Ecological site R107XB008MO
Loamy Footslope Savanna

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Accessed: 05/03/2024

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 Missouri Deep Loess Hills (MLRA 107B) includes the Missouri Alluvial Plain, Loess Hills, Southern Iowa Drift Plain, and Central Dissected Till Plains landform regions (Prior 1991; Nigh and Schroeder 2002). It spans four states (Iowa, 53 percent; Missouri, 32 percent; Nebraska, 12 percent; and Kansas 3 percent), encompassing over 14,000 square miles (Figure 1). The elevation ranges from approximately 1,565 feet above sea level (ASL) on the highest ridges to about 600 feet ASL along the Missouri River near Glasgow in central Missouri. Local relief varies from 10 to 20 feet in the major river floodplains, to 50 to 100 feet in the dissected uplands, and loess bluffs of 200 to 300 feet along the Missouri River. Loess deposits cover most of the area, with deposits reaching a thickness of 65 to 200 feet in the Loess Hills and grading to about 20 feet in the eastern extent of the region. Pre-Illinoian till, deposited more than 500,000 years ago, lies beneath the loess and has experienced extensive erosion and dissection. Pennsylvanian and Cretaceous bedrock, comprised of shale, mudstones, and sandstones, lie 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. This prairie-oak savanna ecosystem formed the dominant landscapes until the arrival of European settlers (Baker et al. 1992).

Classification relationships

Major Land Resource Area (MLRA): Iowa and Missouri Deep Loess Hills (107B) (USDA-NRCS 2006)

USFS Subregions: Central Dissected Till Plains Section (251C), Deep Loess Hills (251Ca) Subsection; Nebraska Rolling Hills Section (251H), Yankton Hills and Valleys (251Ha) (Cleland et al. 2007)

U.S. EPA Level IV Ecoregion: Steeply Rolling Loess Prairies (47e), Nebraska/Kansas Loess Hills (47h), Western Loess Hills (47m) (USEPA 2013)

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

Ecological Systems (National Vegetation Classification System, Nature Serve 2015): North-Central Interior Oak Savanna (CES202.698)

Iowa Department of Natural Resources (INAI 1984): Loess Hills Savanna

Missouri Natural Heritage Program (Nelson 2010): Dry-Mesic Loess/Glacial Till Savanna

Plant Associations (National Vegetation Classification System, Nature Serve 2015): Quercus macrocarpa – (Quercus alba, Quercus stellata)/ Andropogon gerardii Wooded Herbaceous Vegetation (CEGL002159)

Rosburg (1994): Bur Oak Woodland

Ecological site concept

Loamy Footslope Savannas are generally located within the green areas on the map (Figure 1). They occur on footslopes. Soils are colluvium-derived Entisols and Mollisols that are well-drained and very deep. The loess parent material results in fertile soils with high soil uniformity. This increases nutrient- and water-holding capacity, increases organic matter retention, and promotes good soil aeration that allows deep penetration by plant roots generally increasing plant productivity (Catt 2001). Relative to other upland savanna ecological sites in the MLRA, Loamy Footslope Savannas occur on a lower landscape position.

The historic pre-European settlement vegetation on this site was dominated by tallgrass prairie species, with oaks interspersed across the landscape. Big bluestem (Andropogon gerardii Vitman) and Indiangrass (Sorghastrum nutans (L.) Nash) represent the dominant herbaceous species, while white oak (Quercus alba L.) and bur oak (Quercus macrocarpa Michx.) are the dominant tree species (Nelson 2010). Forb species typical of an undisturbed plant community associated with this ecological site include Virginia bunchflower (Veratrum virginicum (L.) W.T. Aiton) and purple milkweed (Asclepias purpurascens L.) (Drobney et al. 2001; Ladd and Thomas 2015). Fire was the primary disturbance factor that maintained this site, while drought and native large mammal grazing were secondary factors (Nelson 2010; NatureServe 2015).

Associated sites

R107XB006MO	**Calcareous Loess Exposed Backslope Prairie** Calcareous loess soils on slopes greater than fifteen percent with south and west aspects, including Dow, Hamburg, and Ida
R107XB012MO	**Calcareous Loess Upland Prairie** Calcareous loess soils on upland summits and shoulders on slopes less than fifteen percent, including Dow and Ida

Similar sites

R107XB013MO	**Calcareous Loess Protected Backslope Savanna** Calcareous Loess Protected Backslope Savannas occur on higher on the landscape on calcareous loess soils
R107XB003MO	**Deep Loess Exposed Backslope Savanna** Deep Loess Exposed Backslope Savannas occur higher on the landscape on loess soils

Table 1. Dominant plant species

Tree	(1) *Quercus alba* (2) *Quercus macrocarpa*
Shrub	Not specified
Herbaceous	(1) *Andropogon gerardii* (2) *Sorghastrum nutans*

Physiographic features

Loamy Footslope Savannas occur on footslopes with slopes generally less than fifteen percent (Figure 2). This ecological site is situated on elevations ranging from approximately 500 to 1,545 feet. This site does not experience flooding but rather generates runoff to adjacent, downslope ecological sites.

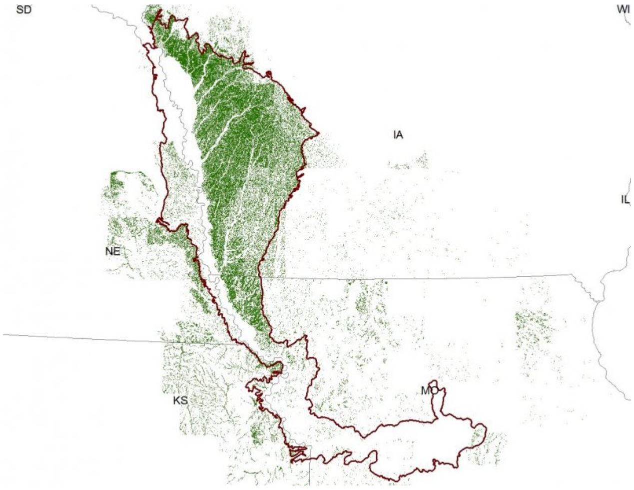


Figure 2. Figure 1. Location of Loamy Footslope Savanna ecological site within MLRA 107B.

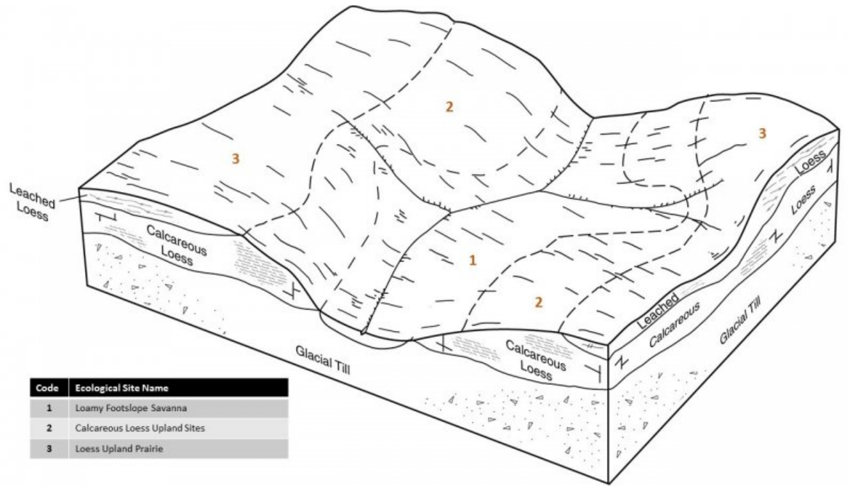


Figure 3. Figure 2. Representative block diagram of Loamy Footslope Savanna and associated ecological sites.

Table 2. Representative physiographic features

Hillslope profile	(1) Footslope
Slope shape across	(1) Linear
Slope shape up-down	(1) Concave
Landforms	(1) Hillslope
Flooding frequency	None
Ponding frequency	None
Elevation	152–471 m
Slope	1–14%
Water table depth	122–203 cm
Aspect	Aspect is not a significant factor

Climatic features

The Iowa and Missouri Deep Loess Hills falls into two Köppen-Geiger climate classifications (Peel et al. 2007): hot humid continental climate (Dfa) dominates the majority of the MLRA with small portions in the south falling into the humid subtropical climate (Cfa). 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 (Decker 2017). Occasionally, high pressure will stagnate over the region, creating extended droughty periods. These periods of drought have historically occurred on 22-year cycles (Stockton and Meko 1983).

The soil temperature regime of MLRA 107B 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 you travel. The average freeze-free period of this ecological site is about 172 days, while the frost-free period is about 148 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 35 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 38 and 60°F, respectively.

Climate data and analyses are derived from 30-year average gathered from ten 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)	131-136 days
Freeze-free period (characteristic range)	151-173 days
Precipitation total (characteristic range)	813-914 mm
Frost-free period (actual range)	124-146 days
Freeze-free period (actual range)	146-177 days
Precipitation total (actual range)	762-940 mm
Frost-free period (average)	134 days
Freeze-free period (average)	162 days
Precipitation total (average)	838 mm

Climate stations used

- (1) DENISON [USC00132171], Denison, IA
- (2) SHENANDOAH [USC00137613], Shenandoah, IA
- (3) ATLANTIC 1 NE [USC00130364], Atlantic, IA
- (4) AUDUBON [USC00130385], Audubon, IA
- (5) HARLAN 1N [USC00133632], Harlan, IA
- (6) MAPLETON NO.2 [USC00135123], Mapleton, IA
- (7) SIOUX CITY GATEWAY AP [USW00014943], Sioux City, IA
- (8) CASTANA EXP FARM [USC00131277], Mapleton, IA
- (9) OAKLAND [USC00136151], Oakland, IA
- (10) TARKIO [USW00014945], Tarkio, MO

Influencing water features

Loamy Footslope Savannas are not influenced by wetland or riparian water features. Precipitation is the main source of water for this ecological site. Infiltration is slow to moderate (Hydrologic Groups B and C), and surface runoff is low to medium. Precipitation infiltrates the soil surface and percolates downward through the horizons unimpeded by any restrictive layer. The Dakota bedrock aquifer in the northern region of this ecological site is typically deep and confined, leaving it generally unaffected by recharge. However, there are surficial aquifers in the Pennsylvanian strata in the southern extent of the ecological site that are shallow and allow some recharge (Prior et al. 2003). Surface runoff contributes some water to downslope ecological sites. Evapotranspiration rates occur on a latitudinal gradient, with the northern end of the ecological site receiving a greater number of days with sun and high winds resulting in a higher average evapotranspiration rate compared to the southern end (Visher 1954).

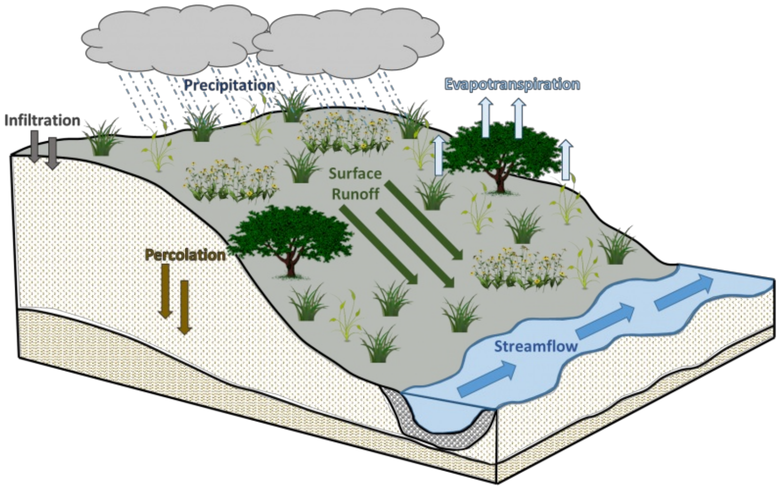


Figure 10. Figure 5. Hydrologic cycling in Loamy Footslope Savanna ecological site.

Soil features

Soils of Loamy Footslope Savannas are in the Entisol and Mollisol order, further classified as Mollic Udifluvents, Oxyaquic Udifluvents, Aquic Cumulic Hapludolls, and Entic Hapludolls. The soil series associated with this site includes Castana, Colo, Danbury, Deloit, Ely, Judson, Napier, Nodaway, Olmitz, Udarents, and Udorthents. The parent material is loess, and the soils are poor to well-drained and very deep with no coarse fragments. Soil pH classes are moderately acid to moderately alkaline. No rooting restrictions are noted for the soils of this ecological site.

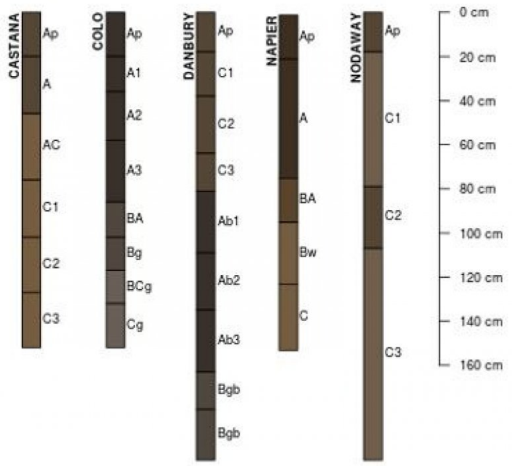


Figure 11. Figure 6. Profile sketches of soil series associated with Loamy Footslope Savanna.

Table 4. Representative soil features

Parent material	(1) Colluvium
Surface texture	(1) Silt loam (2) Silty clay loam
Family particle size	(1) Fine-silty (2) Fine-loamy
Drainage class	Moderately well drained to well drained
Permeability class	Slow to moderately slow
Soil depth	203 cm
Available water capacity (0-101.6cm)	15.24–22.86 cm

Calcium carbonate equivalent (0-101.6cm)	0–30%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	5.6–8.4

Ecological dynamics

The Loess Hills region lies within the transition zone between the eastern deciduous forests and the Great Plains. The heterogeneous topography of the area results in variable microclimates and fuel matrices that in turn are able to support prairies, savannas, woodlands, or forests (Novacek et al. 1985; Nelson 2010). Loamy Footslope Savannas form an aspect of this vegetative continuum throughout the prairie-forest borders of the Loess Hills (NatureServe 2015). This ecological site occurs on footslopes on colluvium-derived soils. Species characteristic of this ecological site are scattered oaks and sun-loving, fire- and drought-adapted prairie plants in the understory.

Fire is the most important ecosystem driver for maintaining this ecological site (Nelson 2010; Gucker 2011). Fire intensity was influenced by aspect, topography, weather, and plant productivity but typically consisted of periodic, low-intensity surface fires (Stambaugh et al. 2006; 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 and village clearing, and enhancing vital ethnobotanical plants (Day 1953; Barrett 1980; White 1994). Fire frequency has been estimated to occur on average every 6.6 years in the Loess Hills region (Stambaugh et al. 2006). This continuous disturbance provided critical conditions for perpetuating the native savanna ecosystem.

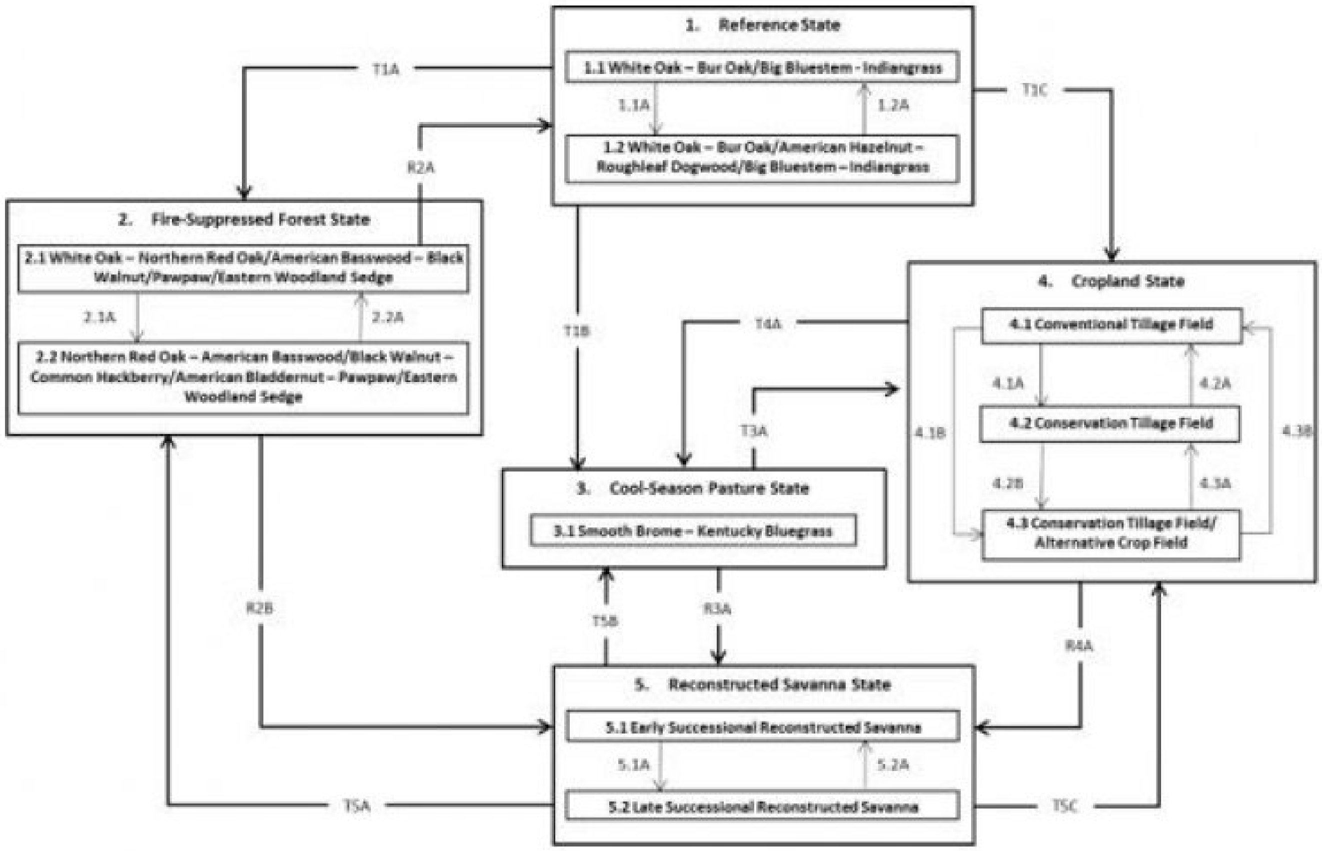
Grazing by native ungulates is often cited as an important disturbance regime of North American grasslands, with bison (Bison bison), prairie elk (Cervus elaphus), and white-tailed deer (Odocoileus virginianus) serving as the dominant herbivores of the area. However, plant community succession in the Loess Hills region does not necessarily follow this hypothesis. The steep and rugged topography of the Loess Hills has been considered an impediment to grazing by large ungulates such as bison. Any role bison played in the area was most likely relegated to the northwestern extent where the terrain is milder (Dinsmore 1994). Browsing by elk and deer is believed to have played a relatively minimal role in reducing woody biomass in the Loess Hills (Farnsworth 2009; LANDFIRE 2009).

Drought has also played a role in shaping the prairie-savanna trajectories in the Loess Hills. The periodic episodes of reduced soil moisture in conjunction with the well-drained soils have favored the proliferation of plant species tolerant of such conditions (Stambaugh et al. 2006). In addition, drought can also slow the growth of plants and result in dieback of certain species. When coupled with fire, periods of drought can also greatly delay the recovery of woody vegetation, substantially altering the extent of shrubs and trees (Pyne et al. 1996).

Today, Loamy Footslope Savannas are extremely limited in their extent, having been reduced as a result of conversion to pasture or for agriculture. Long-term fire suppression, woody encroachment, and lack of oak regeneration have resulted in a type conversion from oak savanna to a closed-canopy, mixed deciduous forest (Nelson 2010; McKenzie et al. 2012). Native and non-native invasive species (e.g., eastern redcedar (*Juniperus virginiana* L.), garlic mustard (*Alliaria petiolata* (M. Bieb.) Cavara & Grande)), and tree of heaven (*Ailanthus altissima* (Mill.) Swingle)) have invaded these type-converted stands, presenting significant challenges for land managers (Steinauer and Rolfsmeier 2010; Barney 2017). A return to the historic plant community is likely not possible, but long-term restoration efforts can help to restore some natural diversity and ecological functioning.

State and transition model

R107BY008MO Loamy Footslope Savanna



Code	Process
T1A	Fire suppression in excess of 50 years
T1B, T4A, T5B	Woody species reduction, fire suppression, non-selective herbicide, interseeding of non-native cool-season grasses, and continuous grazing
T1C, T3A, T5C	Agricultural conversion via tillage, seeding, and non-selective herbicide
1.1A	Fire-free period, 5-10 years
1.2A	Fire-free period, 1-5 years
R2A	Selective tree removal and reintroduction of historic fire regime
2.1A	Fire-free period, +30 years
2.2A	Single fire event
R2B,R3A, R4A	Site preparation, invasive species control, and seeding native species
4.1A	Less tillage, residue management
4.1B	Less tillage, residue management, and implementation of cover cropping
4.2B	Implementation of cover cropping
4.2A, 4.3B	Intensive tillage, remove residue, and reinitiate monoculture row cropping
4.3A	Remove cover cropping
T5A	Management practices abandoned
5.1A	Invasive species control and implementation of disturbance regimes
5.2A	Drought or improper timing/use of management actions

State 1
Reference State

The reference plant community is categorized as an oak savanna and includes a canopy of widely spaced bur and white oaks, continuous ground layer of grasses and forbs, and a sparse layer of shrubs (Nelson 2010). The two community phases within the reference state are dependent on a fire frequency of every one to ten years (LANDFIRE 2009). Shorter fire intervals maintain dominance by grasses, while less frequent intervals allow woody vegetation to increase their importance in the plant canopy. Grazing and drought disturbances have less impact in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- white oak (*Quercus alba*), tree
- big bluestem (*Andropogon gerardii*), grass
- Indiangrass (*Sorghastrum nutans*), grass

Community 1.1
White Oak – Bur Oak/Big Bluestem - Indiangrass

This reference community phase supports sparse, widely-scatted white and bur oaks with a canopy coverage of ten to twenty percent. Mean fire return interval is approximately five years (LANDFIRE 2009). Oaks are 30 to 60 feet tall and medium-sized (9 to 21 inch DBH) (LANDFIRE 2009; Nelson 2010). The understory supports a variety of tallgrass herbaceous species with big bluestem and Indiangrass forming the dominant ground cover (Schoolcraft 1819; Schroeder 1981). Forb diversity is high, especially following a fire event (McKenzie et al. 2012). Typical forbs include purple milkweed, Virginia bunchflower, Culver's root (*Veronicastrum virginicum* (L.) Farw.), and sawtooth sunflower (*Helianthus grosseserratus* M. Martens) (Nelson 2010).

Dominant plant species

- white oak (*Quercus alba*), tree
- bur oak (*Quercus macrocarpa*), tree
- big bluestem (*Andropogon gerardii*), grass
- Indiangrass (*Sorghastrum nutans*), grass

Community 1.2
White Oak – Bur Oak/American Hazelnut – Roughleaf Dogwood/Big Bluestem - Indiangrass

This reference community phase can occur when fire frequency is reduced to approximately every ten years (LANDFIRE 2009). The oak component matures, where trees grow to large size classes (21 to 33 inch DBH) and canopy coverage increases to 30 percent (LANDFIRE 2009; Nelson 2010). The native prairie grasses continue to form the dominant herbaceous canopy cover, but the reduced fire interval allows taller grasses to shade out some of the shorter stature species. American hazelnut increases its cover in the shrub canopy with roughleaf dogwood becoming co-dominant (Rosburg 1994; Nelson 2010).

Dominant plant species

- white oak (*Quercus alba*), tree
- bur oak (*Quercus macrocarpa*), tree
- American hazelnut (*Corylus americana*), shrub
- roughleaf dogwood (*Cornus drummondii*), shrub
- big bluestem (*Andropogon gerardii*), grass
- Indiangrass (*Sorghastrum nutans*), grass

Pathway P1.1A
Community 1.1 to 1.2

Natural succession as a result of a 5-10 year fire-free period.

Pathway P1.2A
Community 1.2 to 1.1

Natural succession as a result of a fire-free period of less than five years.

State 2
Fire Suppressed Forest State

Long-term fire suppression can transition the reference savanna community into a fire-suppressed forest state. As the natural fire regime is removed from the landscape, encroachment by shade-tolerant species ensues and the overstory canopy becomes denser (Asbjornsen et al 2005). Succession to this state can begin to occur in as little as 50 years from the last fire (LANDFIRE 2009).

Dominant plant species

- northern red oak (*Quercus rubra*), tree
- white oak (*Quercus alba*), tree
- pawpaw (*Asimina triloba*), shrub
- eastern woodland sedge (*Carex blanda*), grass

Community 2.1
White Oak – Northern Red oak/American Basswood – Black Walnut/Pawpaw/Eastern Woodland Sedge

This community phase represents the early stages of long-term fire-suppression of the native savanna. The tree canopy height ranges between 50 and 100 feet tall, and canopy closure approaches 80 percent. White oaks are the dominant canopy component, but as the canopy closes shade-intolerant bur oak are replaced by northern red oak (*Quercus rubra* L.). A ten to 30 foot-tall subcanopy of American basswood (*Tilia americana* L.) and black walnut (*Juglans nigra* L.) begins to develop, while pawpaw (*Asimina triloba* (L.) Dunal) occupies the three to seven foot tall shrub canopy. The ground layer begins to shift away from the sun-loving prairie species to more shade-tolerant sedges and forbs, including eastern woodland sedge (*Carex blanda* Dewey) (Steinauer and Rolfsmeier 2010).

Dominant plant species

- white oak (*Quercus alba*), tree
- northern red oak (*Quercus rubra*), tree
- pawpaw (*Asimina triloba*), shrub
- eastern woodland sedge (*Carex blanda*), grass

Community 2.2
Northern Red Oak – American Basswood/Black Walnut – Common Hackberry/American Bladdernut – Pawpaw/Eastern Woodland Sedge

Sites falling into this community phase have continued to have fire suppressed, resulting in a closed canopy (nearly 100 percent canopy cover) forest. Northern red oak and American basswood are the dominant tree species for the site with a well-developed subcanopy of black walnut and common hackberry (*Celtis occidentalis* L.) (Steinauer and Rolfsmeier 2010). Other species that can occur include elms (Ulmus L.), ashes (Fraxinus L.), and Kentucky coffeetree (*Gymnocladus dioicus* (L.) K. Koch) (Mutel 1989; Steinauer and Rolfsmeier 2010). Although pawpaw is shade-tolerant, it begins to die out under the maturing canopy and American bladdernut (*Staphylea trifolia* L.) and roughleaf dogwood (*Cornus drummondii* C.A. Mey) become the dominant shrub species (Sullivan 1993; Steinauer and Rolfsmeier 2010). The ground layer continues to be populated with shade-tolerant herbaceous species (Steinauer and Rolfsmeier 2010).

Dominant plant species

- northern red oak (*Quercus rubra*), tree
- American basswood (*Tilia americana*), tree
- pawpaw (*Asimina triloba*), shrub
- American bladdernut (*Staphylea trifolia*), shrub
- eastern woodland sedge (*Carex blanda*), grass

Pathway P2.1A
Community 2.1 to 2.2

Fire is removed from the landscape in excess of 30 years.

Pathway P2.2A
Community 2.2 to 2.1

Mechanical or chemical control of undesirable woody species and reintroduction of a historic fire regime restore the site back to the reference state (1).

State 3
Cool Season Pasture State

The cool-season pasture state occurs when the reference state has been anthropogenically-altered for livestock production. Fire suppression, seeding of non-native cool-season grasses, removal of woody vegetation, and grazing by domesticated livestock transition and maintain this simplified grassland state (Rosburg 1994). Early settlers seeded such non-native cool-season species as smooth brome (*Bromus inermis* Leyss.) and Kentucky bluegrass in order to help extend the grazing season (Smith 1998). Scattered bur oaks may have escaped harvest by settlers and could be present. Over time, as lands were continually grazed by large herds of cattle, the non-native species were able to spread and expand across the prairie habitat, reducing the native species diversity.

Dominant plant species

- smooth brome (*Bromus inermis*), grass
- Kentucky bluegrass (*Poa pratensis*), grass

Community 3.1
Smooth Brome – Kentucky Bluegrass

Species characteristic of this community phase include big bluestem, smooth brome, and Kentucky bluegrass. While the native big bluestem forms the dominant component of the canopy, smooth brome and Kentucky bluegrass occur in higher frequencies across the site. Annuals and biennials are important components of this community phase and are indicative of the disturbed nature of the site (Rosburg 1994).

Dominant plant species

- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass

State 4
Cropland State

Loess is the main contributing factor to the Midwest’s highly-productive agricultural soils, and as a result, much of the MLRA has been converted to cropland, including significant portions of this ecological site (USGS 1999). The continuous use of erosional terracing, tillage, row-crop planting, and chemicals (i.e., herbicides, fertilizers, etc.) have effectively eliminated the reference community and many of its natural ecological functions in favor of crop production. Corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merr.) are the dominant crops for the site. These areas are likely to remain in crop production for the foreseeable future.

Community 4.1
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 corn-soybean rotations. The frequent use of deep tillage, low crop diversity, and bare soil conditions during the non-growing season negatively impact 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 4.2
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 system, conservation tillage methods can reduce soil erosion, increase organic matter and water availability, improve water quality, and reduce soil compaction.

Community 4.3
Conservation Tillage Field/Alternative Crop Field

This condition 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. 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 P4.1A
Community 4.1 to 4.2

Tillage operations are greatly reduced, crop rotation occurs on a regular schedule, and crop residue is allowed to remain on the soil surface.

Pathway P4.1B
Community 4.1 to 4.3

Tillage operations are greatly reduced or eliminated, crop rotation is either reduced or eliminated, and crop residue is allowed to remain on the soil surface, and cover crops are implemented to prevent soil erosion.

Pathway P4.2A
Community 4.2 to 4.1

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

Pathway P4.2B
Community 4.2 to 4.3

Cover crops are implemented to prevent soil erosion.

Pathway P4.3B
Community 4.3 to 4.1

Intensive tillage is utilized, cover crops practices are abandoned, monoculture row-cropping is established, and crop rotation is reduced or eliminated.

Pathway P4.3A
Community 4.3 to 4.2

Cover crop practices are abandoned.

State 5
Reconstructed Savanna State

Savanna reconstruction has become an important tool for repairing natural ecological functioning and providing habitat protection for numerous grassland-dependent species. The historic plant community of the tallgrass oak savanna was extremely diverse and complex, and habitat replication is not considered to be possible once the native vegetation has been altered by post-European settlement land uses. 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. White and bur oak plantings or selective tree thinning of non-oak species will be required in order to reconstruct 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).

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- white oak (*Quercus alba*), tree

Community 5.1
Early Successional Reconstructed 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 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 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 5.2
Late Successional Reconstructed 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 no on a cycle no less than every five years in order to allow the oaks to establish and mature (Gucker 2011).

Pathway P5.1A
Community 5.1 to 5.2

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 P5.2A
Community 5.2 to 5.1

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

Fire suppression transitions this site to the fire-suppressed forest state (2).

Transition T1B
State 1 to 3

Woody species reduction, fire suppression, non-selective herbicide, interseeding of non-native cool-season grasses, and continuous grazing transition this site to the cool-season pasture state (3).

Transition T1C
State 1 to 4

Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (4).

Restoration pathway R2A
State 2 to 1

Mechanical or chemical control of undesirable woody species and reintroduction of a historic fire regime restore the site back to the reference state (1).

Restoration pathway R2B
State 2 to 5

Site preparation, invasive species control (native and non-native), and seeding native species transition this site to the reconstructed savanna state (5).

Transition T3A
State 3 to 4

Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (4).

Restoration pathway R3A
State 3 to 5

Site preparation, invasive species control (native and non-native), and seeding native species transition this site to the reconstructed savanna state (5).

Restoration pathway T4A
State 4 to 3

Non-selective herbicide, seeding of non-native cool-season grasses, and continuous grazing transitions the site to the cool-season pasture state (3).

Restoration pathway R4A
State 4 to 5

Site preparation, invasive species control (native and non-native), and seeding native species transition this site to the reconstructed savanna state (5).

Transition T5A
State 5 to 2

Fire suppression and removal of active management transitions this site to the fire-suppressed forest state (2)

Restoration pathway T5B
State 5 to 3

Land is converted to the cool-season pasture state through the use of non-selective herbicide and seeding of non-native cool-season grasses (3).

Transition T5C
State 5 to 4

Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (4).

Additional community tables

Animal community

Wildlife*

Prairie Phase:
Game species that utilize this ecological site include:
Northern Bobwhite will utilize this ecological site for food (seeds, insects) and cover needs (escape, nesting and roosting cover).

Cottontail rabbits will utilize this ecological site for food (seeds, soft mast) and cover needs.

Turkey will utilize this ecological site for food (seeds, green browse, soft mast, insects) and nesting and brood-rearing cover. Turkey poults feed heavily on insects provided by this site type.

White-tailed Deer will utilize this ecological site for browse (plant leaves in the growing season, seeds and soft mast in the fall/winter). This site type also can provide escape cover.

Bird species associated with this ecological site's reference state condition:
Breeding birds as related to vegetation structure (related to time since fire, grazing, haying, and mowing):

Vegetation Height Short (< 0.5 meter, low litter levels, bare ground visible):
Grasshopper Sparrow, Horned Lark, Upland Sandpiper, Greater Prairie Chicken, Northern Bobwhite

Mid-Vegetation Height (0.5 – 1 meter, moderate litter levels, some bare ground visible):
Eastern Meadowlark, Dickcissel, Field Sparrow, Upland Sandpiper, Greater Prairie Chicken, Northern Bobwhite, Eastern Kingbird, Bobolink, Lark Sparrow

Tall Vegetation Height (> 1 meter, moderate-high litter levels, little bare ground visible):
Henslow's Sparrow, Dickcissel, Greater Prairie Chicken, Field Sparrow, Northern Bobwhite, Sedge Wren, Northern Harrier

Brushy – Mix of grasses, forbs, native shrubs (e.g., Rhus copallina, Prunus americana, Rubus spp., Rosa carolina) and small trees (e.g., Cornus racemosa): Bell's Vireo, Yellow-Breasted Chat, Loggerhead Shrike, Brown Thrasher, Common Yellowthroat

Winter Resident: Short-Eared Owl, Le Conte's Sparrow

Amphibian and reptile species associated with this ecological site's reference state condition: prairies with or nearby to fishless ponds/pools (may be ephemeral) may have Eastern Tiger Salamander (Ambystoma tigrinum tigrinum) and Western Chorus Frog (Pseudacris triseriata triseriata); prairies with crawfish burrows may have Northern Crawfish Frog (Rana areolata circulosa); other species include Northern Prairie Skink (Eumeces septentrionalis septentrionalis), Ornate Box Turtle (Terrapene ornata ornata), Western Slender Glass Lizard (Ophisaurus attenuatus attenuatus), Eastern Yellow-bellied Racer (Coluber constrictor flaviventris), Prairie Ring-necked Snake (Diadophis punctatus arnyi), and Bullsnake (Pituophis catenifer sayi).

Small mammals associated with this ecological site's reference state condition: Least Shrew (Cryptotis parva), Franklin's Ground Squirrel (Spermophilus franklinii), Plains Pocket Gopher (Geomys bursarius), Prairie Vole (Microtus ochrogaster), Southern Bog Lemming (Synaptomys cooperi), Meadow Jumping Mouse (Zapus hudsonius), Thirteen-lined Ground Squirrel (Spermophilus tridecemlineatus) and Badger (Taxidea taxus).

Invertebrates: Many native insect species are likely associated with this ecological site, especially native bees, ants, beetles, butterflies and moths, and crickets, grasshoppers and katydids. However information on these groups is often lacking enough resolution to assign them to individual ecological sites.

Insect species known to be associated with this ecological site's reference state condition: Regal Fritillary butterfly (Speyeria idalia) whose larvae feed primarily on native prairie violets (Viola pedata, V. pedatifida, and V. sagittata); Mottled Dusky Wing butterfly (Erynnis martialis), Golden Byssus butterfly (Problema byssus kumskaka), Delaware Skipper butterfly (Atryone logan logan), and Crossline Skipper butterfly (Polites origenes). The larvae of the moth Eucosma bipunctella bore into compass plant (Silphium laciniatum) roots and feed and the larvae of the moth Eucosma giganteana bore into a number of Silphium species roots and feed. Native bees, important pollinators, that may be associated with this ecological site's reference condition include: Colletes brevicornis, Andrena beameri, A. helianthiformis, Protandrena rudbeckiae, Halictus parallelus, Lasioglossum albipennis, L. coreopsis, L. disparilis, L. nymphaereum, Ashmeadiella bucconis, Megachile addenda, Anthidium psoraleae, Eucera hamata, Melissodes coloradensis, M. coreopsis, and M. vernoniae. The Short-winged Katydid (Amblycorypha parvipennis), Green Grasshopper (Hesperotettix speciosus) and Two-voiced Conehead katydid (Neoconcephalus bivocatus) are possible orthopteran associates of this ecological site.

Other invertebrate associates include the Grassland Crayfish (Procambarus gracilis).

Savanna Phase:
Oaks and hickories provide an important food source for many animals including White-tailed Deer, Wild Turkey, and Fox Squirrel.

Both snags and live cavity or den trees provide important food and cover for vertebrate wildlife. Snags are also very important to invertebrate species. Fox Squirrel, Red-headed Woodpecker and Eastern Bluebird utilize snags and den trees for foraging, nesting or shelter. "Wolf" trees are a particularly valuable type of live cavity tree. These large diameter, often open-grown, old-ages, hollow trees provide both cavities for wildlife and usually hard or soft mast food sources. Large diameter snags and den trees are particularly important wildlife habitat features to retain.

Game species that utilize this ecological site include:

Northern Bobwhite will utilize this ecological site for food (seeds, insects) and cover needs (escape, nesting and roosting cover).

Cottontail rabbits will utilize this ecological site for food (seeds, soft mast) and cover needs.

Turkey will utilize this ecological site for food (seeds, green browse, soft mast, insects) and nesting and brood-rearing cover. Turkey poults feed heavily on insects provided by this site type.

White-tailed Deer will utilize this ecological site for browse (plant leaves in the growing season, seeds and soft mast in the fall/winter). This site type also can provide escape cover.

Bird species associated with this ecological site's reference state condition:
Breeding birds: Northern Bobwhite, Eastern Kingbird, Eastern Bluebird, Brown Thrasher, White-eyed Vireo, Prairie

Warbler, Field Sparrow, Eastern Towhee, Red-headed Woodpecker, Great Crested Flycatcher, Loggerhead Shrike

Winter resident: American Tree Sparrow, Harris' Sparrow

Amphibian and reptile species likely associated with this ecological site's reference state condition: Ornate Box Turtle (Terrapene ornata ornata), Northern Fence Lizard (Sceloporus undulates hyacinthinus), Five-lined Skink (Eumeces fasciatus), Western Slender Glass Lizard (Ophisaurus attenuatus attenuatus), Eastern Yellow-bellied Racer (Coluber constrictor flaviventris), Prairie Ring-necked Snake (Diadophis punctatus arnyi), and Rough Green Snake (Opheodrys aestivus aestivus). Sites containing or nearby to fishless or ephemeral ponds/pools may support the Eastern Tiger Salamander (Ambystoma tigrinum tigrinum).

Small mammals likely associated with this ecological site's reference state condition: Fox Squirrel (Sciurus niger), Woodland Vole (Microtus pinetorum), Least Shrew (Cryptotis parva), and Indiana Bat (Myotis sodalis). Indiana bats utilize suitable live, dying or dead roost trees for summer habitat and raising young. Suitable roost trees typically have exfoliating or flaking bark and are larger in diameter.

Invertebrates – Many native insect species are likely associated with this phase of this ecological site's reference state condition, especially native bees, ants, beetles, butterflies and moths, and crickets, grasshoppers and katydids. However we don't have enough information on these groups to assign them to this phase of this ecological site's reference state condition at this time.

*This section prepared by Mike Leahy, Natural Areas Coordinator, Missouri Department of Conservation, 2013

Other information

Forestry

Management: This ecological site is not recommended for traditional timber management activity. Historically this site was dominated by a ground cover of native prairie grasses and forbs. Some scattered open grown trees may have also been present. May be suitable for non-traditional forestry uses such as windbreaks, environmental plantings, alley cropping (a method of planting, in which rows of trees or shrubs are interspersed with rows of crops) or woody bio-fuels.

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.

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Approval

Chris Tecklenburg, 5/21/2020

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

Iowa Department of Natural Resources:
Lindsey Barney District Forester Oakland, IA
John Pearson Ecologist Des Moines, IA

LANDFIRE (The Nature Conservancy):
Randy Swaty Ecologist Evanston, IL

Natural Resources Conservation Service:
Rick Bednarek IA State Soil Scientist Des Moines, IA
Stacey Clark Regional Ecological Site Specialist St. Paul, MN
Tonie Endres Senior Regional Soil Scientist Indianapolis, IA
John Hammerly Soil Data Quality Specialist Indianapolis, IN
Lisa Kluesner Ecological Site Specialist Waverly, IA
Sean Kluesner Earth Team Volunteer Waverly, IA
Jeff Matthias State Grassland Specialist Des Moines, IA
Kevin Norwood Soil Survey Regional Director Indianapolis, IN
Doug Oelmann Soil Scientist Des Moines, IA
James Phillips GIS Specialist Des Moines, IA
Dan Pulido Soil Survey Leader Atlantic, IA
Melvin Simmons Soil Survey Leader Gallatin, MO
Tyler Staggs Ecological Site Specialist Indianapolis, IN
Jason Steele Area Resource Soil Scientist Fairfield, IA
Doug Wallace Ecological Site Specialist Columbia, MO

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)	Lisa Kluesner
Contact for lead author	
Date	05/03/2024
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):**

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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):**

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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:**
