

Ecological site R104XY008IA Wet Loamy Upland Savanna

Last updated: 5/18/2020

Accessed: 07/08/2025

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.

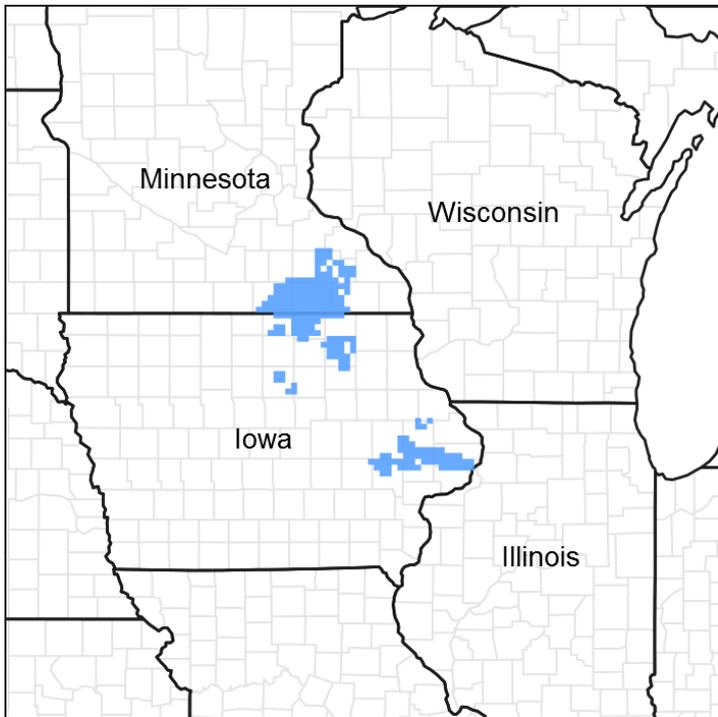


Figure 1. Mapped extent

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): 104X–Eastern Iowa and Minnesota Till Prairies

The Eastern Iowa and Minnesota Till Prairies (MLRA 104) includes the Iowan Surface, Oak Savanna, and Western Coulee and Ridges landforms (Prior 1991; MDNR 2005;

WDNR 2015). It spans three states (Iowa, 74 percent; Minnesota, 22 percent; Wisconsin, 4 percent), encompassing approximately 9,660 square miles (Figure 1). The elevation ranges from approximately 1,310 feet above sea level (ASL) on the highest ridges to about 985 feet ASL in the lowest valleys. Local relief is mainly 10 to 20 feet. Glacial till and outwash deposits cover the uplands of the MLRA with recent alluvium located in the major river valleys. Paleozoic bedrock sediments, comprised primarily of shale and limestone, lies beneath the glacial material. The depth to limestone is shallow, resulting in karst topography across much of the area (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

USFS Subregions: North Central U.S. Driftless and Escarpment (222L), Minnesota and Northeast Iowa Morainal-Oak Savannah (222M), Central Dissected Till Plains (251C) Sections; Menominee Eroded Pre-Wisconsin Till (222La), Oak Savannah Till and Loess Plains (222Me), Southeast Iowa Rolling Loess Hills (251Ch) Subsections (Cleland et al. 2007)

U.S. EPA Level IV Ecoregion: Eastern Iowa and Minnesota Drift Plains (47c), Rolling Loess Prairies (47f), Lower St. Croix and Vermillion Valleys (47g), Rochester/Paleozoic Plateau Upland (52c) (USEPA 2013)

Biophysical Settings: North-Central Interior Oak Savanna (BpS 4213940) (LANDFIRE 2009)

Iowa Department of Natural Resources: Tallgrass Savanna (INAI 1984)

Minnesota Department of Natural Resources: Ups24 Southern Mesic Savanna (MDNR 2005)

Ecological site concept

Wet Loamy Upland Savannas are located within the green areas on the map (Figure 1). They occur on uplands. The soils are Alfisols that are poorly-drained and deep, formed in

loess or loamy sediments. Low hydraulic gradients create a shallow depth to water table during the growing season.

The historic pre-European settlement vegetation on this ecological site was dominated by upland and hydrophytic tallgrass savanna vegetation. But oak (*Quercus macrocarpa* Michx.) is the dominant tree, and big bluestem (*Andropogon gerardii* Vitman) and purple meadow-rue (*Thalictrum dasycarpum* Fisch. & Avé-Lall.) are dominant and characteristic herbs, respectively. Other grasses present can include switchgrass (*Panicum virgatum* L.), prairie cordgrass (*Spartina pectinata* Bosc ex Link), Canada wildrye (*Elymus canadensis* L.) and various sedges. The understory likely resembled that of Wet Loamy Upland Prairies, potentially including such conservative species as fourflower yellow loosestrife (*Lysimachia quadriflora* Sims), pride of Ohio (*Dodecatheon meadia* L.), and marsh bellflower (*Campanula aparinoides* Marsh) (Drobney et al. 2001). Fire is the primary disturbance factor that maintains this site, while herbivory and drought are secondary factors (LANDFIRE 2009).

Associated sites

R104XY007IA	<p>Loamy Upland Savanna</p> <p>Loamy sediment parent material that is not shallow to a water table including Atterberry, Bassett, Billett, Donnan, Donnan variant, Dowagiac, Downs variant, Franklin, Kasson, Lourdes, Mantorville, Menomin, Newry, Oran, Racine, Riceville, Schley, Schley variant, Wabeek and Wacoma series and Somewhat poorly drained soils</p>
-------------	--

Table 1. Dominant plant species

Tree	(1) <i>Quercus macrocarpa</i>
Shrub	Not specified
Herbaceous	(1) <i>Andropogon gerardii</i> (2) <i>Thalictrum dasycarpum</i>

Physiographic features

Wet Loamy Upland Savannas occur on uplands. They are situated on elevations ranging from approximately 525 to 1499 feet ASL. The site does not experience flooding, but rather allows for groundwater recharge due to low hydraulic gradients (Table 1).

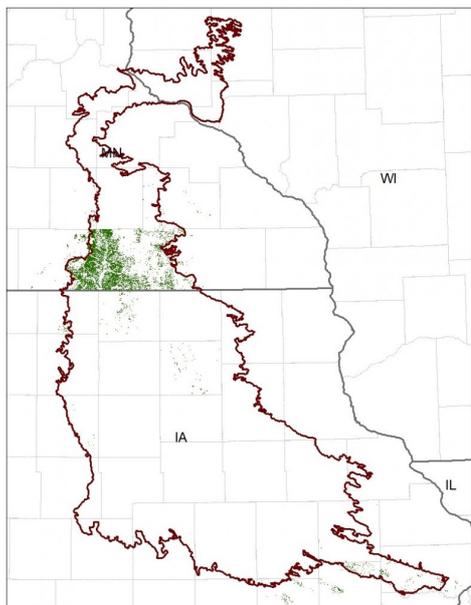


Figure 2. Figure 1. Location of Wet Loamy Upland Savanna ecological site within MLRA 104.

Table 2. Representative physiographic features

Slope shape across	(1) Linear (2) Concave
Slope shape up-down	(1) Linear (2) Concave
Landforms	(1) Upland
Runoff class	Low
Elevation	525–1,499 ft
Slope	0–3%
Water table depth	0–6 in
Aspect	Aspect is not a significant factor

Climatic features

The Eastern Iowa and Minnesota Till Prairies falls into the hot-summer humid continental climate (Dfa) and warm-summer humid continental climate (Dfb) Köppen-Geiger climate classifications (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 104 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 131 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 37 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 35 and 56°F, respectively.

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)	129-133 days
Freeze-free period (characteristic range)	145-158 days
Precipitation total (characteristic range)	36-38 in
Frost-free period (actual range)	128-134 days
Freeze-free period (actual range)	142-161 days
Precipitation total (actual range)	35-38 in
Frost-free period (average)	131 days
Freeze-free period (average)	152 days
Precipitation total (average)	37 in

Climate stations used

- (1) LOWDEN [USC00134963], Lowden, IA
- (2) AUSTIN WWT FAC [USC00210355], Austin, MN
- (3) NEW HAMPTON [USC00135952], New Hampton, IA

Influencing water features

Wet Loamy Upland Savannas are classified as a MINERAL SOIL FLATS: saturated, recharge, herbaceous wetland under the Hydrogeomorphic (HGM) classification system (Smith et al. 1995; USDA-NRCS 2008) and as a Palustrine, Persistent Emergent, Seasonally Saturated wetland under the National Wetlands Inventory (FGDC 2013). Precipitation is the main sources of water for this ecological site (Smith et al. 1995). Infiltration is very slow (Hydrologic Group D) for undrained soils, and surface runoff is low (Figure 4).

Primary wetland hydrology indicators for an intact Wet Loamy Upland Savanna may include: A2 High water table and A3 Saturation. Secondary wetland hydrology indicators may include: C2 Dry-season water table and D5 FAC-neutral test (USACE 2010).

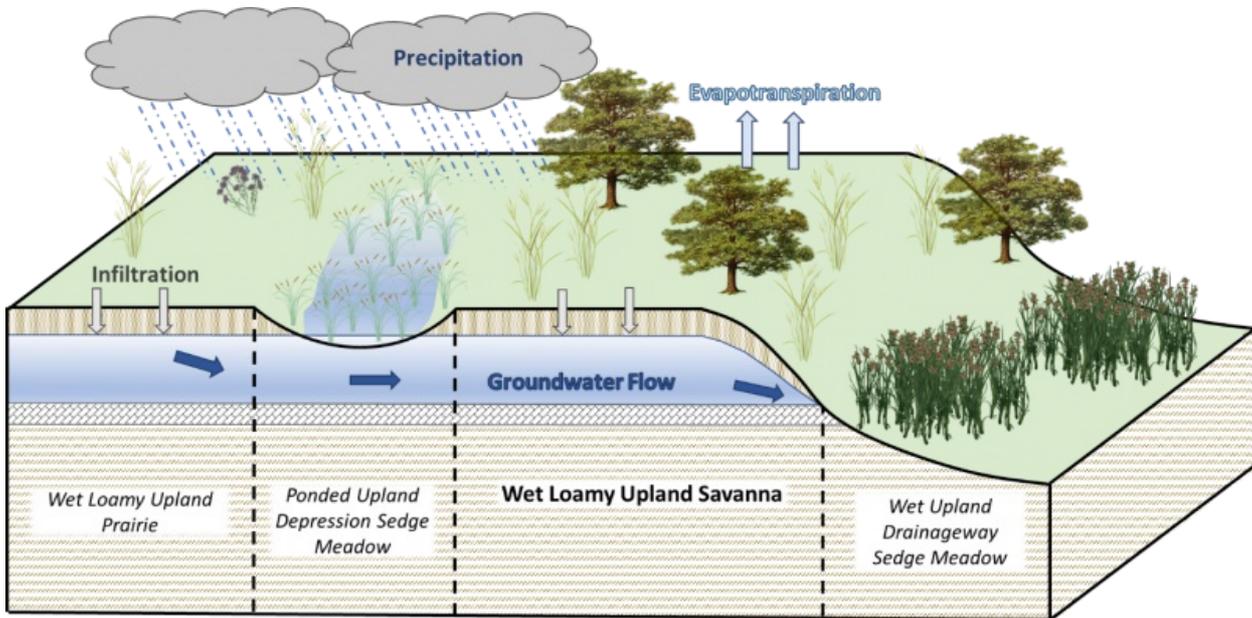


Figure 9. Figure 4. Hydrologic cycling in Wet Loamy Upland Savanna ecological site.

Soil features

Soils of Wet Loamy Upland Savannas are in the Alfisols orders, further classified as Mollic Endoaqualfs, Udollic Epiaqualfs and Vertic Epiaqualfs with very slow infiltration and low runoff potential. The soil series associated with this site includes Ansgar, Brownsdale, Havana, Skyberg, Stateline, and Udolpho. The parent material is loess or loamy sediments, and the soils are poorly-drained and deep with seasonal high-water tables. Soil pH classes are strongly acid to moderately alkaline. No rooting restrictions are noted for the soils of this ecological site (Table 5).

Some soil map units in this ecological site, if not drained, may meet the definition of hydric soils and are listed as meeting criteria 2 of the hydric soils list (77 FR 12234).

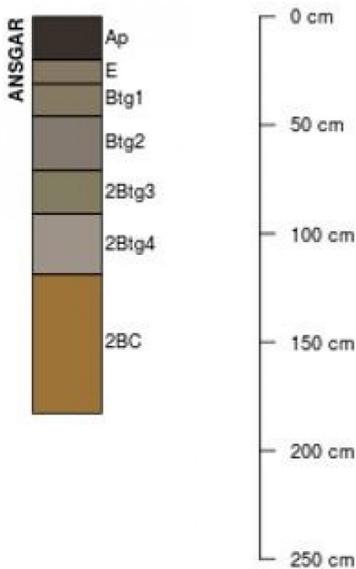


Figure 10. Figure 5. Profile sketches of soil series associated with Wet Loamy Upland Savanna.

Table 4. Representative soil features

Family particle size	(1) Fine-loamy
Drainage class	Poorly drained
Permeability class	Slow
Depth to restrictive layer	80 in
Soil depth	80 in

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.

Ecological Dynamics

The MLRA lies within the transition zone between the eastern deciduous forests and the tallgrass prairies. The heterogeneous topography of the area results in variable microclimates and fuel matrices that in turn support prairies, savannas, woodlands, and forests. Wet Loamy Upland Savannas form an aspect of this vegetative continuum. This ecological site occurs on uplands on poorly-drained soils. Species characteristic of this ecological site consist of both upland and hydrophytic woody and herbaceous vegetation.

Fire is a critical disturbance factor that maintains Wet Loamy Upland Savannas. Fire

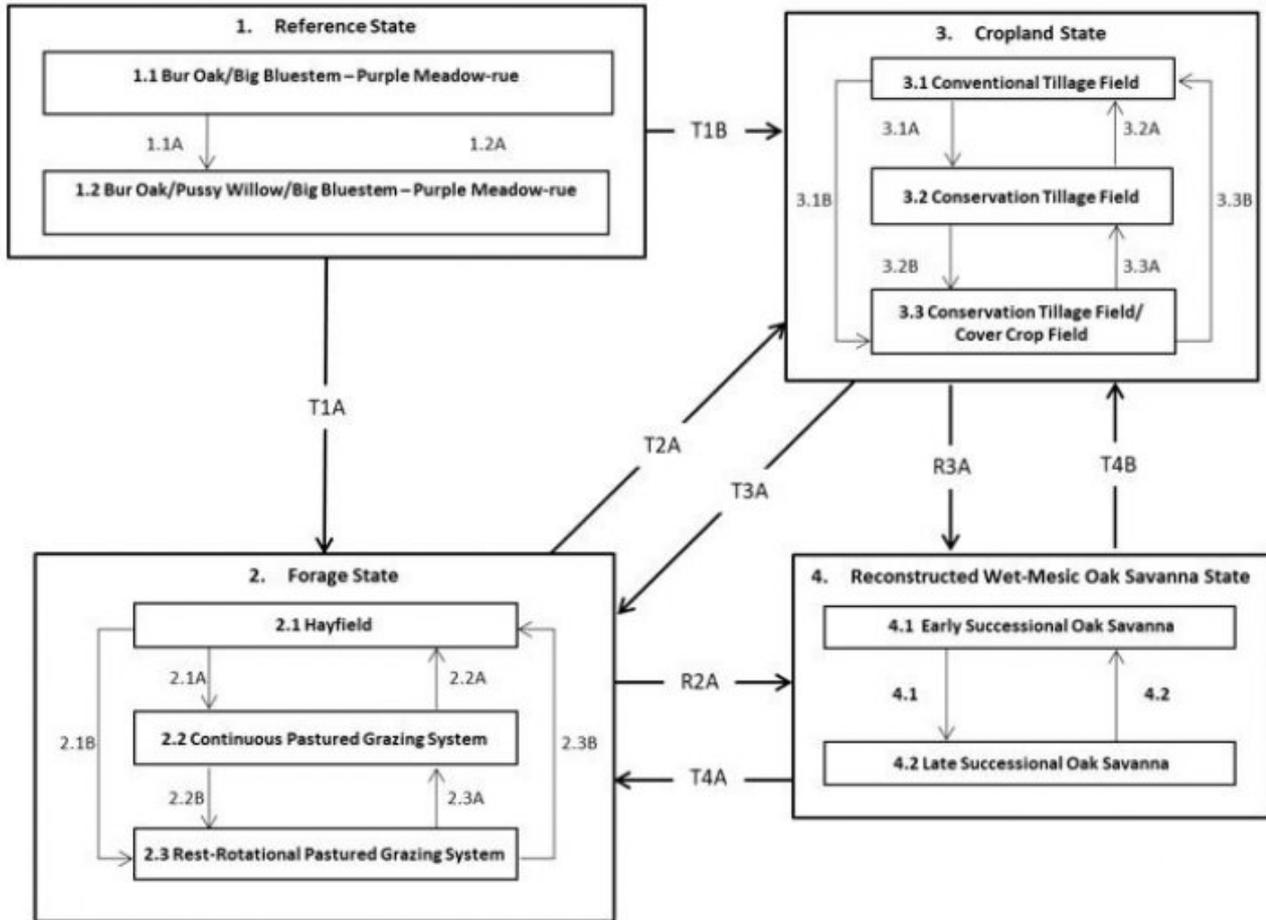
intensity typically consisted of periodic fires occurring every 1 to 5 years (LANDFIRE 2009). Ignition sources included summertime lightning strikes from convective storms and bimodal, human ignitions during the spring and fall seasons. Native Americans regularly set fires to improve sight lines for hunting, driving large game, improving grazing and browsing habitat, agricultural clearing, and enhancing vital ethnobotanical plants (Barrett 1980; White 1994).

Drought and herbivory by native ungulates have also played a role in shaping this ecological site. The periodic episodes of reduced soil moisture in conjunction with the poorly-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. Bison (*Bos bison*) grazing, while present, served a more limited role in community composition and structure than lands further west. Prairie elk (*Cervus elaphus*) and white-tailed deer (*Odocoileus virginianus*) likely contributed to woody species reduction but are also considered to be of a lesser impact compared to the west (LANDFIRE 2009). When coupled with fire, periods of drought and herbivory can further delay the establishment of woody vegetation (Pyne et al. 1996).

Today, Wet Loamy Upland Savannas have been greatly reduced, if not extirpated, as most areas have been converted to agricultural production. Corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merr.) are the dominant crops grown, but patches of forage land may be present. A return to the historic plant community may not be possible following extensive land modification, but long-term conservation agriculture or savanna 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

R104XY008IA WET LOAMY UPLAND SAVANNA



Code	Process
1.1A	Extended fire return interval in excess of 5 years
1.2A	Mixed or replacement fire
T1A, T3A, T4A	Cultural treatments are implemented to increase forage quality and yield
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 by mechanical harvesting
2.2B	Implementation of rest-rotational grazing
2.3A	Implementation of continuous grazing
T1B, T2A, T4B	Agricultural conversion via tillage, seeding, and non-selective herbicide
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, and 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 wet-mesic savanna community, dominated by upland and hydrophytic vegetation. The two community phases within the reference state are dependent on periodic fire. Surface fires are the dominant fire regime,

comprising approximately 96 percent of all fires and occurring every five years. Mixed and replacement fires comprise the remaining 4 percent, occurring approximately every 3 and 1 years, respectively (LANDFIRE 2009). The intensity and frequency alter species composition, cover, and extent, while regular fire intervals keep woody species from dominating. Drought and native mammal grazing have more localized impacts in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

Community 1.1

Bur Oak/Big Bluestem – Purple Meadow-rue

Sites in this reference community phase are dominated by a mix of grasses and forbs with scattered trees. Bur oak is the dominant tree species on the site. The tree canopy comprises no more than 20 percent cover and tree size class is medium (9 to 21-inch DBH). Vegetative cover is continuous (up to 100 percent) and plants – such as big bluestem, purple meadow-rue, and Virginia strawberry (*Fragaria virginiana* Duchesne) – can reach heights up to 3 feet tall (DeLong and Hooper 1996; LANDFIRE 2009). Surface fires every 5 years will maintain this class, but an extended fire return interval will shift the community to phase 1.2 (LANDFIRE 2009).

Community 1.2

Bur Oak/Pussy Willow/Big Bluestem – Purple Meadow-rue

This reference community phase represents a successional shift following an extended fire return interval. This fire-free period allows woody shrubs to establish including pussy willow (*Salix discolor* Muhl.). Tree cover increases to as much as 60 percent, and tree size class moves from medium to large (21 to 33-inch DBH). Surface fires every 5 years will maintain this class, but mixed or replacement fires will shift the community back to phase 1.1 (LANDFIRE 2009).

Pathway 1.1A

Community 1.1 to 1.2

Extended fire return interval in excess of 5 years.

Pathway 1.2A

Community 1.2 to 1.1

Mixed or replacement fire.

State 2

Forage State

The forage state occurs when the site is converted to a farming operation 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, the non-native species were able to spread and expand across the landscape, reducing the native species diversity and ecological function.

Community 2.1

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 microorganisms (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 also reduce the site's carbon sequestration capacity (Skinner 2008).

Community 2.2

Continuous Pastured Grazing

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

Periodic-rest Pastured Grazing

This community phase is characterized by periodic-rest grazing where the pasture has been subdivided into several smaller paddocks. Subdividing the pasture in this way allows livestock to 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). Periodic-rest pastured grazing include deferred periods, rest periods, and periods of high intensity – low frequency, and short duration methods. Vegetation is generally more diverse and can include orchardgrass (*Dactylis glomerata* L.), timothy (*Phleum pratense* 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 utilizing continuous grazing.

Pathway 2.1B **Community 2.1 to 2.3**

Mechanical harvesting is replaced with domestic livestock utilizing periodic-rest grazing.

Pathway 2.2A **Community 2.2 to 2.1**

Domestic livestock are removed, and mechanical harvesting is implemented.

Pathway 2.2B **Community 2.2 to 2.3**

Periodic-rest grazing replaces continuous grazing.

Pathway 2.3B **Community 2.3 to 2.1**

Domestic livestock are removed, and mechanical harvesting is implemented.

Pathway 2.3A **Community 2.3 to 2.2**

Continuous grazing replaces periodic-rest grazing.

State 3 **Cropland State**

Subsurface soil drainage and 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.

Community 3.1

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 alternating periods of corn and soybean crops. 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

This community phase is characterized by periodically alternating crops and utilizing 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 operations. 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 operations 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 operations, 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

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 row crop operation.

Pathway 3.1A **Community 3.1 to 3.2**

Tillage operations are greatly reduced, alternating crops occurs on a regular interval, and crop residue remains on the soil surface.

Pathway 3.1B **Community 3.1 to 3.3**

Tillage operations are greatly reduced or eliminated, alternating crops occurs on a regular interval, crop residue remains on the soil surface, and cover crops are planted following crop harvest.

Pathway 3.2A **Community 3.2 to 3.1**

Intensive tillage is utilized, and monoculture row-cropping is established.

Pathway 3.2B **Community 3.2 to 3.3**

Cover crops are implemented to minimize soil erosion.

Pathway 3.3B **Community 3.3 to 3.1**

Intensive tillage is utilized, cover crops practices are abandoned, monoculture row-cropping is established on a more-or-less continuous basis.

Pathway 3.3A **Community 3.3 to 3.2**

Cover crop practices are abandoned.

State 4 **Reconstructed Wet-Mesic Oak Savanna State**

Savanna 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 savanna 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 savanna state is the result of a long-term commitment involving a multi-step, adaptive management process. Oak plantings or selective tree thinning of non-oak species will be required in order to reproduce the overstory canopy (Asbjornsen et al. 2005). Diverse, species-rich seed mixes may be 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, shrubs, and eventually mature oaks. Establishing a prescribed fire regime 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 undesirable woody vegetation (Brudvig et al. 2007).

Community 4.1

Early Successional Reconstructed Oak Savanna

This community phase represents early community assembly and is highly dependent on the timing and priority of planting and/or tree thinning operations and the herbaceous seed mix utilized. If oak planting is needed, acorns should be planted shortly after harvest as acorns germinate shortly after seedfall and require no cold stratification. Browse protection may need to be installed to protect newly established seedlings from animal predation (Gucker 2011). If selective tree removal is needed, canopy reduction should encompass between 16 to 45 percent of the undesirable species in a single year (Asbjornsen et al. 2005). The seed mix should look to include a diverse mix of native cool-season and warm-season annual and perennial grasses and forbs typical of the reference state. Native, cool-season annuals can help to 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 in order 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 and over time close the canopy.

Community 4.2

Late Successional Reconstructed Oak Savanna

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 oak savanna communities are

dominated by grasses, these species can suppress forb establishment and reduce overall diversity and ecological functioning (Martin and Wilsey 2006; Williams et al. 2007). Reducing accumulated plant litter from such tallgrasses as big bluestem and Indiangrass allows more light and nutrients to become available for forb recruitment, allowing for greater ecosystem complexity (Wilsey 2008). Prescribed fire should be used on a cycle no less than every five years in order to allow the oaks to establish and mature (Gucker 2011).

Pathway 4.1A

Community 4.1 to 4.2

Selective herbicides are used to control non-native species, and prescribed fire and/or light grazing help to increase the native species diversity and control non-oak woody vegetation.

Pathway 4.2B

Community 4.2 to 4.1

Reconstruction experiences a decrease in native species diversity from drought or improper timing of management actions (e.g., reduced fire frequency, use of non-selective herbicides).

Transition T1A

State 1 to 2

Cultural treatments to enhance forage quality and yield transitions the site to the forage state (2).

Transition T1B

State 1 to 3

Tillage, seeding of agricultural crops, and non-selective herbicide transition the site to the cropland state (3).

Transition T2A

State 2 to 3

Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (3).

Restoration pathway R2A

State 2 to 4

Site preparation, invasive species control, and seeding native species transition this site to

the reconstructed wet-mesic oak savanna state (4).

Transition T3A

State 3 to 2

Cultural treatments to enhance forage quality and yield transitions the site to the forage state (2).

Restoration pathway R3A

State 3 to 4

Site preparation, invasive species control, and seeding native species transition this site to the reconstructed wet-mesic oak savanna state (4).

Transition T4A

State 4 to 2

Cultural treatments to enhance forage quality and yield transition the site to the forage state (2).

Transition T4B

State 4 to 3

Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (3).

Additional community tables

Inventory data references

No field plots were available for this site. A review of the scientific literature and professional experience were used to approximate the plant communities for this provisional ecological site. Information for the state-and-transition model was obtained from the same sources. All community phases are considered provisional based on these plots and the sources identified in ecological site description.

Other references

Asbjornsen, H., L.A. Brudvig, C.M. Mabry, C.W. Evans, and H.M. Karnitz. 2005. Defining reference information for restoring ecologically rare tallgrass oak savannas in the midwestern United States. *Journal of Forestry* 103: 345-350.

Baker, R.G., C.A. Chumbley, P.M. Witinok, and H.K. Kim. 1990. Holocene vegetational changes in eastern Iowa. *Journal of the Iowa Academy of Science* 97: 167-177.

Baker, R.G., L.J. Maher, C.A. Chumbley, and K.L. Van Zant. 1992. Patterns of Holocene environmental changes in the midwestern United States. *Quaternary Research* 37: 379-389.

Barrett, S.W. 1980. Indians and fire. *Western Wildlands Spring*: 17-20.

Bharati, L., K.-H. Lee, T.M. Isenhardt, and R.C. Schultz. 2002. Soil-water infiltration under crops, pasture, and established riparian buffer in Midwestern USA. *Agroforestry Systems* 56: 249-257.

Brudvig, L.A., C.M. Mabry, J.R. Miller, and T.A. Walker. 2007. Evaluation of central North American prairie management based on species diversity, life form, and individual species metrics. *Conservation Biology* 21: 864-874.

Changes in Hydric Soils Database Selection Criteria. 77 *Federal Register* 12234 (29 February 2012), pp. 12234-12235.

Cleland, D.T., J.A. Freeouf, J.E. Keys, G.J. Nowacki, C. Carpenter, and W.H. McNab. 2007. *Ecological Subregions: Sections and Subsections of the Conterminous United States*. USDA Forest Service, General Technical Report WO-76. Washington, DC. 92 pps.

DeLong, K.T. and C. Hooper. 1996. A potential understory flora for oak savanna in Iowa. *Journal of the Iowa Academy of Sciences* 13: 9-28.

Drobney, P.D., G.S. Wilhelm, D. Horton, M. Leoschke, D. Lewis, J. Pearson, D. Roosa, and D. Smith. 2001. *Floristic Quality Assessment for the State of Iowa*. Neal Smith National Wildlife Refuge and Ada Hayden Herbarium, Iowa State University, Ames, IA. 123 pps.

Eilers, L. and D. Roosa. 1994. *The Vascular Plants of Iowa: An Annotated Checklist and Natural History*. University of Iowa Press, Iowa City, IA. 319 pps.

Federal Geographic Data Committee. 2013. *Classification of Wetlands and Deepwater Habitats of the United States*. FGDC-STD-004-2013. Second Edition. Wetlands Subcommittee, Federal geographic Data Committee and U.S. Fish and Wildlife Service, Washington, D.C. 90 pps.

Fierer, N., J. Ladau, J.C. Clemente, J.W. Leff, S.M. Owens, K.S. Pollard, R. Knight, J.A. Gilbert, and R.L. McCulley. 2013. Reconstructing the microbial diversity and function of pre-agricultural tallgrass prairie soils in the United States. *Science* 342: 621-624.

Franzluebbers, A.J., J.A. Stuedemann, H.H. Schomberg, and S.R. Wilkinson. 2000. Soil organic C and N pools under long-term pasture management in the Southern Piedmont USA. *Soil Biology and Biochemistry* 32:469-478.

Gucker, C.L. 2011. *Quercus macrocarpa*. In: Fire Effects Information System [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available at <https://www.crs-feis.org/feis/>. (Accessed 23 March 2018).

Iowa Natural Areas Inventory [INAI]. 1984. An Inventory of Significant Natural Areas in Iowa: Two year Progress Report of the Iowa Natural Areas Inventory. Iowa Natural Areas Inventory, Iowa Department of Natural Resources, Des Moines, IA.

Karol, P. and D.A. Wardle. 2010. How understanding aboveground-belowground linkages can assist restoration ecology. *Trends in Ecology and Evolution* 25: 670-679.

LANDFIRE. 2009. Biophysical Setting 4213940 North-Central Interior Oak Savanna. In: LANDFIRE National Vegetation Dynamics Models. USDA Forest Service and US Department of Interior. Washington, DC.

Leake, J., D. Johnson, D. Donnelly, G. Muckle, L. Boddy, and D. Read. 2004. Networks of power and influence: the role of mycorrhizal mycelium in controlling plant communities and agroecosystem functioning. *Canadian Journal of Botany* 82: 1016-1045.

Martin, L.M. and B.J. Wilsey. 2006. Assessing grassland restoration success: relative roles of seed additions and native ungulate activities. *Journal of Applied Ecology* 43: 1098-1110.

Martin, L.M. and B.J. Wilsey. 2012. Assembly history alters alpha and beta diversity, exotic-native proportions and functioning of restored prairie plant communities. *Journal of Applied Ecology* 49: 1436-1445.

Minnesota Department of Natural Resources [MDNR]. 2005. Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Forest Province. Ecological Land Classification Program, Minnesota County Biological Survey, Natural Heritage and Nongame Research Program, Minnesota Department of Natural Resources, St. Paul, MN.

National Climate Data Center [NCDC]. 2006. Climate of Iowa. Central Region Headquarters, Climate Services Branch, National Climatic Data Center, Asheville, NC.

Peel, M.C., B.L. Finlayson, and T.A. McMahon. 2007. Updated world map of the Köppen-Geiger climate classification. *Hydrology and Earth System Sciences* 11: 1633-1644.

Prior, J.C. 1991. Landforms of Iowa. University of Iowa Press for the Iowa Department of Natural Resources, Iowa City, IA. 153 pps.

Pyne, S.J., P.L. Andrews, and R.D. Laven. 1996. Introduction to Wildland Fire, Second Edition. John Wiley and Sons, Inc. New York, New York. 808 pps.

Skinner, R.H. 2008. High biomass removal limits carbon sequestration potential of mature temperate pastures. *Journal for Environmental Quality* 37: 1319-1326.

Smith, R.D., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. *An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices*. U.S. Army Corps of Engineers, Waterways Experiment Station, Wetlands Research Program Technical Report WRP-DE-9. 78 pps.

Smith, D.D. 1998. Iowa prairie: original extent and loss, preservation, and recovery attempts. *The Journal of the Iowa Academy of Sciences* 105: 94-108.

Smith, D.D., D. Williams, G. Houseal, and K. Henderson. 2010. *The Tallgrass Prairie Center Guide to Prairie Restoration in the Upper Midwest*. University of Iowa Press, Iowa City, IA. 338 pps.

Teague, W.R., S.L. Dowhower, S.A. Baker, N. Haile, P.B. DeLaune, and D.M. Conover. 2011. Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. *Agriculture, Ecosystems and Environment* 141: 310-322.

Tomer, M.D., D.W. Meek, and L.A. Kramer. 2005. Agricultural practices influence flow regimes of headwater streams in western Iowa. *Journal of Environmental Quality* 34:1547-1558.

Undersander, D., B. Albert, D. Cosgrove, D. Johnson, and P. Peterson. 2002. *Pastures for Profit: A Guide to Rotational Grazing (A3529)*. University of Wisconsin-Extension and University of Minnesota Extension Service. 43 pps.

U.S. Army Corps of Engineers [USACE]. 2010. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region (Version 2.0)*. U.S. Army Corps of Engineers, Wetlands Regulatory Assistance Program, U.S. Army Engineer Research and Development Center, Vicksburg, MS. 141 pps.

United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS). 2003. *National Range and Pasture Handbook, Revision 1*. Grazing Lands Technology Institute. 214 pps.

United States Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS). 2006. *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin*. U.S. Department of Agriculture Handbook 296. 682 pps.

United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS). 2007. *Iowa NRCS Plant Community Species Lists*. Des Moines, IA. Available at <https://www.nrcs.usda.gov/wps/>

portal/nrcs/detail/ia/technical/ecoscience/bio/?cid=nrcs142p2_008160. (Accessed 19 January 2018).

United States Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS). 2008. Hydrogeomorphic Wetland Classification: An Overview and Modification to Better Meet the Needs of the Natural Resources Conservation Service. Technical Note No. 190-8-76. Washington, D.C. 8 pps.

U.S. Environmental Protection Agency [EPA]. 2013. Level III and Level IV Ecoregions of the Continental United States. Corvallis, OR, U.S. EPA, National Health and Environmental Effects Research Laboratory, map scale 1:3,000,000. Available at <http://www.epa.gov/eco-research/level-iii-andiv-ecoregions-continental-united-states>. (Accessed 1 March 2017).

White, J. 1994. How the terms savanna, barrens, and oak openings were used in early Illinois. In: J. Fralisch, ed. Proceedings of the North American Conference on Barrens and Savannas. Illinois State University, Normal, IL.

Williams, D.A., L.L. Jackson, and D.D Smith. 2007. Effects of frequent mowing on survival and persistence of forbs seeded into a species-poor grassland. *Restoration Ecology* 15: 24-33.

Wilsey, B.J. 2008. Productivity and subordinate species response to dominant grass species and seed source during restoration. *Restoration Ecology* 18: 628-637.

Wisconsin Department of Natural Resources (WDNR). 2015. The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management. Wisconsin Department of Natural Resources, PUB-SS-1131 2015, Madison, WI.

Contributors

Lisa Kluesner
Ryan Dermody

Acknowledgments

This project could not have been completed without the dedication and commitment from a variety of partners and staff. Team members supported the project by serving on the technical team, assisting with the development of state and community phases of the state-and-transition model, providing peer review and technical editing, and conducting quality control and quality assurance reviews.

Drake University:
Dr. Tom Rosburg, Professor of Ecology and Botany, Des Moines, IA

Iowa Department of Natural Resources:

John Pearson, Ecologist, Des Moines, IA

Greg Schmitt, Private Lands Biologist, West Union, IA

Conservation Districts of Iowa:

Sean Kluesner, Private Lands Wetland Easement Team Specialist, New Hampton, IA

LANDFIRE (The Nature Conservancy):

Randy Swaty, Ecologist, Evanston, IL

Natural Resources Conservation Service :

Rick Bednarek, Iowa State Soil Scientist, Des Moines, IA

Scott Brady, Acting Regional Ecological Site Specialist, Havre, MT

Leland Camp, Soil Scientist, Waverly, IA

Patrick Chase, Area Resource Soil Scientist, Fort Dodge, IA

Stacey Clark, Regional Ecological Site Specialist, St. Paul, MN

James Cronin, State Biologist, Des Moines, IA

Ryan Dermody, Soil Survey Leader, Waverly, IA

Tonie Endres, Senior Regional Soil Scientist, Indianapolis, IN

Gregg Hadish, GIS Specialist, Des Moines, IA

John Hammerly, Soil Data Quality Specialist, Indianapolis, IN

Lisa Kluesner, Ecological Site Specialist, Waverly, IA

Jeff Matthias, State Grassland Specialist, Des Moines, IA

Louis Moran, Area Resource Soil Scientist, Sioux City, IA

Kevin Norwood, Soil Survey Regional Director, Indianapolis, IN

James Phillips, GIS Specialist, Des Moines, IA

Neil Sass, Area Resource Soil Scientist, West Union, IA

Jason Steele, Area Resource Soil Scientist, Fairfield, IA

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	07/08/2025

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:

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

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

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

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:**

17. **Perennial plant reproductive capability:**
