Ecological site R107XB030IA
Sandy Dune Prairie

Last updated: 5/21/2020
Accessed: 04/19/2024

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); Loess Hills (251Cb) Subsection (Cleland et al. 2007).

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

Biophysical Setting (LANDFIRE, 2009): Central Tallgrass Prairie (4214210)

Ecological Systems (National Vegetation Classification System, Nature Serve 2015): Central Tallgrass Prairie (CES205.683)

Eilers and Roosa (1994): Sandy Dunes

Nebraska Game and Parks Commission (Steinauer and Rolfsmeier 2010): Missouri River Valley Dune Grassland

Ecological site concept

Sandy Dune Prairies are generally located within the green areas on the map (Figure 1). They occur on hillslopes, ridges, and interfluves. Soils are Entisols, Inceptisols, and Mollisols that are well- to excessively-drained and very deep, formed from glacial or alluvial sediments that have been reworked by wind. Soils are poorly-developed with limited water- and nutrient-holding capability, resulting in a sparsely vegetated plant community.

The historic pre-European settlement vegetation on this site was dominated by a variety of tallgrass prairie species. Canada wild rye (Elymus canadensis L.) and sand dropseed (Sporobolus cryptandrus (Torr.) A. Gray) are the dominant and diagnostic species of this ecological site (Steinauer and Rolfsmeier 2010). Herbaceous species typical of the plant community include cuman ragweed (Ambrosia psilostachya DC.), winged pigweed (*Cycloloma atriplicifolium* (Spreng.) J.M. Coult.), prairie threeawn (Aristida oligantha Michx.), and slickseed fuzzybean (Strophostyles leiosperma (Torr. & A. Gray) Piper) (Eilers and Roosa 1994; Steinauer and Rolfsmeier 2010). Devil's-tongue (Opuntia humifusa (Raf.) Raf.) can be a present but uncommon shrub component (Steinauer and Rolfsmeier 2010). Fire and sand blowouts were the primary disturbance factors that maintained this site, while drought and large mammal grazing were secondary factors (Lesica and Cooper 1999).

Relative to other prairie ecological sites in the MLRA, Sandy Dune Prairies have a lower overall species diversity.

Associated sites

R107XB013MO	**Calcareous Loess Protected Backslope Savanna** Calcareous loess soils on upland backslopes including Dow, Hamburg, and Ida
R107XB019MO	**Wet Floodplain Prairie** Somewhat-poorly to poorly drained clayey soils on floodplains including Ackmore, Aquents, Bremer, Calco, Colo, Cooper, Fluvaquents, Forney, Grantcenter, Holly Springs, Kezan, Lakeport, Larpenteur, Lawson, Mt. Sterling, Nishna, Orthents, Solomon, Tieville, Uturin, Vesser, Wabash, Woodbury, and Zook
R107XB008MO	**Loamy Footslope Savanna** Colluvium on upland footslopes including Castana, Colo, Danbury, Deloit, Ely, Judson, Napier, Nodaway, Olmitz, Udarents, and Udorthents
R107XB027IA	**Calcareous Till Upland Prairie** Calcareous till soils including Burchard, Liston, and Steinauer
R107XB018MO	**Ponded Floodplain Marsh** Ponded soils on floodplains including Aquolls, Darwin, Fluvaquents, Forney, and Levasy

Similar sites

R107XB006MO	**Calcareous Loess Exposed Backslope Prairie** Calcareous Loess Exposed Backslope Prairies are derived from calcareous loess and have greater species diversity, composition, and cover
R107XB012MO	**Calcareous Loess Upland Prairie** Calcareous Loess Upland Prairies are derived from calcareous loess and have greater species diversity, composition, and cover
R107XB002MO	**Deep Loess Upland Prairie** Deep Loess Upland Prairies are derived from leached loess and have greater species diversity, composition, and cover
R107XB027IA	**Calcareous Till Upland Prairie** Calcareous Till Upland Prairies are derived from glacial till and have greater species diversity, composition, and cover

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Elymus canadensis* (2) *Sporobolus cryptandrus*

Physiographic features

Sandy Dune Prairies occur on hillslopes and bluffs on uplands on dissected till plains (Figure 2). This ecological site is unique to the Loess Hills landform situated on elevations ranging from approximately 500 to 1,560 feet ASL. This site does not experience flooding but rather generates runoff to adjacent, downslope ecological sites.

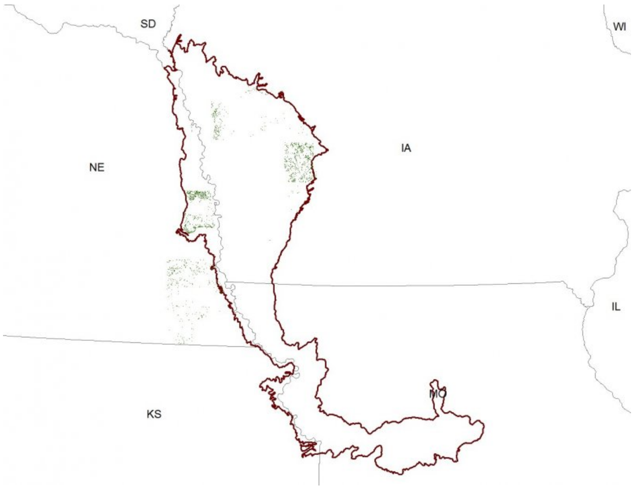


Figure 2. Figure 1. Location of Sandy Dune Prairie ecological site within MLRA 107B.

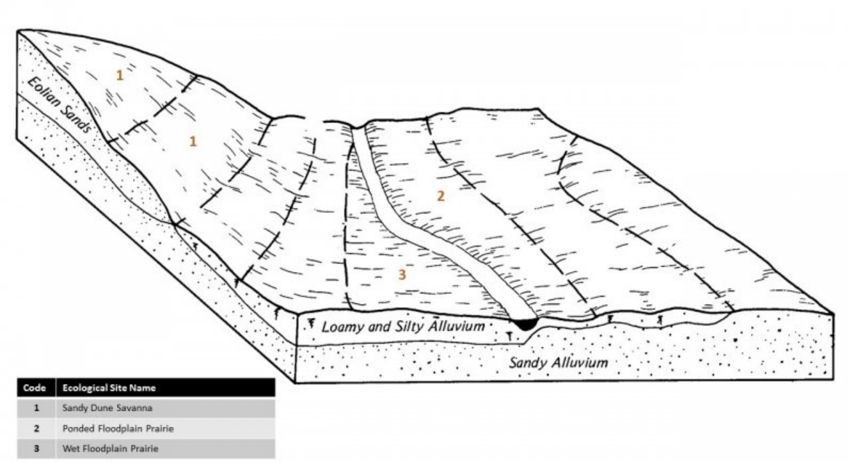


Figure 3. Figure 2. Representative block diagram of Sandy Dune Prairie and associated ecological sites.

Table 2. Representative physiographic features

Hillslope profile	(1) Shoulder (2) Backslope
Slope shape across	(1) Convex (2) Linear
Slope shape up-down	(1) Convex
Landforms	(1) Hill (2) Bluff
Elevation	499–1,558 ft

Slope	4–30%
Water table depth	80 in
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 34 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 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)	132-153 days
Freeze-free period (characteristic range)	151-184 days
Precipitation total (characteristic range)	32-35 in
Frost-free period (actual range)	128-166 days
Freeze-free period (actual range)	150-192 days
Precipitation total (actual range)	29-40 in
Frost-free period (average)	142 days
Freeze-free period (average)	168 days
Precipitation total (average)	34 in

Climate stations used

- (1) MAPLETON NO.2 [USC00135123], Mapleton, IA
- (2) GRETNA 4NE [USC00253467], Omaha, NE
- (3) CASTANA EXP FARM [USC00131277], Mapleton, IA
- (4) SIOUX CITY GATEWAY AP [USW00014943], Sioux City, IA
- (5) AUDUBON [USC00130385], Audubon, IA
- (6) ST JOSEPH ROSECRANS AP [USW00013993], Wathena, MO
- (7) MARSHALL [USW00013991], Marshall, MO

Influencing water features

Sandy Dune Prairies are not influenced by wetland or riparian water features. Precipitation is the main source of water for this ecological site. Infiltration is high (Hydrologic Group A), and surface runoff is low to very low. 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).

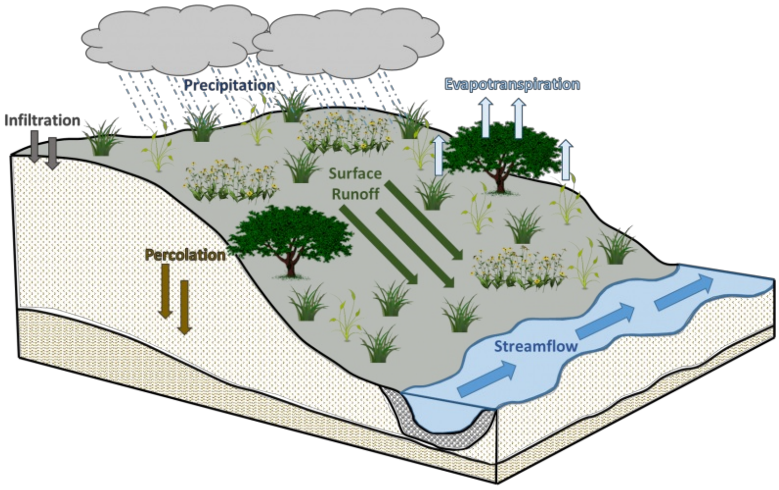


Figure 10. Figure 5. Hydrologic cycling in Sandy Dune Prairie ecological site.

Soil features

Soils of Sandy Dune Prairies are in the Entisol, Inceptisol and Mollisol orders, further classified as Typic Quartzipsamments, Typic Udipsamments, Dystric Eutrudepts, Entic Hapludolls, and Typic Hapludolls. The soil series associated with this site includes Boone, Chute, Dickinson, Dickman, and Sparta. The parent material is glacial or alluvial material that has been reworked by wind, and the soils are well- to excessively-drained and very deep with limited fragments. Soil pH classes are slightly acid to neutral. No rooting restrictions are noted for the soils of this ecological site. Average clay content is very low and limits extreme compaction, but erosion from wind and water can, in turn, be very high.

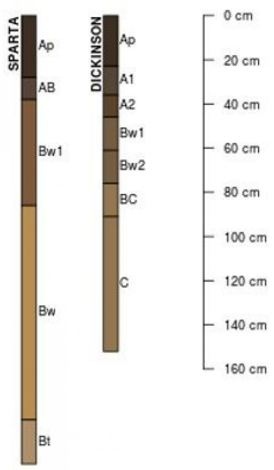


Figure 11. Figure 6. Profile sketches of soil series associated with Sandy Dune Prairie.

Table 4. Representative soil features

Parent material	(1) Eolian sands
Family particle size	(1) Coarse-loamy (2) Sandy
Drainage class	Well drained to excessively drained
Permeability class	Moderate to rapid

Soil depth	80 in
Available water capacity (0-40in)	3–5 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6.1–7.3

Ecological dynamics

Prairie ecosystems are regarded as the most endangered ecosystem in North America where an estimated four percent of the tallgrass prairie habitat remains (Steinauer and Collins 1996). The Loess Hills region of MLRA 107B were once dominated by tall and mixed-grass prairies, extending across more than 90 percent of the area (Farnsworth 2009). However, by the early twenty-first century much of the land had been converted to agriculture, leaving an estimated 20 percent of the region to be classified as “grassland” and another three percent classified as “remnant prairie” (Farnsworth 2009).

Sandy Dune Prairies form a vegetative continuum throughout the Loess Hills, where soil moisture serves as the primary influence on community composition (White 1983; White and Glenn-Lewin 1984). This ecological site can occur on nearly any aspect. Species characteristic of this ecological site are sun-loving, drought- and disturbance-tolerant plants.

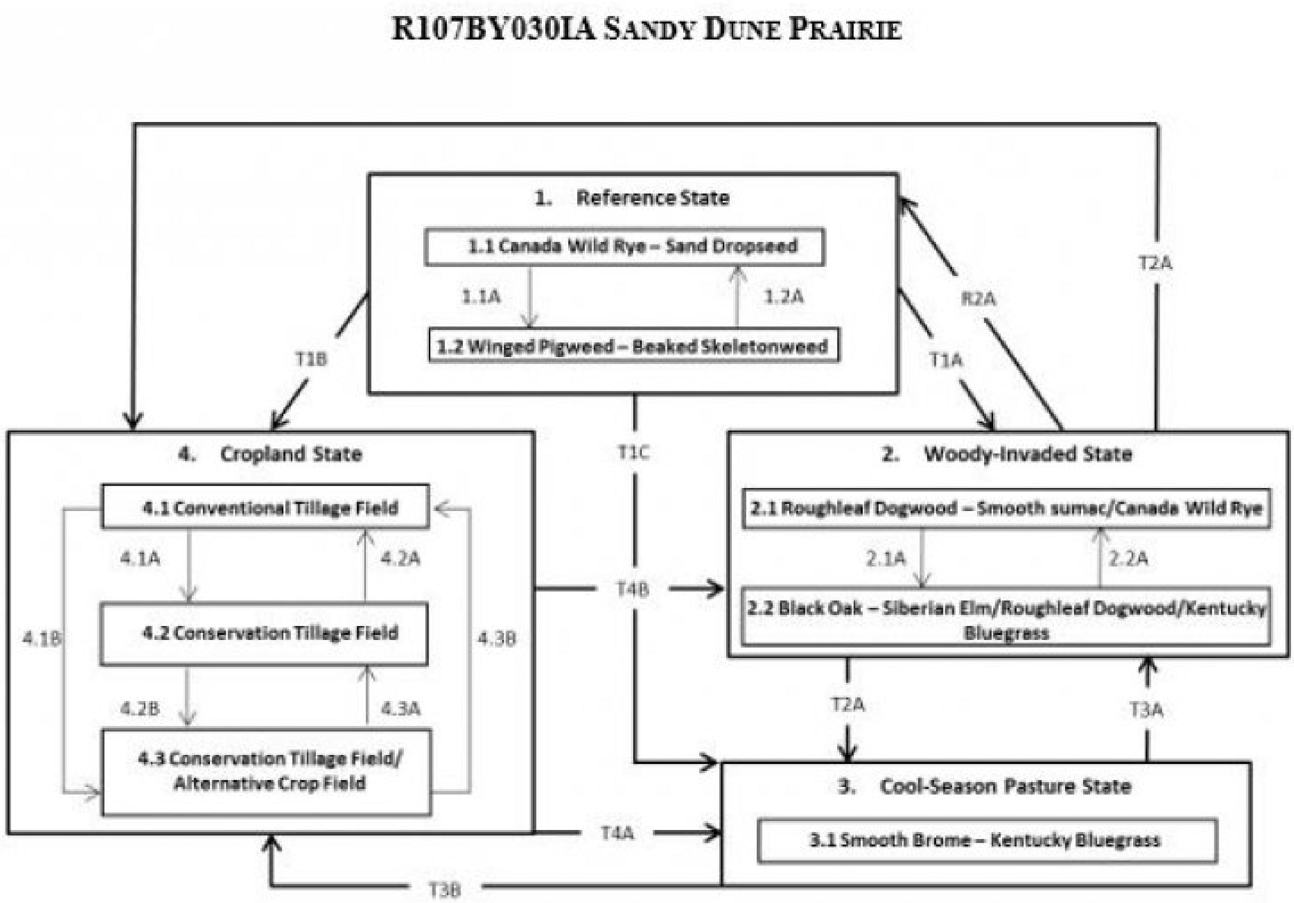
Blowouts are the dominant disturbance factor for Sandy Dune Prairies. The very high sand content allows for much erosion or shifting, creating numerous bare soil pockets across the site. These conditions result in a near-perpetual early-successional phase as evidenced by the inhabitation of annual herbaceous species and disturbance-tolerant vegetation.

The vegetation of this ecological site is sparse and patchy making fire a limited, but important, ecosystem driver for maintaining this ecological site. Fire intensity typically consisted of periodic, low-intensity surface fires. 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). This continuous disturbance provided critical conditions for perpetuating the native prairie ecosystem.

Drought has also played a role in shaping the prairie ecosystems 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, Sandy Dune Prairies are limited in their extent, having been converted to pasture or agricultural land. What remnants do exist are dominated by woody species and show evidence of indirect anthropogenic influence as some non-native species (e.g., Kentucky bluegrass (*Poa pratensis* L.), Siberian elm (*Ulmus pumila* L.)) are present on the site.

State and transition model



Code	Process
T1A, T3A	Woody invasion following fire-suppression and/or land abandonment
T1B, T3B	Agricultural conversion via tillage, seeding, and non-selective herbicide
T1C, T2A, T4A	Interseeding of non-native cool-season grasses and grazing
1.1A	Slope failure and/or fire exposes bare soil
1.1B	Natural succession after more than 2 years of no soil disturbance
R2A	Restore historic fire regime
2.1A	Natural succession as a result of no fire
2.2A	Natural succession following medium-intensity fire
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
T2B, T3C, T4B	Site preparation, non-native species control, and native seeding

Figure 12. STM

State 1
Reference State

The reference plant community is categorized as a sand dune prairie and is sparsely vegetated with drought- and disturbance-tolerant grasses and forbs. The reference community phase is dependent on a relatively continuous disturbance regime that exposes bare soil, such as from natural blowouts or fire. Shorter intervals maintain dominance by annual herbs, while less frequent intervals allow perennial vegetation to increase their importance in the plant canopy.

Community 1.1
Canada Wild Rye - Sand Dropseed

Species diversity is low for the site, and it is sparsely vegetated. The dominant species for this community include Canada wild rye and sand dropseed. Characteristic forbs include cuman ragweed and winged pigweed, and hairy bugseed (*Corispermum villosum* Rydb.) is a diagnostic species in Nebraska sites. Shrubs are limited in their extent but can include roughleaf dogwood (*Cornus drummondii* C.A. Mey.) and Devil's-tongue (Steinauer and Rolfsmeier 2010).

Dominant plant species

- Canada wildrye (*Elymus canadensis*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass

Community 1.2
Winged Pigweed-Beaked Skeletonweed

This community phase represents a recent disturbance event such as slope failure or fire that subsequently leaves expanses of bare soil. Overall species diversity may be highest during this recently disturbed phase as a result. Early-successional species dominate in these areas and include winged pigweed (*Cycloloma atriplicifolium* (Spreng.) J.M. Coult.) and beaked skeletonweed (*Shinnersoseris rostrata* (A. Gray) S. Tomb) (Steinauer and Rolfsmeier 2010).

Dominant plant species

- winged pigweed (*Cycloloma atriplicifolium*), other herbaceous
- beaked skeletonweed (*Shinnersoseris rostrata*), other herbaceous

Pathway P1.1A
Community 1.1 to 1.2

Slope failure and/or fire exposes bare soil.

Pathway P1.2A
Community 1.2 to 1.1

Fire on the landscape and/or treatment of weeds and grass seeding.

State 2
Woody Invaded State

The woody-invaded state occurs when the reference state is devoid of any disturbance. Two community phases define this state and are ultimately determined by time since last disturbance occurred. Initially, the shrub component generally increases its canopy cover and species diversity decreases. As the land remains untouched from natural or anthropogenic disturbances, woody species begin to dominate eventually forming a near continuous canopy.

Community 2.1
Roughleaf Dogwood – Smooth Sumac/Canada Wild Rye

This community phase represents the early stages of woody vegetation invasion and is characterized by an increasing shrub layer. During this phase, the site becomes dominated by weedy shrubs such as roughleaf dogwood (*Cornus drummondii* C.A. Mey) and smooth sumac (*Rhus glabra* L.). Herbs tolerant of a closing canopy (e.g., Canada wild rye) remain patchy in the understory (Steinauer and Rolfsmeier 2010).

Dominant plant species

- roughleaf dogwood (*Cornus drummondii*), shrub
- smooth sumac (*Rhus glabra*), shrub
- Canada wildrye (*Elymus canadensis*), grass

Community 2.2
Black Oak – Siberian Elm/Roughleaf Dogwood/Kentucky Bluegrass

Sites falling into this community phase are strongly dominated by a woody overstory. Black oak (*Quercus velutina* Lam.) is highly-adapted to sandy substrates and readily established during this phase (Carey 1992). Siberian elm is a frequent mid-canopy invader of the site and can become co-dominant with black oak. Roughleaf dogwood continues to dominate the shrub canopy while Kentucky bluegrass can invade the understory (Steinauer and Rolfsmeier 2010).

Dominant plant species

- black oak (*Quercus velutina*), tree
- Siberian elm (*Ulmus pumila*), tree
- roughleaf dogwood (*Cornus drummondii*), shrub
- Canadian wildrye (×*Elyleymus hirtiflorus*), grass

Pathway P2.1A
Community 2.1 to 2.2

Natural succession as a result of no disturbance

Pathway P2.2A
Community 2.2 to 2.1

Fire or other disturbance factor is used to control and eliminate the woody plant cover.

State 3
Cool Season Grassland State

The cool-season grassland 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 Kentucky bluegrass (*Poa pratensis* L.) in order to help extend the grazing season (Smith 1998). 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

- Kentucky bluegrass (*Poa pratensis*), grass
- reed canarygrass (*Phalaris arundinacea*), grass

Community 3.1
Smooth Brome - Kentucky Bluegrass

Species characteristic of this community phase include sand dropseed, smooth brome, and Kentucky bluegrass. While the native sand dropseed 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.

Dominant plant species

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

State 4
Cropland State

The Midwest is well-known for its 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 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 forseeable 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.

Transition T1A
State 1 to 2

Fire suppression transitions this site to the woody-invaded state (2).

Transition T1C
State 1 to 3

Overgrazing, interseeding non-native cool-season grasses, and brush control transition this site to the cool-season grassland state (3).

Transition T1B
State 1 to 4

Installation of drain tiles, 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 brush and non-native species and reintroduction of a historic fire regime restore the site back to the reference state (1).

Transition T3A
State 3 to 2

Land is abandoned and transitions this site to the woody-invaded state (2).

Transition T3B
State 3 to 4

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

Transition T4B
State 4 to 2

Land is abandoned and left fellow; natural succession by opportunistic species transitions this site to the woody-invaded state (2).

Restoration pathway T4A
State 4 to 3

Non-selective herbicide and seeding of non-native cool-season grasses transitions the site to the cool-season grassland 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 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

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.

Carey, J.H. 1992. *Quercus velutina*. In: Fire Effects Information System [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory. Available at http://www.fs/fed/us/database/feis. (Accessed 24 April 2017).

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 Coterminous United States. USDA Forest Service, General Technical Report WO-76. Washington, DC. 92 pps.

Day, G. 1953. The Indian as an ecological factor in the northeastern forest. Ecology 34: 329-346.

Decker, W.L. 2017. Climate of Missouri. University of Missouri, Missouri Climate Center, College of Agriculture, Food and Natural Resources. Available at http://climate.missouri.edu/climate.php. (Accessed 24 February 2017).

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.

Farnsworth, D.A. 2009. Establishing restoration baselines for the Loess Hills region. M.S. Thesis. Iowa State University, Ames, IA. 123 pps.

LANDFIRE. 2009. Biophysical Setting 4214210 Central Tallgrass Prairie. In: LANDFIRE National Vegetation Dynamics Models. USDA Forest Service and US Department of Interior. Washington, DC.

Lesica, P. and S.V. Cooper. 1999. Succession and disturbance in sandhills vegetation: constructing models for managing biological diversity. Conservation Biology 13: 293-302.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1 NatureServe, Arlington, VA. Available at http://explorer.natureserve.org. (Accessed 13 February 2017).

Nigh, T.A. and W.A. Schroeder. 2002. Atlas of Missouri Ecoregions. Missouri Department of Conservation, Jefferson City, Missouri.

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.

Prior, J.C., J.L. Boekhoff, M.R. Howes, R.D. Libra, and P.E. VanDorpe. 2003. Iowa's Groundwater Basics: A Geological Guide to the Occurrence, Use, & Vulnerability of Iowa's Aquifers. Iowa Department of Natural Resources, Iowa Geological Survey Educational Series 6. 92 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.

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.

Stambaugh, M.C., R.P. Guyette, E.R. McMurry, and D.C. Dey. 2006. Fire history at the Eastern Great Plains Margin, Missouri River Loess Hills. Great Plains Research 16: 149-59.

Steinauer, E.M. and L. Collins. 1996. Prairie ecology: the tallgrass prairie. In: Samson, F.B. and F.L. Knopf, eds. Prairie Conservation: Preserving North America's Most Endangered Ecosystem. Island Press, Washington, D.C. 351 pps.

Steinauer, G. and S. Rolfsmeier. 2010. Terrestrial Natural Communities of Nebraska, Version IV. Unpublished report of the Nebraska Game and Parks Commission. Lincoln, NE. 224 pps.

Stockton, C.W. and D.M. Meko. 1983. Drought recurrence in the Great Plains as reconstructed from long-term tree-ring records. Journal of Climate and Applied Meteorology 22: 17-29.

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.

United States Department of Agriculture – Natural Resource 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.

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).

U.S. Geological Survey. 1999. Geology of the Loess Hills, Iowa. Information Handout, July. U.S. Department of the Interior, U.S. Geological Survey. Available at https://pubs.usgs.gov/info/loess/. (Accessed 27 February 2017).

Visher, S.S. 1954. Climatic Atlas of the United States. Harvard University Press, Cambridge, MA. 403pps.

White, J.A. 1983. Regional and Local Variation in Composition and Structure of the Tallgrass Prairie Vegetation of Iowa and Eastern Nebraska. M.S. Thesis. Iowa State University, Ames, IA. 168 pps.

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.

White, J.A. and S.C. Glenn-Lewin. 1984. Regional and local variation in tallgrass prairie remnants of Iowa and eastern Nebraska. Vegetatio 57: 65-78.

Approval

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Rangeland health reference sheet

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

Author(s)/participant(s)	Lisa Kluesner
Contact for lead author	
Date	04/19/2024
Approved by	Chris Tecklenburg
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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

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

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

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

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

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

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

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

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

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

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

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:**