MINNESOTA'S WILDLIFE ACTION PLAN 2025-2035

CONSERVING HABITATS AND BIODIVERSITY

PRAIRIE AND OTHER GRASSLANDS

DEPARTMENT OF NATURAL RESOURCES

NONGAME WILDLIFE PROGRAM

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Prairie and Other Grasslands

Habitat Description

Prairie ecosystems are dominated by native graminoids (grasses and grasslike plants) with a species-rich component of forbs (flowering plants other than grasses or sedges). Prairie native plant communities are often found on mollisols, soils with a dark colored surface horizon high in organic matter. These fertile, base-rich mineral soils span a soil moisture spectrum from dry sand-gravel prairies on coarse droughty soils, to wet prairies on poorly drained sites with a variety of soil textures. Prairies are primarily distributed in the western and southern parts of the state in the Prairie Parkland Province, and in the southernmost portions of the Anoka Sandplain Subsection in the Eastern Broadleaf Forest Province.

Ecological processes including fire and grazing have shaped prairie and other grasslands of Minnesota. Frequent fire helps to reduce invasion by trees and shrubs. In tallgrass prairie, average fire intervals were thought to be 10 years or less (Zouhar, 2021). Fire is critical for maintaining the dominance of herbaceous species by preventing trees and shrubs from becoming large enough to survive fire. The burning process also removes litter and stimulates grass production. Grazing by bison (*Bos bison*) and elk (*Cervus canadensis*) was a vital ecological process on pre-European settlement prairies. Grasses, which grow from lateral meristems at the base of the plant, are well adapted to the process of grazing, because it generally removes only the upper portion of the plant. Grazing by large ungulates also facilitated forb diversity and abundance on native prairies by suppressing grasses from dominating the plant community.

Grassland types cover a wide spectrum, ranging from prairie remnants to many types of restored and working grasslands. The following are reference descriptions of Minnesota's prairies and grasslands (for more information visit the DNR's Minnesota Prairie website).

Photo: Prairie, Hole in the Mountain Wildlife Management Area, Megan Benage

Native (Remnant) Prairie

Native prairie, or remnant prairie, refers to grasslands dominated by native prairie vegetation, typically occurring where the sod has never been broken. These grass-dominated communities host a large diversity of forbs (wildflowers) and wildlife. Prairies are often further classified by soil moisture, species composition, and geography.

Dry Prairies

Dry prairies can vary widely in species composition based on soils and topography but are usually dominated by grasses such as big bluestem (*Andropogon gerardii*), prairie dropseed (*Sporobolus heterolepis*), and little bluestem (*Schizachyrium scoparium*). The most common forbs are in the sunflower or pea families (Asteraceae and Fabaceae). Woody species are limited to dwarf shrubs such as leadplant (*Amorpha canescens*) and prairie rose (*Rosa arkansana*). This plant community is likely to be found in areas featuring conditions that preclude plants needing mesic or wet conditions. These range from wind-blown sand dunes to sandy riverine outwash, to excessively drained gravelly ridges or slopes. Most sites containing dry prairie experience frequent and severe growing-season moisture deficits due to soil type and/or topography.

Mesic Prairies

Mesic prairies are frequently dominated by tallgrass species such as big bluestem and yellow prairie grass (*Sorghastrum nutans*), with prairie dropseed often a codominant or subdominant component. Forb cover is variable by soil type, again with plants in the sunflower or pea families frequently present. Prairie rose and leadplant are the most common woody species, occasionally with patches of wolfberry (*Symphoricarpos occidentalis*). Various other native shrubs are typically not abundant. Mesic prairies cover a wide gradient of soil types and topography, with much species overlap between dry prairies and wet prairies. Changes between mesic prairie and other prairie types are often subtle, with hydrological and topographical features differentiating the cover types.

Wet Prairies

Wet prairies typically feature big bluestem and prairie cordgrass (*Spartina pectinata*) as major species and a variety of sedges (*Carex spp.*). Wet prairies include numerous forbs, dwarf shrubs (such as prairie rose), and true shrubs like red-osier dogwood (*Cornus sericea*) and willows (*Salix spp.*). Wet prairies are typically found in shallow depressional areas within the larger prairie landscape, most often on poorly drained loam soils. Wet prairies can also occasionally be found on loamy sands in areas with a shallow water table.

Bluff Prairies

Bluff prairies, or sometimes referred to as 'goat prairies', are characteristic on dry, steep south and west facing slopes on the bluffs in the Driftless region of southeastern Minnesota. Species composition is similar to dry prairies, consisting of species tolerant of lower quality rocky soils. These include big bluestem, little bluestem, sideoats grama (*Bouteloua curtipendula*), hairy grama (*Boutleloua hirsuta*), leadplant, hoary puccoon (*Lithospermum canescens*), pasqueflower (*Pulsatilla patens*), and prairie smoke (*Geum triflorum*). Bluff (goat) prairies require regular disturbance, and reduced frequency of fire and grazing on these prairies has led to the encroachment of red cedar (*Juniperus virginiana*) and other native and non-native woody species including prickly ash (*Zanthoxylum americanum*) and multiflora rose (*Rosa multiflora*).

Photo: Bluff prairie, Mound Prairie Scientific and Natural Area

Brush Prairies

In brush-prairies, herbaceous prairie plants are still a major component of the vegetation, but the woody components are more prevalent than in other prairie types. Brush prairies are characterized by an abundance of taller shrubs, oak "grubs" and sprouts, and quaking aspen (*Populus tremuloides*) suckers. In the absence of fire, both savannas and brush-prairies rapidly succeed to woodland; brush-prairie moves to woodland faster than does savanna. Today, most brush-prairies occur in the Tallgrass Aspen Parklands Province in northwestern Minnesota.

Reconstructed and Restored Prairies

These grasslands result from efforts to re-build prairies by planting native prairie seeds or plants (plugs) back into areas previously converted to another land use, typically agricultural fields. Prairie reconstructions seek to support biologically diverse native plants and wildlife (including Species in Greatest Conservation Need (SGCN). This restores ecological function and increases resistance to invasion by non-native plants, while being cost-effective to manage. In recent years, much attention has been given to data collection and monitoring of reconstructed and restored prairies to compare restoration efforts against remnant prairies (see the Prairie Reconstruction Initiative).

Reconstructed prairies are often more species-rich than conservation plantings, though less so than remnant prairies. It is challenging to produce seed for many native species found in remnant prairies, often limiting the number of species available to practitioners for prairie reconstructions. Though modern conservation plantings generally feature native grassland species, they are often tailored to programmatic goals. In contrast, prairie reconstructions are usually focused on reconstructing overall ecosystem function. Consequently, prairie reconstructions will often include more grass and forb diversity than conservation plantings and are typically planted at a 1:1 grass-forb ratio.

Photo: Reconstructed prairie, Lisa Gelvin-Innvaer

Conservation Plantings

Conservation plantings are generally created through conservation programs, such as the Conservation Reserve Program (CRP) administered by Farm Service Agency through the United States Department of Agriculture, funded by the federal Farm Bill. Other similar programs include the Reinvest in Minnesota (RIM) program administered by the Minnesota Board of Water and Soil Resources, and numerous other programs administered by a variety of state/federal agencies and non-governmental organizations. Grasslands planted through conservation programs vary widely in their composition. Each program typically has unique specifications for seed mix requirements that lead to variations in habitat quality. For instance, a seed mix meant to control soil erosion might consist of 90% grasses, while a mix meant to attract pollinators might contain 75% wildflowers (forbs). Many conservation plantings completed in the 1980s and 1990s contained non-native species such as smooth brome (*Bromus inermis*), alfalfa (*Medicago sativa*), and bird's-foot trefoil (*Lotus corniculatus*). Unfortunately, these competitive species are known increasers (grazing-tolerant or unpalatable plants) and can invade native prairie. Despite being a source of non-native species, these older plantings do still provide marginal habitat for many grassland wildlife species and can contribute to habitat complexes alongside higher quality remnant and reconstructed prairies. Nearly all new conservation plantings focus on native species in seed mixes.

Other Grasslands

Other grasslands include old agricultural fields, hayfields, pastures, and roadsides, along with open space and park grasslands in developed areas. They provide various benefits, but do not have the full biodiversity and function of native prairies. Termed "surrogate grasslands" in prior Minnesota SWAPs, they could also be termed 'developed grasslands,' described in the 2005 Plan as "grasslands that have developed as a result of human activities since settlement." These sites occur in areas that once supported prairie or forest communities and are found statewide but less commonly in the northeast. Developed grasslands are typically dominated by non-native, cool-season grasses, such as smooth brome (*Bromus inermis*), quackgrass (*Agropyron repens*), redtop (*Agrostis gigantea*), timothy (*Phleum pratense*), and Kentucky bluegrass (*Poa pratensis*). Reed canary grass (*Phalaris arundinacea*), is an increasing species that can dominate and exclude other species on wetter sites. The forb component of surrogate grasslands is also dominated by invasive species, such as yellow sweet clover (*Melilotus officinalis*), white sweet clover (*M. alba*), alfalfa (*Medicago sativa*), dandelions (*Taraxacum spp.*), bird's-foot trefoil (*Lotus corniculatus*), and canada thistle (*Cirsium arvense*). Native forbs may also occur in these grasslands, especially goldenrods, milkweeds, and asters. Left unmanaged, these grasslands are often encroached on by native and invasive trees and shrubs. Encroachment by non-native species such as Siberian elm (*Ulmus pumila*) and Russian olive (*Elaeagnus angustifolia*), and by natives such as green ash (*Fraxinus pennsylvanica*), cottonwood (*Populus deltoides*), and sumacs (*Rhus spp.*), can convert grasslands to woodlands or shrublands, reducing or eliminating their habitat value for many grassland species.

Savanna

This type of habitat hosts few trees in a grassland matrix; please see the Savanna Sub-chapter.

Habitat Map

To depict Prairie and Other Grassland habitat (see Figure 3.5), we compiled spatial data from several sources: the DNR's Native Plant Communities and the Midwest Terrestrial Habitat System created by the USFWS Midwest Landscape Initiative (for more information, see Habitat Map Methods in Chapter 3. Habitats). We note included sub-types below; underlined items have links to online descriptions.

Associated Native Plant Community Classes by Ecological Systems

Upland Prairie (UP)

UPn12 Northern Dry Prairie (PDF)

UPn23 Northern Mesic Prairie (PDF)

UPs13 Southern Dry Prairie (PDF)

UPs23 Southern Mesic Prairie (PDF)

Wetland Prairie (WP)

WPn53 Northern Wet Prairie (PDF)

WPs54 Southern Wet Prairie (PDF)

Midwest Terrestrial Habitat System

From the Midwest Terrestrial Habitat System we included these groups: Northern Tallgrass Prairie, Eastern North American Ruderal Meadow and Shrubland, and Northern Great Plains Ruderal Exotic Grassland and Shrubland.

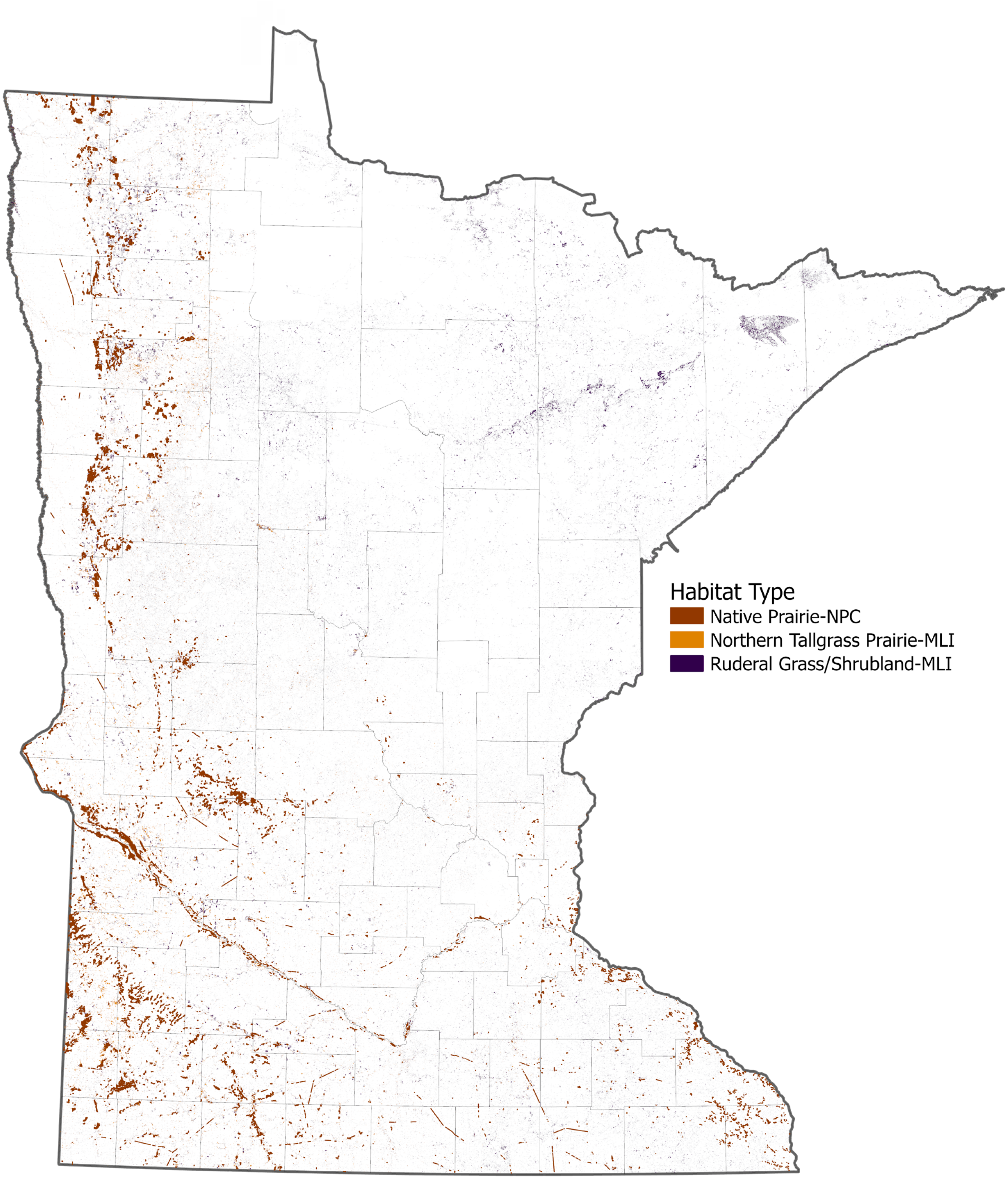

Figure 3.5. A map depicting Prairie and Other Grassland habitat in Minnesota, including DNR Native Plant Community Classes in the Ecological Systems of Upland Prairie and Wetland Prairie as well as three types from the Midwest Terrestrial Habitat System.

Conservation Overview

Temperate prairie is a globally rare habitat. Tallgrass Prairies are Critically Endangered (the highest level of imperilment short of collapse), according to the International Union for the Conservation of Nature (IUCN) Red List of Ecosystems. The list evaluates the extent, degradation, and biotic processes of ecosystems globally (Comer et al., 2022).

The prevalence of native, remnant prairies in Minnesota has dramatically declined from once covering over a third of the state (about 18 million acres; Marschner, 1974) to about 250,000 acres today, or about 1–2 percent of the historical area. This is largely due to land conversion (DNR, 2018). Conversion of remnant prairies continues, with over 200 acres lost per year on average, and 4,248 acres documented as converted since 1987 (MBS, 2017). Thus, remaining remnant prairie is of the highest priority for protection and restoration.

To guide prairie conservation efforts, Minnesota DNR developed a 25-year Minnesota Prairie Conservation Plan that lays out core areas, connective corridors, and establishes local landscape teams. Many of the largest remaining tracts of remnant prairie are managed for conservation purposes. These remaining tracts provide a space for public engagement with the prairie community including its Species in Greatest Conservation Need. They are also essential for growing our understanding of the prairie community through research and adaptive management. To complement these large areas, ongoing protection for smaller prairies across the landscape is offered to private landowners through the DNR's Minnesota Native Prairie Bank.

The scarcity of remnant prairie underscores the importance of restored prairie and other grasslands in providing vital ecosystem functions including habitat for wildlife and plant SGCN. Restoring, enhancing, and managing other grasslands complements the function of the prairie at an ecosystem level by providing connectivity for animals to move, buffering sensitive communities like wetlands and streams, and enhancing watershed, soil health, and water quality. Focusing grassland habitat restoration around building larger complexes of both remnant prairie and other grasslands will be crucial for restoring and maintaining ecosystem health into the future.

As an example, according to the DNR's long-term Sustaining Prairie in a Changing Environment (SPICE) study (see the Case Study in Chapter 5: Monitoring), declining trends of grassland birds appear to be similar in protected, relatively high-quality remnant prairies as they are regionally. Indeed, most SPICE grassland bird species' population trends mirror the negative statewide trends from prairie region Minnesota transects of the North American Breeding Bird Survey (BBS) data, roadside surveys that cross different habitats of various quality and protection status, (see Table 2.5 in the Birds Sub-chapter). Of the 11 prairie obligate bird species (9 of which are SGCN) for which data were sufficient to determine trends, seven were found to have declining trends that were generally similar in magnitude in both SPICE and BBS. This suggests that mechanisms other than local-scale habitat protection are needed to address the declining trends in grassland bird populations. Protection or management focused on reserves, while important, is not enough. For grassland birds at least, conservation efforts should be expanded into the surrounding landscape. Similar effects may be found for other wildlife, such as prairie-obligate insects, some of which have declined dramatically in the past 20 years.

Prairies and other grasslands have also been affected by a change in disturbance regimes including a loss of fire and grazing. Ecosystem productivity and species diversity decline when litter and thatch are not periodically removed by fire, grazing, or haying (Anderson, 1990, Knapp et al., 2009). Minnesota remnant prairies have been shown to significantly decline in native species richness in the absence of fire (Larson et al., 2020). Grasses have a positive feedback relationship with fire, which creates strong barriers to tree and shrub establishment (Ratajzcak et al., 2014). Before European settlement fires were frequent, estimated to occur every 1-5 years (Hartman and Steel, 2015). Frequent fire with return intervals of less than 10 years is critical for the occurrence of upland prairies in Minnesota (Upland Prairie System Summary). It is widely recommended that prescribed fire be implemented every 3-5 years to increase native plant diversity and decrease encroachment by woody plant species.

Historically, native ungulates like bison (*Bison bison*), elk (*Cervus canadensis*), and white-tailed deer (*Odocoileus virginianus*) were widely abundant and were a significant influence on prairie composition and diversity (Knapp et al., 1999). Following European settlement, all three species were effectively extirpated from the prairie ecosystem, to be replaced by cattle, sheep, and goats (Hartman and Steele, 2015). Concurrently, fire suppression began in earnest, and many grasslands were intensively grazed and even overgrazed. The absence of fire coupled with intensive, sustained grazing represented a large shock to the ecological dynamics of the prairie ecosystem.

Subsequently, changes to policy and scale in the agricultural economy resulted in many small, family farms being consolidated into larger commodity operations from the 1960s–2000s. This led to widespread reductions in livestock grazing in many areas, many of which have not been grazed since (Hartman and Steele, 2015). The sudden removal of all grazing pressure following decades of intensive grazing represents another shock to the ecology of the prairie ecosystems.

In locations where fire and grazing have both been removed, remaining prairies are at risk of conversion to woody plant communities (Hartman and Steele, 2015). As such, many remnant prairies have been degraded to some degree resulting from the removal of any disturbance regime.

In the bluff prairies of the driftless region of Southeastern Minnesota, native grazers including bison, elk, and white-tailed deer (*Odocoileus virginianus*) were present before European settlement and likely contributed to disturbance to an unknown degree (Hartman and Steele, 2015). As elk, bison, and most white-tailed deer were extirpated, intermittent grazing was taken over by domesticated livestock including sheep, cattle, and goats (Hartman and Steele, 2015).

Photo: prescribed burn, Hole in the Mountain Wildlife Management Area, Lisa Gelvin-Innvaer

Grazing by livestock increased from the early to mid-1900's and likely became very intensive during the droughts of the 1930's as farmers struggled to find enough forage (Hartman and Steele, 2015). These habitats likely became overgrazed and became subject to varying degrees of erosion, but varying and diverse grazing systems helped to maintain the overall structure of these habitats (Hartman and Steele, 2015). From the 1960's to present, farm practices changed including the reduction of diversity of livestock and grazing of bluff prairies and associated savannas altogether.

Today, Minnesota's prairie region is dominated by cropland, though hayfields, developed areas, riparian areas, streams, rivers, wetlands, and lakes are also present. Working lands, most of which are privately owned, such as ranches, farms, and lands used for energy production, are essential for both the state's economy and natural resource stewardship. These lands produce food, fiber, fuel, and other goods, while also offering the opportunity for animal and plant conservation when managed sustainably. Multi-faceted approaches including diverse financial incentives, technical guidance, and effective landowner engagement can lead to the application of more conservation practices to benefit SGCN and their key habitats. Private landowners can benefit economically and ecologically by engaging in sustainable practices that are compatible with their management objectives, and such practices also provide additional "stackable benefits" such as carbon sequestration, soil health, and water quality.

Climate Profile

This section on the anticipated effects of climate change on Prairies and Other Grasslands is built from two main information sources, both sponsored by the Midwest Climate Adaptation Science Center. The first is derived from a set of reports completed for various habitat types in support of State Wildlife Action Plans, similar to what is presented for other habitat types in this Plan. The second is a supplemental exploration of climate exposure and the literature specifically in relation to the plants Minnesota grasslands, as conducted by the University of Wisconsin-Madison for this report.

The anticipated effects of climate change on Prairies and Other Grasslands were profiled in the report "Effects of Climate Change on Midwestern Ecosystems: Central and Eastern North American Grassland and Shrubland" published by the Midwest Climate Adaptation Science Center (Ratcliffe et al., 2025a). The most impactful changes in climate for this system include more frequent droughts and shifts in seasonality — earlier springs and longer growing seasons.

Drought is an important factor that shapes grasslands, including species composition, ecosystem function, and ecosystem boundaries (i.e., the extent of grassland vs shrubland or woodland). Increased evapotranspiration demands driven by higher temperatures, measured as increased vapor pressure deficit, will likely cause drier soil conditions and intensify drought conditions (Ratcliffe et al., 2025a; Figure 3.6).

Anticipated ongoing seasonal shifts including earlier spring conditions, more frost-free days, and longer growing seasons (see Table 3.4). These shifts can affect plant and animal phenology, community productivity, and ecological function (Ratcliffe et al., 2025a). Earlier spring warming can shift flowering dates for blooming plants with recent evidence of some species now flowering 8–16 days earlier (Geissler and others, 2023; Memmott and others, 2007; Prevéy and others, 2020 in Ratcliffe et al. 2025a). Expanded growing seasons can enhance productivity, but spring fluctuations in temperature (e.g., early thaw and late frosts) are challenging for species lacking frost tolerance.

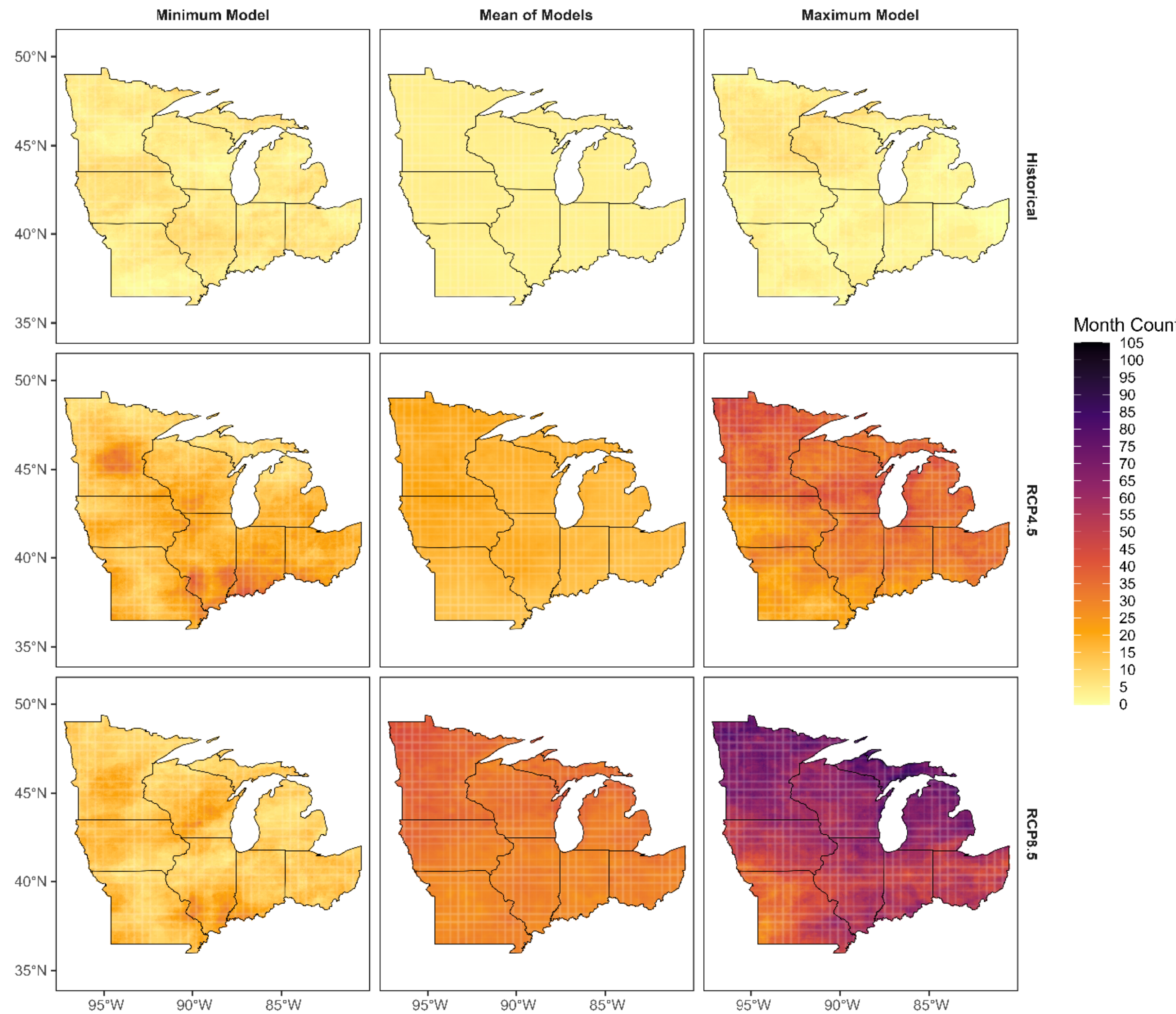

Figure 3.6. Reproduced with permission from Ratcliffe et al. 2025a. Projected changes in 30-year extreme drought incidence in the Midwest region. Projections use gridded Standardized Precipitation-Evapotranspiration Index (SPEI) values obtained via Thota and others (2025) based on 20 CMIP5 climate models downscaled using MACAv2-METDATA for moderate- and high-emissions (RCP 4.5 and 8.5) scenarios (Abatzoglou, 2013; Abatzoglou and Brown, 2012). Thirty-year extreme drought incidence is defined as the number of months within a 30-year period with an SPEI value of ≤ -2, corresponding to the driest 2.5% of months relative to a reference period (1981–2020) under RCP 4.5 (Li and others, 2015; McKee and others, 1993). Values show mean historical (1971–2000, top row) and projected (2070–2099) 30-year extreme drought incidence (months) for each emissions scenario (RCP 4.5, middle row; RCP 8.5, bottom row). To capture variation across climate models, models with the lowest (minimum model, left column) and highest (maximum model, right column) projected 30-year extreme drought incidence under RCP 8.5 are presented in addition to the mean of all models (middle column).

Table 3.4. Projected changes in growing season length in the Northern Plains ecoregion. Projections use data obtained via the Climate Toolbox Climate Mapper (Hegewisch and Abatzoglou, 2024) based on 20 CMIP5 climate models downscaled using MACAv2-METDATA for moderate- and high-emissions (RCP 4.5 and 8.5) scenarios (Abatzoglou, 2013; Abatzoglou and Brown, 2012). Values show mean historical (1971–2000) and projected growing season length (consecutive days with minimum temperatures above freezing) by mid- (2040–2069) and end of the century (2070–2099), as well as the percent change relative to the historical value (in parentheses), for each emissions scenario. To capture variation across climate models, models with the lowest (minimum model) and highest (maximum model) projected growing season length under RCP 8.5 are presented in addition to the mean of all models. Modified from Ratcliffe et al. 2025a.

Model Type	Historical (1971-2000)	RCP 4.5 Midcentury (2040-2069)	RCP 8.5 Midcentury (2040-2069)	RCP 4.5 Late Century (2070-2099)	RCP 8.5 Late Century (2070-2099)
Minimum model	147.6	154.8 (5%)	160.6 (9%)	146.8 (-1%)	160.1 (8%)
Mean of models	149.2	168.9 (13%)	178.3 (20%)	165.7 (11%)	187.0 (25%)
Maximum model	150.6	196.5 (30%)	207.9 (38%)	192.0 (27%)	217.8 (45%)

Key Climate Change Effects (from Ratcliffe et al., 2025a; please reference to find source citations):

- **Habitat structure:** Drought will reduce soil moisture, plant productivity and cover, and potentially intensify erosion and nutrient loss impairing soil health. High temperatures combined with drought can cause physiological stress in plants ultimately suppressing growth and reproduction and increasing mortality, which may be more detrimental to plants with less robust and shallow root systems.
- **Community composition:** Changing mean annual temperature and precipitation patterns may favor expansion of prairie in the aspen parkland region of northwestern Minnesota by favoring drought-tolerant species such as little bluestem (*Schizachyrium scoparium*) or gramas (*Bouteloua* spp.) while reducing the dominance of aspen. However, droughts may increase the encroachment of other woody species that are more deep-rooted shrubs, particularly in the absence of fire. Earlier spring conditions may favor early-growing and phenotypically plastic species and challenge less flexible plant species, potentially creating phenological mismatches and detrimental effects on species such as pollinators.
- **Invasive species:** Climate change is predicted to favor species with ruderal traits, such as rapid growth, and high fecundity, and those with high plasticity and an ability to exploit warmer conditions, variable precipitation, and readily recover from drought stress. Warmer spring conditions may give advantage to cool season invasive grasses such as smooth brome (*Bromus inermus*) and Kentucky bluegrass (*Poa pratensis*), enabling them to better compete against later-emerging native grasses.
- **Herbivory:** If white-tailed deer populations expand under warmer and more droughty future climate conditions, this could contribute to declines in native forb diversity via reduced plant defenses and extended foraging window.

- **Microbial and fungal communities:** Drought may negatively affect soil function through reductions in microbial biomass and, in particular the function of arbuscular mycorrhizal fungi, which supports drought tolerance in plants.

A second project through the Midwest Climate Adaptation Science Center and University of Wisconsin assessed the climatic factors of importance to grasslands and how changes in those factors under future climate projections may affect the health and composition of grasslands in Minnesota. The project created maps of climate exposure (Figure 3.7), of the primary factors that influence grassland plant communities using climate projections from the Minnesota CliMAT (Climate Mapping and Analysis Tool). In addition, it included a systematic literature review to assess how climatic stressors affect grassland and wetland habitats within Minnesota, based on empirical statistical tests extracted from research papers from the upper Midwest and Great Plains (Barfknecht et al., in prep.).

Climate exposure

Plant community layers were based on the Midwest Terrestrial Habitat System (MWTHS) layer that uses attributes based on the National and International Vegetation Classification (NVC and IVC, respectively) designations for all natural landcover types, and LANDFIRE classifications for all non-natural landcover types. Central Tallgrass Prairie (CTP) communities are largely within the western, central, and southeastern portion of the state, but are mainly concentrated in the southern portions of the state in the Eastern Broadleaf Forest Province (Rollins, 2009; Tracey et al., 2024; Fig. 3.7). In comparison, Northern Tallgrass Prairie (NTP) communities largely reside within the entire western, central, and southwestern portions of the state, including the Tallgrass Aspen Parklands, Prairie Parkland Provinces, and are scattered in the southwestern portions of the Laurentian Mixed Forest Province. CTP communities are characterized by deeper and richer soils compared to NTP communities.

Climate projections within CTP communities show uniform increases in drought whereas projected changes in precipitation and temperature are more geographically complex (Figure 3.7; Liess et al., 2022 & 2023). Across the southeastern portion of the state, regions that support CTP communities are predicted to experience higher drought and growing season temperature and lower spring and growing season precipitation. The greatest warming trends are expected to occur in the western regions of CTP. In comparison, NTP communities are expected to exhibit higher drought in the southwestern portion of the state with decreased spring and growing season precipitation and increased growing season temperature in the northwest.

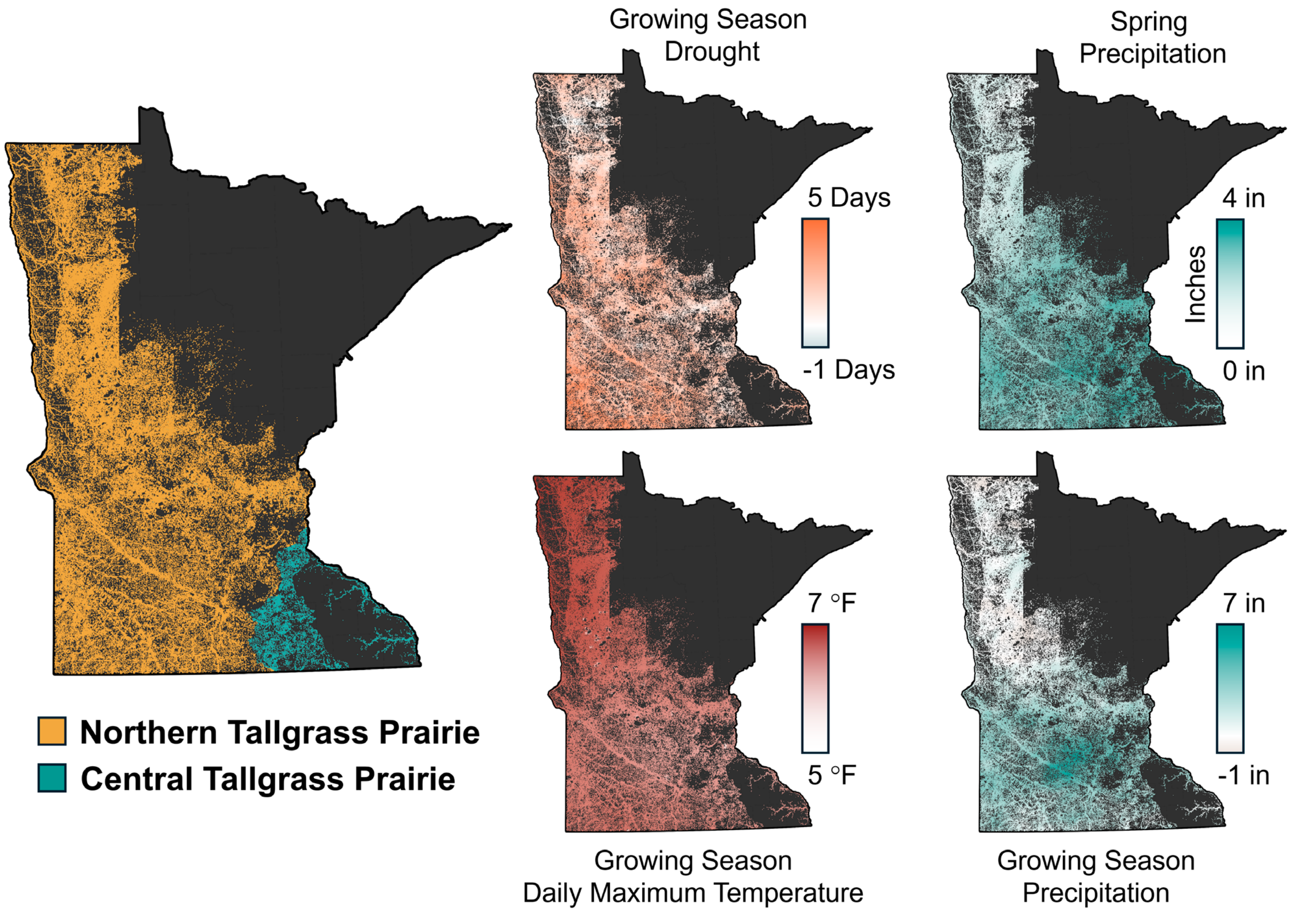

Figure 3.7. This figure depicts projected Climatic changes in Minnesota prairies. The left map depicts the extent of Northern Tallgrass Prairie and Central Tallgrass Prairie communities; as these are illustrated by points to highlight geographic range, they do not accurately portray the area of these communities. The right four panels depict the differences in future projected climate variables based on an ensemble of five climate models for the late century period (2060-2079) compared to historical simulations (1995-2014) under the SSP-585 (high emissions) scenario (Minnesota CliMAT).The factors depicted are growing season drought (maximum consecutive days with less than 0.01 in. of precipitation), growing season maximum temperatures (°F), and spring and growing season precipitation (in.).

Climate literature review

The systematic literature review identified 42 studies focused on grassland systems with 912 total statistical tests (Table 3.5). Studies were reviewed to assess statistical results for plant-climate relationships and summarized using a vote counting approach to determine directionality and consensus of each relationship. Across all studies, positive results were assigned a "+1", insignificant results were assigned a "0", and negative results were assigned a "-1". Results for each plant-climate relationship were summarized across all studies and then averaged.

Based on these findings, drought appears to reduce overall grassland plant diversity, functional traits (such stem density and total number of stems), and plant productivity (Table 3.4), but with varying responses based on species and populations due to local adaptability (specifically based on big bluestem; Galliart et al., 2019).

Table 3.5. Plant-climate relationship tests (912 tests) from 42 grassland research papers based on the vote counting approach. Columns represent the respective number of tests for each plant-climate relationship category (Tests), number of studies (Studies), and the number of significantly positive (POS), insignificant (NULL), and significant negative (NEG) tests. The overall directionality of these tests (SUM) and the average vote counting (VC Mean) represent the consensus response.

Plant-climate relationship	Tests	Studies	POS	NULL	NEG	SUM	VC Mean
Diversity and drought	116	6	3	86	26	-23	-0.207
Diversity and precipitation	189	18	66	107	16	50	0.265
Diversity and temperature	63	7	6	41	16	-10	-0.159
Functional trait and drought	48	5	5	31	12	-7	-0.146
Functional trait and precipitation	49	5	16	26	7	9	0.184
Functional trait and temperature	43	2	6	36	2	1	0.116
Population and drought	15	1	7	7	1	6	0.400
Population and precipitation	192	8	38	131	4	34	0.078
Population and temperature	4	2	2	2	0	2	0.500
Productivity and drought	90	7	11	56	23	-12	-0.133
Productivity and precipitation	67	10	35	27	5	30	0.448
Productivity and temperature	36	2	8	27	1	7	0.194

In experimental studies of precipitation, Koerner et al. (2014) and Koerner and Collins (2014) observed lower species richness, evenness, diversity, stem density, stem number, and aboveground net primary productivity in rainfall amendment (lower precipitation) treatments established in tallgrass prairie plots at Konza Prairie, Kansas compared to ambient control (higher precipitation) treatments, representing a large-scale pattern across multiple grasslands. Similarly, Serafini et al. (2019) observed lower plant species richness and diversity and both total and relative productivity under lower precipitation (“rainout”) treatments in grasslands in southeastern Ontario compared to control treatments. At Cedar Creek Natural History Area, in Minnesota, Tilman and Haddi (1992) and Tilman (1996) observed that severe drought and low precipitation conditions reduce plant diversity and productivity, often driven by the loss of foundational and rare species. Although less pronounced, there was some evidence for warmer temperatures to be positively associated with productivity and functional traits, while negatively associated with plant diversity.

In summary, an increased incidence of drought would be expected to negatively affect many grassland plant species and hinder overall grassland plant diversity, while increased precipitation will promote plant diversity, functional traits, and productivity. Higher temperatures may increase productivity but reduce plant diversity.

Species in Greatest Conservation Need

Prairies and Other Grasslands provide habitat for 222 animal and 119 plant SGCN as primary or secondary habitat (see Table 3.6) Habitat associations for insects were not differentiated into primary and secondary habitats and are shown in the total column. Primary habitats are those that species rely on and use most consistently. Loss or degradation of these habitats would have the most significant negative effect on their populations. Secondary habitats are used by the species less frequently.

Animals with more general habitat requirements are associated with multiple habitat types, while specialists are associated with only one or a few. Plant species were only associated with their single most primary habitat. Detailed tables associating each SGCN with the 15 habitats identified in the 2025-2035 SWAP can be found in Appendix D (animals) and Appendix E (plants).

Prairie and other grasslands support significantly more SGCN than any other habitat. This is likely due in part to their significant reduction over the past 150 years. The 54 vertebrate SGCN represents 33% of all vertebrate SGCN; the 119 plants represent 27% of all plant SGCN; and the 168 terrestrial invertebrates represent nearly 64% of all terrestrial invertebrates. Examples of selected SGCN are described below; state-listed species are linked to their account in the Rare Species Guide.

In addition to implications for individual SGCN animals, some species perform keystone roles for prairie ecosystem function. For example, the digging behavior of American badgers (*Taxidea taxus*), northern pocket gophers (*Thomomys talpoides*), and Richardson's ground squirrels (*Spermophilus richardsonii*) create patches of bare soil and nesting sites for insects such as some wild bees and tiger beetles. Other mammals, birds, and reptiles may use their burrows for shelter and to hunt prey. Soil disturbance, burrowing, seed eating and dispersal, and micro-grazing by rodents all create unique micro-habitats which help to support prairie diversity. Lastly, many SGCN are important parts of the prairie food web as predators, prey, or herbivores.

Table 3.6. Numbers of species of SGCN associated with Prairie and Other Grasslands habitat as either primary or secondary habitat.

Species Group	Primary Habitat	Secondary Habitat	Total
Amphibians	1	0	1
Birds	22	7	29
Mammals	12	1	13
Reptiles	11	0	11
Bees	-	-	83
Beetles (terrestrial)	-	-	4
Butterflies	-	-	15
Moths	-	-	56
Snails (terrestrial)	0	2	2
Spiders	4	2	6
True Bugs	-	-	2
Plants	119	-	119
Total	**169**	**12**	**341**

Amphibians

The great plains toad (*Anaxyrus cognatus*) is the only amphibian SGCN that is primarily associated with open grassland habitats. Remnant tallgrass prairie, wet meadows, and even agricultural fields provide summer forage and overwintering habitat. Shallow wetlands provide breeding habitat; even small depressions in agricultural fields that accumulate small pools of water following heavy rainstorms may be used for breeding. The toads spend much of their time in underground burrows throughout the rest of the year and may estivate (become dormant with reduced activity and metabolism) during hot and dry periods.

Birds

Grassland birds are declining at greater rates than any other habitat guild, with an overall 53% decline since 1970 (Rosenberg et al., 2019). The great imperilment of grassland birds is likely indicative of the status of other wildlife and plants that use prairie. Birds are very detectable and common subjects of monitoring and are widely viewed as indicators of ecosystem health and function. A growing body of work focused on other species, such as butterflies, suggests threats and population declines extend beyond birds (Edwards et al., 2025).

The decline of grassland habitat, and subsequently grassland bird populations is not unique to Minnesota. Indeed, scientists have been sounding the alarm for decades regarding steep population-level declines in grassland bird species (Brennan and Kuvlesky, 2005; Rosenberg et al., 2019; Bernath-Plaisted et al., 2023). These declines are likely the result of landscape-scale conversion of grassland habitat to cropland as well as the disruption of historic fire and grazing regimes (Knopf, 1994; Samson et al., 2004; Augustine et al., 2019; Bernath-Plaisted et al., 2023). With ~80% of the remaining grasslands in the United States being privately owned and managed (Bernath-Plaisted et al., 2023), future trends for grassland bird populations may be largely dependent upon private land conservation efforts.

Photo: Greater prairie-chicken, Bob Dunlap

Ultimately, these continent-wide population declines in grassland bird species underscore the critical need to protect remaining intact grasslands, while subsequently investing heavily in prairie restoration and reconstruction efforts, both on public and privately owned land.

Three bird SGCN, Sprague's pipit (*Anthus spragueii*), chestnut-collared longspur (*Calcarius ornatus*), and Baird's sparrow (*Centronyx bairdii*), are native prairie specialists that were common in portions of western Minnesota prior to settlement by people of European descent, but are now extremely rare. Pipits and longspurs prefer dry prairie sites with short and mid-height grasses. Typically, natural disturbance such as fire or grazing are necessary to provide suitable grassland structure for these species. Baird's sparrows are largely restricted to native prairie with structural diversity maintained by natural disturbance, occupying areas with taller grasses than the previous two species. However, they have been found to use non-native grasslands in other parts of their breeding range (Green et al., 2020).

All other grassland bird SGCN may be found in both native and non-native (surrogate) grasslands if suitable microhabitat features are present. Species found in mesic grasslands with taller grasses include sedge wrens (*Cistothorus stellaris*), LeConte's (*Ammospiza leconteii*) and Henslow's sparrows (*Centronyx henslowii*), bobolinks (*Dolichonyx oryzivorus*), and eastern meadowlarks (*Sturnella magna*). Grasslands with a short grass component, often maintained by grazing or fire, are preferred by upland sandpipers (*Bartramia longicauda*), western kingbirds (*Tyrannus verticalis*), and grasshopper sparrows (*Ammodramus savavvarum*). Sharp-tailed grouse (*Tympanuchus phasianellus*), lark sparrows (*Chondestes grammacus*), and field sparrows (*Spizella pusilla*) occupy grasslands with scattered low shrubs or small trees.

Mammals

Prairies and other grasslands are the primary habitat for the largest number of SGCN mammals (12). The extensive loss and degradation of this habitat across western and southern Minnesota is likely responsible for the declining populations and vulnerability of so many species. Historically, one of most visible, abundant and iconic inhabitants of Minnesota's grasslands were elk (*Cervus canadensis*). Reintroduced in the 1930s, the free roaming population now consists of only 200-250 animals in northwestern Minnesota. Most of the SGCNs are small to mid-sized mammals that are limited to grassland habitats. These prairie-specialist mammals include but are not limited to the white-tailed jack rabbit (*Lepus townsendii*), American badger, prairie vole (*Microtus ochrogaster*), Northern grasshopper mouse (*Onychomys leucogaster*), plains pocket mouse (Perognathus flavescens), and Richardson's ground squirrel; each can also be found in savanna habitats.

The important ecological roles that small and mid-sized mammals play in grassland systems were summarized by Ayodele (2025) (see the DNR Prairie Wildlife webpage). They include nutrient cycling, soil disturbance, grazing, dispersal of seeds and mycorrhizal fungi,

Photo: Plains pocket mouse, Abby Benson

and serving as both predators and prey for other animals. SGCN mammals can be vital to populations of SGCN from other groups. For example, Richardson's ground squirrels are widely cited as being strongly associated with the population health of key SGCN predators such as the burrowing owl (*Athene cunicularia*) and Swainson's hawk (*Buteo swainsoni*) (Houston and Bechard, 1984; Conway, 2018). White-tailed jackrabbit's selective grazing activities play an important role in the distribution of grassland plants while their burrows can act as seed pits or refuges (Schlater et al., 2021). Both these SGCN species have experienced population declines. White-tailed jackrabbit populations, for example have significantly declined over the past century, primarily due to eradication efforts (e.g., hunting and poisoning) aimed at reducing crop damage in the early 1900s (Brown et al., 2018) and the loss of the species' preferred habitats, including grasslands, pastures, hayfields, and small grains. Today, the species' population is only a fraction of what it was throughout its range compared to the previous century (Brown et al., 2020), and it is rarely seen in Minnesota (DNR ARS 2024). Despite this decline in the species' population, it is not well researched (Schlater et al., 2021).

Other grasslands such as pastures also provide habitat for several SGCN. Most of these species are adapted to prairie but some find appropriate habitat features in these grasslands, particularly those who are seeking sparser or shorter vegetation structure. For instance, plains pocket mice require sparse grassland vegetation. Prairie voles prefer relatively dry upland prairies and pastures with a high diversity of forbs. Richardson's ground squirrels are usually found in short grass prairie or pasture where they can see over the vegetation. Some SGCN will use surrogate grasslands that contain certain soil textures for burrowing, such as plains pocket mice using exposed, sandy soils.

Reptiles

Eleven of the thirteen reptile species that have been designated SGCN use prairies and other grasslands as one of their primary habitats. Other related open habitats commonly used by these species that depend on the sun for thermoregulation include savannas and cliffs, talus, and rock outcrops. Included are seven snake species, two lizards (six-lined racerunner [*Aspidoscelis sexlineatus*] and common five-lined skink [*Plestiodon fasciatus*]), and two turtles (Blanding's turtle [*Emydoidea blandingii*] and wood turtle [*Glyptemys insculpta*]). Among the seven snake SGCN, the plains hog-nosed snake (*Heterodon nasicus*) is limited almost entirely to prairies, open grasslands, and savannas. This habitat specialist prefers well-drained, loose loamy or sandy soils, sparsely vegetated habitats and frequently uses the burrows of pocket gophers. Gophersnakes (*Pituophis catenifer*) also are closely tied with all open habitats including prairies, savannas, and old fields; sites with sandy soils are especially important (Moriarty & Hall, 2014).

Insects

It has long been known that fragmentation and destruction of grassland reduces insect species diversity and abundance (Collinge, 2000). Several prairie specialists have already been extirpated in Minnesota, including these butterflies: the arogos skipper (*Atrytone arogos*), Poweshiek skipperling (*Oarisma poweshiek*), Ottoe skipper (*Hesperia ottoe*), Assiniboia skipper (*Hesperia assiniboia*), Garita skipperling (*Oarisma garita*), and Uhler's arctic (*Oeneis uhleri varuna*). Many insect SGCN are prairie specialists. These insect SGCN often require habitat features provided by native or perhaps restored prairie that are not found in other grassland habitats, such as a specific host plant or microhabitat structure limited to prairie. Insects that require a specific host plant as larvae to complete their life cycle include the regal fritillary (*Speyeria idalia*) and prairie violet (*Viola pedatifida*), and bird's foot violet (*Viola pedata*); red-tailed leafhopper (*Aflexia rubranura*) and prairie dropseed; and the phlox moth (*Schinia indiana*) whose host plant is prairie phlox (*Phlox pilosa*), typically found in remnant native prairie.

In addition, some butterflies may require a particular microhabitat structure. For example, several skippers, including the Dakota skipper (*Hesperia dacotae*), require bunchgrasses characteristic of the prairie habitat as opposed to sod-forming grasses, which often characterize other grasslands. All butterflies require flowering forbs as nectar sources on which adults feed.

Though actions that benefit prairie plant communities generally benefit prairie dwelling insects as well, it is important to note that any given management action may negatively affect some insect species and positively affect others depending on location, method, and time of year. Insects may winter above or below ground as eggs, larvae, pupae, or adults. Many species are capable of flight in adult stage for only a short time and are immobile or less mobile the rest of the year. Therefore, the seasons during which insects are vulnerable to above-ground disturbance (e.g., fire, mowing, haying, grazing) or below-ground disturbances such as digging or disking differ by species. As emphasized by Leone et al. (2022), prairie management should be conceptualized as a mosaic of practices and conditions across prairie landscapes and through time, rather than a "one size fits all" approach.

Plants

Prairie systems support many endangered, threatened, and special concern plants with a wide range of ecological retirements. Plants such as Sullivant's milkweed (*Asclepias sullivantii*) or small white lady slipper (*Cyperpedium candidum*) require the varying hydrology of wet prairies associated with intact wetlands. Species of inland dunes like sea-side three-awn (*Aristida tuberculosa*), blue toadflax (*Nuttlanthus canadensis*), and goat's rue (*Tephrosia virginiana*) colonize sparsely vegetated areas of wind-deposited fine sand. In the Southeast, prairies support many species on the edge of their ranges such as Indian plantains (*Arnoglossum* spp.) and wild quinine (*Parthenium integrifolium*).

Photo: Western prairie fringed orchid, Blue Mounds State Park

In the Western prairies, many species of the great plains have their most eastern populations in Minnesota's dry prairies. In the past, many short statured plants like cross-leaved milkwort (*Polygala cruciata*) or prairie shooting star (*Dodecatheon meadia*) were advantaged by fire and grazing in prairie systems which would have created openings for these plants. Other species, like kinnickinnick dewberry (*Rubus multifer*), or kitten-tails (*Synthris bullii*) occur in the transitional communities between prairies and forests that were maintained in greater abundance by past fire and grazing.

Due to these microhabitat requirements, most rare SGCN plant species appear to be restricted to remnant prairies. Restoration plantings of the surrounding landscape may benefit remnant species by increasing connectivity for pollinators and buffering communities containing plant SGCN from invasive species and edge effects. These include: earleaf false foxglove (*Agalinis auriculata*), roundstem false foxglove (*Agalinis gattingeri*), winter bentgrass (*Agrostis hyemalis*), clasping milkweed (*Asclepias amplexicaulis*), prairie milkweed (*Asclepias hirtella*), narrow leaved milkweed (*Asclepias stenophylla*), Sullivant's milkweed (*Asclepias sullivantii*), slender milkvetch (*Astragalus flexuosus var. Flexuosus*), Missouri milkvetch (*Astragalus missouriensis var. Missouriensis*), spike oat (*Avenula hookeri*), plains wild indigo (*Baptisia leucophaea*), prairie moonwort (*Botrychium campestre*), frenchman's bluff moonwort (*Botrychium gallicomontanum*), plains reedgrass (*Calamagrostis montanensis*), hooker's sedge (*Carex hookerana*), blunt sedge (*Carex obtusata*), Hill's thistle (*Cirsium pumilum* var. *Hillii*), white prairie clover (*Dalea candida* var. *Oligophylla*), and blanketflower (*Gaillardia aristata*).

Primary Stressors in this Habitat

Throughout Minnesota, habitats have been lost and degraded due to pressures associated with human settlement, intensive agriculture, subsistence, livelihoods, and recreation. Habitat loss or alteration remains the primary threat to most, if not all SGCN. In this section we identify key "stressors" that may continue to contribute to habitat degradation and loss. The list is adapted from a globally recognized threats lexicon developed by the International Union for the Conservation of Nature (Salafsky et al., 2024). For additional details, see the "Stressors" section in Chapter 1: Species in Greatest Conservation Need.

It is important to note that some of the factors listed as "stressors" can also be used to advance conservation goals. Broad terms such as "fire management" reflect the dual nature of these factors as they may function as stressors in some contexts while serving as valuable conservation tools in others. For example, an intense wildfire following prolonged fire suppression may cause significant stress for the habitat and species affected, while prescribed fire, when planned appropriately, can enhance ecosystem health and resilience.

Information about a subset of primary stressors specifically affecting this habitat is included below, followed by a set of conservation actions addressing those stressors.

Development

Pressure from urban and exurban development encroaches on grasslands, with particular pressure on sand barrens and sand prairies near large urban areas. Development accounts for 25% of documented prairie acres lost between 1987 and 2015 (MBS, 2017). In addition, the conversion of prairie habitat to development often alters hydrology, affecting adjacent prairie patches.

According to the Minnesota State Demographic Center, our state's population is projected to grow from 5.78 million in 2024 to 6.11 million in 2075. The addition of 330,000 people over the next 50 years will add to current development pressure and will likely threaten conversion of some remaining grasslands. Specifically, MNDOT estimates that 70% of population growth over the next 20 years will be focused on the seven-county metro area, putting substantial pressure on remaining dry prairie habitats in this region.

Crop Production

Conversion of native prairie to agricultural use has drastically reduced the prevalence of native prairie in the last 150 years, and in some economic markets remains an ongoing threat. Conversion to row crops remains the largest land use conversion of documented remnant prairies in Minnesota, accounting for 62% of acres lost between 1987 and 2015 (MBS, 2017).

Agricultural practices can alter hydrology in prairie systems, by increasing runoff from heavy rain events and introducing sediment and chemical residue into streams and wetlands. Draining of fields with pattern drain tiling alters the water table depth and may increase flash flooding during heavy rain events (see also Water Management and Use).

Abundant and widespread fertilizer use has long been a feature of Minnesota's agricultural system. However, high usage of nitrogen may degrade Minnesota's remaining prairie communities. High rates of nitrogen application can change the bacterial composition and nitrogen availability of the soil and is not restricted to the area of application (McLeod et al., 2016). This additional nitrogen can promote and facilitate the spread of invasive species (Morghan and Seastedt, 1999; McLeod et al., 2016), with reed canary grass (Rickey and Anderson, 2004) and smooth brome (Clark, 2008) being notable issues in Minnesota.

Pesticide use from agricultural practices have been identified as a leading factor in the declines of grassland dependent species (Mineau et al., 2005; Gibbs et al., 2009; Gibbons et al., 2015; Forister et al., 2016; Sánchez-Bayo and Wyckhuys, 2019). Neonicotinoids (systemic insecticides often applied as seed coats to corn, soybeans, and other crops) have become one of the most widely applied classes of insecticides and have been widely posited as a primary driver of insect declines and potentially other wildlife (Mason et al., 2013; Goulson, 2013; Gibbons et al., 2015; Pecenka and Lundgren, 2015; Gilburn et al., 2015; Forister et al., 2016; Basley and Goulson, 2018; Olaya-Arenas and Kaplan, 2019; Li et al., 2020; Roy and Chen, 2023). Insecticides applied via aerial spraying include broad-spectrum insecticides such as organophosphates (especially chlorpyrifos) and pyrethroids. Often targeting soybean aphid and other crop pests, these can be easily transported into non-target prairie preserves from neighboring and even distant crop fields (Foreman et al., 2000; Mackay et al., 2014). Two of these, chlorpyrifos (organophosphate) and bifenthrin (pyrethroid), have been frequently documented far within prairies designated as Critical Habitat for listed butterflies including Dakota skipper, and whose applications are at least correlated with their declines (Runquist et al., 2024).

Mechanical harvest through haying can be a very effective method to enhance grassland stands by removing weeds, stimulating root development in grasses, and reducing the duff layer to allow native grass species to increase in density. However, haying can have negative effects on ground nesting birds and other wildlife species through nest destruction and habitat loss. Haying should be planned during times that will minimize effects on ground-nesting birds. The nesting season is generally considered to be between April 15th and August 1st. As a result, haying should be conducted in August or September. To avoid significant effects on wildlife, it is recommended that no more than fifty percent of a field be hayed in any given year to maintain adequate cover for wildlife habitat. Flushing bars and mowing patterns that drive wildlife to the outer edges of the field should also be used.

Livestock Management

Livestock operation management can either benefit or degrade a grassland ecosystem and directly influences the plants and wildlife that utilize the associated habitat. Properly managed grazing can stimulate plant diversity and create diverse vegetative structure across the landscape. Overgrazing, if left unchecked, can reduce diversity in vegetative cover and structure, and have severe negative effects on biodiversity, ecosystem function, soil health, and forage production.

Over the last 30 years, advances in range science, grazing management practices, technology, and increased education and outreach efforts within the agricultural community have allowed livestock producers to manage their herds to meet economic goals while preserving healthy grasslands for future generations. However, overgrazing is still widespread in Minnesota and is exacerbated by increasing drought patterns. Overgrazing favors plants that are grazing increasers (species tolerant to intensive grazing), which eventually take over and are often undesirable, non-native, or even invasive. Under heavy continuous grazing, plant diversity can decrease by reducing or eliminating plant species intolerant to intensive grazing such as big bluestem (*Andropogon gerardii*), porcupine grass (*Hesperostipa spartea*), little bluestem (*Schizachyrium scoparium*), yellow prairie grass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), prairie onion (*Allium stellatum*), leadplant (*Amorpha canescens*), prairie clovers (*Dalea spp.*), narrow-leaved purple coneflower (*Echinacea angustifolia*), stiff sunflower (*Helianthus pauciflorus*), and blazing stars (*Liatris spp.*).

Low diversity grasslands also limit native species of pollinators that have evolved alongside native plants. In addition, overgrazing reduces grass and forb heights and can increase bare ground on many sites. Along with increasing the risk of erosion, these conditions are generally not as favorable for species adapted to the tallgrass prairie such as bobolinks and Henslow's sparrow, which prefer mid-height to tall vegetation with 1-3 years of thatch.

Care must be taken when treating livestock for pests and parasites, as treatments often contain insecticides. Some insecticides persist in the environment weeks after treatment and can harm beneficial insects and contaminate soil and water via the animals' feces.

Mining and Quarrying

Sand and gravel mining in particular affects dry prairies, especially sand prairies, by converting habitat in order to extract the sub-surface aggregate material. Mining accounted for 12% of conversions of documented remnant prairie from 1987 to 2015 (MBS 2017), and conversions from prairie to mining appear to be increasing over time.

The construction of roads, trails, and railroads requires aggregate material. In areas with remnant dry prairie, the substrate beneath the dry prairie is often targeted for extraction to build these lines of infrastructure. It is impossible to repair these dry prairies once they have been mined for aggregate.

Dry prairies in closer proximity to highly developed areas and/or major roadways are at serious risk for sand and gravel mining. Developers and road authorities typically try to source aggregate material near the project site to reduce costs, putting prairies near emerging projects at high risk. As developmental pressures increase, the risk of these prairies being lost will increase substantially.

Wind and Solar Energy Infrastructure

According to Our Minnesota Climate "The amount of energy our state produces from renewable resources like solar power and wind has risen 60% over the past decade. Today, renewable energy accounts for 28% of Minnesota's electricity generation, with 52% of our energy coming from carbon-free sources like renewables, nuclear, and hydropower." These successes in renewable energy production, while critical to reducing climate-warming greenhouse gas emissions, can be complex in the context of wildlife and habitat effects. Both wind and solar development can indirectly affect SGCN due to loss and fragmentation of grassland habitat. In addition, some SGCN, such as the greater prairie chicken, have shown avoidance behaviors toward wind developments (Winder et al., 2014; LeBeau et al., 2017). Wind turbines are associated with direct effects on birds and bats. particularly during migration, with wind turbine collisions documented as a high source of mortality for both groups. Loss and his colleagues (2013b) estimated between 140,000 and 328,000 birds are killed annually at wind turbines across the contiguous United States; mortality increased with the height of the turbine hub. Foliage and tree-roosting bats, such as hoary bats and eastern red bats, also are frequently found dead below wind turbines (Arnett et al. 2008). Although variable in timing, most mortality occurs during late summer and fall, corresponding with migration and mating seasons. Estimates place the loss at approximately 888,000 bats per year (Smallwood 2013). To date, lighting and noise appear to not influence the level of mortality.

Similarly, land-use effects in and around solar arrays and wind turbines can negatively affect native plant communities (predominantly prairie) and rare features. Taking lessons from traditional power infrastructure and development, we can be mindful to wildlife considerations in the siting and design of immerging alternative energy resources.

Roads, Trails, and Railroads

Railroads, roads, and trails, while essential, fragment grassland habitats. They can also alter hydrology, increase sedimentation and runoff, and act as a vector for the introduction of invasive species. The associated effects from initial construction as well as routine maintenance and infrastructure installation can have detrimental effects on habitat within the right of way for the life of the road, trail or railroad.

Utility Corridors

Utility corridors intersect prairie and other grasslands throughout the state and can include pipelines, telephone lines, and power lines. These lines can be aerial or below ground. Regardless of type, utility corridors can fragment habitat based on their size, purpose, and the upkeep that is required to maintain them.

The initial construction of the associated utility infrastructure as well as the long-term maintenance of that infrastructure can have lasting effects on native plant communities and the SGCN associated with them. Increased funding for rural broadband, conversion of aboveground powerlines to belowground, and development of new utilities (solar, wind, etc.) continue to pressure grassland habitats.

These corridors and the increased travel from vehicles and equipment that they require act as vectors for invasive plant species. The required vegetative management practices often include herbicide applications, removal of woody vegetation, and/or mowing. This increased disturbance increases the likelihood of establishing invasive plant species within the corridors and then spreading to adjacent lands.

Hunting and Collecting Animals

Small mammals can be affected by deliberate trapping or shooting. For example, while Northern pocket gophers are rare, the Plains pocket gopher is very abundant and is unprotected, meaning that hunting and trapping is not limited. Several other SGCN, Richardson's ground squirrels and Franklin's ground squirrels and American badgers are still to this day considered pests. The burrowing nature of these species is concerning to some agricultural producers and may result in increased control measures.

Gathering Plants and Fungi

In Minnesota state parks, recreation areas, waysides, forests, and Aquatic and Wildlife Management Areas, gathering of fruits and mushrooms for personal consumption is allowed (see Harvesting Plants and Harvesting on State Forest Lands). However, it is illegal to dig up or damage plants on any state lands (Minnesota Statute 6100.0900). Harvesting can cause numerous effects, which can negatively affect natural resources and other visitors' experiences, such as: disturbing soils and trampling other plants, which can lead to invasive species taking hold; removing food sources otherwise available for wildlife; reducing the natural reproduction of some species; and preventing other people from having the same experience.

A threat to Minnesota grasslands is the overcollection of seed and, in some cases, illegal collection of plants, for use in native plant sales. The rarest species, with the smallest amount of seed produced, and those with the highest market value, are the most vulnerable from overcollection. One of the most popular plants for collection is narrow-leaved coneflower (*Echinacea angustifolia*).

Another type of plant harvesting is for the use of medicinal, herbal, or food purposes. Species that are most vulnerable to overharvesting include species with edible tubers such as prairie turnip (*Pediomelum esculentum*) and wild/prairie onion (*Allium stellatum*). Natural areas close to large population centers are most vulnerable to over harvesting.

Timber Harvest

Timber harvest is a forest management tool that can affect wildlife habitat by changing forest structural and compositional diversity. Forest management decisions, including inaction, typically have positive effects for some species and negative effects for others. Timber harvest in the Tallgrass aspen parkland region may alter patch dynamics between aspen and prairie stands by increasing root suckering and clonality of aspen.

Recreation

Recreational overuse can threaten sensitive grassland plants and grassland communities. Foot traffic in popular hiking areas may degrade plant communities and rare plants could be trampled if visitors do not stay on established trails. Foot traffic also introduces the risk of spreading invasive species.

Fire Management

Fire is a necessary and natural feature of Minnesota's native grasslands. Fire-adapted ecosystems, which includes all of Minnesota's grassland habitats, have evolved to thrive with fire disturbance. Sediment cores from the Northern Great Plains indicate that grasslands, drought, and fire have been a key feature of this landscape for much of the past 10,000 years (Nelson and Hu, 2008; Grimm et al., 2011). If litter or thatch are not periodically removed by fire, grazing, or haying, ecosystem productivity and species diversity decline (Anderson, 1990; Knapp et al., 2009).

In the modern era, landscape conversion and development has led to most remaining grasslands of all types being highly fragmented, scattered, and (in most cases) small in size. Though fire is necessary to maintain grassland habitat, the current nature of small, isolated grasslands means that, without careful planning, SGCN populations could be critically reduced and even extirpated by fire.

Lack of fire is a stressor for many prairie plant communities, including dry and mesic tallgrass prairie, bluff prairies, brush-prairies, and savannas. Fire suppression leads to woody species encroachment, such as eastern red cedar (*Juniperus virginiana*) and/or Siberian elm (*Ulmus pumila*); for additional information, see Problematic Native Species and Invasive Species, respectively. If left unchecked, these woody species can result in wholescale ecosystem conversion (DeSantis et al., 2011).

Invasive Species (Problematic Non-native Species)

Invasive plant species can have negative effects on native plant communities in prairie and grassland ecosystems. While both native and non-native plant species can become overdominant and be problematic in prairies and grasslands, non-native invasive plant species are of particular concern. Non-native plants did not evolve within the ecosystem that they now inhabit and were likely imported for their ability to establish easily and spread quickly. As a result, they are able to outcompete native plant species for available resources while decreasing biodiversity and degrading already limited habitat for SGCN.

A prevalent example of this is smooth brome (*Bromus inermis*). Smooth brome is a perennial cool season grass native to Europe and Asia. It has become quite dominant in prairies across much of the state. In remnant prairies, smooth brome has been shown to reduce native plant richness (Jones et al., 2023; Otfinowski et al., 2007), reduce native cover (Fink and Wilson, 2011), and alter soil dynamics (Vinton, 2006; Bell et al., 2023). Like many non-native cool season grasses, smooth brome is difficult to manage once it is established. Work is ongoing to develop effective management strategies to reduce smooth brome in grassland habitats. Anecdotal evidence to date suggests that late fall (post-hard frost) herbicide applications and late spring burns can help to suppress smooth brome and allow native prairie species room to compete. Treatments will likely need to be repeated through time. Careful consideration should be exercised in using these techniques, particularly on remnant prairies. While already affecting many remnant prairies, smooth brome is predicted to become more problematic in prairie ecosystems under increased nitrogen deposition (Clark, 2008), increased atmospheric carbon dioxide concentrations, and increased spring rainfall (Prevey, 2014; Printz and Hendrickson, 2015). Understanding effective management practices for reducing smooth brome in tallgrass remnant prairies is increasingly important. Likewise, Kentucky bluegrass (*Poa pratensis*) is another invasive cool-season grass that causes degradation similar to smooth brome (Gannon, 2024).

From 1960 to present, invasive woody species including common buckthorn (*Rhamnus cathartica*) and bush honeysuckle (*Lonicera spp.*) have proliferated and continued to invade natural areas including bluff prairies and adjacent savanna (Hartman and Steele, 2015). Invasive forb species such as sweetclover (*Melilotus officinalis*) are also common invasive species in these habitat types (Hartman and Steele, 2015). As buckthorn and honeysuckles continue to spread, all prairie habitat types are now being affected by these woody invaders. These species are an impending challenge for prairie land managers, particularly in areas that are difficult to burn.

Problematic Native Species

Native plant species can possess characteristics associated with invasive species (non-native problematic species), such as encroaching into prairie habitat. These plant species are often referred to as pioneer or volunteer species. These characteristics can make them problematic under certain conditions. This is especially true in the absence of disturbance such as fire, thinning, or grazing. Historically disturbance was a limiting factor for many of these problematic native species. Frequent disturbance through fire limited the spread of these species by killing them before maturity and reproductive age.

An example of this is eastern red cedar (*Juniperus virginiana*). Its seeds are readily consumed and transported by birds and small mammals. Young red cedar trees will not tolerate fire and are killed. In the absence of fire this native tree species can encroach into prairie and grassland ecosystems and grow to maturity. Once established, mature cedar trees develop an extensive fibrous root system that can extend laterally up to 20 ft from the root crown. Mature trees are able to take advantage of moisture and nutrients in the soil profile and eventually shade out many if not all of the native prairie vegetation at the ground level. This prevents grasses and forbs from growing, thus eliminating the fine fuels needed to carry fire and kill the trees. This self-reinforcing feedback loop allows cedar to continue to spread once firmly established. In prairie and grassland ecosystems these eastern red cedar groves eliminate native perennial grasses and forbs, fragment habitat, provide hunting perches for raptors that prey on ground nesting birds, and generally degrade the biodiversity in the area they inhabit.

Another increasing species is reed canary grass, previously classified as an invasive species but more recently thought to be native in at least some of Minnesota based upon research at the University of Minnesota (Reed Canary Grass). Reed canary grass is particularly damaging in wet prairies. The thick sod layer and dense growth can rapidly outcompete desirable native species, and it is common to see former wet prairies transition to a near monoculture of reed canary grass in areas where this species is present. To date, land managers have been unable to find an effective management strategy to reduce or eliminate reed canary grass.

Air-borne Pollution

Experiments under controlled greenhouse conditions have shown that increased levels of atmospheric carbon dioxide may favor the competitiveness of woody plants and cool season invasives by stimulating photosynthesis and growth. It may also reduce mild to moderate abiotic stress in woody plants if root growth and nutrients are not limited.

Nitrogen levels in the atmosphere are driven by natural processes as well as transportation and agricultural sources, primarily fertilizer (Burke et al., 2002; Wall and Pearson, 2013). A study indicates that increased atmospheric deposition of nitrogen reduced plant species numbers by 17% by increasing soil acidity and increasing above ground production of certain plants that reduces light availability to other plant species. This can lead to competitive exclusion. This suggests that chronic but low-level nitrogen deposition may have a greater effect on diversity than previously thought (Clark & Tilman, 2008).

Light and Noise Pollution

Nearly half of the United States land surface has light-polluted skies (Falchi et al. 2016). Sources of light pollution at night include interior and exterior lights on homes, buildings, billboards, parking lots, and streets as well as lighted sports fields, industrial plants, and airports (DarkSky International 2025a). Studies also point to the ecological effects created during the daytime by polarized light that reflects off surfaces such as asphalt roads, glass panes, and solar panels (Chock et al. 2020; Horvath et al. 2009).

Effects of light pollution include disrupting the behavior of amphibians whose breeding calls are delivered at night, drawing nocturnal insects to artificial lights that increase their predation risk, and disorienting birds that use environmental cues to guide their nighttime migration (DarkSky International 2025a, 2025b). In addition, the phenology, growth rates and biomass of plants are affected (Bucher et al. 2023). Bright day and dark night cycles synchronize the internal clocks of plants and animals, and alterations to these cycles can affect hormone production, reproductive behavior, neural activity, and metabolic functions (Bumgarner & Nelson, 2021).

Noise pollution from aircraft, vehicles, boats, and other human causes is pervasive. Anthropogenic noise was detected in 36% of national parks surveyed (Buxton et al. 2019), and 12% of wilderness areas had anthropogenic noise levels 3 decibels higher than levels predicted to occur naturally (Buxton et al. 2017). Exposure to increasing noise levels can change the spatial distribution and movement patterns of wildlife, cause avoidance of feeding and nesting areas, and interrupt sleeping patterns and communications (Kok et al. 2021). For plants, noise can reduce seedling recruitment (Phillips et al. 2021).

Changes in Temperature related to Climate

Minnesota has experienced a clear warming trend over the past century. Between 1895 and 2020, average statewide temperatures increased by 3.0 degrees Fahrenheit (°F; Climate Trends). This warming has become more pronounced in recent decades and during the winter months. Since 1985, average winter temperatures in Minnesota have risen by 5.4°F, with average winter low temperatures increasing even more significantly by 6.8°F (Climate Change in Minnesota). According to the Minnesota Pollution Control Agency and the Minnesota Department of Commerce these changes have led to a shortened season of snow cover and a reduction in lake ice duration by 10-14 days over the past 50 years. Furthermore, these shifts in thermal regimes are ecologically significant. Many species are adapted to narrow temperature ranges, and such rapid changes can result in increased thermal stress, the spread of invasive species, and heightened disease and pathogen risks (Ratcliffe et al., 2025b).

This warming trend is expected to continue. By mid-century (2040-2059), Minnesota's average annual temperature is projected to rise by an additional 3.8 - 4.5 °F, depending on future greenhouse gas emissions scenarios (Liess et al., 2022; Climate Change in Minnesota). Climate change does not act in isolation, interacting with invasive species dynamics, land-use change, and shifts in water quality and quantity, compounding ecological effects (He et al., 2019; Finch et al., 2021). For additional context and resources, refer to the Climate Adaptation section in Chapter 6: Implementation.

Changes in Precipitation and Hydrology related to Climate

From 1895 to 2020, Minnesota's average annual precipitation increased by 3.4 inches (in; Climate Trends). The state has also seen a notable rise in the frequency and intensity of heavy precipitation events. Since 2000, very heavy rains (6 in. or more in a single day) have occurred two to three times more frequently than during the 20th century (Williams-Sether & Sanocki, 2025; Runkle, J., et al (2022)). These extreme events have led to a corresponding increase in flooding, which can disrupt ecosystems, human infrastructure, and water quality (Williams-Sether & Sanocki, 2025).

Future projections indicate continued increases in annual precipitation, especially during the winter and spring months, which are likely to exacerbate flooding risks. The same climate models also forecast an increase in late summer drought events, underscoring the variability and unpredictability of hydrologic patterns under a changing climate (Climate Change in Minnesota).

Photo: Restoration planting at Glendalough State Park

By mid-century (2040-2059), average annual precipitation is projected to increase by up to 1.2 in., depending on emissions scenario (Liess et al., 2022; Climate Change in Minnesota). This seemingly counterintuitive pattern — wetter winters and springs, punctuated by hotter, drier late summers — has profound implications for water availability, wetland health, soil stability, and species dependent on seasonal hydrologic cycles (Runkle et al., 2022). For more information and resources for climate-adapted management strategies, see the Climate Adaptation section in Chapter 6: Implementation.

Case Study: Regenerative Grazing and Audubon Conservation Ranching

Audubon Conservation Ranching (ACR) is the flagship grassland habitat program of the National Audubon Society. With most remaining grasslands privately owned and operated as working lands, partnering with landowners is the most effective conservation collaboration to impact habitat and bird populations on a landscape scale. North America's grassland bird populations have experienced a steep decline of more than 53% over the last 50 years. By partnering with regenerative-minded farmers and ranchers through the ACR Program, Audubon is working to stabilize and grow those populations across the continent by building resilient lands that support wildlife, ecosystem services, people, and agriculture. Promoting regenerative grazing practices such as rotational grazing, reduced chemical use, cover crops, and native plant establishment, can lead to improved forage quality, drought resiliency, soil stability, carbon sequestration, animal health, and water quality. These key ecological benefits lend to long-term sustainability and improved bottom lines of each individual farm and ranch. To be certified in the ACR program, landowners must meet habitat management, environmental sustainability, and animal welfare standards. Once qualified by a third-party audit, producers then use the Audubon Certified Bird-Friendly seal for packaging and promotion of beef or bison products, which recognizes lands managed for birds and biodiversity. Consumers can then support conservation when they select products from these certified bird-friendly lands.

Photo: Conservation grazing in prairie, Lisa Gelvin-Innvaer

Lonetree Ranch, spanning 9.000 acres in Wyoming and Utah, produces organic, grass-fed cattle and is an excellent example of ACR certified bird-friendly land. The Taylor family manages their sage dominated acres for forage and habitat for species such as the greater sage grouse, mule deer, pronghorn, elk, and moose. Their priority is to increase the biodiversity of their vegetative community to establish resiliency and ensure consistent forage for their cattle and wildlife. Lonetree Ranch partnered with Audubon and the Wyoming Department of Conservation to rejuvenate sagebrush habitat. When sagebrush goes too long without disturbance, such as fire, drought, or grazing, it grows so densely that other plants can't survive in the understory. Project partners performed sagebrush mowing to open the canopy, increasing forb presence and diversity, while also encouraging younger sagebrush to establish. In addition, Audubon replaced barbed wire fences with wildlife friendly alternatives to provide safe migration corridors for mule deer and pronghorn.

In Minnesota, Audubon began certifying farms through the ACR program in 2024. With funding from the National Fish and Wildlife Foundation, the Minnesota Environment and Natural Resources Trust Fund, and a USDA NRCS Conservation Innovation Grant, Audubon is dedicated to providing technical and financial assistance to participating ACR producers in addition to monitoring the effects of the applied regenerative practices on birds, vegetation, and soil health.

Priority Habitat Conservation Strategies

To implement the Habitat Goal of this Plan (Protect and enhance the resilience, function, and ability of habitats to support biodiversity, especially for SGCN), five strategies were identified:

Strategy 1. Protect, buffer, and connect high quality habitats to optimize biodiversity, SGCN, and landscape benefits, particularly across the Conservation Action Network.

Strategy 2. Restore, enhance, and maintain lands and waters to benefit SGCN, biodiversity, and ecosystem resilience

Strategy 3. Collaborate with conservation partners and landowners to enhance conservation delivery, particularly in the Conservation Action Network and Conservation Opportunity Areas

Strategy 4. Monitor SGCN, native plant communities, habitats, and ecosystems for changes through time including responses to natural disturbances, conservation actions, and climatic conditions

Strategy 5. Connect to develop, innovate, incentivize, and disseminate evidence-based habitat management practices to benefit SGCN habitat management practices to benefit SGCN habitat management practices to benefit SGCN.

Examples of conservation actions are grouped below under these five strategies and tagged with icons for the stressor(s) that they address. Some of these actions are widely in place as best practices while others may be more novel. Some actions will combine multiple strategies, in which case we present it under the one it fits best. Also note that some strategies, such as Strategy 3, collaborating with partners, could truly be applied to all actions to most broadly and effectively implement them. Other actions, such as those related to monitoring, might be difficult to relate to a specific stressor, in which case they are marked as not applicable (NA).

Potential Conservation Actions for Prairie and Other Grasslands

Strategy 1. Protect, buffer, and connect high quality habitats to optimize biodiversity, SGCN, and landscape benefits, particularly across the Conservation Action Network.

Stressor	Action
	Protect remaining remnant prairie from conversion to other land uses.
	To protect prairie remnants from pressure for mining resources, increase funding for acquisitions and payments through programs such as the Minnesota Native Prairie Bank.

Stressor	Action
	Prevent further fragmentation of grassland habitat. Support diverse financial incentives to help landowners avoid conversion of grasslands into row crops where remnant prairie and/or SGCN occur. Implement landowner outreach and engagement activities. Prioritize access for landowners to a variety of programs for implementation of land protection options such as conservation easements. Support conservation programs that provide economic benefits for set aside and conservation programs and assist in public outreach. Improve access to USDA Farm Bill and other wildlife resources for landowners.
	Control or prevent the invasion of grasslands by trees and shrubs with mowing and cutting woody vegetation, prescribed fire, grazing, and careful use of herbicides with consideration for SGCN.
	Control spread of invasive species on native-dominated sites. Ensure equipment is cleaned prior to moving mowers, haying equipment, and seed harvesters among sites to prevent spreading invasive species.
	Livestock treated with systemic insecticides for pest or parasite control (such as ivermectin, doramectin, or eprinomectin) should not be released on conservation lands for at least 30 days following treatment. If parasite treatment is needed during the grazing period, the best practice is to remove affected animals for treatment and return them to the site after the recommended amount of time.

Strategy 2. Restore, enhance, and maintain lands and waters to benefit SGCN, biodiversity, and ecosystem resilience

Stressor	Action
	Promote and participate in prairie reconstruction and restoration to expand the amount of prairie and provide a diversity of native plants to sustain biodiversity and provide ecosystem benefits including healthy soil, carbon storage, improved hydrology, watershed health, and cleaner water. Projects that restore more natural hydrology, such as breaking up drain tile, can also benefit streams and downstream habitats. Planning projects to be resilient under anticipated changes in climate regimes will be the most successful (see also climate section in Chapter 6: Implementation).
	To protect nesting SGCN birds in hayfields and mowed grasslands, consider adopting these bird-friendly measures: use flushing bars, lengthen cutting rotations, and avoid early-season (May-June) mowing and haying.
	Where people recreate, provide outreach and education on cleaning gear and equipment to reduce the introduction and spread of invasive species. The DNR's Prevent the Spread webpage includes specific actions for different land-based activities like biking, hiking, and off-highway vehicle riding. At trailheads, add invasive species prevention messages, such as those on the boot brush kiosks developed by the PlayCleanGo: Stop Invasive Species in Your Tracks program. Consider maintaining buffers around and minimizing disturbance to bluff prairies when designing and maintaining trails.

Stressor	Action
	Avoid soil compaction in areas occupied by mammal and reptile SGCN.
	Incentivize conservation grazing practices that benefit grassland SGCN habitat. Increase landowner knowledge of the methods and benefits of various regenerative grazing practices and provide diverse funding opportunities to transition to sustainable grazing and incentivize better habitat management on private lands. Promote the use of rotational grazing, adaptive grazing, and other regenerative practices to build higher quality habitat in addition to boosting cattle production. Support practices to improve soil health (structure, water retention, etc.), prevent erosion, and lower inputs (reseeding, fertilizer, etc.). Specific practices will depend on the targeted SGCN, site conditions, landscape context, and other objectives. See for instance Minnesota Grazing Lands Conservation Association for more information and training opportunities as well as the Case Study on regenerative grazing and the Audubon Conservation Ranching program below.

Strategy 3. Collaborate with conservation partners and landowners to enhance conservation delivery, particularly in the Conservation Action Network and Conservation Opportunity Areas.

Stressor	Action
	Increase incentives and planning, and potentially ordinances, to include higher density housing, such as multi-dwelling housing, and create zones of no net growth in areas where grasslands are pressured by urban and exurban development. Awareness, education, economic incentives, community support, and working with local governments can all be part of this effort.
	Support more regular and well-planned fires in the prairie. Support the formation of Prescribed Burn Associations. Maintain and encourage the collaboration of agencies and nonprofits to meet prescribed fire objectives on a larger landscape scale. Ensure that burn plans incorporate best practices for SGCN; for example, noting the timing of butterfly and moth larval emergence and use of burn units, rotations, and fire exclusion areas to avoid negatively affecting butterfly and moth populations when they are vulnerable to fire. Creating permanent non-fire refuges within fire-managed sites can benefit Lepidopteran populations (Kwilosz and Knutson, 1999; Swengel and Swengel, 2007). Likewise, other factors like timing, time of day, frequency, ambient temperature, fire intensity, fire direction, buffers around hibernacula, and refuges are considerations for SGCN reptiles and amphibians.
	Increase incentives to develop solar in and on developed areas (e.g, atop buildings and parking lots) rather than in undeveloped lands. Site wind and solar developments on low-use croplands and prohibit development in areas with prairie remnants. Consult with parties earlier in planning processes, including with counties. Explore options with wind energy companies to modify wind easements that are only intended to preclude development that would block wind to allow opportunities for acquisition and easements for conservation.

Stressor	Action
	Implement best practices for minimizing light and noise pollution, especially near grassland preserves. Consider wildlife-friendly lighting solutions as recommended by conservation organizations such as DarkSky and National Audubon Society's Lights Out Program. Best practices include using outdoor lighting only where and when it is actually needed, use of motion detectors and/or automatic timers so lights only turn on when they are most needed, placing light covers or shields so that light only shines down to the ground, and keeping landscape lighting low to the ground, and away from white or reflective surfaces. If lighting is necessary, swap out lights for less bright and warmer (yellow or red) bulbs, or cover existing bulbs with a filter that does the same. Consider closing your curtains at night to keep your light indoors (Xerces Society Firefly Friendly Lighting).

Strategy 4. Monitor SGCN, native plant communities, habitats, and ecosystems for changes through time including responses to natural disturbances, conservation actions, and climatic conditions.

Stressor	Action
	Implement rigorous effectiveness monitoring or research to assess SGCN responses to management practices to help inform evidence-based adaptive management.

Strategy 5. Connect to develop, innovate, incentivize, and disseminate evidence-based habitat management practices to benefit SGCN

Stressor	Action
	Develop more evidence-based guidance for conservation grazing that is based on effectiveness monitoring and research, including not only vegetative targets but also responses by Species in Greatest Conservation Need.
	Research, better understand, and share information about the potential to use climate-smart regenerative agricultural practices to improve soil health, prevent soil erosion, build carbon storage, and reduce the carbon footprint of agricultural production to benefit SGCN.
	Share information about the Northern pocket gopher and encourage counties to eliminate bounties on ground squirrels and gophers in their range.
	Promote the coexistence of burrowing SGCN and livestock grazing. Emphasize the benefits of diverse grassland communities, discourage activities related to varmint hunting and pest control.

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