Minnesota Prairie Conservation Plan

A habitat plan for native prairie, grassland and wetlands
in the Prairie Region of western Minnesota

2nd edition, 2018

Blazing star plants at Glacial Lakes State Park © Alison Mickelson\Greater

Table of Contents

JANUARY 5, 2018

Executive Summary

In 2010, Minnesota's conservation partners collaborated to develop a 25-year strategy for accelerating conservation in the Prairie Region of the state. This strategy was precipitated by several factors:

- Continuing loss and degradation of prairie, grassland, wetland, lake and stream habitats, along with the fish and wildlife that depend on them.
- An acknowledged need to better coordinate between conservation programs and organizations to maximize efficiency and effectiveness.
- Tremendous opportunities created in 2008 by the passage of the Clean Water, Land, and Legacy constitutional amendment that provides significant conservation funding through 2034.

In 2016, the partners met again to review and refine the Minnesota Prairie Conservation Plan (hereafter the Prairie Plan). This second edition calls for the same four approaches to conservation in the Prairie Region as the first edition:

1. First, all areas of native prairie should be protected from conversion to other land uses.
2. Second, core areas with a high concentration of native prairie, other grasslands, wetlands and shallow lakes should be enhanced and restored to ensure that the land remains 40% grassland and 20% wetland, at a minimum, with the remainder used as cropland or for other uses.
3. Third, habitat corridors connecting core areas have been more clearly defined, and they continue to include large grassland/wetland complexes at about six-mile intervals along the corridors. Within the corridor complexes, there is a goal of 40% grassland and 20% wetland, and for the remainder of the corridors, 10% of each legal land section should be maintained in permanent herbaceous perennial cover.
4. Fourth, in the remainder of the Prairie Region, there is a goal to maintain 10% of each major watershed in perennial grassland and wetland vegetation.

The existing Wildlife Management Area Plan, Pheasant Plan, Duck Plan and other resource plans provide guidance in setting goals for protection, restoration and enhancement. These earlier plans set a habitat goal for the Prairie Region of protecting and restoring a total of 2.0 million acres of grassland and savanna, along with 1.3 million acres of wetlands and shallow lakes.

Based on this framework and the analysis in this plan, we propose taking the following steps to contribute toward the habitat goals within the other existing resource plans in Minnesota:

1. Permanently protecting through acquisition from willing sellers of fee title or easement of the remaining 108,875 acres of unprotected native prairie and a minimum of 277,000 additional acres of other grassland and wetlands in core areas and strategic habitat complexes. Within the corridors and in the remainder of the Prairie Region, acquisition, easement, or temporary contracts should be used to protect at least 702,000 acres of other grassland and wetlands.
2. Restoring grasslands, wetlands and other habitats, including at least 295,000 acres in core areas, 82,000 acres in corridors and strategic habitat complexes, and 44,000 acres elsewhere.
3. Enhancing prairies, other grassland and wetlands via prescribed fire, conservation grazing, haying, invasive species control and wetland management on 603,000 acres annually. Enhancement of existing wetlands and shallow lakes through control of invasive species and intensive water level management is included in this total.
4. Incorporating "working lands" conservation to manage grassland habitat and contribute directly to local economies via "grass-based" agriculture. Well-managed, private, working lands contribute to the viability of grassland and wetland systems, and private income generated from grasslands can be the single largest driving force for grassland conservation. The promotion of a full range of conservation best management practices on agricultural lands will increase natural resources benefits while still allowing for production agriculture. Wildlife and agriculture can co-exist, and this plan helps determine where the co-existence can occur.

The Minnesota Prairie Plan Working Group established goals and cost estimates associated with these outcomes. Measures of success were developed to gauge progress toward creating functioning landscapes. The strategies should be re-evaluated regularly following monitoring activities, after which management practices should be adjusted accordingly. The overall cost of all the actions described in this plan is $2.8 billion. Given that certain activities will be accomplished with "traditional" funding sources, partners will need $625 million from the Outdoor Heritage Fund over 15 years to achieve the desired outcomes.

Cropland and adjacent native prairie near Randall Waterfowl Production Area in west-central Minnesota ©TNC\Susan Chaplin

Acknowledgments

Members of the Minnesota Prairie Plan Working Group who contributed to this edition include:

Audubon Minnesota: *Kristin Hall*

The Conservation Fund: *Steve Hobbs, Emilee Nelson*

Ducks Unlimited: *Jon Schneider*

Minnesota Board of Water and Soil Resources: *Tabor Hoek*

Minnesota Department of Agriculture: *Kelly Anderson, Robert Sip*

Minnesota Department of Natural Resources: *Greg Hoch (Facilitator), Marybeth Block, Crystal Boyd, Jason Garms, Fred Harris, Jessica Petersen, Judy Schulte*

Natural Resources Conservation Service: *Mark Oja*

The Nature Conservancy: *Marissa Ahlering, Steve Chaplin, Neal Feeken*

Pheasants Forever: *Matt Holland, Eran Sandquist*

U.S. Fish and Wildlife Service (USFWS): *Sheldon Myerchin*

The chief author and editor of this edition was Steve Chaplin of the Nature Conservancy. Rich Johnson of The Nature Conservancy oversaw the GIS analysis and cartography work, with assistance from Bruce Gerbig. Ryan Drum and Diane Granfors from the USFWS Habitat and Population Evaluation Team Office provided the corridor pathway analysis. Sean Fields from the USFWS Prairie Pothole Joint Venture provided the Conservation Reserve Program data analysis. Most of the basic data used in this plan was developed by the Minnesota Department of Natural Resources, especially the Minnesota Biological Survey.

Foreword

Grass Is Immortal

John J. Ingalls (1833–1900), U.S. Senator 1873–1891

Lying in the sunshine among the buttercups and dandelions of May, scarcely higher in intelligence than the minute tenants of that mimic wilderness, our earliest recollections are of grass, and when the fitful fever is ended, and the foolish wrangle of the market and forum is closed, grass heals over the scar which our descent into the bosom of the earth has made, and the carpet of the infant becomes the blanket of the dead.

Grass is the forgiveness of Nature—her constant benediction. Fields trampled with battle, saturated with blood, torn with the ruts of cannon, grow green again with grass, and carnage is forgotten. Streets abandoned by traffic become grass grown, like rural lanes, and are obliterated. Forests decay, harvests perish, flowers vanish, but grass is immortal.

Beleaguered by the sullen hosts of winter, it withdraws into the impregnable fortress of its subterranean vitality, and emerges upon the first solicitation of spring. Sown by the winds, by wandering birds, propagated by the subtle horticulture of the elements, which are its ministers and servants, it softens the rude outline of the world. Its tenacious fibers hold the earth in its place, and prevent its soluble components from washing into the wasting sea. It invades the solitude of deserts, climbs the inaccessible slopes and forbidding pinnacles of mountains, modifies climates, and determines the history, character, and destiny of nations.

Unobtrusive and patient, it has immortal vigor and aggression. Banished from the thoroughfares and the field, it abides its time to return, and when vigilance is relaxed, or the dynasty has perished, it silently resumes the throne from which it has been expelled, but which it never abdicates. It bears no blazonry of bloom to charm the senses with fragrance or splendor, but its homely hue is more enchanting than the lily or the rose. It yields no fruit in earth or air, and yet should its harvest fail for a single year, famine would depopulate the earth.

Hole-in-the-Mountain Prairie © Justin Meissen

A Vision for the Future of Minnesota's Prairie Region

Minnesota lies mid-continent at the intersection of North America's prairie, eastern broadleaf forest and boreal forest/peatlands. Prairie habitats once covered one-third of the state, but little more than 1% of this habitat remains. Across the globe, temperate grasslands are the most threatened and least protected major habitat type.

Native prairie, other grasslands that provide habitat for native species, wetlands, lakes and streams are key components of functional prairie landscapes that can adapt to changing environmental conditions. These functional landscapes are dominated by grasslands and wetlands that support sustainable populations of fish, wildlife and native plants at the same time that they contribute to the economy.

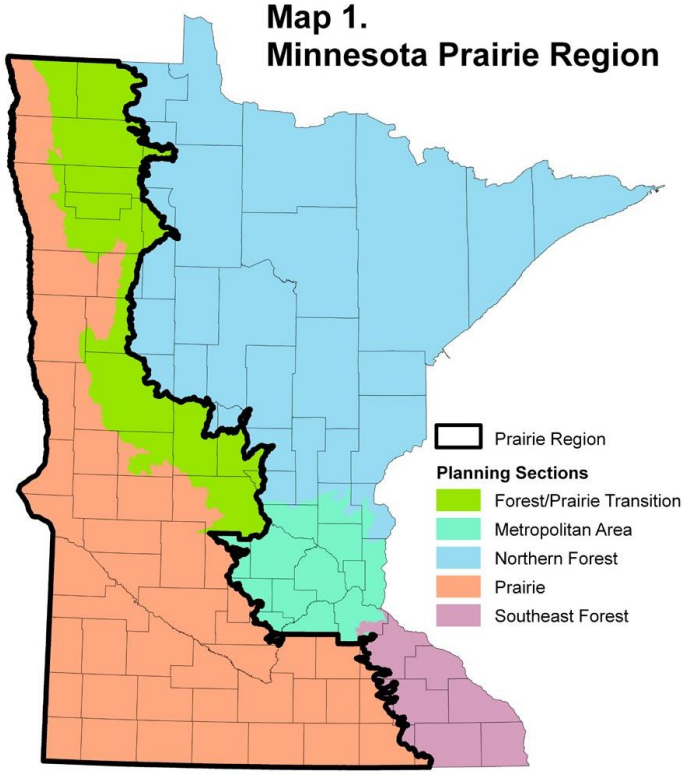
Agricultural uses continue to dominate the Prairie Region. Protecting the remaining native prairie and associated habitats, reconstructing additional grasslands, expanding perennial crops and implementing more conservation practices will make agriculture in these areas more sustainable and will enhance existing wildlife habitat. In strategic locations, large areas of prairie, grassland, and associated habitats should be protected and restored to create functioning prairie systems that provide major opportunities for sustainable grass-based agriculture, such as grazing and hay production. These functioning landscapes will also contribute toward clean water, fish and wildlife habitat complexes, high-quality recreational opportunities, and thriving rural communities where Minnesotans will want to live and visit.

Purpose of a Minnesota Prairie Landscape Plan

With the passage of the Clean Water, Land, and Legacy Constitutional Amendment in 2008, Minnesotans placed a new emphasis on conservation. The organizations that created the Prairie Plan strongly believe that unified efforts will result in more effective and efficient conservation. Strategic coordination will prevent potential duplication of efforts, missed opportunities, and the confusion that could stem from conservation entities pursuing their own plans independently. The development of this plan has also strengthened working relations between the partners and builds on past efforts coordinating prairie, wetland and wildlife conservation. This plan has a 25-year timeline, starting in 2008, and spans a geography that includes the Prairie and Forest/Prairie Transition Planning Sections employed by the Lessard-Sams Outdoor Heritage Council (Map 1). The eastern portions of the Prairie Region coincide with the well-known Prairie/Forest border, an ecologically dynamic part of the state. Over the course of human history, this border has almost continuously fluctuated in vegetation composition, making it a "shifting mosaic," due to the various interactions of topography, water bodies, weather events, fire and major climate shifts. A portion of this Prairie/Forest border contains substantial forest habitats that are not explicitly addressed in this plan.

This plan primarily focuses on prairie landscapes. Within those landscapes, native prairies are the most endangered habitat type and thus are the highest priority for immediate protection. Other grassland, wetland and associated prairie habitats throughout the Prairie Region of Minnesota are also covered in the plan. Associated habitats include the savanna, woodlands, parklands and brush prairies that characterize the transitional border and that were often mapped as prairie complexes by the Minnesota Biological Survey (MBS). This Prairie Plan does not address the 17,802 acres of native prairie that occur mostly in the Southeast Forest and Metro Regions of Minnesota. These prairies are unquestionably important habitats, but with the exceptions of the Anoka Sandplain and dunes along the Mississippi River, they are best viewed as inclusions within a forested landscape. As such, they should be included in the planning efforts for those regions of Minnesota. We hope that these efforts will incorporate the concepts set forth in this plan.

Map 1.
Minnesota Prairie Region



The Prairie Plan includes spatially explicit recommendations for protecting, enhancing and restoring Minnesota's prairie heritage, with detailed acreage goals and realistic budgets for sustaining functional systems. The plan is meant to complement and supplement the efforts of all conservation partners, including the Lessard-Sams Outdoor Heritage Council, to more effectively direct activities and funding for prairie conservation.

Prairie and Grasslands in Minnesota

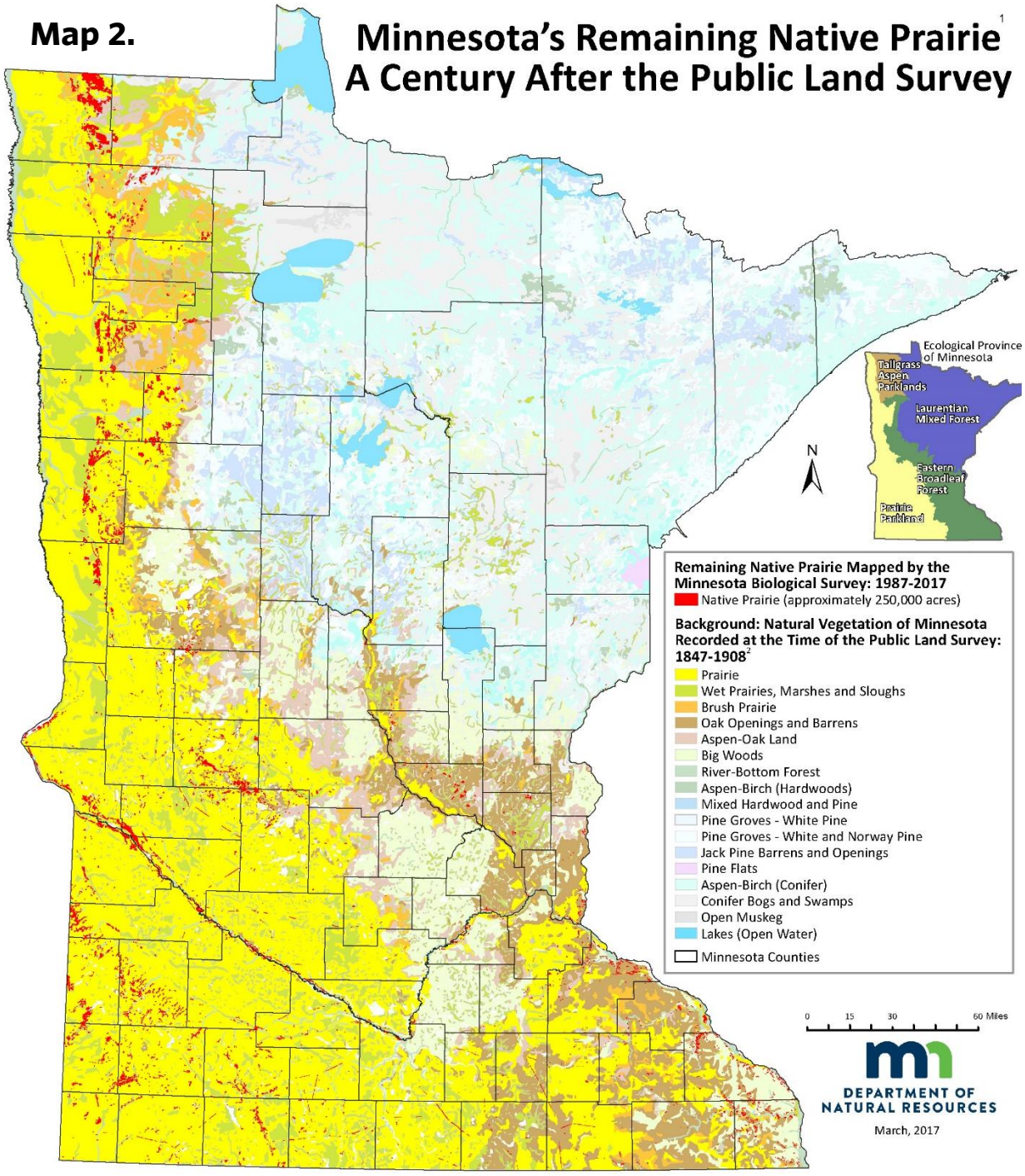
Tallgrass prairie once covered about one-third of Minnesota, or approximately 18 million acres, as shown in yellow on Map 2 (Marschner, 1974). The soil developed by prairie plants over thousands of years is now the basis of Minnesota's rich agricultural economy. Over the last 160 years, the landscape has been largely converted to row crop agriculture. Most of the prairie and associated habitats are now gone, along with the bison, elk and other key species that were integral to the functional prairie system.

Native prairies are defined here as unplowed plant communities originating on the site and dominated by grass and sedge species, with a rich mix of broad-leaved herbs and a few low shrub species. Since 1987, the Minnesota Department of Natural Resources' Minnesota Biological Survey has recorded the locations of native prairie and other native plant communities in the state. Map 2 shows (in red) the 248,663 acres of remaining native prairie and prairie complexes statewide (Minnesota Biological Survey, 2017a). Only about 128,000 acres of these areas are protected through conservation ownership or with a conservation easement.

In addition to native prairies, Minnesota also has substantial other grasslands of various origins. In the past, some prairies were modified by spraying with broad-leaf herbicides and/or overseeding with cool season grasses in hopes of increasing the pasture value for cattle. The result was floristically impoverished grassland dominated by a few species of grass. In other places, before the benefits of managed grazing were recognized, prairies were so heavily overgrazed that most of the native species were destroyed and replaced with a few hardy native species and a host of non-native invasive plants. Still other prairies were plowed to grow row crops but were then allowed to "go back" to perennial pastures. In fields that were only plowed for a few years, many native plant species survived or re-established themselves through the surviving seed bank. After several decades, these regenerated prairies are very similar to native prairie that has seen prolonged heavy use and degradation.

In addition to the grasslands that were derived from native prairie, described above, an even larger area was cropped for decades prior to being planted back to grassland. A substantial portion of the current grassland area is enrolled in the Conservation Reserve Program (CRP). This U.S. Department of Agriculture program pays farmers to retire highly erodible or environmentally sensitive cropland for 10–15 years, during which it is planted to grassland or trees. Some of the land was planted with native grass species and is important habitat for pheasant and other wildlife species. In 2015, approximately 893,000 acres were enrolled in CRP in the Prairie Region of Minnesota and about 1,041,000 acres were enrolled statewide (Minnesota Board of Water and Soil Resources, 2015). Of the Prairie Region acreage, about 860,000 acres were grassland habitat and another 31,000 acres were wetland (Fields, 2016).

In total, there were 4,455,584 acres of non-native prairie grassland in CRP fields, pasture, hayfields, roadways, railroads and other land uses in the Prairie Region of Minnesota, as delineated by the 2001 National Land Classification Data and modified by the USFWS Habitat and Population Evaluation Team (HAPET). In addition to the grasslands, there are 1,320,791 acres of existing wetlands in the Prairie Region that often grade into grasslands with indefinite boundaries.



Functioning Prairie Systems

To date, Minnesota's efforts to conserve prairie have consisted mainly of purchasing native prairie parcels and wetlands to add to a Wildlife Management Area (WMA), Scientific and Natural Area (SNA), State Park, Waterfowl Production Area (WPA), National Wildlife Refuge or Nature Conservancy Preserve. The state, federal government, and conservation organizations have achieved permanent protection of some of the state's highest quality native prairies and associated habitats (see Table 1). For example, WMAs contain 67,733 acres of native prairie. To the extent that land managers can control woody plant expansion and invasive species, small prairie parcels can serve as reservoirs of biological diversity. However, these protected prairies are often too small and isolated to be functioning prairie systems that can permanently maintain most prairie animal populations and ecosystem services.

There is no standard definition of a functioning system. Different priorities emphasize different features, but the following list includes the attributes that the authors of this Prairie Plan recognize as key parts of a functioning prairie system.

Biological Attributes of a Functional Prairie System

1. Supports moderate to high diversity of vegetation types and native species within predominantly native prairie and associated habitats
2. Maintains viable populations of prairie landscape-dependent fauna and flora
3. Is large enough to support animal species that have large home ranges or require a variety of different habitat types throughout their life cycle (e.g., greater prairie-chicken, American badgers, many amphibians)
4. Provides connectivity between grassland sites for plant and animal populations by facilitating movement and gene flow, including for species with relatively low capacity for movement
5. Links upland and wetlands for animals that utilize both habitats
6. Has a disturbance regime (e.g., fire, grazing, changing water levels)
7. Represents grasslands and wetlands with different histories of fire and grazing and different lengths of time since disturbance (different successional stages)
8. Contains a complex of different habitat types, including savannas, brush prairie, groundwater seepages, and a variety of wetlands ranging from temporary wetlands to shallow lakes
9. Exhibits ecosystem stability, adaptability and resilience to environmental change

Physical Attributes of a Functional Prairie System

1. Cycles, transforms and stores elements and nutrients (e.g., carbon, oxygen, nitrogen, phosphorus)
2. Transfers energy between trophic levels
3. Filters and stores water
4. Anchors and builds soil

The physical attributes of prairie systems can be a main selling point for the maintenance and restoration of functional prairie systems. There are substantial public benefits to intact systems, including reduced sedimentation rates, improved water quality, reduced peak run-off events, and enhanced ground-water recharge.

Disturbance Regimes in Landscapes: Prairie landscapes need regular disturbance. Without disturbance, most grasslands, prairies and some wetlands in Minnesota would rapidly transition into woodlands and forest. Prior to European settlement, fire, grazing by large herbivores and drought were the disturbances that maintained the prairies. The time of year the disturbance occurs, its intensity and the time between disturbances are all critical in determining the plant community that will occur in any area (Minnesota Department of Natural Resources, 2005). Altering these factors can cause great variation in the structure and composition of grasslands.


Controlled fire © Chris Helzer/TNC

The goal of landscape-scale management is to maintain the full range of community types, structures and successional stages in the prairie landscape. This means that a diversity of management practices should be applied at different times and places within the landscape.

The large-scale disturbances that maintained prairies in the past are no longer practical today. Large herds of free-roaming bison are gone, and for the safety of people and property, wildfires cannot be allowed to burn across large areas. However, well-managed cattle grazing can approximately replicate some of the effects of bison grazing. Likewise, prescribed fire, mowing or haying can offer many of the benefits of wildfires, while reducing the risks and negative impacts.

Historically, there was a strong interaction between fire and grazing. Fire clears dead and senescent vegetation, volatilizes nitrogen, warms the soil, increases the amount of light close to the ground and increases rainwater percolation (Seastedt & Ramundo, 1990). Nutrients are also released back to the soil where they are incorporated into new plant growth. The new growth typically is more palatable to grazers because of its succulent nature and higher protein content.

Both fire and grazing in pre-European settlement times were disturbances that were followed by a rest period when the vegetation had time to recover. When herds of bison moved through an area, grazing pressure could be intense, but this time was usually followed by a period of light or no grazing for over a year. In the past, fire burned most prairies in Minnesota every three to six years, on average (Collins, 1990), with recovery periods in between. This sequence of disturbance and recovery is key to maintaining a healthy prairie ecosystem.

Grazing and fire also play important roles in maintaining the diversity and productivity of wetlands. Without disturbance, marshes across much of Minnesota's prairie region have become choked by invasive narrow leaf and hybrid cattails, phragmites and reed canary grass. Grazing in these marshes can increase the amount of open water and bare soils, elements that are required by waterfowl and shorebirds.

Drought is another important environmental factor that shaped the nature of grasslands and wetlands. Only species that could survive drought conditions endured in natural communities over time. Droughts alone were not enough to maintain treeless prairies in Minnesota, but coupled with fire they had a profound effect on the structure and composition of grasslands.

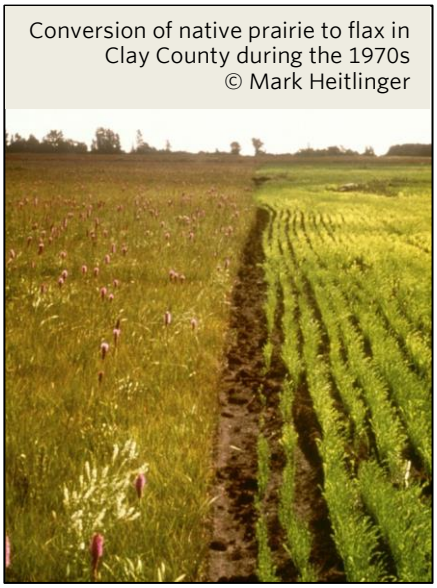
Wetlands, too, are affected by drought cycles. Their quality and ecological productivity is driven by changing climatic conditions. Periodic water level draw-downs play a critical role in some wetlands in maintaining the diversity of vegetation that is most beneficial to prairie wildlife.

Size of Landscapes: We don't know how large a prairie landscape must be to maintain ecosystem function and viable prairie animal and plant populations. Many of the attributes listed above are likely to be functional at different scales. For example, even small parcels of grassland can cycle nutrients and may maintain viable populations of some plant and small animal species. However, larger areas are necessary to retain natural hydrology and support viable populations of larger animals. Wild populations of large herbivores, such as bison and elk, and predators, such as prairie wolves, are now largely gone from Minnesota's prairie, and this plan does not propose to re-establish them. However, it may still be possible to maintain mid-size carnivores, such as American badgers, burrowing owls and short-eared owls, as well as other area-dependent species, such as the greater prairie chicken and sharp-tailed grouse.

Work at Glacial Ridge National Wildlife Refuge, the largest prairie restoration in Minnesota, showed that when re-creating prairie landscapes, it is best to build from concentrations of existing prairie remnants. The Minnesota Statewide Conservation and Preservation Plan (Swackhammer, Coleman, & Shardlow, 2008) recognized this with its first habitat recommendation to "restore ecoregion-appropriate, landscape-scale complexes of habitat centered on concentrations of existing remnant habitat."

Threats to Prairie Systems in Minnesota

Across the original tallgrass prairie region, the native landscape is almost completely gone. Illinois, Indiana, Iowa and Wisconsin have all lost 99.9% of their prairies, largely due to the conversion to row-crop agriculture (Samson & Knopf, 1994). Minnesota has fared marginally better but still has lost more than 98% (Minnesota Biological Survey, 2017a).



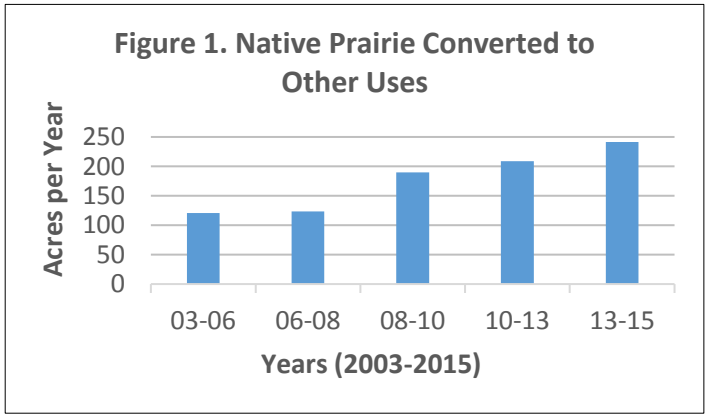
Conversion of native prairie to flax in Clay County during the 1970s
© Mark Heitlinger

The wetlands in Minnesota's Prairie Region have declined nearly as much as the prairies. The 49 counties found in the Prairie Region have lost an average 91.9% of their original wetlands (Anderson & Craig, 1984). Of these counties, 28 have lost at least 97.5% of their wetland area. Wetland quality has also declined. Based on a survey of invertebrate communities, 47% of the remaining wetland basins in the Temperate Prairie Ecoregion of Minnesota are in poor condition (Minnesota Pollution Control Agency, 2009).

There are eight primary threats to the remaining native prairie and associated habitats in Minnesota.

1. ***Land conversion, development and mining***

According to the Minnesota Biological Survey, 4,248 acres of the private land in Minnesota that was high-quality native prairie or savanna was converted to other uses between 1987 and 2015 (Minnesota Biological Survey, 2017b). Over the past 15 years, the amount converted per year has been increasing (Fig. 1). Nearly 62% of the loss statewide was to cultivation, 25% to development, 12% to mining and 1% to other uses. In some areas, housing may be as great a threat as agricultural conversion because many remaining prairies are on hilltops or other scenic areas that are valued by developers.



A similar threat is the loss of prairie and associated habitats to mining, sand and gravel removal or boulder extraction for landscaping. Some prairies survived agricultural conversion only because they were too rocky or sandy to be farmed profitably. Now the same geologic resources that protected the prairie are themselves the reason for the land's conversion, as aggregate demand continues to grow.


Plowed wetland near Paynesville, MN
© Steve Chaplin/TNC

Associated with agricultural production are the effects of drainage on seasonal and temporary wetlands, sedge meadows, wet prairies and other wet-mesic habitats. These habitats were difficult to farm in the past, but new drainage technologies and materials have made it more feasible to drain them. The increased installation of subsurface drain tile on agricultural land improves crop yields but can also disrupt local groundwater recharge/discharge patterns that are responsible for maintaining wet and wet/mesic prairies (Blann et al., 2009). Direct discharge from drain tile to wetlands disrupts natural hydrologic regimes, adversely affecting native plant communities and compromising the habitat value of prairie-wetland complexes. In some parts of the state, the expansion of pattern tile drainage, while expected, has been dramatic. One example is the Bois de Sioux watershed, where over 15,000 miles of new tile was installed between 2000 and 2016 (Bois de Sioux Watershed District, 2016).

2. Invasive species

Minnesota's native prairies and associated habitats are beset by a host of invasive plant species, such as smooth brome, reed canary grass, leafy spurge, various thistles, sweet clover, hybrid cattail, invasive phragmites and many others. These species often outcompete native plants, and efforts to control them with spraying and mowing can damage native plants. The most pervasive invasive plants on drier prairies in Minnesota are smooth brome and Kentucky bluegrass. On the wetter prairies, reed canary grass takes their place. Near monocultures of each of these three species often occur, and native wildflowers disappear. Not only are there fewer flowering plants, but there are fewer flowers per plant on those that remain. The impact on pollinators is yet to be fully determined, but recent surveys have shown that native bee and butterfly populations are declining throughout Minnesota.

Another issue of concern in Minnesota is the accidental planting of noxious weeds during grassland restoration. Palmer amaranth was first discovered in the state in 2016, in plots planted with a contaminated conservation seed mix (Minnesota Department of Agriculture, 2017). This species could have a devastating impact on soybean yields and also has the potential to impact pastures and other grasslands. Care must be taken to prevent the introduction or movement of invasive plants during management or restoration.

In addition, invasive animals can be major threats to prairie systems, especially in wetlands and shallow lakes. These systems often occur in one of two trophic states: one characterized by clear water and an abundance of rooted aquatic plants, the other characterized by turbid water with large amounts of algae (phytoplankton) and few

rooted aquatic plants. The clear-water state is heavily utilized by waterfowl and other wildlife species. Basins in either of these states tend to be stable, but can and do switch states in response to perturbations. Invasive fish (such as non-native common carp and native fathead minnows) can drive wetlands and shallow lakes to the turbid state (Norris, 2007).

3. Unmanaged grazing practices

Throughout Minnesota, many grasslands are subject to season-long stocking of cattle at moderate-to-heavy densities. This regimen results in a relatively uniform, low grass height and leaves relatively little tallgrass habitat. Continual overgrazing by cattle also lowers native plant diversity, increases the potential for erosion, and increases the landscape's susceptibility to invasive species. This is particularly true when cattle selectively choose native plants and the land is repeatedly grazed without a rest period allowing for recovery. In contrast, rotational grazing with substantial rest periods can simulate the grazing patterns once provided by large bison herds and may enable conservation disturbance goals to be met while supporting a local grazing industry.

4. Woody plant encroachment

Trees change the very nature of the open prairie landscape. Under a pre-settlement fire regime, the extent and distribution of most woody species was naturally limited in native prairies. However, fire suppression and inadequate prescribed fire allowed woody plants to survive and sometimes to dominate portions of the prairie habitat. Extensive research shows that many species of grassland specialist birds avoid nesting near trees (Bakker, 2003), including native (e.g., eastern red cedar, cottonwood, aspen, boxelder) and nonnative (e.g., buckthorn, Siberian elm) species. Trees form perches for predators such as hawks, owls or crows, and the bases of trees form den sites for nest predators such as raccoons, skunks and foxes. The limited amount of prescribed burning that is done today is not enough to keep unintended trees in check. In many cases, woody vegetation must be removed by hand, which is expensive, or by mechanical equipment.

In addition to invading prairies naturally, trees are planted to provide wildlife habitat and windbreaks. To counter the adverse effects of inappropriate plantings, the Natural Resource Conservation Service has developed recommendations to guide tree and forest establishment and management in Minnesota's Prairie Region (U.S. Department of Agriculture, 2013).

5. Energy development

Economic incentives often motivate the installation of wind turbines in grassland areas, as they have lower real estate value. In addition, steeply sloping, rocky moraines, where many prairies are found, often provide the best local wind conditions. Turbines are potential risks to wildlife in four ways:

1) Collisions with turbines can result in direct mortality of birds and bats (Leddy, Higgins, & Naugle, 1999; Osborn et al., 2000; Arnett et al., 2008).

2) Their presence can deter some grassland species from utilizing nearby nesting habitat that is otherwise of high quality (Pruett, Patten, & Wolfe, 2009).
3) They require access roads and activity that can disturb wildlife and habitats.
4) Turbines and related infrastructure can complicate or prevent the use of prescribed fire as a management tool.

The use of native prairie and grassland as a source of biomass and feedstock for energy production can pose a threat if grasslands are harvested too heavily or at inappropriate times. Wildlife, especially ground-nesting birds, can be negatively affected. In addition, newly created grasslands that are planted for bioenergy production as monocultures (switchgrass) or with inappropriate species (elephant grass) can be "sinks" for wildlife populations. These areas attract some wildlife species because they appear to have appropriate habitat structure, but they are unsuitable because they lack food or other key resources that the species needs to survive or breed successfully. Energy plantings may also introduce inappropriate ecotypes that are bred for maximal yield production at the expense of other adaptive traits. Pollen from these ecotypes can be blown into surrounding local populations of the same species and contaminate them. Despite these potential issues, appropriately managed energy development can provide additional grassland wildlife habitat as well as generating revenue for local economies.

6. Climate change

The Prairie Region of Minnesota is expected to become warmer, to have higher evapotranspiration rates, and to experience shifts in precipitation in the next 50 years (Johnson et al., 2005, 2010; Galatowitsch, Frelich, & Phillips-Mao, 2009; Runkle et al., 2017). Temperatures are projected to rise 2–6°F by 2050 and 5–10°F by 2100 (Pryor et al., 2014). The most likely scenario will be a disruption of climate, leading to more extreme weather, especially widespread drought and heat waves. Precipitation will come as more intense, local storms, and some areas will experience heavy rain and flooding, while others will face severe drought and higher risk of wildfires (Interagency Climate Adaptation Team, 2013). Each prairie species will react differently to the changes. Some will be able to withstand the new conditions, but others will not.

7. Nutrient overload

A growing threat to prairies is the increased amount of biologically active nitrogen entering prairie systems from the air. There are now large regions of the world where average rates of nitrogen deposition are more than an order of magnitude higher than they would have been in the absence of human influence (Galloway et al., 2008). Chronic increased nitrogen, even at low levels, reduces native prairie species (Clark & Tilman, 2008) and increases non-native weeds and pasture grasses (Wedin & Tilman, 1996).

Nutrients appear to be more of a threat in prairie wetlands and aquatic systems than in upland prairies. Nitrogen and phosphorus enter prairie aquatic systems not only from aerial deposition but also in runoff from surrounding agricultural areas. Nutrient inputs

can cause significant degradation in wetlands and lakes, leading to species loss and increased susceptibility to invasive species (Van der Valk, 2005).

8. Insecticides and herbicides

Although synthetic pesticides have been environmental concerns since at least World War II, when DDT was first used extensively, the environmental impact of many insecticides and herbicides is still not understood. This is especially true when multiple different pesticides interact at low levels simultaneously. The populations of some prairie-obligate insects are declining in Minnesota and we do not know precisely why. For example, the Poweshiek skipperling (*Oarisma poweshiek*) and the Dakota skipper (*Hesperia dacotae*) are small butterflies that could be reliably found on many Minnesota prairies until 2003. Between 2003 and 2009, the Poweshiek skipperling disappeared completely from the state and the Dakota skipper became restricted to a single small population. Some biologists believe that a new class of insecticides, the neonicotinoids, may play an important role in the decline of these species and other pollinators (USFWS, 2014), but the level of impact and source of exposure still needs to be determined. Another potential cause of decline is drift from the aerial application of organophosphates and pyrethroids. These chemicals are widely used to control the invasive soybean aphid, which arrived in Minnesota around 2004 (Rundquist & Heimpel, 2017).

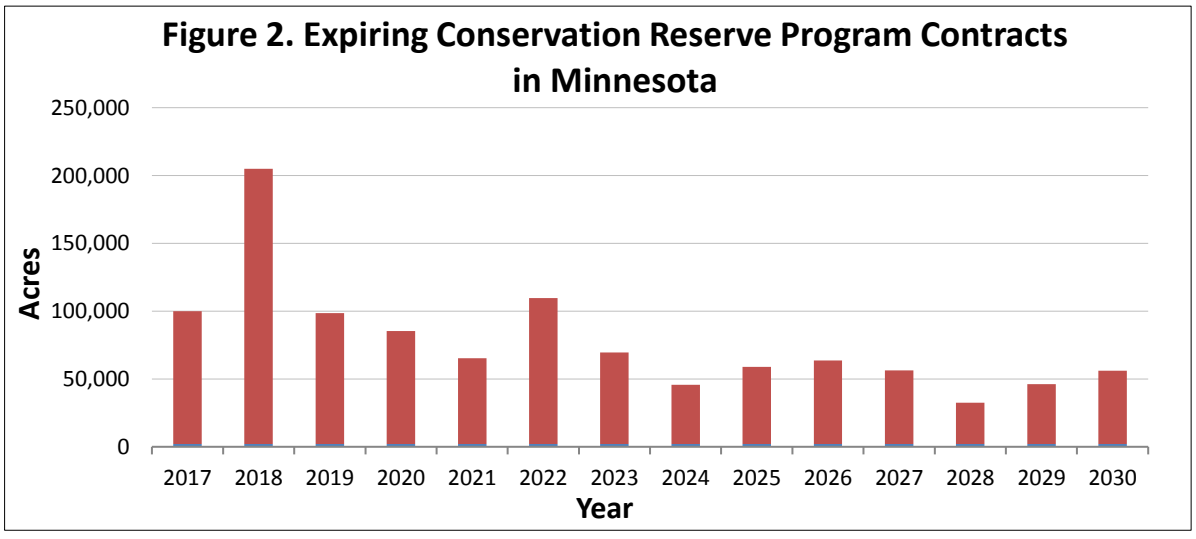
Agriculture and Prairie Landscape Conservation

The nature of agriculture in the United States has been greatly influenced by federal policy. For at least the last 70 years, the U.S. Department of Agriculture has maintained a stable and inexpensive food supply by supporting the production of corn, soybeans and a few other commodity crops. This policy was born out of the need to provide agricultural products to a growing nation. Today, the increasing global demand for U.S. agricultural products continues to drive policies that support a stable supply of commodity crops. As a result, land use has been driven toward production of those crops and away from livestock grazing and other uses.

Policies that bolster commodity crop production can have unintended consequences. For example, native prairie was plowed so that the land could be enrolled in federal farm programs, an activity known as "sodbusting" that had dramatically negative consequences for prairie plants and animals (and that is now somewhat restricted). Federal farm policy has also altered markets in other ways. Having a safety net for commodity crops encouraged farmers to plant more acres to these crops, and steep increases in crop productivity and efficiency have also contributed to an increased grain supply, driving prices down. Low prices make it more economical to use grain for livestock feed and put producers of grass-finished livestock at a disadvantage.

Starting in the 1950s, federal spending partially shifted from commodity production to conservation programs. The CRP alone has been responsible for greatly increasing the amount of grassland in Minnesota. Other federal programs such as the Conservation Reserve Enhancement Program (CREP), the Conservation Stewardship Program (CSP), the Environmental Quality Incentives Program (EQIP), the Agricultural Conservation Easement Program (ACEP), the Water Bank Program (WBP), and state programs, such as Reinvest in Minnesota (RIM) and Native Prairie Bank, have contributed to the protection and restoration of wetlands and grasslands. We hope the scope and effectiveness of these programs in prairie landscape conservation will continue or increase in the future.

However, there are two reasons to be concerned about the future of lands enrolled in CRP, the largest farm program in Minnesota. When commodity prices are high, as they were between 2006 and 2008, there is strong pressure to remove land from conservation programs and convert it back to crop land. Figure 2 shows the potential maximal loss of CRP lands in Minnesota for the period 2007–2020 (U.S. Department of Agriculture, 2010). A second problem is the decline in funding for the CRP program nationally, which has resulted in lower program enrollment caps. When the CRP was created in 1985, the enrollment was 37 million acres nationally, but the cap was reduced to 32 million acres by 2008, and then 24 million acres by 2017. Minnesota's CRP enrollment followed a similar pattern, from a high of 1.83 million acres in 2007 to 1.15 million acres in 2016. Most of the acres that have been lost from the program in Minnesota were planted grassland that had important value for wildlife. To stabilize and possibly reduce the loss of grasslands in the future, Minnesota needs to encourage the continuance and expansion of federal farm program funds (and acres) and provide state funds as an incentive for farmers to invest in long-term grassland and wetland protection.



Multifunctional Landscapes: An Economic Strategy

Agriculture has been and will continue to be focused on providing food and fiber for a growing human population. It is, however, increasingly expected to provide a suite of non-traditional services, including energy production, surface water purification, floodwater retention, sequestration of carbon and maintenance of healthy wildlife habitats. To accomplish all of these concurrently requires a shift in our approach to agricultural production.

One strategy that strives to accomplish these goals while maintaining the economic vitality of rural communities is referred to as multifunctional landscapes (Boody et al., 2005) or ecoagriculture (Scheer & McNeely, 2008). Multifunctional landscapes go beyond the implementation of traditional best management practices for agriculture by fully integrating agriculture, conservation, and rural communities to maximize the ecological and economic potential within a landscape.

Within Minnesota's Prairie Region, there are several opportunities for multifunctional landscapes. One potential approach is to increase the use of cover crops to reduce erosion and minimize the need for nutrient application. A second potential approach is to diversify crop rotations to include more acres of traditionally planted perennials, such as alfalfa; annual small grains, including wheat, oats and barley; and perennials that are currently grown as annuals, such as wheat, flax and sunflower. These changes and others can create more diverse cropping systems and improved habitat for wildlife.

Blann (2006) and others have identified the ideal multifunctional landscape system as one that closely mimics the structure and function of natural systems. In the prairie region, the industry that is best positioned to achieve this ideal is livestock production designed to mimic the activities of bison and other wildlife during pre-European settlement times. In areas of the world where large areas of native grasslands have survived, it is usually because local residents can earn a greater net return from grazing livestock than they can by tilling and annually planting the land. As the demand for U.S. agricultural products rises, coupled with the development of increasingly drought-resistant crop varieties, farmers face increasing pressure to convert existing grasslands to crops. However, this trend could be reversed if farmers could benefit more by utilizing marginal cropland to raise livestock than by continuing the necessary high input costs required to maintain production of row-crop agriculture on marginal lands.

Surveys of current and beginning farmers show that access to available pasture or hayland, affordable tillable land and capital are primary barriers to expanding or starting a livestock business. The additional costs of restoring land to make it suitable as range lands and pastures make entry into this sector difficult (Stettler, 2010). To a great extent, this situation is a direct result of federal farm policy, as safety nets and support programs are inadequate to justify large up-front costs or to qualify for needed

financing. New or expanded grazing operations could support rural economies while accomplishing the ecologically necessary functions of the land management.

Protection and restoration of prairie and wetland systems that contribute to both economic viability and ecological function is conceivable through innovative partnerships with agricultural producers, local communities, private organizations and government. Public and private conservation funding and grazing opportunities on conservation lands can be the catalyst to make this happen. No other factor plays a greater role in the creation and maintenance of prairie landscapes than the profitability of private and leased public grasslands.

Cattle on native prairie at Sheepberry Fen © Susan Chaplin

Conservation Strategies for Prairie Landscapes

The strategy for achieving functional prairie systems involves protecting, restoring and enhancing the land, as follows.

1. **Protect** the native prairie and prairie complexes, selected other grasslands and associated habitats such as wetlands, riparian areas along streams and shallow lakes. The Minnesota Biological Survey has identified some 248,663 acres of native prairie. The goal should be to protect and sustain all of these remnants through either ownership by a public or private conservation organization or a conservation easement on private lands. About 117,000 acres of native prairie are owned by conservation organizations, and another 13,000 acres are protected with conservation easements (Table 1). The remaining 119,000 acres of native prairie statewide have no legal protection.

Table 1. Acres of Native Prairie Protected Statewide. All overlap in protection has been removed.

	Owned	Easement	Total
State Park	6,178	0	6,178
Wildlife Management Area	67,576	0	67,733
Scientific and Natural Area and Native Prairie	6,133	6,028	12,161
U.S. Fish and Wildlife Service Refuge and Waterfowl Production Area	17,516	4,046	21,702
Board of Water and Soil Resources (Reinvest in Minnesota Reserve program)	0	2,036	2,036
The Nature Conservancy	19,279	59	19,877
Natural Resources Conservation Service (Wetlands Reserve Program)	0	616	616
TOTAL	**116,682**	**12,785**	**129,467**
Percent of Statewide Total	46.9%	5.1%	52.0%

In addition to protecting native prairie from conversion, it is necessary to retain some percentage of the non-prairie grasslands in the state (degraded prairie or planted grasslands) as grasslands permanently. Part of the permanent grassland will need to be fee title or easement ownership by public agencies and conservation organizations, but a larger share can be continuously enrolled within temporary contracts such as the Conservation Reserve Program (CRP).

2. **Restore** landscapes by connecting and buffering the native prairie and other protected habitats. Even if all native prairies in Minnesota were protected and managed properly, there would still be insufficient habitat for the long-term survival of some

prairie habitat–specialist species. Where there is insufficient grassland, the habitat should be reconstructed.

In areas with high concentrations of native prairie, most of the restoration will buffer and connect the remnant native prairie, but outside these areas, more of the restoration will be in areas where there are no prairies nearby. Although the quality of prairie restoration will depend on funding, expertise, and site characteristics, the goal is for the land to meet the Minnesota legislative definition of restored prairie. Minnesota Statute 84.02 calls for planting at least 25 representative and biologically diverse native prairie plant species. The outcomes of restoration need to be assessed, documented, and if necessary corrected, using an adaptive management framework.

Restoration should include previously drained and filled wetlands in association with grasslands and other surface water features. Wetland restoration should help establish wetland complexes that range in water permanence. The impact of climate change is likely to be particularly severe on ephemeral and seasonal wetlands. Wetland types that have decreased the most from their historical distribution need particular attention.

3. **Enhance** natural disturbance regimes on Minnesota's native prairie. As fires and grazing were fundamental components of the prairie system historically, both prescribed fire and grazing management must be expanded and improved. The use of livestock grazing or haying to approximate these disturbances may be acceptable for some prairies and other habitats, with proper planning, management and monitoring. As more prairies and wetlands are protected and restored, the collective capacity to conduct management activities, including prescribed burns and draw-downs, must be expanded. For example, if each acre of native prairie is burned every four years, the annual burning goal for existing native prairie alone would be 62,000 acres. This number would be dwarfed by the prescribed burning needs of restored prairie and grasslands if they were all brought into a regular burn rotation.

Associated wetlands will also require active management to regain habitat quality. Intensive water level management, burning or grazing may be needed, depending on the condition of the wetlands. Shallow lakes with degraded watersheds and invasive fish will require investments in fish barriers, water level control structures and active management.

The collective knowledge of management activities in Minnesota also needs to improve. New techniques such as "mob grazing" (short-duration, high-intensity rotational grazing), restoring seasonal flooding regimes and biofuel harvest need to be tested to determine their effectiveness, cost and impact on native plants. We also need a better understanding of how to manage prairies for prairie obligate insects. For example, we need to know how much buffering is needed to create areas that are protected from pesticides, how much land is safe to burn, and whether disturbance alternatives to fire will enhance insect populations.

Three Approaches for Targeting Prairie Conservation

The protection, restoration and enhancement of the remaining native prairie, grasslands, and associated wetlands of Minnesota (along with their full range of native animals and plants and geographical diversity) will require a three-pronged conservation approach.

Prairie core area–based conservation: Species and ecosystem processes that require large expanses of perennial grasslands can be conserved only in areas of suitable size, composition and quality. To reach the minimum critical area needed to maintain species and processes, most landscapes will need some restoration to buffer and reconnect the remaining prairie fragments. The goal is to create functioning prairie systems that retain the capacity for evolutionary adaptation in the face of environmental change.

Corridor-based conservation: Core areas need to be connected to enable the interchange of plants and animals, and to provide pathways for species to seek refuge in times of stress or environmental change. Strategically located grassland/wetland complexes within the corridors can provide stepping stones between the larger prairie core areas.

Local conservation: If conservation activities are restricted to areas with relatively high concentrations of native prairie, large areas of Minnesota, especially in the southern and central portions of the state, will be left unprotected. This scenario is undesirable for two principal reasons:

1. Prairie animals and plants throughout the state are adapted to their local environmental conditions. There are important geographical differences in the genetic makeup of populations in different parts of the state. To conserve this geographic genetic diversity, we need to protect populations throughout the state. Although we may never be able to recreate prairie habitats on the scale of thousands of acres in some parts of Minnesota, we can protect good examples of smaller prairie and wetland parcels. Some of these parcels may be less than a hundred acres in size, but they still constitute an important reservoir of local biodiversity and ecotypes of the species that are found there.

2. An important aspect of conservation is the provision of recreational opportunities. Minnesotans are most likely to use conservation lands for hunting, wildlife viewing and other types of outdoor recreation if the lands are located near their homes. Prairie-based conservation in every county within the Prairie Region of Minnesota would provide grassland-oriented recreation in all parts of the state where native prairie once dominated.

Prairie Conservation at a Glance

Core Areas

- 28 large areas (10,000–370,000 acres) that retain some features of a functioning prairie landscape and include 77% of Minnesota's remaining native prairie habitat
- Function as a habitat base for wildlife species that need large areas of grassland/wetland habitat
- Goal: Each core area should include 40% grassland and 20% wetland, with permanent protection of at least 50% of that land

Corridors

- Linear stretches of habitat 6 miles wide that connect core areas and moderate the effects of a highly fragmented landscape
- Function as dispersal corridors that allow an exchange of individuals and genetics between populations
- Goal: 10% of each square mile in the corridor should be protected (on a permanent or temporary basis) grassland or wetland habitat

Strategic Habitat Complexes

- Habitat complexes of about 9 square miles established every 6 miles within the corridors or large wetland complexes
- Function as habitat "stepping stones" for mobile wildlife species within the corridors
- Goal: The land within each strategic habitat complex should be 40% grassland and 20% wetland, and at least 50% of that land should be permanently protected.

Agricultural Matrix

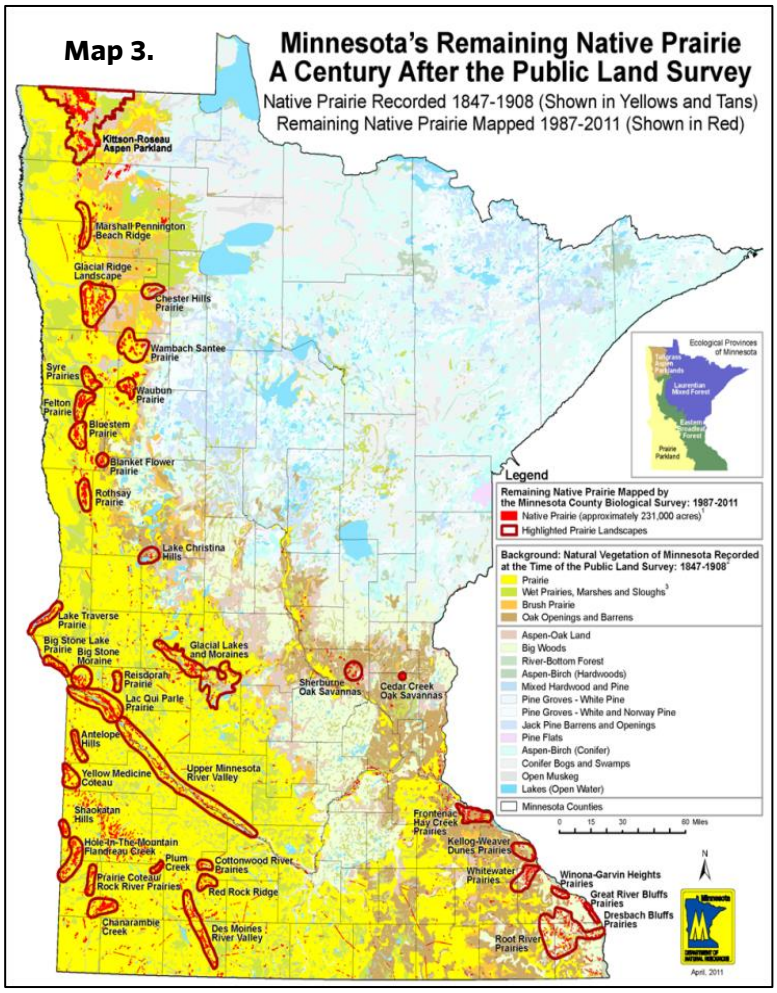
- All the remaining area of the Prairie Region outside core areas, corridors and strategic habitat complexes (20.8 million acres)
- Function as habitat for species adapted to live within an agricultural countryside
- Goal: 10% grassland and wetland cover within each major watershed with at least half (5%) protected on a permanent or temporary basis

Prairie Core Areas

The Minnesota Biological Survey has been evaluating and mapping areas of native prairie in Minnesota since 1987. Their data (as of October 2015) show that the remaining native prairie in Minnesota is not evenly distributed. In some parts of Minnesota, prairie tends to be more common. The primary causes of these concentrations are the soils and geologic landforms that drove the nature and historical uses of the land. Prairie once covered most of western and southern Minnesota (yellow on Map 3) and was largely unbroken until settlers discovered that prairie soils are some of the most productive agricultural soils in the world. Starting in the early 1900s, people rapidly converted native prairie to agricultural production, using technological improvements in tillage, harvesting, and drainage equipment. Public agricultural policy provided strong incentives for these activities. With a few minor exceptions, the only places that were left as native untilled prairie were areas that were too rocky, too wet, too steep, or too sandy to be profitably farmed. However, as technology continually improved, more and more of the formerly unsuitable areas were converted. This conversion continues today.

The remaining native prairies tend to be concentrated because of unusual landforms across the state. Areas of steep slopes, such as those found along the edges of the Prairie Coteau and Buffalo Ridge; areas of extensive sand and gravel, such as those found in the Agassiz Beach Ridges; areas of rocky outcrops, such as those along the upper Minnesota River; and areas of excessive moisture, such as those in the Aspen Parklands, are places with a relatively high density of native prairies.

In 2009, Minnesota Biological Survey prairie biologists delineated rough boundaries around locations where native prairie and associated habitats seemed concentrated. The result was 29 locations in the Prairie Region of Minnesota (Map 3;



Minnesota Biological Survey, 2010). The boundaries of these prairie polygons were admittedly rough, but they captured about 152,000 of the 235,076 acres of known native prairie within a total area of 2.1 million acres. The 152,000 acres represented 65% of all the known native prairie remaining in Minnesota.

Using this initial work (Map 3), The Nature Conservancy in 2010 further refined the boundaries of the prairie concentration areas for the first edition of the Prairie Plan. These revisions increased the number of prairie core areas to 36 but decreased their total size to 1,582,280 acres. Within these core areas were 166,458 acres of native prairie, representing an average 10.5% of the area in the landscapes. The 36 landscapes together captured 71% of the identified native prairie in Minnesota.

Since the publication of the first edition of this Prairie Conservation Plan (Minnesota Prairie Plan Working Group, 2011), the Minnesota Biological Survey has completed additional native prairie inventories, remote imagery for the state has greatly improved, and GIS technology has developed rapidly. The Implementation Strategy of the original Prairie Plan (Minnesota Department of Natural Resources, 2013) anticipated that data and technology would improve and called for a reanalysis of the core areas in five years as part of a second edition of the plan. The reanalysis resulted in the merging of several core areas, the addition of three new ones (Camden Prairie Marshes, Blue Mounds State Park–Touch the Sky Prairie, and Split Rock Creek), the removal of cropland along the edges of core areas, and the inclusion of adjacent grassland and wetlands (see Appendix 3 for details). This second edition now recognizes 28 core areas totaling 2,003,923 acres (Map 4). The amount of native prairie captured in this set of core areas totals 191,050 of the 248,663 acres (76.8%) now known in the state.

To illustrate the Prairie Plan's effectiveness in capturing native prairie, a Native Prairie Density Index (NPDI) was calculated for the entire state. The NPDI value for any place in Minnesota is the percentage of surrounding quarter-quarter sections (40-acre parcels) within one mile that contain at least 5 acres of native prairie. Map 5 shows that the new set of core areas captures nearly all the high native prairie density areas within the Prairie Region of the state.

The common features exhibited by these prairie core areas allow us to define a Minnesota Prairie Core Area as follows:

An area composed of at least 10,000 acres that retains at least some of the features of a functioning prairie system. At least 15% of the area is grassland, with a substantial portion being native prairie. Prairie core areas often contain other natural communities, including wetlands, aquatic systems, savannas, shrublands and a minor component of forest.

In addition to locating and defining the prairie core areas, another key task in prairie landscape conservation planning is to define the desired future condition of each core

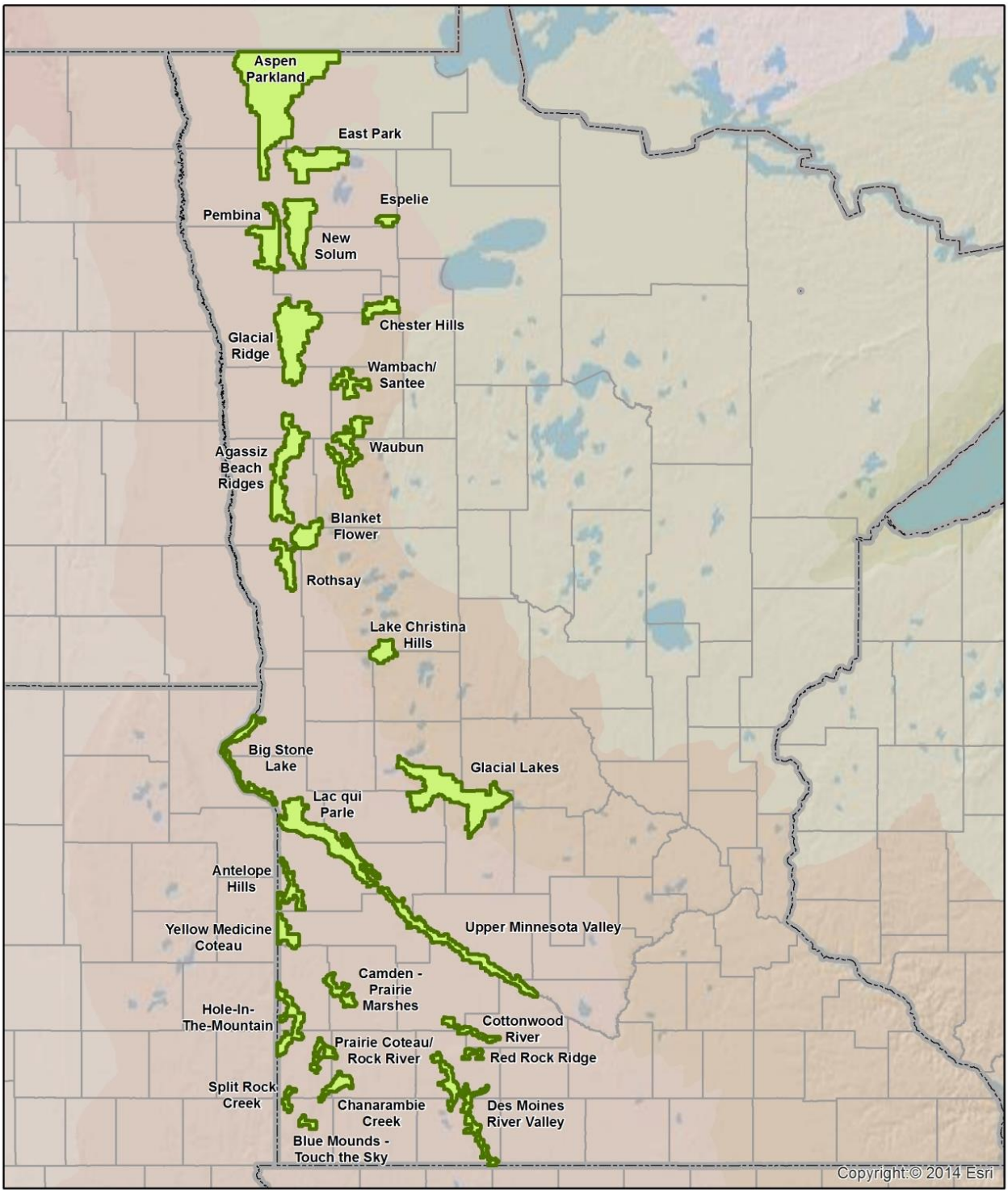
area. The Working Lands Initiative (Minnesota Department of Natural Resources, 2010) used one approach to establish conservation goals for grassland/wetland complexes that were four to nine square miles in area. It describes a mix of habitats that can sustain populations of breeding ducks, pheasants, black terns, and upland nesting shorebirds. Based on population models, the predicted optimal habitat mixture is a minimum of 40% grassland and 20% wetland. The Duck Plan (Minnesota Department of Natural Resources, 2006) goes further and calls for half of the wetlands in the total landscape (10%) to be seasonal or temporary in nature. The remaining 40% of land beyond grassland and wetlands could be designated for other uses, including crop-based agriculture. Although these values might not be ideal for all prairie species, they likely represent a conservative estimate of what most prairie species need, as long as there are some expanses of contiguous grassland covering thousands of acres within each prairie core area (Minnesota Department of Natural Resources, 2006). An additional goal requires 50% of the grassland and wetland to be permanently protected (through fee or easement).

Although native prairie makes up only 9.5% of the identified core areas, the core areas have retained more natural habitat than have other parts of agricultural Minnesota (Table 2). There is significant variation among areas, but on average they consist of 50.0% grasslands (native prairie plus pastures and other grasslands) but only 6.4% wetlands. Many core areas surpass the 40% grassland minimum, and eight of the core areas have also reached the protection goals for grasslands (Table 3), assuming all native prairie will be protected, but no core area meets the 20% wetland minimum set by the Working Lands Initiative.

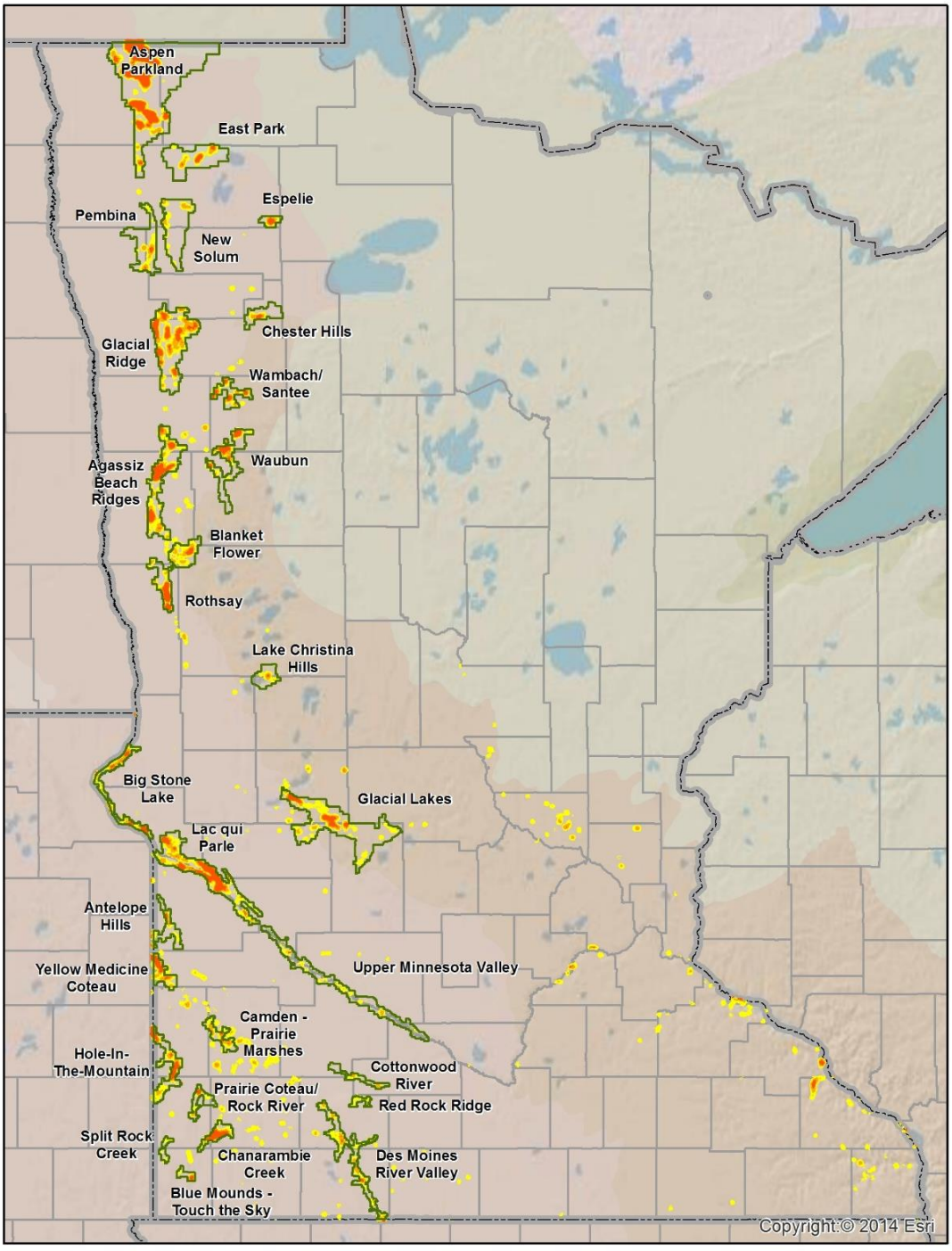

Cottonwood River Core Area © Susan Chaplin

As might be expected, the agricultural suitability of the soils is lower in the core areas than outside. The average Crop Productivity Index (CPI) for prairie core areas is 55.0, compared with an average of 76.5 for the rest of the lands in the Prairie Region of Minnesota. CPI uses a 0–100 scale with higher scores indicating better agricultural soils. The value of CPI that constitutes prime farmland varies across the state, but as an example, values above 57 are considered prime soils in Scott County (Schweser, 2009). Within the core areas, Red Rock has the highest average CPI, at 78.4, while Aspen Parkland has the lowest, at 36.1 (see Appendix 5).

Map 4. Prairie Core Areas



Map 5. Native Prairie Density



Native Prairie Density

- 10 - 25%
- 25 - 40%
- Greater than 40%

0 25 50 100 150 200 Miles

M:\mxd\State\MN\Special Project\
Prairie Plan Analysis - 20160415\Prairie Density 20160421.mxd
Map created by SJC TNC in MN\ND\SD

Table 2. Habitat in Prairie Core Areas

Prairie Core Area	Core Area (acres)	Native Prairie (acres)	Other Grassland (acres)	Grassland Habitat Shortfall from 40% Goal (acres)	Wetland (acres)	Wetland Habitat Shortfall from 20% Goal (acres)
Agassiz Beach Ridges	109,172	17,765	49,819	0	4,205	17,629
Antelope Hills	36,261	2,491	15,261	0	3,394	3,858
Aspen Parkland	372,481	46,693	165,056	0	13,843	60,653
Big Stone Lake	48,055	5,708	8,996	4,518	2,125	7,486
Blanket Flower Prairie	41,124	3,779	16,200	0	2,780	5,444
Blue Mounds - Touch the Sky	10,527	1,066	832	2,312	106	1,999
Camden -- Prairie Marshes	29,548	2,805	7,966	1,048	957	4,952
Chanarambie Creek	27,213	3,657	7,251	0	753	4,690
Chester Hills	31,015	1,111	17,732	0	1,476	4,727
Cottonwood River	23,589	773	9,599	0	1,403	3,315
Des Moines River Valley	85,353	5,492	27,857	792	3,080	13,991
East Park	87,064	3,288	29,836	1,702	1,640	15,773
Espelie	11,890	2,099	5,718	0	715	1,663
Glacial Lakes	207,940	10,313	88,051	0	36,461	5,127
Glacial Ridge	151,502	19,718	79,426	0	5,488	24,813
Hole-in-the-Mountain	56,987	5,506	19,709	0	1,177	10,220
Lac qui Parle	147,607	20,737	47,292	0	16,353	13,168
Lake Christina Hills	30,381	925	11,721	0	3,145	2,931
New Solum	89,597	2,914	48,536	0	676	17,244
Pembina	71,076	2,857	44,739	0	2,077	12,139
Prairie Coteau/Rock River	25,053	1,588	9,414	0	1,155	3,856
Red Rock Ridge	10,192	836	2,402	839	90	1,948
Rothsay	40,795	8,631	17,329	0	1,490	6,669
Split Rock Creek	11,370	855	3,351	342	166	2,108
Upper Minnesota Valley	114,220	2,770	35,178	7,740	9,233	13,611
Wambach Santee	34,044	5,015	6,153	2,449	3,195	3,613
Waubun	69,095	7,310	20,277	51	9,600	4,219
Yellow Medicine Coteau	30,773	4,348	10,397	0	768	5,386
Total	**2,003,923**	**191,050**	**806,099**	**21,794**	**127,552**	**273,233**

Table 3. Current Protection and Protection Shortfall in Prairie Core Areas

Prairie Core Area	Protected Native Prairie (acres)	NP Protection Shortfall (acres)	Protected Other Grassland (acres)	Other Grassland Protection Shortfall (acres)	Grassland in CRP 2015 (acres)	Protected Wetland (acres)	Wetland Protection Shortfall (acres)	Wetland in CRP 2015 (acres)
Agassiz Beach Ridges	9,621	8,144	14,054	0	9,935	1,599	9,318	132
Antelope Hills	728	1,763	4,444	318	7,032	1,629	1,997	198
Aspen Parkland	33,588	13,105	53,869	0	40,782	9,839	27,409	435
Big Stone Lake	1,148	4,560	1,428	2,474	912	455	4,351	79
Blanket Flower Prairie	901	2,878	2,817	1,629	3,381	894	3,218	39
Blue Mounds - TtSky	1,015	51	644	395	0	48	1,005	56
Camden Prairie Marsh	863	1,941	2,070	1,035	2,138	366	2,589	52
Chanarambie Creek	416	3,241	431	1,355	1,505	242	2,479	10
Chester Hills	27	1,084	451	4,641	2,852	84	3,018	63
Cottonwood River	394	379	2,868	1,076	3,370	717	1,641	132
Des Moines River	1,740	3,752	5,464	6,115	6,638	950	7,586	50
East Park	2,442	846	5,006	9,118	9,703	1,306	7,400	14
Espelie	1,543	556	780	0	1,978	479	710	1,013
Glacial Lakes	4,788	5,524	15,407	15,869	23,820	8,755	12,039	287
Glacial Ridge	13,856	5,862	29,530	0	15,117	2,895	12,255	51
Hole-in-the-Mountain	1,809	3,696	1,792	4,099	2,585	336	5,362	107
Lac qui Parle	12,461	8,276	21,267	0	6,682	12,185	2,576	79
Lake Christina Hills	304	621	1,591	3,560	1,864	746	2,292	154
New Solum	594	2,321	1,312	13,693	14,895	12	8,947	69
Pembina	1,442	1,416	3,822	7,536	15,878	1,498	5,610	30
Prairie Coteau/Rock R.	556	1,032	452	2,971	1,731	181	2,324	11
Red Rock Ridge	442	394	975	227	759	25	994	156
Rothsay	4,804	3,826	4,437	0	5,478	381	3,699	12
Split Rock Creek	272	583	829	590	186	41	1,096	165
Upper Minnesota Valley	775	1,995	9,274	10,800	6,384	2,761	8,661	157
Wambach Santee	4,698	317	2,451	0	1,268	2,114	1,291	147
Waubun	5,031	2,278	7,785	0	2,275	4,062	2,848	27
Yellow Medicine Coteau	1,470	2,878	1,782	24	2,415	226	2,851	132
Total	**107,730**	**83,320**	**197,032**	**87,525**	**191,565**	**54,826**	**145,566**	**3,725**

Aquatic Features in Core Areas

In addition to grasslands, aquatic features such as lakes, streams, and wetlands are integral parts of prairie landscapes. With changes in water levels over seasons and during weather events, it is often difficult to determine where the terrestrial system ends and the aquatic system starts. In fact, many prairie systems are actually mosaics of grasslands, wetlands and open water. They are inhabited by aquatic and wetland habitat specialists as well as by many seemingly terrestrial prairie animals that use aquatic habitats for critical resources or protection during parts of their life cycle or at certain times of the year. The protection of all remaining native prairie is the primary goal of this Prairie Plan, but the maintenance of functioning prairie systems and the viability of native prairie plants and animals is a close second. If we want to protect all native prairie species, conservation of aquatic habitats within the prairie system is essential.

Just as conservation of the highest functioning grasslands (native prairie) is the primary target in prairie core areas, we also need to identify and conserve the highest functioning aquatic features. The following aquatic habitat categories capture the diversity within core areas and are appropriate targets for local conservation action:

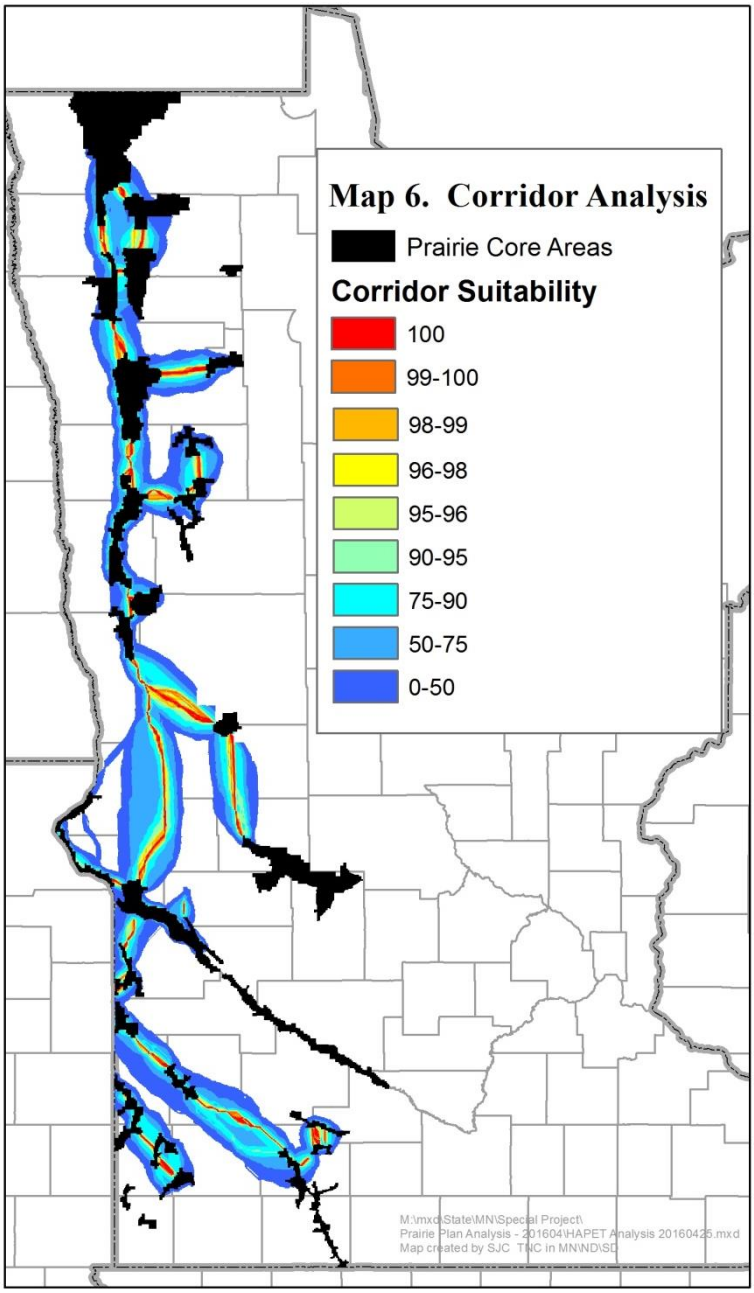
- Headwater streams, stream orders 1–2
- Mid-order streams, stream orders 3–5
- Large, shallow lakes (> 50 acres, < 15 feet deep)
- Large, deep lakes (> 50 acres, > 15 feet deep)
- Small lakes (< 50 acres)
- Existing permanent wetlands
- Existing temporary and seasonal wetlands
- Fens and other special features

Within prairie core areas in Minnesota, there are 478 lakes, including 252 that are larger than 50 acres and 143 that are both greater than 50 acres and less than 15 feet deep. In addition, there are 2,986 miles of headwater streams (stream orders 1–2), and 1,102 miles of mid-order streams (stream orders 3–5).

We know less about the best existing aquatic features in Minnesota than about prairies and grasslands. Thus, it is not yet possible to specify over large areas which features in each category have the highest levels of aquatic biodiversity, water quality and habitat productivity. However, local knowledge can offer a good first approximation as to which features might quality in specific areas. This plan suggests that teams of local biologists and habitat managers in each core area meet to identify the best examples of each aquatic habitat type, then work locally to conserve (through protection, management and restoration) the areas that they deem important to maintain a functioning prairie system.

Prairie Corridors

When prairie covered more than one third of Minnesota, there were few barriers to dispersal for prairie plants and animals. In today's landscape, dominated by agriculture, grasslands are highly fragmented and there are many barriers to movement. Scattered prairie remnants are separated by many miles of unsuitable habitat, making dispersal and successful colonization of some organisms to new locations extremely difficult. Many prairie species have disappeared from portions of their former distributions, such as the greater prairie chicken and sharp-tailed grouse. Two hundred years ago, these species ranged throughout the Prairie Region of Minnesota, but they are now restricted to isolated populations in the western and northwestern parts of the state (Berg, 1997; Robb & Schroeder, 2005). As additional grassland is restored and protected, more suitable habitat for these prairie grouse species will be available, allowing for increased dispersal and genetic exchange.

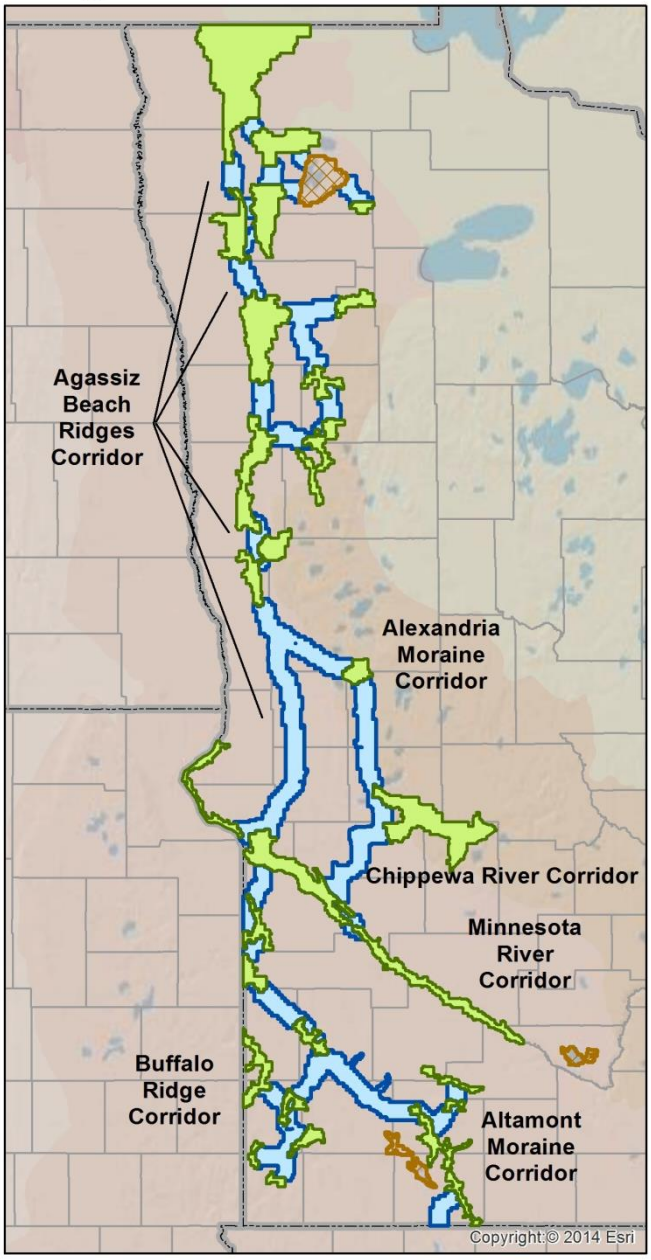


Dispersal corridors can increase species movement in fragmented landscapes, and it is worth the effort to create and maintain those corridors (Gilbert-Norton et al., 2010). Without corridors, species will require facilitated movement (translocation by humans) to recolonize old habitat and establish in new territory in the face of changing environmental conditions.

For prairie organisms in Minnesota, there are five major natural dispersal corridors: Agassiz Beach Ridges, Alexandria Moraine, Minnesota River, Buffalo Ridge (Bemis moraine or Inner Prairie Coteau), and Altamont Moraine (slopes of the Outer Prairie Coteau). These five corridors are based on geologic features

(Hobbs & Goebel, 1982) and contain high concentrations of native prairie. The Minnesota River corridor was defined as a prairie core area and will be treated in that category, although it functions as a dispersal corridor as well. The Habitat and Population Evaluation Team (HAPET) of the U.S. Fish and Wildlife Service in Fergus Falls conducted a habitat suitability analysis using ArcGIS to identify pathways for corridors for six species of waterfowl, four species of marsh birds, eight species of grassland passerine birds, eight species of shorebirds and two game birds (see Appendix 3 for detailed description). Together, these species are good conservation umbrella species, or species whose conservation can protect other species that use the same habitat. Four areas were evaluated for corridor selection, using the Aspen Parklands, Lac qui Parle, Glacial Lakes, Chanarambie Creek, and Des Moines River Valley core areas as endpoints for corridors. Map 6 shows the result of this analysis, with the quality of habitat for these species adjusted by the feasibility of establishing connectivity. The final corridors were extended three miles on either side of the center line, creating corridors six miles wide and totaling 1,657,515 acres (Map 7). This total increased from 1,412,628 acres in the 2010 version of the Prairie Plan primarily because of the addition of new corridors to connect the new Blue Mounds State Park–Touch the Sky Prairie and Split Rock Creek core areas, the extension of a corridor to the Espelie core area, and the creation of corridors to connect the Buffalo Ridge corridor to the Altamont Moraine corridor, the Lac qui Parle core area to the Glacial Lakes core area, and the Des Moines River Valley core area to Iowa's Little Sioux Prairie Focal Area.

Map 7. Prairie Corridors



Within corridors, individuals must be able to move between habitat patches. This concept led to a two-pronged approach: 1) protect at least 10% of each square mile section in perennial grassland or wetland habitat and 2) create larger "stepping stone" grassland/wetland complexes containing at least 2,000 grassland acres, every six miles along the corridors.

To estimate the amount of protection and restoration needed within corridors, it is necessary to identify where the "stepping stone" corridor complexes could most easily be established based on current land cover and land ownership. Each of these complexes should be about nine square miles, or at least 5,374 acres. The specific locations were chosen to maximize the amount of native prairie, grassland and protected lands in complexes (Map 8, Table 4).

In the initial version of the prairie plan, there were 36 corridor complexes totaling 207,965 acres. In the reanalysis for this second edition, a set of 35 corridor complexes was needed within the corridors to maintain roughly six miles between complexes. One of these complexes, Agassiz National Wildlife Refuge (ANWR, #2 on Map 8), is very large (91,161 acres) but was included as a single complex because it is a single management unit. The calculated grassland and wetland shortfalls for ANWR were excluded from the restoration totals because ANWR is permanently protected and almost entirely classified as wetland.

In addition to the corridor complexes, three other areas centered on iconic wetland complexes deserve recognition in this second edition. These large wetland complexes (Heron Lake, Talcot Lake, and Swan Lake, in addition to ANWR), lack sufficient amounts of native prairie, but they met the other size and composition criteria for core areas. These four wetlands total 151,516 acres.

Together the corridor complexes and large wetland complexes are grouped into a new category of features called strategic habitat complexes. The boundaries of all the strategic habitat complexes were based on land use, including grassland and wetland while excluding as much cropland as possible. Unlike the earlier corridor complexes, none of the strategic habitat complexes (including those functioning as corridor complexes) were required to be 3 x 3 mile squares. In a few cases, strategic habitat complexes serving as "stepping stone" complexes extending between the boundary of the corridor to better capture contiguous prairie/grassland features.

Map 8. Strategic Habitat Complexes

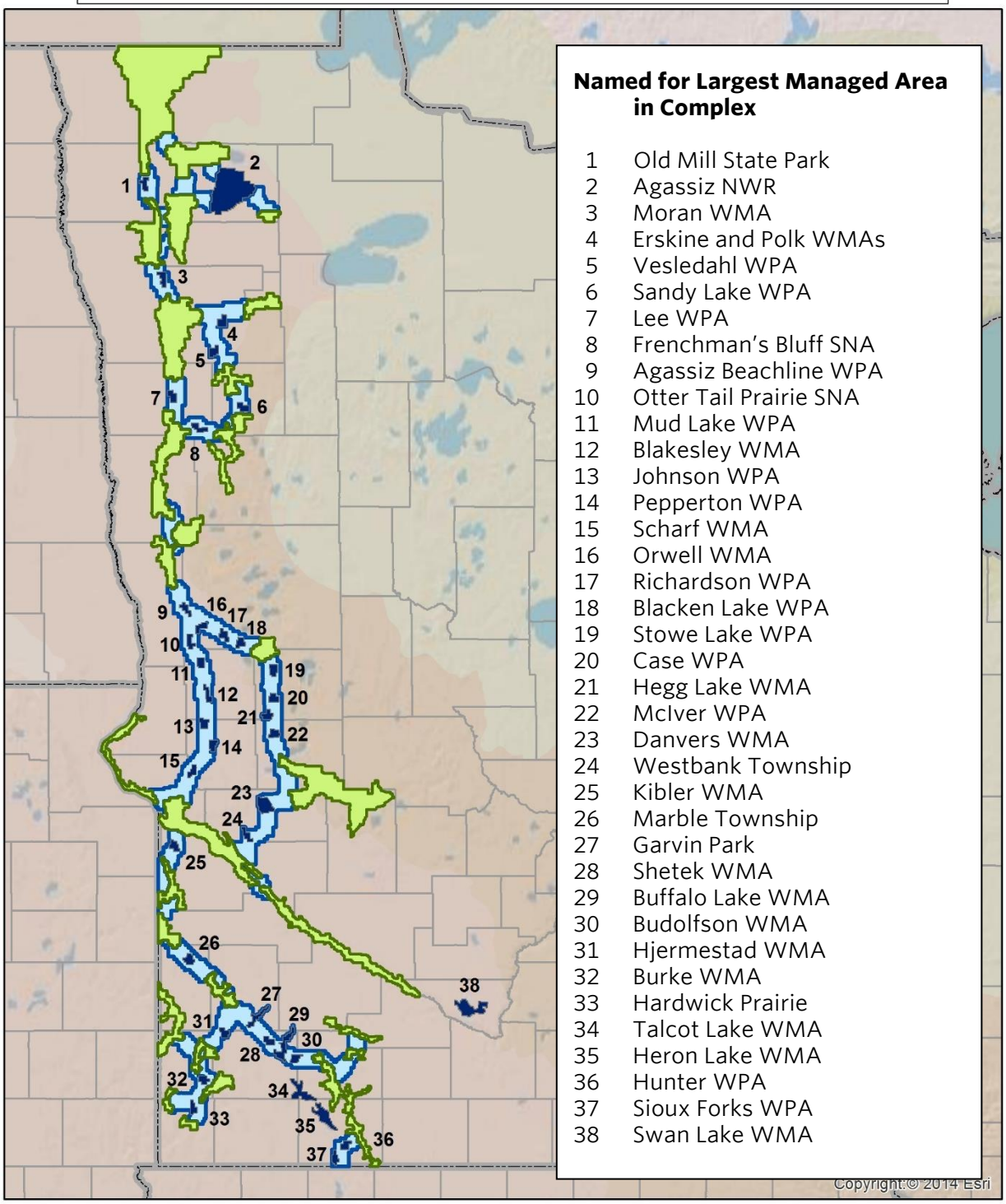


Table 4. Habitat and Protection in Strategic Habitat Complexes (Acres)

Strategic Habitat Complex Name	Complex Acres	Native Prairie	Other Grassland	Grassland Habitat Shortfall	Wetland	Wetland Habitat Shortfall	Protected Native Prairie	Protected Other Grassland	Grassland Protection Shortfall	Grassland in CRP 2015	Protected Wetland	Wetland Protection Shortfall	Wetland in CRP 2015
Agassiz Beachline WPA	5,617	748	622	877	239	885	741	235	141	80	153	409	2
Agassiz NWR	91,160	0	8,826		57,849	0	0	5,452		1,281	57,631		19
Blacken Lake WPA	5,625	1	1,149	1,099	499	626	0	328	796	155	76	486	3
Blakesley WMA	5,785	0	2,612	0	1,029	128	0	970	187	771	584	0	93
Budolfson WMA	5,409	16	730	1,417	362	720	0	272	794	123	232	309	6
Buffalo Lake WMA	15,854	684	4,702	955	1,118	2,053	194	1,971	516	1,808	811	774	15
Burke WMA	5,806	34	1,017	1,271	198	963	5	12	1,115	9	65	515	0
Case WPA	5,758	0	2,097	206	686	465	0	439	713	206	180	395	2
Danvers WMA	15,569	20	6,034	174	2,651	463	0	1,100	1,994	2,830	2,093	0	160
Erskine & Polk WMA	6,275	0	3,007	0	1,118	137	0	1,556	0	627	873	0	24
Frenchman's Bluff SNA	5,900	229	1,573	557	261	919	49	33	917	220	23	567	0
Garvin Park	9,316	588	1,880	1,259	368	1,495	37	132	1,144	709	8	924	23
Hardwick Prairie	5,597	363	1,077	798	74	1,046	0	0	756	0	0	560	0
Hegg Lake WMA	5,828	20	1,970	341	823	343	12	886	259	213	404	178	8
Heron Lake WMA	18,702	72	3,478	3,931	3,425	316	13	1,710	1,959	426	339	1,532	12
Hjermestad WMA	5,927	62	1,960	349	639	547	52	143	980	630	254	339	23
Hunter WPA	5,745	0	926	1,372	65	1,084	0	464	685	91	54	520	0
Johnson WPA	6,003	0	1,867	535	718	483	0	1,264	0	151	337	263	9
Kibler WMA	6,284	82	1,660	772	520	736	16	342	833	509	332	297	10
Lee WPA	5,881	151	3,248	0	501	675	12	269	756	711	19	569	33
Marble Township	6,802	680	2,394	0	76	1,284	179	368	313	679	7	673	6
McIver WPA	6,076	26	1,400	1,005	492	723	26	180	1,009	153	173	435	6
Moran WMA	6,246	48	1,742	708	162	1,087	0	54	1,147	227	102	523	4
Mud Lake WPA	5,379	0	2,318	0	316	760	0	534	542	552	235	302	4
Old Mill State Park	5,617	158	2,198	0	164	959	66	211	754	1,201	14	548	15
Orwell WMA	5,522	0	866	1,343	308	797	0	626	478	15	244	308	0
Otter Tail Prairie SNA	6,096	448	3,384	0	426	793	388	2,474	0	274	344	266	1
Pepperton WPA	5,785	0	2,120	194	1,015	142	0	1,135	22	381	552	27	30
Richardson WPA	5,961	9	1,403	973	795	397	9	648	535	63	572	24	0
Sandy Lake WPA	5,824	0	2,015	315	485	680	0	124	1,041	268	64	518	11
Scharf WMA	5,374	0	1,398	752	465	610	0	536	539	381	191	347	49
Shetek WMA	5,796	0	1,324	994	442	717	0	187	972	460	220	360	6
Sioux Forks WPA	5,642	222	2,098	0	1,041	87	218	1,203	0	229	673	0	12
Stowe Lake WPA	6,018	0	1,346	1,061	719	485	0	413	791	28	294	308	1
Swan Lake WMA	23,838	0	1,846	7,689	10,084	0	0	675	4,093	250	750	1,634	19
Talcot Lake WMA	17,816	90	6,789	247	2,083	1,480	80	3,190	283	1,470	1,424	357	82
Vesledahl WPA	5,732	0	2,306	0	471	675	0	659	488	65	208	365	3
Westbank Township	5,812	0	2,451	0	176	986	0	435	727	1,004	48	533	8
TOTAL	***373,377***	***4,752***	***89,832***	***31,195***	***92,863***	***26,746***	***2,097***	***31,231***	***28,277***	***19,252***	***70,584***	***15,756***	***701***

For the land within habitat corridors but outside the strategic habitat complexes, land use must be analyzed on a section-by-section basis to ensure that at least 10% of each legal section is dedicated to conservation. There are 2,895 sections (typically but not always 640 acres each) that include at least 10 acres within the corridors but outside the complexes. Of these sections, 860 contain less than the 10% goal of perennial cover (excluding open water) of each section. To reach the 10% goal in each section, an additional 24,300 acres of restored grasslands and wetlands are needed, even though there are 411,000 acres of wetlands and grasslands total within the corridors and outside the complexes (Table 5). To meet protection goals, we assume that all the remaining 4,267 acres of unprotected native prairie within the corridors will be acquired through fee or easement. Beyond the native prairie, an additional 131,000 acres of non-native prairie grasslands and wetlands will need to be acquired, placed under conservation easement or enrolled/continued in a long-term conservation program to reach the goal of having at least 10% of each section in protected conservation lands.

Table 5. Corridor Section Analysis (Acres)

Land in corridors but outside strategic habitat complexes (includes open water)	**1,657,515**
Existing open water	**42,173**
10% perennial cover goal per section (excludes open water)	**161,534**
Existing native prairie	**5,887**
Existing other grassland (excludes native prairie)	**336,833**
Existing wetlands (excludes native prairie)	**68,375**
Existing native prairie, other grasslands and wetlands	**411,095**
Protection shortfall for grassland and wetland below 10% goal	**24,322**
Native prairie permanently protected	**1,620**
Protection shortfall for native prairie	**4,267**
Other grassland permanently protected	**38,754**
Other grassland in 10–15 year contract (2015 CRP)	**82,833**
Wetland permanently protected	**15,357**
Wetland in 10–15 year contract (2015 CRP)	**2,987**
Native prairie, other grassland, and wetland permanently protected	**55,731**
Protection shortfall for grassland and wetland in addition to native prairie to reach 10% goal. Existing CRP is not included in current protection.	**130,964**

Local Conservation within the Agricultural Matrix

Agriculture is an important part of Minnesota's economy and culture, and it is the dominant land use in much of the state. Minnesota has a long history of supporting a strong farm economy and is a leader in the nation in productivity (Minnesota Department of Agriculture, 2015). While agricultural producers have made significant progress toward improving both soil and water health while increasing yields, there are still some worrisome trends. Demand on limited groundwater resources is increasing, nitrates in surface water and groundwater are not improving, and populations of many grassland species continue to decline. Farm economics, land use choices, global markets, commodity prices and many other factors greatly influence the condition of natural resources throughout the state and in all the states downstream. Minnesota has the opportunity to surround the first 694 miles of the Mississippi River with sustainable farming practices, demonstrating to the rest of the nation a model of harmonized productivity and sustainability.

There are nearly 25 million acres of land and water within the Prairie Region of Minnesota. If the roughly 2 million acres found within prairie core areas and the 2 million acres located in dispersal corridors and strategic habitat complexes are subtracted, the remaining amount is 21 million acres (hereafter called the agricultural matrix) that makes up the heart of Minnesota's agricultural economy. We need to determine how to sustain grassland wildlife, habitats, and water quality in the agricultural matrix while supporting the economic vitality of the region.

Minnesota is home to a diverse range of farm operations, and there are opportunities to improve conservation on all types of farms, regardless of their scale, basic production choices or business model. Conservation can look different on different farms. However, precipitation falls on every Minnesota farm, and when that water leaves the farm, it should leave as clean as when it arrived. It is reasonable to expect every landowner within the agricultural matrix to achieve some minimum level of environmental stewardship, and in strategic locations, to create opportunities for wildlife. While the CRP and more recently the Conservation Reserve Enhanced Program (CREP) will continue to be conservation strategies in the agricultural matrix, additional resource management strategies that are integrated into normal production systems are necessary.

An example of an additional resource management strategy would be accelerating the implementation of soil health practices. The five principles of soil health (Minnesota Sustainable Farming Association, 2016) are to keep the soil covered, minimize soil disturbance, increase crop diversity, incorporate livestock, and keep living roots in the soil. While this plan does not prescribe specific goals for conservation practices within row crop settings, it does recommend adopting practices that benefit soil health.

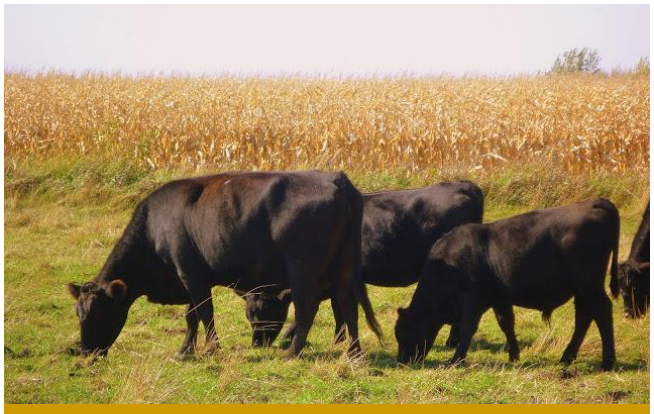
Continuing advancements in technology and precision agriculture will offer new opportunities to conserve natural resources while meeting the world's growing demand for agricultural products.

We propose a combination of strategic conservation efforts: one focusing on grassland/wetland complexes of up to several thousand acres and the other focusing on a more even and comprehensive distribution of small conservation projects. These projects could involve ditch and stream-side vegetation buffers, grass waterways and small restored wetlands.

Goals for the Agricultural Matrix

To ensure conservation representation in all parts of the state, a minimum of 10% of the terrestrial lands in each major watershed outside the core areas, corridors and strategic habitat complexes should be set aside for soil, water and wildlife conservation purposes. As many private grasslands and wetlands have been and will continue to be managed well as working pasture lands, a protection goal of only 5%, half the habitat goal, is needed to maintain the desired level of herbaceous perennial vegetation in each major watershed. The 5% should be protected either in conservation areas such as Wildlife Management Areas or through conservation easements or contracts on private lands. These acres do not need to be left fallow but can be used for managed grazing or haying.

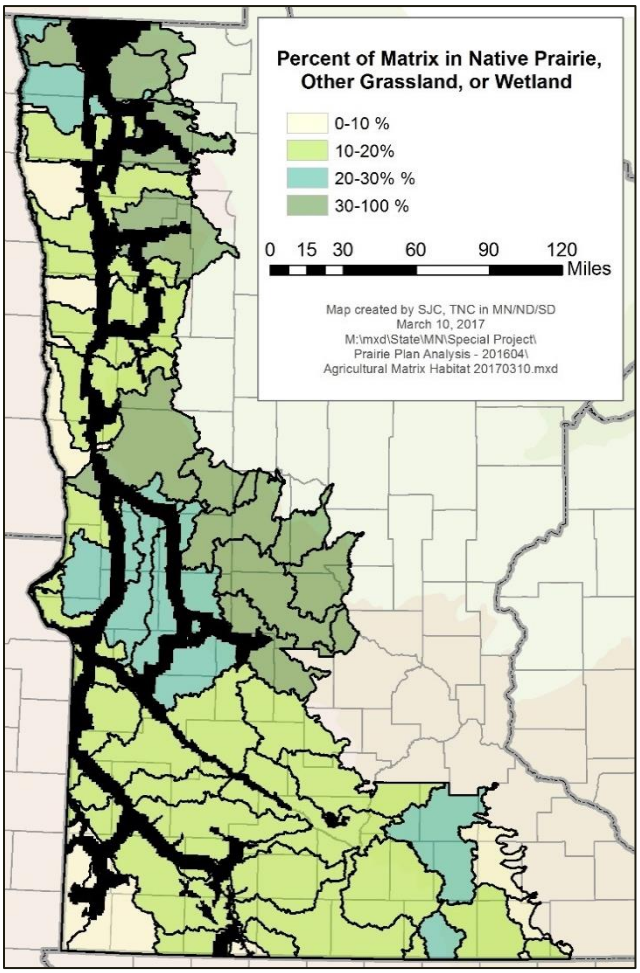
The 10% perennial habitat goal should be viewed as a starting point. Local decision makers, with research-validated support tools, need to determine the percentage of perennial cover that is needed in any given watershed to achieve the desired environmental results. The justification for maintaining at least 10% of each watershed in grassland, wetland or other appropriate perennial cover is based on recent scientific studies that suggest only 10% of a small watershed needs to be in perennial prairie strips to reduce sediment loss by 90–95% (Jarchow & Liebman, 2010). This percentage is also the goal established by the Land Stewardship Project for the Chippewa 10% Project to "meaningfully improve the safety of the water, reduce flood potential, restore wildlife habitat, and stimulate a thriving local and regional foods economy" (Ness, 2010).



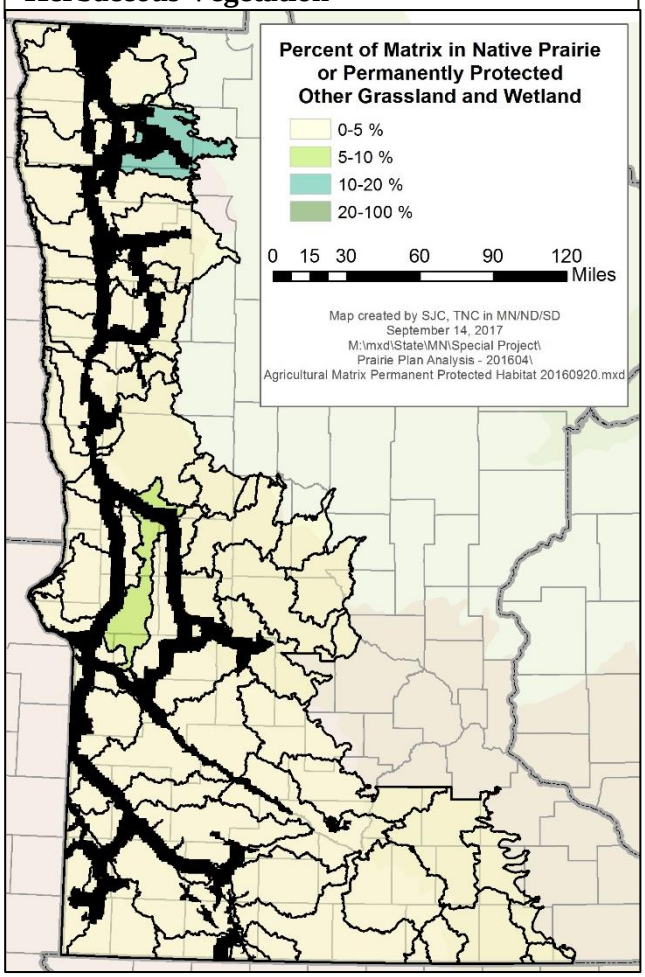
Maintaining land for grazing is an ideal way to incorporate perennial land cover in the Agricultural Matrix. © Kelly Anderson/MDA

It is essential to conserve land in the correct areas of the watershed. Projects must be located strategically to achieve the desired positive environmental impacts (Harris, Iyer, & Miller, 2014).

Map 9. Percent of the Agricultural Matrix in Each Major (HUC 8) Watershed in Perennial Herbaceous Vegetation



Map 10. Percent of the Agricultural Matrix in Each Major (HUC 8) Watershed in Permanently Protected Perennial Herbaceous Vegetation



Within the Prairie Region, there are 53 major watersheds containing about 20.2 million terrestrial acres outside core areas, corridors and strategic habitat complexes. There are 4.3 million acres of native prairies, grasslands and wetlands within this agricultural matrix, well above the 2.0 million acres needed to reach the 10% habitat goal. Only nine major watersheds do not contain 10% perennial cover (Map 9). The habitat shortfall (restoration goal) in these nine watersheds needed to meet the starting point of 10% habitat cover totals about 44,000 acres (Table 6). About 590,000 acres of grassland and wetland in the agricultural matrix are enrolled in the CRP as of 2015. If this level of CRP were maintained and employed strategically by watershed (Map 10), over 25% of the habitat goals and all of the temporary-contract protection goals for the agricultural matrix could be minimally met by this program alone.

Table 6. Agricultural Matrix Analysis (Area Outside Core, Corridors, and Strategic Habitat Complexes in the Prairie Region) by Major Watershed (HUC 8)

Major Watershed	Agricultural Matrix (Acres)	NP (Acres)	Other Grassland (Acres)	Wetland (Acres)	Total NP, Grassland, Wetland (Acres)	Habitat Shortfall Grass & Wetland (Acres)	Permanently Protected NP, Grass, Wetland (Acres)	Permanently Protected Shortfall (NOT including CRP) (Acres)	NP, Grass, Wetland in CRP (Acres)
Big Sioux–Medary	14,409	2	1,526	192	1,721	0	0	716	278
Big Sioux–Pipestone	233,939	216	17,557	2,744	20,517	2,741	699	10,882	3,046
Blue Earth	774,770	1,219	68,945	12,441	82,606	0	12,746	24,305	9,978
Bois de Sioux	263,595	194	25,182	4,047	29,424	0	3,575	9,302	4,883
Buffalo	526,852	1,113	67,276	26,290	94,680	0	13,270	11,554	9,964
Cannon	678,046	655	118,601	36,465	155,720	0	14,865	17,245	24,662
Cedar	454,907	471	50,670	5,409	56,550	0	5,137	17,143	5,789
Chippewa	890,702	1,664	138,406	50,995	191,065	0	29,580	11,690	35,817
Clearwater	571,600	409	172,078	45,799	218,285	0	5,958	21,546	16,649
Cottonwood	664,358	2,456	58,362	12,314	73,132	0	13,069	17,719	14,857
Crow Wing River	61,078	0	20,767	12,217	32,985	0	49	2,965	1,056
East Fork Des Moines	128,999	204	10,905	2,759	13,867	0	1,199	4,857	889
Grand Marais Creek	341,553	172	30,210	1,632	32,014	1,817	526	16,218	14,404
Lac qui Parle River	348,977	460	38,186	9,067	47,713	0	9,103	7,965	12,682
Le Sueur River	711,871	305	57,502	21,979	79,785	0	10,775	23,842	14,107
Little Sioux River	161,553	408	15,009	4,158	19,575	0	3,135	4,492	1,985
Long Prairie River	476,754	11	141,427	74,998	216,437	0	8,388	13,601	13,461
Marsh River	209,384	108	7,532	1,588	9,228	11,518	209	10,056	2,632
Minnesota–Granite Falls	1,154,722	2,111	100,857	26,260	129,228	0	32,147	23,405	34,523
Minnesota–Headwaters	244,704	457	34,075	9,617	44,150	0	8,522	3,297	6,972
Minnesota–Mankato	768,115	1,007	71,148	23,841	95,995	0	11,286	25,946	10,083
Minnesota–Shakopee	569,622	63	62,314	25,533	87,910	0	6,798	21,160	10,390
Mississippi-Brainerd	257,327	179	61,492	50,417	112,088	0	6,261	6,068	1,642
Mississippi-Sartell	395,342	612	118,956	57,020	176,588	0	5,546	13,093	6,151
Mississippi–St. Cloud	107,325	7	26,452	17,010	43,469	0	412	4,778	1,934
Mustinka	468,022	383	79,766	16,597	96,747	0	10,360	12,496	15,320
North Fork Crow	431,379	284	101,287	53,500	155,072	0	14,725	5,388	19,536
Otter Tail	919,994	394	220,593	82,040	303,027	0	19,087	18,944	26,565
Pomme de Terre	426,547	1,552	80,479	26,610	108,641	0	20,660	0	17,732
Red Lake	494,753	267	91,517	5,319	97,103	0	814	23,370	13,250
Red River of the North	274,189	21	8,993	1,370	10,384	16,786	2,737	10,827	1,300
Redeye	237,750	4	78,249	31,745	109,998	0	4,619	6,967	11,345
Redwood	370,564	684	32,068	10,557	43,309	0	9,297	8,452	8,589
Rock	448,051	1,082	34,580	5,309	40,971	3,437	2,143	19,057	4,888
Root	108,978	52	8,245	678	8,975	1,885	171	5,221	728
Roseau	224,082	0	74,073	11,462	85,535	0	9,665	1,479	23,671
Sandhill	300,340	167	27,846	10,465	38,478	0	2,363	12,147	5,386
Sauk	657,776	986	198,172	75,607	274,765	0	18,796	12,385	15,898
Shell Rock	157,357	114	34,220	4,648	38,981	0	6,224	1,253	3,519
Snake	327,146	0	53,948	1,690	55,638	0	571	15,704	17,055
South Fork Crow	520,729	403	44,959	30,901	76,263	0	14,266	10,626	9,237
Tamarac	474,423	99	103,897	3,838	107,833	0	1,160	22,311	46,336
Thief	341,590	430	85,684	61,700	147,815	0	39,934	0	15,831
Two	445,732	18	131,831	7,970	139,819	0	2,504	19,686	40,253
Upper Iowa	72,672	299	9,807	477	10,583	0	1,926	1,656	879
Upper/Lower Red Lake	1,396	0	2	1,327	1,329	0	1,280	0	0
West Des Moines–Hdwts	629,542	3,417	55,292	10,688	69,396	0	11,883	16,681	11,363
West Des Moines–Lower	43,995	0	2,242	41	2,283	2,098	138	2,053	84
Wapsipinican	8,007	0	521	8	529	271	0	400	18
Watonwan	533,526	1,010	44,246	11,459	56,715	0	9,814	15,710	9,018
Wild Rice	592,173	1,301	75,534	26,222	103,056	0	7,417	20,711	10,818
Winnebago	45,582	13	6,690	1,937	8,640	0	432	1,789	507
Zumbro	287,107	171	21,786	2,742	24,698	3,880	1,069	13,078	2,185
Total	**20,853,905**	**27,652**	**3,221,963**	**1,031,698**	**4,281,314**	**44,432**	**417,313**	**602,235**	**590,146**

Aquatic Habitat and Water Quality Conservation in the Agricultural Matrix

Lakes, wetlands and streams are important ecological features throughout the Prairie Region. There are 3,140 lakes greater than 10 acres in size in the agricultural matrix, including 2,007 that are greater than 50 acres in size and 1,139 that are shallow lakes (greater than 50 acres in size and less than 15 feet deep). In addition to the lacustrine systems, there are more than 44,349 linear miles of rivers and streams, of which 6,513 miles are larger streams or rivers (stream order 4 or higher).

More than 24,000 miles of the rivers and streams in the agricultural matrix have been channelized to facilitate drainage of wetlands and shallow lakes. A number of projects are underway to restore meanders to rivers, streams and ditches, but restoring the natural function of channelized segments while allowing legal agricultural drainage will be a major challenge for the future. Another widespread concern about the streams and ditches in the Prairie Region is the cultivation of lands immediately adjacent to waterways despite a Minnesota Rule requiring a 50-foot buffer setback from public waters (Minnesota Board of Water and Soil Resources, 2010). Within the counties included in the Prairie Region, about 225,000 acres are cultivated riparian areas, and some counties have over 60% of their riparian buffers in cultivation (Minnesota Board of Water and Soil Resources, 2009a). Cultivation within the 50-foot setback often results in destabilization of stream banks and direct run-off of sediments, pesticides and nutrients into public waters.

To deal with these issues, the Minnesota State Legislature passed an updated buffer law in 2015 that requires a 50-foot average and a 30-foot minimum buffer on all public waters. In addition, all public drainage systems must have a minimum 16.5-foot buffer. These new requirements should be an impetus for a substantial increase in the amount of herbaceous perennial vegetation within the agricultural matrix that will help meet the perennial vegetation goal within each watershed. A properly managed public ditch system buffer can also reduce both private and public ditch system maintenance costs for landowners and local drainage authorities. Buffers, in conjunction with side inlet controls and other drainage management practices, can help maintain channel stability, reduce erosion and limit the effects of bank sloughing. They should result in enhanced water quality and additional perennial vegetation that may provide sufficient habitat to increase the size and viability of local wildlife populations.

Unmanaged cultivation in riparian areas impacts the quantity and quality of aquatic habitats that support fish and other aquatic species. Whereas local land conservation efforts can have a direct impact on the water quality, fish assemblages and other key aquatic species in lower order streams (headwaters), it is much more difficult to improve the ecological quality of larger streams and rivers. The water quality and fish assemblage of any one stretch of river or lake depends on all the activities upstream in the watershed. For this reason, planning for the conservation and protection of aquatic systems often needs to take place at large scales and in strategic locations. It is difficult to be spatially specific about the best places to work without an in-depth analysis of local conditions and the impact of the upstream watershed. It is even more difficult to show actual improvements in water quality or aquatic biota as a result of any specific

local conservation activity.

Despite these difficulties, several planning efforts have attempted to identify priority basins and lakes for conservation activities (Blann & Cornett, 2008; Minnesota Department of Natural Resources Division of Fish and Wildlife, 2010). This plan does not try to duplicate these efforts but rather relies on them to help prioritize the aquatic features and lands within the agricultural matrix that should be targeted for conservation activities. Significant research and analysis are needed to better integrate the needs of large-scale aquatic systems into comprehensive conservation planning.

Local Conservation Planning

Reaching the overall conservation goals for the agricultural matrix will require a myriad of collaborative planning decisions by officials, conservationists and landowners at the local level. It will also require this plan to be integrated with local water and comprehensive land use plans.

Some of the conservation actions that come out of local planning efforts should focus on the creation and management of larger complexes of grassland and wetlands that create optimal habitat for many game and non-game species. Far more of the conservation focus will be on smaller but more pervasive and evenly dispersed projects to address water quality and habitat improvement issues unique to each area of the state.

Grassland/Wetland Complexes

The concept of large grassland/wetland complexes as a conservation approach in Minnesota was developed by the Minnesota Duck Plan (Minnesota Department of Natural Resources, 2006). Many waterfowl need not only wetland and open water habitat but also surrounding grassland for nesting cover. The grassland complex concept has also been adopted by the Minnesota Pheasant Plan (Minnesota Department of Natural Resources, 2015) because the "life cycle needs of pheasants and other grassland wildlife species are best met in landscapes that are at least 9 square miles in size with 40 percent or more grass cover."

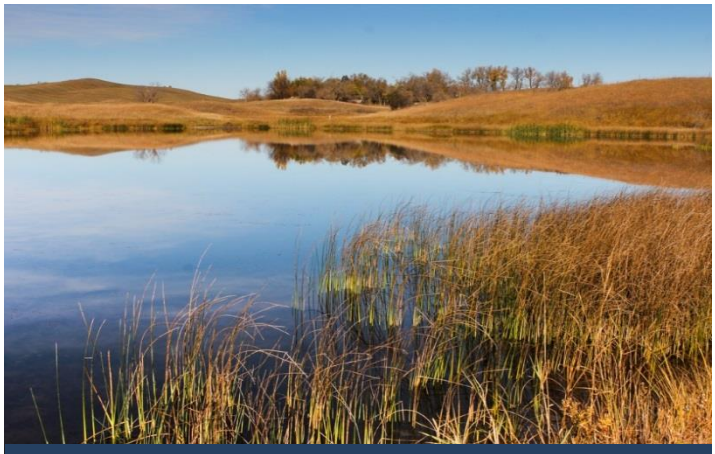
Specific grassland/wetland complexes have been identified by the Pheasant Plan, Duck Plan, and Wellhead Protection Programs. These areas that overlap to achieve multiple conservation benefits should be the backbone of a portfolio of complexes that help meet the perennial vegetation goal in each major watershed of the Prairie Region.

Miller Hills Waterfowl Production Area and Leif Mountain Preserve
© Susan Chaplin

Small Conservation Projects

This plan does not attempt to identify particular places where conservation activities should be located to meet the perennial vegetation goals within major watersheds. These choices will be made over time and depend on local circumstances, opportunities and agreements with landowners. However, we do suggest priorities to guide the selection of projects. The permanent protection projects chosen for local conservation efforts in the agricultural matrix should be in areas with the highest probability of building wetland and grassland habitat complexes over time; protecting rare communities, including forests, savannas, lakes and streams; and achieving the greatest possible improvement in water quality and fisheries habitat. Much of this voluntary, private lands conservation work will be done by Soil and Water Conservation Districts, Watershed Districts, and other local units of government working with state and federal agencies. Protection may use funds from federal farm programs and easement programs such as RIM/WRE and CREP (Table 7) and state funds such as the Clean Water Legacy. Some criteria that could be employed to select projects are listed here in unranked order:

1. Close to native prairie
2. Designated as an Area of High or Outstanding Biodiversity Significance (according to Minnesota Biological Survey)
3. Contains restorable wetlands
4. Contains priority basins or basins with portfolio lakes
5. Close to high-priority shallow lakes
6. Adjacent to high-priority warm-water streams
7. Adjacent to other watercourse or water body
8. Lies within a Grassland Bird Conservation Area (HAPET) or Important Bird Area (Audubon)
9. Contains known populations of Species of Greatest Conservation Need
10. Borders public conservation land
11. Does not contain highly productive agricultural soils



Near Sheepberry Fen, Glacial Lakes Core Area © Susan Chaplin

A great deal of additional work and planning is needed to integrate these criteria and make spatially explicit recommendations. This work will be especially challenging because improvement in water quality and other ecosystem functions are not likely to be evident until some yet undefined threshold of land conservation is achieved over large areas.

Table 7. Prairie and Wetland Conservation Programs

	Core Areas	Corridors	Agricultural Matrix
Protect Native Prairie			
Fee Acquisition	WMA, SNA, WPA, SP, TNC, NWR	WMA, SNA, WPA, SP, TNC	WMA, SNA, SP, WPA
Easement	NPB, GEP	NPB, GEP	NPB, GEP
Protect Other Grassland and Wetlands			
Fee Acquisition	WMA, WPA, NWR, SP	WMA, SP, WPA	WMA, SP, WPA
Easement	WPA, GEP, RIM	WPA, GEP, RIM	WPA, GEP, RIM
Under 10–15 Year Contract	CRP, CCRP, WBP	CRP, CCRP, WBP	CRP, CCRP, WBP
Restore Grassland and Wetlands			
After Acquisition	TNC, WMA, WPA, SP, NWR	WMA, SP, WPA, TNC	WMA, WPA
After Easement	PFW, RIM, WRE	PFW, RIM, WRE	PFW, RIM, WRE
Under 10–15 Year Contract	PFW, CRP, CCRP	PFW, CRP, CCRP	PFW, CRP, CCRP
Enhancement on Public Lands			
Prescribed Fire	WMA, SNA, SP, WPA, TNC, NWR	WMA, SNA, SP, WPA, TNC	WMA, SNA, SP, WPA
Grazing Management	WMA, SNA, WPA, TNC	WMA, SNA, WPA, TNC	WMA, SNA, WPA, TNC
Invasive Species Control	WMA, SNA, WPA, TNC, SP	WMA, SNA, WPA, TNC	WMA, SNA, WPA, TNC
Enhancement on Private Lands			
Prescribed Fire	TNC, LIP, HE, PFW, EQIP, NPB	WHIP, LIP, HE, PFW, EQIP, NPB	WHIP, LIP, HE, PFW, EQIP, NPB
Grazing Management	TNC, EQIP, LIP, HE, PFW, NPB, CSP	EQIP, LIP, HE, PFW, NPB, CSP	EQIP, LIP, HE, PFW, NPB, CSP
Invasive Species Control	TNC, EQIP, LIP, HE, PFW, NPB	EQIP, LIP, HE, PFW, NPB	EQIP, LIP, HE, PFW, NPB

ACEP = NRCS Agriculture Conservation Easement Program

BWSR = Board of Water and Soil Resources

CCRP = FSA Continuous Conservation Reserve Program

CRP = FSA Conservation Reserve Program

CSP = NRCS Conservation Stewardship Program

DNR = Department of Natural Resources

EQIP = NRCS Environmental Quality Incentives Program

FSA = Farm Service Agency

GEP = USFWS Grassland Easement Program

HE = DNR Heritage Enhancement Projects

LIP = NRCS Landowner Incentive Program

NPB = Minnesota DNR Native Prairie Bank

NRCS = Natural Resources Conservation Service

NWR = USFWS National Wildlife Refuge

PFW = USFWS Partners for Fish and Wildlife Program

RIM = BWSR Reinvest in Minnesota Reserve Easement

SNA = Minnesota DNR Scientific and Natural Area

SP = DNR State Park

TNC = The Nature Conservancy

USFWS = U.S. Fish and Wildlife Service

WBP = NRCS Water Bank Program

WMA = MN DNR Wildlife Management Area

WPA = USFWS Waterfowl Production Area

WRE = NRCS Wetlands Reserve Easement

Measures of Success for Prairie Conservation

This plan is an ongoing attempt to bring all organizations working toward prairie conservation together to devise a common vision and explicit goals, to make more effective use of limited conservation resources. Thus, it is important to measure the progress made toward desired outcomes. This plan lays out three primary conservation strategies to advance prairie conservation in Minnesota (Protect, Restore and Enhance) and one economic strategy (Multifunctional Landscapes). These strategies are designed to address the threats to prairie, other grasslands and wetlands in the Prairie Region that have been outlined in this plan (i.e., conversion of habitat, invasive species, unmanaged grazing practices, woody plant encroachment, energy development, climate change, nutrient overload and use of insecticides and herbicides). The implementation of these strategies will move us closer to restoring functioning grassland landscapes in Minnesota. However, it is essential to articulate measures of success clearly so that we can assess the effectiveness of this plan, better understand the results of management activities and adapt our strategies as needed to meet our goals.

Activity Measures

Typically, the success of a plan is measured by the types and amount of activity each conservation organization conducts toward reaching conservation goals. Often this is measured in terms of money spent or area of land conserved. The partners in this Prairie Plan are fully committed to tracking how they spend conservation funds and how many acres are protected, enhanced and restored, but even these seemingly simple measures have proven difficult to aggregate, for several reasons. First, multiple agencies and groups often work on the same project, but only one entity should report the acres. Second, there is often a lag period between project completion and the time when project results become apparent. For example, protection projects may require a year or more of realty dealings and several more years of site cleanup, signage installation and infrastructure development before they are opened to the public. Restoration projects can take much longer because the site must be prepared, seed must be gathered and planted, and weeds must be controlled before the site becomes good wildlife habitat. Third, data on land management can be extremely cumbersome to gather and digitize due to their varied nature and often their lack of geographic specificity. Furthermore, management data are often held by local operating units, making them difficult to aggregate.

The best approach to these issues would be for all partners to enter key project information into a geographically specific database that could be easily shared or aggregated. At this time, some management data cannot be tracked because of the time and effort required. However, if at least some current and accurate data were available in a Geographic Information System, it would be a relatively simple matter to summarize changes over time for those measures.

The conservation partners also must agree on what constitutes grassland and wetlands in the state and develop ways to easily create an accurate land cover layer from aerial photo

and satellite imagery. If current land cover data are available, it will be possible to track the amount of grassland and wetland present and conserved over time.

Ecological Measures

We need to monitor the ecological outcomes of conservation activities to determine the effectiveness of land protection and management practices on prairie species, communities and ecosystems. One major category of monitoring measures is habitat/plant-based measures that focus on vegetation and habitat characteristics (e.g., size, extent, condition, structure) or plant populations (including rare or invasive species). Another category is wildlife population measures that document the responses of animal populations to land conservation and management accomplishments. In addition to monitoring, we should address numerous research questions to improve our ability to manage and sustain grassland systems.

Habitat/plant community monitoring

Several long-term efforts to track the composition and condition of prairie grassland vegetation and plant populations are well underway in Minnesota. The Grassland Monitoring Team, a multi-agency effort led by staff of the U.S. Fish and Wildlife Service, The Nature Conservancy, and the Minnesota DNR, began in 2007. This team is now tracking grassland vegetation in over 80 locations in Minnesota and documenting the effects of different combinations of management practices, including prescribed fire, conservation grazing and rest, on the condition of upland and lowland prairie vegetation (Vacek et al., 2012).

Species population monitoring

Stakeholders need to know how well land protection, restoration and management activities are sustaining grassland animal and plant populations. The choice of indicators and actual implementation of a monitoring program has proven to be more difficult than anticipated in the first edition of the Prairie Plan. In the first edition, we chose measures that represented many of the different components of functioning landscapes. The seven different wildlife indicators were chosen because they represented different aspects of the prairie/wetland ecosystem and because several of these targets are being assessed at a statewide/regionwide level by existing monitoring programs, so some data for these indicators already existed. For example, the Minnesota DNR annually censuses populations of selected rare plant species, including two rare, native prairie plant species whose largest concentration of populations is found in Minnesota: the federally listed western prairie fringed orchid (*Platanthera praeclara*) (Sather & Anderson, 2014) and the state-listed small white lady's slipper orchid (*Cypripedium candidum*) (Anderson & Ruby, 2014).

Since the first edition of the Plan, the primary scale at which we will evaluate prairie plan actions has shifted from statewide to the core landscapes defined by the plan, and data availability from the national datasets is limited to the scale of the core landscapes. To accurately assess the effects of prairie plan actions on wildlife species, a sufficient

number of sample sites should be established within areas where prairie plan activities are taking place. This requires us to know where the prairie plan activities are taking place on the ground; the activity measures mentioned above are important for determining where to monitor wildlife populations. In addition, several prairie obligate butterfly species named as a potential monitoring target in the first edition have nearly vanished from Minnesota and are now too rare to be good targets for monitoring.

New monitoring projects are needed to assess the status of wildlife populations in locations where prairie plan conservation actions are taking place. These projects need careful research designs to identify appropriate objectives and protocols that meet those objectives.

Greater prairie chicken © Susan Chaplin

Rather than prescribing a set of indicators in this second edition of the Plan, we set up a framework for thinking about monitoring and measures of success. Ideally, the indicator chosen should be quick and inexpensive to measure, easy to replicate, meaningful in a variety of habitats and applicable across large areas. Some measures may work well in small areas but are not feasible for whole regions. Our proposed framework to measure conservation success includes four different kinds of indicators at three different geographic scales (Table 8). Indicators for the health of individual species (or groups of species), habitat/plants, the human grass-based economy, and water quality all need to be assessed at the local (management unit), intermediate (core area), and regional scales. Rather than picking the indicators to be monitored, this second edition calls for the Prairie Plan's Statewide Working Group to continue the discussion with the Local Technical Teams to identify appropriate indicators. Preference should be given to indicators that are already in use and yielding useful data. Table 8 shows some of the

Table 8. Example Indicators

	Species	**Habitat**	**Economic**	**Water Quality**
Prairie Region	Stable or increasing grassland bird populations	Acres of grassland and wetland	Statewide pheasant harvest	Change in acres of permanent wetlands
Core Area	Waterfowl populations	Percent of native prairie protected	Number and % of cattle using conservation grazing	% of watershed in perennial cover
Management Unit	Number and diversity of butterflies and bees	% of plant species that are native	# vendor contracts for habitat management	EPT Index (**E**mpheroptera, **P**lecoptera, **T**richoptera)

indicators that can be considered, including a few that are already in use, such as the Breeding Bird Survey for grassland birds and statewide pheasant harvest counts.

Modeling

With limited resources, it is nearly impossible to directly count most animal species at the large spatial scales covered by the Prairie Plan. One way to indirectly count animal populations at these scales is to measure the amount and spatial location of different habitat types, then model how many individuals will likely be supported by those habitats. The USFWS HAPET (Habitat and Population and Evaluation Team) office in Fergus Falls, as well as academic institutions across the state, have extensive modeling expertise that can be used to estimate the populations of key animal species and can predict how conservation activities that impact habitat will influence them.

However, we may not have all the data necessary to provide inputs or parameters for these models. In these cases, we will need to integrate research from partner agencies and organizations, as well as working with universities in the state to refine existing models or develop new ones.

Research

In addition to monitoring, which focuses on the overall status of a particular population or habitat over a long period of time, research focuses on answering hypotheses concerning specific variables affecting species, populations or ecosystems. Ongoing research is providing important insights into grassland and wetland ecology and management that will improve our ability to conserve functioning systems. For example, the Minnesota DNR is examining gene flow between subpopulations of the greater prairie chicken (*Tympanuchus cupido*) in northwestern Minnesota, which will increase our understanding of dispersal patterns and landscape connectivity for this species. As another example, University of Minnesota researchers are studying how past fire and grazing management affect plant community composition and pollinator populations.

Additional research is needed to improve our ability to manage and conserve grassland and wetland species and ecosystems in Minnesota. Prairie core areas and protected native prairie can play an important role as a "living laboratory" where prairie function can be studied. Future research should also include more study of the effects of environmental factors (such as pesticide spraying) or management practices (e.g., controlled burn, different grazing techniques, water management) on pollinators, other wildlife and invasive species.

Funding Needs for Prairie Landscape Conservation

Based on the calculations in Appendix 5 (summarized in Table 9), the overall cost of prairie landscape conservation in Minnesota could reach $2.8 billion over 15 years. Although this is a daunting figure, it may be more feasible than it initially appears. The first mitigating factor is that the actual cost to purchase fee title or conservation easements from willing sellers may be less than assumed. Land within prairie landscapes is often less productive than average farm land in the same vicinity due to its rocky, steep, sandy or wet nature. Generally, the value of crop ground is correlated to its productivity. Some transactions also may be partial donations. In addition, land values seem to be plateauing in 2016 and may fall in the next 15 years, after steadily rising in the past decade. The second mitigating factor is that the overall cost of conservation activities will be borne by many different entities. On privately owned land, a substantial portion of the landscape restoration and management activities will be paid by the landowner to enhance the value of the land aesthetically, to make it more suitable for agricultural purposes, or to meet the legal requirements of the buffer law and others. The role of public agencies should be to catalyze these private activities. Public funding and resources are sorely needed to help conduct management activities on private lands, such as prescribed burning.

Publicly funded conservation activities can be paid for by many different agencies and programs (see Table 7). Federal farm programs already pay for temporary conservation activities and many long-term easements. Farm programs could be targeted more toward activities that would further this prairie landscape plan. If a greater proportion of farm subsidies went to conservation and ecosystem services payments, these payments would go a long way toward creating functioning prairie systems in Minnesota.

One goal of this plan was to roughly estimate what could be used from the Clean Water, Land, and Legacy Amendment to complete prairie conservation activities in the Prairie Region of Minnesota. The overall cost of this plan was calculated as $2.8 billion over the next 15 years. Federal farm programs such as the CRP could largely pay the $802 million costs of temporary protection (under 10–15-year contracts), especially if CRP was more targeted to meet the goals of this plan. Other farm programs, plus private landowners, are predicted to cover $185 million of restoration costs on private lands. Finally, half of the costs ($55 million) for enhancement on private unprotected lands should be covered by private landowners.

The remaining total of $1.8 billion is the amount needed from state, federal and private conservation sources. The 2017 Minnesota Conservation Reserve Enhancement Program is expected to spend about $500 million on buffer strips, wetland restoration and wellhead protection. Since the Clean Water, Land and Legacy Amendment approximately doubled the amount of funding for conservation purposes in Minnesota, the amount that might be allocated from the Outdoor Heritage and Clean Water Funds could approach $625 million dollars.

Table 9. Prairie, Grassland and Wetland Conservation Goals (Acres and Cost)

	Core Area	General Corridor Sections	Strategic Habitat Complex	Agricultural Matrix	Total	Cost
Native Prairie Protection Goals						
Fee Acquisition ($2,800/acre)	24,996	1,281	797	5,589	32,663	$91,456,400
Easement ($1,872/acre)	58,324	2,988	1,858	13,042	76,212	$142,668,864
Total	83,320	4,269	2,655	18,631	108,875	$234,125,264
Preliminary Protection Goals for Other Grassland and Wetlands Based on Protection Shortfalls						
Fee Acquisition ($2,880/acre)	93,236	9,992	17,613	60,224	181,065	
Easement ($1,812/acre)	139,855	19,983	26,420	120,447	306,705	
Contract ($1,109/acre)		69,941		421,565	491,506	
Total	233,091	99,916	44,033	602,236	979,276	
Restoration Goals for Grassland and Wetlands						
After fee acquisition ($4,800 + $500 restoration/acre)	29,503	2,432	5,794	4,443	42,172	$223,511,600
After easement ($4,320 + $500 restoration/acre)	59,005	4,864	11,588	8,886	84,343	$406,533,260
After signing 10–15-year contract ($1,109 + $500 restoration/acre)	206,519	17,026	40,559	15,551	279,655	$449,964,895
Private unprotected lands				15,551	15,551	$3,110,200
Total	295,027	24,322	57,941	44,431	421,721	$1,083,119,955
Final Protection Goals for Other Grassland and Wetlands (Subtracts Land Protected as Part of Restoration)						
Fee Acquisition ($2,880/acre)	63,733	7,560	11,819	55,781	138,893	$400,011,840
Easement ($1,812/acre)	80,850	15,119	14,832	111,561	222,362	$402,919,944
Contract ($1,109/acre)		52,916		390,463	443,379	$491,707,311
Total	144,583	75,595	26,651	557,805	804,634	$1,294,639,095
Annual Goals for Enhancement on Protected Lands – Management Every Four Years (Cost Over 15 Years)						
Native Prairie ($20/acre/year)	26,933	405	524	2,256	30,118	$9,035,400
Other Grasslands ($20/acre/year)	49,258	9,689	7,808	61,397	128,152	$38,445,600
Wetland ($20 /acre/year)	13,707	3,839	17,646	40,676	75,868	$22,760,400
Total	89,898	13,933	25,978	104,329	234,138	$70,241,400
Annual Goals for Enhancement on Unprotected Lands – Management Every Four Years on Half the Lands (Cost Over 15 Years)						
Native Prairie ($20/acre/year)	10,415	534	332	2,329	13,610	$4,083,000
Other Grasslands ($20/acre/year)	75,567	16,828	10,889	202,806	354,771	$106,431,300
Wetland ($20 /acre/year)	43,245		5,436			
Total	129,227	17,362	16,657	205,135	368,381	$110,514,300
TOTAL	**742,055**	**135,481**	**129,882**	**930,331**	**1,937,749**	**$2,792,640,014**

Works Cited

Anderson, D. and J. Ruby. (2014). Small white lady's-slipper (*Cypripedium candidum*) monitoring activities in Minnesota – 2013. Minnesota Department of Natural Resources, St. Paul, MN. http://files.dnr.state.mn.us/eco/mcbs/2013_cypripedium_candidum_report.pdf

Anderson, J.P. and W.J. Craig. (1984). Growing energy crops on Minnesota's wetlands: The land use perspective. *Center for Urban and Regional Affairs* 84(3), 95 pp.

Aquatic Management Area Acquisition Planning Committee. (2007). Minnesota's Aquatic Management Area Acquisition Plan. Minnesota Department of Natural Resources, St. Paul, MN.

Arnett, E.B., W.K. Brown, W.B. Erickson, J.K. Fiedler, B.L. Hamilton, T.H. Henry, et al. (2008). Patterns of bat fatalities at wind energy facilities in North America. *Journal of Wildlife Management* 72:61–78.

Bakker, K.K. (2003). A synthesis of the effect of woody vegetation on grassland nesting birds. *Proceedings of the South Dakota Academy of Sciences* 82:119–141.

Berg, W. (1997). The Sharp-tailed Grouse in Minnesota. Minnesota Wildlife Report 10, Minnesota Department of Natural Resources, St. Paul, MN.

Blann, K. (2006). Habitat in agricultural landscapes: how much is enough? A state of the science literature review. Defenders of Wildlife, West Linn, OR.

Blann, K.L., J.L. Anderson, G.R. Sands, and B. Vondracek. (2009). Effects of agricultural drainage on aquatic ecosystems: A review. *Critical Reviews in Environment Science and Technology* 39:909–1001.

Blann, K. and M. Cornett. (2008). Identifying Lake Conservation Priorities for The Nature Conservancy in Minnesota, North Dakota, and South Dakota. The Nature Conservancy, Minneapolis, MN.

Bois de Sioux Watershed District. (2016). Tile Permit Growth (map). Wheaton, MN. http://www.frontiernet.net/~bdswd/Files/Tile_Permit_Growth_Map_Reduced.pdf

Boody, G.B., B. Vondracek, D. Andow, M. Krinke, J. Zimmerman and P. Welle. (2005). Multifunctional agriculture in the United States. *Bioscience* 55:27–38.

Campaign for Conservation. (2008). A Fifty-Year Vision: Conservation for Minnesota's Future. Belwin Conservancy, Afton, MN.

Chapman, K., K. Hiller, and J. Haferman. (1998). Identification of Important Bird Sites in the Northern Tallgrass Prairie Ecoregion: A Step in Ecoregional Planning. The Nature Conservancy, Minneapolis, MN.

Citizens' Advisory Committee. (2002). Minnesota's Wildlife Management Area Acquisition —The Next 50 Years. Minnesota Department of Natural Resources, St. Paul, MN.

Clark, C.M. and D. Tilman. (2008). Loss of plant species after chronic low-level nitrogen deposition to prairie grasslands. *Nature* 451:712–715.

Collins, S.L. (1990). Introduction: Fire as a natural disturbance in tallgrass prairie ecosystems. In S. L. Collins & L. L. Wallace, *Fire in North American Tallgrass Prairies,* University of Oklahoma, Norman, OK, pp. 3–7.

Division of Conservation Planning, Midwest Region, U.S. Fish and Wildlife Service. (2007). Proposal to Focus Northern Tallgrass Prairie NWR Conservation Efforts in Areas of High Conservation Interest. US Fish and Wildlife Service, Fort Snelling, MN.

Fields, S. 2016. Personal communication. Prairie Pothole Joint Venture.

Gagnon, P., P. Gerla, B. Schreurs, M. Cornett, M. Khoury, and J. Hall. (2004). The Northern Tallgrass Prairie Ecoregion: A River and Stream Conservation Portfolio. The Nature Conservancy, Minneapolis, MN.

Galatowitsch, S., L. Frelich, and L. Phillips-Mao. (2009). Coping with climate change: Conservation planning in Minnesota. *CURA Reporter* 39(3–4):3–10.

Galloway, J.F., A.R. Townsend, J.W. Erisman, M. Bekunda, Z. Cai, J.R. Freney, L.A. Martinelli, S.P. Seitzinger, and M.A. Sutton. (2008). Transformation of the nitrogen cycle: Recent trends, questions, and potential solutions. *Science* 320:889–892.

Gilbert-Norton, L., R. Wilson, J.R. Stevens, and K.H. Beard. (2010). Meta-analytic review of corridor effectiveness. *Conservation Biology* 24:660–668.

Harris, M., G. Iyer, and L. Miller. (2014). Small Changes, Big Impacts: Prairie Conservation Strips. Iowa State University, Ames, IA. http://www.nrem.iastate.edu/research/STRIPs/files/publication/Small-changes-big-impacts-prairie-conservation-strips%20201407.pdf

Hobbs, J.C. and J.E Goebel. (1982). Geologic Map of Minnesota: Surficial Geology. Minnesota Geological Survey Map S-1, St. Paul, MN.

Interagency Climate Adaptation Team. (2013). Adapting to Climate Change in Minnesota. Minnesota Pollution Control Agency, St. Paul, MN. 38 p.

Jarchow, M.E. and J. Liebman (2010). Incorporating Prairies into Multifunctional Landscapes. Iowa State University Extension, Ames, IA.

Johnson, W.C., B.V. Millett, T. Gilmanov, R.A. Voldseth, G.R. Guntenspergen, and D.E. Naugle. (2005). Vulnerability of northern prairie wetlands to climate change. *BioScience* 55(10):863–872.

Johnson, W.C., B. Werner, G.R. Gunterspergen, R.A. Voldseth, B. Millett, D.E. Naugle, et al. (2010). Prairie wetland complexes and landscape functional units in a changing climate. *BioScience* 60:128–140.

Lazarus, W.F. (2017). Minnesota Farm Real Estate Sales 1990–2016. Staff Paper P17-1, Department of Applied Economics, University of Minnesota, St. Paul, MN. 53 p.

Leddy, K.L., K.F. Higgins, and D.E. Naugle. (1999). Effects of wind turbines on upland nesting birds in the Conservation Reserve Program. *Wilson Bulletin* 111:100–104.

Management Analysis and Development. (2009). LSOHC Strategic Planning and Recommendation Development Process— Summary of Input Meetings. Minnesota Management and Budget, St. Paul, MN.

Marschner, F.J. (1974). The original vegetation of Minnesota, compiled from U.S. General Land Office Survey notes by Francis J. Marschner [map] Redrafted from the original by P.J. Burwell and S.J. Haas under the direction of M.L. Heinselman. North Central Forest Experiment Station, USDA. St. Paul, MN.

Minnesota Biological Survey. (2017a). Minnesota's Remaining Native Prairie a Century after the Public Land Survey (map). Minnesota Department of Natural Resources, St. Paul, MN.

Minnesota Biological Survey. (2017b). The conversion of documented prairie native plant communities in Minnesota until 2015: an analysis of the MNDNR Native Prairie Communities layer [compiled by Dustin Graham]. Department of Natural Resources, St. Paul, MN.

Minnesota Biological Survey. (2010). Minnesota's Remaining Native Prairie a Century after the Public Land Survey – Highlighted prairie landscapes (map). Minnesota Department of Natural Resources, St. Paul, MN. http://files.dnr.state.mn.us/eco/mcbs/prairies_highlighted_areas.pdf

Minnesota Board of Water and Soil Resources. (2015). Conservation Land Summary – Statewide. St. Paul, MN. http://www.bwsr.state.mn.us/easements/CLS%20Statewide%20Summary%20August%2013%202015.pdf

Minnesota Board of Water and Soil Resources. (2014). Pollinator Plan. St. Paul, MN.

Minnesota Board of Water and Soil Resources. (2010). Study of Riparian Buffer Areas. St. Paul, MN.

Minnesota Board of Water and Soil Resources. (2009a). Cultivated Riparian Zone Estimates. St. Paul, MN.

Minnesota Board of Water and Soil Resources. (2009b). Wetlands Restoration Strategy: A Framework for Prioritizing Efforts in Minnesota. St. Paul, MN.

Minnesota Department of Agriculture (2017). Palmer Amaranth Fact Sheet. St. Paul, MN. http://www.mda.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist/palmeramaranth/palmeramaranthfs.aspx.

Minnesota Department of Agriculture. (2015). Minnesota Agricultural Profile. St. Paul, MN. https://www.mda.state.mn.us/~/media/Files/agprofile.ashx

Minnesota Department of Agriculture. (2014). Pollinator Report: Pollinator Bank, Habitat Protection, and Pesticide Special Review. St. Paul, MN.

Minnesota Department of Natural Resources. (2016a). Minnesota's Wildlife Action Plan 2015–2025. St. Paul, MN.

Minnesota Department of Natural Resources. (2016b). Wildlife Management Areas Grazing Operation Plan. St. Paul, MN.

Minnesota Department of Natural Resources. (2015). Pheasant Summit Action Plan. St. Paul, MN. 20 pp.

Minnesota Department of Natural Resources. (2014). Pollinator Habitat Program Guidelines. St. Paul, MN.

Minnesota Department of Natural Resources. (2013). Implementation of the Minnesota Prairie Conservation Plan 2013–2017. St. Paul, MN. http://www.mda.state.mn.us/~/media/Files/news/govrelations/pollinators/dnrprairieconsplan.ashx.

Minnesota Department of Natural Resources. (2010). Working Lands Initiative Legislative Report. St. Paul, MN.

Minnesota Department of Natural Resources. (2006). Long Range Duck Recovery Plan. St. Paul, MN.

Minnesota Department of Natural Resources. (2005). Field Guide to the Native Plant Communities of Minnesota: The Prairie Parkland and Tallgrass Aspen Parklands Provinces. Ecological Land Classification Program, Minnesota Biological Survey, and Natural Heritage and Nongame Research Program, St. Paul, MN.

Minnesota Department of Natural Resources. (1997). Minnesota Wetlands Conservation Plan. St. Paul, MN.

Minnesota Department of Natural Resources, Division of Ecological Resources. (2006). Tomorrow's Habitat for the Wild and Rare: An Action Plan for Minnesota Wildlife. St. Paul, MN.

Minnesota Department of Natural Resources, Division of Ecological Resources. (2004). Scientific and Natural Areas Long Range System Plan. St. Paul, MN.

Minnesota Department of Natural Resources, Division of Fish and Wildlife. (2005). Long Range Plan for the Ring-necked Pheasant in Minnesota. St. Paul, MN.

Minnesota Department of Natural Resources, Division of Fish and Wildlife, Wildlife Management Section. (2010). Managing Minnesota's Shallow Lakes for Waterfowl and Wildlife. St. Paul, MN.

Minnesota Pollution Control Agency. (2009). Wetland Status and Trends in Minnesota. St. Paul, MN.

Minnesota Prairie Plan Working Group. (2011). Minnesota Prairie Conservation Plan 2010. Minneapolis, MN. 55 p.

Minnesota Sustainable Farming Association. (2016). Soil Health Tools and Techniques for Small-Scale Producers. Minneapolis, MN. http://www.sfa-mn.org/wp-content/uploads/2016/02/Soil-Health-for-Small-Producers.pdf

National Fish and Wildlife Foundation. (2010). Business Plan: Conserving and Restoring Tallgrass Prairie in the Prairie Coteau, South Dakota and Minnesota. Washington, DC.

Ness, J.A. (2010). Profits from Perennials. *The Land Stewardship,* 28(3):26–27.

Norris, D. (2007). Fish culture in wetlands: a review of the science and recommendations for licensing criteria. Wetlands Values Technical Committee, Minnesota Department of Natural Resources Special Publication 164. St. Paul, MN.

Northern Tallgrass Prairie Ecoregional Planning Team. (1998). Ecoregional Planning in the Northern Tallgrass Prairie. The Nature Conservancy, Minneapolis, MN.

Osborn, R.G., K.F. Higgins, R.E. Usgaard, C.D. Dieter, and R.D. Neiger. (2000). Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota. *American Midland Naturalist* 143:41–52.

Pruett, C.L., M.A. Patten, and D.H. Wolfe. (2009). Avoidance behavior by prairie grouse: Implications for development of wind energy. *Conservation Biology* 23:1253–1259.

Pryor, S.C., D. Scavia, C. Downer, M. Gaden, L. Iverson, R. Nordstrom, J. Patz, and G.P. Robertson. (2014). Chapter 18: Midwest. In J.M. Melillo, T.C. Richmond, and G.W. Yohe, eds. *Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program, pp. 418–440.

Ringelman, J.K. (2005). Prairie Pothole Joint Venture 2005 Implementation Plan. Prairie Pothole Joint Venture. U.S. Fish and Wildlife Service, Denver, CO.

Robb, L.A. and M.A. Schroeder. (2005). Greater Prairie-Chicken (*Tympanuchus cupido*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region, Golden, CO. http://www.fs.fed.us/r2/projects/scp/assessments/greaterprairiechicken.pdf

Rundquist, E. and G.E. Heimpel. (2017). Potential Causes of Declines in Minnesota's Prairie Butterflies with a Focus on Insecticidal Control of the Soybean Aphid. University of Minnesota, St. Paul, MN. https://mitppc.dl.umn.edu/sites/g/files/pua746/f/media/mitppc_soybean.final_.pdf

Runkle, J., K. Kunkel, R. Frankson, D. Easterling, and S. Champion. (2017). Minnesota State Summary. NOAA Technical Report NESDIS 149-MN, 4 pp.

Samson, F. and F. Knopf. (1994). Prairie conservation in North America. *BioScience* 44:418–421.

Sather, N. and D. Anderson. (2014). Twenty-five years of monitoring the western prairie fringed orchid (*Platanthera* Sheviak and Bowles) in Minnesota. 22nd North American Prairie Conference, pp. 126–134.

Scheer, S. and J. McNeely. (2008). Biodiversity conservation and agricultural sustainability: towards a new paradigm of "ecoagriculture" landscapes. *Philosophical Transactions of the Royal Society B* 363:477–494.

Schweser, G. (2009). Scott County Prime Farmland Mapping Project. Community Growth Options, University of Minnesota, Minneapolis, MN.

Seastedt, T.R. and R.A. Ramundo. (1990). The influence of fire on belowground processes of tallgrass prairie. In S.L. Collins and L.L. Wallace. *Fire and the Tallgrass Prairie*. University Oklahoma Press, Norman, OK. pp. 99–117.

Stettler, K. (2010). Access to land: The next step. *Land Stewardship,* 28:20–21.

Swackhammer, D.L., J. Coleman and J. Shardlow. (2008). Minnesota Statewide Conservation and Preservation Plan. University of Minnesota Institute on the Environment, St. Paul, MN.

The Nature Conservancy. (2001). The Prairie-Forest Border Ecoregion: A Conservation Plan. Madison, WI.

U.S. Department of Agriculture. (2017). Conservation Reserve Program Statistics. Retrieved May 2017 from CRP Enrollment and Rental Payments by State, 1986-2016. https://www.fsa.usda.gov/programs-and-services/conservation-programs/reports-and-statistics/conservation-reserve-program-statistics/index

U.S. Department of Agriculture. (2013). Recommendations for tree and forest establishment and management in Minnesota's Prairie Region. Natural Resources Conservation Service, Minnesota State Technical Committee Forestry Subcommittee. St. Paul, 11 pp.

U.S. Department of Agriculture. (2010). Conservation Reserve Program. Retrieved July 2010, from Monthly Summary July 2010. http://www.fsa.usda.gov/Internet/FSA_File/july2010crpstat.pdf

U.S. Fish and Wildlife Service (2014). Threatened Species Status for Dakota Skipper and Endangered Species Status for Poweshiek Skipperling. *Federal Register* 79:63672–63748.

U.S. Fish and Wildlife Service. (2009). *Platanthera praeclara* (Western Prairie Fringed Orchid), Five-Year Review: Summary and Evaluation. Bloomington, MN.

U.S. Fish and Wildlife Service. (2003a). Comprehensive Conservation Plan and Environmental Assessment — Big Stone Wetland Management District. Odessa, MN.

U.S. Fish and Wildlife Service. (2003b). Comprehensive Conservation Plan and Environmental Assessment — Detroit Lakes Wetland Management District. Detroit Lakes, MN.

U.S. Fish and Wildlife Service. (2003c). Comprehensive Conservation Plan and Environmental Assessment — Fergus Falls Wetland Management District. Fergus Falls, MN.

U.S. Fish and Wildlife Service. (2003d). Comprehensive Conservation Plan and Environmental Assessment — Litchfield Wetland Management District. U.S. Fish and Wildlife Service, Litchfield, MN.

U.S. Fish and Wildlife Service. (2003e). Comprehensive Conservation Plan and Environmental Assessment — Morris Wetland Management District. Morris, MN.

U.S. Fish and Wildlife Service. (2003f). Comprehensive Conservation Plan and Environmental Assessment — Windom Wetland Management District. Windom, MN.

U.S. Fish and Wildlife Service. (1998). Northern Tallgrass Prairie Habitat Preservation Area Final Environmental Impact Statement and Interim Comprehensive Conservation Plan. Ft. Snelling, MN.

Vacek, S., M. Cornett, D. Carlson, and M. Ahlering. (2012). Grassland Monitoring Team Standardized Monitoring Protocol. https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/minnesota/Documents/GMT_Protocol_v7.pdf

Van der Valk, A.G. (2005). The prairie potholes of North America. Chapter 11. In L.H. Fraser and P.A. Keddy (eds). *The World's Largest Wetlands: Ecology and Conservation*. Cambridge University Press, New York. pp. 393–423.

Wedin, D.A. and D. Tilman. (1996). Influence of nitrogen loading and species composition on the carbon balance of grasslands. *Science* 274:1720–1723.

Appendix 1: Definition of Terms

Adaptive management: An iterative process of decision making in which decisions are continually evaluated and adjusted as new information emerges.

Conservation grazing: Sustainable grazing with rest periods that achieves conservation goals by mimicking natural processes, in addition to providing economic returns

Enhancement: The improvement of prairie, grassland, savanna or aquatic habitat condition through proper management. Common enhancement activities include the increased use of prescribed fire, conservation grazing practices, natural water level management, and effective invasive species control.

Functional system: A native ecosystem that has sufficient size, habitat condition and landscape composition to maintain natural ecological processes and viable populations of nearly all the native animals and plants that would naturally be found there.

Grass-based agriculture: Economic activities based on native prairie or other grasslands to produce a sustainable economic return.

Grassland: A plant community dominated by grass or sedge species. Trees are scattered and infrequent. Native prairies are one type of grassland, as are planted monoculture grass stands.

Invasive species control: The use of chemicals, biological control vectors and mechanical means to reduce the populations of invasive species or to prevent their spread.

Native prairie: An unplowed plant community originating on the site that is dominated by grass and sedge species, with a rich mix of broad-leaved herbs and a few low shrub species.

Prairie Region: The portion of Minnesota covered by the Prairie and Forest-Prairie Transition Planning Sections employed by the Lessard-Sams Outdoor Heritage Council. This area is the part of Minnesota that was dominated by prairie and associated plant communities prior to European settlement.

Prescribed fire: A controlled burn of vegetation to accomplish a number of objectives, including the reduction of unwanted plant species, the alteration of vegetation structure, the removal of potential fire hazards, and the improvement of habitat for cattle grazing or other purposes.

Protection: The legal protection of land for conservation purposes, either permanently or temporarily. The most typical protection activity would be the purchase of land or a conservation easement from a willing seller.

Restoration: The replanting of degraded habitats, including former cropland, with the original vegetation type that existed on the site, using local ecotypes of native species that are appropriate to the habitat.

Wetland draw-down: The temporary lowering of water levels in wetlands and shallow lakes to simulate natural drought conditions, reduce invasive fish, and increase water clarity, aquatic plants and invertebrates.

Appendix 2: Highlights from Past Planning in the Prairie Region of Minnesota

Minnesota Wetlands Conservation Plan (Minnesota Department of Natural Resources, 1997)

The Wetlands Conservation Plan describes the current conditions of wetlands in Minnesota and sets a goal of restoring the quality and diversity of wetlands while increasing their overall quantity. To achieve this goal, regional management within 14 wetland ecological units (regional areas) is necessary, as well as regulatory simplification and education. Although no quantitative goals are set, general strategies in each regional area are established.

Important Bird Sites in the Northern Tallgrass Prairie Ecoregion (Chapman, Hiller, & Haferman, 1998)

This first update to the Northern Tallgrass Prairie Ecoregional Plan adds additional sites to the portfolio to capture important bird species and assemblages. Although not all the bird species are imperiled, they are good indicators of habitat quality and size. A total of 46 species of birds were evaluated and 15 were chosen as targets because they were not found regularly at conservation sites. These 15 species were used to select 35 important bird habitat sites, including six in Minnesota that were not previously identified in the ecoregional plan (Heron Lake, Swan Lake, Lake Traverse, Minnesota Lake, Thielke Lake and Thief Lake).

Northern Tallgrass Prairie Ecoregion Plan (Northern Tallgrass Prairie Ecoregional Planning Team, 1998)

This first ecoregional plan by The Nature Conservancy identified 38 ecoregional portfolio sites in Minnesota. Sites were chosen according to the presence of imperiled species and high quality natural communities. Of the 38 sites, four were given highest priority for conservation action: Aspen Parklands, Glacial Ridge, Bluestem Prairie and Felton Prairie.

Northern Tallgrass Prairie Habitat Preservation Area Plan (U.S. Fish and Wildlife Service, 1998)

This environmental impact statement examines ways to preserve, restore and manage up to 77,000 acres of the remaining critical northern tallgrass prairie in Minnesota and Iowa. The preferred alternative would protect and enhance native prairie remnants through partnership, incentives, education, cooperative agreements, acquisition and conservation easements. In addition, about 7,000 acres of cropland would be restored to native grassland.

Prairie–Forest Border Ecoregional Plan (The Nature Conservancy, 2001)

A total of 166 sites were selected that protect all native natural communities, globally rare species and other important species of the Prairie–Forest Border Ecoregion. Oak savannas cover only 1/100th of 1% of their original extent prior to European settlement, and native prairies cover less than 1/10th of 1% of this transitional ecoregion. Ecological Significant Areas (portfolio sites) in the Prairie Region included the Chester Hills Prairies, Glacial Lakes, Rollag Hills and Waubun Prairie, as well as the Otter Tail, North Fork Crow, Minnesota, Straight and Turtle Rivers.

WMA Plan (Citizens' Advisory Committee, 2002)

Minnesota's WMA Acquisition Plan for the Next 50 Years calls for acquiring an additional 702,200 acres of land for WMAs, including 263,050 acres at existing WMAs and 439,150 acres of new WMAs. Over 73% of this total is slated for the Prairie Region of the state, including 182,340 acres of inholdings at existing WMAs and 331,818 acres of new WMAs. The goal of the plan in the Prairie Region is to double the pheasant population and to create 40 large grassland complexes of at least 2,000 acres each to maintain prairie-dependent species.

Big Stone WMD Comprehensive Conservation Plan (U.S. Fish and Wildlife Service, 2003a)

Detroit Lakes WMD Comprehensive Conservation Plan (U.S. Fish and Wildlife Service, 2003b)

Fergus Falls WMD Comprehensive Conservation Plan (U.S. Fish and Wildlife Service, 2003c)

Litchfield WMD Comprehensive Conservation Plan (U.S. Fish and Wildlife Service, 2003d)

Morris WMD Comprehensive Conservation Plan (U.S. Fish and Wildlife Service, 2003e)

Windom WMD Comprehensive Conservation Plan (U.S. Fish and Wildlife Service, 2003f)

These are a series of Wetland Management District plans that cover most of the Prairie Region of Minnesota. Each plan follows the same format and reaches the same general goals to preserve diversity and increase the abundance of waterfowl and other key wildlife species in the Northern Tallgrass Prairie Ecosystem. Other goals include restoring native prairie plant communities, creating functioning wetland complexes and maintaining the cyclic productivity of wetlands. In total, the plans call for the purchase of 391,460 acres and the acquisition of perpetual conservation easements on another 587,320 acres. These goals have been approved by the appropriate county governments. As of 2003, 183,212 acres had been purchased and conservation easements had been placed on 285,351 acres.

Northern Tallgrass Prairie Ecoregional River and Stream Plan (Gagnon et al., 2004)

The second update to the Northern Tallgrass Prairie Ecoregional Plan adds the aquatic component to what had been solely a terrestrial plan previously. A total of 27 stream systems were added to the ecoregional portfolio, including the Otter Tail, Red Lake and Wild Rice Rivers in the Red River Basin, the Rock and Little Sioux Rivers in the Missouri Basin, and the Chippewa, Cottonwood, Blue Earth and Redwood Rivers in the Minnesota River Basin.

Scientific and Natural Area Plan (Minnesota DNR, Division of Ecological Resources, 2004)

The protection objective of the SNA Program is to protect through SNA designation up to three occurrences of each plant species, animal species, geological feature or other special feature and up to five occurrences of each plant community in each landscape region (subsection) where they occur. This approach may be impossible in the southern and western portions of the state where so little natural habitat remains. Protecting every natural site of statewide significance in that portion of the state may be a more realistic goal.

Pheasant Plan (Minnesota DNR, Division of Fish and Wildlife, 2005)

The goal of Minnesota's Pheasant Plan is to double the state's 1987–2000 pheasant harvest to 750,000 roosters, which represents a fall population of 3 million birds. To accomplish this goal, 1.56 million acres of additional grassland habitat is required, most of it within the Prairie Region. On average, one acre of new grassland is needed to increase the pheasant population by one bird in the fall population (up to a maximum of 50% grassland).

Prairie Pothole Joint Venture Plan (Ringelman, 2005)

The PPJV Plan focuses on four groups of bird species: waterfowl, shorebirds, waterbirds, and landbirds. The foundation of the waterfowl plan is to keep critical wetland and grassland habitats intact by securing 1.4 million wetland acres and 10.4 million grassland acres across portions of five states covered by the Prairie Pothole Joint Venture. The goals of the shorebird, waterbird, and grassland bird plans are less specific, calling for the protection of existing wetlands and native grasslands.

Duck Plan (Minnesota Department of Natural Resources, 2006)

The primary objective of the Duck Plan is to restore a breeding population of one million birds that will produce a fall population of 1.4 million ducks from Minnesota. The primary strategy is to restore and protect 2 million additional acres, of which 30% should be wetland and 70% grassland. From a 2006 base of about 1.0 million acres of wetland and 1.86 million acres of grassland in the Prairie Region of Minnesota, the additional lands must include about 580,000 acres of wetland and 1,420,000 acres of grass. Of the lands protected, 60% will be under a permanent or long-term easement and 40% will be owned by a conservation entity.

Minnesota State Wildlife Action Plan (SWAP) (Minnesota DNR, Division of Ecological Resources, 2006)

The SWAP identifies 292 Minnesota species as Species of Greatest Conservation Need (SGCN). This plan discusses the actions needed to stabilize and increase SGCN populations, improve knowledge about SGCNs and enhance people's appreciation and enjoyment of SGCNs. Within each ecological subsection of the Prairie Region, the set of SGCNs are highlighted, their key habitats are described and priority conservation actions for management, survey, research, monitoring and education are identified.

AMA Plan (Aquatic Management Area Acquisition Planning Committee, 2007)

The focus of the AMA plan is to set acquisition priorities to protect Minnesota's aquatic ecosystems. Two priorities are trout streams and lakes and warm-water rivers/streams. The plan includes the acquisition of 1,100 miles of lake and warm-water stream habitat statewide by 2032, of which 35 miles will be in the Northern Prairies and Parklands Section, 65 miles in the Red River Valley Prairie Section, 125 miles in the Minnesota River Prairies Section, and 444 miles in the Deciduous Transition Section (only a small part of which falls in the Prairie Region of Minnesota).

Northern Tallgrass Prairie NWR Focus Proposal (Division of Conservation Planning, Midwest Region, U.S. Fish and Wildlife Service, 2007)

GIS technology was used to identify five focus areas in Minnesota and five in Iowa to complete the Northern Tallgrass Prairie Refuge. The data used in the analysis included the density of prairie species or communities, the density of conservation estate lands and the density of grasslands. The five focus areas in Minnesota are

the Northern Border (Aspen Parkland), Glacial Ridge, Beach Ridge (Agassiz Beach Ridges), Big Stone and Prairie Coteau.

Fifty-Year Vision: Conservation for Minnesota's Future (Campaign for Conservation, 2008)

This effort by the Belwin Conservancy and partners describes a conservation vision for 14 conservation regions in Minnesota, including five in the Prairie Region. The primary conservation action varies by conservation region. In the Red River Valley, it is the restoration of wetlands and grasslands in the context of coordinated flood management and wildlife corridors. In the Glacial Lake Agassiz Beach Ridges, the focus is on protecting large tracts of habitat, building on existing native prairie. In the northern Aspen Parklands, the goal is to maintain the 90% of the region that is currently wetlands and grasslands (compared with the 50:50 mix of cropland to grassland/wetlands in the southern region). In the Minnesota River Prairie, the primary conservation work is ensuring that 15% of the region remains covered in native vegetation, concentrated as vegetative buffers around rivers, lakes, streams and surviving wetlands. In the Prairie Coteau, it is protecting the remaining native prairie, bringing back some of the most important wetlands and restoring the health of those that remain.

Statewide Conservation and Preservation Plan (Swackhammer, Coleman, & Shardlow, 2008)

The SCPP makes recommendations on strategic planning, habitat, land use, transportation and energy. The habitat recommendations include the protection of critical lands, including the high-priority examples of native prairie, savanna, old-growth forest, and any areas that add to or provide linkages between large, intact ecosystems. A key factor in the conservation and preservation of Minnesota's critical habitats is to restore ecoregion-appropriate landscape-scale complexes of habitat centered on concentrations of existing remnant habitats, with a broader goal of developing and maintaining conservation corridors between existing and restored habitats.

LSOHC Strategic Plan (Management Analysis and Development, 2009)

This plan resulted from a series of meetings with conservation professionals with public input in five regions of Minnesota (including a Prairie Section). The participants set 25-year goals for native prairie (88,000 acres), restored prairie (884,000 acres), surrogate grasslands (500,000 acres), wetlands (178,500 acres), lakeshore (1030 miles), shallow lakes (2,000 acres), and streams and rivers (25,000 shoreline miles). The total cost of all activities over 25 years was estimated to be over $10 billion.

Wetlands Restoration Strategy (Minnesota Board of Water and Soil Resources, 2009b)

This strategy calls for the targeting of wetland restorations to the sites that provide the greatest environmental benefits at a landscape, watershed or flyway scale. Criteria for targeting include improved water quality, wildlife habitat, surface water flows and groundwater recharge. Pilot projects in the Chippewa and Wild Rice River watersheds illustrate a potential approach to prioritization.

Prairie Coteau Business Plan (National Fish and Wildlife Foundation, 2010)

This 10-year conservation plan calls for a variety of conservation actions in the Prairie Coteau subsection of southwest Minnesota. The most pertinent action is to acquire 5,000 acres and place conservation easements on another 10,000 acres of the remaining native prairie in the Minnesota portion of the Coteau. A second major strategy is to restore 24,000 acres of marginal cropland to grassland within eight prairie landscapes (half by acquisition and restoration on public land and half by conservation easement and restoration on private land). In addition, 12 other major strategies are proposed to deal with the conversion of prairie and grassland, fragmentation of prairie landscapes, degradation and homogenization of native habitats and other threats unique to high priority species.

Shallow Lakes Program Plan (Minnesota Department of Natural Resources, Division of Fish and Wildlife, Wildlife Management Section, 2010)

The goal of the statewide shallow lakes program is to protect and manage at least 1,800 lakes that are at least 50 acres in size but less than 15 feet deep. This includes maximizing management for waterfowl habitat of all 154 shallow lakes inside WMAs, WPAs, NWRs, and all Designated Management lakes and increasing wildlife management of the 1,959 shallow lakes that have a portion of the shoreline in public ownership or access.

Pollinator Habitat Program Guidelines (Minnesota Department of Natural Resources, 2014)

These guidelines provide Best Management Practices for restoring and enhancing habitat for native insect pollinators on DNR land and state-funded prairie restorations. BMPs include activities that benefit pollinators with regard to prescribed fire, insecticide use, mowing, conservation grazing, farming and habitat restoration.

Pollinator Plan (Minnesota Board of Water and Soil Resources, 2014)

A key habitat goal of BWSR's Pollinator Plan is to target habitat protection and restoration efforts on habitat complexes and corridors that can act as pollinator reserves or refuges. The RIM program restores 5,000–8,000 acres per year (230,000 total) on marginal agricultural lands.

Pollinator Report (Minnesota Department of Agriculture, 2014)

This report advocates for the enhancement of pollinator habitat already in the landscape, rather than the creation of new habitat. The use and proper implementation of pollinator Best Management Practices in roadsides, ditches, rights-of-way, parks, wildlife areas, conservation program lands, hayfields and pastures holds great promise to improve the viability of pollinator populations.

Pheasant Summit Action Plan (Minnesota DNR, 2015)

The Pheasant Summit Action Plan makes 10 recommendations to increase pheasant populations across Minnesota. The first is to target habitat enhancement and protection across the pheasant range to complexes of at least 9 square miles with a goal of 40% permanent protection. The plan also advocates increasing land enrollment and retention in short-term conservation programs and the enrollment of permanent conservation easements by private landowners.

Minnesota's Wildlife Action Plan 2015–2025 (Minnesota Department of Natural Resource, 2016a)

This update of the 2006 SWAP increases the number of Species of Greatest Conservation Need to 346 and adds a habitat approach to species conservation. The plan identifies 36 Conservation Focus Areas, most of which in the Prairie Region overlap prairie core areas.

WMA Grazing Plan (Minnesota Department of Natural Resources, 2016b)

Conservation grazing is an important management tool to provide the disturbance that grasslands and wetlands need to maintain diversity and productivity. The Department of Natural Resources seeks to implement conservation grazing on 50,000 Wildlife Management Area acres annually (less than 4% of total WMA acreage). Each WMA will need to develop its own site-specific plan to address goals, objectives, methods and desired future condition.

Minnesota River Valley Recreation and Conservation Master Plan (draft) (Great Outdoors Consultants, 2017)

Redwood and Renville Counties partnered with the Minnesota DNR to develop this master plan for a portion of the Minnesota River Valley core area. They established a goal to create a connected network of high-quality natural and visual resource areas that support larger conservation goals such as the Prairie Plan.

Appendix 3: Methods

1. *Identifying areas of native prairie*

Native prairie locations were based on field survey data covering work performed from 1987–2015 by the Minnesota Biological Survey. By the end of the 2009 season, the initial field survey of all the counties in the prairie portions of Minnesota was complete. The data used in this analysis were downloaded in February 2015. Some of the prairies may have been destroyed since the time of their documentation (Minnesota Biological Survey, 2017b).

2. *Calculating the amount of grassland and wetland in an area*

Grassland and wetland areas were delineated using a modified land cover layer developed by The Nature Conservancy in spring 2015. The initial step was to remove areas identified as native prairie by the Minnesota Biological Survey. After excluding these areas, the starting point was the National Land Classification Data (2011) as reclassified by the USFWS HAPET office in Fergus Falls (2014). Grasslands included all land classified as 71 (Grassland/Herbaceous), 76 (Undisturbed grassland), 80 (Hay) and 81 (NLCD Pasture/Hay).

Calculating wetlands acreage was more complicated. The reclassified NLCD (2011) was again the starting point. Excluding native prairie, the following categories were included: 90 (NLCD Woody Wetlands), 95 (NLCD Emergent Herbaceous Wetlands), 112 (FWS Seasonal Wetlands) and 113 (FWS Semi-Permanent Wetlands). Several categories required further processing with National Wetlands Inventory (NWI) data: 11 (NDWI water from first cloud-free Landsat of 2011), 52 (Shrub), 114 (FWS Lake Wetlands) and 115 (FWS Riverine Wetlands). For these categories, only areas identified by NWI as Palustrine were included as wetlands.

3. *Identifying protected lands*

The area of protected lands and their division into fee and easement interests was calculated using GIS data from several public and partner sources.

Ownership information for state lands in State Parks, Wildlife Management Areas, Scientific and Natural Areas, State Forests and Aquatic Management Areas were downloaded from the Minnesota Department of Natural Resources Geospatial Commons in September 2015. Information on the DNR's Prairie Bank easement program was gathered in December 2014. Data on permanent easements administered by the Minnesota Board of Water and Soil Resources were acquired in September 2015.

Ownership and easement information for the U.S. Fish and Wildlife Service was acquired from the Service in August 2014. Only permanent FWS easements classified as conservation or grassland easements were included. Data for the Wetland Reserve Program administered by the Natural Resources Conservation Service were acquired in January 2014. Data for CRP contracts were not available directly, so the necessary analyses were conducted by Sean Fields of the USFWS Prairie Pothole Joint Venture.

Data on ownership and permanent easements held by The Nature Conservancy were provided by the Conservancy in September 2015. Where an ownership interest overlapped a permanent easement (e.g., Conservancy-owned land enrolled in WRP), the easement was not included in our analysis.

4. *Choosing the prairie core areas*

Prairie biologists from the Minnesota Biological Survey used their knowledge of prairie landscapes across the state, along with the compiled MBS and Natural Heritage databases, to delineate rough boundaries around locations where native prairie and associated habitats are concentrated. The result was 29 locations in the Prairie Region of Minnesota that were drawn on a map showing the locations of native prairie in Minnesota. The prairie landscape map is available on the Minnesota DNR's website: http://files.dnr.state.mn.us/eco/mcbs/prairies_highlighted_areas.pdf.

Additional prairie core areas were identified using a prairie density analysis. Using the ArcGIS Point Statistics function, a native prairie density index was derived for each quarter-quarter section (40-acre parcel) in the state by

calculating the percentage of surrounding quarter-quarter sections within one mile that contained at least five acres of native prairie. Areas with high Native Prairie Density Index values were considered by Prairie Plan Local Technical Teams as potential new core areas.

5. Defining the boundaries of prairie core areas

The starting point was a file of Prairie Landscapes created by the Minnesota Biological Survey in 2009 (Minnesota Biological Survey, 2010). Staff members from The Nature Conservancy refined the rough boundaries by reducing the buffer around areas of surveyed native prairie to a half-mile buffer. If adjacent core areas were within one mile or there was a continuous cover of grassland and wetlands, the core areas were merged. The resulting 28 core areas were then re-examined using on-screen digitizing to refine the boundaries to include additional areas with rare species habitat (Minnesota Element Occurrence Data, MN CBS, 2008), areas of high biodiversity significance (Minnesota Biodiversity Significance Data, MN CBS, 2008), areas of extensive grassland and wetlands (MN/ND/SD Grasslands Analysis, TNC 2015 and NLCD Land Cover Data 2011) and Grassland Bird Conservation Areas (USFWS HAPET). Final boundary adjustments were made to follow ownership/field boundaries or major road/railroad corridors, where appropriate, and to remove extensive areas of cropland using summer 2015 NLCD imagery.

6. Determining the centerline of dispersal corridors

In 2010, the USFWS HAPET Office developed a series of corridors to connect prairie core areas (not including Espelie, which was excluded because it fell outside the Prairie Pothole boundaries). A cost surface was created using a suite of habitat models for waterfowl (e.g., mallard, blue-winged teal, gadwall, northern pintail, northern shoveler, wood duck), marsh birds (e.g., pied-billed grebe, American bittern, sora, Virginia rail), grassland passerine birds (e.g., bobolink, clay-colored sparrow, dickcissel, grasshopper sparrow, LeConte's sparrow, savannah sparrow, sedge wren, western meadowlark), shorebirds (e.g., marbled godwit, American avocet, willet, Wilson's phalarope, semipalmated sandpiper, Hudsonian godwit, dunlin, white-rumped sandpiper) and game birds (e.g., pheasants, prairie chickens). This combination of spatial models consisted exclusively of bird habitat models but was developed to represent of a broad range of ecological/functional requirements for many prairie species. Corridors were identified using the cost distance and corridor analyses (least cost path) in ArcGIS 9.3, where the "cost surface" was inversely proportional to habitat quality; high-quality habitat (including native prairie) was considered low cost and relatively poor-quality habitat was considered high cost. Thus, the corridor paths identified are intended to maximize the benefits of existing habitat and native prairie throughout the landscape, to achieve maximum efficiency and to promote landscape-scale connectivity.

Three new core areas were added to the Prairie Plan between 2010 and 2015. They were connected to other core areas by visually searching maps for the shortest pathways that captured the most native prairie, other grasslands and wetlands. The proposed new corridors were reviewed and altered by local experts on the Prairie Plan Local Technical Teams. A similar process was used to locate corridors joining the Buffalo Ridge corridor to the Altamont Moraine corridor, the Glacial Lakes core area to the Upper Minnesota Valley core area, the Des Moines River core area to core areas in Iowa, the Wambach/Santee core area to the Chester Hills corridor, and the Espelie core area via Agassiz NWR to the New Solum and East Park core areas.

7. Selecting the number and location of stepping stone complexes along dispersal corridors

The complexes are placed at approximately 6-mile intervals along the corridors. These are areas of approximately nine square miles located to maximize the amount of native prairie, grassland and protected lands in the complex. TNC staff used "heads-up" digitizing to define these complexes in 2010, with some changes in 2015 to better capture prairie and grassland and add complexes in new corridors. Each complex was named for the largest managed area unit

within the complex, or if there was no public land, for the name of the township.

8. Calculating habitat and protection shortfalls

Habitat shortfall is calculated by subtracting the current habitat acreage from the habitat goal. Within the core areas and strategic habitat complexes, the habitat goal for other grasslands is 40% of each core area or strategic habitat complex. For wetlands, the goal is 20% of the total area of each core area or strategic habitat complex. The current number of habitat acres for grassland is equal to the current number of acres of native prairie plus the current number of acres of other grassland. The current number of habitat acres for wetlands is simply the current wetland acres.

- Core area or strategic habitat complex grassland habitat shortfall [or grassland restoration goal] = (total acres x 0.40) – (current acres of native prairie + current acres of other grassland)

- Core area or strategic habitat complex wetland habitat shortfall or wetland restoration goal = (total acres x 0.20) – (current acres of wetland)

Within the corridor sections and agricultural matrix, the habitat goal is 10% of each section, or the part of the section within the corridor or major watershed or part of the watershed, in perennial herbaceous vegetation. Sections with less than 10 acres in the corridor were excluded from the analysis. The current habitat acreage of perennial herbaceous vegetation is the sum of the current number of acres of native prairie, current number of acres of grassland, and current number of acres of wetland.

- Corridor section or agricultural matrix habitat shortfall = (total acres in section or major watershed – acres of open water in section or major watershed) x 0.1 – (current acres of native prairie + current acres of other grassland + current acres of wetland)

For the corridor sections and agricultural matrix, the protection shortfall is calculated by subtracting the current protected habitat acreage from the protected habitat goal, assuming all native prairie will be protected. For core areas and strategic habitat complexes, the protected habitat goal is equal to 50% of the habitat goal.

- Core area or strategic habitat complex grassland protection shortfall = (total acres x 0.4 x 0.5) – (current acres of native prairie + protected acres of grassland)

- Core area or strategic habitat complex wetland protection shortfall = (total acres x 0.2 x 0.5) – protected acres of wetland

For corridor sections or agricultural matrix, the protected habitat goal is equal to 10% of the non-open water habitat goal.

- Corridor section or agricultural matrix protected protection shortfall = (total acres in each section or major watershed – acres of open water in each) x 0.1 – (current acres of native prairie + protected acres of other grasslands + protected acres of wetlands)

Appendix 4. Goals and Objectives (Acres and Costs)

Protection

As defined earlier, protection is the acquisition of land rights that will influence future land use either permanently or temporarily. The most common forms of protection are the acquisition of fee title (outright purchase of all rights) and the purchase of a conservation easement that prevents certain activities on the land in the future. Prairie and grassland easements are permanent and typically prevent the current owner from plowing, developing or subdividing the land. USFWS wetland easements are similar, although they may allow tillage if wetland basins are not filled, leveled, drained or burned. Shoreline easements typically restrict development and may require a riparian buffer.

All the easements discussed in this plan are assumed to be permanent. Although this plan makes recommendations on the amount of land that should be acquired, the actual proportion of

land that is protected via easement versus outright purchase from willing sellers will be determined on a parcel-by-parcel basis, depending on factors such as landowner preference, relative cost, available funding, and the anticipated future use of the land.

Protecting Native Prairie

A key goal of this plan is to protect all remaining native prairie in Minnesota that lacks legal protection. The unprotected native prairie within core areas, corridors, strategic habitat complexes and the agricultural matrix within the Prairie Region totals 108,875 acres.

Minnesota's Native Prairie Bank Program has shown that landowners have chosen fee title acquisition in 30% of the transactions to protect native prairie and conservation easements in 70% of the cases. Assuming this same split in the future, 32,663 acres will be acquired through fee title acquisition and 76,213 acres protected via conservation easement.

The fair market value of native prairie in Minnesota in 2010 was estimated at $2,700 per acre by the Lessard-Sams Outdoor Heritage Council (Management Analysis and Development, 2009). Based on the current BWSR non-crop value of land in the Prairie Region and recent purchases of native prairie in the last several years, this value increased to about $2,880 per acre in 2016. Using this value, the cost of acquiring fee-title for 32,700 acres of native prairie would be $91.5 million.

The two most common types of land conservation easements used in the Prairie Region of Minnesota are the U.S. Fish and Wildlife Service grassland easement and the Minnesota Department of Natural Resources Native Prairie Bank easement. The USFWS easement rate is based on an adjusted assessed land value of the individual parcel. The Native Prairie Bank rate is roughly comparable to the USFWS rate but is based on a formula that multiplies the average tillable land value for the township by 60% to estimate the non-crop rate. That value is then multiplied by 65% to reach the Native Prairie Bank rate. The average value for cropland statewide was about $4,800 per acre in 2016, but there are significant regional differences, ranging from $2,500 in the northwest to $7,200 in the southwest (Lazarus, 2017). The $4,800 value might be an overestimate statewide because land near existing prairies tends to be lower quality cropland. The estimated cost of placing an easement on 76,000 acres at 39% (65% of 60%) of $4,800 per acre is $143 million.

Protecting Grasslands and Wetlands

In addition to native prairie, other types of grasslands and wetlands will be needed to reach the desired levels set for perennial natural habitat. Establishing goals for the protection of these grasslands and wetlands was a two-step process. First, preliminary acreage goals based on protection shortfalls were set without considering how many acres will be protected during the restoration process to meet the habitat shortfall. Second, after restoration needs were established, the acres protected prior to restoration were subtracted from the preliminary protection goals to establish the final protection goals.

Within the core areas, there are 806,099 acres of existing non-prairie grassland and 127,552 acres of wetlands. Our intent was to have 40% of the core areas in grasslands and prairies, with half of those acres in permanent protection. As the goal is to protect all the remaining native prairie, whatever shortfall exists for the combined prairie and grasslands will be made up by protecting non-native prairie grasslands. To reach that goal in the core areas, fee acquisition or conservation easements are needed on 87,525 acres of non-native prairie grasslands. The goal for wetlands is 20% of the core areas, with half in permanent protection. To reach the wetland protection goal in the core areas, 145,566 acres of wetland will need to be protected. If the newly protected grassland and wetland acres are protected using a 40:60 acquisition:easement split, as recommended in Minnesota's Duck Plan, 35,010 acres of grassland and 58,226 acres of wetland (93,236 total) will need to be purchased from willing sellers and 52,515 acres of grassland and 87,340 acres of wetland (139,855 total) will need to be placed under a conservation easement within the core areas. With half the grassland and wetlands needed to reach the core area 40%/20% habitat goals under permanent

protection, that leaves the other half or 233,091 total acres of grasslands and wetlands that will be in private ownership, either under voluntary conservation management or enrolled in 10–15-year conservation contracts (e.g., CRP).

In the general corridors, there are only about 55,731 acres of land protected in fee or by conservation easements, leaving 105,803 acres yet to be protected to reach the 10% goal of each legal section in protected perennial cover. Assuming that all native prairie will be permanently protected, an additional 99,916 acres of grasslands and wetlands needs to be protected. Using a split that emphasizes farm and conservation program contracts and voluntary conservation management where 10% is fee title, 20% is easement, and 70% is contract or voluntary conservation management, this translates to 9,992 acres of fee acquisition, 19,983 acres of easement, and 69,941 acres of 10–15-year contract or voluntary conservation management.

In strategic habitat complexes, 35.2% of the native prairie and other grassland is protected. If we assume all native prairie will be protected, another 28,277 acres of grassland will need to be protected to reach the goal of 40% of each complex in grassland, with half permanently protected. For wetlands, the goal is half of 20% of each complex protected or 15,756 acres. Assuming the same 40:60 acquisition:easement split used in the core areas, this translates to the fee purchase of 11,311 acres of grassland and 6,302 acres of wetlands (17,613 acres total) and conservation easements on 16,966 acres of grassland and 9,454 acres of wetlands (26,420 acres total) in the strategic habitat complexes. The habitat goals require that the unprotected half or 22,017 acres of grassland and wetlands either be maintained in voluntary conservation management or be enrolled in 10–15-year contracts.

The protection goal for the agricultural matrix was 5% of each major watershed. Although 417,313 acres, including 9,023 acres of native prairie, 245,586 acres of grassland, and 162,704 acres of wetland, are protected via easement or conservation ownership within this area, an additional 602,235 acres needs protection to reach the 5% level of each HUC 8, assuming all native prairies are purchased or placed under conservation easement. These figures do not include lands that are currently enrolled in CRP and other temporary protection programs. If we assume a 10:20:70 ratio for purchase, easement, and contract (although this ratio is flexible and could change), 60,244 acres would need to be purchased, 120,447 placed under conservation easement, and 421,565 enrolled in conservation contracts.

For this plan, we assume that the value of existing grassland and wetlands is the same as native prairie ($2,880 per acre) but that a conservation easement on existing grassland or wetland would be $1,812 per acre (based on the 2017 easement rate of the Native Prairie Bank Program). These values include only the land cost, not the costs associated with real estate acquisitions or the long-term monitoring of conservation easements.

Restoration

To provide ample habitat to maintain viable populations of prairie landscape species and processes, existing prairies and grasslands will need to be supplemented with reconstructed grasslands and wetlands. Within this plan, the restoration of grassland and wetlands are equal in priority to protecting remaining native prairie and prairie systems. If state funds are used for restoration, the work should take place only on public lands or on private lands subject to a conservation easement, deed restriction or contract. The same ratio of 10:20:70 is used to allocate restoration for lands protected through fee acquisition, easement, and conservation contract.

Within core areas, 21,794 acres of new grassland and 273,233 acres of restored wetlands (295,027 total) will be needed to reach a minimal goal of 40% grasslands and 20% wetlands in each core area (Table 2). These figures are likely to be substantially underestimated because even in core areas that currently exceed the 40% grassland and 20% wetland minimums, there will be a need to buffer and connect areas of native prairie to increase their viability.

Based on 2015 land cover data, the corridors outside the corridor complexes contain 411,095 acres of grassland and wetland (5,887 acres of

native prairie, 336,833 acres of other grassland, and 68,375 acres of wetlands). Only 161,534 acres are needed to reach the 10% herbaceous perennial vegetation goal in each section. However, the grasslands and wetlands are not evenly distributed among sections. As a result, an additional 24,322 acres of grassland and wetland in sections missing the 10% goal are still needed.

There is enough grassland habitat at 10 of the strategic habitat complexes to reach the 40% goal, but there is a shortfall of 31,195 acres in the remaining 27. For wetlands, all except Agassiz National Wildlife Refuge have a habitat shortfall, with a total need of 26,746 more wetland acres to reach the 20% goal in each strategic habitat complex.

Within the agricultural matrix, an additional 44,432 acres of new wetlands, grasslands, or other appropriate native vegetation are needed to meet the goal of having 10% of each major watershed outside of cores, complexes, and corridors in herbaceous perennial natural cover.

The cost of restoration varies with the cost of acquiring the rights to conduct restoration and then carrying out the restoration work. Since most restoration work will take place on former or existing cropland, we assume a value of $4,800 per acre for land purchased in fee, $4,320 per acre for a conservation easement based on 2015 RIM-WRP Partnership sign-ups (90% of the Average Township Tillable Land Value), or $1,109 per acre for the present value of a conservation contract paying $99.71/per acre/year (2016 CRP payment rate, U.S. Department of Agriculture, 2017) for 15 years with a 4% discount rate. We assume a split of 10:20:35:35 for acquisition:easement:conservation contract:private restoration to calculate the percentage of restoration work done under different types of protection. Restoration of either grassland or wetlands costs $500 per acre, according to LSOHC estimates (Management Analysis and Development, 2009). However, a cost of $500 per acre may greatly overestimate grassland restoration costs for pastures or stream buffers if a low-diversity grassland seed mix is used. For restoration on unprotected private lands (with no easement or conservation contract), a value of $200 per acre is used.

Enhancement (Management)

In order for grassland systems to remain vital, they must be ecologically disturbed (or managed) at regular intervals. This plan calls for disturbances in the form of prescribed fire, conservation grazing, and mowing (which includes haying), every four years on average.

Native Prairies

There are 108,595 acres of native prairie in conservation ownership in the Prairie Region of Minnesota. Due to a lack of resources, many prairies have not received timely management actions. The primary management techniques for prairies in conservation ownership have been prescribed fire or mowing. Grazing is another tool that can be used for regular management of native prairies. Utilizing conservation grazing can reduce the cost of management, as the cost is often covered or offset by the owner of the livestock in exchange for the value received from the forage. This Prairie Plan calls for an annual goal of burning, mowing or grazing one quarter of all conservation-owned native prairies. This amounts to 27,149 acres annually. This total will grow as additional prairies are publicly protected. Local resource managers will decide which prairies to burn, mow or graze.

For native prairie that is privately owned, 11,875 acres are under conservation easement. All native prairie lands with conservation easements should be managed using prescribed fire, mowing or grazing at least every four years. Some easements, such as the Native Prairie Bank, may restrict the types and amount of grazing that are permissible. The native prairie lands with conservation easements add another 2,969 acres that should receive the same management as public prairie lands, for a total of 30,118 acres annually.

The remaining 108,876 acres of native prairie on private land lack any form of legal protection. Much of this unprotected land is being grazed, but the grazing is often continuous or long-rotation in nature. The goal of this plan is to encourage private landowners by offering them technical and/or financial assistance to

incorporate prescribed fire into their management regime and to practice more sustainable grazing. An aggressive goal would be to implement disturbance management (fire, mowing or grazing followed by rest) at four-year intervals on at least half of the privately-owned prairies that have no legal protection. The annual acreage affected by this goal would be 13,610 acres.

The cost of management activities depends greatly on the specific needs of a parcel. The cost for prescribed burning can vary greatly depending on size, complexity, risks and other variables. For example, the Nature Conservancy calculated in 2010 that a rough cost estimate for prescribed fire is about $20 per acre. However, prescribed burning costs can range from $20 to $120 per acre in Minnesota, depending on the grassland fuel types. The net cost of grazing management or haying will also vary, but for this plan, the same per acre cost is used.

Grasslands and Wetlands

Like native prairies, other grasslands and wetlands can benefit from disturbance management as well. There are 4,455,584 acres of non-native prairie grasslands in the Prairie Region of Minnesota (Table 7), with 512,649 acres under permanent protection (public ownership or conservation easement). There are 1,320,791 acres of wetlands total, including 303,484 acres that are protected.

For protected grasslands and wetlands, the same four-year disturbance cycle and management cost estimate ($20 per acre) was used to calculate total annual acreage goals and total 15-year cost. Cost estimates for both grassland and wetland management need further verification.

It is difficult to estimate the cost of managing unprotected grasslands and wetlands. For the sake of consistency, the same methods for unprotected grasslands and wetlands were used that were employed for unprotected native prairies. We assume that half of the unprotected grasslands and wetlands will be managed once every four years. Many of the unprotected grasslands are currently enrolled in the CRP, and this status will influence the allowable management options. Except in emergency situations, CRP acres cannot be grazed or hayed, and there may be restrictions on prescribed fire as well.

Appendix 5: Cropland Productivity Index (CPI)

	Core Name	Average CPI
1.	Agassiz Beach Ridges	56.4
2.	Antelope Hills	70.2
3.	Aspen Parkland	36.1
4.	Big Stone Lake	56.5
5.	Blanket Flower Prairie	54.6
6.	Blue Mounds/Touch the Sky	68.8
7.	Camden Prairie Marshes	68.9
8.	Chanarambie Creek	71.7
9.	Chester Hills	33.6
10.	Cottonwood River	66.3
11.	Des Moines River Valley	72.6
12.	East Park	45.9
13.	Espelie	62.9
14.	Glacial Lakes	50.0
15.	Glacial Ridge	58.4
16.	Hole-in-the-Mountain	73.0
17.	Lac qui Parle	57.5
18.	Lake Christina Hills	39.1
19.	New Solum	58.8
20.	Pembina	62.0
21.	Prairie Coteau/Rock River	73.3
22.	Red Rock Ridge	78.4
23.	Rothsay	63.1
24.	Split Rock Creek	66.4
25.	Upper Minnesota Valley	56.0
26.	Wambach Santee	77.6
27.	Waubun	67.4
28.	Yellow Medicine Coteau	75.0
All core areas		**55.0**
All corridors		**77.3**
All strategic habitat complexes		**54.5**
Agricultural matrix (excluding above)		**76.3**

Appendix 5: Farmland Classification for Minnesota