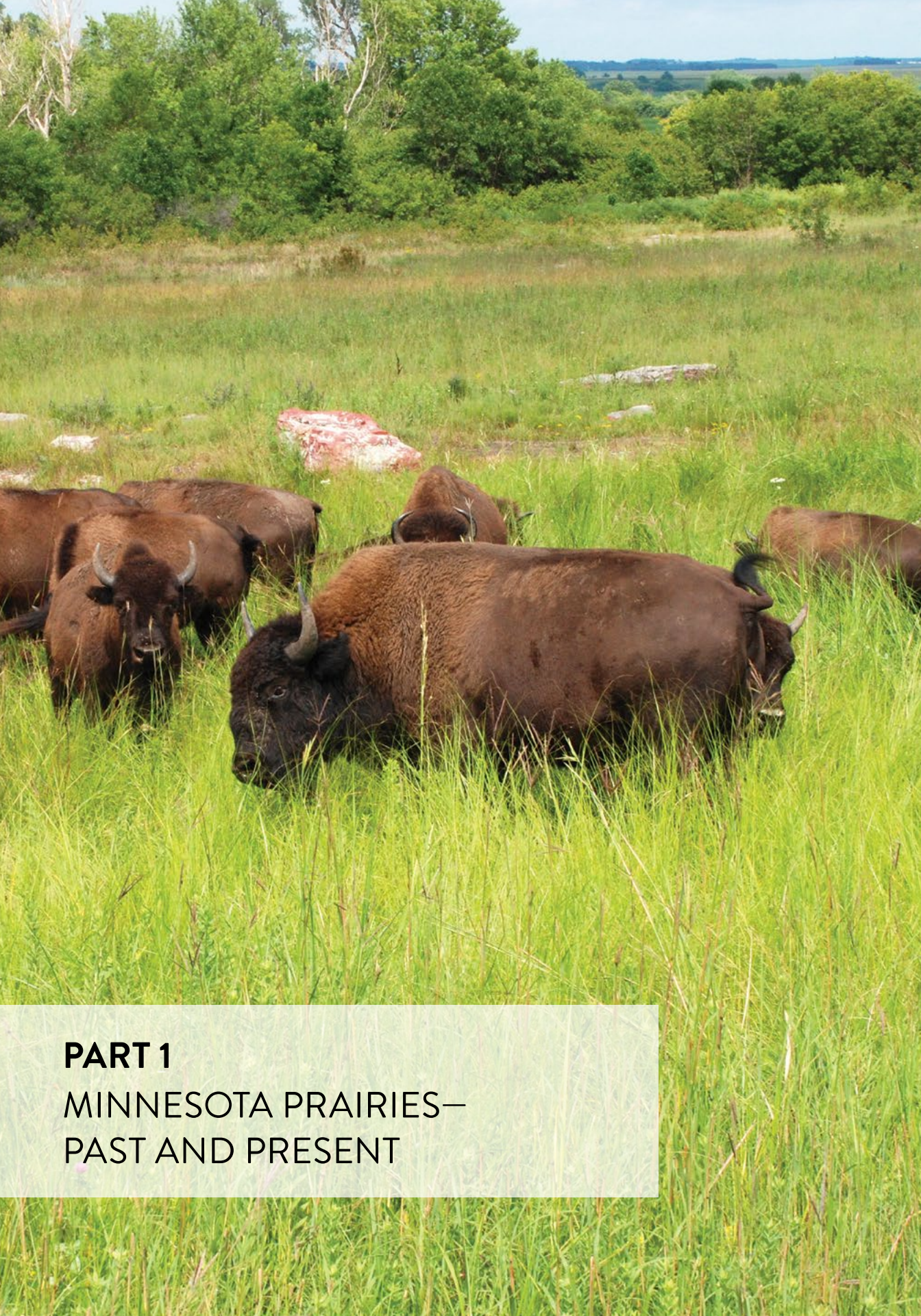
This handbook is intended to serve as both a reference and a workbook (Appendix D). As a reference, it provides information on the past and present status of land in the prairie region, types of prairies and other grasslands (along with special considerations for each), wildlife concerns in prairie landscapes, benefits of prairies, and challenges for management.

As a workbook, it offers practical resources to help landowners achieve their goals on their properties. This includes step-by-step guidance on addressing issues common to prairie environments, finding sources for advice and funding, and planning for the future.

This handbook also provides advice regarding specific management practices (see Part 3: Managing Your Prairie). These chapters are designed to give landowners a good overview of the practices, how they can help achieve desired outcomes, and things to consider when planning and implementing management activities.

Insights offered here can inform managers undertaking large-scale and small-scale initiatives. Readers are encouraged to reach out to agencies and resource professionals (see Chapter 13) at any point along the way for clarification or further information. The aim is to provide readers additional information and tools to help them succeed in their conservation efforts.

Photo credit on left: Katelin Goebel



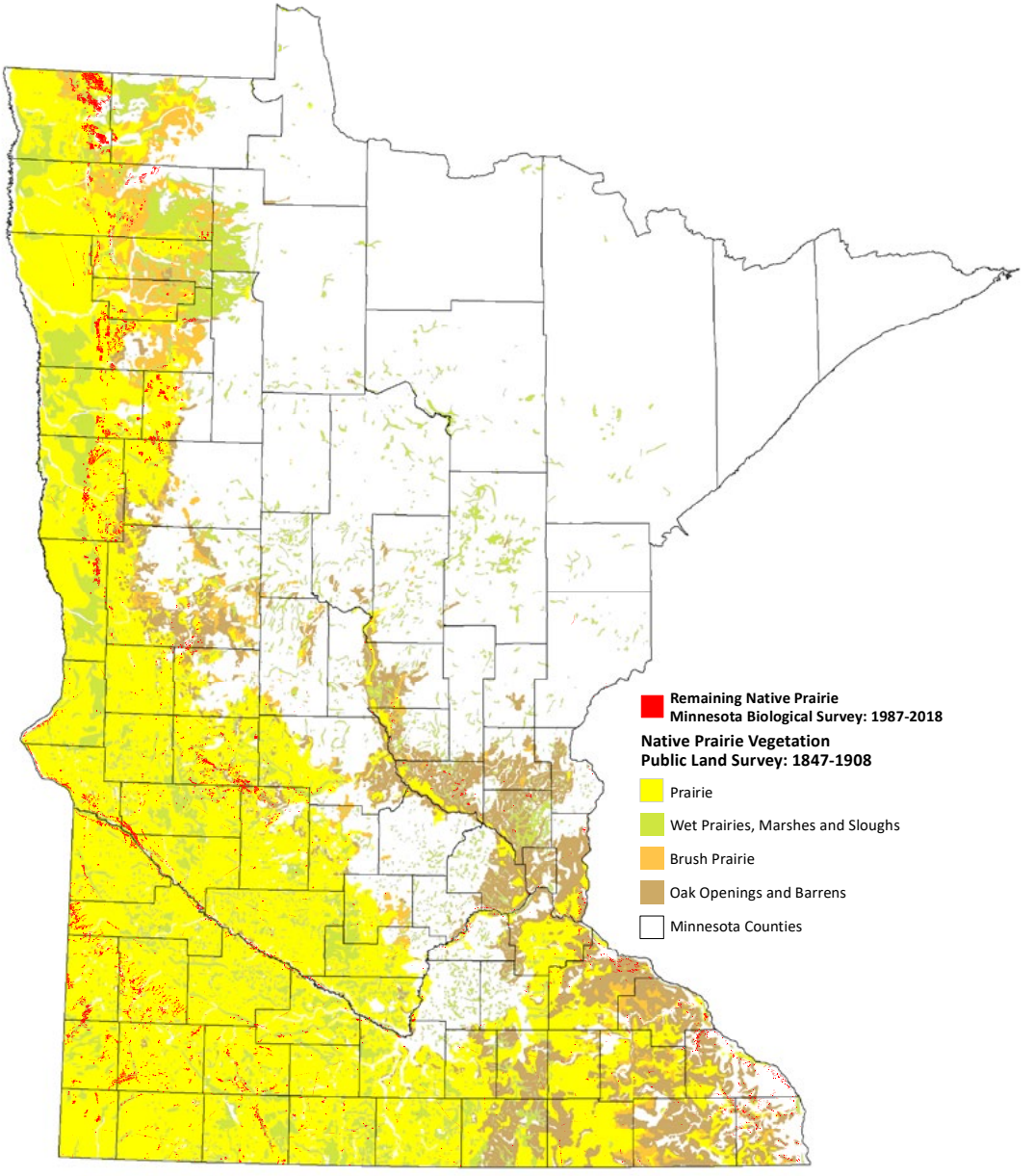
PART 1
MINNESOTA PRAIRIES—PAST AND PRESENT

Chapter 1: The Prairie Landscape

Prairies are Minnesota's native grasslands. Prairie ecosystems are dominated by native herbaceous (non-woody) perennial plants and occur where climate and disturbance regimes (such as fire and grazing) favor grasslands over forests (Anderson, 2006; MN DNR, 2005).

A prairie landscape includes a dynamic mix of interacting ecosystems, relationships, and processes developed over hundreds to thousands of years. A landscape is far more than the sum of its parts, with properties and functions beyond those of its individual components. For example, many wildlife species associated with grasslands, such as the greater prairie chicken, need multiple community types to complete their life cycles (see Spotlight on page 32). Along with its component elements—prairies, wetlands, woodlands, rock outcrops, and other native plant communities—the prairie landscape also includes humans.

Prairies in Minnesota once covered about 1,888,000 acres (29,500 square miles), which is a little over a third of the state (MN DNR, 2005). Today, prairie communities in Minnesota cover about 250,000 acres, or about 1–2 percent of their historical area, and much of what remains is degraded or threatened (Minnesota Biological Survey, 2017). Prairies are recognized as one of the most threatened ecosystems in North America (Sampson et al., 2004), and temperate grasslands as one of the most endangered in the world (Heidenreich, 2009; White et al., 2000).



Map comparing the prairie that existed during the 1847-1908 Natural Prairie Vegetation Public Land Survey (~1,888,000 acres) compared to the prairie mapped by the Minnesota DNR Biological Survey during the 1987-2018 survey (~250,000 acres).

Much of the state's area that was historically occupied by prairie has been converted to other land uses (agriculture, development, mining, etc.). Waterways have been diverted from their natural paths and wetlands have been drained. Roads, agriculture, and development divide the land and have left remnant prairies isolated from one another, compromising the continuity of habitat. Nutrient cycles, climate patterns and the growing season have changed. Critical natural disturbance regimes that maintained the prairie landscape have been interrupted: the lack of fire, in particular, has allowed woodlands to overtake former grasslands. These altered conditions can give increased competitive advantage to non-native invasive species, compromising the diversity of prairie ecosystems.

The prairie region of Minnesota (including The Prairie Parkland and Tallgrass Aspen Parklands Provinces) is mostly the western and south-central part of the state (see map, area 10 on page 2). Prairie ecosystems also occur in southeast and central Minnesota where local factors, such as soils and slopes, favor grasslands.

A **native prairie plant community (remnant prairie)** is a grassland dominated by original native prairie vegetation usually occurring where the sod has never been broken (MN DNR, 2005). In native prairies, grasses and grass-like plants generally make up the bulk of the biomass, and forbs (wildflowers and herbs), make up the majority of the plant species diversity. Prairies are complex ecosystems with plants, fungi, insects, birds, mammals, and many other organisms that interact with each other and their environments in a web of intricate relationships developed over hundreds to thousands of years.

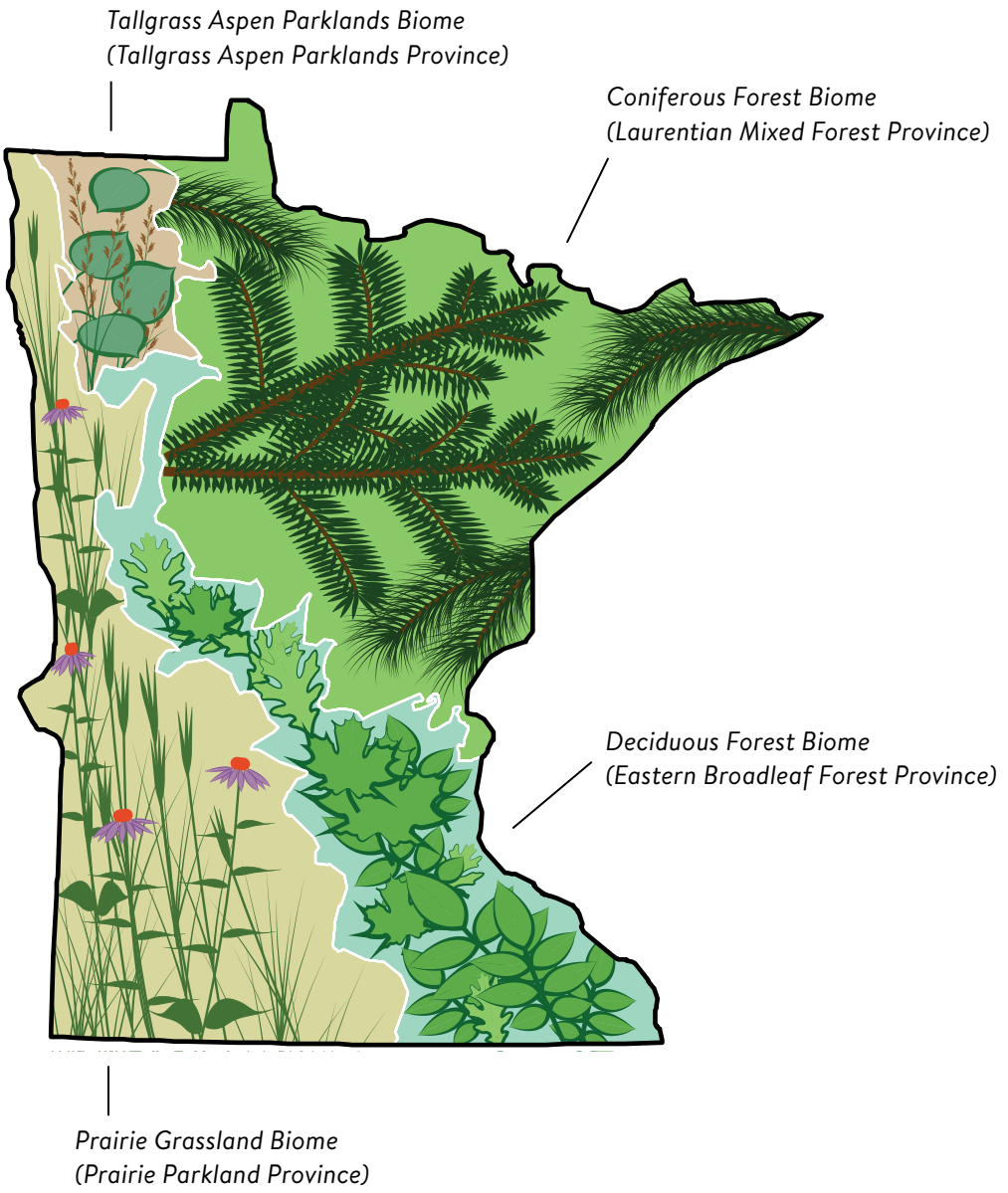
Not all grasslands are native prairie: old fields, conservation plantings, restorations, and biomass plantings are examples of grasslands that are not native prairie. These other grasslands provide various benefits at both the local and landscape scales, but they do not have the full biodiversity and functions of true native prairie.

The purpose of this handbook is to help landowners plan and execute grassland management, with an emphasis on the management of native prairie communities. As true native prairies are now rare in Minnesota, it is important to preserve and manage them to promote their long-term health and persistence.

How We Classify Prairies Today

Minnesota ecologists use an ecological classification system (ECS) to identify patterns in the landscape. This system is hierarchal and divides the state's lands into progressively smaller areas based on similarities and differences in climate, geology, natural features, and types of vegetation. The largest units of the ECS in Minnesota are four provinces, which follow the major biomes (MN DNR, 1999).

MINNESOTA BIOMES MAP



Ecological Classification System

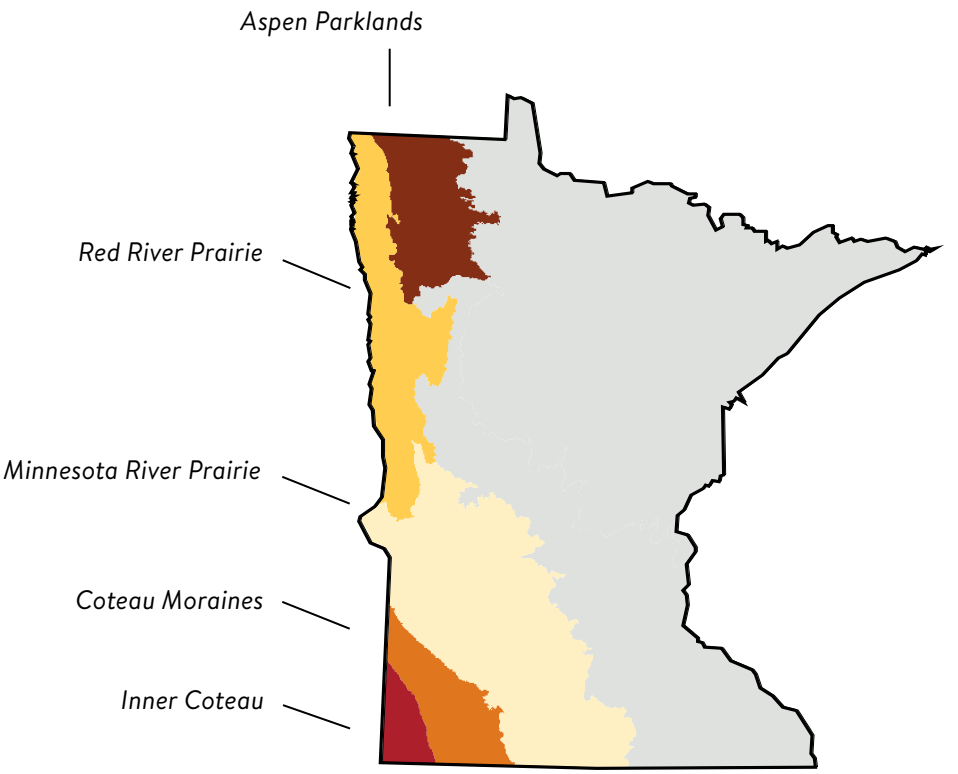
This handbook covers prairies in the Prairie Parkland Province and the Tallgrass Aspen Parklands Province and to a lesser extent, the Eastern Broadleaf Forest Province.

Minnesota's four provinces are divided into 10 sections and further divided into 26 subsections. The subsections where prairie is a major component of the landscape include:

- Inner Coteau Subsection
- Coteau Moraines Subsection
- Minnesota River Prairies Subsection
- Red River Prairie Subsection
- Aspen Parklands Subsection

More information on the Ecological Classification System and the prairie subsections can be found in Appendix A.

ECOLOGICAL CLASSIFICATION SYSTEM—PRAIRIE SUBSECTIONS



Minnesota Ecological Classification System Map with Inner Coteau, Coteau Moraines, Minnesota River Prairie, Red River Prairie and Aspen Parklands Subsections highlighted.

Exploring Your Property: Native Plant Communities

When people first begin to get acquainted with prairie, it is often by learning to recognize individual species: the tall, purple-blue "turkey foot" grass seed head of big bluestem, or a showy wildflower such as butterfly weed.

In time, as the number of familiar plants grows, it becomes apparent that certain prairie plants tend to be found together, in particular types of habitat, under certain conditions. One can start to anticipate the kind of place where a given species may be seen, and become aware of other species that will likely be in its company.

These patterns and associations are at the heart of the native plant community concept. A **native plant community (NPC)** is a group of coexisting native plant populations that interact with one another and their environment and have not been significantly altered by human activities or introduced species. Native plant communities form recognizable units that repeat over space and time with a similar expression (MN DNR, 2005).

If a landowner is interested in maintaining or restoring prairie, one of the first things they should do (or to ask a natural resources professional to help with) is determine whether native plant communities are present on the property, and if so, their ecological condition. Some tips to help determine whether a grassland is native prairie are given in Appendix C. The plant communities that are present, and their quality, are important considerations when determining desired outcomes and management strategies. For example, grazing can be a good management tool for moderate quality prairies, but may degrade high quality sites if not carefully applied.

In addition to remnant native prairie grassland communities, there are many non-prairie grassland habitats. Examples of non-prairie grasslands include conservation plantings, old fields, restorations/reconstructions, and biomass

Photo credit: Fred Harris

plantings. Non-prairie grasslands are beneficial in many ways, but they do not have the full biodiversity and functions of true native prairie. Some management strategies that are beneficial for non-prairie grassland may not be appropriate for high quality remnant prairies. For example, adding food plots can improve wildlife habitat in non-prairie grasslands, but remnant prairie should never be destroyed for food plots.

The **Minnesota Biological Survey (MBS)** classifies Minnesota's native plant communities based on the plant species that are present and the factors—such as moisture, nutrients, and floristic region—which contribute to the flora (MN DNR, 2005). The classification structure developed by MBS for use in Minnesota defines system groups based on general vegetation structure and hydrology; each system group includes one or more distinct native plant communities. A given species may be found in multiple native plant communities, but the more dominant species usually differ between community types. In the field, gradual transitions between native plant communities can create challenges in mapping. In some cases, ecologists will define sites as a complex of multiple communities.

The prairie native plant communities in Minnesota include Upland Prairie Systems (including dry prairie, mesic prairie, and savanna communities), and wetland prairie communities. In addition to these prairie communities, other NPCs are part of the prairie landscape. Prairie wet meadow/carr, prairie marshes, prairie fens, and rock outcrop communities are locally important communities that are part of the prairie landscape. Woodland communities are also part of the prairie landscape and historically occurred in areas protected from fire. In the modern landscape, woodlands have expanded into prairies due to climate changes, introduced species, plantings, and lack of disturbance.

Native Plant Communities That Are Most Associated With Minnesota's Prairie Regions

Dry prairie communities are dominated by mid-height grasses, many of them bunch grasses like porcupine grass, prairie dropseed, little bluestem, plains muhly, and the grama grasses. Tall prairie grasses are also often present, but less dominant than they are in mesic and wet prairies, where more soil moisture is available. Some commonly abundant wildflowers are pasque flower (or prairie crocus), pale purple coneflower, silky aster, stiff goldenrod, sages, dotted blazing star, and prairie smoke. Dry prairie communities are often found on steep slopes with coarse, well-drained soils, and the plants that inhabit them are adapted to dry conditions.

HABITAT SPOTLIGHT

Dry Hill Prairies

Dry hill prairies are found throughout the Minnesota Prairie Region and range from beach ridge prairies in the northwest, to hillside prairies in the Minnesota River Valley, to bluff prairies in the southeast. The hillside position, especially when combined with a southern or western exposure, leads to the drier conditions in which these communities occur. Hill prairies are grass-dominated but rich in forb species. Side-oats grama is a common grass in these communities throughout Minnesota.

Photo credit: Kelly Randall

Dry savanna communities have a mix of herbaceous plants similar to dry prairies, but also have scattered trees. Tree cover usually consists mostly of bur oak, but in southeastern Minnesota can sometimes include considerable black oak, pin oak, or jack pine (MN DNR, 2005). Trees have an open-grown form and are spreading and gnarled. Pockets of woodland (with over 50% tree cover) can be common on north-facing slopes. Savannas require some disturbance, such as fire or grazing, or they can quickly succeed to woodlands. Mesic savannas also occurred historically in Minnesota, though they are now thought to be all but gone due to conversion for other land uses, alteration of the disturbance regime, and succession to forest.

Mesic prairie communities are usually dry through most of the year with the water table below the rooting zone, but with adequate water held in the soil. Mesic prairie communities are dominated by the tall grasses big bluestem and Indian grass, but also can have prairie dropseed, porcupine grass, little bluestem, and switchgrass. Abundant wildflowers include Maximilian sunflower, heart-leaved alexander, goldenrods, purple and white prairie clovers, smooth blue aster, tall meadow-rue, and wood lily. The short shrubs leadplant, prairie rose, and wolfberry are often also present. These prairies can look very different in drought years versus wet years when different plant species are favored (MN DNR 2005). In southern Minnesota, mesic to dry-mesic prairies can be habitat for the federally threatened prairie bush clover (MN DNR, 2018).

Know Your Plants: Wood Lily (prairie lily)—*Lilium philadelphicum*

Wood lily is most commonly found in mesic prairies, but can grow in other habitats. On the open prairie it stands out with its vivid orange, six-parted flowers. It is the only native lily in Minnesota that holds its flowers upright; the others have nodding, downward-facing blossoms. Wood lily is sensitive to some unnatural disturbances (such as heavy grazing) and is a good indicator of a high-quality native prairie.

Wood lily

Photo credit: Curt Vacek

Wet prairie communities are characterized by tall grasses and sedges, but can have about equal cover of wildflowers. Big bluestem and prairie cordgrass often dominate but switchgrass, Indian grass, narrow reedgrass, mat muhly, and a number of sedges can also be abundant. Commonly abundant wildflowers include tall blazing star, goldenrods, tall meadow rue, white panicled aster, clasping dogbane, and Virginia mountain mint. Wet prairies usually have surface saturation for only short periods of the year and the water table generally stays within the rooting zone, so in average years the plants face neither desiccation (excessive drying) nor soil anoxia (deprivation of oxygen). The invasive reed canary grass is a serious threat to wet prairie communities. Especially in northern Minnesota, wet prairies can have a significant shrub cover of bog birch, red osier dogwood, and willows (MN DNR, 2005). Wet prairies can be habitat for the western prairie fringed orchid, a species federally listed as endangered (MN DNR, 2018).

Know Your Plants: Maximilian Sunflower—*Helianthus maximiliani*

Photo credit: Rhett Johnson

Maximilian sunflower is a common wildflower of mesic and wet prairie communities. It can grow up to 9 feet high and can have dozens of flower heads, each over 2 inches wide with vibrant yellow ray petals. The leaves distinguish this species from other sunflowers in Minnesota: rough and sickle-shaped, with a fold down the middle.

This showy sunflower is named for Prince Maximilian of Wied-Neuwied, a German prince who led an expedition across the Great Plains in 1832. Among other things, the expedition catalogued the diversity of plant and animal species encountered and, famously, documented the native peoples of the Great Plains and their cultures.

Prairie wet meadow/carr communities are characterized by mid-height to tall graminoids (grasses, sedges and rushes), including prairie cordgrass, narrow reedgrass, Sartwell's sedge, Buxbaum's sedge, and wooly sedge. Tussock sedge or Canada bluejoint are sometimes dominant. Common wildflowers include giant and sawtooth sunflowers, white panicled aster, water smartweed, swamp milkweed, water hemlock, wild mint, and spotted Joe Pye weed. Prairie wet meadow/carr communities are found in lowlands around waterways, shallow swales, and depressions—frequently occurring in complexes with wet prairie and marshes. They are generally inundated in the spring and after heavy rains, and the water table is near the surface most years. They are dry enough, however, that organic matter decomposes and peat soils do not form (MN DNR, 2005). "Carr" refers to a shrubby wetland. The combination of wet meadow/carr refers to the community having no distinct cutoff between wet meadow and carr in Minnesota. The shrub cover can vary from dominant to absent and it is often highly variable across a site.

HABITAT SPOTLIGHT

Calcareous Fens

Calcareous fens are rare wetlands that occur where mineral-rich groundwater discharge is the primary source of water. The cold, calcium-rich water creates conditions for specialist plants, many of them quite rare and found nowhere else. Calcareous fens are peat-accumulating communities and some have been found to be 10,000 years old. Minnesota's prairie region is notable for having a significant number of these globally rare systems.

Photo credit: John Pearson

Rock outcrop communities are an important facet of the prairie landscape in some regions of Minnesota. These sparsely vegetated plant communities are associated with level or sloping bedrock exposures. Where soil is thin and prone to extreme drying, plants such as brittle cactus may be found. Where soil is sufficient, these communities may support species of dry prairie, such as hairy grama, little bluestem, Junegrass, and bracted spiderwort.

In the Minnesota River Valley, for example, rock outcrop communities occur on exposures of ancient bedrock unearthed by Glacial River Warren. The unique communities associated with rock outcrops are among the state's rarest natural features (Minnesota County Biological Survey, 2007). Vulnerable to mining, they have been the focus of several conservation efforts.

More information on the native plant communities of Minnesota can be found at **mndnr.gov/npc**

Photo credit: Kelly Randall

Rare Features of Minnesota's Prairie Region

Rare features can include species of plants and animals as well as animal aggregations (such as prairie chicken booming grounds), and geologic features that are uncommon, vulnerable, and warrant special protection and consideration in management. In Minnesota, rare species of plants, fungi, and animals are categorized as **endangered, threatened,** or **special concern**. This status is based on how uncommon a species is (its rarity), its distribution in the state, and its vulnerability to extinction. The state's Wildlife Action Plan also identifies **Species of Greatest Conservation Need (SGCN),** which are animals whose populations are rare, declining, or vulnerable to decline and are below levels that would ensure their long-term health and stability.

Prairie is home to many of Minnesota's rare species, some of which are found in no other habitats in the state. Populations of rare species that occur in small or isolated remnant prairies are particularly at risk because they may not have the numbers to recover from losses or the possibility of immigration from outside populations. Since many rare species are associated with prairies, their needs should be considered when planning and implementing management. Federally-listed rare species that occur in Minnesota's prairies include the western prairie fringed orchid and prairie bush clover (both listed as threatened), and a number of butterflies including the Poweshiek skipperling (listed as endangered) and Dakota skipper (listed as threatened).

Native plant communities are also assigned conservation status ranks by the DNR, based on an assessment of their risk of extinction. It is notable that nearly all of the native plant communities in the state's Upland Prairie System are ranked S1 (critically imperiled) or S2 (imperiled).

The loss of grassland habitat has been linked to steep declines in many bird species, even those once common and widespread. A 2019 report in Science found that populations of birds have declined more in grasslands than in any other biome in the United States and Canada. According to the report, "Across breeding biomes, grassland birds showed the largest magnitude of total population loss since 1970—more than 700 million breeding individuals across 31 species—and the largest proportional loss (53%)" (Rosenberg et al., 2019).

Landowners can make a valuable contribution to helping rare species by protecting existing prairie remnants on their land, restoring altered sites to native vegetation for wildlife habitat, and adopting management practices on remnant prairies and adjacent properties that foster rare species.

Select resources for more information on rare features:

- State-listed endangered and threatened species are afforded certain protections under the law. The Minnesota Department of Natural Resources' (MN DNR) responsibility to conserve rare features is described in Minnesota Statute 84.0895 at **revisor.mn.gov/statutes/cite/84.0895**
- Comprehensive information about the biology, habitat, and conservation of rare species may be found in the Minnesota DNR's rare species guide at **mndnr.gov/rsg**
- Information on Species of Greatest Conservation Need may be found in Minnesota's Wildlife Action Plan at **mndnr.gov/mnwap**
- State and global Conservation Status Ranks of native plant communities may be found at **mndnr.gov/npc/status.html**

Know Your Plants: Western Prairie Fringed Orchid—*Platanthera praeclara*

Western prairie fringed orchids are striking flowers found almost exclusively in high quality remnant wet and mesic prairies and prairie wet meadows. In flower, it is very distinctive, with clusters of up to 20 or more bright white flowers that have long nectar spurs. Prairie fringed orchids are listed as state endangered and federally threatened. Minnesota has some of the largest remaining populations of this species, and monitoring efforts here have found that individual plants can live over 25 years. The flowers have a sweet, delicate fragrance that becomes stronger after nightfall, when its hawkmoth pollinators are active.

Photo credit: Rhett Johnson

Challenges to Prairie Conservation

Many of the issues faced by conservation-minded managers and landowners in prairie regions are not unique to prairies, however each must be considered through the lens of the grassland ecosystem in order to set priorities and choose optimal management strategies. Here, we discuss some common concerns that warrant attention. See Part 3: Managing Your Prairie, for step-by-step guidance and resources.

Habitat Loss: Fewer Acres, Farther Between

The fragmentation of the formerly contiguous prairie extending for miles into smaller, isolated patches has resulted in the remaining remnants having a greater "edge to area" ratio. Even the most interior part of a small prairie remnant may be relatively near a boundary and subject to impacts from surrounding lands.

Among the effects of prairies being broken into smaller pieces (or patches) is a reduction in grassland bird species, including grasshopper sparrows, bobolinks, upland sandpipers, western meadowlarks and dickcissels. Nebraska researchers looking at wet meadow grasslands in the floodplain of the central Platte River concluded "species richness [the total number of bird species present] is maximized when patches are large, greater than 50 hectares [123.5 acres], and shaped so that they provide abundant interior areas, free from the impacts of edges" (Helzer & Jelinski, 1991).

Smaller patches with a greater edge to area ratio are also more likely to be negatively impacted by surrounding land use. This means easier access for invasive species and predators (including feral animals), greater likelihood of pesticide drift, exposure to excess nutrients carried in runoff, and development-related disturbance such as alterations to hydrology from roads.

Native plant and animal species once able to expand their range, increase in population, or temporarily relocate during a fire or other disturbance may not find suitable habitat nearby.

Strategies to address these challenges include:

- Restoration of adjacent lands to grassland and the creation of corridors with grass-based land use to offer connection between "core" native prairie remnants.
- Leaving undisturbed habitat when implementing management practices such as fire and haying to ensure suitable refuge habitat is retained for nesting birds and low-mobility organisms.

Water Pollution and Changes to Watersheds

The health of prairie landscapes is closely tied to the health of the surface- and groundwater systems in which they are found.

According to the Minnesota Pollution Control Agency's (MPCA) 2020 Impaired Waters List, more than half of Minnesota's lakes, rivers, streams and other waters are classified as "impaired" or polluted (Minnesota Pollution Control Agency, 2020). Degraded water quality is widespread, yet more prevalent in the southern part of the state. Eighty-five percent of Minnesota's impairments are due to nonpoint source pollution, which comes from diffuse sources rather than specific locations. Nonpoint pollution includes nitrogen, bacteria, chloride, phosphorus, and excess sediment (Minnesota Pollution Control Agency, 2020).

Water quantity and rates of runoff are of particular concern. Watersheds across southern Minnesota have seen an increase in the amount of flow (or discharge) which cannot be accounted for by increases in precipitation alone. Fluctuating water levels and/or sustained high water can have drastic impacts on prairie, agricultural land, infrastructure, and residences.

Why is more water coursing through these systems at a faster rate? Alterations to watersheds have decreased the storage capacity of the landscape. Contributing factors include loss of wetlands and perennial cover, channelization and drainage, impervious surfaces, and storm sewers. Many prairie pothole wetlands, which were isolated basins that held water, are now connected to and drain into streams and rivers. According to the Minnesota Altered Watercourse Project, 49.6% of streams in the State of Minnesota have been altered to some degree (i.e., ditching, straightening or channelization) by human activity (Minnesota Pollution Control Agency, 2013). Together, these alterations force the rivers to carry a greater volume of water in a shorter period of time, increasing the risk of downstream flooding.

Many native plant communities associated with prairie landscapes are sensitive to changes in the volume, flow, and quality of water sources. Calcareous fens and seepage wetland communities, for example, rely on upwelling flows of mineral-rich groundwater. Local and regional pumping and other diversions of water can effectively eliminate these communities by decreasing flows below the amount needed to support their species. Alterations to hydrology and associated nutrient pollution and sedimentation can also contribute to non-native species invading native plant communities. Reed canary grass and non-native cattail are known to spread and overtake wetlands with increased sediment and nitrogen inputs (Green & Galatowitsch, 2001; Werner & Zedler, 2002).

Wildlife that utilize prairie wetlands are also impacted by degraded water quality resulting from sediments carried in runoff. A report on wetlands in the prairie pothole region in the north central states by the U.S. Environmental Protection

Agency noted, “In virtually all cases, sedimentation diminishes all natural functions of wetlands. It does so mainly by impeding water circulation, infiltration, oxygen exchange, and light penetration. Moreover, much sediment runoff contains adsorbed contaminants.” Invertebrates, fish, and entire food chains associated with these wetlands may be impacted, including herons, grebes, and waterfowl (Adamus, 1992).

Such water-related concerns can and do negatively impact prairie landscapes and present challenges to land managers. These concerns can also serve as justification for increased support of prairie conservation efforts, since grassland landscapes are part of the solution to many of the state’s water problems. See Benefits of Prairie in Chapter 2.

Invasive Species in Prairie Landscapes

As defined in state statute (Minnesota Statute 84D.01), invasive species are species that are not native to Minnesota and cause economic or environmental harm or harm to human health. They can occur on land or in the water. Non-native, invasive plant species that degrade prairies include but are not limited to: smooth brome, Canada thistle, Kentucky bluegrass, reed canary grass, wild parsnip, Queen Anne’s lace, leafy spurge, spotted knapweed, crown vetch, common buckthorn, Siberian elm, and Russian olive.

Invasive species represent one of the greatest threats to the remaining prairies in Minnesota and across the prairie region. They can negatively impact prairies by:

- Reducing native plants and the wildlife that depend on them for food and cover.
- Changing ecosystem processes such as altering fire regimes, changing nutrient availability in the soil, excessive shading, or increasing erosion.
- Reducing the availability of suitable forage for grazing animals.
- Creating favorable conditions for additional invasive species.
- Limiting seedling establishment and restoration efforts.
- Requiring ongoing, costly maintenance that uses resources that could otherwise be devoted elsewhere.

Native woody vegetation also encroaches and spreads in prairies and, if unchecked, can alter the open conditions required for native prairie species and communities to thrive. These include trees and shrubs such as eastern red cedar, sumac, dogwood, willows, cottonwoods, green ash, and aspen.

See Chapter 7 for a detailed discussion of control measures for non-native and native species managed in prairie settings and Chapter 8 for more information on woody encroachment.

A Changing Climate

Minnesota's climate is changing rapidly, and more changes are coming. In the past several decades our state has seen substantial warming, along with increased precipitation and more extreme storm events.

Minnesota's prairie regions have warmed by an average of over 2°F since 1970. This warming has been observed in every season, but is most pronounced at night and during winter. For the period 1970 through 2019, average daily low temperatures increased more than twice as fast as average daily high temperatures, and winter temperatures increased about ten times faster than summer temperatures. Winter nights have warmed the fastest, with December through February low temperatures increasing by an average of 5.7°F across Minnesota's prairies. The observed warming patterns vary from north to south, with the fastest warming for all seasons seen in northern areas.

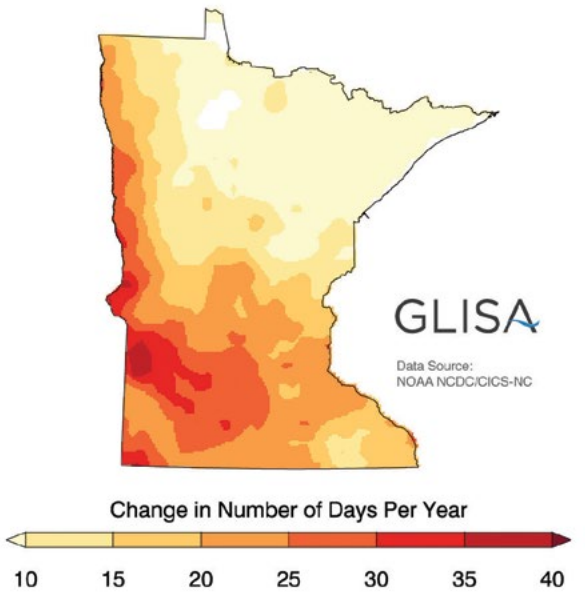
Minnesota's prairie regions have become wetter as well, with annual precipitation increasing by an average of 4 inches between 1970 and 2019. Heavy precipitation events have also become more frequent and more intense, with daily precipitation totals of at least 1 inch now 15–30 percent more common than they were in the middle of the 20th century. The observed precipitation increases have been much faster in Minnesota's southern prairie regions than in northern areas. In fact, far northwestern Minnesota gained an average of 0.55 inches of annual precipitation between 1970 and 2019, but southwestern Minnesota gained 6.1 inches of annual precipitation during that same period.

More climatic changes on the way for Minnesota's prairies

Located in the middle of the continent, half-way between the equator and the North Pole, our region is highly sensitive to large-scale climatic changes, and since 1970 has warmed 40 percent faster than the global average. With continued global temperature increases expected, virtually all climate model scenarios run at a wide variety of scales project that Minnesota will get much warmer in the decades ahead, including during the summer, with increased heat extremes by the middle of this century, if not sooner (Prior et al., 2014; Angel et al., 2018). The heat extremes expected in Minnesota's prairie regions are projected to get hotter, sooner than those in others parts of the state.

Climate models run for the Midwest Chapter of the 2014 National Climate Assessment indicate that even with a lower emissions scenario, western Minnesota could see a doubling of the annual number of 90-degree days by the middle of the century (Pryor et al., 2014).

PROJECTED CHANGE IN THE NUMBER OF DAYS OVER 90° FAHRENHEIT
PERIOD: 2014–2070 | LOWER EMISSIONS: B1



Courtesy of: Great Lakes Integrated Sciences and Assessments (GLISA)

The same models project not just more precipitation, but also more heavy and extreme precipitation. Minnesota will, of course, continue to have a highly variable climate, meaning that even as we see overall warmer and wetter conditions, we will still have some cool years, some dry years, and even some significant drought.

What will these climatic changes mean for Minnesota's prairies? Many changes are happening at an accelerated pace, making it extremely difficult for land managers to predict and adjust management regimes in a timely enough fashion, if it is possible to account for the change at all. Climate change is especially problematic when it favors invasive species over natives. For example, smooth brome (a cool-season non-native grass) has been increasingly abundant in Minnesota prairies over the last decade. Smooth brome greens-up early in the year, and benefits from warmer winters and springs and increased spring rainfall. It also photosynthesizes more efficiently under increased atmospheric carbon dioxide. Compounding the problem, increased spring precipitation complicates fire, mowing and haying management, and may reduce the effectiveness of those controls on smooth brome.

Chapter 2: Why Your Prairie Matters

In addition to their intrinsic value and their role in providing essential habitat for native plant and wildlife species, prairies provide an array of benefits to people and the landscape, many reaching beyond property lines. Appreciation of prairies has grown with greater understanding of these societal benefits, commonly described as "ecosystem services."

Benefits of Prairies to You and Your Community

Prairie landscapes provide benefits to surface water and groundwater quality, flood moderation, carbon sequestration, and outdoor recreation-based tourism. These values have important economic, public health, and quality of life implications for surrounding local communities.

Consider the Work That Prairies Do

Erosion control, soil stabilization, soil-building

The perennial cover of grasslands stabilizes the soil, limiting loss of sediment in runoff and reducing gullying. This is particularly important in areas with steep terrain and in riparian areas (areas around rivers and streams) that are prone to erosion. Decomposition of prairie plants following each growing season also rebuilds valuable topsoil.

Flood Moderation, Water Storage

Due to expansive root systems, the majority of prairie plant biomass exists below ground. This makes soils well-aerated, well-bound, and capable of conducting gas and moisture. When these root systems decay, tiny canals are created throughout the soil which serve to enhance infiltration and water storage capacity. The perennial above-ground vegetation of a prairie slows surface runoff, while its below-ground structure holds and stores water.

The same qualities that make a prairie resilient in times of drought can benefit human communities by lessening the impacts of flooding. Hydrological research on U.S. rivers has demonstrated that the absence of native vegetation is accompanied with a dramatic increase in flooding (Apfelbaum, 1993). Protecting and restoring native vegetation on prairie landscapes can help to prevent flood-related property damage and reduce the need for costly flood control infrastructure.

Photo credit: Minnesota DNR River Ecology Unit

Groundwater benefits

Nearly all water that falls on prairie is either absorbed directly into plants, or channeled deep into the soil. This benefits both local and landscape-scale groundwater recharge and filtration. In agricultural regions, this helps to mitigate the impacts of tillage, tiling, ditching, and soil compaction, which can disconnect these recharge pathways.

Promoting surface water quality

Wetland communities and perennial grasses in riparian (stream side) areas can improve water quality downstream—though this can come at a cost to the prairies and wetlands receiving the runoff, sediments and pollutants. Researchers have estimated that nitrate loading to the Gulf of Mexico could be reduced by 300,000 to 800,000 dry metric tons per year (1.4–3.8%) by creating or restoring wetlands and riparian buffers of perennial grasses on 0.7–1.8% of the land in the Mississippi River Basin (Kreig et al., 2019).

Photo credit: Kristy A. Cowdin

Source of forage/hay

When carefully managed to retain ecosystem health (See Chapters 5 and 6), remnant native and restored prairies can be a source of forage and hay, important resources in agricultural settings.

Storehouse of biodiversity

At its most basic, the term "**biodiversity**" is an expression of the variety, or diversity, of life. Ecologists study and view biodiversity at different levels. These include species, genetic, and ecosystem levels, as well as functional diversity (the range of behaviors and roles of species within their communities). Greater biodiversity has been associated with values such as stability, biomass productivity, and resilience of ecosystems (Tilman & Downing, 1994). Humans, as organisms, are reliant on many of the same systems that support all life on Earth for their well-being.

Prairies and other grasslands offer a range of conditions to support a diversity of native species. A native prairie can have hundreds of plant species and many hundreds of other species that are associated with those plants. A field of brome by comparison has few plant species and supports fewer associated species.

Less evident to the eye, genetic diversity in a prairie grassland represents an archive of traits and chemical properties that may be important to advances in human medicine, solutions to crop diseases, and resiliency under conditions of climate change. For example, Kansas-based researchers investigating medicinal properties of Great Plains native plants discovered fourteen compounds new to science in *Physalis longiflora* (commonly known as ground cherry or wild tomatillo), four of which showed some cytotoxicity against specific types of cancer in a laboratory setting (Kindscher et al., 2012).

Cultural values

Landscapes and wildlife of the state's prairie region offer recreational opportunities for local residents and tourists. Popular outdoor recreation activities in grasslands include hiking, waterfowl and small-game hunting, and birdwatching. Communities such as Crookston and Rothsay, for example, promote outings for visitors to view the courtship rituals of prairie chickens and sharp-tailed grouse on their "booming grounds" each spring. Minnesota's public natural areas are also enjoyed as places of beauty and solitude.

Sites within Minnesota's prairie landscapes are also recognized as sacred or spiritually significant by many cultures, especially Native American communities, with which they share a long history. These include well-known sites such as the Jeffers Petroglyphs, an outcropping of Sioux quartzite with sacred rock carvings that lies at the heart of numerous native prairie preserves.

Carbon sequestration

Carbon sequestration is removing carbon dioxide from the atmosphere and retaining it within the landscape. This is particularly important today when carbon dioxide levels are artificially amplified due to human activities. Prairie biological communities store significant carbon in the U.S. Great Plains (Pendall et al., 2018).

Prairies are capable of removing a significant amount of carbon from the atmosphere and incorporating it into the soil. Prairie grasses have fibrous root systems and much of their root biomass is replaced each year. The soil ecosystem breaks down old roots, releases nutrients and further binds carbon in the microbiological community. A healthy soil ecosystem is an important part of this sequestration.

Benefits of prairie insects

The prairie invertebrate community provides many benefits locally and across the landscape. Pollinators play an essential role in seed and fruit production (see Spotlight Minnesota's Pollinators in Chapter 10). Decomposition is another ecosystem service provided by insects such as dung beetles and flies (Nichols et al., 2008). Ants are important in turning over and adding channels to the soil, and some are important seed dispersers. Insects are an important part of the food chain. Some species are predators and parasites of other insects (e.g. robber flies are predators of various insects), and many are a critical part of the diet of game and nongame wildlife.

Photo credit: Megan Benage

PART 2
PLANNING FOR THE FUTURE OF YOUR PRAIRIE

Chapter 3: Setting Goals, Getting Advice, Preparing for Action

Thus far the handbook has considered the greater context of Minnesota's grasslands; the broad sweep of Minnesota's prairie history; and the communities, values and challenges of the state's prairie ecosystems. Now, the focus shifts to the future. How are natural resource professionals planning for the future of Minnesota's prairies and other grasslands? What plans would you like to make for yours?

Considering the Big Picture—Your Prairie's Role in the Landscape

When seeking to manage a property with prairie values in mind, it is good to first look outward, beyond the property's boundaries, to see how it fits into the larger landscape. Landscapes with substantial natural habitat complexes have conservation benefits beyond those of the individual parcels. Consider, for example:

- Wildlife is influenced by habitat conditions beyond property lines.
- Native plant communities and wildlife can be helped or hindered by how one prairie parcel connects to surrounding prairie and other habitat.
- A single prairie parcel may be home to unique plants, animals, habitat, cultural resources, or other features that are rare in the broader landscape.
- Water quality in other parts of the watershed is influenced by how streambanks, hillsides, and wetlands are managed on individual parcels.

This "outward" look can inspire new ideas for goal-setting. Opportunities may arise to tie goals on individual properties with landscape features found beyond property lines. Actions taken on a single prairie parcel can also help support broader conservation goals in the region.

Photo credit on left: Dave Jungst

SPOTLIGHT—GREATER PRAIRIE CHICKEN

A Case Study for Landscape-Scale Wildlife Management

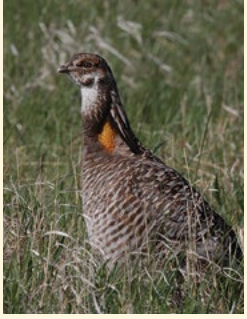


Photo credit: Brad Bolduan

Greater prairie chickens need multiple community types to complete their life cycle. For spring courtship display, males prefer short cover where they can see potential predators and be seen by females that are receptive for mating. Females nest in moderately dense cover 15–20 inches tall with 2 inches or so of residual vegetation, but thick mats of residual vegetation may be undesirable since this tends to attract nest predators. After hatching, hens move chicks to moderately dense cover that is relatively open at ground level to facilitate chick movement. Also important to chicks is abundant insect food. Broods tend to roost wherever they happen to be when nightfall comes, but if adults are given the choice, they prefer heavy cover. This may even be in wet areas if the water depth is not excessive. Roosting habitat is a very important habitat component since birds spend over half their lives there! Snow cover for roosting can also be important to provide concealment from predators as well as thermal insulation.

Two factors are important when considering greater prairie chicken habitat complexes: community type and land use. Community type is determined by soil type, soil water, and slope conditions which favor a particular plant composition. Habitat can also be affected by land use and management, such as grazing, burning, and mowing. The intensity, seasonality, and frequency of these management activities are also important. Proximity is also key—how are these habitats' components located with respect to one another? This is especially important for brood habitats; young chicks have to walk where they go so optimum brood habitat should not be too distant from optimum nesting areas. For year-round resident species, like prairie chickens, consideration must also be given to winter and spring food sources. Generally speaking, most Minnesota prairie tracts are close enough to agricultural crops that birds will move to them in the winter, but how close are secure roosting habitats? Excessive movements use energy and may unduly expose birds to predators.

Fredrick and Frances Hamerstrom, the Wisconsin prairie chicken research pioneers, recommended in their early landmark publication (Hamerstrom et al., 1957), that 40-acre (16.2 ha) nest-brood habitat tracts be established throughout private land in the Wisconsin range. They called this a "scatter-pattern" in recognition of the diversity of habitats needed by the birds. While this proportion of land uses/community types would not be practical in the current Minnesota range, the concept of ecological patterning is solid; diversify the landscape with various management practices/land uses to meet a variety of needs (Svedarsky, 1979). After a closing of the Minnesota hunting season in 1943, a prairie chicken season was re-opened in 2003 in recognition of a positive population response to habitat acquisition and management by conservation agencies and organizations (MN DNR, USFWS, and MN Prairie Chicken Society). Generally speaking, if a landscape can be managed to provide the year-round needs of greater prairie chickens, this can assure that the habitat needs of a broad array of other grassland species are being met as well (Svedarsky et al., 2003).

The Minnesota Prairie Conservation Plan: A Coordinated Effort

Conservation partners from across the state came together in 2010 to create the Minnesota Prairie Conservation Plan, a 25-year strategy for prairie protection and management (Minnesota Prairie Plan Working Group, 2018). This "blueprint" for Minnesota prairies lays out specific conservation strategies and target areas aimed at creating functional prairie systems. Increasing the size and connectivity of these systems supports animal species with larger home ranges, facilitates species movement, and increases gene flow. Functional prairie systems also provide a variety of diverse complex habitats that exhibit stability, adaptability, and resilience to environmental changes.

The Minnesota Prairie Conservation Plan lays out three core conservation goals (strategies):

1. **Protection** of native prairie and prairie complexes, selected other grasslands and associated habitats such as wetlands, riparian areas along streams, and shallow lakes.
2. Connecting and buffering native prairie and other protected habitats through **restoration**.
3. Maintaining and improving prairie system functionality through active **enhancement** (management).

An interesting aspect of the Plan is that it incorporates the concept of "working lands" conservation, in which some lands are managed as grassland habitat that contributes directly to local economies via "grass-based" agriculture. As stated by the plan, "Well managed, private, working lands contribute to the viability of grassland and wetland systems, and private income generated from grasslands can be the single largest driving force for grassland conservation." This approach operates on the understanding that wildlife and agriculture can co-exist and seeks to determine where that co-existence can occur most successfully.

See where you fit in. Landowners may wish to review the Minnesota Prairie Conservation Plan to see where their land and their personal goals potentially fit into the big picture of prairie conservation in the state. Find Minnesota's Prairie Conservation Plan online at **mndnr.gov/prairieplan**.

Getting Organized: Your Prairie Workbook

As you move forward in your planning, the workbook (Appendix D) can be used as a place to record observations, document the current condition of the prairie, and list desired outcomes and the management activities to achieve them. Getting to these desired outcomes may take multiple projects, each with their own goals, over a period of years, so be sure to have reasonable expectations when preparing timelines. These will be adjusted as needed after assessing the effects of individual projects to see whether they are making progress toward the desired outcomes. Do not feel that you need to do it on your own, you can seek help from natural resource professionals anywhere along the way.

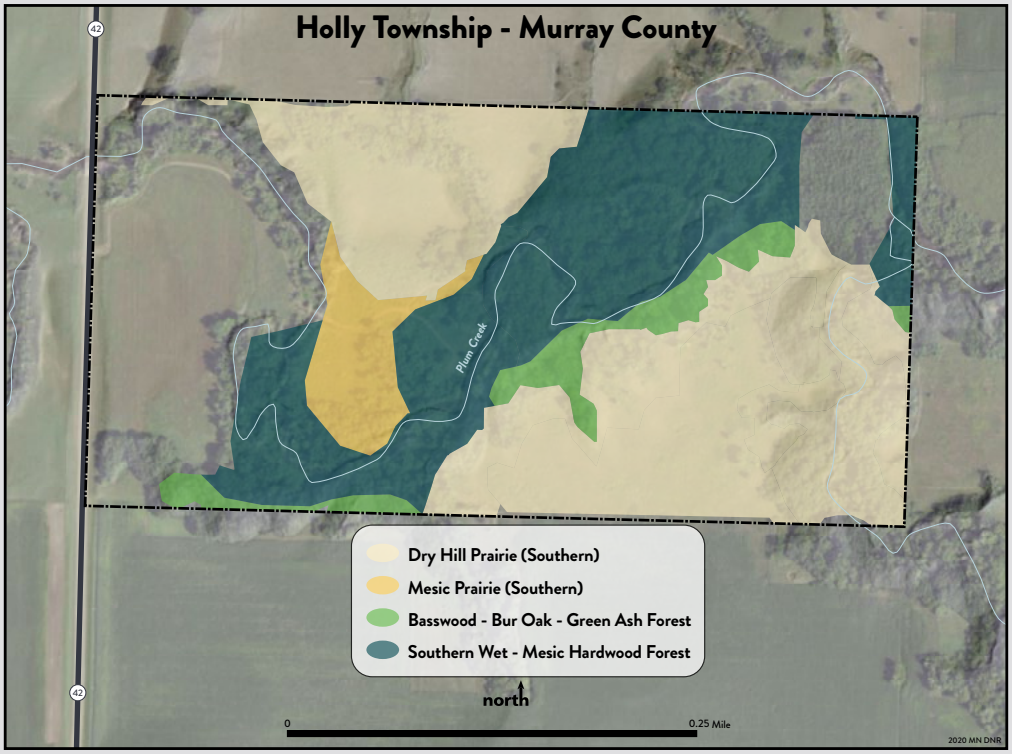
Patricia and Larry Wahl—Walnut Grove, Minn.

COTEAU MORAINES LANDSCAPE

Private landowners across the state have made remarkable, long-term commitments to the management and stewardship of natural features. Patricia (Pat) and Larry Wahl are among these inspiring stewards of the land.

Photo credit: Judy Schulte

The couple's adventure started in 1975 when they purchased an 80-acre parcel along Plum Creek near Walnut Grove, Minnesota. At that time, the land was still being rented out as pasture with 10 acres of tillable ground. Pat and Larry recognized early on that management was essential to the health of the prairie and woodlands on the property, so they began working with DNR Forestry to certify their property as a tree farm with the American Forest Foundation in 1979. Later, in 1999, they enrolled the 10 acres of tillable ground into the Conservation Reserve Program (CRP) and seeded it down into a native warm-season grass and forb mixture. In 2006, the Wahls invited Minnesota Biological Survey (MBS) ecologists to visit their site and map its various native plant communities. The ecologists identified four major native plant communities on the Wahl property (shown on the map).



Pat and Larry's property is a mix of wet-mesic hardwood forest, basswood-bur oak-green ash forest, mesic prairie and dry hill prairie.

After this plant community inventory, the Wahls started to work closely with the DNR Scientific and Natural Areas (SNA) Program to focus not only on the forest plant communities but also on the adjacent 30 acres of Southern Dry Hill and Southern Mesic Prairie. In the years that followed they worked on cutting undesirable woody species that had spread into these prairie and forest communities, using the wood as a source of heat for their home.

During the spring of 2014, with help from the Prairie Plan Partnership, Pat and Larry took on their largest project, working with a local contractor to cut undesirable woody species throughout 60 acres of the site. Since then, the Wahls have used prescribed burning and mowing to help improve prairie quality and minimize woody regrowth.

Thanks to their hard work and dedication, the Wahls' children and grandchildren will one day inherit the legacy of a healthy, diverse landscape. One-hundred years after Laura Ingalls Wilder passed through this same area, this family continues to preserve the historic and aesthetic values of the banks of Plum Creek.

Defining Your Desired Outcomes

What are your goals for your prairie? Is it your goal to make a sound investment that will be a source of income? To improve the health of a prairie remnant? To provide habitat for wildlife or create opportunities for outdoor recreation? For some landowners, their greatest wish is to be able to pass their land onto the next generation and know that it will be cared for.

The purpose of this section is to get you, as a landowner, thinking about how you use your prairie and how you would like it to be used in the future. Many of these outcomes can have overlapping benefits, for example high diversity conservation prairie can be great pollinator habitat, great wildlife habitat, and provide a good source of seed for harvest income.

Following are some outcomes that are often of interest to landowners and strategies that can help to get you there. (Find more detail in Part 3: Managing Your Prairie.)

Conservation/high diversity prairie. A prairie with high native species diversity has many benefits. If you are starting with a high diversity prairie, then managing it to sustain the native diversity should be your goal. Biological diversity includes not only the number of species present, but also their relative abundances. Managing to increase the diversity in an existing prairie can include applying disturbances (such as prescribed fire or grazing) unevenly across the site to increase the variability of conditions.

If a grassland site has limited biodiversity, perhaps due to past management, improving it can include inter-seeding (seeding into existing, established vegetation) or planting plugs or bare root plants. Restoring a degraded site to high diversity grassland requires careful preparation of the site and using a suitable native seed mix.

Wildlife habitat. Prairies can offer critical habitat for wildlife, including species that do not exist outside of grassland environments. They can also provide opportunities for wildlife-related pursuits enjoyed by people, such as deer hunting, upland game hunting and birdwatching. Providing wildlife habitat can require a variety of short-term goals depending on the wildlife that are the focus. Many wildlife species benefit from different vegetation structure in different areas of the site. For example, game birds benefit from having tall vegetation in some areas for cover and shorter, sparser vegetation in other areas for easier feeding on ground-dwelling insects. Water features, such as prairie potholes or ephemeral (temporary) pools, can serve important needs for a range of wildlife, from amphibians to waterfowl. Enhancing existing water features and restoring lost ones can provide many wildlife benefits.

Photo credit: Dave Jungst

Grazing pasture. A healthy pasture for grazing can be the desired outcome of management, and grazing, as a practice, can be a tool to help achieve other outcomes. Maintaining a healthy, productive pasture requires finding the right timing and stocking rate. Improperly applied grazing (overgrazing) not only hurts the grassland, it reduces the quantity and quality of forage and can encourage non-native species. Grazing can negatively impact the diversity of native prairies under some grazing regimes and should be approached carefully on such sites.

Hay meadow. Haying, like grazing, can be a tool or an outcome. Annual haying can reduce some species and encourage others, so it is recommended to leave different areas of the site uncut each year. A concern with haying is the introduction of non-native invasive species on equipment, especially if the equipment is also used in ditches or other highly invaded sites. Haying also typically takes place in late summer, favoring early-flowering plants at the expense of the late season species. A primary concern in hay pasture is keeping undesirable species from taking over. Properly used, haying can be very beneficial to the prairie and hay prairies include some of the nicest working remnants.

Pollinator habitat. Providing lands that support pollinators requires having a good diversity of wildflowers and having species that flower throughout the growing season. Grasses are also important, as many insects will overwinter in grass stems and many caterpillars feed on grasses. Many pollinators are very specific and feed only on certain plants. Managing for pollinator habitat can include using practices that increase wildflower diversity, maintaining refuge habitat when applying disturbances, and adopting practices to reduce pesticide drift that would harm pollinators.

Seed harvest. Remnant prairies can be a good source of seed for prairie restoration efforts. Thus, prairie seed harvesting can be a source of income for a prairie landowner. Prairies tend to produce a lot of seed the year after a burn and burning synchronizes flowering, so more seed ripens at the same time. Some prairies managed as seed sources are burned in multiple, small units a few weeks apart so different species are stimulated and harvest can be spread out. If mechanical harvest is the goal, the prairie should be kept free of weeds that would bring down the seed value or even make it unusable. If hand harvest is the goal, it can help to mark the desired plants when they are in flower so they can be found again when their seed is ripe.

Multiple benefits. A healthy, diverse prairie can provide many of the benefits listed above. Every management activity is good for some species, and not as good for others. Where appropriate to the setting, rotating management practices over time can result in different outcomes in different areas, offering a broader range of benefits.

Photo credit: Nicole Davros

Getting Advice: Key Players

How do you know if your desired outcomes are feasible? Who could help you design a Prairie Stewardship Plan or conduct a prescribed burn? Where is a good source for local seed? Minnesota's prairie community—the human one, that is—is large and has many active players. No matter how seasoned the manager, knowing who to go to with questions can be key to a project's success.

Following is a selected sampling of groups and organizations active in the state that focus at least in part on prairies. Most counties have a Soil and Water Conservation District (SWCD) with staff that keep up with current programs, making SWCDs a great place to start. If unable to answer specific questions, their professional staff can direct you to other local, regional or state experts as needed. The Minnesota DNR also has an email account for general native prairie questions: **prairie.protection@state.mn.us.**

- MN Department of Natural Resources (DNR): **mndnr.gov**
- MN Association of Soil and Water Conservation Districts: **maswcd.org**
- MN Board of Water and Soil Resources (BWSR): **bwsr.state.mn.us**
- United States Fish and Wildlife Service (USFWS): **fws.gov/midwest/**
- The Nature Conservancy (TNC): **nature.org/minnesota**
- The Conservation Fund: **conservationfund.org/where-we-work/minnesota**
- Pheasants Forever: **pheasantsforever.org**
- Prairie Chicken Society: **prairiechickens.org**
- The Prairie Enthusiasts: **theprairieenthusiasts.org**
- Audubon: **mn.audubon.org**
- Ducks Unlimited: **ducks.org/Minnesota**
- Natural Resource Conservation Service: **nrcs.usda.gov/wps/portal/nrcs/mn/home/**

Many private, independent prairie experts and vendors can assist as well.

Taking Stock: Evaluating the Property

The Prairie Workbook (Appendix D) guides you through some general questions regarding your property's terrain and vegetation to document the natural features as a baseline for management planning. If possible, walk the land with a person knowledgeable about native prairie plants and the basic distinctions between different types of prairies (wet, mesic, dry). The trained eye of a prairie botanist may spot native prairie plants within old fields and areas altered by land use, which can be a hopeful indicator that the native plant community could be restored with management. They can also help to identify trouble spots, such as invasive species. You can evaluate your property yourself using the suggestions in Appendix C: How to Tell if You Have Native Prairie.

Larger sites with relatively intact native plant communities may have already been evaluated and mapped by the Minnesota Biological Survey (MBS) (See Spotlight, Biodiversity Counts). It is worth finding out whether the property is on or near a site mapped as a native plant community by MBS.

Another possible source for information is the Minnesota's Natural Heritage Information System (NHIS), which has information on native plant communities and rare features. This system is commonly used by researchers, as well as by natural resource agencies and nonprofit organizations for planning purposes. Program staff can help you determine whether records exist in the database for your location and how to submit a data request. See **mndnr.gov/nhnrp.**

Choosing a Work Project

After determining the existing condition and defining desired outcomes for your prairie, it is time to choose specific work projects and management practices that can be used to achieve those outcomes. Whether you want to knock back invasive species or re-invigorate your prairie with a prescribed burn or other disturbance, Chapters 4-11 provide detailed guidance and resources pertaining to specific management practices that may help achieve objectives. Chapters 11-13 provide information on programs that offer budget assistance and other resources to support your efforts. The Prairie Workbook (Appendix D) can help you pull all of this information together in a personalized plan with timelines realistic for your schedule.

Photo credit: Dave Jungst

SPOTLIGHT

Biodiversity Counts: The Minnesota Biological Survey (MBS)

When developing goals for the landscape, biodiversity counts. The Minnesota Biological Survey is an effort by the state to collect detailed information on rare plants and animals, native plant communities, and local landscapes. Surveying began in 1987 and an initial survey has been completed for most counties. Work continues as ecologists update this data on an ongoing basis. The results of this work have contributed greatly to understanding Minnesota's flora and fauna. It is a vital resource for land-use planning at state and local levels. Visit **mndnr.gov/mbs** to learn more.

Adaptive Management

As you proceed from plan to action, consider that managing prairies is often about applying disturbance and manipulating competition among different plant species. **Manipulating competition** can mean controlling invasive species, promoting a diverse plant community by applying practices that harm an undesired species, or applying practices that help desirable species. Most of the time management is focused on the plant community, but the vegetation can also be manipulated for the benefit of wildlife. For example, not all habitat in an area should be disturbed at one time so that refuge habitat is left as cover for wildlife species and for "low mobility" species that cannot easily move to avoid the disturbance.

Manipulating competition also includes practices that specifically target undesirable species, such as cutting trees or using herbicides. Often these practices work best when coupled with disturbance management. For example, after cutting invasive woody plants from a prairie it may be hayed or burned annually for a few years to set back seedlings.

Historically, fire, grazing, and drought were the primary disturbances that shaped and maintained prairies. Common disturbances used in managing prairies today include prescribed fire, grazing, haying, and mowing. Each has advantages and disadvantages, and how they affect the prairie plant community is very dependent on the timing, intensity, and frequency of the disturbance.

To promote biodiversity, it is good to mix up the disturbance, the type of disturbance or the timing. Practically speaking, however, this is not always possible. For example, if cool-season non-native grass control is the primary goal it may mean burning or haying in the late spring for many years. Note that applying the same disturbance over and over at the same time of year will strongly favor some species and lead to others declining. For example, a long history of season-long grazing on pastures usually leads to thistles, non-native cool-season grasses, or other weeds increasing (Svedarsky et al., 2002). Another example is annually hayed prairies, where short species, and those that set seed before cutting, increase in abundance. Management is often a balancing act between managing for a primary goal and addressing the associated repercussions.

A part of the adaptive management process is evaluating results and refining approaches to pursuing goals. It is unlikely that a single disturbance event will drastically harm the plant community, so do not worry if one event did not give the desired results, but look at it as a learning experience. After applying disturbance, check whether objectives were achieved, and continue to monitor over time.

Whether you have a 200-acre prairie or a 25-square foot pollinator planting, disturbance and invasive species control are important. The following chapters provide details about some management practices commonly used on larger prairies and other grasslands, but know that these practices can also be implemented on a smaller scale with just a few adjustments in equipment and process. For example, haying is discussed large-scale, but a homeowner with a small pollinator plot can mimic haying by mowing at the tallest lawn mower setting (or weed whipping) a small portion (being sure to leave refuge for the pollinators), raking and removing the cut material.

Each situation is unique. Properties differ in size, ecological condition, management needs, and the management actions that are possible on them. The goal of the following chapters is to let you, as a landowner, know whether a practice is reasonable for your situation and, if so, how to plan and prepare for that action. As you read, be sure to be thinking specifically about your property and what would work best in your situation.

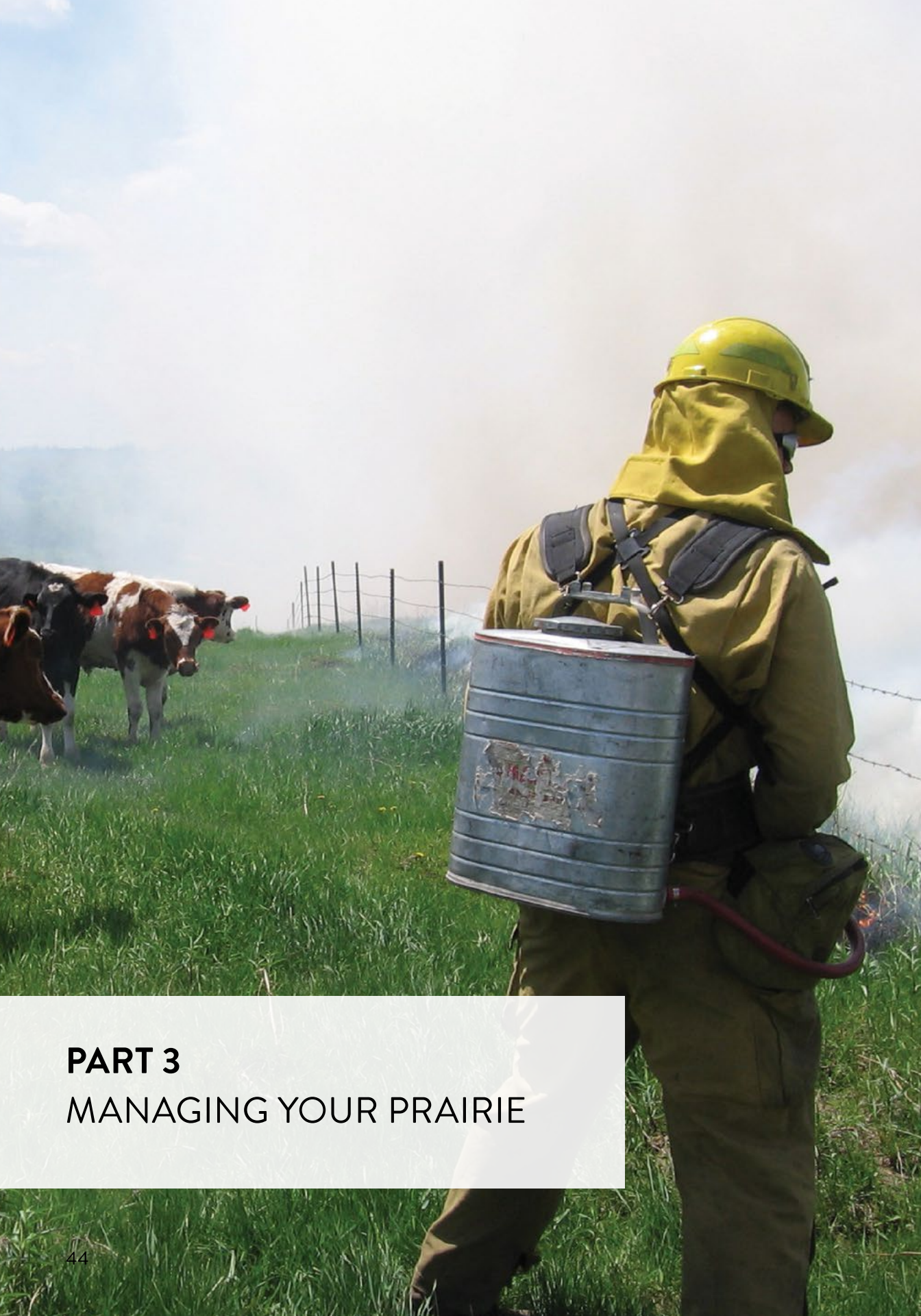
Warm-Season and Cool-Season Grasses

Cool-season and warm-season functional groups are often referred to as targets of management activities in prairies. In particular, cool-season non-native grasses are a concern due to their ability to aggressively invade prairies and displace native species (see Chapter 1: A Changing Climate).

Cool-season plants are adapted to cooler, wetter periods and benefit from higher nitrogen levels. Cool-season grasses start growth early in the spring, go dormant in the hottest part of the summer, then resume growth in the fall. Non-native cool-season grasses include smooth brome, Kentucky bluegrass, reed canary grass and others, including many pasture grasses. Native cool-season grasses include porcupine grass, needle-and-thread, green needlegrass, June grass, manna grasses, and wildryes as well as most sedges (*Carex* spp.).

Warm-season plants grow better in high temperatures and bright sunlight, and require less water and nitrogen. Warm-season grasses start growth in late spring and grow through the summer. Native warm-season grasses include big bluestem, little bluestem, Indian grass, switchgrass, prairie cordgrass, dropseed grasses, and the grama grasses.

Management can favor cool-season or warm-season grasses by the timing of disturbances. Chapters 4–9 detail different management strategies for controlling non-native invasive grasses.



PART 3
MANAGING YOUR PRAIRIE

Chapter 4: Prescribed Fire

Prescribed fire is a commonly used management practice in grasslands and can benefit prairies in many ways. Burning the accumulated plant litter affects the nutrient balance by removing some nutrients in smoke and releasing others in ash, which can benefit native plants. Removing litter also opens the vegetation, resulting in more light reaching live plants, greater airflow so plants can get carbon dioxide for photosynthesis, and allowing more moisture to reach the ground surface (though the dark surface of a burned prairie can also contribute to water stress in dry periods) (Knapp & Seastedt, 1986). The black ash and exposed soil left after a fire heat more rapidly and can stimulate plant growth. Also, some seeds require heat, smoke, or ash chemicals to stimulate germination (Blank & Young, 1998; Brown & van Staden, 1997). The open ground left after a fire can benefit some wildlife species (Higgins et al., 1987; Svedarsky et al., 2003), though it can be temporarily detrimental to others. Invertebrates, amphibians and reptiles, and lichens can be particularly vulnerable to fire.

Prescribed fire can also be used to achieve specific management goals by burning at certain plant growth stages or under specific environmental conditions (Ditomaso et al., 2006). For example, burning when smooth brome is undergoing stem elongation (when its root reserves are depleted) can help in setting it back, while burning when it is dormant might encourage its growth (Wilson & Stubbendieck, 2000). Targeting a particular species will require understanding how it is affected by fire. Good information regarding fire (and grazing) effects on plant species can be found at the U.S. Forest Service's Fire Effects Information System at **feis-crs.org/feis.**

While fire is one tool that may be useful for management, it may not be the right tool for a specific goal. It can help in reducing woody plant cover, but how well it works depends on the species, its growth stage, and the seasonality of the fire. Some species, like eastern red cedar, may be killed by fire. Other trees may have thick bark that resists fire (like oaks) or may re-sprout after being top-killed by fire (like buckthorn, non-native honeysuckle, and aspen). Though fire may not be sufficient on its own to kill some invasive species, it might still be a useful tool to remove litter, making later herbicide treatments easier or more effective.

Fire can stimulate seed germination. This can benefit the prairie by increasing the genetic mixing of native species, but can also result in a flush of unwanted plants. Sweetclovers, for example often show a short-term explosion in

Photo credit on left: Ellen Fuge

abundance after a fire. This flush offers opportunities for control with follow-up management such as haying or mowing. Since sweetclover is biennial, mowing or haying the second summer after a burn is effective in reducing seed production (Svedarsky et al., 2002).

Fire is inherently dangerous, so have a plan and a goal before lighting the match. The safest thing you can do is not light the fire, so if you are going to burn, do it when you can expect the results you want. This includes being sure you can safely burn under the conditions with your available resources (equipment and people). The purpose of this section is to help you decide whether fire is appropriate for the situation and how to plan and execute a fire safely and effectively.

Historical Fire in Minnesota Prairies

Before European settlement and the conversion of the landscape to agriculture and development, fire was a common disturbance in the prairie region (Wilson & Stubbendieck, 2000). Some fires occurred naturally from lightning strikes, and Native Americans burned prairies for many reasons. Though it is difficult to know with certainty, the fire return interval in the northern tallgrass prairie is thought to be 2-13 years (FEIS, 2020; Higgens, 1986), with Minnesota prairies burning at an interval of less than 10 years between fires (Higgens et al., 1989). It is generally believed that burning on a 3- to 5-year rotation is beneficial for Minnesota prairies.

Fire Effects and Prescribed Fire Goals

First-order fire effects are the immediate effects of the fire: changes that occur in the system when fire goes through it. First-order effects include things like removal of litter, cambium kill on woody plants (the growing layer just beneath the bark), top-killing herbaceous plants, and soil heating. First-order effects are related to fire behavior, which is affected by characteristics of the fuel (such as moisture content, accumulation, and degree of green-up). They are also related to weather before and during the fire, and to topography (such as slope and aspect). Fire behavior includes the rate of spread (how fast the fire moves) and flame length, as measured from the base to the tip of the flames.

Second-order fire effects are the ecological effects of the fire: how the fire influenced the community and succession. In managing prairie, the second-order effects are often the goals of the fire. Examples of second-order effects include boosting native seed production, reducing brush, keeping an undesirable species from producing seed, promoting blooming of wildflowers for pollinators, or providing habitat for an animal species. Second-order effects are influenced by first-order effects, the season/timing of the fire, the composition of the community before the fire, post-fire weather, and other disturbances or management following the fire.

Prescribed burning can target ecological effects in many ways. A burn can target a susceptible stage in a plant's life cycle, such as burning when smooth brome is elongating, or burning an annual weed before it produces seed. Burning under specific environmental conditions can also yield particular fire characteristics. For example, burning when duff is very moist might protect emerging shoots from excessive heat. The ignition method (how the fire is lit) can influence the fire effects as well. A fire running in the direction of the wind (a headfire) is faster and hotter than a fire burning into the wind (a backing fire); but being slower, backing fires produce heat in the area they burn for a longer duration. If the goal is to top-kill brush, a backfire might do a better job of killing the cambium (first-order fire effect) and reducing the brush in the community (second-order fire effect).

Fire can be used in combination with other treatments to achieve goals that fire alone could not accomplish. For example, fire can make herbicide treatments more effective by removing litter and depleting target species' root reserves. Fire and herbicide can also be used in combination to effectively prepare a restoration site for seeding. Patch-burn grazing uses a combination of fire and grazing to achieve management goals by combining multiple types of disturbance.

Prescribed fire can be a great tool for managing prairies, but it is not always the right tool for a particular goal. The table below presents some common goals of prescribed fire and notes on their effectiveness.

COMMON GOALS FOR PRESCRIBED FIRE

Goal	Optimal Timing	Notes
Remove litter	Any, dry conditions	
Stimulate native seed production	Spring	Synchronizes flowering for the year
Manage smooth brome	Late spring, optimally during elongation, about when plants have five leaves	Dormant season burns may favor smooth brome
Kill red cedar	Any	Red cedar does not re-sprout from stumps
Set back brush (willows, dogwood, sumac)	Summer during drought stress is best, late spring is also good	Results may be short-lived, many species re-sprout. Will likely require repeated burning or other follow-up treatments
Kill mature buckthorn in thickets	None, fire alone won't work	Buckthorn litter does not carry fire well, mature trees have fire-resistant bark, and all but first year seedlings will re-sprout

If you have questions about using prescribed fire to accomplish your management goals, contact a professional land manager with prescribed fire experience.

Planning for Prescribed Fire

If you have decided that prescribed fire will help to accomplish the desired management goals, the next step is to determine whether a burn can be safely accomplished. Look at the area to be burned (the **burn unit**) and determine any safety concerns. Two important safety concerns should be addressed at the earliest stages of planning: fire escapes and smoke impacts.

A prescribed fire can escape from a burn unit by burning across a holding line, by burning materials carried through the air or rolling down hill, or by the actions of firefighters. Look for things that could be threatened if the fire gets out of the burn unit. Is there contiguous fuel between the burn unit and any homes or other structures? Are there power line poles, utility boxes, wooden fence posts, structures, desirable trees or shrubs, hay or forage piles in or around the burn unit? Are there any fuels (such as cattails or standing dry corn) that could send embers into the air? Are there any fuel jackpots (concentrations or accumulations), such as slash piles or dead trees, near the holding lines? Determine how to mitigate concerns. For example, a brush pile could be moved away from the control line, excluded from the burn unit, or burned in winter so it won't be a concern for a spring burn.

Smoke impacts must be considered when planning a prescribed fire. Great caution is required near roads, nearby residences, schools, hospitals, livestock, airports, power lines, and sensitive populations. Putting heavy smoke over a road can cause accidents, and the prescribed burner may be held legally responsible. High voltage power lines near the fire may arc in heavy smoke. Some livestock, especially in confinement barns, are very sensitive to smoke. People vary in their sensitivity to smoke and their agreeability to it, and smoke can be deadly to those with certain medical conditions.

It is essential to keep smoke away from all sensitive receptors. You may be able to mitigate smoke issues by planning a burn to take place under specific wind conditions (direction and speed), humidity, and green-up of fuels. Keep in mind that live, green vegetation in the fuel causes thicker, heavier smoke, but also generally a slower fire. Note that poison ivy on the site can affect people through its smoke, sometimes severely.

Preparing a Burn Plan

If it has been decided that prescribed fire is an appropriate tool to achieve the desired outcomes and a burn can be safely conducted regarding escapes and smoke impacts, the next step is to prepare a burn plan. To start, map out the burn unit, preferably using an aerial image of the property to be burned and the surrounding area. Examples of burn plans can be found at: **mndnr.gov/rxfire/planexamples.html.**

Burn unit map. When mapping the burn unit, include burn breaks (see details in the next section), fuels in the burn unit, surrounding fuels, fuel jackpots, access points, steep slopes that could affect fire behavior or pose difficulties to travel, fences and other barriers, flammable items to avoid burning, and any water sources. To maintain habitat for fire-prone wildlife, it is important that not all of the vegetation in an area is burned at one time—keep refuge habitat in mind when designing the burn unit.

Different fuels will create different fire behavior, and the fire's behavior may change as it moves across the burn unit. Pay particular attention to areas with tall grasses such as reed canary grass, prairie cordgrass, phragmites, or tall warm-season grasses. These can have increased flame lengths and stems can burn off at the base and fall over holding lines. Cattails can be very volatile and produce high flames, but may be hard to backfire; it is advised to avoid putting holding lines close to cattails. After a winter with a lot of snow, the herbaceous vegetation is usually packed down, which can reduce fire behavior. Greater flame lengths can be expected when there is a lot of standing, dead vegetation.

Burn breaks (holding lines, firebreaks). Burn breaks are areas where the fire can be expected to be contained. Burn breaks can include natural features (such as streams and lakes), man-made features (like roads and cropland), and mowed breaks. An **anchor point** is a place where the break is very secure and can stop a fire from flanking around holding forces. An anchor point is often used as the point of ignition in prescribed fires or as the start of a holding line in fighting wildfires or escapes.

Hard breaks are barriers that require little attention to hold fire (though it may still be possible for fire to cross them). Streams, roads, and plowed fields are examples of hard breaks. **Soft breaks** are flammable breaks that will not hold fire without direct attention (from fire crew using water or hand tools) during the burn. Mowed breaks, hayed grass, and grazed areas are examples of soft breaks. If using the ring fire technique (see page 58), you may want the backing fire line to be held on a hard break if possible. Generally, straight burn breaks are easier to hold and allow better observation and monitoring down the holding line. Consider your situation when planning a burn unit, for example the equipment and people you have available. Potential burn breaks include:

- **Streams, drainage ditches, and other water bodies** can work as burn breaks if they are sufficiently wide. In the spring after a winter with a lot of snow the lush vegetation around streams may be packed down and the streams are usually full, making streams good burn breaks. In fall, the litter around streams may be tall and streams are usually low, so they may not function well as burn breaks. If an ember starts a fire on the opposite side of a stream it may be difficult to get to.

- **Roads** can be good burn breaks as long as firefighters are safe from traffic and smoke will not cause traffic hazards. If burning a road ditch, check it first for "surprises" like tires, car batteries, etc. Contacting the Minnesota Department of Transportation (required for trunk highways) or local road authority is recommended before burning right of way areas. Railways are not a good option for burn breaks; the railway authority may not allow it and there is risk of igniting ties.
- **Heavily grazed pasture** can work as a burn break but will probably need attention from fire crews during a burn with water and flappers on hand (see tools, page 52). Keep in mind that wooden posts and plastic insulators will need attention to prevent them from being damaged by the fire.
- **Cropland** can serve as a burn break, provided that there is no crop residue that could carry fire. Plowed or tilled fields without residue are superb burn breaks and make secure anchor points. Burning in fall with adjacent dry crops, especially standing corn, is extremely risky and should be avoided. If a fire escapes into an unharvested crop field the burner could be responsible for paying damages for crop losses.
- **Mowed breaks** may be needed if there are not sufficient existing barriers or to split up the grassland for retaining refuge habitat. Breaks can be mowed with tractors, pull-behind brush mowers, brush-cutters, or lawn mowers. A few passes with a lawnmower to get vegetation really short next to the burn unit will make it easier to hold the fire with less water. It is best to have breaks at least twice as wide as expected flame lengths, or about four times the fuel height; as a general rule at least 12 feet wide. Hayed grassland can work as a burn break if the stubble is short enough.

  After mowing, it helps to rake the duff off the break or use a leaf blower to remove it. Throw the duff away from the burn unit, not into it. If using mowed breaks, count on needing water to hold them: how much water largely depends on how well the breaks have been prepared. When burning off of mowed breaks the mowed fuels are wetted down (**wetlining**) ahead of ignition. Mowing a few additional passes inside the break at 12–15 inches high will provide fuel adjacent to the break that will burn well, but with shorter flames and less heat, making the fire easier to hold on the mowed break. If breaks are mowed in the fall, cool-season plants (if present) will green up in spring, making the breaks easier to hold for spring burns (due to moisture in the live fuels).

Be careful not to accidentally start a wildfire while mowing breaks. Be sure equipment is kept clean and in good working order. Watch for rocks, which could throw a spark if hit by the mower blades.

Prescription. When the burn unit is defined and the burn breaks are determined, the next step is writing the **prescription:** the suite of conditions under which the burn will take place.

Start with objectives, the management goals you want to accomplish with fire. Next, define the fire behavior needed to get the desired first-order fire effects and resources required to safely handle the fire behavior. Finally, determine the season and window of weather conditions that can achieve the desired fire behavior and effects.

A prescription should include:

- The season or a **phenology** (plant growth stage) indicator.
- A range of fire behavior (flame length and rate of spread).
- A range of temperatures.
- A range of wind speeds and directions.
- A relative humidity range.

A professional land manager with fire experience can help to determine the range of conditions that will suit your situation. Consider the fuels outside the burn unit as well as the fuels you intend to burn. Could your resources catch and stop an escape into the surrounding fuels? Be sure to consider any special circumstances, for example cutoff dates for burning on Conservation Reserve Program (CRP) lands.

As a general rule, at a relative humidity (RH) of less than 30%, fires in Minnesota tallgrass grasslands can be pretty intense and difficult to control, especially in the dormant season with no live vegetation in the fuel. On the other hand, at an RH of over 60% the grass might not burn, at least not well enough to achieve objectives. Remember, too, that RH changes throughout the day. The extent of green-up also affects fire behavior. If burning in the summer with 2-foot high, live vegetation, a lower RH might be preferred.

An acceptable range of wind speeds should also be defined as part of the prescription. With winds over about 10 mph a fire in grassland fuels, especially dry fuels, can be hard to hold and hard to stop if an escape occurs. Higher wind speeds should be avoided if the plan is to ignite a backing fire and hold it along a mowed break. Very light winds can also be tricky because they tend to shift around and updrafts from the fire can have a driving influence on the local winds (the fire takes control of the wind). Light and variable winds can be good for lifting smoke, but can also make the fire behavior unpredictable and potentially difficult to control. Smoke will lift better in an unstable air mass; under an inversion (as is often the case toward the evening) smoke can hang close to the ground. Wind direction is also a consideration. A burn plan should point out smoke-sensitive areas and address how they will be avoided.

Resources. The burn plan should list all resources that will be available to conduct the burn. Resources include people, tools, and equipment.

People. How many firefighters will it take to safely conduct the burn? There must be sufficient people for both ignition and for holding. It also helps to have someone who can hang back and patrol the holding lines. In case of an escape, consider the number of people it would take to address the escape while others continue to contain the prescribed fire. Identify who is responsible for directing ignition, and determine an overall command structure; coordination can be crucial for containment and firefighter safety. Burning alone is risky and should only be considered when the burn unit is very secure, for example surrounded by tilled fields.

Personal Protective Equipment (PPE). At minimum, members of a fire crew should have long-sleeved shirts and pants made of wool or cotton; synthetic fibers should never be worn around fire. High leather boots are preferred, though rubber boots might be acceptable if the area is wet. Participants should also wear heavy leather gloves, eye protection, and something to cover or secure hair. A bandana can help filter out ash and some particulates, but will not block small particulates or gasses in the smoke. If planning to use fire regularly, consider purchasing specialized fire-resistant clothing made for use in wildland fire.

Tools. Many specialized hand tools are used in prescribed fire. Drip torches and propane torches are commonly used for ignition. Backpack pumps and bladder bags carry about five gallons of water for holding fire lines. If the need for more water is anticipated, refill jugs can be staged around the unit. Flappers/swatters are rubber mats on the end of a shovel handle and are used to smother fire. They can be used alone but work better in combination with water. A steel rake can be used for a variety of purposes including cleaning litter and debris off of breaks before a fire and pulling along burning litter for ignition. Many DNR Wildlife and Forestry offices have fire line tools that they loan out to landowners.

Equipment. An all-terrain or utility task vehicle can be a huge asset in prescribed fire. It can be used with an inexpensive water tank and electric-powered pump sprayer for holding a fire, as well as for patrolling the fire line and transporting water jugs. A sprayer that has been used with pesticides should be cleaned well before using it on a fire. If there is a good water source in the burn unit, a portable pump and hose might be able to take the place of a mowed break if the pump can deliver ample water and the fine fuels are not too heavy (though a mowed break will be more secure). A tractor with a large water tank may also deliver sufficient water to hold fire without a mowed break. Be sure it is clean, and check that it will not run out of water prematurely.

Holding a fire in tallgrass fuels without a firebreak requires a lot of water. *Test the capability of your equipment to hold fire before relying on it for holding on a burn. Burning in tallgrass fuels without breaks is extremely risky and tricky and should not be done by those with limited experience. Even very experienced prescribed burners avoid burning without good breaks.*

Ignition and holding plan. In the prescription, describe the manner in which the fire will be ignited and how it will be contained in the burn unit. The ring fire technique (see page 58) is commonly used in grasslands. Consider the goals and the particular fire behavior needed to accomplish them. A backing fire will cause different fire effects than a headfire or flank fire; what is better for your goals? Draw the ignition plan on the burn map (either in the planning phase or on the day of the fire). Show the sequence of ignitions, the point of ignition, and the location of the test fire.

Communications plan. Coordination between ignitions and holding is essential. If using the ring fire technique, the igniters must not get too far ahead of each other or there is a risk of an escape or someone getting burned. If the burn unit is small, firefighters may be able to communicate directly, but if it is large they should have communications devices. Mobile phones can work, though radios are better. The communications plan should also include important phone numbers, such as neighbors and the sheriff's dispatch or local fire authority.

This fire crew is using a weather kit.

Photo credit: Kevin Berens

Contingency plan. A contingency plan is a plan of action in case events occur that could result in loss of control or risk to firefighters. Trigger points are events that have been identified as cues that action is needed to maintain control of the fire or ensure peoples' safety. They can occur before or during a burn. Examples of trigger points include weather not fitting the forecast, fire getting outside of holding lines, fire behavior exceeding the prescription, an injury, and equipment breaking down. Think about possible trigger points and what will be done in each situation. Map buildings and things of value that might be threatened if the fire escapes and how they will be protected. Include secondary holding lines (contingency breaks) where fire can be stopped in case of an escape. Through the process of examining contingencies, you may change other parts of the plan or revise prescription conditions to make the burn safer.

Conducting the Burn

Before burning, obtain a burn permit from the sheriff's office or local fire authority (such as the DNR). On the day of the burn, you will need to call in to let them know you will be burning and activate the permit. Under certain conditions, burning may not be allowed. Be sure to get an accurate weather forecast on the day of the burn. The National Weather Service website has good local forecasts including hourly forecasts. You may want to invest in a weather kit or weather meter in order to check the conditions onsite the day of the burn.

Before lighting the fire, designate a burn boss and hold a briefing to review the burn plan with everyone involved. Be sure all participants know their duties and what is expected of them. Discuss hazards, potential escape points, firefighter limitations, and safety. Ensure everyone has a means of communicating. Check equipment and tools to see that everything is operational and everyone knows how to use their equipment.

Firefighter safety. At all times on a fire, every person participating or even observing the prescribed burn should know a safe location (**safety zone**) and a means of getting there (**escape route**). Usually when burning grasslands, the **black** (burned out areas) serve as safety zones. When lighting backing or flanking fires, set a pace that provides sufficient black for a safety zone within a distance you can get to quickly. If someone goes into an area with unburned fuel in the burn unit, they should have someone watching their back (a **lookout**) who can warn them if something such as a change in wind or flare-up occurs. All participants must have a means of communicating with all other participants.

Wildland fire smoke contains harmful substances and people should limit their exposure to it. Exposure can be particularly high for those holding a backfire, especially when significant green vegetation is being burned. Having good breaks and giving the backing fire plenty of time to burn out a swath of black will help lessen the exposure of firefighters to heavy smoke.

Photo to right: Judy Schulte

Photo credit: Kevin Berens

Test fire. To begin, light a small test fire in the downwind corner of the burn unit. Let the fire burn for a duration that allows you to get an idea of the fire behavior (rate of spread and flame length) and smoke dispersion. Make sure your resources will be sufficient for holding the firebreaks. Also, check that the fire behavior will give the desired effects. If everything checks out, and fire behavior falls within your prescription, you can proceed to the prescribed fire, if not you may want to extinguish the test fire. Prescribed burns are commonly shut down after test fires indicated potential issues with fire behavior or containment.

Prescribed fire. If the test fire indicated fire behavior within your prescription and ability to control, move on to the prescribed fire. When following the ring fire technique (see page 58) start by lighting a test fire and tying to an anchor point if possible. Then, after sufficient black is created on the backing fire line (the downwind break), slowly ignite around the burn unit. Keep ignition at a pace the holding forces can keep up with, wetting fuels ahead of ignition and checking that breaks are holding behind ignition. If there is more than one ignition team, be sure they keep pace with one another. Once the backfire line is lit, let it burn out into the burn unit for a while to get a good swath burned before lighting the flank and head fires. As a general rule, a swath of black

at least twice the flame length (preferably more) is needed before moving on to lighting flank fires. It is critical that the downwind (backing fire) line is secure before lighting the flank and head fires. When the backing fire line is secure you can widen the black by lighting additional strips inside the burn unit parallel to the flaming front. As a general rule these strips should be no farther into unburned fuels than the width of the existing black. This will create short headfires, so the line must be secure and under observation while lighting strips. Patrol the holding lines behind the main ignition to be sure they remain secure. Any smoking materials near the holding line should be extinguished or thrown farther into the burn unit.

Mop up. After ignitions, the burn unit should be checked for smoldering fuels. Start near firebreaks, extinguish any smoking materials or move them farther into the burn unit to let them burn away. Stay on the burn unit until all materials are completely cold; you may be fined for leaving a fire unattended. Particular smoldering fuels to watch for include heavy or matted down duff, thatch ant mounds, cow pies, wildlife droppings, peat, corn cobs, fuels buried by soil, and partially rotten stumps and logs. These fuels can smolder a long time and may not produce much smoke. Sometimes, the duff layer close to the ground may be too moist to burn during the initial fire, but could dry out later and become flammable. If smoldering fuels are left in the unit, the unburned duff could provide a burnable path and cause an escape when no one is around to stop it.

Monitoring. Taking notes before, during, and after the prescribed fire can help with planning future burning. Before the fire, note the weather conditions, the plants that are actively growing, the height of the live plants, and the litter depth. During the fire, note the flame lengths, the rate of spread, smoke dispersal, and any other noteworthy fire behavior. After the fire, check the first-order fire effects. If the goal was to control brush, cut a few stems to see if the cambium was burned. Later in the season, keep track of which plants are more prominent in the community. If cool-season grass control was an objective, check to see if that grass flowers. Good records guide the adaptive management process.

Summary

Prescribed fire can be a good tool for accomplishing some prairie management goals, though it is not the only tool and may not achieve every goal. Timing of a fire and conditions during the burn will affect fire behavior and fire effects. For safety and effectiveness, have a well-thought-out burn plan that addresses the goals, smoke management, acceptable conditions for burning, firing techniques, contingencies, and safety.

RING FIRE OR PERIMETER FIRE TECHNIQUE

The ring fire or perimeter fire technique is commonly used for prescribed fire in grasslands. The basic idea is to use more easily controlled backing fires (fire burning into the wind or downhill) and flanking fires (burning parallel to the wind) to form a black line which can contain the more intense headfire (fire burning with the wind or uphill). This technique is often used with two ignition/holding crews.

When designing the burn unit and planning the burn it is best if the downwind break is a hard break, such as water or plowed cropland. The downwind break is where the backfire will be lit and where holding will be against a headfire crossing the break. If a hard break is not possible on the downwind side of the burn unit a mowed break can also be used, it will just require more diligence and work to hold the break. (In this example, the mowed break on the south is being used for the backfire line because of smoke concerns for the road on the north.)

First, a test fire is lit in the downwind corner of the burn unit with all resources present. A test fire is small enough that it can be quickly extinguished using available resources, but large enough to observe the fire behavior that may be expected for the rest of the burn. Based on observations during the test fire, a decision is made whether or not to proceed with the burn. (In this example there are two ignition/holding crews, both start out at the test fire location).

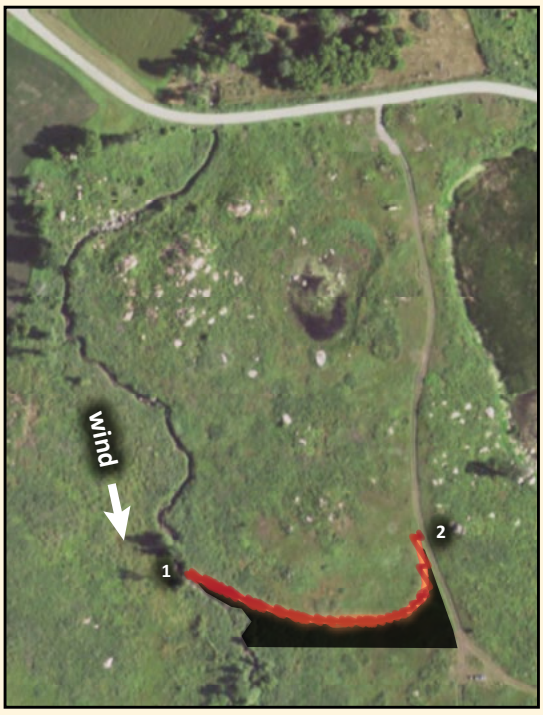
Burn unit and burn breaks.

Test fire.

Second, ignition/holding crews light off the backfire line and let it burn out until it is secure and sufficiently wide to hold a headfire. Typically, one person on the crew lights while the others use water and/or hand tools to keep the fire from crossing the break. Usually a wet line—a continuous line of sprayed water along the firebreak—is applied ahead of the ignitor, just before ignition. When lighting the back and flank fires, it is good to light in increments and wait for the fire to burn out away from the break before continuing ignition. After the backing fire is lit and is holding at the break, a narrow strip can be lit upwind of the backing fire inside the burn unit to widen the blackline more quickly. This produces a headfire, so be sure the existing black is sufficient to hold it. The backfire line is critical to holding when flank and headfires are lit. At minimum, attain a secure swath of black at least twice as wide as the longest flame lengths.

Third, keeping pace with each other, ignition/holding crews light the flanking fires and allow them to burn out enough to contain the headfire. The flanking fires are on the sides of the burn unit parallel to the direction of the wind. When lighting flanking fires with two ignition/holding crews, the crews should keep pace with each other to keep from sending a headfire toward the opposite flank. For example, if the backing fire was on the south break, and there is a northwest wind, the east flank should stay ahead of the west flank.

Light backing fire.



Start lighting flanks.

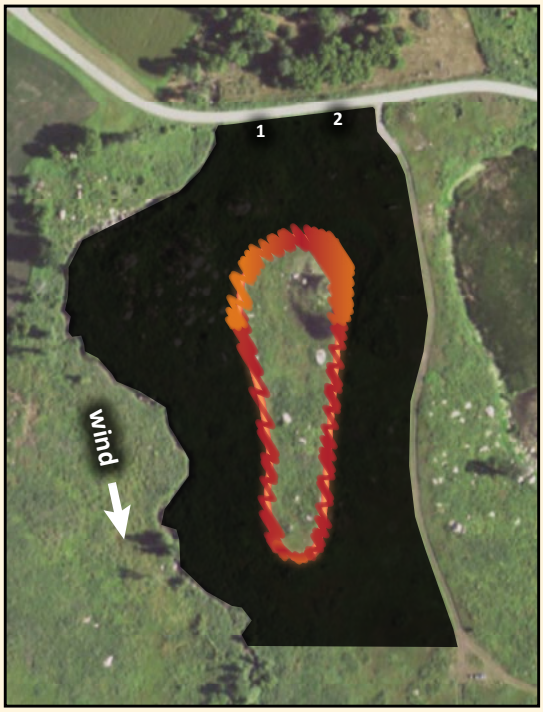
Continue lighting flanking fires with ignitions coordinating pace.

Finally, the crews come together to light the headfire and "ring" the burn unit. When ringing the fire on a straight break with consistent winds, containment is generally easy. If the ignition/holding crews come together in a corner, the crews should pick up the pace at the end, as the fires tend to pull together and race to the corner.

Completely-ringed fire, burning remaining fuel.
Photo credit: Judy Schulte

Ring fire technique showing fire back-burning from firebreak into burn unit.
Photo credit: Judy Schulte

Ring the fire.



Wait for burnout.

Prescribed burns are routinely accomplished safely by natural resource managers throughout Minnesota's prairie region—still, the fact remains that if something goes wrong with a prescribed burn, it can have drastic consequences. The intent of this section has been to provide information on factors to be aware of when considering using fire as a management tool. Many aspects of conducting a prescribed burn can only be learned from actually participating in one, especially the safe rate of ignition in different conditions and fire behavior trigger points. If you are new to prescribed burning, you should get help, both in planning and in conducting the burn, from someone with prescribed fire experience. You can also gain experience by volunteering to help on burns led by experienced burners.

Additional information on the procedures of prescribed burning can be found in *Prescribed Burning Guidelines in the Northern Great Plains* (Higgens et al., 1989). Available at **openprairie.sdstate.edu/cgi/viewcontent.cgi?article=1436&context=extension_circ.**

More information on prescribed burning in Minnesota and links to other resources can be found on the Minnesota DNR prescribed fire webpage at **mndnr.gov/rxfire.**

Chapter 5: Mowing and Haying

Over the last century, farmers preserved many of our best examples of prairie left in the state as "wild hay" ground. Hay prairies were foundational to agriculture in Minnesota and remained common until the 1930s (Granger & Kelly, 2005). More recently, mowing in prairies has become common as a means to promote biodiversity by controlling invasive plants, helping seedlings establish, creating structural variability, and reducing brushy cover. Haying and mowing can be good tools for maintaining healthy prairies.

Difference Between Mowing and Haying

Mowing prairies entails cutting swaths of vegetation and leaving the residue. While mowing is more commonly used for targeted goals, it can be used as a form of general disturbance. Since one of the major benefits of disturbance on prairies is removal of accumulated duff, it may seem counterintuitive to mow and leave cut vegetation on a prairie. While larger piles may smother plants, dispersed cut material is less problematic. The lower carbon to nitrogen ratio of plant material cut during the growing season increases the rate at which decomposers can degrade the material and return the nutrients to the soil (Enríquez et al., 1993). In more practical terms, hay rots faster than straw. However, mowing has been shown to be less effective than fire or haying at altering prairie composition (Tix & Charvat, 2005). If a prairie needs disturbance, removing the cut material more closely mimics the historical disturbances of fire or grazing.

Haying involves both cutting and removing plant material from the site, removing nutrients in the process. In healthy prairies the native plants replace the lost nutrients. Nitrogen is replenished by legumes (plants in the bean family) and by deposition from the atmosphere (Maron & Jefferies, 2001; Tilman et al., 2006). For this reason, healthy prairies do not require fertilizer. Fertilized prairies may show increased productivity for a short time, but are likely to become overrun with non-native cool-season grasses, which benefit more from the increased nitrogen (Hautier et al., 2020; Suding et al., 2005). Long term, this can reduce overall diversity and lead to lower productivity and land less suitable as habitat for wildlife.

Effects of Mowing and Haying on Prairie Composition

If prairie has not had disturbance for a while, haying has been shown to increase productivity and native species richness to a level comparable to prescribed fire (Wagle & Gowda, 2018). These positive effects may last for a number of years, but long-term annual mowing and haying also have consequences to consider.

Photo credit: Fred Harris

While mowing and haying promote diversity, they may not benefit all groups of plants. Over time, as with other regular disturbances, repeated cutting may lead to declines in plants which are triggered to germinate by fire and plants that are at critical growth stages during the time of the season when cutting occurs. Important nitrogen fixers in the bean family can be negatively impacted by long-term haying, excluding leadplant which is stimulated by cutting to reproduce vegetatively (Rooney & Leach, 2010). For this reason, it may be important to monitor vegetation in areas managed with long-term mowing or haying and occasionally refresh the plant populations with a prescribed fire.

Long-term, repeated haying and mowing during summer can promote the growth of cool-season grasses and early forbs and decrease the abundance of highly productive warm-season grasses (Wagle & Gowda, 2018). This shift can become problematic when it favors cool-season invasive plants. Of special concern is the abundance of invasive grasses such as smooth brome, redtop, and Kentucky bluegrass. In healthy prairies without these invasive cool-season grasses, the encouragement of cool-season plants under summer haying can lead to some spectacular displays of spring wildflowers.

Invasive Species

Introducing a new infestation of invasive species on equipment is a major concern with mowing or haying. Equipment needs to be thoroughly cleaned before each use in prairie. Some species especially prone to transportation on mowing equipment include smooth brome, wild parsnip, crown vetch, Queen Anne's lace, leafy spurge, spotted knapweed, and bird's foot trefoil. These species are common in roadsides throughout most of the prairie portion of the state, partly because they do well under mowing and haying regimes and are easily spread by that equipment.

Common Goals

Hay Production, Working Lands Priority

Many prairies continue to be managed with the primary goal of hay production. These prairies are typically hayed in late June to July. In healthy prairies, this timing captures the new growth of warm-season grasses and is the best timing for abundant, nutritious hay. Nevertheless, be cautious with repeated mid-summer haying of the long-term shift toward cool-season exotics and decline of legumes mentioned above.

If you see undesirable shifts occurring on your hay prairie, there are some options: 1) refresh the prairie with fire, especially a later spring burn to set back cool-season species, germinate legumes, and encourage reproduction by warm-season species, and 2) alter the haying regime to relieve repeated stress on warm-season grasses. While July may be the optimal timing for the quantity and quality of hay, it may be worth compromising slightly on hay productivity to recover prairie health. This could mean haying slightly earlier in the year when cool-season plants are at their maximum, but warm-season grasses have just begun growing. While this compromises somewhat on hay quantity, it reduces competition and gives warm-season grasses time to recover after haying. The alternative, haying after warm-season species have matured in late August to September, may also be effective at recovering the abundance of warm-season plants. Haying at this time would provide the most material, but nutritive quality would be somewhat lower.

Biodiversity: Disturbance and Habitat Heterogeneity

Changing around the timing, pattern, and frequency of mowing or haying can increase the variability across the site and provide more diversity of habitat, or "**heterogeneity**." This can take the form of rotational haying, where only a portion of an area is hayed each year, and where timing of haying is varied. To leave a portion of the field as habitat, small patches or swaths may be intentionally missed in hayed areas to provide additional smaller refuges for wildlife.

Targeted Cutting: Brush Control

Shrubs are a healthy part of some of Minnesota's prairie plant communities, but when they become over-dominant it may be difficult or impossible to recover the desired community through fire or grazing. Brush mowing can be an effective tool in these cases and is best when paired with other management to shift the community back toward a more open community. When large equipment is required, mowing can be done when the ground is frozen to avoid soil disturbance, especially in wetter communities.

Establishment Mowing

Mowing has been shown to be useful for reducing competition while establishing a prairie restoration or interseeding into established vegetation. One or more cuttings may be done each year with the goal of keeping vegetation short enough that newly established seedlings are not shaded out by established plants. See Chapter 9: Prairie Restoration and Enhancement for more on this topic.

Targeted Cutting: Invasive Species Control

When the goal is to use cutting to reduce undesirable, usually invasive species, it is important to understand the biology and ecology of the target species. Reproduction of biennial species may be greatly reduced by mowing or haying right before seed maturity. Timing is essential. If you mow too late, when seeds are mature, it will benefit the invasive species by spreading its seed. If you mow too early, the plant will just send up a new flowering stalk.

Some evidence suggest that well-timed haying may reduce the abundance of the most problematic invasive plants in prairies. Well-timed mowing or haying may reduce the abundance of the invasive smooth brome (Foster et al., 2009, p. 1891). Published literature is less optimistic about the effects of haying to manage invasive reed canary grass in wet prairie and wet meadow (Lavergne & Molofsky, 2006), but there are multiple locations in the state where annual haying appears to have been effective at least in keeping reed canary in check so that a native community remains on the site. Other species may be nearly impossible to control with cutting or mowing, including: Kentucky bluegrass, crown vetch, and bird's foot trefoil. Alternative management practices should be considered if those species are problematic.

Chapter 6: Grazing

Grazing by ungulates (hooved animals like bison and elk) is one of the natural disturbances that shaped and maintained the prairies of North America. Grazing is a common practice, but can take many forms depending on the goals of the landowner and the **producer** (a person who owns livestock and applies grazing). Utilizing good grazing practices can help maintain healthy pastures and provide forage for livestock while at the same time providing wildlife habitat and a diverse plant community.

As in any management project, the first step is determining specific goals, choosing the appropriate tool or tools, and setting benchmarks for measuring success. A healthy pasture for livestock production may be your goal for your grassland, but grazing can also be a tool to help accomplish other goals.

If grazing is determined to be a tool that can help achieve management objectives, the next step is to look at whether it can be utilized on the property and how it should be implemented. Whether or not a site can be grazed depends on having a water source, fencing, access, shade, and a producer with livestock available. Appropriate implementation practices to achieve desired outcomes will depend on grazable acres, forage production, timing, stocking, rotation, and the type of livestock.

Photo credit: Judy Schulte

Each of these must be approached with due diligence to achieve management objectives while providing for the health and needs of the livestock. This section provides information to help decide whether grazing is an option and a fit for management goals. Given that cattle are the most commonly utilized livestock in this setting, much of the following discussion refers to grazing with cattle. Other livestock and their particularities are treated later on.

Fencing

Many types of fences can be used and they vary in their costs, advantages, and disadvantages. The right type of fence will depend on the property and the project, the type of livestock, and whether the fences can be maintained. Commonly used fences include barbed wire and electric fence.

Barbed Wire

Barbed wire is a time-proven way to keep animals in place and widely considered the standard. One drawback to barbed wire is that it is relatively permanent; once installed, chances are that fence is not moving for a long time. This is one reason barbed wire is frequently used for perimeter and boundary fences, as those lines do not often move.

Other drawbacks to barbed wire relate to maintenance and wildlife impacts. It tends to need some annual maintenance, particularly after winter. It will stretch to some degree, but heavy vegetation and snow loads can cause it to break. Barbed wire can also be hard on wildlife. It is not uncommon to see birds that have flown into wires, become tangled and died, or deer that have tried to cross a fence and caught a leg or antlers. Birds that fly low in dim light conditions are particularly susceptible to wire collisions.

Barbed wire also has advantages. It is widely accepted as a good physical barrier and handles fluctuating water levels better than other types of fencing. Barbed wire is more fire resistant when built with metal posts instead of wood. In grass fires, metal posts will not burn and the fast pulse of heat does not compromise the wire's integrity. Fires in woodlands, where the heat is more intense and for a longer duration, can compromise fence wire (regardless of wire type). Keeping space between the fence and heavy wood fuels will reduce the potential for damage to the fence in a prescribed fire or wildfire.

Electric Fencing

Electric fence technology has advanced much in recent years. Like barbed wire, it has its pros and cons, but depending on management objectives, it might be a good fit for the project. Unlike barbed wire, electric fencing can be portable as well as permanent. Power sources can vary from a 120V fence charger to a

solar fence charger that can be placed on a post or on the ground. Relying on electric fence chargers can be worrisome during severe summer weather, as all chargers are susceptible to lighting strikes. Lightning diverters can save the expense of replacing a charger because the diverters absorb the shock and need to be replaced, instead of the more expensive charger. Another downside is that fluctuating water levels in wetlands and streams that electric fences may cross or be adjacent to can wreak havoc on the fence. Despite their challenges, electric fences can be a very effective tool.

For **permanent electric fence**, 12-gauge high tensile wire is the standard for infrastructure. High tensile tends to have excellent memory, making it a hassle to wind up and difficult to reuse for temporary fencing. Permanent electric fencing takes some maintenance through the course of the summer. If fence is in contact with a lot of vegetation, it can draw down the voltage on the wires. If the wires are vegetation-free when the fences are turned on, it will generally singe the vegetation (setting it back) where it touches the wires.

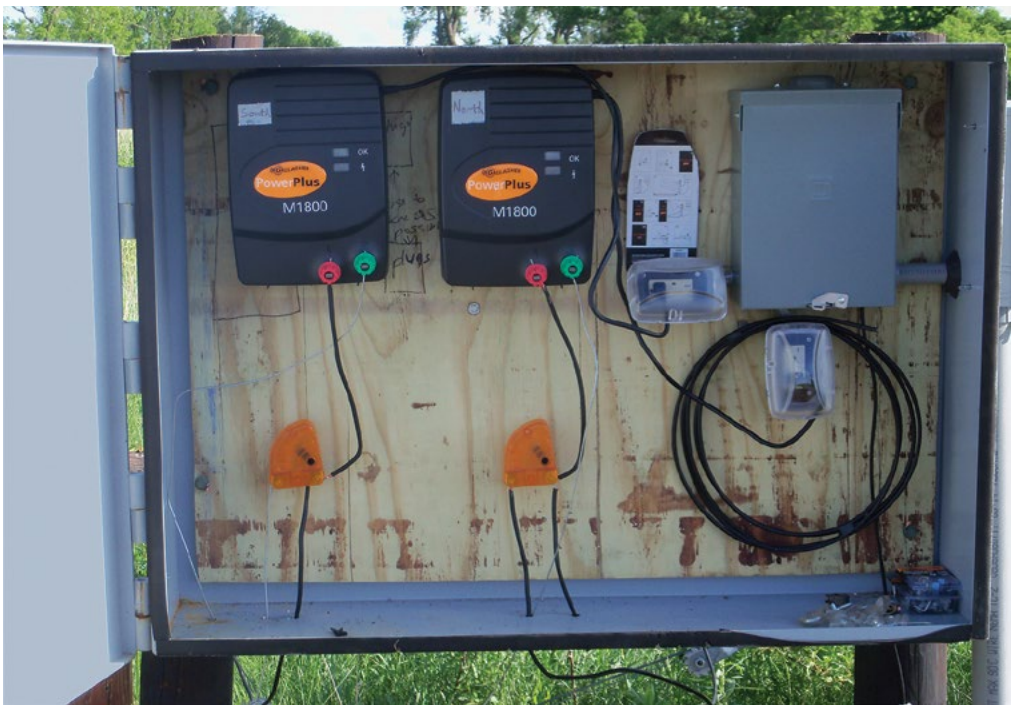
For **temporary electric fencing**, various wire materials are available that can be used with step-in posts including polywire, polyrope, polytape, and zinc-coated cables, which are pliable and can be reeled up on handheld spools. Temporary, movable fencing provides management flexibility by allowing the manager to adjust the amount of pasture available based on management objectives, the herd's forage needs, current forage availability, and current growing conditions.

Strong fences are important to contain livestock.
Photo credit: Joe Blastick, The Nature Conservancy

Compared to barbed wire, electric fences are generally cheaper to install and require less maintenance. Temporary electric fence is fairly straightforward to install and use. Permanent high tensile fence, however, requires specialized tools for construction. It is recommended to seek advice from someone who has experience with the proper methods of building high tensile fence before installing to save you time and money and help ensure a quality final product.

Another advantage of electric fence is that it is more wildlife friendly than barbed wire. High tensile fences are more psychological barriers than physical barriers. The wires have more give than barbed wire fences, so deer can more easily pass through the fence if they run into it. Also electric fences do not have wildlife-entangling barbs. Electric fencing also has some disadvantages, one of which is that it does not present as much of a physical barrier as barbed wire. While it uses electricity as a deterrent to animals, they may physically be able to push through it, especially if the power is down. It is also more vulnerable to fire because the most commonly used insulators and posts are made of plastic or fiberglass.

The Natural Resource Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) can offer cost share to help with developing grazing infrastructure.



The lightning diverter lies between the hot fence and the charger itself and is designed to absorb any lightning strike and protect the charger.

Photo credit: Joe Blastick, The Nature Conservancy

Water Sources

When designing a grazing system, it is critical to have ample clean water for the livestock, whatever the herd size. It is generally accepted that 30–40 gallons of water per cow-calf pair per day is required in the hottest part of the summer. Another way to determine the herd's water needs is to allow for 2 gallons of water per 100 pounds of animal weight per day at a minimum (Institute of Agriculture and Natural Resources, 2020; Rasby & Walz, 2011). This can be provided by having large tanks, or by having a pump system that can keep smaller tanks full and keep up with demand. Tanks can also be kept full by delivering bulk water at regular intervals, although this puts demand on a producer's time.

Water sources receive heavy use and trampling, so they should be located away from high quality prairie areas. Gravel or concrete bases can be added around water tanks to help minimize the disturbance. Though streams are sometimes used as water sources, this is discouraged as it can lead to pollution of the waterway and severe erosion. In addition, streams can dry up and leave the pasture without water.

Wetlands can also be used as water sources and, in some situations, grazing wetlands can provide management outcomes. Marshes choked out by invasive narrow-leaf cattail lose some of their ecological function. Cattle can be allowed in the wetland to trample down cattail and open it up, which improves habitat for waterfowl and shorebird use. Note that some types of wetlands (such as fens) may be susceptible to severe damage from livestock and some may be hazards for animals that may become stuck, it may be advisable to fence these wetlands off.

Water can also be pumped out of a pond or stream into water tanks. Cows will prefer to drink the cleaner water and it is healthier for them, though they may still enter the waterbody to cool off or get away from flies. Many portable pump systems are available and they can be used to move the livestock around the pasture. Small, self-contained solar pump units are very portable and quick to set up once tanks are in place. Solar pumps must either store energy in batteries or water in tanks to ensure water availability at night or during long periods of heavy cloud cover. Solar systems vary in the volume of water they can provide and how far they can move water, especially how far they can push water uphill. Companies that supply solar systems can help determine the proper system for your pasture.

If using a natural waterway for a water source, check with local and state authorities to insure compliance with wetland, drainage and pumping regulations.

Portable solar pump systems in action.

Photo credit: Joe Blastick, The Nature Conservancy

Shade

In planning a grazing system, consider sources of shade. Be aware that these can be high use areas. In the hot days of summer, the herd will stick to the shade under a single tree or in a grove. Depending on management goals, the hoof action and disturbance may be desirable for knocking down underbrush and opening the woodland. Over time however, the underbrush will often be replaced with shrubs, such as prickly ash, which cattle avoid.

Mineral Supplements

Mineral supplements are important for the health of the livestock, and they will spend more time in areas where supplements are placed. This can be used to your advantage, for example to get higher trampling in areas where brush control, particularly snowberry/buckbrush control, is desired. The additional hoof action can temporarily set back thickets. Mineral can also be used to get livestock moving around the pasture as they will travel between the mineral and the water source. Placing mineral close to the water supply will focus the animals and the disturbance they cause in one location. Moving mineral periodically can help spread the disturbance across the pasture. One note: some mineral supplements contain seed of non-native species, mostly clovers, which livestock spread in their dung. On non-native pastures, adding legumes can be beneficial, but on native prairies this introduces non-native plants that can be invasive and are best avoided.

Grazable Acres

When determining stocking rates recognize that not all acres of a property provide good forage for grazing. Wetlands, groves, streams, rock outcrops, and other features that do not provide forage should be excluded when determining grazable acres. Grassland productivity will also vary between soil types, plant communities, and dominant species. Not accounting for ungrazable areas and differences in productivity can lead to overstocking and failure to meet objectives and maintain grassland health.

Stocking

Grazing impacts to grasslands are largely a factor of the number of animals, when they are present, and how long they are on the pasture. Grasslands should be stocked based on objectives. For example, a short-term high stocking rate for 2–3 weeks in May/early June can set back non-native cool-season grasses like smooth brome and Kentucky bluegrass and allow for more warm-season plant growth. This can provide better wildlife habitat in the fall. Undesirable plants can be targeted by grazing, though it can be tricky for some weeds. At the right time, many weeds are palatable to livestock, but timing is critical and the optimal time varies by weed and the type of livestock.

Even if the goal is just to maintain a healthy pasture, if too many animals are on it for too long the objective will not be met. To determine the stocking rate for management objectives the forage production must be determined. To maintain pasture health, it is generally held that, of the total production, 25% is available for livestock consumption (see Harvest Efficiency below). Also, by leaving enough aboveground vegetation post-grazing, the grass maintains a healthy root system and will grow back faster, which is beneficial for pasture health and for future grazing. Of course, maintaining pasture might not be your primary goal, some objectives might be better achieved by removing more or less of the available forage.

In determining stocking rates there are two main considerations: 1) how much forage is available for grazing, and 2) the size of the animals. Most published calculations for determining rates are based on a 1000-pound cow (considered one Animal Unit, or AU). If the animals being stocked are larger or smaller, adjust your calculations. For example, if the cattle being stocked are a large breed weighing 1200 pounds, then each animal is considered 1.2 AU. The actual, accurate numbers for AU and forage production should be used as much as possible. The following is a breakdown of the process of determining the optimal stocking rates.

Definitions of Inputs for Calculating Stocking Rates

Total available grazable acres: All the acres that produce usable forage, excluding wetlands, lakes, groves, and other areas where conditions are not suitable.

Forage production: The average number of pounds per acre of forage produced in the pasture in one growing season. This can vary from year to year due to weather. Estimates are available for some soil types, or samples can be clipped from the pasture and weighed.

Harvest efficiency: This accounts for matching forage consumption with available forage while also leaving enough stubble behind for regrowth. Commonly referred to as “take half, leave half,” this allows sufficient aboveground biomass to support the root systems and to speed forage regrowth. To leave half, the loss due to trampling and defecation must also be considered; together, these account for about half the losses during grazing. This leaves 25% of the total forage available for animals to consume. It breaks down as 50% retained for pasture health, 25% consumed, and 25% lost to trampling and defecation. If more than 50% of the aboveground biomass is removed, the root systems of the grasses can no longer be supported by the remaining photosynthetic surface and will start to die, which in turn greatly slows the aboveground regeneration.

Daily forage consumption: How much an animal actually eats in a day. It is commonly calculated using 2.5% of the animal’s weight, but 3% builds in a conservation buffer.

Number of animals: This number will dictate how long the cows stay in a particular paddock. If fewer animals are used, they can stay longer, and vice versa. However, for some management objectives, leaving fewer animals on the pasture for a longer time may not be the best practice.

Animal weight: The actual average weight of animals in the herd. The calculations are based on how much forage is consumed. If livestock weight is under estimated, it will lead to overgrazing.

Number of days: The days on the pasture or paddock as determined by the numbers of animals grazed and how much they consume.

Animal Unit Month (AUM): Calculated when determining stocking rates (e.g. for rental agreements) as one 1000-pound animal (one AU) grazed for 30 days.

Determining Forage Production

Knowing how much forage a site produces is essential for determining a stocking rate to meet management objectives (Pratt & Rasmussen, 2001). There are many ways to determine forage production. The quickest and easiest way is to utilize a "grazing stick" (Meehan et al., 2015; SDSU Extension, 2014). A grazing stick is a modified four-sided yard stick that allows a producer to do a rapid assessment of production and stocking on their pasture, as well as identify when the forage is short and it is time to move the herd.

Another tool is the Web Soil Survey (USDA NRCS, 2020) that is free and available through the Natural Resources Conservation Service (NRCS). The Web Soil Survey allows a producer to look at the various soil types and plant communities to estimate production, though this information is not available for every soil type. The same information can sometimes be found in county soil surveys as well.

A third option is to physically clip and weigh samples taken from the pasture (Meehan & Sedivec, 2017). Although this method requires some work on the front end, it is the most reliable method. When done correctly it actually measures the production on your pasture, which is the most accurate information.

A simple way to find biomass through clipping is to make a hoop from a 42.54-inch long piece of stiff rope or hose. Ounces of forage clipped in the hoop area is equivalent to tons of forage per acre. The clipped samples must be dried before weighing. To dry samples, place in paper bags and set in a warm dry place for several days. The more samples that are clipped in the pasture, the more accurate the production estimate will be.

Calculating how long to graze a pasture based on the herd size:

1. Calculate forage production for the paddock or pasture.
   - Forage production = total grazable acres × average forage production per acre (Example 100 acres × 2000 lbs/acre = 200,000 lbs)

2. Calculate harvest efficiency target.
   - Harvest efficiency target = total forage production × 25% (Example 200,00 × 0.25 = 50,000 lbs)

3. Calculate daily forage consumption for the herd.
   - Total daily forage consumption = 3% consumption rate × actual animal weight × number of animals. (Example 0.03 × 1200 lbs × 30 animals = 1080)

4. Finally, calculate the duration of grazing.
   - Total number of days to graze based on forage = harvest efficiency target/total daily consumption (Example 50,000 lbs /1080 lbs per day = 46 days)

Stocking rate calculations to determine Animal Unit Months based on a specified time frame:

1. Calculate available forage production for the pasture.
   - Available forage = grazable acres × average forage production per acre × 25% harvest efficiency (Example 100 acres × 2000 lbs/acre × 0.25 = 50,000 lbs available forage)

2. Calculate Animal Unit equivalency for the animals.
   - AU = average animal weight/1000 lbs (Example 1200 lb cow-calf pair/1000 lbs = 1.2 AU per pair)

3. Calculate daily forage consumption.
   - Daily consumption = animal weight × 3% (Example 1200 lb cow-calf pair × 0.03 = 36 lbs per day per pair)

4. Calculate forage consumption per animal for the desired grazing window.
   - Forage consumption per season = grazing days × daily consumption (Example 120 days × 36 lbs = 4320 lbs for the season)

5. Calculate holding capacity of pasture for timeframe.
   - Holding capacity (animals) = available forage/grazing window consumption (Example 50,000 lbs available/4320 lbs = 11.6, round to 11 cow-calf pairs)

6. Calculate Animal Unit Months (AUM).
   - AUM = holding capacity (animals) × AU equivalency (Example 11 pair × 1.2 AU per pair = 13.2 AUM)

If grazing multiple paddocks, determine the stocking rate and timing for each of the paddocks. The size and production of each paddock may be different, so length of the grazing period for different paddocks may differ. If the calculated stocking rates do not produce the desired management effects, the rate can be changed in successive years. A one-time overgrazing event will probably not have drastic consequences, but many years of overgrazing will.

Determining forage production and stocking rates to meet objectives can be one of the more challenging aspects of grazing planning. For help in determining stocking rates consult a local natural resources professional. The NRCS, extension services, and others have grazing professionals who can help. You can also consult local ranchers with experience in the area.

Rental Agreements

Pasture rental leases are very important for both the landowner and the tenant, and both parties need to be clear on expectations and outcomes. As a landowner it is critical that leases specify how many animals can be in the pasture and for how long. These agreements are typically done by specifying AUMs, but other specific language about stocking numbers and timing can also work. The desired residual (stubble height) to be left at the end of the grazing season can also be a part of the agreement and can account for unforeseen events (like droughts) that could impact forage production. If the agreement is just written to allow grazing for the season, there is no incentive to leave residual plant material. This can lead to overgrazing and grassland degradation, which can in turn lead to less forage production and an increase in weeds over time. A rental agreement should reflect management objectives for the land. By using AUM or specific timing and numbers in agreements, the renter is paying for the actual forage the landowner wants removed, which allows for better regulation and pasture management.

Access and Moving Livestock

Determining how animals will be brought into and moved out of a pasture can take some planning. Animals are commonly moved in with trucks. Trailers full of livestock are heavy, and could get stuck or cause significant disturbance in soft or wet soils. Choose a dry place with a firm surface for loading and unloading. It is best to consider the worst-case scenario for weather and conditions. If the trucks cannot get in to move animals out, it could mean the pasture becomes overgrazed, the producer must haul in supplemental feed, or worse, the animals' forage needs are not met. The holding system must also be considered. A permanent corral system has the advantage of being durable, but can be expensive and limited to one location. Permanent corrals are not a good choice on high quality native prairie, since very heavy use in the corral area can degrade or destroy the prairie. However, locating a corral on adjacent non-prairie could be an option. Wooden corrals will require upkeep and are vulnerable to fire. Pipe and rod corrals are fireproof and low maintenance.

In many cases a portable corral consisting of free-standing panels may be used, which gives the producer more flexibility for site selection—though they still need to provide for maneuvering trucks and trailers. A holding pen and/or ramp can be useful for loading and unloading animals, and for separating sick animals.

Consider the particular situation for your grassland when looking at grazing options. If a neighbor to the property has grazing livestock, they may be willing to move their animals onto your property for a specified duration. This could provide an opportunity to choose timing and stocking rates that can target specific management goals (for example, reducing non-native cool-season grasses). Producers generally do not want to move large numbers for a short duration, but opening a fence is relatively easy.

Quarantining

Consider the pastures or feed supplies provided to the livestock prior to grazing a pasture, especially a native prairie pasture. If the pasture or feed has mature seeds of non-native species, those seeds may be able to pass through the animal and out in their dung as viable seeds, which may introduce non-native species into the pasture. The animals may need to be quarantined or confined in a pasture consisting of forage without weed seed heads, or fed weed-free feeds for up to 3 days.

Considerations for Different Types of Livestock

Different animals graze differently and have different effects on the plant community. They also differ in their infrastructure and water requirements. In designing a grazing project for specific objectives, the choice of the type of livestock can be an important consideration. AU equivalents for various types of livestock are available in the **NRCS National Range and Pasture Handbook** (USDA NRCS, 2003).

Cattle are more readily available than other livestock and eat broadleaf plants as well as grasses. If a specific plant needs addressing on the pasture, cows can be trained to target certain species (Shaffer & Bauman, 2020) on both a large and small scale, which adds some versatility to their use for management purposes. Depending on the stocking rates, they can be used to consume all the forage, or if stocked appropriately, will consume mostly grasses.

Sheep are notable for eating broadleaf weeds, including leafy spurge, thistles, common tansy, and other broadleaf plants. They will target broadleaves over grasses, and are more effective when kept in smaller pens. Be aware that grazing sheep for many years can greatly reduce the forb component of grasslands. They should not be grazed on pastures with a lot of needlegrasses when they have seeds, since the seeds get caught in their wool and can cause serious problems. Sheep are often accompanied by donkeys, llamas, or guard dogs for protection from predators.

Photo credit: Dave Jungst

Goats will devour woody stems, shrubs, and broadleaf plants, including weeds. Although goats can be challenging to contain, there are ways to contain them and they are often used in tree groves or areas overrun with buckthorn. Goats like to stay together and are more effective when they compete with each other, so smaller pens/paddocks are preferred. These are typically electric fencing pens that can be moved around once objectives are met. Goats have been known to climb on top of each other to eat woody plants. Like sheep, they are often accompanied by guard animals.

Bison are known for typically targeting grasses before forbs, which is an attractive trait for grassland managers looking to increase diversity. The challenges with bison are that they require much more extensive infrastructure, need more space, are more difficult to find, and do not work very well on smaller project areas. If the goal is to graze with bison, a producer must be found early in the process of developing the project, and the property must have sufficient capacity and infrastructure.

Grazing Systems

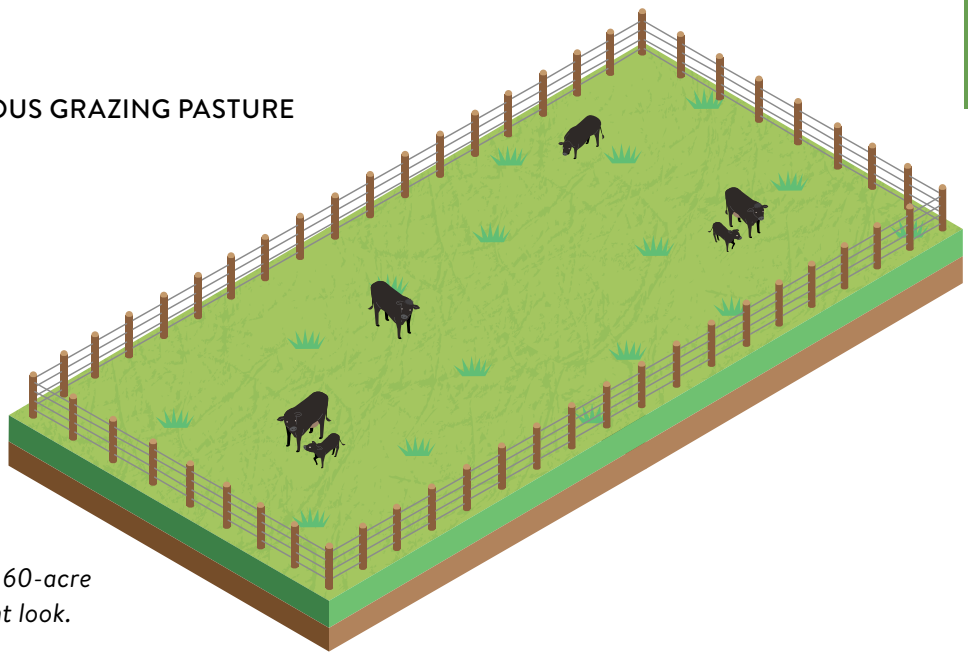
Grazing systems are strategies for moving livestock throughout the grazing season. There are a number of grazing systems that differ in the effort they require, the infrastructure that is needed, and the impact to the pasture. The keys to achieving management objectives on a pasture are to provide sufficient rest for plants to recover between grazing events, leaving adequate residual for plant recovery, and to manage the length of time livestock spend in a paddock.

Continuous/Season-Long Grazing

Continuous grazing is common in Minnesota for a variety of reasons. This type of system is very hands-off and low maintenance for the producer. Once any needed infrastructure repairs are made following winter, the producer essentially puts the animals in a pasture and checks on them throughout the grazing season. Since only one perimeter fence is involved, the investment in infrastructure is lower than other grazing systems.

Continuous grazing has some disadvantages. When given free range of the site, livestock will select more palatable plants and return to the same areas to graze on regrowth of preferred plants. Over time this can lead to sensitive plants, or more palatable plants, decreasing and less palatable plants increasing. The term "**increaser**" refers to plants that increase under grazing pressure; many of these are undesirable weeds such as gumweed and biennial thistles. The term "**decreaser**" refers to plants that decline with grazing pressure; many decreasers are native prairie plants that are important components of a healthy prairie plant community (Svedarsky et al., 2002). Continuous grazing also leads to increased trampling, manure accumulation and associated fly problems in those areas.

CONTINUOUS GRAZING PASTURE



This is how a 60-acre pasture might look.

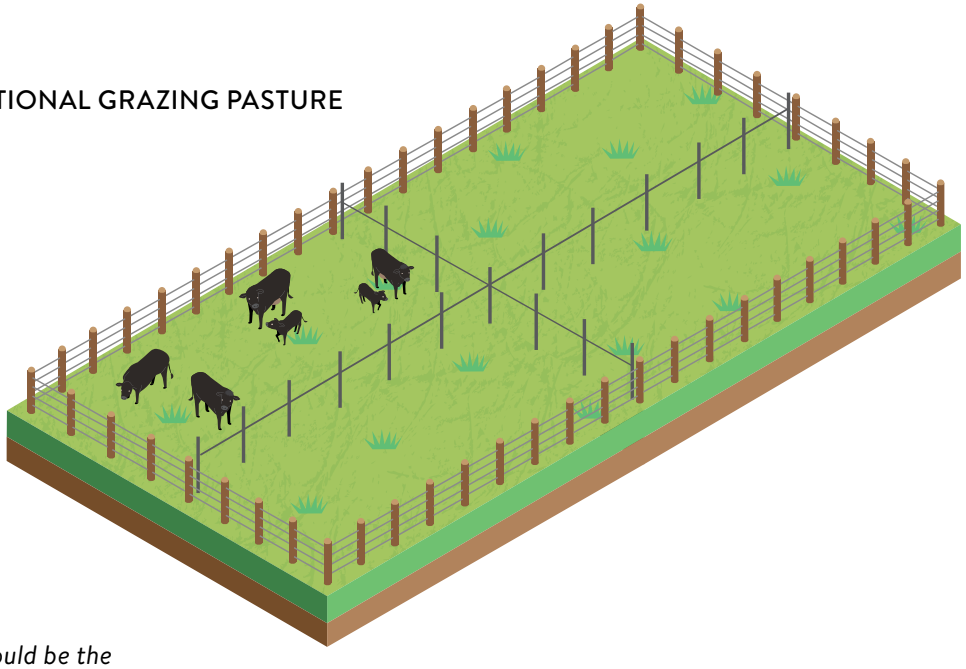
Rotational Grazing

In rotational grazing the pasture is split into two or more paddocks and the herd is moved between paddocks throughout the season. Livestock are kept in one paddock until the calculated grazing duration is reached, or until the desired utilization is achieved. The livestock are then moved to the next pasture to graze until they reach the point where they need to be moved again. The goal of rotational grazing is to get more even consumption across the pasture. If done correctly, it can give higher overall production and improve the pasture's condition. By moving the herd around, vegetation in the paddocks is less impacted by each grazing event and gets more time to recover between grazing events. Another benefit of rotational grazing is that it puts distance between the herd and old manure, reducing fly pressure on the animals.

The amount of residual needed for recovery depends on the plant species composition of the pasture. Shorter-stature native species such as side-oats grama and little bluestem require less stubble for recovery than taller species like big bluestem and Indiangrass.

Splitting the pasture into paddocks requires more investment in fence infrastructure and water supply, though a centralized water supply may provide for multiple paddocks and portable electric fence can be used between paddocks. Moving the herd between paddocks is also a time investment.

ROTATIONAL GRAZING PASTURE



This would be the same 60 acres with more fencing.

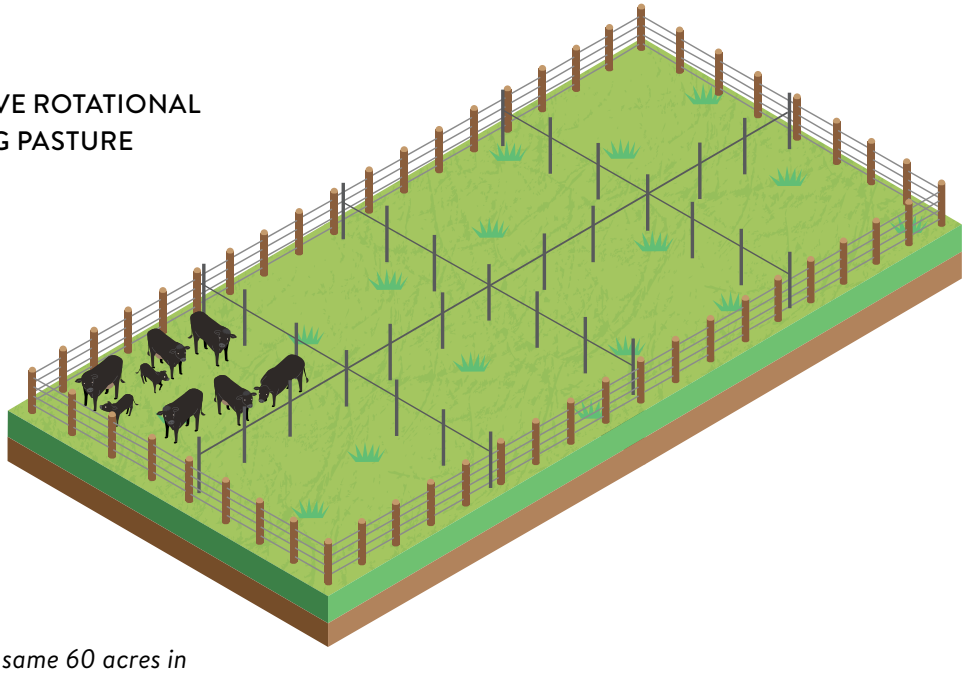
Though more investments are involved, rotational grazing gives better pasture utilization than season-long grazing and can greatly benefit the grassland community and the overall forage production. Ideally, the individual paddocks are rotated and grazed at different times each year, which can improve plant diversity. Wildlife also benefits from rotational grazing because it provides a heterogeneous (varied) structure across the pasture, including ungrazed (rested) areas, which especially benefits the grassland bird community.

Intensive Rotational Grazing

High-intensity rotational grazing (also called flash grazing) is similar to traditional rotational grazing, but instead of moving the herd a few times a season they are moved every few days (or even every few hours). These systems require more producer time and investments in fence and water infrastructure. Decisions on when to move the herd are based on vegetation response, which requires close monitoring of the forage and careful management of the herd. Knowing when to move the herd through the system is important and requires a good understanding of forage production.

Putting more animals on a smaller area forces competition between animals, and they race to consume as much as they can. This leads to pretty even consumption of the different forage plants and a more uniform utilization across the paddock. Manure is also more evenly distributed using these systems which is good for fertilization and fly control.

INTENSIVE ROTATIONAL GRAZING PASTURE



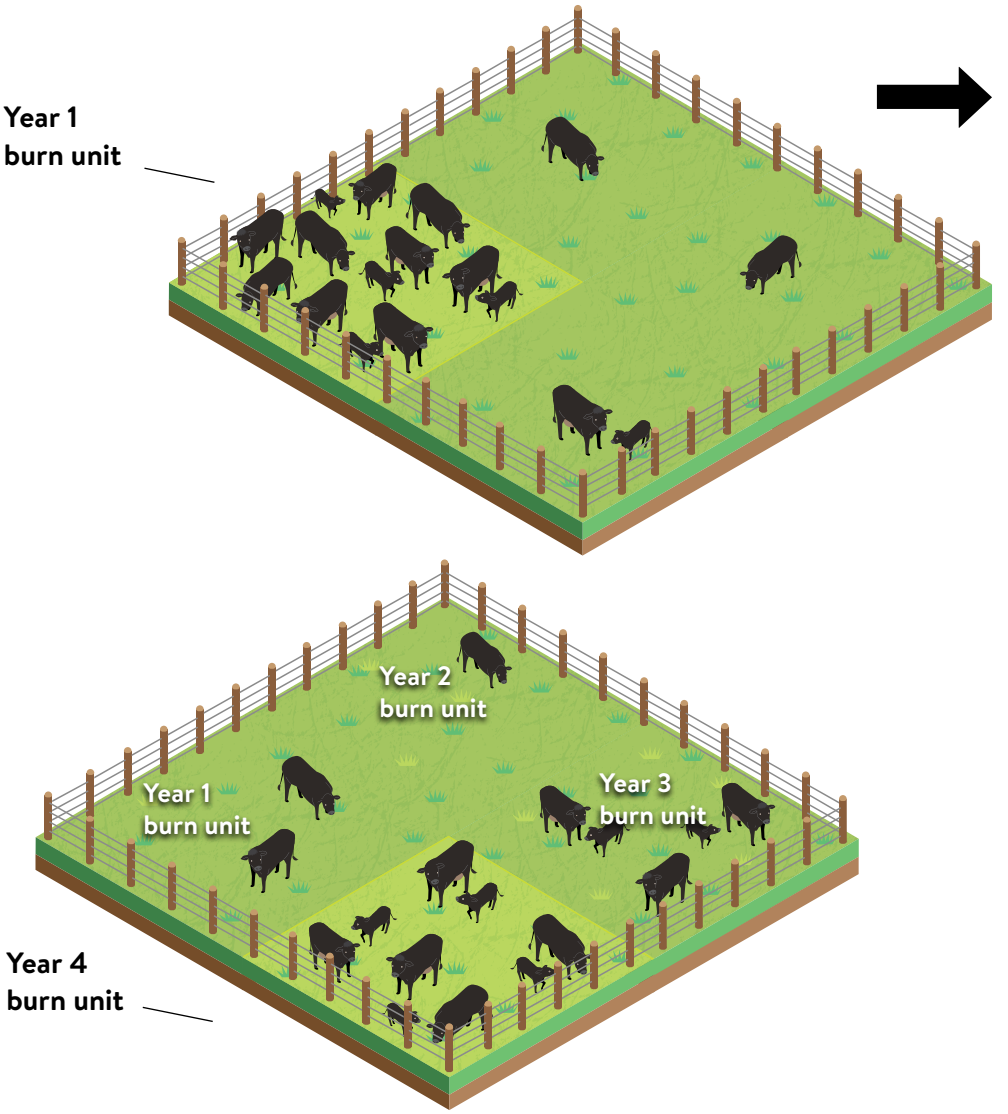
This is the same 60 acres in the intensive system: more animals and more paddocks.

Patch-Burn Grazing

Patch-burn grazing is a system that relies on prescribed fire to move livestock around a site. Cattle have an affinity for the lush green grass that comes up after a fire and will preferably spend their time grazing that area. No interior fences are used, so cattle can move freely around the site. Although the whole pasture is open to them, the cattle will spend most of their time on the burned unit, which in effect rests the remaining pasture. The season of high grazing pressure is made up for by the rest years that follow as burn units are rotated. Different units are burned each year, so the cattle target different areas, which is beneficial to wildlife, since it provides heterogeneous vegetation structure across the site.

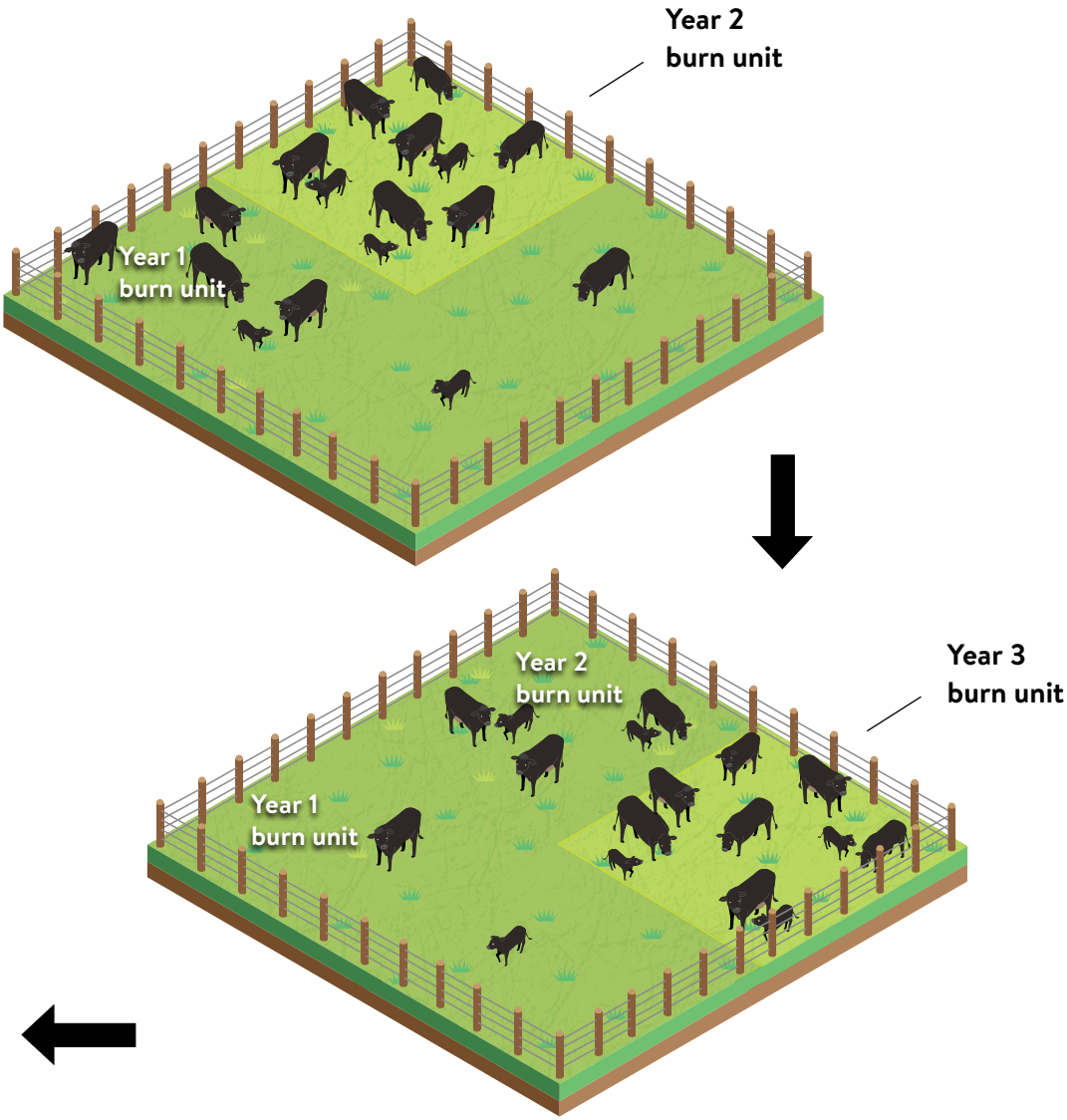
PATCH-BURN GRAZING PASTURE

Cattle will spend approximately 80% of their time on the current year burn unit and 15% on the previous year burn unit.



Patch-burn systems have some challenges, the greatest being the ability to burn. The cattle can help, since heavily grazed areas from the previous year can be used as burn breaks. If burning is not possible it can be simulated using the cattle. With portable electric fence the herd can be held in the "burn unit" until it is grazed down very short, then the fence is removed to allow access to the whole pasture. Though prescribed fire is better for the pasture and gives better results, mimicking it with grazing can be an option when fire is not possible.

Patch-burn grazing may not be a good option in all pastures. For one thing, there are all the concerns related to prescribed fire (such as escapes and smoke impacts). Also, it tends to work better in bigger pastures. With proper stocking rates, it can be used on pastures as small as 120 acres. Patch-burn grazing does not work well on pastures smaller than 120 acres, as it is too easy for the herd to access the whole pasture (and becomes like season-long grazing).



Grazed sand-gravel prairie in Lincoln County.
Phoho credit: Fred Harris

Targeted Grazing

Targeted grazing is the use of livestock to accomplish very specific management goals. One example is stocking during a specific timeframe to target a susceptible phase of a plant's growth cycle, such as grazing cattle in May and early June to target non-native cool-season grasses. Another example is fencing sheep or goats in an area with an infestation of a woody or herbaceous invasive species. Much like with prescribed fire, it requires knowing when the target weeds are most susceptible to the disturbance. Targeted grazing can be effective in reducing undesirable plant cover in the short term, but lasting results may take several years to achieve.

While it can be the best application of grazing for many management objectives, targeted grazing can be hard to implement as producers may not want to move animals if they can only be on the pasture a short time. Often targeted grazing is used in combination with other grazing systems. For example, targeting one area of a pasture for the specified time and then releasing the livestock to the rest of the pasture as described in the patch-burn grazing section. In rotational grazing, troublesome areas of the pasture could be grazed more intensely in the specified timeframe to target a particular problem there.

TARGETED GRAZING OBJECTIVES, TIMING, AND UTILIZATION RATES

Grazing frequency
Disturbance is needed every 1-5 years, depending upon management objectives and site characteristics including soil, topography and weather. For introduced cool-season grass and sweet clover control, grazing is required once in year one and twice in year two. Continued management beyond 2 years is likely.

The suggested timings and durations are approximate and may vary by annual conditions. Stocking rates to achieve desired objectives are determined by desired utilization and individual circumstances.

Mangement objectives:	**Suggested timing and rates:**
• Litter reduction • Cool-season grass control • Sweet clover control • Tree encroachment control • Improve structural diversity of stand	**Spring** April 15–June 15 Duration: 14–30 days Utilization: Moderate–heavy Stocking rate:_____
• Litter reduction • Sweet clover control • Tree encroachment control • Encourage tillering of warm-season grass • Improve structural diversity of stand • Enhance nesting cover	**Summer** June 1–September 15 Duration: 30–45 days Utilization: Light–moderate Stocking rate:_____
• Litter reduction • Cool-season grass control • Enhance ephemeral wetlands	**Fall** September 1–October 30 Duration: 14–45 days Utilization: Moderate–heavy Stocking rate:_____

Information based on a diagram provided by Jeff Duchene, NRCS Grazing Lands Specialist.

Monitoring

With any form of management, it is important to know if the practices are achieving the desired outcomes. This is particularly true of grazing because it concerns the health of grassland and the livestock. Many methods can be used to monitor grazing projects. A grazing stick can be used to look at remaining forage when animals are taken off the pastures and can be used to track recovery. Photo point monitoring consists of standing at the same place and taking a picture facing the same direction (for example, stand at a particular fence post and take a picture with a particular feature centered). Pictures should be taken at the same time each year or at the time of a particular indicator (for example when a certain species starts flowering). Pictures can also be taken prior to and after grazing. This is a quick and simple way of monitoring that can show changes through the season or year to year.

Exclosures are areas of the pasture from which the animals are excluded. They can be very helpful in seeing what the effects of the grazing are compared to the ungrazed forage inside the exclosure. This can help determine what the animals are consuming and whether grazing is accomplishing objectives. A quick, easy, and portable exclosure can be made from cattle panels, or sections of cattle panels, wired to t-posts. Larger exclosures will reveal more, but even small ones offer some insight. Whatever method is used, monitoring helps to determine whether objectives are being met and how the grazing regime should change to better meet them.

Conclusion

Grazing can be a great tool for grassland management but requires planning and monitoring. It is not the right tool for every goal, but used together with other practices, properly applied grazing can benefit the grassland resource while also benefiting the producer. Many resources are available to help with planning a grazing management project, including NRCS Range and Grazing Specialists, Private Lands Biologists, and local Soil and Water Conservation District staff. There are also programs available to help landowners with cost-share and grassland enhancements.

For More Information

Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement: **webpages.uidaho.edu/rx-grazing/handbook.htm**

NRCS National Range and Pasture Handbook. Available at: **nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture**

University of MN Grazing Systems Planning Guide: **conservancy.umn.edu/bitstream/handle/11299/49821/7606.pdf**

Grazing and Browsing: How Plants are Effected: **researchgate.net/publication/26904527**

Chapter 7: Invasive Plant Species Control

As was noted in Chapter 1: Challenges in the Prairie, an invasive species as defined by Minnesota statute is a species that is not native to the state and which causes economic or environmental harm or harm to human health. Not all non-native species are invasive, and some native species, especially trees, can be just as problematic in prairies as non-native invasive species. The list of definitions below may help sort out related terms that are commonly encountered.

Definitions

Invasive species (as defined in Minnesota Statute 84D.01): a non-native species that (1) causes or may cause economic or environmental harm or harm to human health; or (2) threatens or may threaten natural resources or the use of natural resources in the state.

Native species: a species naturally present within Minnesota or that expands from its historic range into the state without human intervention.

Non-native species: a species that is not native to Minnesota, but was brought by human movement or activity to the state. An "introduced species" is a similar term that refers to a species brought intentionally or accidentally to Minnesota.

Weed: a plant that is growing in a place where a person does not want it to be. A weed could be a native or non-native species. For example, poison ivy is native to Minnesota, but if it is growing in your garden you are likely to consider it a weed. If it is growing in a state forest, it is generally not a concern. A "nuisance species" is a similar term that could refer to a native or non-native species.

Noxious weed: a plant regulated as a Prohibited or Restricted Noxious Weed under the Minnesota Department of Agriculture's noxious weed law. Noxious Weeds and Specially Regulated Plants have specific legal restrictions and requirements under this law.

Prohibited and regulated aquatic invasive species: aquatic invasive species regulated by the Minnesota Department of Natural Resources.

Preventing the initial introduction of an invasive species into a site should always be a primary goal in prairie stewardship planning. Once an invasive species is present, the management goal becomes controlling its spread and impacts on the plant community.

Managing invasive species involves suppressing the invasive species populations and encouraging native prairie species populations. The appropriate strategy

depends on the characteristics of the site, the species of concern, management goals, and available resources. Though eradicating all invasive species from the prairie would be ideal, eradication is not always a feasible goal and alternative goals may be more realistic given the available resources.

Management Goals (Strategies) for Invasive Species

Eradication: The total removal of a population of invasive species from the site. This is often not feasible and generally can only be achieved for invasive populations with very limited occurrence or species with life history traits that can be exploited. Even if a population is eradicated from a site, it does not mean that it is permanently gone, it can reinvade the site.

Suppression (population management): Using tools (fire, herbicide, prescription grazing, flooding, etc.) to limit the dominance of a species in the target community. This is used when the population cannot realistically be reduced to the point where eradication is possible and where the species is already well-established throughout the site. Examples are managing smooth brome with spring fire and leafy spurge with biological control insects.

Containment: Restricting the spread of an invasive population that is already present on a site. This often involves working the edge of a large population and/or treating any satellite (outlier) occurrences. This strategy is often used where eradication or suppression are not practical due to the effort required or collateral ecological damage.

Exclusion (prevention): Keeping a species that is not yet present from invading the site, or keeping a present species from invading a specific part of a site. For example, if reed canary grass dominates a ditch next to a remnant prairie, it could be mowed in the spring to prevent seed set, and satellite patches could be treated to halt spread into the prairie.

Major Types of Plants That Can Require Management in Prairies

Invasive non-native cool-season grasses including smooth brome, Kentucky bluegrass, reed canary grass.

Invasive non-native herbaceous plants (broadleaves, flowers, forbs) including biennial thistles, wild parsnip, Queen Anne's lace, leafy spurge, spotted knapweed, crown vetch.

Invasive non-native woody plants including buckthorn, Siberian elm, Russian olive, non-native honeysuckles.

Native woody plants that encroach and spread into prairies including eastern red cedar, sumac, dogwood, cottonwoods, aspen, green ash, and willow. Woody encroachment in prairies is covered in detail in Chapter 8.

Control Methods

Summarized below are different methods of invasive species management used by land managers. Each control method (except prevention) has pros and cons in any specific situation. Researching the best management strategy and control method for the target invasive plant and the plant community will help avoid undesired consequences. If the plant community is damaged, it can reduce the native competition and open the community to further invasion.

Native prairies deserve special consideration when selecting approaches to invasive species management. Native prairies have very diverse plant and animal communities, which means there are many species (including rare species) that could be harmed by invasive species management, especially the incautious use of pesticides. Be aware of potential non-target impacts when applying any management, but especially when using pesticides.

Prevention

Preventative control is any activity done to reduce the chances of an invasive species introduction. This can include such practices as using certified weed-free seed, cleaning equipment before moving it from one location to another, avoiding known infestations, stopping periodically to clean off equipment if working on long corridors, cleaning off boots while hiking and horses' hooves while riding, and flushing livestock with clean feed before moving from one pasture to another. Prevention is truly the most effective method of controlling invasive species and takes much less effort than controlling an established population.

Biological Control

Biological control (also referred to as bio-control) utilizes an invasive plant's natural enemies to help reduce infestations and the population's ability to compete with native species. Biological control can be more cost-effective and sustainable than some other control methods once proven to be effective. Before they can be used, biological controls are researched to ensure they are effective, specific to the target weed, and do not have unintended consequences. Due to this, they are currently only available for a limited number of species. Note that biological control is generally a suppression, rather than eradication strategy.

Example: Leafy spurge is a non-native herbaceous plant (native to Eurasia) that was introduced to Minnesota around 1890 and spent much of the next century invading native plant communities. In order to control leafy spurge without significant side effects to native species, leafy spurge beetles (also native to Eurasia) were brought over to reunite leafy spurge with its natural enemy. The larvae of the beetles feed on the plant roots and root crown, damaging the plants.

INTRUDER ALERT! SPOTTED KNAPWEED

Spotted Knapweed

Photo credit: ©ColdSnap Photography

Spotted Knapweed Root Weevil

Photo credit: Lindy Ekola

Spotted knapweed (native to Eurasia) is a biennial or short-lived perennial herbaceous plant with pink flowers that grows 2 to 3 feet tall. It releases chemicals that are poisonous to other plants (allelopathic toxins) and can form dense cover and reduce desirable species in prairies, pastures, and open habitats. Cattle and other animals avoid eating it, which further enables its spread, resulting in serious reductions in available food for grazing animals.

Mechanical control: This involves digging with a sharp shovel or pulling by hand to remove as much of the taproot as possible. Mowing before seed development can help reduce seed spread, but may also spread the plant's toxins. Do not mow if seed is present (July and later) as it will spread the seed.

Chemical control: Some herbicides are effective in treating spotted knapweed. Contact your extension agent or visit the DNR spotted knapweed webpage (**https://www.dnr.state.mn.us/invasives/terrestrialplants/herbaceous/spottedknapweed.html**) for specific recommendations. Spotted knapweed forms a rosette of leaves in its first year, and herbicide treatments are most effective when applied to this leaf rosette stage. Fall can be a good time to find and target the rosettes. Herbicides are also effective on the stem bolting stage of the plant in spring of its second year.

Biological control: A number of beetles are in use as bio-controls, including seed head weevils and root boring weevils.

Caution: Spotted knapweed can be a skin irritant for some people, so cover your skin by wearing gloves and long sleeves. Always follow herbicide label requirements for personal protective equipment.

Cultural Control

Cultural control refers to manipulating management and farming practices to suppress the growth and productivity of an invasive species.

Example: Allowing a pasture to be overgrazed can weaken the desirable plant communities and encourage invasive weed growth. Properly grazing to maintain healthy, desirable cover can reduce invasive weed growth, reduce the need for chemical and mechanical treatments, and improve forage quality and quantity.

Mechanical Control

Mechanical control is any manual technique that kills or injures plants through physical damage. Mechanical control includes but is not limited to:

- Pulling (by hand or with equipment).
- Mowing, haying or chopping.
- Appropriately timed prescribed burning or grazing.
- Cutting.
- Girdling (stripping bark around the stems of trees and shrubs).

Example: Smooth brome is an aggressive non-native grass. It often out-competes native species to create a monotype (single species) habitat that is not suitable for many wildlife needs. In spring, when brome starts to green up, prior to the emergence of warm-season species, a prescribed burn (or other disturbance such as haying or grazing) may suppress brome and favor more desirable native species. If repeated at the right time and frequency over many years, the overall brome cover may be reduced and native species diversity may increase.

Mowing to control sweet clover.
Photo credit: Dave Jungst

INTRUDER ALERT! WILD PARSNIP

Photo credit: Dave Jungst

Wild Parsnip
Wild parsnip (native to Eurasia) spends one or more years as a low lying clump of leaves with no vertical stem. Following this stage, it sends up a flowering stalk with yellow flowers, blooms, then dies after setting seed. It is about 6 inches tall in the rosette stage and up to 4 feet tall (or taller) in the flowering stage. Wild parsnip is one of the first plants to green up in the spring and remains green well into the fall. Seeds spread via human and animal activity and through the movement of wind and water. The flattened seeds persist into fall and can get into folds of clothes and boots. Seeds can also be spread on mowing and haying equipment. Wild parsnip readily moves into disturbed habitats and is often found along roadsides, in ditches and stream banks, and along forest edges and trails. Once a population builds up, it spreads rapidly and can severely impact native plant communities.

Mechanical control: Pull or cut the plant below the root crown before seeds set. Mowing when plants have developed flowers, but before seeds mature, can reduce (but generally not eliminate) flowering and seed production. Clipping off seed heads and removing them from the site can be more effective than mowing for small infestations.

Chemical control: Spot spraying can be done after a prescribed burn when wild parsnip is one of the first plants to green up or in the fall. Many herbicides are ineffective on wild parsnip. If considering herbicides be sure to check labels and contact your extension agent or visit the DNR wild parsnip webpage (**dnr.state.mn.us/invasives/terrestrialplants/herbaceous/wildparsnip.html**) for specific recommendations.

Caution: Avoid skin contact with the toxic sap of the plant by wearing gloves, long sleeves and long pants. When the juice of wild parsnip comes in contact with skin in the presence of sunlight it can cause blistering and discoloration of the skin (phytophotodermatitis).

Chemical Control

Chemical control refers to any method that utilizes the application of a chemical (herbicide). When using herbicides, the intent is to harm the target species while minimizing impacts to desirable species (non-target species). This can be done by using selective herbicides or through selective application. When selecting a chemical and application method, consider these factors:

Herbicide selectivity. **Selective herbicides** control specific weed species or weed categories (as labeled) and may be non-toxic or less toxic to non-target species. For example, some selective herbicides only kill broadleaf plants and do not kill grasses. **Non-selective, or "broad spectrum" herbicides** control both broadleaf and grass species.

Persistence (residual action). Some chemicals have residual activity, meaning they remain active in the soil and continue to have an effect long after application. Persistent herbicides may cause problems in sites that are slated for restoration and may have lasting impacts on native plants.

Means of uptake. **Contact herbicides** kill the parts of the plant touched by the chemical. **Systemic herbicides** are absorbed by the plant through the leaves, stem, or roots and transported internally throughout the plant.

Mode of action. The way a chemical controls or kills the plant. This could mean preventing the metabolism of sugars, inhibiting development of an essential hormone, or some other plant system manipulation.

Chemical application methods

Application methods and timing are often a vital component of achieving effective chemical control while minimizing impacts to non-target species. Methods include, but are not limited to the following.

- *Broadcast spraying (foliar application).* Herbicide is sprayed across the infested area, so that all plants in the area are potentially treated. This method should only be used with selective herbicides or where timing can reduce non-target impacts. Note that even carefully applied broadcast spraying can have impacts on non-target species.
- *Spot spraying (foliar application).* Targets individual plants or patches with selective or non-selective herbicides.
- *Wick application.* This method involves wiping (instead of spraying) herbicide on target plants.
- *Hack and squirt/frilling*. This requires making slashes or cuts in the bark of a woody plant and applying herbicide to the cuts.
- *Low volume basal spraying or treating*. In this method, herbicide is applied on the bark around the base of a woody plant.

- *Cut stump treating.* This involves cutting a woody plant and applying herbicide to the cut surface (and for some herbicides, the surrounding bark).
- *Stem injection.* In this method, specialized tools are used to inject pellets or liquid herbicide into the target plant.

Be sure to check labels as chemical application method effectiveness varies by herbicide.

Herbicides vary in their modes of action and appropriateness for the application methods described above. Timing and environmental conditions can also be important to both the effectiveness against the target, and avoiding non-target species. The concentration of the mix and adjuvants, which can increase herbicide effectiveness, are also important. Before using herbicides, research the invasive species and the herbicide, the most effective timing, application methods, concentration, and adjuvants. Be sure to follow safety measures. Much of this information can be found on the product (specimen) label. Always follow label instructions, including safety precautions and rates of application. Not following label guidelines is a violation of the law.

For best success, consult with others who have experience with the target species. Local knowledge will often lead to more effective control. Even the right chemical, if used at the wrong time or through the wrong application, can lead to an expensive, time-consuming project with poor results.

PlayCleanGo

While important for recreation, trails also provide pathways for invasive species that can damage your prairie. To help prevent this, clean dirt, bugs, and plant material from shoes, clothes, equipment, vehicles, and pets before and after trail use. Hikers can adopt the simple habit of using boot brushes to prevent transporting seeds of invasive species from one site to another.

PlayCleanGo.org

Chapter 8: Woody Plant Control

Woody Plant Encroachment

Over the last century, many grasslands worldwide have experienced major increases in tree and shrub cover in a short period of time, a phenomenon referred to as woody plant encroachment (WPE) (Ratajczak et al., 2011). This is distinctly different from other biological invasions in that the encroaching woody vegetation is often composed of native species that have been present in the regional flora for thousands of years (Van Auken, 2009).

Causes of Woody Plant Encroachment

While not fully understood, several factors have been proposed as potential causes for this wide-scale encroachment of woody plants into grasslands, including increased atmospheric carbon dioxide concentration, climate change, nitrogen deposition, fire suppression and over-grazing (Ratajczak et al., 2012, p. 701). Governing processes appear to be highly dependent on context and influenced by interacting factors related to climate, fire frequency and intensity, grazing/browsing regimes, soil properties, and functional traits of the encroaching species and native browsers (Archer et al., 2017). In the western United States, rates of encroachment vary significantly by region, with the highest rates documented in more humid grassland regions such as the Great Plains, which includes western Minnesota (Barger et al., 2011).

Impacts to Prairie

Historically, the primary threat to grasslands was conversion to row-crop agriculture. While this conversion continues today, woody plant encroachment has emerged as one of the greatest contemporary threats to mesic grasslands in the United States (Briggs et al., 2005). WPE has significant effects on biodiversity and threatens the very existence of grassland and savanna ecosystems and their endemic (native to the region) plants and animals (Archer et al., 2017).

Even native trees and shrubs can have serious impacts on grassland environments. Encroaching woody plants displace and suppress native grassland vegetation through shading and competition from forest-adapted species. They fragment grasslands, leading to reduced connectivity and gene flow between patches (Fu et al., 2008).

Additionally, encroachment of woody plants into previously open systems significantly changes vegetation structure, a key determinant of animal diversity. As a result, populations of animals sensitive to vegetation structure, like birds, mammals and reptiles, often significantly change in areas experiencing WPE. As woody plant cover increases, grassland habitat declines, leading to declines in populations of grassland dependent species (Briggs et al., 2005). Unfortunately for Minnesota's prairies, these species diversity declines due to WPE appear to be most severe in more humid grassland systems, including tallgrass prairie (Ratajczak et al., 2012).

Replacement of open grasslands with woody species also has the potential to profoundly alter other ecosystem processes. These include local and regional water budgets, above ground net primary productivity (the rate at which organic matter is generated by photosynthesis), nutrient cycling and availability, and soil organic carbon stores (Bond, 2008; McKinley et al., 2008).

The spread of woody plants into grasslands also adversely impacts local economies. Livestock grazing is an important economic activity throughout grassland regions of the world. Loss of grasslands due to encroachment of woody vegetation reduces the quantity and quality of palatable forage available for livestock grazing, complicates animal handling, and improves habitat for parasites (Archer et al., 2017). In high productivity areas like the tallgrass prairie region, a 1% increase in tree cover has the potential to reduce average livestock production by 2.5% (Anadon et al., 2014).

The Minnesota Prairie Conservation Plan lists WPE as one of the eight main threats to prairies in the state (Minnesota Prairie Plan Working Group, 2018). The state's remnant native prairies appear particularly vulnerable to this because:

- relatively modest changes to woody plant cover at a regional scale could have disproportionate impacts to native prairie due to the small amount that remains intact (less than 2% of Minnesota's original native prairie still exists);
- average annual precipitation and other climate variables in Minnesota's prairie region are generally capable of supporting closed forests in the absence of disturbance or other factors limiting tree growth; and
- the state's prairies are highly fragmented and typically imbedded within agricultural landscapes largely incapable of supporting widespread wildfires necessary to limit woody growth without human intervention.

Photo credit: Kelly Randall

Woody Plant Management

Not surprisingly, managing and controlling woody plant abundance and encroachment is a major management objective for tallgrass prairie land managers. In Minnesota, encroaching woody species vary by location in the state and by site-specific conditions including moisture, nutrient availability and topography. The most common encroaching native woody species in northern Minnesota prairies include quaking aspen, willows, balsam poplar, smooth sumac and cottonwood. In southern Minnesota prairies, they include eastern red cedar, green ash and sumac. Additionally, non-native woody species like common buckthorn, Siberian elm, and Tatarian honeysuckle pose significant problems across the state.

First Step: Determining Rate and Extent of Encroachment

Since WPE often results from a slow, steady progression over many years or decades, it can be difficult to determine its rate and extent through field visits alone. Fortunately, resources are available that can help landowners and prairie managers assess trends on their lands.

Google Earth (**googleearth.com**) is an excellent online resource that allows users to view geo-referenced aerial photography for most locations on earth. Google Earth also maintains a cache of past aerial photography dating back to 1991 for most of Minnesota. This allows users to toggle between past and present air photos to assess the expansion of woody vegetation on a given property.

Another good source of aerial photography is the National Agricultural Imagery Program, which provides air photo resources to the Farm Service Agency (FSA) and the Natural Resource Conservation Service (NRCS). If estimates of woody plant encroachment over a longer period of time are desired, the University of Minnesota maintains a database of historic air photos with nearly complete coverage of the state from 1939/1940 and 1954. These historical maps can be found online at: **apps.lib.umn.edu/mhapo/.**

Another source of information on historic land cover is the hand-drawn township maps and section line notes from the original land surveys in the 1880s created by the Government Land Office surveyors. These are available online at: **mngeo.state.mn.us/chouse/GLO/.**

Developing a Management Plan for Woody Plants

Management of WPE in prairies should begin with development of a treatment plan. Since treatment can be labor intensive and/or expensive, prioritizing efforts in areas most likely to recover is recommended. After first identifying areas experiencing WPE, the next step is to assess the ground layer vegetation in these locations to evaluate how much prairie vegetation remains intact beneath the woody vegetation. Generally speaking, areas of more recent woody encroachment that still retain prairie grasses and forbs are more likely to positively respond to treatment than areas of older encroachment that have become dominated by shade tolerant forest ground layer species or invasive species.

The choice of treatment methods is based on factors such as the size of the treatment area, the ecology/biology of the encroaching species, desired level of control, site sensitivity, available work force and cost.

Knowledge of the ecology/biology of the encroaching species is particularly important. For example, quaking aspen forms extensive clonal colonies and propagates primarily through root sprouts, with each stem in an aspen clone connected to the same below-ground root system. One-time treatments that sever the stem (like logging, tree cutting and mowing) stimulate root suckering and are generally not effective long-term control methods. Quaking aspen is sensitive to top-kill by fire, but fire's effectiveness as a stand-alone control method can be limited because fire also stimulates vigorous root sucker development.

In contrast, eastern red cedar only reproduces by seed. Severing the stem (either by manually cutting or with machines) will usually kill the tree if the cut is made close to ground level and removes all green foliage (Launchbaugh & Owensby, 1978). Additionally, eastern red cedar has thin bark and flammable foliage that easily ignites, making it highly susceptible to fire. Unlike in aspen, fire does not stimulate root suckering in red cedar, therefore with adequate fuel conditions, fire kills most eastern red cedar trees less than 4 feet tall and large trees up to 20 feet are occasionally killed by fire (Owensby et al., 1973).

Woody Plant Control Methods

The most common treatment methods for WPE in Minnesota prairies are hand cutting, prescribed fire, mechanical mowing, and herbicide application. In many instances, various combinations of these methods are utilized on the same site over several years to maximize effects.

Hand cutting is mostly used on smaller areas of encroachment or when woody plants occur in small, dispersed patches. If the target species is known to stump sprout or develop root suckers, the freshly cut stump is often treated with a herbicide approved for woody species control.

Periodic wildfires were one of the primary mechanisms controlling the extent and distribution of woody plants before European settlement. Not surprisingly, **prescribed fire** is often used by prairie managers to treat woody encroachment. However, the effect of fire on controlling encroaching woody species is highly variable and dependent on the level of woody encroachment, woody species traits, fine fuel availability, timing of the burn, and fire return interval. As was noted in Chapter 4 of this handbook, it is advised to consult with experienced natural resource managers when considering using prescribed fire.

Mechanical mowing is frequently used to control WPE over large areas, or in places where woody growth is very heavy. Light infestations of smaller diameter species (less than 1-inch diameter) such as young willows can often be mowed using a tractor and mower or possibly a small, pull-behind ATV mower. Heavy infestations of larger diameter woody plants often require specialized equipment such as a skid steer with a forestry mower.

Stand-alone herbicide application to control WPE is most often done as a basal bark treatment and less frequently using a hypo-hatchet or other tools in a method referred to as “hack and squirt” or “frilling.” In both methods, each individual woody stem is treated with an herbicide approved for these particular applications on woody plants. In nearly all cases, one-time treatments of WPE only provide temporary control. The most effective woody control projects include multiple treatments over several years and include ongoing follow-up management.

Foliar herbicide application can also be considered in some cases, though broadcast spraying poses a greater risk of damaging non-target plants. Foliar application may be appropriate when there is a flush of new growth from the seed bank after a cutting project, or for spot spraying individual small plants. Foliar treatment can also be used to take advantage of the fact that buckthorn holds its leaves very late into the fall; foliar treating small buckthorn plants after desirable plants have gone dormant can help avoid non-target impacts. If using herbicides be sure to check the product label, some are only effective for certain applications.

Photo credit: Judy Schulte

INTRUDER ALERT! EASTERN RED CEDAR

Eastern red cedar, though native to Minnesota, grows rapidly, stays dense long after maturity, resists drought, and provides fleshy cones (berries). These features make for an easy-to-establish windbreak that provides winter and early spring food for birds. However, some of these same attributes make red cedar spread and form dense cover in grassland ecosystems. Birds eat and spread the fleshy cones some distance, and the competitive qualities of red cedars allow them to establish dense populations that shade the ground and desirable plants, eliminating food and habitat for wildlife and livestock.

Red cedar encroachment in grasslands is a relatively recent problem. Since the species is very susceptible to fire, it was historically suppressed by the regular presence of fire. As fire decreased on the landscape, red cedar has increased. The end result of this encroachment is degradation of the natural habitats needed by many Minnesota wildlife species. Red cedar has numerous impacts, including but not limited to:

- Reduction in ground cover under cedars results in the loss of herbaceous prairie plants and reduced forage for deer and livestock.
- Dense stands limit turkeys' line of sight, increasing their vulnerability to predators.
- Encroachment adjacent to woodlands eliminates much needed nesting and brood rearing cover.
- Providing habitat that allows raccoons and other nest predators to extend their range far into grasslands, increasing predation rates on the nests of pheasants, waterfowl, and other ground nesting birds.

Red cedar poses a grave threat to Minnesota's remaining grasslands. More southerly states, such as Oklahoma and Nebraska, have already lost hundreds of thousands of acres of grassland and rangeland to encroaching red cedar. While Minnesota has already lost significant grassland to cedar, there is still time to avoid the extent of loss that has already occurred elsewhere.

What can be done? First and foremost, do not plant red cedar in windbreaks. Spruce are a good alternative for dense windbreaks and can provide winter cover for wildlife.

Second, red cedar encroaching into grasslands should be removed as soon as possible and on-going prescribed disturbance (haying, prescribed fire, etc.) should be implemented to reduce re-infestation. Chemical treatment is not necessary for cedar control. Simply removing all green foliage (cutting it down or burning it) can kill the plant. In addition, because red cedar is dioecious (individual trees are either male or female), removing pistillate (female) trees will stop seed spread.

Chapter 9: Prairie Restoration and Enhancement

The science of prairie restoration has advanced significantly since the first tallgrass prairie restoration was done on Curtis Prairie at the University of Wisconsin–Madison in 1936. Restoration ecology continues to advance as new methods are tested and goals are refined. At one time, it was common to plant a high percentage of grasses with the goal of getting quick ground cover and nesting cover for waterfowl and upland game. Now, restoration ecologists see the value of planting a diverse mix of plant species to improve habitat for waterfowl and upland game and also provide for more types of wildlife, along with the many other functions that come with a diverse plant community.

Abundant literature is available to help with planning and implementing a restoration or reconstruction project, far more than can be covered herein. The purpose of this brief overview is to help you decide whether a restoration or reconstruction project is appropriate for your desired outcomes, and if so, how to proceed.

The terminology of restoration science can be a bit confusing. This handbook defines **reconstruction and restoration** as rebuilding an ecosystem where a native plant community no longer exists. Usually reconstruction occurs on former cropland, but it can also occur on abandoned roadbeds, yards, and other areas. **Enhancement** is defined here as management to improve a remnant native plant community. This can include applying management practices such as prescribed burning or grazing, and can also include **interseeding** (sowing seed into established vegetation), planting plug/bare roots, or controlling invasive species. The term ”rehabilitation” can refer to applying a series of enhancement activities to recover a degraded prairie. Note that some sources use “reconstruction” to refer just to building a plant community where it has been lost, and “restoration” for improving an existing remnant community (what we are calling “enhancement”).

A restored community is a replica of a native plant community. The goal is to make it as close to the real thing as possible, or as close as needed to give the desired functional outcomes. Healthy native prairie consists of thousands of different organisms. Plants, animals, invertebrates, bacteria, and fungi are all part of the complex functioning system. These organisms interact with each other and their environment in complex, interconnected ways that have developed over centuries. Prairies in Minnesota took hundreds to thousands of years to develop, and recreating the full evolution of the prairie, and hence the true prairie community, is not possible.

Restoring a prairie community where it has been completely lost takes time, patience, planning and diligence, but the effort can be well rewarded. The basic process is to 1) know the site and define objectives, 2) select an appropriate seed mix for the site that meets objectives, 3) prepare the site for planting, 4) seed the site, and 5) conduct follow-up management to encourage the desired community.

Know the Site

The first step in planning any management activity is to know the present condition of the site. Things to look at include the soils, wet and dry areas, areas prone to flooding or erosion, and invasive species. It is also important to know the history of the site, for example, whether pesticides with residual effects have been used there or if there are residual nutrients from fertilizing. In many cases the site conditions may factor into what objectives are practical. For example, a heavy infestation of certain invasive species might mean it is not possible to deplete the weed seed bank, which could make reaching certain objectives very difficult.

Determining Objectives

The development of management objectives is presented in Chapter 3. Two common objectives for prairie restoration are 1) high quality, diverse conservation grassland offering multiple benefits, and 2) buffer grassland to protect remnant prairie, waterways, or other landscape features.

Generally speaking, more diversity offers more benefits, though getting that diversity can be expensive. Higher diversity provides for more wildlife uses (including pollinators and other invertebrates) and also can help make the community more resilient because different species are present to handle changing conditions from year to year. For example, some species may thrive in wetter years and others may do better in dry years.

In contrast, there are times when high diversity is not appropriate for desired outcomes. For example, if the area being restored is by a roadway where invasive broadleaf weeds are present, you may want a buffer of all grass so future herbicide spraying does not kill what you have planted.

Determining a Seed Mix

For most restorations, a good diversity of species and a balance between grasses and forbs will give results that provide the most benefits. A good target is 40-50% grasses and 50-60% forbs, measured by seeds per square foot. Including different plant species from different functional groups increases the chance of a successful planting and also provides more benefits. For graminoids, include warm-season grasses, cool-season grasses, some bunchgrasses, and sedges and rushes if appropriate for the site. For forbs, include legumes, non-legumes, species from different plant families, and species that flower through different parts of the growing season.

Knowing the features of the restoration site is important for developing seed mixes. The seed mix should fit the soil type and moisture regime of the site where it will be planted. If the restoration area has multiple soil types or moisture regimes, it is beneficial to have multiple seed mixes to fit the different conditions. Planting one mix across a variable site can mean wasting a lot of seed and having a less successful planting.

Some native species can be aggressive in the early growth of a restoration and their abundance in the seed mix should be limited. Highly aggressive, dominant species include big bluestem, switchgrass, Indian grass, northern bedstraw, yellow coneflower, and cup plant. If these species are very abundant in the seed mix they can gain a competitive foothold soon after planting and outcompete other species. These species are an important part of a healthy prairie community, just be sure to use them judiciously in restoration projects.

Many reputable restoration companies can help develop a seed mix for your project. The Minnesota DNR maintains a list of native plant suppliers, landscapers, and restoration consultants by region at: **mndnr.gov/gardens/nativeplants/suppliers**.

If you are purchasing seed, shop around and find a reputable vendor who can provide appropriately local seed. Be cautious with “wildflower mixes” of unknown origin because these often contain non-native and potentially invasive species. Look for Latin names in the species list as some common names can refer to more than one species. For example, “purple coneflower” can mean *Echinacea angustifolia* (a Minnesota prairie native) or *Echinacea purpurea* or *Echinacea pallida* (both species of the southern and southeastern U.S.). Also avoid any cultivars of native species, especially when planting near remnant prairies. Cultivars are artificially and selectively bred varieties; they can be particularly aggressive and can pollute the native gene pool. Any purchased seed should have a seed test that lists pure live seed (PLS). The seed test will tell you how much viable seed is present, any weed seed that is present, and some measure of the amount of the major species present. Be careful, a small weed presence can lead to big problems down the road.

Some general guidelines for developing seed mixes for prairie restorations to increase the established diversity include (Smith et al., 2010):

- Minimum total seeding rate of 40 (live) seeds per square foot (Smith et al., 2010).
- At least 40% of the total seeding rate should be composed of perennial forbs.
- Seven or more native grass or sedge species with at least two species of bunchgrass.
- Limit aggressive dominant species.
- Fulfill the functional guilds: cool-season and warm-season grasses; sedges and rushes; legume and non-legume forbs.
- Include species from different plant families.
- Include 20 or more native forb species with at least five species in each bloom period: early, middle, and late season.

Site Preparation

Important considerations for site preparation include controlling weeds, seedbed preparation, and sometimes depleting residual nutrients or pesticides. The steps in preparing the site will vary based on the starting condition. Whatever is done, getting good seed-to-soil contact is critical to successful establishment.

If starting with cropland, site preparation is relatively easy. Prairie seed can be directly planted into soybean stubble, but corn residue will block seed-soil contact and should have management to prepare the seedbed, such as light tillage, harrowing, burning, or using temporary covers. For future management and for seed-soil contact, create a flat seedbed. If tilled up, the seedbed should be packed or allowed to settle so seeds do not end up sinking too deep in the soft soil. In some cases cropland may have residual fertilizers or pesticides that could cause problems with restoration, killing desirable plants in the case of herbicides, or favoring weeds in the case of fertilizer. If residual agricultural chemicals are present, it may be beneficial to plant a cover crop for a year or two before seeding the restoration mix.

If the restoration area is an old field or other non-native dominated system the site preparation may be much more demanding. The first step will be to reduce the non-native plants as much as possible. With old fields this usually means controlling the dominant grasses, generally smooth brome, reed canary grass, or other non-native cool-season grasses. This can be challenging and will probably take a combination of methods such as herbicide, tillage, fire, or temporary covers. Old fields may also have other perennial weeds of concern as well as trees and shrubs. If the dominant perennial weeds are not controlled, there is very little chance of a successful restoration. A restoration professional can help with determining the appropriate site preparation for your individual situation.

Some other methods of seed bed preparation include using plastic, cardboard, or other mediums to smother current growth; using temporary covers like oats and barley to boost soil health, take-up excess nutrients, and provide competition for early-successional weeds; or using a combination of these. The Xerces Society (Jordan et al., 2016) provides guidelines on these and other methods of preparing a seed bed.

Timing of Planting

Seeding can occur at different times of the year, and the timing can influence the success in reaching restoration outcomes. The optimal timing of planting varies among species. Some species need stratification (a cold period) before they will germinate. These will do better if planted in the fall or winter; if planted in the spring they will not germinate until the next year. Other species do not require cold stratification; these species may perish if planted in the fall if they germinate before freezing temperatures set in. Planting late in the spring runs the risk of a dry season with insufficient moisture to support the emerging seedlings.

The following are some general recommendations for planting in different seasons:

- Growing season plantings should occur from May 1–July 1 when the soil temperature is at least 60 degrees Fahrenheit or higher. The optimal timing will differ from southern to northern Minnesota.
- Frost seeding or dormant seeding should occur after October 15 in the northern half of the state and after November 1 in the southern half of the state, or after soil temperatures fall below 50 degrees Fahrenheit for a consistent period of time, but before soils freeze.
- Seeding into snow is an option if the snow is not too deep. It can have the advantage of pulling the seed into contact with the soil when the snow melts, but meltwater can also pull seed unevenly across the site.

Photo credit: Darren Wheeling, USFWS

Planting Method

Seed mixes can be planted by drilling or broadcast seeding. Though restoration practitioners have different opinions on the outcomes of drilling vs. broadcast seeding, some recent research has found that the planting method may not have a significant effect in the long-term outcome of species establishment (Larson et al., 2017).

Drilling seed involves using specialized equipment to place the seed under the surface of the soil and usually requires cleaned seed. If drilling is the planting method, seed drills designed specifically to plant prairie grasses and flowers should be used. Species vary in their optimal planting depth and some drill implements allow for varying depths. An aesthetic disadvantage of drilling is that it leaves rows from planting, though this is not very apparent after the vegetation has established. This can also be reduced by cross planting in different directions.

Broadcasting seed is spreading seed out on top of the prepared soil surface (or over snow in the case of snow seeding). If broadcasting is the planting method, native-seed broadcasters should be used as they are adapted to spread mixes with different sized seeds. Broadcasting has the advantage that it can handle uncleaned seed. A disadvantage in broadcast seeding is that in windy conditions the lighter seed may be blown farther than the heavier seed, leading to uneven coverage of species. Following up a broadcast seeding with rolling can increase seed to soil contact, but may lead to increased wind erosion.

Photo credit: Curt Vacek

Seed can also be broadcasted by hand. This is an option where the restoration area is small or where a large force of volunteers can help with seeding. Hand broadcasting can also be used to target seeding individual species in appropriate microhabitats, for example at the edges of wetland basins or on dry knobs. Seeding by hand is notoriously imprecise and generally leads to over applying seed at the start and running out of seed before completing the area.

Seeding is not the only option for getting diversity into a restoration. **Bare root and plug planting** involve installing already germinated plants that have been started in a greenhouse or nursery to increase diversity or fit particular microclimates. Many restoration conservative species that have a lower success rate from seed are ideal targets for this type of planting. A disadvantage is that plugs and bare root plants may be expensive and can involve an extra time commitment for planting and early maintenance. Plugs will need to be watered regularly until their roots establish. Bare root plants planted in the fall do not need to be watered and will benefit from spring rains.

Follow-up Management

Prairie communities need regular disturbance (such as burning, mowing/haying, or grazing) to maintain them. In restorations, long-term maintenance disturbance usually starts a few years after planting. Details on long-term management practices are covered in chapters 4-11.

Before reaching the point of long-term maintenance, problems may show up in the restoration that require follow-up management. Many prairie species can take three years or longer to establish, and often annual weeds will dominate the first year or two. This can make it seem like the project has failed, but it likely just needs more time. Mowing/haying or grazing may be necessary to control annual weeds or tree seedlings. Spot spraying with herbicide, hand pulling, prescribed fire, or grazing may be needed for invasive species control. If spot spraying, target the undesirable plants by using selective herbicides and/or using care to avoid hitting non-target plants.

In some situations, broadcast herbicide application may be needed for invasive species control, but doing so can significantly impact the native species you are trying to establish, especially in high-diversity seedings. If considering broadcast spraying, consult an experienced professional. In many cases what might seem like a huge problem early on may dwindle after a few years as native species establish. Prairie restorations take time to establish and flourish. A restoration professional can help determine whether a problem needs attention, or whether it is better left alone.

First year restoration temporarily dominated by annual weeds.

After several years, annual weeds decrease and native species begin to dominate.
Photo credit: Nicole Davros

Resources for Information on Prairie Restoration

A huge body of information is available related to prairie restoration.

Technical Guides

- Tallgrass Prairie Center Technical Guides for Restoration: **tallgrassprairiecenter.org/technical-guides**
- Native Vegetation Establishment and Enhancement Guidelines by the Board of Water and Soil Resources: **bwsr.state.mn.us/vegetation-establishment-and-management**
- Going Native: A Prairie Restoration Handbook for Minnesota Landowners: **files.dnr.state.mn.us/assistance/backyard/prairierestoration/goingnative.pdf**
- Guides to Prairie Restoration in Minnesota—The Nature Conservancy: **nature.org/en-us/about-us/where-we-work/united-states/minnesota/stories-in-minnesota/prairie-restoration-guides/**

Identifying Remnant Prairie

- Minnesota Geospatial Commons (Download the Native Plant Communities Layer) Requires GIS capabilities to use: **gisdata.mn.gov**
- Native Plant Communities: **mndnr.gov/npc**
- Appendix C of this handbook

Information on Plant Species and Whether They Are Native

- MNTaxa: Minnesota Vascular Plant Checklist (Here you can create your own reports to get a checklist for your county): **mndnr.gov/eco/mcbs/plant_lists.html**
- Minnesota Wildflowers (great online guide): **minnesotawildflowers.info**
- USDA Plants Database: **plants.sc.egov.usda.gov/java**

Books About Prairie Restoration

- Packard, S. and C.F. Mutel (eds.) 2005. *The Tallgrass Restoration Handbook: For Prairies, Savannas, and Woodlands (The Science and Practice of Restoration Series)* 2nd ed., Revised. Island Press. Washington DC.
- Helzer. 2010. *The Ecology and Management of Prairies in the Central United States.* University of Iowa Press, Iowa City, Iowa.
- Lenhart, C. and P.C. Smiley Jr. (eds.) 2018. *Ecological Restoration in the Midwest: Past, Present, and Future.* Bur Oak Books, University of Iowa Press, Iowa City, Iowa.
- Smith, D., D. Williams, G. Houseal and K. Henderson. 2010. *The Tallgrass Prairie Center guide to prairie restoration in the upper Midwest* University of Iowa Press, Iowa City, Iowa. 301 pp.
- Dixon, C., Paula Comeau, K. Askerooth, J. Norland, K. Sedivec. 2017. *Prairie Reconstruction Guidebook for North Dakota (R1840).* North Dakota State University, Fargo, North Dakota. Available at **https://www.ag.ndsu.edu/publications/environment-natural-resources/prairie-reconstruction-guidebook-for-north-dakota**

Chapter 10: Wildlife Considerations

A prairie is more than grass—it is a diverse ecosystem containing a myriad of animals, large and small, whose presence and activity can vary daily and seasonally. A high level of interdependence exists within and between the plant and animal communities in the prairie. To the untrained eye, a prairie landscape may seem uneventful and somewhat boring in contrast to a tropical rain forest, but it has a special way of coming alive depending on when it is visited and the awareness of the visitor.

Previous sections have set the dynamic vegetation stage for the animals. How one views the animal community depends on the interest of the individual landowner or recreationist. Are you a hunter or trapper interested in game animals? Do you wish to experience certain animals in the community with binoculars, camera, sketchpad, or sound recorder? Perhaps you have interest in both game and non-game animals. Managing prairies and other grasslands for wildlife requires providing for the different needs of animals throughout the year.

In Minnesota, birds can be year-round residents, summer residents who nest and move south for the winter, or non-residents simply migrating through. Some birds even winter in Minnesota but fly to the high Artic to breed. Some mammals spend part of the year in a dormant or inactive state while others are active year-round. Reptiles, amphibians, and insects are quite variable as to the strategies they use to get through the winter period, and can be below ground, underwater or in the leaf litter, stems or trunks of vegetation.

How the prairie landscape is managed with various techniques may affect the quality of both the ordinary living habitat and the overwintering sites used by resident and migrant species. All animals have four basic requirements for life: space, food, cover or shelter, and water. Individual species' needs for these requirements vary, and particular management actions may have positive, negative, or neutral effects on them.

Some species benefit from certain management actions while others may not. For example, prescribed burning can be beneficial for pheasant nesting and brood-rearing but can negatively affect prairie insects if burn units are too big. Grazing can help some birds like upland sandpipers but harm others like Henslow's sparrows which require thicker layers of residual vegetation. Management can be designed to be as diverse as possible to let all species benefit—at least some of the time. No matter what species you might want to attract to a property, there are some general considerations to keep in mind.

Birds

Ring-necked pheasant
Photo credit: Brad Bolduan

Upland game. The greater prairie chicken, discussed in Chapter 3, is a prime example of the habitat variety needed for prairie bird life-history requirements. Prairie chickens, sharp-tailed grouse, ring-necked pheasants, and gray partridge are upland game species that can be found in parts of Minnesota's prairie region. The latter two species will nest in native prairie as well as non-native grasslands and are more tolerant of intensive agricultural areas, with pheasants preferring dense wetland covers like cattails for roosting. Ruffed grouse and woodcock occur along the forest/prairie fringe in the Aspen Parklands. Upland game birds are vitally dependent upon secure nesting cover but also must have access to insects within safe surroundings in order to feed their chicks. Unlike songbirds, upland game birds are "**precocial**," that is, the young are mobile soon after hatching and follow the adult female in search of food. Precocial birds may benefit from recently burned or hayed areas where litter is sparse and insects are easier for them to obtain. This points to the benefit of using management to provide a variety of vegetation structure, with heavier cover for nesting and sparser vegetation for feeding.

Waterfowl. Waterfowl includes ducks, geese, and swans with ducks broadly classified into "**dabblers**" that mostly feed on what they can reach from the surface, and "**divers**" that dive below the surface to feed. Generally, dabblers nest in upland cover and divers in overwater cover. Representatives of both groups may also nest in tree cavities (e.g. wood duck, a dabbler; and hooded merganser, a diver). Waterfowl and other wetland birds are dependent on a spectrum of wetland types occurring in prairies (as well as forests). The U.S. Fish and Wildlife Service has classified wetlands according to the permanency of water, depth, and nature of the vegetation (Cowardin et al., 1979). The spectrum ranges from shallow, temporary wetlands that dry up most summers to deeper, more permanent basins, and the different types of wetlands provide a variety of wildlife needs. Ducks use temporary wetlands in early spring to feed on highly nutritious invertebrates and for courting and resting.

The value of temporary wetlands is often underappreciated since these wetlands tend to dry up in mid-summer. Later, when broods hatch, they seek out more permanent wetland basins. It is this complex of wetland types in the prairie landscape that created the highly productive "duck factory" of the Prairie Pothole region. Many of these shallow basins have been drained in agricultural areas since they can inconvenience farming operations; nonetheless they do have significant value for waterfowl. Many basins have been overtaken by reed canary grass in natural or reconstructed wetlands which can lower their values as feeding sites.

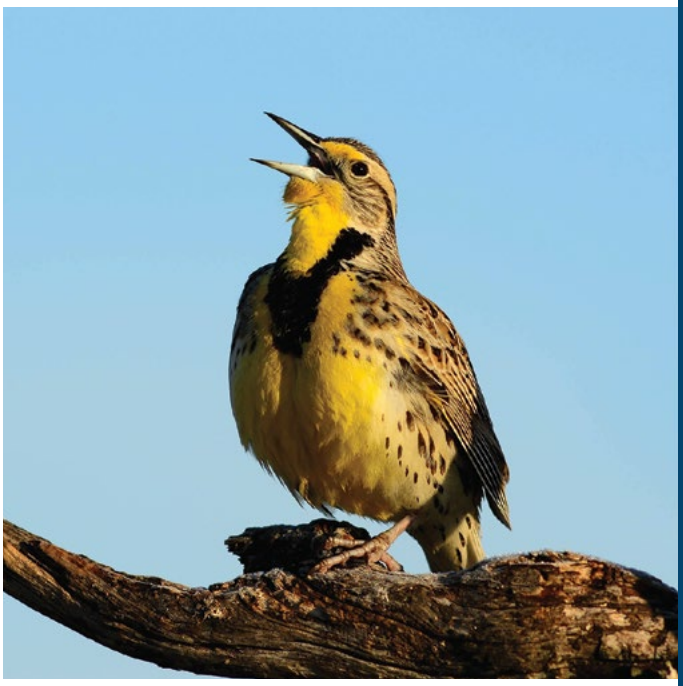
Prairie wetland basins are also essential migratory bird stopover habitats for birds that nest to the north. Occasionally, permanent wetland basins are the receiving waters for draining other wetlands. Although the deeper water wetlands are sometimes viewed as a positive for waterfowl, the deepened water may actually diminish adult feeding areas and brood habitat due to the loss of shallow fringe areas. Further, the deepened water may support fish, which in turn reduce invertebrate food supplies as well as the tadpoles of reproducing amphibians. Improving the condition of degraded wetlands (such as by restoring hydrology or managing invasive species) and adding wetland areas to a prairie restoration project can be very beneficial for wildlife, but existing prairie should not be sacrificed to create artificial basins.

Similar to the importance discussed for greater prairie chickens (see case study, Chapter 3), if wetlands in prairie and other grasslands are provided for waterfowl, a numbers of other birds will also find the variety of habitats to their liking. This includes rails, bitterns, herons, sandhill cranes, northern harriers, short-eared owls, some shorebirds, and other birds. Many other wildlife groups will benefit as well.

Shorebirds. Many birds in the category of "shorebirds" migrate through Minnesota's prairies and only stop by en route to and from Canada and Alaska and then back through to their winter ranges. True to their name, they have a special attraction to shorelines of wetlands and rivers as well as the shallow, open waters and mudflats of wetlands that are drying up. These rich feeding areas are vital for continental shorebird populations. Other shorebirds, like marbled godwits, upland sandpipers, common snipe, Wilson's phalarope, and spotted sandpipers breed in Minnesota prairies that are of sufficient size. They often select shorter (less than 12 inches) vegetation covers. An extreme example of a short cover nester is the killdeer, which prefer bare ground with a few pebbles. Often, shorebirds nest at some distance from water.

Songbirds or passerines. Grassland birds vary in their fine-scale habitat selection and this is especially true with the "songbird" group. Ground-nesting songbirds select differing amounts of litter or residual vegetation, ranging from heavy cover in the case of Henslow's sparrow, to chestnut-collared longspurs

which prefer very short cover, often grazed, dry prairies. Intermediate cover is selected by bobolinks and savannah sparrows. Birds nesting 2–3 feet off the ground in herbaceous vegetation include dickcissels and sedge wrens. Common yellowthroats, song sparrows, and yellow warblers tend to select brushy areas of shrubs and young trees. In contrast to the precocial young of upland game birds, waterfowl, and most shorebirds, songbirds have "**altricial**" young, which are helpless after hatching. They are completely dependent upon the parents to feed and shelter them in the nest until fledging. Once fledged, young songbirds can fly short distances and are led away from the nest site to help avoid detection by predators.



Western meadowlark
Photo credit: Rick Bohn, USFWS

Management to control woody encroachment within and along the edges of your prairie is important for prairie-dependent birds for two primary reasons: nest predation and brood parasitism. Nest predation is a leading cause of nest failure of grassland birds. Predator activity can be higher near field corners (Kuehl & Clark, 2002) and closer to edges, but this pattern is not consistent across landscapes and some studies have even documented positive edge effects (Benson et al., 2013). Trees and brush provide perches for brown-headed cowbirds, a common nest and brood parasite. Rather than making her own nest, the female cowbird finds a host nest in which to lay her eggs. The host birds then raise the cowbird young, to the detriment of their own offspring. Yellow warblers, which prefer nesting in brushy areas, are common hosts chosen by cowbirds. Cowbirds evolved in open grassland systems following nomadic herds of large grazers, particularly bison. In the modern landscape the grazer herds are stationary, the habitat is fragmented, and cowbird parasitism is more concentrated along woodland edges, leading to higher nest parasitism rates (Benson et al., 2013; Robinson et al., 1995). Even a few scattered trees on a prairie can serve as perches for cowbirds or predatory birds.

Mammals

Native herds of large grazing mammals like bison and elk are gone from the open prairie landscape in Minnesota except for a small herd of elk in the Aspen Parklands in extreme northwest Minnesota near Lancaster. Small herds of bison and elk are kept for private purposes and for public display in parks. Occasional elk "stragglers" show up where there are prairie remnants or even in farm country. Signs of the former presence of bison still exist, though, in the form of depressions (wallows) surrounding boulders that were used for rubbing. Many of these "buffalo rocks" still occur on native prairie areas or in the center of rock piles. Sometimes the buffalo rocks were too large to move so farmers breaking prairie simply pushed smaller rocks up around them. Bones and elk antlers may also be found along rivers and boggy areas. Moose have become scarce statewide in recent years but still occur in limited numbers along the prairie/forest transition area in northwestern Minnesota. They prefer woody vegetation like willow and aspen but are also known to use standing corn fields for winter feeding.

White-tailed deer are relatively abundant statewide and are very much a generalist with regard to food habits, subsisting on both herbaceous vegetation (grazing) and woody material (browsing). They are generally associated with forest or brushy areas but do very well in prairies and often winter in lowland areas of cattail or even in patches of relatively open prairie or other grassland; particularly if it is close to agricultural food sources. Even a small prairie tract may be chosen by a doe to raise her fawns. White-tailed deer have adapted well to the modern human-dominated landscape.

Whitetail deer
Photo credit: Curt Vacek

Many landowners plant food plots for wildlife, particularly deer. Though wildlife will use food plots, they usually are not necessary as wildlife are adapted to wild foods and there is much agricultural land in the prairie region. Food plots should never be installed on native prairie; besides the loss of the prairie sod, it could introduce invasive species. More information regarding food plots can be found at: **files.dnr.state.mn.us/publications/wildlife/wildlife_food_plots.pdf**.

Minnesota has a variety of carnivorous mammals that live in the prairie. Coyotes and red fox are two of the most common, with grey foxes occurring in wooded areas particularly along streams and rivers. Of note is that gray wolves have recently expanded their range along the prairie/forest transition zone, as well as bobcats and black bears. Badgers are common on the prairie and feed principally on the plains pocket gopher which they are well equipped to dig out, along with 13-lined and Richardson's ground squirrels. Another carnivore that has become somewhat common in the last 20 years, especially along prairie stream woodlands, is the fisher, a member of the weasel family. In fact, fishers have become so common in places that it is a significant predator of ducks using natural or man-made nesting cavities. Other members of the weasel family include the long-tailed weasel, short-tailed weasel (or ermine), and the least weasel. The mink (also in the weasel family) is common anywhere there is water as it is particularly fond of muskrats and waterfowl (young and eggs). Raccoons, opossums, and skunks are carnivorous as well but are quite adaptable and will readily feed on plant foods, especially raccoons.

There are many small prairie mammals that are an important primary food source for carnivorous mammals and birds of prey. Smaller prairie mammals with herbivorous food preferences include the ubiquitous muskrat (found wherever there is water), three species of ground squirrels, the beaver (associated with woody vegetation and water), the woodchuck, the cottontail rabbit, and the white-tailed jackrabbit. Of interest are the three species of ground squirrels and their different habitat preferences. The Franklin's ground squirrel prefers taller cover, often 3 feet high, and inhabits both the prairie and woodlands. It has been found to be a significant egg predator of ground-nesting birds. The thirteen-lined ground squirrel prefers short to medium height cover about as tall as it is when it stands on its hind feet—about 10 inches or so. It is also referred to as a "gopher", as in the "Golden Gophers" mascot name of the University of Minnesota athletic teams—apparently, someone thought "Golden Gophers" sounded better than "Golden Ground Squirrels"!

Weasel

Photo credit: Dave Jungst

The Richardson's ground squirrel is only found where the cover is very short, either in shortgrass, dry prairie or any grassland that is continually grazed. It is sometimes referred to as the "flickertail" in reference to its habit of nervously flicking its tail outside its burrow entrance. Like other true hibernators, ground squirrels spend approximately half of their life in their underground burrows in a deep state of dormancy during which their heart rate and body temperature are dramatically reduced.

There are also a number of small prairie mammals which feed on plants and insects. Principal species include meadow voles, white-footed mice, red-backed voles, and jumping mice. Shrews are also common, especially in prairies providing heavier cover. They are primarily carnivores feeding mainly on insects but commonly feed on small mammals as well; this is aided by having venomous saliva which helps them subdue their prey. The most common is the short-tailed shrew, which is as large as meadow voles and white-footed mice.

Reptiles and Amphibians

Due to its northerly location, Minnesota does not have an abundance of reptile and amphibian species. As would be expected, more species are found in the southern part of the state than in the northern part. Minnesota has 50 species of reptiles and amphibians, including 14 toads and frogs, 6 salamanders, 3 lizards, 17 snakes, and 10 turtles. Since they are ectotherms (cold-blooded), all seek protected areas in the winter, except turtles which are mostly aquatic and winter in mud or water. One of the most common snakes is the plains gartersnake which often finds rock crevices leading to warmer spots underground. The gartersnake, along with the greensnake and red-bellied snake, will also use mounds of prairie mound ants as hibernacula (over-wintering sites). These mounds are commonly up to 3 feet high and wide. They usually contain a network of plant stems which creates a dead air space that, when covered with snow, is a secure place to spend the winter. Tiger salamanders often use pocket gopher burrow systems as overwintering sites as do some snakes.

Manitoba toads (Canadian toads) were found to have a unique overwintering strategy of seeking out mima mounds in remnant Minnesota prairies (Ross et al., 1968). Mima mounds are lens-shaped mounds which are commonly 3 feet higher in the center than the surrounding ground and as much as 130 feet in diameter. The soils have been repeatedly disturbed over many years by the burrowing activities of pocket gophers, ground squirrels, badgers and the toads. Studies determined that toads burrow down just ahead of winter frost levels, thus contributing to a looser, less dense soil. Additionally, mounds are covered with the prairie shrub snowberry which catches snow, further enhancing the insulating properties of the mound. Researchers found one mound to contain 3,276 overwintering toads (Tester & Breckenridge, 1964)!

Pollinators and Other Invertebrates

Though not always the first thing that comes to mind when people think about wildlife, invertebrates are an essential component of all ecosystems, including prairies. Besides their intrinsic value, invertebrates are important for the interactions they have with other species and the many roles they fill in prairie ecosystems.

Native insects are the primary pollinators of prairie plants and contribute to pollinating crop and orchard plants. Snails (including dead shells) are important sources of calcium for some birds during egg development. Herbivorous insects and plant parasites (such as nematodes) are often specific to a group of plants and can thus keep those plants in check and help maintain a diverse plant community. Ants and many other invertebrates help aerate the soil. Flies, beetles, and others help with decomposition and recycling nutrients. Invertebrates are a vital part of the food web and play many roles, including being an important food source for birds, mammals, reptiles, and amphibians. Some insects can benefit crops, such as lacewings and lady beetles that prey on aphids. With all the important roles invertebrates play, they should be a prime consideration when managing prairies.

Many of Minnesota's prairie insects appear to be in decline. For example, 10 of the 15 butterflies listed as Endangered, Threatened, or Special Concern by the State of Minnesota are prairie specialists, and six of these ten have likely recently disappeared from the state. Two of these butterflies, the Poweshiek skipperling and Dakota skipper, are now listed as Endangered and Threatened federally. These are a few of the species we know about, but the invertebrate community is exceptionally diverse, and there could be many more species whose losses are going unnoticed—species that could be playing important roles in the prairie ecosystem.

The invertebrate community faces many threats in today's landscape. Habitat fragmentation means that many prairie invertebrate populations are essentially isolated, with many

Regal fritillary butterfly (state status: special concern).
Photo credit: Dave Jungst

low-mobility species unable to travel between their home prairie and other remnants. This also means that a management activity that destroys all habitat on one remnant might mean a loss of some species from the site. Fragmentation also contributes to more edge compared to interior areas, which increases the impacts of pesticides drifting in from adjacent lands.

Pesticides

Pesticides are contributors to declines in prairie wildlife populations. Pesticides can impact wildlife directly as when insecticide drift harms the invertebrate community. Pesticide impacts can also be indirect by harming the insects other wildlife need for food, or when herbicide drift harms plants needed by wildlife. A few pesticides of particular concern lately are dicamba, neonicotinoid insecticides, and soybean aphid insecticides.

Dicamba has started to replace glyphosate for treating weeds in soybeans. For years, the herbicide glyphosate has been used to control weeds in glyphosate-resistant crops. However, the widespread use of glyphosate has led to weeds developing resistance to the herbicide. Weed resistance has led to the adoption of an alternative herbicide, dicamba, on dicamba-resistant soybeans. Dicamba is capable of volatilizing (becoming vapor) and moving from the application site to nearby sites as vapor drift. This drift can cause extensive injury to both neighboring crops that are not dicamba-resistant and nearby wild plants that serve as critical sources of nectar, pollen, seeds, and cover for wildlife (Knuffman et al., 2020).

Neonicotinoid insecticides (neonics) are a class of systemic insecticides applied to food crops, including corn and soybeans, to control insect pests. Though they can also be used as foliar and soil treatments, neonics are mostly used as seed treatments on corn and soybeans in Minnesota. The chemical is absorbed by the growing plant and spreads throughout its tissues. Both direct and indirect exposure of wildlife to neonics are of concern. Research has documented the accumulation and persistence of neonics in wetlands and other surface waters (Main et al., 2014; N. Williams & Sweetman, 2018). Additional studies have documented potential negative effects of neonics on a wide variety of organisms from insects (Forister et al., 2016; Kenna et al., 2019; Main et al., 2020; Stanley et al., 2015) to birds (Eng et al., 2017; Franzen-Klein et al., 2020; Tokumoto et al., 2013) to mammals (Berheim et al., 2019).

Although wildlife may sometimes avoid consuming neonic-treated seeds, recent research in Minnesota documented over a dozen species of birds and mammals consuming seeds at simulated spills (Roy et al., 2019). Even if wildlife such as birds and mammals avoid eating treated seeds, there are still concerns about the impacts of neonics on entire food webs, impacts which have yet to be fully evaluated (Frank & Tooker, 2020).

Soybean aphid insecticides are another common group of insecticides used in Minnesota's farmland region. These insecticides are typically sprayed via a ground or airplane sprayer onto infested soybean fields. However, chemical drift into

nearby grasslands can occur during real world spraying applications (Goebel, 2020; Runquist et al., 2018). Potentially lethal doses for honeybees (which may be representative of other bee species) can occur at least 25 yards into the grassland interior and cause reductions in arthropod abundance (particularly insects important in the diets of breeding birds) occurring for at least 21 days post spraying (Goebel, 2020). The true extent of pesticide drift and levels of impact on prairies, are not well known, though multi-year studies by the Minnesota Zoo have regularly found soybean aphid pesticides present in prairies 1 mile from the nearest field (Runquist & Heimpel, 2017). Between 2014 and 2020, Minnesota Zoo staff detected nine different insecticides, three herbicides, and eleven fungicides across four western Minnesota prairies (E. Runquist, personal communication, 2021).

There are a number of different soybean aphid insecticides and they differ in their impacts to non-target wildlife. For example, ring-necked pheasants are highly susceptible to chlorpyrifos exposure, and several other common bird species (e.g., American robins, common grackles, mallard ducks) are moderately susceptible (Solomon et al., 2001). Some others (such as lambda-cyhalothrin) are considered low in toxicity to birds but highly toxic to pollinators such as bees (Besard et al., 2010; National Pesticide Information Center, 2001), and field studies have documented lower insect diversity and abundance in fields exposed to lambda-cyhalothrin (Galvan et al., 2005; Langhof et al., 2005).

Managing With Invertebrates in Mind

For the sake of invertebrates, many of which have limited long-distance mobility, it is important to ensure there are refuge habitats whenever large-scale management practices are implemented. When burning, keep unburned vegetation in the area and wait a few years between burns to allow invertebrates to recolonize burned areas. If haying or grazing, leave sufficient stubble and litter for overwintering invertebrates. It also helps to mix up the timing and type of management so that different organisms are favored or hindered at different times. If planting a restoration, or enhancing an existing grassland, try to provide as much native plant diversity as possible to encourage higher invertebrate diversity. Pollinators will especially benefit from having plants that flower at different times and provide nectar throughout the growing season.

If using pesticides on your property, follow best management practices (BMPs). Many resources exist to help guide you in these efforts, including Minnesota Department of Agriculture's webpage on Pesticide Management Practices which can be found at **mda.state.mn.us/pesticide-fertilizer/pesticide-best-management-practices** and the University of Minnesota Extension Crop Production webpage **extension.umn.edu/crop-production**. If you are reconstructing a prairie, consider its placement on the landscape to help avoid issues with drift. Alternatively, consider how much of the grassland reconstruction is expected to be "edge" habitat with respect to pesticide drift and try to maximize the interior of the habitat (e.g., block-shaped rather than linear).

In Summary

When managing or restoring a grassland, one must not only consider the habitat tract itself, but also its size and proximity to other habitat in the landscape, in order to maximize its overall suitability to wildlife. Larger grassland parcels, especially those that are connected, are generally better than smaller, isolated patches. Wildlife dispersing in a fragmented landscape often face more predation and energy constraints when moving from one suitable patch to another across an agricultural matrix. This may be especially true for less mobile species like small mammals (Duggan et al., 2012) and insects (Williams et al., 2010), but even highly mobile species like birds can be "area-sensitive." Although larger and more connected grasslands have additional habitat values, all grassland areas are important. Even smaller grassland patches and herbaceous buffer strips can be suitable for breeding birds (Davros, 2005; Henningsen & Best, 2005), butterflies and other insects (Davros, 2005; Reeder et al., 2005), and other grassland wildlife (Clark & Reeder, 2005).

SPOTLIGHT

Minnesota's Pollinators

Insects are an integral component of prairies, providing food to wildlife as well as many other ecological services. An essential ecological service performed by insects in prairies is pollination. Pollinators are animals that facilitate plant reproduction by moving pollen between plants, and thus ensuring seed production and promoting genetic mixing within plant species. Most prairie forbs and shrubs rely on pollinators for seed production. Thus, pollinators help populations of these plants persist in prairies over time, maintaining prairie plant community diversity and overall ecosystem function.

There are hundreds of pollinator species found in Minnesota's prairies. While much is known, there continues to be limited understanding of many species' behaviors, key relationships and habitat requirements. Described here are some general patterns in three important groups of pollinators.

Bees: Bees are a species-rich group of insects that collect pollen and nectar for their young (larva). The adults have specialized hairs for collecting and transporting pollen. Bees are often effective pollinators because they both actively gather and transport pollen and frequently visit flowers to provision food for their larva. They are diverse in size, color, behavior, sociality (solitary or colony-forming), and dietary breadth.

Painted lady butterfly
Photo credit: Jessica Petersen

Butterflies and moths: Larvae (caterpillars) of butterflies and moths are voracious herbivores that often consume only specific host plants. Adults of most species feed on plant nectar to fuel flight, in the process picking up and transporting pollen grains among plants. Both larvae and adults are important prey for other prairie wildlife, including birds, small mammals, reptiles, and other insects.

Flies: Certain groups of flies visit flowers to feed on nectar and pollen, in some cases playing a significant role in pollination. Common flower visiting groups include the hover or flower flies (Syrphids) and bee flies (Bombyliids). Larvae in these groups have a variety of lifestyles from aphid predators to aquatic detritivores (feeding on dead organic matter) to parasitoids (parasites) of other insects. Many flies are bee and wasp mimics, but can be distinguished by their single pair of wings, short or reduced antennae, and lack of biting-chewing mouthparts (mandibles). We have a relatively limited knowledge of the prairie flies compared to other pollinators.

For more information about pollinators, check out:

- The University of Minnesota-based Bee Lab: **beelab.umn.edu/learn-more**
- The Xerces Society for Invertebrate Conservation:
  - › General resource page: **xerces.org/resources**
  - › Regional resource pages for habitat planning and management: **xerces.org/pollinator-resource-center**
- The Minnesota DNR's Pollinator Resources webpage: **mndnr.gov/pollinator_resources**

PART 4
RESOURCES FOR PRAIRIE LANDOWNERS

Chapter 11: Tools and Budget

After deciding on your management techniques, the next critical steps are assembling the right tools for the job and creating a budget.

Tools

Preparing a project toolbox includes much more than rounding up hand equipment and sharpening blades. As described in preceding chapters, your tools may include but are not limited to:

- Personal Protect Equipment (PPE)
- Personalized Prairie Workbook (Appendix D) or Prairie Stewardship Plan
- Aerial photographs of the property
- Soils information
- Mechanical equipment
- Names and contact information of resource professionals or other landowners that can help
- Plant and animal identification books
- First aid kit

Safety First!

Working on the prairie can involve some inherently dangerous activities such as operating chainsaws or other mechanical equipment, prescribed burning, using herbicides, handling noxious plants (such as wild parsnip and poison ivy), and working around ticks and biting insects. Protect yourself with the proper equipment (e.g., hard hat, eye protection, gloves, long sleeves, chainsaw chaps, insect repellent) and the right knowledge before trying any of these activities. Some organizations offer short courses on chainsaw safety and herbicide application.

Photo to left: Judy Schulte

Budget and Financial Considerations

Prairie management can be expensive, so it is important to diligently plan prior to starting a project. Sometimes a little creative thinking or asking for help can save thousands of dollars, making an originally unattainable goal attainable.

Treat management projects like home improvement projects. Create a budget, get estimates and have written contracts for any hired service. Know that you are doing both yourself and the contractor a favor by having a plan and budget laid out before the project starts. Whether choosing to do it yourself or hire it out, a good solid budget creates a foundation for the project.

A great way to do this is to create a dedicated prairie management binder (or folder) to track management activities. In the binder, include the completed Prairie Workbook (Appendix D) or other management plans and a table to help track your budget. Also include any contracts, invoices, notes, pamphlets, catalogs, business cards, photos, etc. that are collected along the way. Since prairie management can be a multi-year effort with many phases, it is especially important to keep all the information in one place.

Below are a few ways to get added support for your next project.

Financial Assistance

Cost-share programs

Several cost-share programs focused on prairie/grassland initiatives can help private landowners with projects. These are funded through various federal, state, and local government agencies and non-profit organizations. Funding levels for these can change from year to year, and opportunities can shift with different conservation targets. For example, the recent increase in awareness of declining pollinators has led to an uptick in programs related to pollinator habitat.

To investigate current options, a good first step is a visit or call to the local Soil and Water Conservation District (SWCD). SWCDs do their best to stay up-to-date with current program availability and often will keep your name for future reference if programs later become available. If the land is enrolled in a conservation easement (through a government agency or land trust) or in a program such as the Conservation Reserve Program, the administering agency or organization may offer cost-share opportunities or assistance to help execute management projects as well.

FINANCIAL ASSISTANCE SPOTLIGHT

Partners for Fish and Wildlife: The U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program provides technical and financial assistance to landowners interested in restoring and enhancing wildlife habitat on their land. Projects are custom-designed to meet landowners' needs. Since the program's start in 1987, more than 50,000 landowners have worked with Partners for Fish and Wildlife biologists to complete 60,000 habitat restoration and enhancement projects across 6 million acres. Partners for Fish and Wildlife projects are voluntary. Participating landowners continue to own and manage their land to serve their needs while they improve conditions for fish, wildlife and plants. Program Agreements are for a minimum of ten years.

In-kind trades

Another great option for added support is in-kind trades. In-kind trades are when neighbors, friends or acquaintances help each other out through trading services. For example, if you have an established prairie and your neighbor has an area they are trying to restore, you could offer to provide seed in exchange for the neighbor haying a portion of your property to encourage flower growth prior to harvesting. Your prairie benefits from a disturbance and your neighbor gets seed for their restoration. The sky is the limit on creative trades: perhaps a welder can offer to trade welding services with a farmer who has the tractor needed to haul cut woody material.

In general, the most common obstacle is finding the person with the skill set and tools needed. A few online resources to help with this are:

The **Minnesota Prairie Landowner Network,** which was created to help connect prairie landowners to each other across the state. The network's Facebook group offers an easy and interactive way to meet others and potentially create some partnerships. To join the group, go to **Facebook.com/groups/MNPrairieNetwork**.

Restoring Minnesota—Practitioner's Network is another Facebook group, it discusses and supports prairie (and other plant communities) management in Minnesota. To join the group, go to **Facebook.com/groups/restoreminnesota**.

Income from working prairies
Some prairie management techniques can generate income. Examples include:

Grazing: Whether charging rent to graze rotationally, recouping fence costs to do prescription grazing, or profiting from raising your own cattle, grazing has the potential to build equity and create profit (See Chapter 6: Grazing).

Haying: When site conditions allow, haying is one of the best prairie management activities that can be done while potentially earning a profit from hay sales or rent (See Chapter 5: Mowing and Haying).

Seed harvest: Selling seed harvested or selling the right to harvest, especially local ecotype (native) seed, is a form of recurring income that is often overlooked.

Tax exemption incentives
Minnesota Statute 272.02 covers tax exempt property types. Of these types, two could be applicable to private land: prairies and wetlands. Both encourage protection and management of rare resources through tax incentives.

Wetland Tax Exemption
"Subdivision 11. Wetlands. Wetlands are exempt. For purposes of this subdivision, "wetlands" means: (i) land described in section 103G.005, subdivision 15a; (ii) land which is mostly under water, produces little if any income, and has no use except for wildlife or water conservation purposes, provided it is preserved in its natural condition and drainage of it would be legal, feasible, and economically practical for the production of livestock, dairy animals, poultry, fruit, vegetables, forage and grains, except wild rice; or (iii) land in a wetland preservation area under sections 103F.612 to 103F.616. "Wetlands" under clauses (i) and (ii) include adjacent land which is not suitable for agricultural purposes due to the presence of the wetlands, but do not include woody swamps containing shrubs or trees, wet meadows, meandered water, streams, rivers, and floodplains or river bottoms. Exemption of wetlands from taxation pursuant to this section shall not grant the public any additional or greater right of access to the wetlands or diminish any right of ownership to the wetlands."

The Minnesota Revenue Department Property Tax Administrator's Manual (**revenue.state.mn.us/property-tax-administrators-manual**) provides more information on this tax exemption and others.

Native Prairie Exemption

"Subdivision 12. Native prairie. Native prairie lands are exempt. The commissioner of the Department of Natural Resources shall determine lands in the state which are native prairie and shall notify the county assessor of each county in which the lands are located. Pasture land used for livestock grazing purposes shall not be considered native prairie for the purposes of this subdivision. Upon receipt of an application for the exemption provided in this subdivision for lands for which the assessor has no determination from the commissioner of natural resources, the assessor shall refer the application to the commissioner of natural resources who shall determine within 30 days whether the land is native prairie and notify the county assessor of the decision. Exemption of native prairie pursuant to this subdivision shall not grant the public any additional or greater right of access to the native prairie or diminish any right of ownership to it."

For more information on the Native Prairie Tax Exemption, email **prairie.protection@state.mn.us**, or go to **mndnr.gov/prairierestoration/taxexemption.html**.

Photo credit: Shawn May, USFWS

Chapter 12: Planning Your Prairie Legacy

As stewards of land, most landowners find themselves wondering about what the future holds for their land, their investments in it, and their conservation legacy. The best way to ensure that your prairie will be taken care of according to your wishes is to plan today.

Tools that can help a landowner to plan for the future include but are not limited to:

- Life estate
- Revocable trust
- Irrevocable trust
- Right of first offer
- Conservation easements
- Deed restrictions
- Fee title sale

Be sure to talk to your tax professional, lawyer and other professionals to design the best plan for your property as early as you can. Early planning provides many benefits. An early consultation can lay out the best personalized plan, even if changes are expected and nothing is formalized until a later date.

Planning ahead and communicating decisions with family members can help avoid future issues. Even if the plan is evolving or changing, communication allows family members to understand your plan for the land and your desired legacy.

If a conservation legacy is desired, many of the conservation partners listed earlier in this document (See Chapter 3, Getting Advice: Key Players) have the ability to assist landowners as requested using the tools above. These partners often do early consultations, so you can explore options without needing to make any immediate decisions or having any obligation.

Photo to left: Megan Benage

Conservation Easements

One of the most popular and widely used tools for long-term protection of Minnesota prairies are **conservation easements**, which are voluntary legal agreements that limit the use of land to protect a set of conservation values. Conservation easements can be either limited in duration or permanent (perpetual). Depending on the program, landowners may receive compensation for an easement or may donate an easement. In Minnesota, there are many different conservation easement options offered by multiple different agencies and non-profits, with those that apply most to grasslands described below.

Minnesota Department of Natural Resource (DNR) Conservation Easements

Native Prairie Bank

Native Prairie Bank provides protection of native prairie on private lands through a voluntary conservation easement. In order to be eligible, the parcel must:

- Contain prairie that has never been plowed or significantly altered.
- Maintain enough plant diversity to support a wide variety of plant and animal species.
- Be evaluated by DNR staff and ranked high enough to qualify for enrollment.

In exchange for a one-time payment, the landowner agrees to permanently protect the prairie and related conservation values on the enrolled parcel. Landowners retain hunting and access rights along with some specified agricultural uses such as grazing, haying and seed harvest. Benefits to the landowner include, but are not limited to:

- Guidance and assistance with management of prairie
  - › Prescribed burns
  - › Tree and brush removal
  - › Seeding and restoration
  - › Invasive species control
- Prairie Stewardship, Grazing, Haying and Seed Harvest Plans created for your property by some of the state's leading prairie experts

For information on Native Prairie Bank visit **mndnr.gov/prairierestoration/prairiebank.html** or email **prairie.protection@state.mn.us**.

Other Minnesota DNR easement types

The Minnesota DNR administers several other conservation easement programs (see list below) which vary widely in protections and use. For more information on any of the following, please contact the Minnesota DNR Information Center at (651) 296-6157 or **info.dnr@state.mn.us.**

- Minnesota Forest for the Future (MFF) easements
- Forest Legacy Program (FLP) easements
- Stream Conservation easements
- Wild and Scenic River easements
- Metro Greenway easements
- Scientific and Natural Area (SNA) easements
- Aquatic Management Area (AMA) easements
- Fisheries Public Open Space
- Access Only easements
- Northern Pike Spawning Areas
- Water Bank easements
- Wildlife easements

U.S. Fish and Wildlife Service (FWS/USFWS) Conservation Easements Available in Minnesota

All FWS conservation easements in Minnesota are perpetual and are acquired only from willing sellers. A percentage of the market value is paid, depending on the rights being acquired or restricted. Each local office has focus areas where they work to protect habitat that is most valuable to waterfowl, wetland and prairie-dependent wildlife, and to protect the remaining unbroken native prairie in Minnesota. Contact local FWS offices to determine if your land is eligible and, if so, to get an estimate of the easement payment. Restoration of wetlands and grasslands may be cost-shared when the land is enrolled in an easement. FWS habitat easements allow haying and/or grazing, and staff are excited to work with landowners on enhancements that can increase the productivity of the land for both wildlife and livestock.

FWS Wetland Easement

FWS protects wetlands from being drained, burned, filled or leveled by purchasing those rights on the wetland areas of a parcel of land. The landowner may continue to hay, graze or farm the wetlands if they go dry of natural causes. This easement does not impact the uplands on a parcel of land, so the landowner may continue to use the uplands without restrictions.

FWS Habitat Easement

FWS protects grasslands, native prairie and wetlands by purchasing the right to alter the permanent vegetative cover. This easement will protect all of the wetlands and grassland (prairie) within a property from being altered or destroyed.

Habitat easement with hay option. The "Hay" option allows landowners to continue to hay, mow or harvest native plant seed from the land after July 15 each year. Farming row crops, grazing and any other use that will destroy the vegetation is not allowed without written permission from FWS.

Habitat easement with hay and graze option. The "Hay and Graze" option allows landowners to continue to hay, mow or harvest native plant seed from the land after July 15 each year, and allows the land to be grazed all year. Farming row crops or any other use that will destroy the vegetation is not allowed without written permission from FWS.

Re-Invest in Minnesota (RIM) Easements

The Minnesota Board of Water and Soil Resources (BWSR) acquires conservation easements on behalf of the state to permanently protect, restore and manage critical natural resources without owning the land outright. The land remains in private ownership and the landowner retains responsibility for maintenance and paying applicable real estate taxes and assessments. Landowner easement payment rates are usually based on county township land value rates. BWSR provides statewide program coordination and administration, while implementation is done on the local level by county Soil and Water Conservation Districts (SWCDs).

RIM Grassland Reserve Easements

RIM Grassland Reserve easements protect current grasslands or buffer native prairie within wildlife habitat complexes not typically covered by other conservation programs. Working in coordination with established Prairie Conservation Plan Local Technical Teams, this project aims to enroll and protect remnant prairie grasslands by focusing on landscapes identified in the Minnesota Prairie Plan. These easements:

- Provide habitat for a wide range of grassland-dependent wildlife, including endangered plants, birds and butterflies.
- Focus on protecting current remnant or native prairie grasslands and buffering native prairies that are not typically covered by other state and federal programs.

RIM Wild Rice Conservation Easements

The RIM Wild Rice Conservation Easement Program protects wild rice lakes through permanent conservation easements on privately owned lands in Minnesota's Northern Forest region. This program is available in the following fourteen counties: Aitkin, Becker, Beltrami, Carlton, Cass, Clearwater, Crow Wing, Hubbard, Itasca, Otter Tail, St. Louis, Stearns, Todd and Wadena.

RIM Groundwater (Wellhead) Protection Easements
RIM Reserve easements focus on drinking water supply management areas where vulnerability is designated as High or Very High by the Minnesota Department of Health (MDH). Participating landowners receive a payment to permanently retire land in agricultural production, and to establish buffers of native vegetation.

The Minnesota Conservation Reserve Enhancement Program (MN CREP)
MN CREP is a voluntary state and federal conservation program that uses a science-based approach to target environmentally sensitive land in 54 Counties in southern and western Minnesota. This is accomplished through permanent protection by establishing conservation practices via payments to farmers and agricultural landowners. The project goal is to protect up to 60,000 acres of the highest priority areas across 54 counties.

Here is how it works: Landowners enroll in the federally-funded Conservation Reserve Program (CRP) for 14-15 years. The same land is also enrolled into a state-funded permanent conservation easement through the Reinvest in Minnesota (RIM) Reserve program. After the CRP expires the permanent RIM easement remains.

Other BWSR programs
The RIM Program is ever changing, and new programs and new initiatives are always in the works. For general updates visit **bwsr.state.mn.us/what-programs-are-available**.

For more about the Minnesota Board of Water and Soil Resources visit **bwsr.state.mn.us**.

For additional information on any of the above-mentioned conservation easement options contact **bwsr.rim@state.mn.us** or your local county SWCD.

Minnesota Land Trust

A 501(c)3 public charity, the Minnesota Land Trust has been working with landowners and local communities since 1991 to protect and enhance Minnesota's increasingly threatened lands and waters. Conservation easements are used to protect a variety of lands for their conservation values. The Minnesota Land Trust concentrates its efforts on protecting habitat for wildlife, fish and other species, native plant communities such as prairies, forests, blufflands, and wetlands, lakes, rivers, and streams and scenic landscapes. Each conservation easement is unique and is individually crafted to reflect the special characteristics of the land and the particular situation of the landowner.

For more information on Minnesota Land Trust conservation easements go to **mnland.org**.

Chapter 13: Connecting With Your Prairie Landowner Community

Where can you meet people who share your interests, who give you the benefit of their experience or who may be in a similar position with goals they hope to achieve? They're out there, and you can connect with them.

Whether you own land or not, these groups provide opportunities to learn more, advance skills, give back to the local community, and—yes—have fun. No matter where you live in Minnesota, there is a local group interested in prairie nearby. Connect!

Prairie Oriented Non-Profit Organizations

Below is a selected sampling of regional and national prairie-oriented nonprofit organizations with local chapters:

- Prairie Enthusiasts: **theprairieenthusiasts.org**
- Pheasants Forever: **pheasantsforever.org**
- Ducks Unlimited: **ducks.org/Minnesota**
- Prairie Chicken Society: **prairiechickens.org**
- Minnesota Sharp-Tailed Grouse Society: **sharptails.org**
- Clean Up the River Environment (CURE): **cureriver.org**

Beyond these larger-scale organizations, many local groups and initiatives are scattered throughout the state. Ask local conservation professionals for a list of organizations near you.

Volunteer and Outreach Events

Many organizations host volunteer and outreach events that are easy to attend when time allows without the longer-term commitment of joining an organization. Most list upcoming events on their websites. For instance, check out:

- Minnesota DNR Events: **mndnr.gov/events/index.html**
- The Nature Conservancy Events: **nature.org/en-us/get-involved/how-to-help/volunteer-and-attend-events/**
- Audubon Bird Counts: **mn.audubon.org/volunteer-15**

Volunteering

Volunteering is a great way to learn new skills or advance existing skills. Want to learn how to carry out a prescribed fire, hand harvest seed, control invasive species, etc.? Volunteer for a conservation organization that does a lot of it. Most conservation organizations have a volunteer section on their website, if not, stop by an office or call to ask about opportunities.

Social Media Resources

Social media can be a great resource to discuss ideas and connect with others. Be sure to research any information found online, and remember that different things may work in different areas. It is always a good idea to consult a professional in your community.

Many organizations and programs maintain social media pages where they provide information, announcements, updates, and answer questions. To see the latest published information "follow" and "like" the accounts. The social media accounts for an organization are generally listed at the bottom of their website.

Here are a few organizations in Minnesota that maintain social media accounts:

- The Minnesota Department of Natural Resources
  - **mndnr.gov/social-media**
- The Nature Conservancy in Minnesota
  - **facebook.com/NatureConservancyMinnesota**
  - **twitter.com/nature_mn**
- The Minnesota Pollution Control Agency
  - **pca.state.mn.us/about-mpca/social-media-policy**

- The Minnesota Department of Agriculture
  - **facebook.com/mnagriculture**
  - **youtube.com/mnagriculture**
  - **twitter.com/mnagriculture**
- The Minnesota Board of Water and Soil Resources
  - **facebook.com/MNBWSR**
  - **youtube.com/MNBWSR**
- The U.S. Fish and Wildlife Service
  - **fws.gov/home/socialmedia**
- The University of Minnesota Extension
  - **youtube.com/UofMNExt**
  - **twitter.com/UMNExt**
- Minnesota Ducks Unlimited
  - **facebook.com/MinnesotaDU**
- Pheasants Forever—Minnesota chapter
  - **facebook.com/MinnesotaPF**
- The Minnesota Prairie Chicken Society
  - **facebook.com/MNPrairieChickenSociety**
  - **twitter.com/M_P_C_S**
- The Xerces Society
  - **xerces.org/news/social-media**
- Play Clean Go
  - **PlayCleanGo.org/contact-us**
- The Minnesota Native Plant Society
  - **facebook.com/MinnesotaNativePlantSociety**
- Many Soil and Water County Districts have Facebook groups or pages. Search for them on **facebook.com**

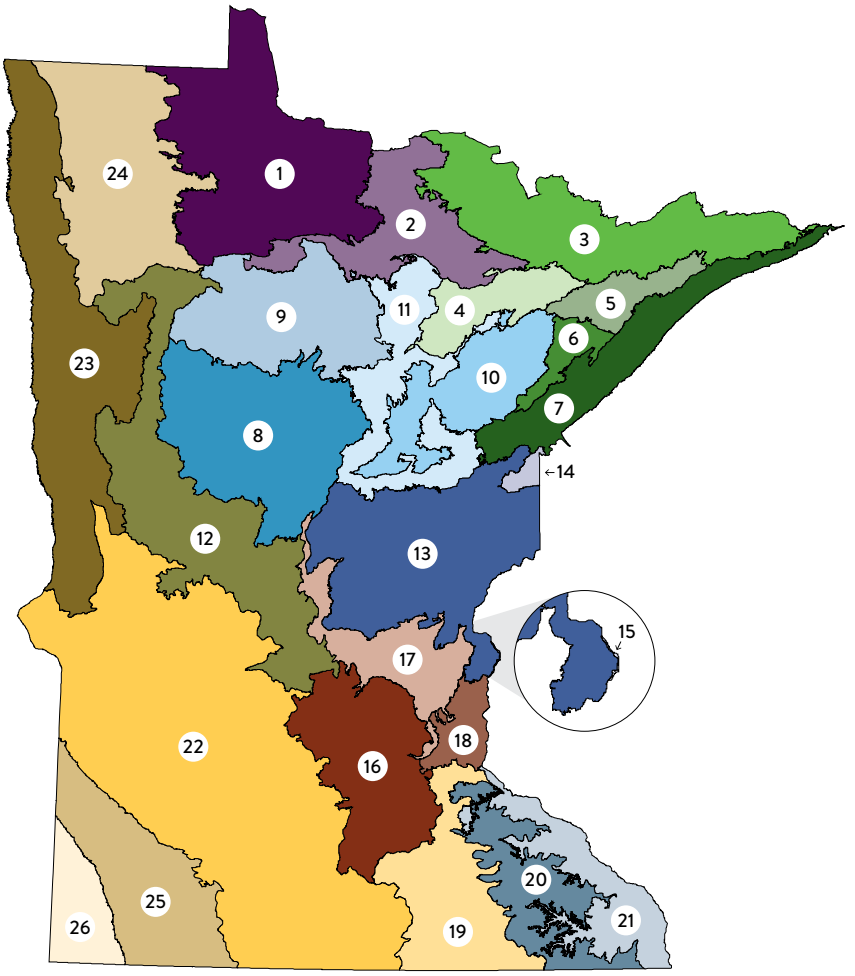
Facebook groups are another way to connect with others who are interested in the same topic. Go to Facebook, search for topics of interest and select the "groups" tab to find communities to join. Nearly any topic, ranging from cover crops to pollinator yards, has a Facebook group. If you cannot find a Facebook group for a particular topic or area of interest, anyone can start a public or private group to fill that need.

As mentioned earlier in the book, a few Minnesota based Facebook groups that frequently discuss prairie management are:

- Minnesota Prairie Landowner Network: **facebook.com/groups/MNPrairieNetwork**
- Restoring Minnesota—Practitioners Network: **facebook.com/groups/RestoreMinnesota**

Ecological Subsections Within Minnesota

1. Agassiz Lowlands
2. Littlefork–Vermilion Uplands
3. Border Lakes
4. Nashwauk Uplands
5. Laurentian Uplands
6. Toimi Uplands
7. North Shore Highlands
8. Pine Moraines–Outwash Plains
9. Chippewa Plains
10. Tamarack Lowlands
11. St. Louis Moraines
12. Hardwood Hills
13. Mille Lacs Uplands
14. Glacial Lake Superior Plain
15. St. Croix Moraine
16. Big Woods
17. Anoka Sand Plain
18. St. Paul–Baldwin Plains and Moraines
19. Oak Savanna
20. Rochester Plateau
21. Blufflands
22. Minnesota River Prairie
23. Red River Prairie
24. Aspen Parklands
25. Coteau Moraines
26. Inner Coteau



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Appendix A: Ecological Classification System

The Ecological Classification System (ECS) was created by ecologists to help people who manage natural resources identify patterns in the landscape to better understand the land's potential. The system divides the landscape into progressively smaller areas based on similarities and differences according to climate, geology, natural features, and the types of vegetation present.

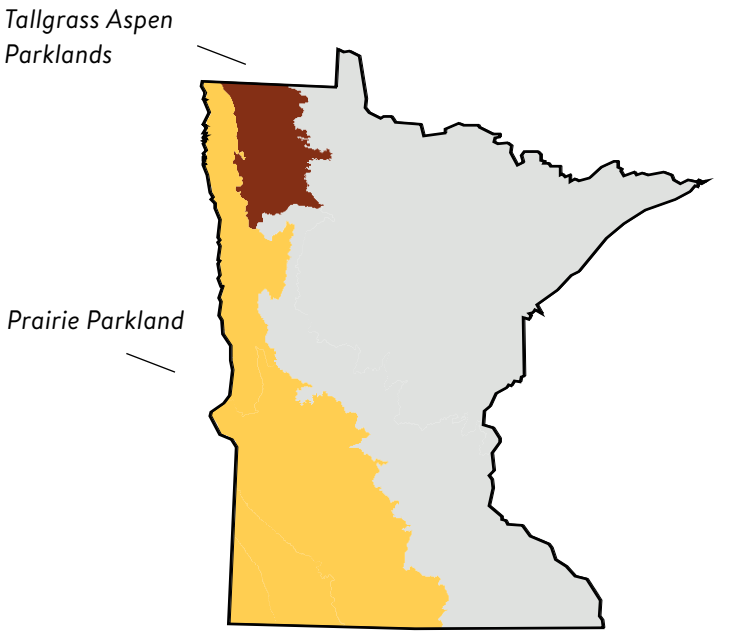
The levels of the ECS hierarchy are nested within each other. The largest units are provinces (the boundaries of which follow the major biomes within the state). These are divided into sections, which are further divided into subsections. The smaller the unit, the more uniform the ecological features. Note that these ecological boundaries extend across state lines.

It is not necessary for a landowner to have a working knowledge of the ECS in order to restore or manage prairie on their land, though it helps to know where a given property fits in the system. This context is useful in setting goals for management and looking at how an individual property fits into the landscape.

Ecological Provinces

Minnesota is divided into four provinces, based on climate, general structure of native vegetation (physiognomy), and biomes (Hanson & Hargrave, 1996; MN DNR, 2005). This handbook covers prairie communities found in the Prairie Parkland Province, the Tallgrass Aspen Parklands Province, and (to a lesser extent) the Eastern Broadleaf Forest Province.

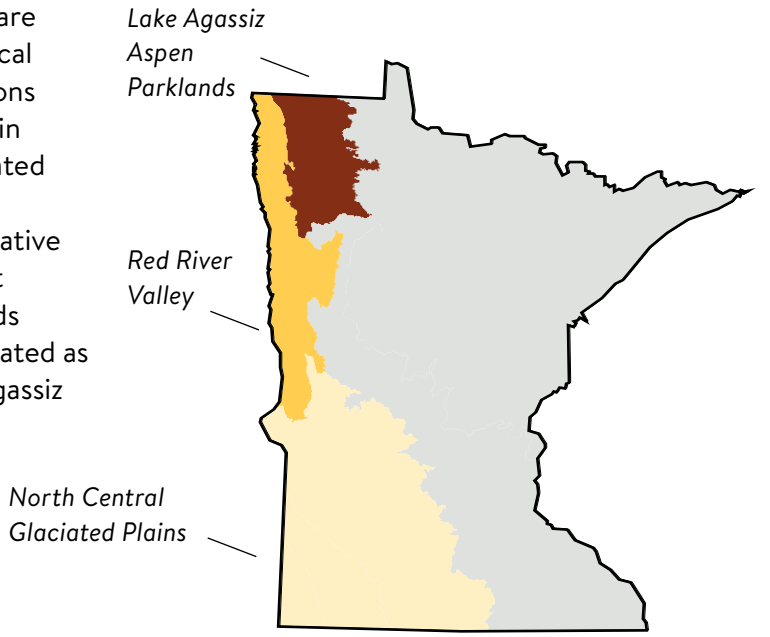
MINNESOTA PRAIRIE PROVINCES



Ecological Sections

Minnesota's four provinces are further divided into ecological sections. There are 10 sections in the state, defined by origin of soil materials (mostly related to glacial deposits), regional elevation and climate, and native plant distribution. Note that the Tallgrass Aspen Parklands Province in Minnesota is treated as a single section, the Lake Agassiz Aspen Parklands Section.

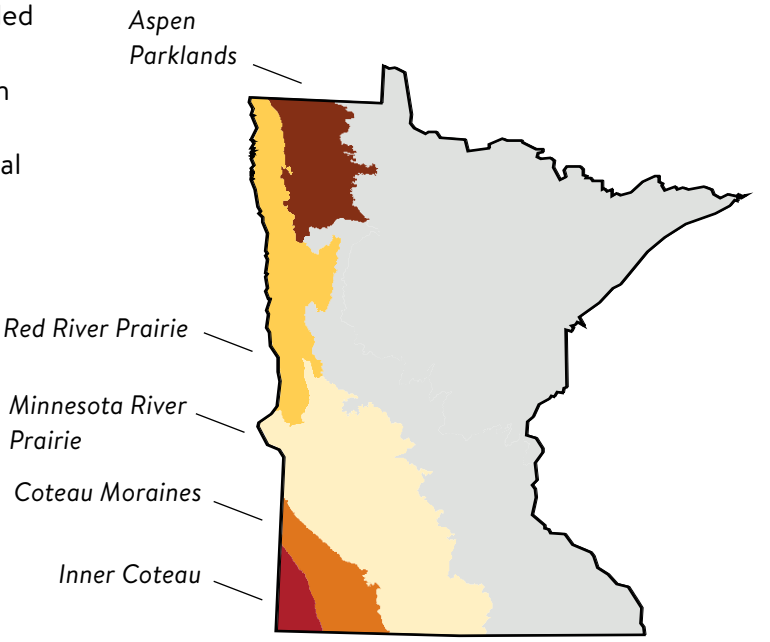
MINNESOTA PRAIRIE SECTIONS



Ecological Subsections

Each section is further divided into ecological subsections, defined by glacial deposition processes, surface bedrock formations, topography, local climate, and native plant distribution. Minnesota has 26 subsections. Here, too, the Tallgrass Aspen Parklands Province is treated as a single subsection, the Aspen Parklands Subsection.

MINNESOTA ECOLOGICAL SUBSECTIONS



Following is an overview of selected subsections that occur within the Prairie Parkland and Tallgrass Aspen Parklands Provinces highlighted by this handbook. While not detailed here, it should be recognized that significant prairie communities also occur in the Eastern Broadleaf Province, although on very different landforms.

GEOLOGICAL TERMS SPOTLIGHT

Terms Used in Defining and Describing Ecological Subsections

Calcareous till—Till rich in calcium carbonate, usually from parent material high in limestone.

Des Moines lobe—The last glacial lobe to spread across Minnesota. It carried gray-brown till with shale from North Dakota. 14,000 years ago it spread from the Red River lowlands south into central Iowa. It melted away in Minnesota by about 10,000 years ago. The Bemis moraine marks its farthest extent.

Drift—Materials moved by glaciers from one area to another. Includes till as well as materials deposited indirectly by water, such as outwash and lacustrine sediments.

End moraine—A landform composed of a belt or zone of hills and valleys deposited at the terminal margin of a glacier. End moraines can be substantial in places where the ice at the margin was melting back while the ice sheet was still advancing.

Escarpment—A landform where the elevation changes rather abruptly, such as a steep slope between two relatively level areas.

Ground moraine—A broad, level or gently undulating landform composed of a continuous layer of till deposited directly beneath a melting glacier; also referred to as a till plain.

Lacustrine—Referring to sediments deposited in lake beds, usually mostly silts and clays.

Loess—An accumulation of wind-blown sediments, mostly silt.

Moraine—An accumulation of glacial till.

Till—Unsorted (mixed up) material deposited directly by a glacier. Till can include clay, silt, sand, and rocks in any proportion.

Wadena lobe—An ice lobe that was present in Minnesota in the early to middle Wisconsin period. Its till is gray and contains limestone from the Winnipeg lowlands. The Alexandria moraine is Wadena lobe till overlain in place by till from later ice lobes.

Wisconsin glaciation (Wisconsinan glaciation)—The last glacial cycle, it lasted from about 75,000-10,000 years ago.

Inner Coteau Subsection

In the southwest corner of Minnesota, this subsection is notable for being one of the few areas of Minnesota not directly impacted by glaciers during the state's most recent glacial episode, the Wisconsin glaciation. Some areas of the Inner Coteau have up to 800 feet of pre-Wisconsin till, other areas have red quartzite outcrops, and much of it is topped by 6–15 feet of loess (wind-deposited silt). The Inner Coteau extends into South Dakota and Iowa and is bounded to the northeast in Minnesota by the Buffalo Ridge (part of the Bemis moraine), which is also the drainage divide between the Missouri River and Mississippi River watersheds.

As a landscape missed by the last round of glaciers, the Inner Coteau has a more dissected topography than much of Minnesota and few lakes. Dry prairie communities predominate, though quartzite rock outcrop communities are locally common. Many western species of dry prairies are more abundant here than in other parts of the Minnesota prairie region. Wet prairie communities and woodlands are not abundant and were historically restricted to streams and ravines.

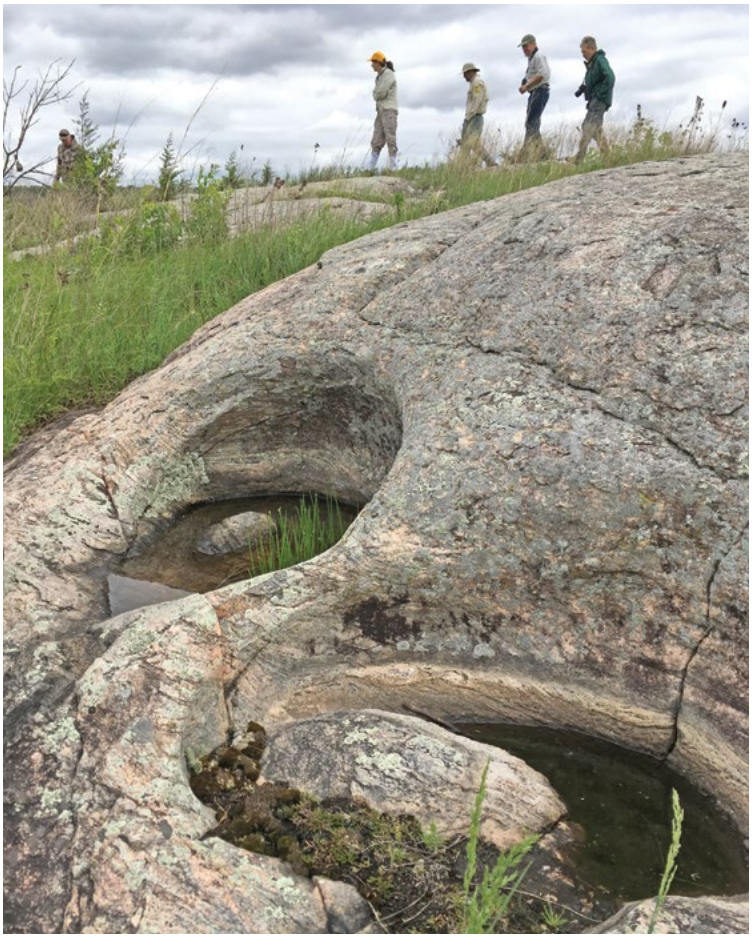


Photo credit: Megan Benage

Coteau Moraines Subsection

The Coteau Moraines Subsection is characterized by a landscape of rolling hills and moraines of late Wisconsin glacial origin. To the southwest, it is bounded by the Buffalo Ridge, which at up to 1,995 feet above sea level, is the highest elevation in southern Minnesota. The subsection has two distinct landforms, the Middle Coteau and Outer Coteau. These landforms were largely shaped by the actions of the Des Moines lobe, which 14,000 years ago extended through the Red River Valley in northwestern Minnesota down to Des Moines, Iowa. This lobe of glacial ice retreated from Minnesota roughly 11,000 years ago, leaving its gray-brown calcareous till across much of the state's prairie region.

The **Middle Coteau** (the southwest part of the subsection) is a landscape of moraine ridges of glacial drift from the late-Wisconsin glaciation deposited at the edge of the Des Moines lobe (the Bemis moraine) and overlain with a mantle of loess 1-3 feet thick. The **Outer Coteau** is a series of end moraines separated by ground moraine with many features of stagnating ice, which record the retreat of the Des Moines lobe. The elevation drops rather steeply from southwest to northeast across the Outer Coteau and streams running through this escarpment have fairly straight, narrow ravines. The landscape ranges from gently undulating to steeply rolling and hilly and includes many lakes and ponds.

These landforms offer a range of environmental conditions that host a diverse array of plant communities. Available soil moisture is a key determinant, with the spectrum of low to high moisture reflected in dry, mesic, and wet prairies. Steep slopes and well-drained soils support dry prairies, especially slopes above natural drainageways. Wet prairies and other wetland communities occur where the soil or local relief impedes drainage, and calcareous fens are present along the Outer Coteau escarpment where groundwater discharges.

Minnesota River Prairie Subsection

Covering 9,322,090 acres, the Minnesota River Prairie Subsection is the largest ecological subsection in Minnesota. This Subsection is mostly a large till plain of gently rolling ground moraine of the Des Moines lobe, though there are other notable features including glacial lake basins, moraines, and the Minnesota River.

The subsection's topography is level to gently rolling, with lakes and ponds scattered in the landscape. Historically, the area supported prairie, with forests in floodplains and often in "fire shadows" that occurred on east sides of lakes and wetlands. Hardwood forests can also be found on the north and east facing slopes of the Minnesota River bluff land. Although fire played a role in these forests, fires were less common than in the areas dominated by prairies. These islands of hardwood forest often resemble areas of the Big Woods Ecological Subsection. Dry prairies could be found on hills and slopes, while

mesic and wet prairies occurred in lowlands and areas with impeded drainage. Rock outcrops are an ecologically significant feature along the Minnesota River and in northeastern Cottonwood County.

The basin of Glacial Lake Minnesota covers much of Blue Earth, Watonwan, Faribault, and Waseca counties; while the basin of Glacial Lake Benson is centered in Chippewa and Swift counties and stretches into Lac qui Parle and Big Stone counties. Glacial lake basins are relatively flat and have rich soil, which has lead to most being utilized as agricultural land.

The Big Stone Moraine in the northwest corner of the subsection is an area of steep hills and abundant lakes. The Alexandria Moraine stretches through Douglas, Pope, and Kandiyohi counties. Composed of Des Moines lobe till over Wadena lobe till, there is significant rise in elevation from southwest to northeast along it. The Alexandria moraine is a hummocky landscape with steep rolling hills, abundant lakes and ponds, and sand and gravel deposits from melting glacial ice. With its diversity of landforms, the Alexandria moraine has a mosaic of plant communities including prairies, savannas, woodlands, lakes, and pothole wetlands.

The Minnesota River bisects this Subsection and has many noteworthy features. The Minnesota River Valley was originally carved by Glacial River Warren when it drained Glacial Lake Agassiz, creating a valley that is oversized for the flow of the Minnesota River today. The great torrent of River Warren

Photo credit: Melissa Driscoll

removed much of the glacial till through the area and the valley has many areas with exposed bedrock supporting rock outcrop communities. The steep slopes of the Minnesota River Valley support dry prairie communities. Mesic to wet prairies and wetlands are found in the valley bottoms. Floodplain forests occur in the river bottoms and woodland communities (similar to those in the Big Woods Subsection) are supported on north and east facing slopes. Locally, groundwater discharge creates seepage fens and calcareous fens.

Red River Prairie Subsection

The landscape of the Red River Prairie Subsection is the result of Glacial Lake Agassiz, which was present in Minnesota from about 13,900 to 8,400 years ago. There are two major landforms in the subsection: the Glacial Lake Agassiz basin and the Agassiz beach ridges. The Agassiz basin is a level, nearly featureless plain of poorly drained soils of lacustrine (lake bed deposited) origin, typically fine-grained sediments that were once submerged and part of the lakebed. Historically, this plain supported tallgrass upland and prairie wetland communities with forests along streams or in areas protected from fire. The Red River Valley drains to the Red River of the North, which marks the western boundary of the subsection in Minnesota. Disturbance by fire was historically common, as were flooding and major storm events. Today, very little prairie remains in the Glacial Lake Agassiz basin.

The Agassiz beach ridges are a distinctive topographic feature on the eastern side of the Red River Prairies Subsection. Also referred to as “strand lines,” the linear ridges are composed of wave-worked till and mark the former shorelines of Glacial Lake Agassiz. Although the elevation of the ridges is relatively modest (ranging from a 40 to 100 feet rise in local relief over a span of roughly 5 miles), they have a considerable influence on the area’s native plant communities and associated wildlife. The ridges’ well-drained sandy and gravelly soils support dry prairie communities and dry oak savannas. Between the beach ridges are poorly drained soils similar to the Agassiz basin where a mosaic of wet prairie, sedge meadow, marsh, and mesic prairie communities is supported.

There are also some ecologically significant dune complexes in the subsection. Rivers fed by the melting glacial ice deposited large deltas of sand when they flowed into Glacial Lake Agassiz; the wind later reworked these sand deposits into dunes. These dune complexes support dry prairie and oak savanna communities.

The Aspen Parklands Subsection

The Aspen Parklands Subsection in northwestern Minnesota is a landscape formed by Glacial Lake Agassiz. Its western portion is a lacustrine plain, once submerged by the waters of the immense lake. The eastern portion is characterized by glacial till, reworked over time by Lake Agassiz. The landscape is rather level with soils ranging from clayey and silty soils in lower areas to sandy and gravely soils along beach ridges.

Wet zones between beach ridges, large peatlands, and river valleys on the west edge of the lake plain historically provided some protection from fire, allowing more tree-dominated communities to persist than in other prairie subsections, though fire was still important determining where communities occurred. While the landscape is generally characterized by low relief, subtle variations in elevation and soils affect the hydrology and the vegetation. This, combined with variability in the fire regime, gives the Aspen Parklands a variety of native plant communities.

The vegetation of the Aspen Parklands includes a mosaic of native plant communities. Upland areas support prairies, brushlands, and woodlands.

Photo credit: Fred Harris

Lowlands host a mix of wet prairies, brush prairies, wet meadows, fens, and wet forests. Peatlands—some of which are extensive—are found in areas where the water table is high. Historically, 40% of the Aspen Parklands was upland prairie or wetland prairie. Since the historic and current climate here is well suited to forests, fire was and continues to be very important in maintaining these prairie communities. The Aspen Parklands has retained more large natural landscapes than other provinces in the Minnesota Prairie region.

More information on the ecological classification, Provinces, Sections, and Subsections can be found at: **mndnr.gov/ecs**.

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Appendix B: Latin Names for Plants Listed in Handbook

Common Name	Botanical (Latin) Name	Type of Plant
Bee Balm	*Monarda fistulosa* L.	Native Forb
Bella Honeysuckle	*Lonicera ×bella* Zabel	Non-native Invasive Shrub
Big Bluestem	*Andropogon gerardii* Vit.	Native Warm-season Grass
Bird Foot Trefoil	*Lotus corniculatus* L.	Non-native Invasive Forb
Black Eyed Susan	Rudbeckia hurta L.	Native Forb
Black Oak	*Quercus velutina* Lam.	Native Tree
Blazing stars	*Liatris* spp.	Native Forbs
Blue Grama	*Bouteloua gracilis* (Willd. ex Kunth) Lag. ex Griffiths	Native Warm-season Grass
Bog Birch	*Betula pumila* L.	Native Tree
Bottle Gentian	*Gentiana andrewsii* Griseb.	Native Forb
Bracted Spiderwort	*Tradescantia bracteata* Small	Native Forb
Brittle Prickly Pear Cactus	*Opuntia fragilis* (Nutt.) Haw.	Native Forb
Broad-leaved Cattail	*Typha latifolia* L.	Native Forb
Bull Thistle	*Cirsium vulgare* (Savi) Ten.	Non-native Invasive Biennial Forb
Bur Oak	*Quercus macrocarpa* Michx.	Native Tree
Butterfly Weed	*Asclepias tuberosa* L.	Native Forb
Buxbaum's Sedge	*Carex buxbaumii* Wahlenb.	Native Sedge
Canada Bluejoint	*Poa compressa* L.	Non-native Cool-season Grass
Canada Thistle	*Cirsium arvense* (L.) Scop.	Non-native Invasive Forb
Clasping Dogbane	*Apocynum sibiricum* Jacq.	Native Forb
Canada Wildrye	*Elymus canadensis* L.	Native Cool-season Grass
Common Buckthorn	*Rhamnus cathartica* L.	Non-native Invasive Tree
Cottonwood	*Populus deltoides* W. Bartram ex Marshall	Native Tree
Crown Vetch	*Securigera varia* (L.) Lassen	Non-native Invasive Forb
Culver's root	*Veronicastrum virginianum* (L.) Farw.	Native Forb
Cup Plant	*Silphium perfoliatum* L.	Native Forb
Dotted Blazing Star	*Liatris punctata* Hook.	Native Forb
Downy Gentian	*Gentiana puberulenta* J. Pringle	Native Forb
Dropseeds	*Sporobolus* spp.	Native Warm-season Grasses
Eastern Red Cedar	*Juniperus virginiana* L.	Native Tree

Common Name	Botanical (Latin) Name	Type of Plant
European Common Reedgrass (Phragmites)	*Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis*	Non-native Invasive Cool-season Grass
Flodman's Thistle	*Cirsium flodmanii* (Rydb.) Arthur	Native Forb
Giant Sunflower	*Helianthus giganteus* L.	Native Forb
Golden Alexander	*Zizia aurea* (L.) W.D.J. Koch	Native Forb
Goldenrods	*Solidago* spp.	Native Forb
Grey Headed Coneflower	*Ratibida pinnata* (Vent.) Barnhart	Native Forb
Green Needlegrass	*Nassella viridula* (Trin.) Barkworth	Native Cool-season Grass
Grama Grasses	*Bouteloua* spp.	Native Warm-season Grasses
Hairy Grama	*Bouteloua hirsuta* Lag.	Native Warm-season Grass
Heart-leaved Alexander	*Zizia aptera* (A. Gray) Fernald	Native Forb
Hill's Thistle	*Cirsium pumilum* Spreng.	Native Forb
Hybrid Cattail	*Typha ×glauca* Godr.	Non-native Invasive Forb
Indian Grass	*Sorghastrum nutans* (L.) Nash	Native Warm-season Grass
Jack Pine	*Pinus banksiana* LaMB.	Native Tree
Junegrass	*Koeleria macrantha* (Ledeb.) Schult.	Native Cool-season Grass
Kentucky Bluegrass	*Poa pratensis* L.	Non-native Invasive Cool-season Grass
Leadplant	*Amorpha canescens* Pursh	Native Shrub
Leafy Spurge	*Euphorbia esula* L.	Non-native Invasive Forb
Little Bluestem	*Schizachyrium scoparium* (Michx.) Nash	Native Warm-season Grass
Manna Grasses	Glyceria spp.	Native Cool-season Grasses
Mat Muhly	*Muhlenbergia richardsonis* (Trin.) Rydb.	Native Warm-season Grass
Maximilian Sunflower	*Helianthus maximiliani* Schrad.	Native Forb
Narrow Reedgrass	*Calamagrostis stricta* (Timm) Koeler	Native Cool-season Grass
Narrow-leaved Cattail	*Typha angustifolia* L.	Non-native Invasive Forb
Needle-and-Thread	*Hesperostipa comata* (Trin.&Rupr.) Barkworth	Native Cool-season Grass
Needlegrasses	*Hesperostipa* and *Nassella* species	Native Cool-season Grasses
Northern Bedstraw	*Galium boreale* L.	Native Forb
Northern Pin oak	*Quercus ellipsoidalis* E.J. Hill	Native Tree
Pale/Narrow-leaved Purple Coneflower	*Echinacea angustifolia* DC.	Native Forb
Pasque Flower/Prairie Crocus	*Anemone patens* L.	Native Forb

Common Name	Botanical (Latin) Name	Type of Plant
Penstemons/ Beardtongues	*Penstemon* spp.	Native Forbs
Plains Muhly	*Muhlenbergia cuspidata* (Torr. ex Hook.) Rydb.	Native Warm-season Grass
Porcupine Grass	*Hesperostipa spartea* (Trin.) Barkworth	Native Cool-season Grass
Prairie bird's foot violet	*Viola pedatifida* G. Don	Native Forb
Prairie Bush Clover	*Lespedeza leptostachya* Engelm.	Native Forb
Prairie Cordgrass	*Spartina pectinata* Bosc ex Link	Native Warm-season Grass
Prairie Dropseed	*Sporobolus heterolepis* (A. Gray) A. Gray	Native Warm-season Grass
Prairie Rose	*Rosa arkansana* Porter	Native Shrub
Prairie Smoke	*Geum triflorum* Pursh	Native Forb
Purple Prairie Clover	*Dalea purpurea* Vent.	Native Forb
Quaking Aspen	*Populus tremuloides* Michx.	Native Tree
Queen Ann's Lace	*Daucus carota* L.	Non-native Invasive Biennial Forb
Red Osier Dogwood	*Cornus sericea* L.	Native Shrub
Redtop	*Agrostis gigantea* Roth	Non-native Invasive Cool-season Grass
Reed Canary-grass	*Phalaris arundinacea* L.	Non-native Invasive Cool-season Grass
Russian Olive	*Elaeagnus angustifolia* L.	Non-native Invasive Tree
Sages	Artemisia spp.	Native Forb
Sartwell's Sedge	*Carex sartwellii* Dewey	Native Sedge
Sawtooth Sunflower	*Helianthus grosseserratus* M. Martens	Native Forb
Siberian Elm	*Ulmus pumila* L.	Non-native Invasive Tree
Side-oats Grama	*Bouteloua curtipendula* (Michx.) Torr.	Native Warm-season Grass
Silky Aster	*Symphyotrichum sericeum* (Vent.) G.L. Nesom	Native Forb
Small porcupine grass	*Hesperostipa curtiseta* (Hitchc.)	Native Cool-season Grass
Smooth Blue Aster	*Symphyotrichum laeve* (L.) Á. Löve & D. Löve	Native Forb
Smooth Brome	*Bromus inermis* Leyss.	Non-native Invasive Cool-season Grass
Smooth Sumac	*Rhus glabra* L.	Native Shrub
Sow Thistle (perennial)	*Sonchus arvensis* L.	Non-native Invasive Forb
Spotted Joe Pye Weed	*Eutrochium maculatum* (L.) E.E. Lamont	Native Forb

Common Name	Botanical (Latin) Name	Type of Plant
Spotted Knapweed	*Centaurea stoebe* L.	Non-native Invasive Forb
Stiff Goldenrod	*Solidago rigida* L.	Native Forb
Swamp Milkweed	*Asclepias incarnata* L.	Native Forb
Switchgrass	*Panicum virgatum* L.	Native Warm-season Grass
Tall Blazing Star	*Liatris pycnostachya* Michx.	Native Forb
Tall Meadow Rue	*Thalictrum dasycarpum* Fisch. & Avé-Lall.	Native Forb
Tatarian Honeysuckle	*Lonicera tatarica* L.	Non-native Invasive Shrub
Tussock Sedge	*Carex stricta* Lam.	Native Sedge
Virginia Mountain Mint	*Pycnanthemum virginianum* (L.) T. Dur. & B.D. Jacks. ex B.L. Rob. & Fernald	Native Forb
Water Hemlock	*Cicuta maculata* L.	Native Forb
Water Smartweed	*Persicaria amphibia* (Raf.) Gray	Native Forb
Western Prairie Fringed Orchid	*Platanthera praeclara* Sheviak & Bowles	Native Forb
White Camas/Death Camas	*Zigadenus elegans* Pursh	Native Forb
White Panicled Aster	*Symphyotrichum lanceolatum* (Willd.) G.L. Nesom	Native Forb
White Prairie Clover	*Dalea candida* Michx. ex Willd.	Native Forb
Wild Honeysuckle	*Lonicera dioica* L.	Native Shrub
Wild Parsnip	*Pastinaca sativa* L.	Non-native Invasive Biennial Forb
Wildryes	*Elymus* spp.	Native Cool-season Grasses
Willows	*Salix* spp.	Native Tree
Wolfberry/buckbrush	*Symphoricarpos occidentalis* Hook.	Native Shrub
Wood Lily	*Lilium philadelphicum* L.	Native Forb
Woolly Sedge	*Carex pellita* Muhl. ex Willd.	Native Sedge
Yellow Coneflower	*Ratibida pinnata* (Vent.) Barnhart	Native Forb

Appendix C: How to Tell if You Have Native Prairie

Not all grasslands are native prairie. Conservation plantings, buffers, old fields, pasture plantings, and restorations are examples of grasslands that are not native prairie, though they all have conservation value. Native prairie is now rare in Minnesota and this should be considered in developing and implementing management. The best management practices on native prairie may be different from the best management practices on planted grassland. The first step in developing a management plan for a prairie or other grassland is knowing what type of grassland it is. If it is native prairie, it is also important to know the native plant communities that make it up. Details on prairie native plant communities can be found in Chapter 1.

There are sources of information to help determine whether a site is native prairie. Historical aerial photos can be helpful in determining whether a site has been tilled or disturbed in the past. There are spatial data sets available that can tell whether the Minnesota DNR has previously determined it to be prairie, or whether it is potentially undisturbed land. A natural resources professional can help with accessing this information and determining whether a site is native prairie.

Some native plants can be good indicators that a site is native prairie. Other native plants, such as big bluestem or Canada wildrye, are usually present in prairie, but also often occur in plantings. Following are some select prairie plants to look for in determining whether a site is remnant native prairie. Please note this is not a definitive guide to identifying native prairie, these are suggested plants to look for in determining whether the property is likely a remnant.

Prairie Plants Rarely Found Outside Remnant Native Prairie

Photo credit: Rhett Johnson

Pasque flower/prairie crocus: *Anemone patens*. Light purplish flowers appear early in the spring (March-May), the deeply divided leaves appearing later. Seeds have long plumes making clusters look like puffy balls. Found in dry prairies.

Photo credit: Dave Jungst

Prairie bird's foot violet: *Viola pedatifida*. Flowering April-June with purple flowers. The leaves look like spread hands and are distinctive. Food source for regal fritillary caterpillars.

Photo credit: Judy Schulte

Any penstemon: *Penstemon* spp. Flowering May-July. Tubular flowers in spikes can be purple, white, or lilac in different species. Leaves are arranged oppositely. Mostly in dry prairies.

Photo credit: Rhett Johnson

White camas: *Zigadenus elegans*. Flowering June-August. Plants 6 inches to 3 feet tall with greenish white, lily-like flowers in an elongated cluster. Found in many prairie types.

Culver's root: *Veronicastrum virginianum*. Flowering June-August. 3-4 feet tall with small white flowers in a dense spikes at the top of the plant. The leaves are attached in whorls of three to eight leaves.

Photo credit: Rhett Johnson

Leadplant: *Amorpha canescens*. Flowering June-August. A native shrub growing to about 3 feet tall, common on dry to mesic native prairies. Leaves are compound with many small leaflets and have a grayish color from their covering of short hairs. The tiny purple flowers are arranged in spike-like clusters that can be very showy.

Photo credit: Rhett Johnson

Flodman's thistle: *Cirsium flodmanii*. Flowering June-August. A 1-3 foot tall native thistle with just one to a few 1½ inch wide pinkish-purple flowers. Stems are white-wooly and not spiny. Leaves are somewhat spiny on the edges and usually have cobweb-like hairs on their surface, especially the underside.

Photo credit: Dave Jungst

Photo credit: Dave Jungst

Prairie onion: *Allium stellatum*. Flowering July-August. Plants grow up to 18 inches tall with spherical clusters of pink lily-like flowers and grass-like leaves that have an onion scent when crushed. Found in many prairie types.

Photo credit: Dave Jungst

Silky aster: *Symphyotrichum sericeum*. Flowering August-October. Plants grow up to 2 feet tall with thin, wiry stems and silky leaves. Flower heads have light lavender rays around a yellow center. Commonly found on dry prairie.

Photo credit: Judy Schulte

Downy gentian: *Gentiana puberulenta.* Flowering August-October. The vivid blue-purple flowers with five spreading lobes are striking in the late summer. It grows under a foot tall and has leaves that are opposite and smooth. A plant of dry prairies.

Bottle gentian: *Gentiana andrewsii.* Flowering August-September. Growing up to 2 feet tall with smooth, opposite leaves. Flowers are blue to violet to white and have a bottle shape. It takes a strong bumblebee to get inside the flowers.

Photo credit: Dave Jungst

Photo credit: Megan Benage

Needlegrasses: *Hesperostipa* spp., *Nassella viridula*. Four species grow in Minnesota's dry prairies. They all grow in clumps and have rather long, slender leaves that have strong ridges on their upper surfaces. All have seeds with long, stiff tails, from about an inch long in green needlegrass to 8 inches long in porcupine grass. Native cool-season grasses generally flowering in late spring–summer.

Photo credit: Dave Jungst

Minnesota needlegrasses—from top to bottom: porcupine grass, needle-and-thread, small porcupine grass, green needlegrass.

Prairie Indicators Sometimes Planted in Restorations and Wildflower Plantings

Alexanders: *Zizia aptera* & *Z. aurea.* Flowering May-July. Two species in Minnesota that both have flat-topped clusters of little yellow flowers and grow to 1-3 feet tall. Leaves are leathery. Don't confuse with wild parsnip (see page 92), which has similar yellow flower clusters.

Zizia aptera
Photo credit: Rhett Johnson

Zizia aurea
Photo credit: Rhett Johnson

Prairie clovers: *Dalea purpurea* & *D. candida.* Flowering June-August. White and purple prairie clovers are common in dry to mesic prairie and are a common addition to restorations. Plants have tight spike-like clusters of flowers and leaves with 3-9 leaflets. Often included in prairie restoration seed mixes.

Photo credit: Dave Jungst

Photo credit: Rhett Johnson

Narrow-leaved purple coneflower: *Echinacea angustifolia.* Flowering June-October. Stems 1-2 feet tall with leaves mostly toward the base. Flowers have lavender rays and a central cone that is "spiky." Leaves and stems are very rough-hairy. A common wildflower of dry prairies. Note that eastern purple coneflower, not native to Minnesota, is often planted in wildflower mixes. This non-native coneflower is taller and has broader leaves that go most of the way up the stem.

Photo credit: Dave Jungst

Photo credit: Rhett Johnson

Any Liatris/blazing star: *Liatris* spp. Flowering July-September. Five species in Minnesota grow in different habitats ranging from wet prairie to dry prairie. Common features are elongated clusters of vibrant magenta flowers and leaves that spread in all directions. Often included in high-diversity prairie restoration seed mixes.

Prairie blazing star (Liatris pycnostachya)
Photo credit: Dave Jungst

Dotted blazing star (Liatris punctata)
Photo credit: Dave Jungst

Photo credit: Dave Jungst

Side-oats grama: *Bouteloua curtipendula*. Flowering July-August. A grass of dry to mesic prairies, also often in restoration plantings where it tends to do well. The long spike of dangling little flower clusters is distinctive. The edges of the leaves have hairs with tiny white pimples at their base, which are also fairly distinctive. Often does well when included in restoration seed mixes.

Photo credit: Dave Jungst

Prairie dropseed: *Sporobolus heterolepis*. Flowering August-October. A densely clustered bunchgrass with long slender leaves that give clumps a mound like appearance. Flowering stems are 1-3 feet tall with open, spreading flower clusters. Usually flowers profusely after a burn. Often included in high-diversity seed mixes, but can be hard to establish and takes many years to develop large clumps.

Prairie Plants Often in Conservation Plantings (and Also Occur in Native Prairie)

Bee balm: *Monarda fistulosa*. Flowering June-August. Stems 2-4 feet tall with oppositely attached leaves. Leaves have a strong, minty smell. Purple to light pink or white flowers are in dense clusters at the top of the plant, later losing their petals to leave behind a spherical seed head. Common in native prairies and is often abundant in restorations and wildflower plantings.

Photo credit: Rhett Johnson

Gray-headed coneflower: *Ratibida pinnata*. Flowering June-August. Up to 7 feet tall, leaves are rough textured and toothed to lobed. Flowers have drooping yellow petals and a brownish, grayish, or greenish clone-like center. A common prairie plant in southwestern Minnesota, but also a common inclusion in conservation plantings and restorations.

Photo credit: Katelin Goebel

Black eyed Susan: *Rudbeckia hirta*. Flowering June-October. Stems 1-3 feet tall. Flowers are sunflower-like with a conical dark brown or purplish center. Leaf surfaces are covered in short, stiff hairs. Common in prairies and other open locations. Often very abundant in restorations.

Photo credit: Rhett Johnson

Canada wildrye: *Elymus canadensis.* Flowering July-August. Stems to 5 feet tall, growing in clumps. The drooping spike is distinctive. A cool-season prairie plant. Often present, but less abundant, on native prairies. Often very abundant on restorations and roadside plantings.

Photo credit: Rhett Johnson

Photo credit: Rhett Johnson

Photo credit: Shawn May, USFWS

Big bluestem: *Andropogon gerardii.* Flowering July-August. A tall grass growing up to 7 feet. The "turkey foot" flower cluster is very distinctive. Very young shoots are usually hairy and have a bluish hue. A very common prairie plant but also often in restoration and conservation plantings, along roadsides, and in other habitats.

Photo credit: Rhett Johnson

Indian grass: *Sorghastrum nutans*. Flowering August-September. A tall grass growing to 7 feet. The big, bronzish flower clusters are distinctive and attractive. At the base of the leaves the sheath has horn-like projections and the stem nodes are fuzzy. Common in dry to mesic prairie, sometimes abundant in plantings.

Photo credit on right: Katelin Goebel

Appendix D: Prairie Workbook

Copy and print the Workbook to fill out by hand or fill out online at **mndnr.gov/prairies** then print, whichever you prefer.

About my property

Begin by answering a few background questions about your property.

How many acres do you own? _____

Is your property in multiple parcels? If so, how many? _____

What county or counties is your land in? _____

What Ecological Classification System Subsection is your land in?
☐ Inner Coteau ☐ Coteau Moraines ☐ Minnesota River Prairie
☐ Red River Prairie ☐ Aspen Parklands ☐ Other:

See **mndnr.gov/ecs** for more information on Ecological Subsections.

What major watershed is your land in? _____

What minor watershed is your land in? _____

See **arcgis.dnr.state.mn.us/ewr/whaf2/** and **mndnr.gov/watersheds/map.html** for more information on Minnesota's watersheds.

Evaluating my property

Take a walk across your property, what do you notice? Consider these questions and take notes. Depending on your level of knowledge, it may be helpful and interesting to invite a local natural resources professional or fellow prairie enthusiast along on your walk.

- What is the terrain like? Is it flat or hilly? Does the overall appearance of the vegetation differ on slopes vs. flat areas?
- What kinds of plants do you see? Information on plants can be found at **minnesotawildflowers.info**
- Is your prairie mostly grasses, wildflowers (forbs), or a good mix of both?
- Try to identify the types of native plant communities on your property. Information on native plants communities can be found at **mndnr.gov/npc**
- Look at which plants are the most abundant. Is your prairie mostly native, or is it dominated by non-native plants?
- Are there a lot of trees and shrubs on your prairie? If so, which species are present?
- Are there any invasive species? Which species are they? Information to identify invasive species can be found at **mndnr.gov/invasives/terrestrialplants**

- Are there wetlands or water bodies on your property? What are their conditions? Which plants dominate the wet areas?
- Do you see any wildlife or signs of animals?
- What wildlife have you or others observed here in other seasons or in past years?
- What are the current land uses? Are you aware of past land uses? Are there signs that past management has affected the prairie communities?

It can be useful to repeat this exercise throughout the growing season; prairies change a lot from week to week.

Identify what interests you about your prairie

First note the topics that interest you, then set goals. Here is a list of topics that may interest you as a prairie landowner. Check any that apply and add other topics that are important to you.

- ☐ Hunting, game wildlife
- ☐ Nongame wildlife
- ☐ Recreation
- ☐ Rare species
- ☐ Wildflowers, pollinators
- ☐ Tree planting
- ☐ Grazing
- ☐ Haying
- ☐ Seed harvest
- ☐ Restoration
- ☐ Prescribed burning
- ☐ Stream health, water quality
- ☐ Wetlands
- ☐ Invasive species management
- ☐ Tree and brush clearing
- ☐ Cost-share
- ☐ Tax incentives
- ☐ Protection programs
- ☐ Investment
- ☐ Other:

Pick your 3 (or more) top topics

_____

_____

_____

Write your goals

Look back on your evaluation of the property. Are there aspects (such as invasive species, woody plant encroachment, over-grazing, or a lack of diversity) that you think would benefit from attention? Write a goal statement for your three (or more) top topics.

Example: If "tree removal" is one of your topics, then your management goal may be to "Clear the encroaching trees from the slopes."

Goal 1: _____

_____

Goal 2: _____

_____

Goal 3: _____

_____

Describe a work project

Choose a goal you want to tackle first. Your goal may involve setting up a work project. Describe the goal(s) of your project and the future condition you desire. If you don't know what work should be done to accomplish the goals, contact a prairie professional.

Example: If your management goal is to "Clear the encroaching trees from the slopes" then your work project goal may be "Cut and remove the buckthorn and red cedar and keep them in check once removed." If your management goal is to "Provide more habitat for native grassland-dependent wildlife," your work project goal may be "Create more structural diversity with corridors linking patches of prairie, manage for varied heights of vegetation, and a mix of grasses and forbs."

Describe a work project that will help to achieve your prairie goal:

_____

_____

_____

Identify action steps

If possible, break down your project into smaller action steps. Take as many steps as you need.

Example: Step 1—Map out the areas where trees are encroaching. Step 2—Consult with a prairie expert on the best practices to remove buckthorn and red cedar. Step 3—Cut red cedar, *cut and stump treat buckthorn, pile slash. Step 4—Burn slash piles. S*tep 5—Burn the *prairie every 3-5 years thereafter.*

Step 1: _____

_____

Step 2: _____

_____

Step 3: _____

_____

Step 4: _____

_____

Step 5: _____

_____

Pull it together

For each project, use this template to list individual action steps, set a time to accomplish each step, estimate budget needs, and record notes about how things go along the way. Also consider whether the project is something you can tackle on your own or if it's something you will need assistance with.

Date/season considerations

For each action step consider the optimal season for the activity, the order of action steps, and the amount of time you will need to accomplish each step.

Example: Cut and pile red cedar any time. Cut and stump treat buckthorn in the fall or winter when the sap is not running. Burn slash piles the next winter when there is 6 inches of snow on the ground.

Tools needed might include aerial photos, chainsaws, sprayers and herbicide, a management plan, tools for prescribed fire, etc. Consider where you might get the tools you need. If bringing equipment onto the site, be sure it is clean and free of weed seeds.

Decide the time frame for routine monitoring and how you will measure progress. Take before and after photos to document your project and see the results of your efforts. Use these to adjust your plans going forward.

Remember to take time to enjoy your prairie!

Action step accomplishment table

Project _____ Year _____

				BUDGET ESTIMATES		
Steps	**Date/Season**	**Tools needed**	**Partners/Contacts**	**My contribution**	**Financial assistance**	**Notes**
1						
2						
3						
4						
5						

Acknowledgments

Special thanks to the landowners who contributed their time and wisdom: Pat and Larry Wahl

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Special thanks: This publication was funded through the Minnesota Department of Natural Resources and the Environment and Natural Resources Trust Fund. The Trust Fund is a permanent fund constitutionally established by the citizens of Minnesota to assist in the protection, conservation, preservation, and enhancement of the state's air, water, land, fish, wildlife, and other natural resources. Currently 40% of net Minnesota State Lottery proceeds are dedicated to growing the Trust Fund and ensuring future benefits for Minnesota's environment and natural resources.

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EWR_0019_21

PRAIRIES OF MINNESOTA

LANDOWNER HANDBOOK

If you own or manage prairie in Minnesota, your decisions can impact the future of this rich and unique prairie landscape.

This handbook is a foundation for taking care of your prairie and connecting your property to the larger landscape. It helps you:

- Identify what you have in your prairie.
- Plan for what you want your prairie to be in the future.
- Understand what you can do to keep your prairie healthy.
- Consider strategies for accomplishing goals in your prairie.

From learning about plant communities to connecting with local prairie professionals and sources of funding, this book shows you how to develop a management plan for your prairie so that your dreams can become reality. Your choices will leave a mark on your future prairie.

What will your prairie legacy be?

DEPARTMENT OF NATURAL RESOURCES

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