

Ecological site R103XY001MN Loamy Wet Prairies

Last updated: 10/04/2023
Accessed: 04/18/2024

General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.



Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 103X–Central Iowa and Minnesota Till Prairies

The Central Iowa and Minnesota Till Prairies MLRA is an expansive and agriculturally important region consisting of nearly 18 million acres and includes all or portions of 63 counties in southern Minnesota and northern Iowa. Because its southernmost extent reaches Des Moines, Iowa, the region is often referred to as the “Des Moines Lobe”. The entire area was glaciated during the most recent glaciation, the Late Wisconsin period ending approximately 12,000 years ago (Ojakangas and Matsch 1982). These geologically young landscapes are mostly gently rolling, low relief till plains and moraines having poorly integrated drainage networks. With the exception of the glacially-scoured valleys, local relief is less than 20 feet over most of the land area. The region is considered the southernmost ecoregion within the vast network of glacially-derived prairie pothole landforms of the northern Great Plains. Young glacial landforms with poorly integrated drainage networks and frequent closed depressions cause nearly ubiquitous drainage issues, resulting in hydric soils covering nearly half of the land area within the MLRA. Lakes and various types of wetlands, ranging from permanently-ponded depressions to non-ponded flats and gentle slopes, are abundant.

Soils are primarily Mollisols but also include Alfisols, Inceptisols, Histosols, and a small area of Vertisols. Nearly 300 soil series are mapped in the MLRA, but the top ten represent over half of the land area. The dominant parent material is calcareous fine-loamy till (18-35% clay) containing distinctive limestone and shale fragments (Ojakangas

and Matsch 1982). Smaller amounts of both fine till (35-60% clay) and coarse-loamy till (<18% clay) occur in the far northern and the far southern portions of the region, respectively. Other parent materials include: alluvium, outwash, lacustrine sediments, and organic deposits. Areas of outwash and alluvium occur along the major rivers and streams (e.g., Minnesota River, Des Moines River, Skunk River, etc.). Ephemeral glacial lakes deposited silty and/or clayey sediments. Organic deposits occur throughout the region but are most common to the east, particularly in the higher relief landscapes of the Le Sueur Moraine.

At a continental scale, MLRA 103 is unique because it is located on the transition from prairie soils to the west and forest soils to the east. In contrast to other parts of the prairie pothole region, the ratio of precipitation to evapotranspiration is nearly equal (or higher) throughout much of the MLRA. Adequate precipitation, coupled with a predominance of fertile prairie soils, makes MLRA 103 one of the most productive agricultural regions in the World. Pre-settlement vegetation was primarily tallgrass prairie interspersed with wet meadow and marsh communities. Oak savanna and woodland occurred on the lee sides of river valleys, lakes, and other topographic features that provided protection from fire. A large area of mixed hardwood forest also occurred in the northeast part of the MLRA, broadly coincident with the rougher topography of the Le Sueur Moraine. Although geologically related, the Le Sueur moraine is ecologically different from other portions of the Des Moines Lobe, and thus other ecological classification systems classify that area as distinct from the prairie landscapes to the west (Cleland et al. 2007, MN DNR 2005a).

Classification relationships

Major Land Resource Area (MLRA): Central Iowa and Minnesota Till Prairies (103)

USFS Subregions: North Central Glaciated Plains Section (251B); Upper Minnesota River-Des Moines Lobe (251BA) and Southern Des Moines Lobe (251Be) Subsections

MN DNR Native Plant Community (MN DNR, 2005); the reference community of this ecological site is most similar to:

Primary: WPs54b Southern Wet Prairie

Secondary: WPs54a Southern Wet Seepage Prairie; UPs23a Southern Mesic Prairie; WMp73a Prairie Wet Meadow/Carr

Vegetation Associations (National Vegetation Classification System, NatureServe 2013); the reference community of this ecological site is most similar to: *Andropogon gerardii* - *Panicum virgatum* - *Helianthus grosseserratus* Herbaceous Vegetation (CEGL002024)

Ecological Systems (National Vegetation Classification System, NatureServe 2013); the reference community of this ecological site is most similar to: Northern Tallgrass Prairie (CES205.686); Eastern Great Plains Wet Meadow, Prairie and Marsh (CES205.687)

Biophysical Setting (Landfire, 2009); the reference community of this ecological site is most similar to: Central Tallgrass Prairie (4214210)

Ecological site concept

Loamy Wet Prairie is nearly ubiquitous and occurs throughout the region, covering over 20% of MLRA 103. These ecological sites are fringe wetlands and have an inherent water table (i.e., endosaturated), but are not ponded. They are developed from low-lying mineral soils occurring mostly as inter-depressional flats with a slight slope, usually not more than two percent. As a result, these sites do not pond but they have restricted drainage and are classified as poorly drained. Parent material is primarily calcareous fine-loamy till, but can also include medium-textured lacustrine materials. Soils are Mollisols that developed under prairie vegetation with dark (black-colored) surface horizons rich in organic matter that generally range from 10 to 24 inches thick above depleted (gray-colored) subsurface horizons. The hydrodynamics of these sites are complex in that subtle differences in landform and elevation affect the depth and duration of the water table, and thus plant community structure and composition.

Plant communities are remarkably diverse and include grass and forb dominated wet-mesic and wet prairies (also known as low prairies) but can be sedge-dominated in wetter conditions. This variation in plant community is dependent on minor variations in depth and duration of water table within the top 12 inches of the soil profile. Since these are fringe wetlands, the Wetland Indicator Status of characteristic plants on a given site ranges from obligate

to upland indicator status.

Dominant grasses are those characteristic of the tallgrass prairie, especially big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*). Prairie cordgrass (*Spartina pectinata*) is an important species indicative of wetland conditions, and can be codominant. Sedges are often an important component, particularly on the wetter end of this ecological site. The most common species are Bicknell's Sedge (*Carex bicknellii*), wooly sedge (*Carex pellita*), and Buxbaum's sedge (*Carex buxbaumii*). Common forbs include classic tallgrass prairie species like prairie blazing star (*Liatris pycnostachya*) and compassplant (*Silphium laciniatum*) as well as species typical of wetland conditions like narrow-leaved loosestrife (*Lysimachia quadriflora*) and swamp milkweed (*Asclepias incarnata*). Shrub cover is typically low, with the most common species being leadplant (*Amorpha canescens*) and prairie rose (*Rosa arkansana*). Other shrubs, like dogwoods (*Cornus* spp.) and willows (*Salix* spp.) quickly establish in the absence of frequent fire.

Associated sites

R103XY016MN	Organic Marsh The Organic Marsh ecological site is characterized by a site on very poorly drained organic soils, frequent ponding, a high water table, and hydrophytic vegetation.
R103XY002MN	Calcareous Upland Prairies The Calcareous Upland Prairies ecological site is located on upland calcareous soils that do not flood or pond. Soils developed under prairie vegetation, and the soil drainage class include somewhat poorly drained to well drained.
R103XY004MN	Loamy Upland Prairies The Loamy Upland Prairies ecological site is located on uplands extensively throughout MRLA 103. Soils are formed from fine loamy till and medium textured lacustrine materials. Soil drainage is somewhat poorly drained to well drained. This site does not flood or pond and is extensive throughout MLRA 103.
R103XY009MN	Calcareous Rim Prairies The Calcareous Rim Prairies ecological site is located on rims surrounding wet depressions. Landforms include till plains, ground moraines, lake plains, and outwash plains. This site is typically part of broader semi-closed wetland basin and hydrologically connected to adjacent ponded depressions. This site does not flood or pond. Slopes range from 0-2%.
R103XY012MN	Wet Footslope/Drainageway Prairies The Wet Footslope/Drainageway Prairies ecological site are located on mainly on footslopes, toeslopes, and upland drainageways. The site concept incurs frequent to occasional extremely brief and very brief flooding. Soils drainage class is poorly drained. Reference vegetation is a wet prairie.
R103XY015MN	Depressional Marsh The Depressional Marsh ecological site is located on landscape positions that include linear to slightly concave (depressional) segments. Soils are very poorly drained and are frequently ponded. The soils also have a relatively high organic matter content in the surface and near surface horizons.

Similar sites

R103XY012MN	Wet Footslope/Drainageway Prairies The Wet Footslope/Drainageway Prairies ecological site is located on lower footslopes, toeslopes, and drainageways. The site may flood frequently. Soils drainage class is poorly drained. Reference vegetation is a wet prairie.
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Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) <i>Amorpha canescens</i>
Herbaceous	(1) <i>Andropogon gerardii</i> (2) <i>Spartina pectinata</i>

Physiographic features

With the exception of the prairie-forest transition area of the Le Sueur Moraine, the finer-textured soils of Glacial

Lake Minnesota, and the dissected Bemis Moraine, Loamy Wet Prairies are a dominant ecological site occurring across the many till plains and moraines of MLRA 103. These sites are typically part of broader semi-closed wetland basins and are commonly hydrologically-connected to adjacent “prairie pothole” marshes. As a result, delineations of these map units are often irregularly-shaped, usually surrounding multiple depressions of varying sizes. These wetland basins were created by multiple types of glacial events (i.e., various till plains and moraines). The speed and timing of glacial melt (whether it melts while stagnant or advancing) determines the size, shape, and density of these depressions. An advancing glacier can mechanically gouge out lower areas, while a stagnant glacier can melt in place, leaving hummocky topography with deeply defined depressions (i.e., stagnation moraines). Uneven sediment load in the glacier can arbitrarily deposit less drift in some locations, forming geographic lows. In some cases, sub-glacial drainage networks leave these depressions. In other cases, blocks of ice are buried by glacial sediment and subsequent melting creates subsurface voids in the sediment (i.e., ice block depressions).

Regardless of the glacial events responsible for these wetland complexes, the term “flat” probably best describes the landscape position of the Loamy Wet Prairies ecological site, which is defined as “a level or nearly level surface or small area of land marked by little or no local relief” (USDA-NRCS 2015). Low relief 0 to 2 percent linear slopes with fine-loamy soil textures interact to make this ecological site wetter than the adjacent upslope areas but drier than adjacent downslope depressional areas. The low slope gradient and linear to slightly concave slope shape are the most defining parameters. As a result, these sites do not typically pond water. However, the water table is usually at or near the soil surface during the spring months.

Often in natural, undrained conditions, minor inclusions of wetter sites that may briefly pond water can occur towards the middle of broader flats, while slightly drier sites occur on footslopes that transition to the upland. Swales, or connections between depressions are often a part of these landforms and receive concentrated groundwater flow, and may pond or flood for brief periods during significant rain events. These aforementioned wetter conditions also have a slightly higher water table and support sedge meadow plant communities.

Elevation ranges from 689 to 1,837 feet. These sites receive runoff and lateral subsurface flow from adjacent, upslope ecological sites. They also produce runoff and lateral subsurface flow downslope into adjacent discharge depressions.

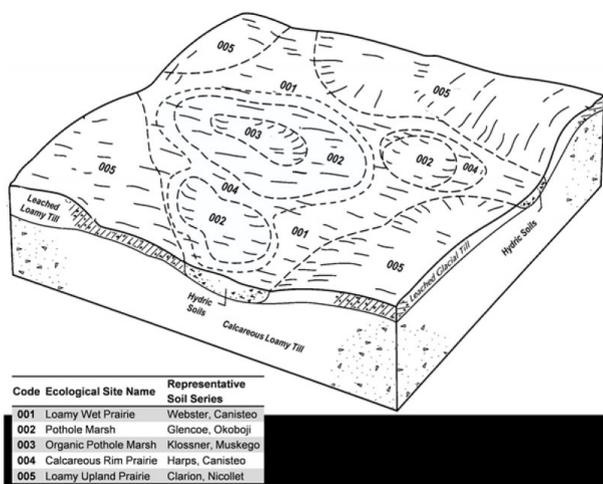


Figure 2. Block diagrams of the representative Wet Loamy Prairie and associated ecological sites.

Table 2. Representative physiographic features

Landforms	(1) Till plain (2) Flat (3) Lake plain
Runoff class	Negligible to low
Flooding frequency	None
Ponding frequency	None
Elevation	689–1,837 ft

Slope	0–2%
Water table depth	0–12 in
Aspect	Aspect is not a significant factor

Climatic features

In contrast to drier prairie regions of the Great Plains, the Des Moines Lobe receives more rainfall (Gilbert et al. 2006) and is considered to be part of the “prairie peninsula”, a region that is widely considered to have been suitable to forest development (Transeau 1935). Instead, because of frequent (sometimes annual) fires over the course of millennia, these areas developed as prairies which form soils high in organic matter content. Although wetland basins and their associated complex of wet prairies, meadows, and marshes are a central concept of all prairie pothole landscapes, only in the milder and wetter climate of MLRA 103 do poorly drained low prairie soils (i.e., Loamy Wet Prairies) become abundant. Elsewhere, these fringe wetlands occur in narrower zones with a shorter distance between ponded depressions and non-hydric, upland soils. In addition, historically the adjacent depressions held more water for longer time periods and had fewer draw-downs than regions to the west and north (Johnson et al. 2010). Severe droughts historically occurred every 10-12 years, often followed by unusually wet cycles (Galatowitsch and van der Valk 1994). It is likely that gradual transition in vegetation composition accompanied these cyclical changes, selecting for upland prairie species during dry times and expansion of sedge meadow species during wetter times.

The soil temperature regime of MLRA 103 is classified as “mesic” (i.e., mean annual soil temperature between 46 and 59°F). The average frost-free period of this ecological site is about 130 days and the average freeze free period is 154 days. Average mean annual precipitation is 31 inches, which includes rainfall plus the water equivalent from snowfall. Two-thirds or more of the precipitation falls during the growing season. The majority of rainfall occurs as high intensity, convective thunderstorms during the summer months (Evans and Freeland 2001). Most of the spring snowmelt runs off the uplands and into adjacent depressions. The average annual temperature is 42.8 to 50°F. Frost pockets and cold air drainage from above and the fact that wet soils are generally colder than dry soils make this ecological site colder than adjacent upland ecological sites. As a result, snow and frost remain longer in the spring, thus resulting in shorter growing seasons. These are averages derived from multiple weather stations across the range of this ecological site. It is important to note this MLRA is quite large (nearly 18 million acres), and there are undoubtedly important temperature and precipitation differences from north to south and west to east (e.g., gradually becoming warmer and wetter).

As mentioned previously, the Loamy Wet Prairie ecological site becomes much less common in the northeast portion of MLRA 103, especially on the northern part of the Le Sueur Moraine. Much of this area is referred to locally as the “Big Woods”, as the pre-settlement vegetation was mature hardwood forest. Higher relief landforms with frequent north-facing slopes were protected from fires, and that combined with a climate conducive to tree growth produced the extensive forests that contrasted sharply with areas of prairie. (Grimm 1984). In the face of a warming climate the region will become drier due to higher temperatures and elevated evapotranspiration (Johnson et al. 2010), although an increase in precipitation may mediate this effect. The weather stations selected are within the range of this ecological site, but were not necessarily located on correlated map units.

Table 3. Representative climatic features

Frost-free period (characteristic range)	126-135 days
Freeze-free period (characteristic range)	148-161 days
Precipitation total (characteristic range)	28-33 in
Frost-free period (actual range)	123-136 days
Freeze-free period (actual range)	143-164 days
Precipitation total (actual range)	28-34 in
Frost-free period (average)	130 days
Freeze-free period (average)	154 days
Precipitation total (average)	31 in

Climate stations used

- (1) POCAHONTAS [USC00136719], Pocahontas, IA
- (2) PERRY [USC00136566], Perry, IA
- (3) ROCKWELL CITY [USC00137161], Rockwell City, IA
- (4) SPENCER 1 N [USC00137844], Spencer, IA
- (5) MARSHALL [USC00215204], Marshall, MN
- (6) SPRINGFIELD 1 NW [USC00217907], Springfield, MN
- (7) WORTHINGTON 2 NNE [USC00219170], Worthington, MN
- (8) LAMBERTON SW EXP STN [USC00214546], Lamberton, MN

Influencing water features

On the Des Moines Lobe, groundwater follows the surface topography along subdued contours (Evans and Freeland, 2001). The Loamy Wet Prairie ecological site, with the natural hydrology intact, receives water from four sources: the regional groundwater table, direct precipitation, runoff from uplands, and recharge through base flow from adjacent upland ecological sites. Interactions among precipitation, evapotranspiration, geomorphology, and permeability at least seasonally produce a positive water balance in these wetland basins (Evans and Freeland, 2001). In the spring months, this ecological site produces surface runoff. The soils are classified as endosaturated, meaning all soil layers to at least 80 inches are saturated, presumably connected to the regional groundwater table. This is in contrast to wet soils that are episaturated, referring to perched water tables, or zones of saturation that terminate within the 80 inch soil profile, well above the regional aquifer. Still, these moderately fine textured soils often have less permeable horizons below 40 inches that function as an aquitard, and under saturated conditions provide lateral flow to downslope ecological sites.

The water table is at or near the soil surface during the spring months and may drop to as low as four feet later in the growing season during dry years. In the hydrogeomorphic (HGM) classification system, this site is considered a Mineral Soil Flat, producing recharge to groundwater and adjacent depressional wetlands (USDA-NRCS, 2008; Gilbert et al., 2006).

Throughout the region groundwater tables have been lowered by ditching and drainage tile (Galatowitsch and van der Valk, 1994). These modern drainage activities bypass the original movement of water from recharge zones to natural points of discharge via shallow sub-surface flow, and directly deliver water as surface discharge to headwater reaches. This overrides the original biogeochemical and hydrologic functions of this ecological site. Hydrologic functions include the temporary storage of water in the soil matrix, and the slow release of that water for downstream baseflow maintenance. Biogeochemical functions include anaerobic cycling of nutrients in the presence of an organic source of energy, such as anaerobic denitrification.

This ecological site has a Land Capability Classification of 2w, having some limitations for agriculture due to a seasonal high water. However, in an effectively drained condition (via drainage tile) these soils are considered prime farmland. Similarly, the Hydrologic Soil Group is classified as a dual class: C/D. This means that natural, undrained sites are unfit for agriculture due to excessive wetness (i.e., class "D"), but when drained they elevated to class "C" and thus, more conducive to a variety of land uses (USDA-NRCS, 2009).

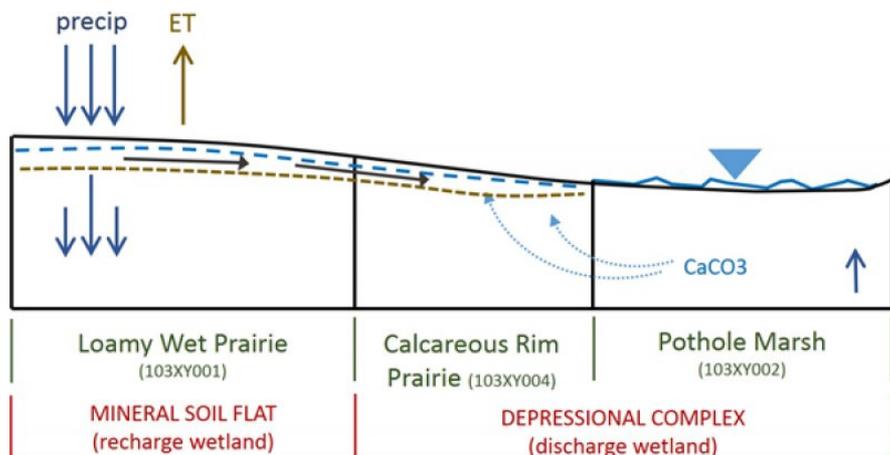


Figure 9. Hydrologic representation of a typical Des Moines

Soil features

Soils for Loamy Wet Prairies are in the Mollisol order and are classified further as Typic Endoaquolls. These mineral soils are rich in organic matter and were developed under prairie vegetation. Prairie soils by definition have thick, dark (nearly black, e.g., N 2/0 and 10YR 2/1) organic-rich surface horizons. The “mollic” surfaces of Loamy Wet Prairies are especially thick, often over 20 inches. Twenty-two inches was the average surface depth the across 40 field observations located at various state natural areas and other unplowed, undrained sites. Roughly one-third of these observations had mollic epipedons over 24 inches, and were classified as cumulic subgroups. It is possible these cumulic phases were more common prior to agricultural conversion and associated tillage practices. The high organic matter associated with these horizons greatly increases the fertility, the ease of tillage, and available water capacity of these soils. Because these sites are wet, which lowers exposure to oxygen, organic matter decomposes (i.e., oxidizes) more slowly than it does within drier soils, which in turn causes thicker A horizons. In addition, these sites are located in landscape positions that can receive runoff and erosional sediments (both natural and human accelerated) which also may lead to thicker dark surface horizons than upslope ecological sites.

These soils were formed under saturated conditions that produced anaerobic conditions during at least part of the year. Thick, dark surfaces tend to mask the typical redoximorphic features used to determine seasonal high water table depths. Beneath the mollic surface horizons, these soils have a depleted matrix with low chroma (2 or less) and high value (4 or more). The primary hydric soil indicators include: Depleted Below Dark Surface (A11), Thick Dark Surface (A12), and Redox Dark Surface (F6, option a; USDA-NRCS 2010).

By far the dominant soil series correlated to this ecological site are Webster and Canisteo, which are also the two highest acreage soils in the MLRA, accounting for well over three million acres. These two soil series provide the central concept for this ecological site, but there are several others included. The parent material for these soils is mostly loamy glacial till but also includes deep silty lacustrine, lacustrine over loamy till, and loamy till over lacustrine. These soils are very deep (>60 inches to bedrock). Drainage class is poorly drained, with a seasonal high water table within six inches of the surface. Minor components within these soil map units can include very poorly drained (seasonally ponded) swales and subtly concave areas, and somewhat poorly drained soils on slight rises within the poorly drained flat or on slopes near the edge of the uplands.

Typical soil textures are loam, silt loam, and clay loam but can also be silty clay loam and sandy loam. The soil family particle size class typically is fine-loamy, but can also be fine-silty or coarse-loamy. Coarse fragments are between 0 and 10 percent by volume. Soil pH classes are moderately acid to moderately alkaline in the surface horizons (i.e., A horizon), slightly acid to moderately alkaline in the subsoil (i.e., the cambic B horizons), and slightly alkaline to moderately alkaline in the Cg horizons.

Included within the concept of this ecological site are moderately calcareous soils like those of the Canisteo series. These soils are closer to the ponded depressions than non-calcareous soils. They draw water by capillary action from nearby ponded depressions. Evapotranspiration of water in this way exceeds downward leaching in comparison to adjacent wetland and upland soils (as in Webster for example; Thompson and Bell 2001). Vigorously growing wet prairie vegetation enhances this lateral/upward water movement. Ultimately the water molecules

evaporate or are transpired by plants, leaving calcium carbonate (CaCO₃) behind in the soil. This phenomenon is apparent to an extreme extent on rims of depressions, where calcic horizons are developed (e.g., Harps or Corvuso series). Those soils are dealt with in another ecological site: Calcareous Rim Prairies (103XY004).



Figure 10. Photo of a Webster soil series (Fine-loamy, mixed,

Table 4. Representative soil features

Parent material	(1) Till–calcareous shale (2) Lacustrine deposits–limestone (3) Drift–granite
Surface texture	(1) Loam (2) Sandy loam (3) Sandy loam
Family particle size	(1) Loamy
Drainage class	Poorly drained
Permeability class	Moderately slow to moderately rapid
Soil depth	80 in
Surface fragment cover ≤3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	8.7–12.6 in
Calcium carbonate equivalent (0-40in)	0–30%
Soil reaction (1:1 water) (0-40in)	5.6–8.4
Subsurface fragment volume ≤3" (Depth not specified)	0–10%
Subsurface fragment volume >3" (Depth not specified)	0–3%

Ecological dynamics

The Loamy Wet Prairies ecological site occurs mostly on inter-depressional linear flats with slight, zero to two percent slopes. With subtle topographic boundaries, these areas gradually transition to upland prairies upslope and to sedge meadows downslope (MN DNR 2005a). A fluctuating seasonal water table that produces anaerobic conditions in the rooting zone is the most important site factor. Species characteristic of this ecological site are adapted to this variation in water saturation. In addition, species common to wet prairies (and prairies in general) have physiological adaptations allowing them to withstand frequent stand-replacing fires, grazing, and extreme changes in temperature (Weaver 1963). Similar wet prairie ecological sites are widely distributed throughout the

prairie pothole region, however, in MLRA 103, the Loamy Wet Prairies ecological site is particularly common, due in large part to lower evapotranspiration and increased precipitation, making poorly drained flats wetter and more expansive compared to adjacent regions (Tom Neuenfeldt, NRCS Soil Scientist, personal communication; Carter et al. 2010).

Prior to European settlement, open prairies have persisted on these sites since the Holocene Thermal Maximum, approximately 9,000 to 5,000 BP (i.e., the hypsithermal time period). Beginning 3,000 to 5,000 years ago, environmental conditions have favored woodland expansion in the region (MN DNR 2005a, Grimm 1984, Transeau 1935). Fire and the interaction of fire with various topographic factors kept much of the MLRA in prairie vegetation leading up to European settlement (Grimm 1984, Gleason 1913). Fire, drought, and native grazing were the primary natural disturbances on pre-settlement Des Moines Lobe prairies. There is little known about historical grazing by native ungulates. It may have been more important in upland areas (MN DNR 2005b). Undoubtedly whitetail deer (*Odocoileus virginianus*) and especially prairie elk (*Cervus elaphus manitobensis*) grazed these sites, particularly as they used the adjacent depressions as water sources (NatureServe 2013). Elk were likely extirpated from the region by the early 1900s, primarily by over-hunting (MN DNR 2015). Bison (*Bison bison*) likely also grazed these sites, although many speculate they weren't abundant this far east (NatureServe 2013, Landfire 2009). For thousands of years, humans have been an integral part of the tallgrass prairies of the Midwest. It has long been understood that the vast majority of prairie fires were ignited by Native Americans, and not by lightning (Grimm 1984, McComb and Loomis 1944, Gleason 1913). However, it seems reasonable to consider that lightning-caused fires from western Great Plains could have periodically been driven into this part of the prairie peninsula given the correct weather conditions. Historically, there was a direct relationship between fire frequency and climate, in that fire occurrence was more likely during times of drought. It is likely that these sites burned at three to five times per decade, and in times of drought burned annually (Landfire 2009). Fires occurred throughout the year, including during the growing season during dry years. However, the most substantial fires occurred during the dormant season, and in particular during the fall months (Gleason 1913). These periodic fires removed built-up thatch and dead litter, stimulated growth and flowering of grasses and forbs, and limited the occurrence of shrubs and trees. Only during long, fire-free intervals, likely associated with times of higher than average precipitation, would shrubs increase on wet prairies. However, areas protected from fire such as stream valleys, high-relief landforms, and areas of high lake density would have likely supported savanna, woodland, or barrens communities. These areas would have provided sources for increased shrub density on some sites.

In general, the various wetland plant communities within Des Moines Lobe prairie potholes have high species diversity. An estimated 350 species are native to these prairies, meadows, and marshes. However, in a given wetland basin only a fraction of these species will be present (Galatowitsch and van der Valk 1994). Specifically, Loamy Wet Prairies are grass-dominated, but forb-rich (and often sedge-rich) herbaceous communities (MN DNR 2005a). Variation in water table allows both wetland and non-wetland species to thrive. As a result, ground flora diversity can be very high, having as many as 60 or more species at a given location. The wetland indicator status of species present on a given site will include the entire range of designations. As with other midwestern tallgrass prairies, grasses and forbs are the two dominant physiognomic groups, both totaling roughly half of a typical site, respectively. For the grasses, big bluestem and Indian grass are the most abundant. Prairie cord grass and switchgrass (*Panicum virgatum*) are important indicators of wet prairies and can sometimes be abundant. Mid-height bunchgrasses typical of drier prairies are also present and add structural diversity, such as little bluestem (*Schizachyrium scoparium*) and prairie dropseed (*Sporobolus heterolepis*). Sedges are an important component as well, and dozens of species of *Carex* are possible. However, a few species deserve specific mention. Bicknell's sedge is the most common, especially in drier conditions. Woolly sedge, Buxbaum's sedge, and rigid sedge (*Carex tetanica*) are also common. And in wetter conditions, tussock-forming species like Hayden's sedge (*Carex haydenii*) and upright sedge (*Carex stricta*) can be present. The most abundant forbs include northern bedstraw (*Galium boreale*), Virginia mountainmint (*Pycnanthemum virginianum*), Canada anemone (*Anemone canadensis*), golden zizia (*Zizia aurea*), downy phlox (*Phlox pilosa*), and Canada goldenrod (*Solidago canadensis*). In addition, a diverse assortment of charismatic prairie forbs are common to the site. Prairie blazing star is the iconic showy forb of Loamy Wet Prairies (Eggers and Reed 2015). Other common prairie forbs include compassplant, purple prairie clover (*Dalea purpurea*), false sunflower (*Heliopsis helianthoides*), stiff goldenrod (*Oligoneuron rigidum*), several species of milkweed (*Asclepias* spp.), and sawtooth sunflower (*Helianthus grosseserratus*). Additional species, which are generally found in more obvious wetlands, include narrow-leaved loostrike (which is very common), swamp milkweed, spotted water hemlock (*Cicuta maculata*), and on the high quality sites, white lady's slipper (*Cypripedium candidum*). Although more so than adjacent upland prairies, these wet prairies historically had low cover of woody plants but added to the structural diversity of plant communities. Species like leadplant and prairie rose were common but not abundant, and typically grew more or less as low-growing herbaceous plants, rarely

putting on enough growth to become a true shrub before being burned back by fire (Smith 2008). Various species of willow and dogwood may be present and will quickly spread in the absence of frequent fire.

Loamy Wet Prairie ecological sites have a long history of post-settlement land use, accompanied by a complicated array of land use policies and legislation. By the mid-1800s the fire frequency needed to maintain the Reference State plant communities was already decreasing, partly due to the early presence of European settlers and partly due to the wide-scale removal of Native Americans from the region. During the early settlement of the Midwest (prior to 1850), prairies in general were thought to be unfertile as well as dangerous because of the presence of prairie fire (Beauchamp 1987). It wasn't until they began farming the land that they realized the fertility of prairie soils (Smith 1992). Initially, settlers kept to prairie margins such as wooded edges and savannas along streams and rivers. As other regions of the Midwest were settled, later arrivals were eventually forced to settle on the prairie. Areas furthest from main water courses, particularly wetland areas, were settled last. Wetlands were widely seen as a nuisance for economic and agricultural development, as evidenced by the Swamp Lands Acts of the mid-1800s, in which the Federal Government granted nearly 65 million acres of wetland to state governments (Dahl and Allord 1997). In exchange, the states agreed to pursue wetland drainage activities. Minnesota and Iowa together received about six million acres, all of which were eventually drained and sold off (Anderson 2005).

Population growth in the Midwest slowed during the Civil War, but picked up again by the 1870s, coincident with railroad expansion and development of new farm machinery technologies. By 1880, settlement was expanding across the Des Moines Lobe prairies (Smith 1998). Ultimately, these prairie wetland landscapes were the last frontier of the once vast tallgrass prairie (Smith 1998). There was originally little interest in the region due to high concentration of wetlands, lack of navigable waterways, and general impassability (Beauchamp 1987, Smith 1998, Galatowitsch and van der Valk 1994). In a wet spring, it was likely that much of the area was a matrix of water-logged prairies, sloughs, wet meadows, and marshes (Smith 1998). Mosquito infestations and associated diseases like malaria and ague caused further dislike of wetlands. The upland prairies were plowed and converted to row crops (mainly corn) while the wettest marshes remained idle. Some Loamy Wet Prairie sites may have been farmed, but in general they were too wet for a profitable crop and were used as wild hay fields and cattle pastures (Smith 1992). Heavy, continuous grazing was most certainly a major factor in degradation of Loamy Wet Prairies during this time period. Nonnative, cool-season grasses like Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*) were introduced and responded well to these disturbances and began replacing native species (Smith 1998). Although transitioning to a degraded state, Loamy Wet Prairies in this condition resembled their native condition.

Drainage of wetlands mainly began in the 1870s and 1880s, initially by draining surface water using shallow, hand dug ditches (Schrader 1955). This resulted in limited success since it was difficult to drain water from one piece of land without flooding another. Ultimately, more aggressive means of draining land on a broad scale were employed by the formation of public drainage districts. By the 1890s wetland drainage had tripled corn production in Iowa and decreased cases of malaria (Crumpton et al. 2012). Excessive ditching took land out of production and it was eventually realized that in order to effectively drain wetlands, both surface and subsurface drainage were needed. Tile drainage using clay tile became a popular means to drain wetlands. Much of the early subsurface tile drainage networks were dug by hand, or by a combination of hand-digging and plowing with teams of horses. Using this method, two men and a team of horses could complete an average of 300-500 feet of trench per day (Beauchamp 1987). Throughout the latter half of the Nineteenth Century various horse-drawn tiling machines were invented, followed by highly mechanized steam engines, and by gasoline engines starting in 1908 (Beauchamp 1987). Even with increasing mechanization some companies specializing in hand-dug drainage tile remained in business into the 1960s (Don Flatness, Freeborn County SWCD, retired, personal communication). The Reclamation Act of 1902 initiated the first direct involvement of the USDA in farm drainage activities on privately-owned lands. By about 1930, 95% of wetlands in the region were at least partially drained (Doak 2015, Shrader 1955). The utilization of wetlands for wild hay also decreased in this time period. An Iowa agricultural census in 1896 showed that 5.5 percent of the prairie was being utilized as wild hay production. This number dropped to nearly zero by 1930 (Smith 1998).

The first signs of wetland drainage slowing came in the early 1930s during the Great Depression due to overproduction and extreme drought (Shrader 1955). In addition, passage of the 1934 Migratory Bird Hunting Stamp Act prompted some of the first attempts at acquiring and restoring wetlands (Dahl and Allord 1997). The Agricultural Act of 1956 and the development of the Soil Bank program worked to balance commodity markets and periodically slowed agricultural production and drainage (Helms 1985). However, during the same time period the Federal Watershed Protection and Flood Prevention Act of 1954 was passed, which authorized USDA to plan and

develop drainage practices in cooperation with local conservation districts (Beauchamp 1987). By the mid-1960s, this led to a resurgence of wide-ranging wetland drainage activities. The priority was to help farmers more effectively drain fringe wetland areas (Don Flatness, Freeborn County SWCD, retired, personal communication). In MLRA 103, these were the Loamy Wet Prairie soils. As a result, an estimated 125,000 acres of prairie pothole wetlands were drained between 1964 and 1968 alone (Weller 1994). By the early 1970s, tile drainage sped up because of the invention of corrugated plastic tubing which replaced clay and concrete drainage tile (Beauchamp 1987). By this time over 99% of wetlands in Iowa, most of which were in MLRA 103, had been drained (Crumpton et al. 2012). Also during this time, small-scale family dairy farms were declining in the region, accompanied by conversion of so-called “permanent pastures” and a variety of other crops to corn and soybean farming (Don Flatness, Freeborn County SWCD, retired, personal communication).

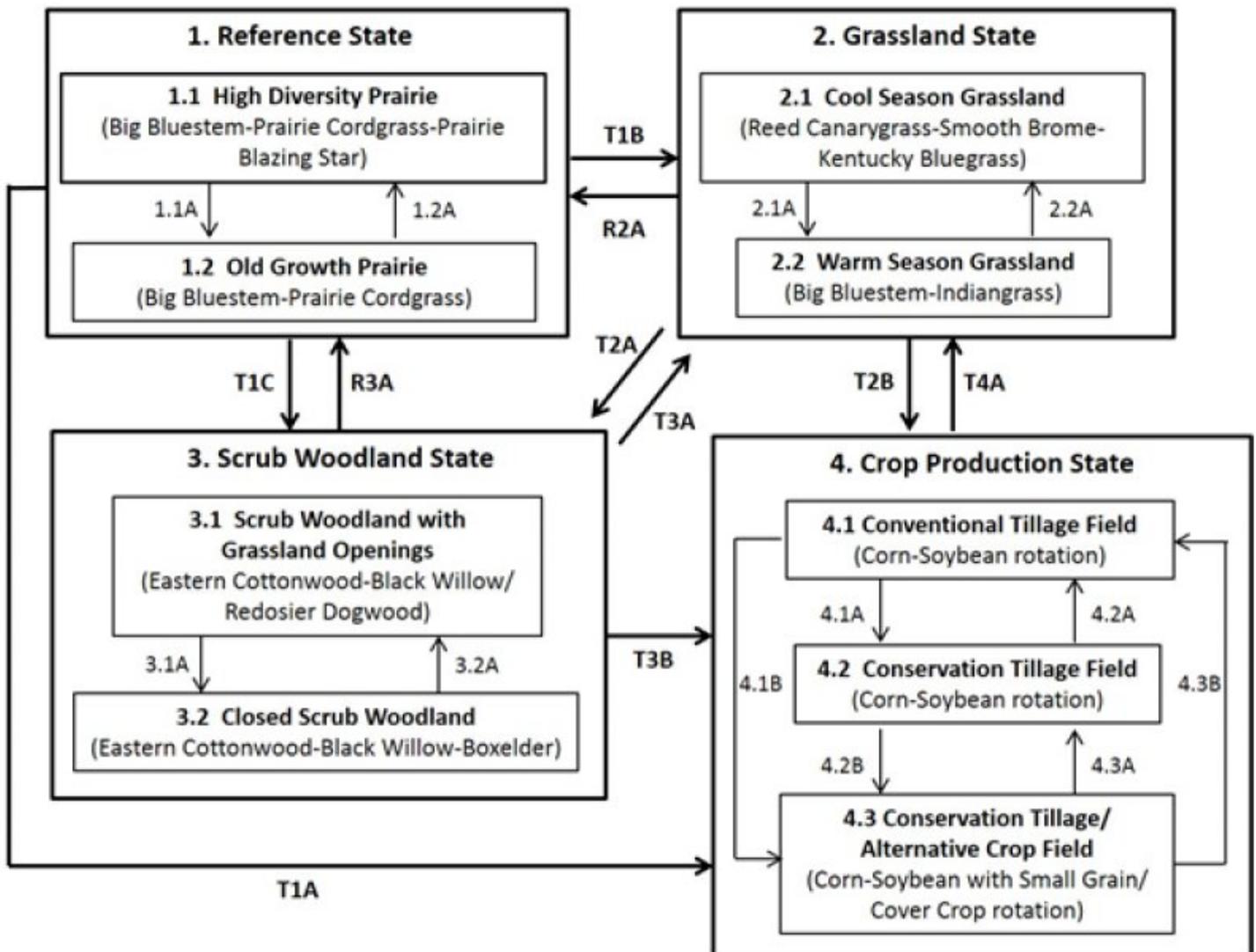
From the mid-1980s through the early-1990s, a number of important conservation measures took place that continue to positively impact the conservation of prairie pothole wetlands today, including Loamy Wet Prairies. In 1985, the first Food Security Act was passed (often referred to as the “Farm Bill”), which introduced two important items related to wetland conservation. First was Swampbuster, which sought to remove Federal subsidies to farmers who drained or otherwise converted wetlands for the purpose of planting crops (Votteler and Muir 2002). This program was meant not only to protect wetlands, but to decrease the amount of land available for agriculture to help maintain stable commodity prices. Swampbuster compliance remains the most important government legislation protecting agricultural wetlands that were not converted prior to December 23, 1985 (Crumpton et al. 2012). The second important item introduced with the 1985 Food Security Act was the Conservation Reserve Program (CRP) which provides rental payments to farmers to take marginal agricultural land out of production for 10 or 15 year contract periods, with the potential to re-enroll. The Wetland Reserve Program (WRP), introduced in the 1990 Food Security Act, is another important program for wetland restoration. The WRP gives landowners financial payment for restoring or protecting wetlands through long term, often permanent easements. Additionally, the State of Minnesota’s Reinvest In Minnesota Reserve Program has partnered with the Federal WRP to provide additional incentives, enhancing 30-year WRP contracts into perpetual easements (BWSR 2005). Finally, in 1991 the State of Minnesota passed the Wetland Conservation Act, creating a “no net loss” policy of Minnesota’s remaining wetlands (BWSR 2015). As a result of these conservation measures, in recent decades the conversion of wetlands has slowed. And meanwhile, many thousands of acres have been protected or reestablished. However, increasing corn and soybean prices since 2007, particularly during the crop years of 2011, 2012, and 2013 which recorded historic highs, averaging over \$6/bushel (Univ. of Illinois 2015). This change in the agricultural market has put increased pressure on remaining wetland areas by providing yet another wide-scale incentive for farmers to take land out of perennial vegetation and further drain wetlands.

In the end, during the span of less than a century, almost all of the original 240 million acres of tallgrass prairie of the prairie peninsula were converted to agriculture (Smith 1992). As a result, there is much we don’t know about these ecosystems. Of all the tallgrass prairie regions, MLRA 103 is perhaps the most ecologically altered. This portion of Minnesota and Iowa was once part of one of the most important wetland regions in the World. As much as three quarters of North American waterfowl reproduction comes from the prairie pothole region during a given year (Mitsch and Gosselink 2007). Loamy Wet Prairies, adjacent to the pothole depressions, once provided critical nesting habitat for many species (Galatowitsch and van der Valk 1994). However, today, the Des Moines Lobe is no longer important for waterfowl production. Despite this reality, remnant and restored wetlands still provide important stopover sites during migration, and during times of excessive precipitation and soil saturation, these former wetland basins show signs of their former self.

Depending on which land cover dataset is analyzed, around 99 percent of the land area of this ecological site is in private landownership, one percent is considered a wetland via the National Wetland Inventory, 90 percent is in cultivated crops, one to four percent in grass or pasture, and the rest is miscellaneous developed land. The information provided in this publication is based on accumulated knowledge gained through the literature as well as data and field experience from both high quality managed prairie natural areas as well as sites in various stages of degradation. Incredibly, there are a number of small virgin prairie pothole basin remnants that escaped conversion. Either by luck, or by the foresight of visionary landowners there are a few blocks of land that were not drained and farmed, but most of these sites are small or are old cemeteries or railroad/road rights-of-way. Few, if any locations within the MLRA remain connected to larger areas of intact prairie-wetland complexes needed to maintain populations of the many declining area-sensitive grassland wildlife species (Galatowitsch and van der Valk 1994).

State and transition model

103XY001 Loamy Wet Prairie (Webster, Canisteo and similar soils)



Code	Process	Code	Process
T1A, T2B	Tillage; artificial drainage; removal of fire and native grazers.	1.1A	Fire-free period 3-5 years.
T1B	Seeding or invasion of cool season grasses; lack of fire; some hydrologic alteration; possible over-grazing.	1.2A	Fire-free period <3 years.
		2.1A	Removal of cool season grasses; seeding of native grasses.
T1C, T2A	Lack of fire and grazing; time.	2.2A	Invasion of cool season grasses.
T3A	Removal of overstory; seeding of grasses.	3.1A	Succession, development of forest structure.
		3.2A	Partial removal of canopy.
T3B	Removal of overstory; artificial drainage; tillage and conversion to row crop agriculture.	4.1A	Less tillage; residue management; crop rotation.
T4A	Removal of tillage activities, seeding of grasses; possible restoration of hydrology.	4.1B, 4.2B	Less tillage (none in fall of year); increased plant diversity; crop rotation; continuous soil cover.
		4.2A, 4.3B	Intensive tillage; less residue; continuous cropping.
T4B	Removal of drainage systems; planting perennial veg.	4.3A	Additional tillage; less residue; no cover crops.
R2A	Long term ecological restoration; potentially impossible.		
R3A	Removal of overstory; long term restoration; uncommon.		

Figure 11. State-and-transition diagram for Loamy Wet Prairie

State 1 Reference State

Community phases within the Reference State are dependent upon the frequency, intensity, and diversity of fire events, usually associated with climatic trends. Fires promote continued herbaceous vegetation dominance and remove dense thatch. Removal of the litter helps cycle nutrients in the dead plant material and allows light to reach the soil surface and the seedbed. Fire return intervals mostly ranged from one to four years, usually during spring or fall. During times of drought these sites historically burned more frequently and with higher intensity, including during the growing season. In turn, the consistent removal of built-up thatch would provide increased light and regeneration opportunities for a diversity of prairie forbs, including short-lived annual and biennial species.

However, with increasing fire frequency and intensity, it is likely many forb species will give way to dominance by grasses which can handle repeated disturbances over longer time periods. More commonly, historic fires were slower moving, creeping fires with flame lengths three to ten feet, resulting in a variety of conditions that increased habitat diversity and provided refugia for wildlife (MN DNR 2005a, Gleason 1913). However, some species would not have been able to compete with the competitive grasses if recurrent fires were too low in intensity (Landfire 2009). Grazing by native ungulates would have also affected the diversity of vegetation by creation of microsites for certain plant species. The combination of fire and grazing was generally sufficient to keep woody species from proliferating. However, in times of higher than average precipitation, some areas may accumulate significant woody cover, although historically this was rare. In addition to fire and grazing, high water tables are needed to maintain plant communities within the Reference State. In natural conditions, at least some part of the top ten inches of the rooting zone is saturated for several weeks during the early growing season. Longer-term, inter-annual changes in precipitation can shift these boundaries and create conditions favorable to species tolerant of wetter or drier conditions. This also contributes to the diversity of species present. As a result, the mesic prairie-wet prairie-sedge meadow continuum can range somewhat, with upland prairie species expanding during dry cycles, and sedges and wetland obligate species expanding during wet cycles. Areas in the Reference State currently are likely degraded to some extent. Undoubtedly remaining natural areas were grazed and/or hayed at one time. And with no source populations nearby it is very likely some plant species have been extirpated. Others likely benefited. For example, Virginia mountainmint, one of the most common forbs encountered, may be more common today because of its ability to persist in the face of heavy grazing (Eggers and Reed 2015).

Community 1.1 High Diversity Prairie



Figure 12. Community Phase 1.1 High Diversity Prairie for Loa

High diversity prairies are maintained by frequent soil saturation and burning. Annual short-duration soil saturation in the rooting zone prevents species characteristic of drier, more upland settings from becoming established. Recurring fire at least once every three years keeps woody vegetation at bay and burns off the dense thatch that builds up to allow for a wide variety of species to flourish. Grazing may increase regeneration of some native species (Gilbert et al. 2006). From blackened soil following a dormant season burn, fire adapted vegetation will grow to maximum height by the end of the growing season (Landfire 2009). Annual and biennial plants are likely to colonize bare soil areas. Graminoids (grasses, sedges, and rushes) and forbs generally make up nearly equal amounts of cover and productivity. In fact, the annual productivity of forbs often supersedes that of the grasses, which is unique to tallgrass prairies, particularly Loamy Wet Prairies (Table 8). Big bluestem is the dominant grass, sometimes growing in excess of eight feet tall. Indian grass and prairie cord grass are co-dominant. Other grasses include switchgrass, fowl bluegrass, prairie dropseed, and scattered little bluestem. Sedges are common but usually not dominant. In cases where sedges are dominant there is likely a water table higher in the soil profile, such as sites that are hydrologically connected to nearby lakes. An individual location can have a wide variety of forbs depending on whether it is on the wet or dry end of the ecological site range. Common species are Canada goldenrod, sawtooth sunflower, Canada anemone, Indian hemp, swamp milkweed, palespike lobelia, winged lythrum, Virginia mountainmint, giant goldenrod, white heath aster, purple meadow rue, swamp verbena, prairie ironweed, Culver's root, and golden zizia.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Forb	1200	2000	3000
Grass/Grasslike	1000	1500	2500
Shrub/Vine	0	250	500
Tree	0	0	0
Total	2200	3750	6000

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0-1%
Grass/grasslike foliar cover	15-30%
Forb foliar cover	15-30%
Non-vascular plants	0-1%
Biological crusts	0-2%
Litter	15-75%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0-2%
Bare ground	0-25%

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/Grasslike	Forb
<0.5	0%	0-1%	10-20%	10-20%
>0.5 <= 1	0%	1-5%	25-50%	35-65%
>1 <= 2	0%	1-10%	25-50%	35-65%
>2 <= 4.5	0%	0-1%	40-70%	25-50%
>4.5 <= 13	0%	0%	10-40%	5-15%
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Community 1.2 Old Growth Prairie



Figure 14. Community Phase 1.2 Old Growth Prairie for Loamy W

This phase occurs when fire frequency is reduced to three to five year intervals, and hydrology is unchanged. Plant litter is removed less frequently which favors the dominant grasses and results in a reduction in overall plant diversity. The dense build-up of plant litter also tends to reduce the height of the dominant species. The plant litter ties up nutrients and also shades the ground in the spring, keeping the soil cooler and slowing germination and early growth. Vegetation on sites in the Old Growth Prairie condition is heavily dominated by grasses, especially big bluestem, Indian grass, and prairie cord grass. Other prairie grasses may increase as well. Due to increased competition and thatch build-up produced by the grasses, native forbs and sedges are still common but have a reduced cover. Leadplant, prairie rose, and other shrubs onsite increase.

**Pathway 1A
Community 1.1 to 1.2**

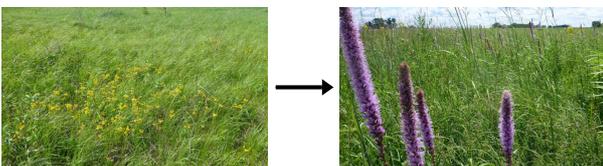


High Diversity Prairie

Old Growth Prairie

Average fire return intervals of three to five years for a decade or more.

**Pathway 2A
Community 1.2 to 1.1**



Old Growth Prairie

High Diversity Prairie

Average fire return intervals of less than three years.

**State 2
Grassland State**

Community phases within this state are essentially simplified grassland plant communities. Beginning in the late 1800s, many Loamy Wet Prairies were transitioning to this state resulting from the removal of fire, cattle grazing, and haying practices. The reduction in fire frequency led to more uniform habitat conditions over time which reduced species diversity. The dominant species were both native warm season grasses and nonnative cool season grasses. At first, native prairie grasses and various shrubs increased, while the majority of other species decreased. During this time, Kentucky bluegrass and smooth brome were introduced to extend the grazing season of prairie pastures (Smith 1998). These nonnative grasses increased following intense over-grazing, at the expense

of native vegetation. At some point nonnative cultivars of reed canarygrass (*Phalaris arundinacea*) were introduced due to its ability to grow in wet areas. Over time it became extremely aggressive and is now one of the most common grasses in the region. Sites that haven't been drained and converted to agriculture are often hayed or grazed. Most restoration sites in the MLRA fit into this state. With active vegetation management, it is possible for remnant sites to be restored to the Reference State. However, due to broad scale ditching and tile drainage, in most locations the regional groundwater tables are unnaturally low which makes it challenging to truly restore hydrology. Currently, the majority of sites in the Grassland State are a result of WRP and CRP vegetation establishment. Vegetation establishment in Loamy Wet Prairie areas is often overlooked due to the focus being on pothole marshes and the perception that ponded water is the only important habitat waterfowl use. Consequently, wetland restorations typically focus on the development of submergent and emergent vegetation in ponded areas (Galatowitsch and van der Valk 1994). Reed canarygrass is almost always a dominant and aggressive invader. In addition, it has been found that sites with greater than 20 years of agriculture will have depleted native seed banks (Weinhold and van der Valk 1989). On Loamy Wet Prairie soils, slope wash from adjacent cultivated uplands may bury the existing seedbank if one exists (Gilbert et al. 2006). Thus, effective restoration will require artificial regeneration of vegetation and intensive management of invasive vegetation. Ultimately, vegetation zonation associated with the wet prairie-sedge meadow continuum will take decades (or more) of active management along with complete hydrologic restoration. If prairie restoration is a management goal, careful selection and establishment of a variety of species in addition to the typical CRP grasses is essential. Too often, forb species are overlooked due to a focus on establishment of warm season grasses. True restoration of a Loamy Wet Prairie site should include roughly half grass/grasslike and half forb cover. Although these plant communities are not considered prairies, grasslands share many of the same important ecological benefits, such as grassland structure for bird species and various soil health qualities.

Community 2.1 Cool Season Grassland



Figure 15. Community Phase 2.1 Cool Season Grassland for Loam

These sites are strongly dominated by nonnative cool season grasses, typically about three to five feet tall. Reed canarygrass is probably the most common across all sites. This species does well in the wet prairie hydrologic regime and grows earlier in the season than the native warm season grasses (Maurer and Zedler 2002). Other nonnative cool season grasses that can be common to abundant are smooth brome, Kentucky bluegrass, redtop (*Agrostis gigantea*), and quackgrass (*Elymus repens*). Vegetation establishment in old crop field settings are mostly likely to result in this community phase (Mulhouse and Galatowitsch 2003).

Community 2.2 Warm Season Grassland



Figure 16. Community Phase 2.2 Warm Season Grassland for Loam

Sites in this community phase are strongly dominated by warm-season native grasses about three to eight feet tall. This community results from either the loss of diversity due to over-grazing, mowing, and removal of fire or from planting for restoration or other conservation purposes. The latter is the most common. Dominant grasses are similar to Community Phase 1.2, but diversity is much lower and the dominants can form near monotypic stands. This is the most common plant community occurring in CRP plantings. Planted grasses include big bluestem, Indian grass and switchgrass. Prairie cord grass may establish at these sites naturally. Due to the increased dominance by grasses and the reduced fire frequency, plant litter buildup tends to be heavy. Most CRP and WRP plantings also include forb species, but they are often few in number and their cover is sparse, in large part due to the competitive nature of the aforementioned grass species. If prairie restoration is a management goal, it is important to prioritize forb establishment, as well as planting additional grasses, sedges, and even wet prairie shrubs.

**Pathway 1A
Community 2.1 to 2.2**



Cool Season Grassland



Warm Season Grassland

Removal of cool season grasses; seeding.

**Pathway 2A
Community 2.2 to 2.1**



Warm Season Grassland



Cool Season Grassland

Invasion of cool season grasses.

**State 3
Scrub Woodland State**

Without fire to kill woody vegetation, trees and tall shrubs can become established and spread, potentially converting the site to a closed woodland. In general, community phases in this state have greater than 25 percent cover with a dense herbaceous, usually grass-dominated, understory. Trees range from short to medium height (15 to 30 feet). Eastern cottonwood (*Populus deltoides*), black willow (*Salix nigra*), green ash (*Fraxinus pennsylvanica*) boxelder (*Acer negundo*), quaking aspen (*Populus tremuloides*), and peachleaf willow (*Salix amygdaloides*) are the

most common trees. Common shrubs are redosier dogwood (*Cornus sericea*), meadow willow (*Salix petiolaris*), Bebb willow (*Salix bebbiana*), pussy willow (*Salix discolor*), Missouri River willow (*Salix eriocephala*), and possibly others. In areas without complete canopy closure, the understory is similar to Community Phase 2.1, dominated by reed canarygrass and smooth brome. Kentucky bluegrass, redtop, and quackgrass may also be present. Giant ragweed (*Ambrosia trifida*) is often a major weed issue, along with stinging nettle (*Urtica dioica*). Areas with higher tree and shrub canopies typically have less herbaceous cover. Fires are essentially absent. High quality remnant prairies transitioning to this state are likely to develop into quaking aspen stands, with open areas retaining native prairie vegetation. Sites that are part of a pasture may receive heavy use by domestic livestock for grazing, access to water in deeper wetlands, and shelter provided by woody vegetation. From a shrub-free prairie or grassland, it may take as little as 10 years to transition to this state. Very little acreage is in this state. In fact, wooded vegetation doesn't show up at all in landcover analyses. Sites in this state may be poorly managed CRP or WRP easements. Areas not in a conservation program are assumed to be jurisdictional wetlands, making it very unlikely they will be transitioned to the Crop Production State due to various wetland programs and laws, including Swampbuster and the Minnesota Wetland Conservation Act.

Community 3.1 Scrub Woodland with Grassland Openings



Figure 17. Community Phase 3.1 Scrub Woodland with Grassland

This phase consists of plant communities with 25 to 75 canopy cover of trees and shrubs, generally ranging from 10 to 30 feet in height. Eastern cottonwood, black willow, green ash, and redosier dogwood are the most frequent woody species. Open areas are generally dominated by reed canarygrass, along with other grasses and weedy forbs. Giant ragweed can sometimes produce monotypic stands in open areas. In rare cases, higher quality sites can be dominated by quaking aspen and scattered wet prairie grasses and forbs.

Community 3.2 Closed Scrub Woodland



Figure 18. Community Phase 3.2 Closed Scrub Woodland for Loam

This phase includes closed, or nearly closed woodlands, ranging from 75 to 100 percent canopy cover. Like Community Phase 3.1, Eastern cottonwood, black willow, green ash, and redosier dogwood are the most frequent woody species. The few open areas will be dominated by reed canarygrass, but herbaceous cover is generally low. Stinging nettle is frequently the most common species. Again, in higher quality sites quaking aspen may be the dominant tree. Eventually these sites will begin to accumulate shade-tolerant herbaceous plants.

Pathway 1A **Community 3.1 to 3.2**



Scrub Woodland with
Grassland Openings



Closed Scrub Woodland

Succession, greater than 20 years without fire or grazing, development of forest structure.

Pathway 2A **Community 3.2 to 3.1**



Closed Scrub Woodland



Scrub Woodland with
Grassland Openings

Partial removal of canopy.

State 4 **Crop Production State**

The vast majority (>90%) of modern Wet Loamy Prairie sites are in the Crop Production State. Most, but not all ecological functions have been destroyed, converted, reverted, or otherwise removed from the system. In farmed conditions, dynamic soil properties can change quickly as a result of various agricultural practices and are the best way to understand the effects of these practices on the condition of individual fields. The vast majority of these sites are and will likely continue to be in corn and soybean production. There are certain management practices that are proven to be destructive, not only to the individual field, but to the watershed as a whole. Collectively, excessive tillage, the pervasive use of fertilizers and other chemicals, and many modern farming practices have unwanted effects that are neither good for the future of the site nor for the ecosystem as a whole. Subsurface tile drainage and tillage are the two primary factors affecting transition to this state. Counties in MLRA 103 are estimated to have had 64 to 100 percent of all wetlands converted to agricultural uses (Gleason et al. 2004). However, it is assumed that virtually all Loamy Wet Prairie sites in the Crop Production State have been completely drained. The main purpose of tile drainage is to produce drier and warmer conditions in the spring so growers can enter fields as soon as possible. In a natural condition, these wetlands are not directly connected to riverine systems. However, modern drainage activities transfer water through drainage tile and ditch networks directly into riverine systems, effectively overriding the hydrogeomorphic classification of this ecological site. Due to their high inherent fertility and largely non-erodible landforms, when drained these soils epitomize a naturally healthy soil. As a result, these soils tend to not be managed using soil health practices, and they are becoming damaged, primarily by excessive tillage. Overall, drainage and tillage has altered dynamic soil properties (and likely even inherent soil properties) and homogenized much of the historic microtopography associated with these sites.

Community 4.1 **Conventional Tillage Field**



Figure 19. Community Phase 4.1 Conventional Tillage Field for



Figure 20. Loss of soil structure resulting from the physical

This is the most common phase within the Crop Production State. The central practice defining this phase is the frequent use of tillage practices that damage the soil coupled with a low diversity of crops. Tillage generally occurs twice a year, once in the fall soon after harvest before freeze-up (i.e., primary tillage) and once in the spring as soon as the snow melts (i.e., secondary tillage). In some cases, growers may till twice in the spring, which severely damages soil structure, especially if the soil is wet. As a result, soils on these fields are not covered by vegetation or crop residue for a significant time period during the year, and thus are exposed to the full force of rainfall impact which destroys soil aggregation and accelerates erosion. Fall tillage equipment include chisels, discs, deep rippers, or moldboard plows which bury residue deep and turn the soil. While spring tillage equipment includes cultivators, harrows, rotary hoes, or vertical/turbo till. The primary crops in this phase are corn and soybeans, and to a much lesser extent, sweet corn or other vegetable crops. Due to high prices, corn is frequently planted on the same field year after year (i.e., "corn-on-corn"). By growing crops this way, there tends to be limited natural organic matter production occurring due to an imbalance in nutrient availability and soil organisms. As a result, growers tend to use more chemical fertilizers, herbicides, and pesticides. Sometimes growers may not till in the fall and plant soybeans directly into the corn stubble the following spring. This helps to build soil structure, however, it is short lived since the field will be tilled again the following year to prepare for corn. A number of dynamic soil properties are affected by this type of management. Tillage destroys the natural soil structure which reduces infiltration of rain water into the soil. In addition, tillage results in the loss of soil organic matter through oxidation, negatively affecting the fertility and water holding capacity of the soil. Heavily tilled soils are almost structure-less, which causes runoff during high intensity rain events, similar to how water runs off paved surfaces. Bulk densities increase as the soil becomes compacted by frequent use of large farm equipment. Entering fields early in the spring when the soil is wet further exacerbates this. Higher bulk densities also decrease the permeability and saturated hydraulic conductivity of the soil.

Community 4.2 Conservation Tillage Field



Figure 21. Community Phase 4.2 Reduced/No Tillage Field for L

This condition is characterized by adopting various methods of conservation tillage, including vertical till, strip till, ridge till, and no till farm management practices. Similar to Community Phase 4.1, the primary crops are corn and soybeans, and to a lesser extent, sweet corn or other vegetable crops. However, these conservation-minded growers are less likely to raise the same crop year after year. Each of the aforementioned tillage practices are doing minimal to no soil disturbance in the fall and the spring. Vertical tillage includes chopping of crop residue and mixing it in the top three inches of soil, ideally leaving most of it at the surface. Strip tillage is done in the fall following harvest. Strip tillage creates a cleared zone (or strip) of soil by using coulters which pulls crop residue away from the area to be planted the following spring. With ridge tillage, the soil is left undisturbed in the fall. This type of tillage is done early in the growing season when the crop is about a foot tall. Finally, no tillage systems disturb the soil the least and only disturb the soil lightly when planting and applying fertilizers. Each of these practices leaves residue on or near the surface of the soil. Often these fields continue to receive heavy applications of chemical fertilizers, herbicides, and pesticides. However, natural fertilizers (e.g., pig or turkey manure) are often used as well. With the adoption of conservation tillage practices, many soil properties are improving at this stage. Soil structure is re-developing, which increases infiltration and available water capacity. Organic matter content is stabilizing, conserving fertility and available water capacity. Bulk density is decreasing, allowing for roots and water to move more easily through the soil. Due to the continued use of chemicals, soil pH values will continue to be more acidic than normal.

Community 4.3 Conservation Tillage / Alternative Crop Field



Figure 22. Community Phase 4.3 Reduced/No Tillage with Altern

This is the optimal, sustainable condition of a cropped field, where a range of conservation practices are implemented with the goal to follow soil health principles. This phase may use all of the tillage-related items described in 4.2, but the guiding principal is to disturb the soil as little as possible. This phase also adds more diversity in crops and other plants used to keep the soil covered throughout the year (i.e., cover crops). These cover crops generally include grasses, legumes, brassicas, non-legume broadleaved, and other small grains. A number of cover crop planting options are available, such as by airplane or helicopter, spinner and pendulum spreaders, highboys, drilling, incorporation with fall tillage, or spreading with manure slurry. Adding cover crops helps to limit pest cycles (e.g., corn root worm or soybean cyst nematode), adds nutrients, and increases soil fertility. Cover crops that are nitrogen-fixing legumes can provide additional fertility. In general, cover crops have different root systems than corn and soybeans, which helps build soil structure by aggregating soil particles with newly made organic matter. The use of a diversity of cover crops produces a variety of root exudates that can feed and encourage a more diverse and balanced soil biota, including predatory biota of various kinds, thus providing natural pest control. Practicing soil health principles can also result in needing less chemical fertilizers and possibly less pesticides. Collectively, the benefits of this farm management system may result in high corn and soybean yields with less financial investment, and thus greater profitability. It is possible to attempt transition to this phase from conventional tillage (Community Phase 4.1), but results will not be immediate. In heavily degraded soils it will take at least three to five years before dynamic soil properties improve, such as development granular soil structure, increased soil organic matter, increased available water capacity, and decreased bulk density. In some cases in southern Minnesota, growers and conservationists have found that soils can be improved to the extent that they rival the productivity of a natural prairie soil. However, this may take decades of continual management to achieve. In MLRA 103, adoption of these management techniques is currently low, but is growing as more farmers learn how to successfully implement soil health principles, including managing cover crops. Once in Community Phase 4.3, it is unlikely the field will transition back to 4.1, unless farm ownership or management changes. Similar to Community Phase 4.2, the implementation of soil health principles through the use of various conservation practices improves a number of dynamic soil properties. Structureless soils begin to re-aggregate, which improves infiltration and available water capacity. Soil organic matter content is increasing, adding to fertility and available water capacity. Bulk density is decreasing. As soil organic matter increases, soil biota diversifies, and pH becomes less acid. Finally, although these fields continue to be tile drained, properly implemented conservation practices result in cleaner water and far less (if any) runoff.

Pathway 1A
Community 4.1 to 4.2



Conventional Tillage Field



Conservation Tillage Field

Less tillage; residue management; crop rotation.

Pathway 1B
Community 4.1 to 4.3



Conventional Tillage Field



Conservation Tillage /
Alternative Crop Field

Less tillage (none in fall of year); increased plant diversity; crop rotation; continuous soil cover.

Pathway 2A
Community 4.2 to 4.1



Conservation Tillage Field



Conventional Tillage Field

Intensive tillage; less residue; continuous cropping.

Pathway 2B
Community 4.2 to 4.3



Conservation Tillage Field



Conservation Tillage /
Alternative Crop Field

Less tillage (none in fall of year); increased plant diversity; crop rotation; continuous soil cover.

Pathway 3B
Community 4.3 to 4.1



Conservation Tillage /
Alternative Crop Field



Conventional Tillage Field

Intensive tillage; less residue; continuous cropping.

Pathway 3A Community 4.3 to 4.2



Conservation Tillage /
Alternative Crop Field



Conservation Tillage Field

Additional tillage; less residue; no cover crops.

Transition 1B State 1 to 2

Seeding or invasion of cool season grasses; lack of fire; some hydrologic alteration; possible over-grazing.

Transition 1C State 1 to 3

Lack of fire and grazing; time (>10 years without disturbance).

Transition 1A State 1 to 4

Tillage; artificial drainage; removal of fire and native grazers.

Restoration pathway 2A State 2 to 1

Long term ecological restoration, including establishment of typical wet prairie vegetation composition and structure, complete restoration of hydrology, and reintroduction of a diversity of disturbances, including multi-season burning and grazing.

Transition 2A State 2 to 3

Lack of fire and grazing for greater than 10 years.

Transition 2B State 2 to 4

Tillage; artificial drainage; removal of fire and native grazers. The majority of early post-settlement areas within the Grassland State were drained and transitioned to crop production.

Restoration pathway 3A State 3 to 1

Removal of overstory; long term restoration; uncommon.

Transition 3A State 3 to 2

Removal of overstory; seeding of grasses.

Transition 3B

State 3 to 4

Removal of overstory; tillage; artificial drainage; conversion to row crop agriculture.

Transition 4A

State 4 to 2

Removal of tillage activities, seeding of perennial grasses; possible restoration of hydrology.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Shrub/Vine					
1	Shrub/Vine			0–500	
	leadplant	AMCA6	<i>Amorpha canescens</i>	100–300	5–10
	prairie rose	ROAR3	<i>Rosa arkansana</i>	100–300	5–10
	willow	SALIX	<i>Salix</i>	0–300	0–10
	dogwood	CORNU	<i>Cornus</i>	0–150	0–5
Grass/Grasslike					
2	Graminoids			1000–2500	
	big bluestem	ANGE	<i>Andropogon gerardii</i>	300–900	15–40
	switchgrass	PAVI2	<i>Panicum virgatum</i>	100–400	5–25
	little bluestem	SCSC	<i>Schizachyrium scoparium</i>	100–400	5–25
	Indiangrass	SONU2	<i>Sorghastrum nutans</i>	100–400	5–25
	prairie dropseed	SPHE	<i>Sporobolus heterolepis</i>	100–400	5–25
	prairie cordgrass	SPPE	<i>Spartina pectinata</i>	100–400	5–25
	sedge	CAREX	<i>Carex</i>	100–350	5–20
	upright sedge	CAST8	<i>Carex stricta</i>	0–350	0–20
	Hayden's sedge	CAHA7	<i>Carex haydenii</i>	0–350	0–20
	Bicknell's sedge	CABI3	<i>Carex bicknellii</i>	10–300	1–15
	woolly sedge	CAPE42	<i>Carex pellita</i>	10–250	1–10
	Buxbaum's sedge	CABU6	<i>Carex buxbaumii</i>	10–100	1–5
	rigid sedge	CATE6	<i>Carex tetanica</i>	0–100	0–5
	Leiberg's panicum	DILE2	<i>Dichanthelium leibergii</i>	0–100	0–5
	flatstem spikerush	ELCO2	<i>Eleocharis compressa</i>	0–100	0–5
	Virginia wildrye	ELVI3	<i>Elymus virginicus</i>	0–100	0–5
	rush	JUNCU	<i>Juncus</i>	0–100	0–5
	fowl bluegrass	POPA2	<i>Poa palustris</i>	0–100	0–5
Forb					
3	Forbs			1200–3000	
	stiff goldenrod	OLRIR	<i>Oligoneuron rigidum var. rigidum</i>	200–600	5–25
	sawtooth sunflower	HEGR4	<i>Helianthus grosseserratus</i>	200–600	5–25
	compassplant	SILA3	<i>Silphium laciniatum</i>	200–600	5–15
	Canada goldenrod	SOCA6	<i>Solidago canadensis</i>	100–400	5–25
	golden zizia	ZIAU	<i>Zizia aurea</i>	100–400	5–25

	northern bedstraw	GABO2	<i>Galium boreale</i>	100–400	5–25
	downy phlox	PHPI	<i>Phlox pilosa</i>	100–400	5–25
	Virginia mountainmint	PYVI	<i>Pycnanthemum virginianum</i>	100–400	5–25
	Canadian anemone	ANCA8	<i>Anemone canadensis</i>	100–400	5–25
	spotted water hemlock	CIMA2	<i>Cicuta maculata</i>	0–400	0–20
	swamp milkweed	ASIN	<i>Asclepias incarnata</i>	200–400	5–15
	common milkweed	ASSY	<i>Asclepias syriaca</i>	200–400	5–15
	Indianhemp	APCA	<i>Apocynum cannabinum</i>	100–300	5–15
	purple prairie clover	DAPU5	<i>Dalea purpurea</i>	100–300	5–15
	showy ticktrefoil	DECA7	<i>Desmodium canadense</i>	100–300	5–15
	prairie blazing star	LIPY	<i>Liatris pycnostachya</i>	100–300	5–15
	fourflower yellow loosestrife	LYQU	<i>Lysimachia quadriflora</i>	100–300	5–15
	purple meadow-rue	THDA	<i>Thalictrum dasycarpum</i>	100–300	5–15
	prairie ironweed	VEFA2	<i>Vernonia fasciculata</i>	0–250	0–10
	swamp verbena	VEHA2	<i>Verbena hastata</i>	0–250	0–10
	prairie violet	VIPE2	<i>Viola pedatifida</i>	0–250	0–10
	white heath aster	SYER	<i>Symphotrichum ericoides</i>	0–250	0–10
	white panicle aster	SYLAL4	<i>Symphotrichum lanceolatum</i> ssp. <i>lanceolatum</i> var. <i>lanceolatum</i>	0–250	0–10
	New England aster	SYNO2	<i>Symphotrichum novae-angliae</i>	0–250	0–10
	skyblue aster	SYOOO	<i>Symphotrichum oolentangiense</i> var. <i>oolentangiense</i>	0–250	0–10
	common yarrow	ACMI2	<i>Achillea millefolium</i>	0–250	0–10
	balsam groundsel	PAPA20	<i>Packera paupercula</i>	0–250	0–10
	Canadian lousewort	PECA	<i>Pedicularis canadensis</i>	0–250	0–10
	Riddell's goldenrod	OLRI2	<i>Oligoneuron riddellii</i>	0–250	0–10
	palespike lobelia	LOSP	<i>Lobelia spicata</i>	0–250	0–10
	winged lythrum	LYAL4	<i>Lythrum alatum</i>	0–250	0–10
	pinnate prairie coneflower	RAPI	<i>Ratibida pinnata</i>	0–250	0–10
	prairie blue-eyed grass	SICA9	<i>Sisyrinchium campestre</i>	0–250	0–10
	bluntleaf bedstraw	GAOB	<i>Galium obtusum</i>	0–250	0–10
	closed bottle gentian	GEAN	<i>Gentiana andrewsii</i>	0–250	0–10
	common sneezeweed	HEAU	<i>Helenium autumnale</i>	0–250	0–10
	smooth oxeye	HEHE5	<i>Heliopsis helianthoides</i>	100–250	5–10
	Maximilian sunflower	HEMA2	<i>Helianthus maximiliani</i>	0–250	0–10
	Richardson's alumroot	HERI	<i>Heuchera richardsonii</i>	0–250	0–10
	common goldstar	HYHI2	<i>Hypoxis hirsuta</i>	0–250	0–10
	marsh pea	LAPA4	<i>Lathyrus palustris</i>	0–250	0–10
	hoary puccoon	LICA12	<i>Lithospermum canescens</i>	0–250	0–10
	smooth horsetail	EQLA	<i>Equisetum laevigatum</i>	0–250	0–10

button eryngo	ERYU	<i>Eryngium yuccifolium</i>	0–250	0–10
flat-top goldentop	EUGR5	<i>Euthamia graminifolia</i>	0–250	0–10
Virginia strawberry	FRVI	<i>Fragaria virginiana</i>	100–250	5–10
stiff tickseed	COPA10	<i>Coreopsis palmata</i>	0–250	0–10
bastard toadflax	COUM	<i>Comandra umbellata</i>	0–250	0–10
white lady's slipper	CYCA5	<i>Cypripedium candidum</i>	0–250	0–10
prairie milkweed	ASSU3	<i>Asclepias sullivantii</i>	0–250	0–10
butterfly milkweed	ASTU	<i>Asclepias tuberosa</i>	0–250	0–10
scarlet Indian paintbrush	CACO17	<i>Castilleja coccinea</i>	0–250	0–10
tall thistle	CIAL2	<i>Cirsium altissimum</i>	0–250	0–10

Inventory data references

A total of 26 integrated plots, ranging from Tier 2 to Tier 3 intensity, were used as a basis for this ecological site. Four of these were Type Locations representing the data-supported Community Phase 1.1 in the state-and-transition model, and included all necessary data elements for a Tier 3 dataset (Table 11). No other community phases were supported with quantitative data analysis. All 26 plots had soil pedon and site data collected by NRCS soil scientists using a form equivalent to SF-232. Pits were hand-dug using spade shovels, sharpshooters, and/or bucket augers. Of the 26 plots, 20 were located at established MN DNR relevé points, obtained and used with permission from the MN DNR County Biological Survey. List of MN DNR relevé plots used with verified soils data: 431, 3295, 4511, 7801, 7817, 7818, 7821, 7908, 7926, 7927, 7943, 7945, 7948, 8999, 9042, 9466, 9473, 9629, 9743, and 9747.

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Approval

Suzanne Mayne-Kinney, 10/04/2023

Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	Kyle Steele, Peter Hartman, John Zinn
Contact for lead author	Kyle.Steele@usda.gov
Date	09/11/2015
Approved by	Suzanne Mayne-Kinney
Approval date	
Composition (Indicators 10 and 12) based on	Foliar Cover

Indicators

- 1. Number and extent of rills:** Rills are none to very rare. Even in farmed settings these landforms are very flat and linear and do not provide significant runoff.

- 2. Presence of water flow patterns:** Water flow patterns are none to rare. Even in farmed settings these landforms are very flat and linear and do not provide significant runoff.

- 3. Number and height of erosional pedestals or terracettes:** Wind pedestals and terracettes are none.

- 4. Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare Ground is not noticeable amidst the thick grass cover. After a spring fire bare ground increases for a short time. Bare Ground is generally close to 0% depending mostly upon the time elapsed since the last fire.

- 5. Number of gullies and erosion associated with gullies:** Typically there are none. Intensive grazing may be the only way in which a gully would form. Even then, these sites are on very stable landforms and water does not move over land fast enough to produce gullies and erosion.

- 6. Extent of wind scoured, blowouts and/or depositional areas:** None.

- 7. Amount of litter movement (describe size and distance expected to travel):** None.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface resistance to erosion is good. Soil stability values should be 3 to 6 on most soil textures found on this site.
-
9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface structure is typically granular. Soil surface colors are black to very dark brown and soils are typified by a mollic epipedon. Organic matter of the surface 5 to 8 inches is typically more than 3 percent dropping off slowly below. Mollic colored A horizons can range from 10 to more than 20 inches thick.
-
10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The plant community composition is relatively uniform. Changes in plant community composition are expected around areas of longer soil saturation but vegetation remains thick and dominated by graminoids (sedges instead of grasses). These areas may also have a higher abundance of shrub due to less intense fires cause by wetness. Infiltration remains throughout.
-
11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** Compacted layers are none.
-
12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**
- Dominant: Deep-rooted, warm season, perennial grasses> perennial forbs > short shrubs (lead plant and prairie rose).
- Sub-dominant: Cool season annual forbs.
- Other:
- Additional: After prescribed fires, the functional/structural dominance of perennial forbs increases and shrubs decrease. With lengthening duration of fire return shrubs increase and small trees begin to appear.
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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** No or little plant mortality is apparent. Most of the perennial plants are long-lived. After a fire dead shrubs may persist for a time.
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14. **Average percent litter cover (%) and depth (in):** Litter cover ranges from 15-75%. After prescribed fires, litter cover and depth decreases dramatically. Because annual production is relatively high, it takes only one growing season for litter to reach pre-fire levels.
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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** For normal or average growing season (end of July beginning of August) \pm 3300 lbs/ac; Favorable years \pm 4000 lbs/ac and unfavorable years \pm 2500 lbs/ac.
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16. **Potential invasive (including noxious) species (native and non-native).** List species which **BOTH** characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is **NOT** expected in the reference state for the ecological site: Potential invaders include reed canary grass, smooth brome, Kentucky bluegrass, yellow parsnip, and sweet clovers. Other invaders include a variety of shrub and tree species, such as dogwoods, willows, green ash, box elder, quaking aspen, and eastern cottonwood.
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17. **Perennial plant reproductive capability:** All functional groups should reproduce in average (or normal) and above average growing season years. Only limitations to reproductive capability are weather related, natural disease, insect infestations, or combinations of all of the disturbances.
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