Ecological site R107XA206IA
Outwash Upland Prairie

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General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

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): 107X–Iowa and Missouri Deep Loess Hills

The Iowa and Minnesota Loess Hills (MLRA 107A) includes the Northwest Iowa Plains, Inner Coteau, and Coteau Moraines landforms (Prior 1991; MDNR 2005). It spans two states (Iowa, 89 percent; Minnesota, 11 percent), encompassing approximately 4,470 square miles (Figure 1). The elevation ranges from approximately 1,700 feet above sea level (ASL) on the highest ridges to about 1,115 feet ASL in the lowest valleys. Local relief is mainly 10 to 100 feet. However, some valley floors can range from 80 to 200 feet, while some upland flats only range between three and six feet. The eastern half of the MLRA is underlain by Wisconsin-age till, deposited between 20,000 and 30,000 years ago and is known as the Sheldon Creek Formation. The western half is underlain by Pre-Illinoian glacial till, deposited more than 500,000 years ago and has since undergone extensive erosion and dissection. Both surfaces are covered by approximately four to twenty feet of loess on the hillslopes, and Holocene alluvium covers the till in the drainageways. Cretaceous bedrock, comprised of sandstone and shale, lies beneath the glacial material (USDA-NRCS 2006).

The vegetation in the MLRA has undergone drastic changes over time. Spruce forests dominated the landscape 30,000 to 21,500 years ago. As the last glacial maximum peaked 21,500 to 16,000 years ago, they were replaced with open tundras and parklands. The end of the Pleistocene Epoch saw a warming climate that initially prompted the return of spruce forests, but as the warming continued, spruce trees were replaced by deciduous trees (Baker et al. 1990). Not until approximately 9,000 years ago did the vegetation transition to prairies as climatic conditions continued to warm and subsequently dry. Between 4,000 and 3,000 years ago, oak savannas began intermingling within the prairie landscape, while the more wooded and forested areas maintained a foothold in sheltered areas. This prairie-forest transition ecosystem formed the dominant landscapes until the arrival of European settlers (Baker et al. 1992).

Classification relationships

U.S. Forest Service Ecological Subregions: North Central Glaciated Plains (251B) Section, Outer Coteau des Prairies (251Bb), Northwest Iowa Plains (251Bd) Subsections (Cleland et al. 2007)

U.S. EPA Level IV Ecoregion: Loess Prairies (47a) (USEPA 2013)

National Vegetation Classification – Ecological Systems: North-Central Interior Sand and Gravel Tallgrass Prairie (CES202.695) (NatureServe 2015)

National Vegetation Classification – Plant Associations: Schizachyrium scoparium – Bouteloua spp. – Hesperostipa spartea Gravel Grassland (CEGL002499) (NatureServe 2015)

Biophysical Settings: North-Central Interior Sand and Gravel Tallgrass Prairie (BpS 4314120) (LANDFIRE 2009)

Natural Resources Conservation Service – Iowa Plant Community Species List: Prairie, Northern Little Bluestem Gravel (USDA-NRCS 2007)

Iowa Department of Natural Resources: Gravel Prairie (INAI 1984)

Minnesota Department of Natural Resources: Ups13b Dry Sand-Gravel Prairie (Southern) (MDNR 2005)

Ecological site concept

Outwash Upland Prairies are located within the green areas on the map (Figure 1). They occur on outwash plains or upland flats, and the soils are Mollisols and Inceptisols that are well to excessively drained and deep, formed in glacial outwash. These soils experience moderate moisture deficits during the growing season most years and frequent deficits during times of droughts (MDNR 2005; NatureServe 2015).

The historic pre-European settlement vegetation on this site was dominated by herbaceous species typical of a midgrass xeric prairie. Blue grama (Bouteloua gracilis) and little bluestem (Schizachyrium scoparium (Michx.) Nash) are the dominant grasses of Outwash Upland Prairies. Other grasses that may occur include sideoats grama (Bouteloua curtipendula (Michx.) Torr.), plains muhly (Muhlenbergia cuspidata (Torr. ex Hook.) Rydb.), prairie Junegrass (Koeleria macrantha (Ledeb.) Schult.), composite dropseed (Sporobolus compositus (Poir.) Merr. var. compositus), and prairie dropseed (Sporobolus heterolepis (A. Gray) A. Gray). Forbs typical of an undisturbed plant community associated with this ecological site include autumn onion (Allium stellatum Fraser ex Ker Gawl.), western silver aster (Symphyotrichum sericeum (Vent.) G.L. Nesom), yellow sundrops (Calylophus serrulatus (Nutt.) P.H. Raven), fiveangled dodder (Cuscuta pentagona Engelm.), and eastern pasqueflower (Pulsatilla patens (L.) Mill.) (Drobney et al. 2001). Terricolous lichens, such as Placidium squamulosum (Ach.) Breuss and Psora decipiens (Hedwig) Hoffm., are present on bare soil and gravel and are often a distinctive component of this ecological site (MDNR 2005; NatureServe 2015; J. Pearson, personal communication 2018). Fire is the primary disturbance factor that maintains this sire, while drought and herbivory are secondary factors (MDNR 2005; LANDFIRE 2009).

Associated sites

R107XA202IA	**Calcareous Till Upland Prairie** Glacial till on uplands that are shallow to calcium carbonates including Moneta and Steinauer
R107XA205IA	**Loamy Sediment Upland Prairie** Loamy sediments on uplands including Bolan, Bolan variant, Dickman, Everly, Fostoria, and Ocheyedan
R107XA203IA	**Calcareous Till Exposed Backslope Prairie** Glacial till on backslopes that are shallow to calcium carbonates including Cornell, Moneta, Steinauer, Steinauer variant, and Soils that are moderately deep to carbonates
R107XA201IA	**Loess Upland Prairie** Loess on uplands including Annieville, Galva, McCreath, Primghar, Primghar variant, Ransom, Sac, Sac variant, and Wilmonton

Similar sites

R107XA212IA	**Stream Terrace Prairie** Stream Terrace Prariies are similar in parent material but occur on stream terraces
R107XA202IA	**Calcareous Till Upland Prairie** Calcareous Till Upland Prairies are derived from glacial till that is shallow to calcium carbonates and have a higher pH
R107XA207IA	**Sandy Dry Prairie** Sandy Dry Prairies are derived from coarse-loamy and sandy materials

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Bouteloua gracilis* (2) *Schizachyrium scoparium*

Physiographic features

Outwash Upland Prairies occur on outwash plains on upland flats (Figure 2). Slopes are generally less than 14 percent. They are situated on elevations ranging from approximately 699 to 1801 feet ASL. This site does not experience flooding but rather generates runoff to adjacent, downslope ecological sites.

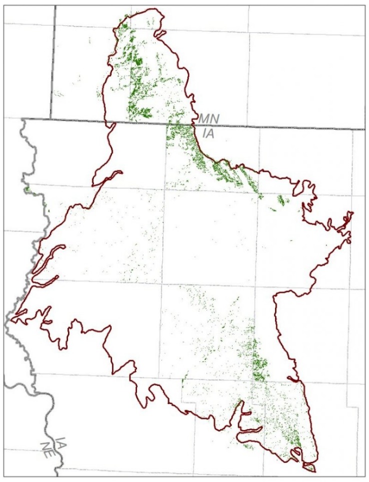


Figure 2. Figure 1. Location of Outwash Upland Prairie ecological site within MLRA 107A.

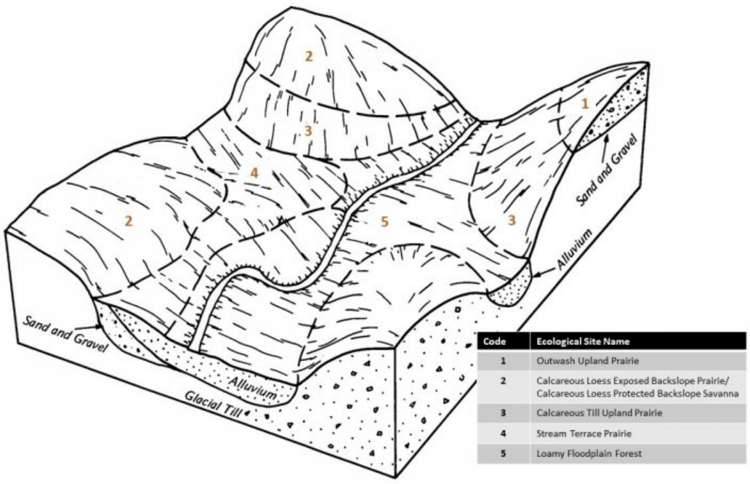


Figure 3. Figure 2. Representative block diagram of Outwash Upland Prairie and associated ecological sites.

Table 2. Representative physiographic features

Slope shape across	(1) Convex
Slope shape up-down	(1) Convex
Landforms	(1) Outwash plain
Runoff class	Very low to medium
Elevation	213–549 m
Slope	0–14%
Water table depth	76–203 cm

Aspect	Aspect is not a significant factor

Climatic features

The Iowa and Minnesota Loess Hills falls into the hot humid continental climate (Dfa) Köppen-Geiger climate classification (Peel et al. 2007). In winter, dry, cold air masses periodically shift south from Canada. As these air masses collide with humid air, snowfall and rainfall result. In summer, moist, warm air masses from the Gulf of Mexico migrate north, producing significant frontal or convective rains. Occasionally, hot, dry winds originating from the Desert Southwest will stagnate over the region, creating extended droughty periods in the summer from unusually high temperatures. Air masses from the Pacific Ocean can also spread into the region and dominate producing mild, dry weather in the autumn known as Indian Summers (NCDC 2006).

The soil temperature regime of MLRA 107A is classified as mesic, where the mean annual soil temperature is between 46 and 59°F (USDA-NRCS 2006). Temperature and precipitation occur along a north-south gradient, where temperature and precipitation increase the further south one travels. The average freeze-free period of this ecological site is about 152 days, while the frost-free period is about 136 days (Table 2). The majority of the precipitation occurs as rainfall in the form of convective thunderstorms during the growing season. Average annual precipitation is approximately 31 inches, which includes rainfall plus the water equivalent from snowfall. The average annual low and high temperatures are 34 and 57°F, respectively (Table 3).

Climate data and analyses are derived from 30-year averages gathered from three National Oceanic and Atmospheric Administration (NOAA) weather stations contained within the range of this ecological site (Table 4).

Table 3. Representative climatic features

Frost-free period (characteristic range)	124-126 days
Freeze-free period (characteristic range)	143-147 days
Precipitation total (characteristic range)	737-762 mm
Frost-free period (actual range)	122-126 days
Freeze-free period (actual range)	142-149 days
Precipitation total (actual range)	737-787 mm
Frost-free period (average)	125 days
Freeze-free period (average)	145 days
Precipitation total (average)	762 mm

Climate stations used

- (1) LUVERNE [USC00214937], Luverne, MN
- (2) CHEROKEE [USC00131442], Cherokee, IA
- (3) SIBLEY 3 NE [USC00137664], Sibley, IA

Influencing water features

Outwash Upland Prairies are not influenced by wetland or riparian water features. Precipitation is the main source of water for this ecological site. Infiltration is moderate to high (Hydrologic Groups A, B) for undrained soils, and surface runoff is very low to moderate. Precipitation infiltrates the soil surface and percolates downward through the horizons unimpeded by any restrictive layer. The Dakota bedrock aquifer underlying this ecological site is typically deep and confined, leaving it generally unaffected by recharge (Prior et al. 2003). Surface runoff contributes some water to downslope ecological sites (Figure 5).

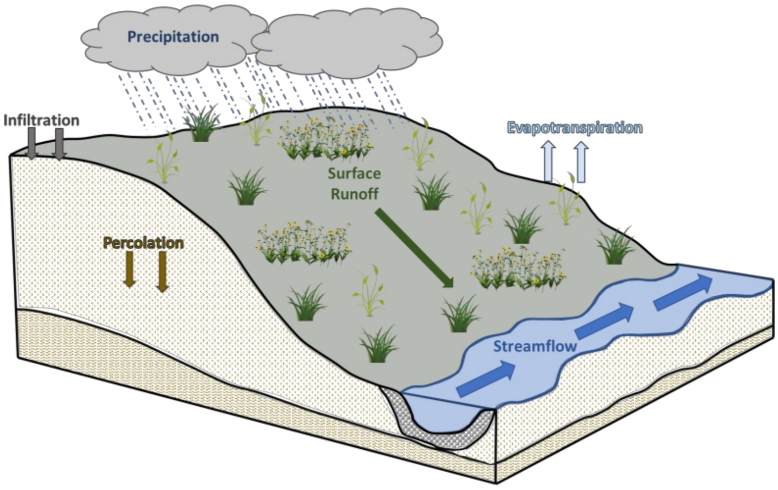


Figure 8. Figure 5. Hydrologic cycling in Outwash Upland Prairie ecological site.

Soil features

Soils of Outwash Upland Prairies are in the Mollisols and Inceptisols orders, further classified as Entic Hapludolls, Typic Endoaquolls, Typic Hapludolls, and Typic Eutrudepts with moderate to high infiltration and very low to medium runoff potential. The soil series associated with this site includes Allendorf, Hawick, Kanaranzi, Kanaranzi variant, Kato, May City, Moderately well-drained soils, Salida, and Soils that are moderately well-drained. The parent material is glacial outwash, and the soils are well to excessively drained and deep. Soil pH classes are slightly acid to moderately alkaline. No rooting restrictions are noted for the soils of this ecological site.

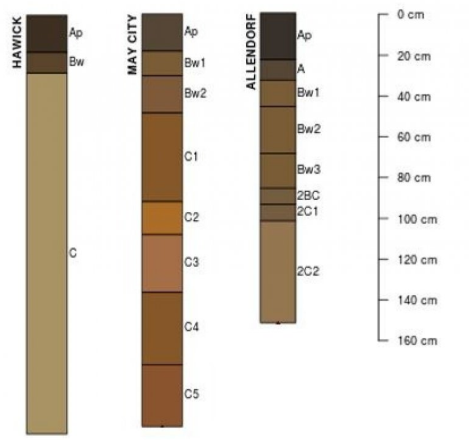


Figure 9. Figure 6. Profile sketches of soil series associated with Outwash Upland Prairie.

Table 4. Representative soil features

Parent material	(1) Outwash
Family particle size	(1) Sandy-skeletal (2) Coarse-loamy over sandy or sandy-skeletal (3) Fine-silty over sandy or sandy-skeletal
Drainage class	Well drained to excessively drained
Permeability class	Slow to moderate
Soil depth	203 cm
Surface fragment cover >3"	10–31%

Ecological dynamics

The information in this Ecological Site Description, including the state-and-transition model (STM), was developed based on historical data, current field data, professional experience, and a review of the scientific literature. As a result, all possible scenarios or plant species may not be included. Key indicator plant species, disturbances, and ecological processes are described to inform land management decisions.

MLRA 107A is defined by a relatively low relief landscape that experiences lower rainfall amounts and available moisture compared to other MLRAs occurring to the south and east. As a result, prairie vegetation communities dominate the uplands, while forested communities are restricted to medium and large streams (Prior 1991; Eilers and Roosa 1994; MDNR 2017a, b). Outwash Upland Prairies form an aspect of this vegetative continuum. This ecological site occurs on outwash plains on upland flats on well to excessively drained soils. Species characteristic of this ecological site consist of xeric, midgrass herbaceous vegetation.

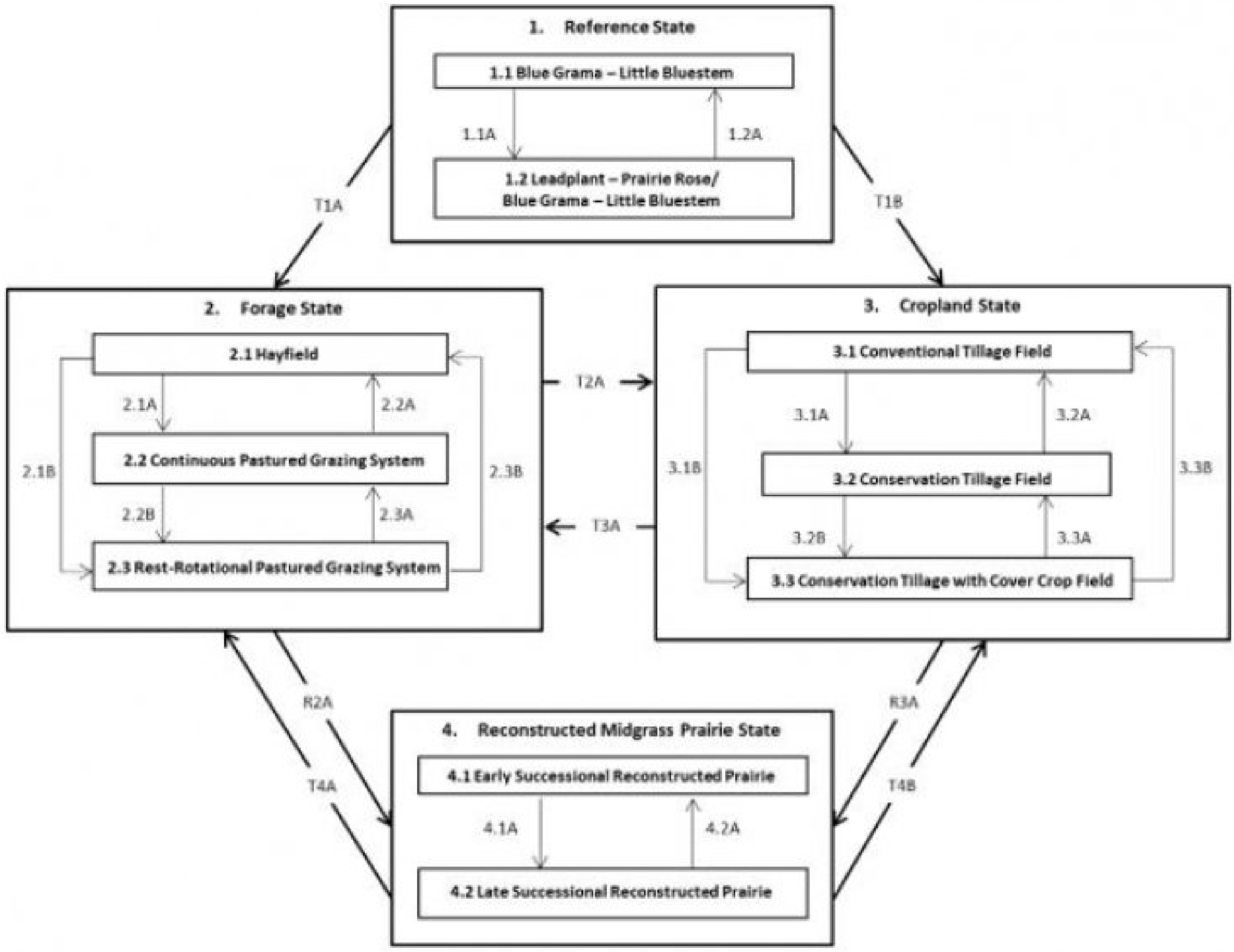
The vegetation of Outwash Upland Prairies can be sparse and patchy making fire a limited, but important, ecosystem driver for maintaining this ecological site. Fire intensity typically consisted of periodic, low-intensity surface fires occurring every 1 to 5 years (LANDFIRE 2009). Ignition sources included summertime lightning strikes from convective storms and bimodal, human ignitions during the spring and fall seasons. Native Americans regularly set fires to improve sight lines for hunting, driving large game, improving grazing and browsing habitat, agricultural clearing, and enhancing vital ethnobotanical plants (Barrett 1980). This continuous disturbance provided critical conditions for perpetuating the native midgrass prairie ecosystem (MDNR 2005).

Drought and grazing by native ungulates have also played a role in shaping this ecological site. The periodic episodes of reduced soil moisture in conjunction with the well to excessively drained soils have favored the proliferation of plant species tolerant of such conditions. Drought can also slow the growth of plants and result in dieback of certain species. Large mammals, specifically prairie elk (Cervus elaphus) and white-tailed deer (Odocoileus virginianus), likely occurred in low densities resulting in limited impacts to plant composition and dominance (LANDFIRE 2009). When coupled with fire, periods of drought and herbivory can greatly delay the establishment of woody vegetation (Pyne et al. 1996).

Today, Outwash Upland Prairies are limited in their extent, having been converted to agricultural land. Corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merr.) are the dominant crops grown on this ecological site, but small patches of forage land are present. A return to the historic plant community may not be possible following extensive land modification, but long-term conservation agriculture or prairie reconstruction efforts can help to restore some biotic diversity and ecological function. The state-and-transition model that follows provides a detailed description of each state, community phase, pathway, and transition. This model is based on available experimental research, field observations, literature reviews, professional consensus, and interpretations.

State and transition model

R107AY206IA Outwash Upland Prairie



Code	Process
T1A, T3A, T4A	Cultural treatments are implemented to increase forage quality and yield
T1B, T2A, T4B	Agricultural conversion via tillage, seeding, and non-selective herbicide
1.1A	Increased fire return interval
1.2A	Reduced fire return interval
2.1A	Mechanical harvesting is replaced with domestic livestock and continuous grazing
2.1B	Mechanical harvesting is replaced with domestic livestock and rest-rotational grazing
2.2A, 2.3B	Domestic livestock grazing is replaced with mechanical harvesting
2.2B	Implementation of rest-rotational grazing
2.3B	Implementation of continuous grazing
3.1A	Less tillage, residue management
3.1B	Less tillage, residue management, and implementation of cover cropping
3.2B	Implementation of cover cropping
3.2A, 3.3B	Intensive tillage, remove residue, reinitiate monoculture row cropping
3.3A	Remove cover cropping
R2A, R3A	Site preparation, non-native species control, and native seeding
4.1A	Invasive species control and implementation of disturbance regimes
4.2A	Drought or improper timing/use of management actions

State 1
Reference State

The reference plant community is categorized as a midgrass community, dominated by xeric vegetation. The two community phases within the reference state are dependent on periodic fire. The intensity and frequency of fire alters species composition, cover, and extent, while regular fire intervals recycle nutrients, encourage flowering and seed production, and keep woody species from dominating (MDNR 2005). Drought and native mammal herbivory have more localized impacts in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity. Community Phase 1.1 Blue Grama – Little Bluestem – Sites in this reference community phase exhibit a patchy to continuous vegetative cover (50 to 100 percent), grass heights are less than 3 feet tall, and patches of bare soil and gravel may be present (MDNR 2005; LANDFIRE 2009). Blue grama, little bluestem, and sideoats grama are the dominant grasses. Plains muhly, composite dropseed, and prairie dropseed are common grass associates. Characteristic forbs can include dotted blazing star (*Liatris punctata* Hook.), purple prairie clover (*Dalea purpurea* Vent.), hoary tansyaster (*Machaeranthera canescens* (Pursh) A. Gray ssp. canescens var. canescens), and blacksamson echinacea (*Echinacea angustifolia* DC.). Terricolous lichens are a diagnostic component of this phase (MDNR 2005; NatureServe 2015).

Dominant plant species

- leadplant (*Amorpha canescens*), shrub
- prairie rose (*Rosa arkansana*), shrub
- blue grama (*Bouteloua gracilis*), other herbaceous
- little bluestem (*Schizachyrium*), other herbaceous

Community 1.1
Blue Grama-Little Bluestem

Blue Grama – Little Bluestem – Sites in this reference community phase exhibit a patchy to continuous vegetative cover (50 to 100 percent), grass heights are less than 3 feet tall, and patches of bare soil and gravel may be present (MDNR 2005; LANDFIRE 2009). Blue grama, little bluestem, and sideoats grama are the dominant grasses. Plains muhly, composite dropseed, and prairie dropseed are common grass associates. Characteristic forbs can include dotted blazing star (*Liatris punctata* Hook.), purple prairie clover (*Dalea purpurea* Vent.), hoary tansyaster (*Machaeranthera canescens* (Pursh) A. Gray ssp. canescens var. canescens), and blacksamson echinacea (*Echinacea angustifolia* DC.). Terricolous lichens are a diagnostic component of this phase (MDNR 2005; NatureServe 2015).

Dominant plant species

- blue grama (*Bouteloua gracilis*), other herbaceous
- little bluestem (*Schizachyrium*), other herbaceous

Community 1.2
Leadplant-Prairie Rose/Blue Grama-Little Bluestem

Leadplant – Prairie Rose/Blue Grama – Little Bluestem – This community phase represents natural succession under an increased fire return interval. Vegetative cover becomes denser, and low shrubs form a sparse (less than 5 percent cover) component of the plant community. Leadplant (*Amorpha canescens* Pursh) and prairie rose (*Rosa arkansana* Porter) are typically less than 20 inches tall (MDNR 2005). The herbaceous component remains relatively similar to community phase 1.1.

Dominant plant species

- leadplant (*Amorpha canescens*), shrub
- prairie rose (*Rosa arkansana*), shrub
- blue grama (*Bouteloua gracilis*), other herbaceous
- little bluestem (*Schizachyrium*), other herbaceous

Pathway 1.1A
Community 1.1 to 1.2

Increased fire return interval

Pathway 1.2A
Community 1.2 to 1.1

Reduced fire return interval

State 2
Forage State

The forage state occurs when the site is converted to a farming system that emphasizes domestic livestock production, known as grassland agriculture. Fire suppression, periodic cultural treatments (e.g., clipping, drainage, soil amendment applications, planting new species and/or cultivars, mechanical harvesting) and grazing by domesticated livestock transition and maintain this state (USDA-NRCS 2003). Early settlers seeded non-native species, such as smooth brome (*Bromus inermis* Leyss.) and Kentucky bluegrass (*Poa pratensis* L.), to help extend the grazing season (Smith 1998). Over time, as lands were continuously harvested or grazed by herds of cattle, these species were able to spread and expand across the prairie ecosystem, reducing the native species diversity and ecological function. This state is more prevalent on sites with higher gravel content.

Community 2.1
Hayfield

Hayfield – Sites in this community phase consist of forage plants that are planted and mechanically harvested. Mechanical harvesting removes much of the aboveground biomass and nutrients that feed the soil ecosystem (Franzluebbers et al. 2000; USDA-NRCS 2003). As a result, soil biology is reduced leading to decreases in nutrient uptake by plants, soil organic matter, and soil aggregation. Frequent biomass removal can in turn reduce the site's carbon sequestration capacity (Skinner 2008).

Community 2.2
Continuous Pastured Grazing System

Continuous Pastured Grazing System – This community phase is characterized by continuous grazing where domestic livestock graze a pasture for the entire season. Depending on stocking density, this can result in lower forage quality and productivity, weed invasions, and uneven pasture use. Continuous grazing can also increase the amount of bare ground and erosion and reduce soil organic matter, cation exchange capacity, water-holding capacity, and nutrient availability and retention (Bharati et al. 2002; Leake et al. 2004; Teague et al. 2011). Smooth brome, Kentucky bluegrass, and white clover (*Trifolium repens* L.) are common pasture species used in this phase. Their tolerance to continuous grazing has allowed these species to dominate, sometimes completely excluding the native vegetation.

Community 2.3
Rest-Rotation Pastured Grazing System

This community phase is characterized by rotational grazing where the pasture has been subdivided into several smaller paddocks. Through the development of a grazing plan, livestock utilize one or a few paddocks, while the remaining area is rested allowing plants to restore vigor and energy reserves, deepen root systems, develop seeds, as well as allow seedling establishment (Undersander et al. 2002; USDA-NRCS 2003). Rest-rotation pastured grazing systems include deferred rotation, rest rotation, high intensity – low frequency, and short duration methods. Vegetation is generally more diverse and can include orchargrass (*Dactylis glomerata* L.), timothy (Phleum pretense L.), red clover (*Trifolium pratense* L.), and alfalfa (*Medicago sativa* L.). The addition of native prairie species can further bolster plant diversity and, in turn, soil function. This community phase promotes numerous ecosystem benefits including increasing biodiversity, preventing soil erosion, maintaining and enhancing soil quality, sequestering atmospheric carbon, and improving water yield and quality (USDA-NRCS 2003).

Pathway 2.1A
Community 2.1 to 2.2

Mechanical harvesting is replaced with domestic livestock and continuous grazing

Pathway 2.1B
Community 2.1 to 2.3

Mechanical harvesting is replaced with domestic livestock and rest-rotational grazing

Pathway 2.2A
Community 2.2 to 2.1

Domestic livestock grazing is replaced with mechanical harvesting

Pathway 2.2B
Community 2.2 to 2.3

Implementation of rest-rotational grazing

Pathway 2.3B
Community 2.3 to 2.1

Domestic livestock grazing is replaced with mechanical harvesting

Pathway 2.3A
Community 2.3 to 2.2

Implementation of continuous grazing

State 3
Cropland State

The low topographic relief across the MLRA has resulted in nearly the entire area being converted to agriculture (Eilers and Roosa 1994). The continuous use of tillage, row-crop planting, and chemicals (i.e., herbicides, fertilizers, etc.) has effectively eliminated the reference community and many of its natural ecological functions in favor of crop production. Corn and soybeans are the dominant crops for the site, and oats (Avena L.) and alfalfa (*Medicago sativa* L.) may be rotated periodically. These areas are likely to remain in crop production for the foreseeable future. This state is more prevalent on sites with lower gravel content.

Community 3.1
Conventional Tillage Field

Conventional Tillage Field – Sites in this community phase typically consist of monoculture row-cropping maintained by conventional tillage practices. They are cropped in either continuous corn or corn-soybean rotations. The frequent use of deep tillage, low crop diversity, and bare soil conditions during the non-growing season negatively impacts soil health. Under these practices, soil aggregation is reduced or destroyed, soil organic matter is reduced, erosion and runoff are increased, and infiltration is decreased, which can ultimately lead to undesirable changes in the hydrology of the watershed (Tomer et al. 2005).

Community 3.2
Conservation Tillage Field

Conservation Tillage Field – This community phase is characterized by rotational crop production that utilizes various conservation tillage methods to promote soil health and reduce erosion. Conservation tillage methods include strip-till, ridge-till, vertical-till, or no-till planting systems. Strip-till keeps seedbed preparation to narrow bands less than one-third the width of the row where crop residue and soil consolidation are left undisturbed in-between seedbed areas. Strip-till planting may be completed in the fall and nutrient application either occurs simultaneously or at the time of planting. Ridge-till uses specialized equipment to create ridges in the seedbed and vegetative residue is left on the surface in between the ridges. Weeds are controlled with herbicides and/or cultivation, seedbed ridges are rebuilt during cultivation, and soils are left undisturbed from harvest to planting. Vertical-till systems employ machinery that lightly tills the soil and cuts up crop residue, mixing some of the residue into the top few inches of the soil while leaving a large portion on the surface. No-till management is the most conservative, disturbing soils only at the time of planting and fertilizer application. Compared to conventional tillage systems, conservation tillage methods can improve soil ecosystem function by reducing soil erosion, increasing organic matter and water availability, improving water quality, and reducing soil compaction.

Community 3.3
Conservation Tillage with Cover Crop Field

Conservation Tillage with Cover Crop Field – This community phase applies conservation tillage methods as described above as well as adds cover crop practices. Cover crops typically include nitrogen-fixing species (e.g., legumes), small grains (e.g., rye, wheat, oats), or forage covers (e.g., turnips, radishes, rapeseed). The addition of cover crops not only adds plant diversity but also promotes soil health by reducing soil erosion, limiting nitrogen leaching, suppressing weeds, increasing soil organic matter, and improving the overall soil ecosystem. In the case of small grain cover crops, surface cover and water infiltration are increased, while forage covers can be used to graze livestock or support local wildlife. Of the three community phases for this state, this phase promotes the greatest soil sustainability and improves ecological functioning within a cropland system.

Pathway 3.1A
Community 3.1 to 3.2

Less tillage, residue management

Pathway 3.1B
Community 3.1 to 3.3

Less tillage, residue management, and implementation of cover cropping

Pathway 3.2A
Community 3.2 to 3.1

Intensive tillage, remove residue, reinitialize monoculture row cropping

Pathway 3.2B
Community 3.2 to 3.3

Implementation of cover cropping

Pathway 3.3B
Community 3.3 to 3.1

Intensive tillage, remove residue, initiate monoculture row cropping

Pathway 3.3A
Community 3.3 to 3.2

Remove cover cropping

State 4
Reconstructed Midgrass Prairie State

Prairie reconstructions have become an important tool for repairing natural ecological functions and providing habitat protection for numerous grassland dependent species. Because the historic plant and soil biota communities of the tallgrass prairie were highly diverse with complex interrelationships, historic prairie replication cannot be guaranteed on landscapes that have been so extensively manipulated for extended timeframes (Kardol and Wardle 2010; Fierer et al. 2013). Therefore, ecological restoration should aim to aid the recovery of degraded, damaged, or destroyed ecosystems. A successful restoration will have the ability to structurally and functionally sustain itself, demonstrate resilience to the natural ranges of stress and disturbance, and create and maintain positive biotic and abiotic interactions (SER 2002). The reconstructed prairie state is the result of a long-term commitment involving a multi-step, adaptive management process. Diverse, species-rich seed mixes are important to utilize as they allow the site to undergo successional stages that exhibit changing composition and dominance over time (Smith et al.

2010). On-going management via prescribed fire and/or light grazing can help the site progress from an early successional community dominated by annuals and some weeds to a later seral stage composed of native, perennial grasses, forbs, and a few shrubs. Establishing a prescribed fire regimen that mimics natural disturbance patterns can increase native species cover and diversity while reducing cover of non-native forbs and grasses. Light grazing alone can help promote species richness, while grazing accompanied with fire can control the encroachment of woody vegetation (Brudvig et al. 2007).

Community 4.1
Early Successional Reconstructed Prairie

Early Successional Reconstructed Prairie – This community phase represents the early community assembly from prairie reconstruction and is highly dependent on the seed mix utilized and the timing and priority of planting operations. The seed mix should look to include a diverse mix of cool-season and warm-season annual and perennial grasses and forbs typical of the reference state (e.g., blue grama, little bluestem, sideoats grama, dotted blazing star). Cool-season annuals can help provide litter that promotes cool, moist soil conditions to the benefit of the other species in the seed mix. The first season following site preparation and seeding will typically result in annuals and other volunteer species forming a majority of the vegetative cover. Control of non-native species, particularly perennial species, is crucial at this point to ensure they do not establish before the native vegetation (Martin and Wilsey 2012). After the first season, native warm-season grasses should begin to become more prominent on the landscape.

Community 4.2
Late Successional Reconstructed Prairie

Late Successional Reconstructed Prairie – Appropriately timed disturbance regimes (e.g., prescribed fire) applied to the early successional community phase can help increase the beta diversity, pushing the site into a late successional community phase over time. While prairie communities are dominated by grasses, these species can suppress forb establishment and reduce overall diversity and ecological function (Martin and Wilsey 2006; Williams et al. 2007). Reducing accumulated plant litter from perennial bunchgrasses allows more light and nutrients to become available for forb recruitment, allowing greater ecosystem complexity (Wilsey 2008).

Pathway 4.1A
Community 4.1 to 4.2

Invasive species control and implementation of disturbance regimes

Pathway 4.2A
Community 4.2 to 4.1

Drought or improper timing/use of management actions

Transition T1A
State 1 to 2

Cultural treatments are implemented to increase forage quality and yield

Transition T1B
State 1 to 3

Agricultural conversion via tillage, seeding and non-selective herbicide

Transition T2A
State 2 to 3

Agricultural conversion via tillage, seeding and non-selective herbicide

Transition T4A
State 2 to 4

Cultural treatments are implemented to increase forage quality and yield

Restoration pathway T3A
State 3 to 2

Cultural treatments are implemented to increase forage quality and yield

Transition R3A
State 3 to 4

Site preparation, non-native species control and native seeding

Restoration pathway R2A
State 4 to 2

Site preparation, non-native species control and native seeding

Restoration pathway T4B
State 4 to 3

Agricultural conversion via tillage, seeding and non-selective herbicides

Additional community tables

Inventory data references

Tier 3 Sampling Plot used to develop the reference state, community phase 1.1:
State County Ownership Legal Description Easting Northing
Iowa O'Brien Thompson Quarry Prairie Wildlife Area – Iowa Department of Natural Resources T94N R39W S11 302686 4761302

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Approval

Chris Tecklenburg, 5/21/2020

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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)	
Contact for lead author	
Date	05/17/2024
Approved by	Chris Tecklenburg
Approval date	

Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

2. **Presence of water flow patterns:**

3. **Number and height of erosional pedestals or terracettes:**

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

5. **Number of gullies and erosion associated with gullies:**

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

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:

    Sub-dominant:

Other:

Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

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14. **Average percent litter cover (%) and depth (in):**

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

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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:**

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17. **Perennial plant reproductive capability:**
