USDA Natural Resources
Conservation Service

Ecological site R107XB003MO
Deep Loess Exposed Backslope Savanna

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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); Deep Loess Hills (251Ca), Loess Hills (251Cb) Subsection; Nebraska Rolling Hills Section (251H), Yankton Hills and Valleys (251Ha), Pawnee City-Seneca Rolling Hill (251Hd) (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 Grassland (CEGL002159); Quercus macrocarpa – (Quercus alba, Quercus velutina)/Andropogon gerardii Wooded Grassland (CEGL002020)

Rosburg (1994): Bur Oak Woodland

Ecological site concept

Deep Loess Exposed Backslope Savannas are mapped in complex with Deep Loess Protected Backslope Woodlands and are generally located within the green areas on the map (Figure 1). They occur on south- and west-facing backslopes with slopes greater than fifteen percent. Soils are Alfisols, Entisols, Inceptisols, and Mollisols that are well-drained and very deep, formed from loess. These fine-silty, fertile soils have high soil uniformity resulting in increased nutrient- and water-holding capacity, increased organic matter retention, and good soil aeration that allows deep penetration by plant roots, which generally results in high plant productivity (Catt 2001). These sites reside downslope from and adjacent to other deep loess ecological sites.

The historic pre-European settlement vegetation on this site was dominated by tall- and midgrass prairie species, with oaks interspersed across the landscape. Bur oak (Quercus macrocarpa Michx.) is the dominant tree species, while white oak (Quercus alba L.) and leadplant (Amorpha canescens Pursh) are characteristic components. Little bluestem (Schizachyrium scoparium (Michx.) Nash) is the dominant grass species and indicative of the dry environment resulting from the south and west exposures (Nuzzo 1994; Whitney 1994; Nelson 2010). Forb species typical of an undisturbed plant community associated with this ecological site include white prairie clover (Dalea candida Michx. ex Willd.) and rattlesnake master (Eryngium yuccifolium Michx.) (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 (LANDFIRE 2009; Nelson 2010).

Associated sites

R107XB006MO	**Calcareous Loess Exposed Backslope Prairie** Calcareous loess soils on slopes greater than 15 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 15 percent, including Dow and Ida

Similar sites

R107XB013MO	**Calcareous Loess Protected Backslope Savanna** Calcareous Loess Protected Backslope Savannas are similar in landscape position but only occur on north- and east-aspects

Table 1. Dominant plant species

Tree	(1) *Quercus macrocarpa* (2) *Quercus alba*
Shrub	(1) *Amorpha canescens*
Herbaceous	(1) *Schizachyrium scoparium* (2) *Dalea candida*

Physiographic features

Deep Loess Exposed Backslope Savannas occur on upland backslopes with slopes greater than fifteen percent on dissected till plains (Figure 2). This ecological site is unique to the Loess Hills landform situated on elevations ranging from approximately 700 to 1,545 feet ASL. This site does not experience flooding but rather generates runoff to adjacent, downslope ecological sites.

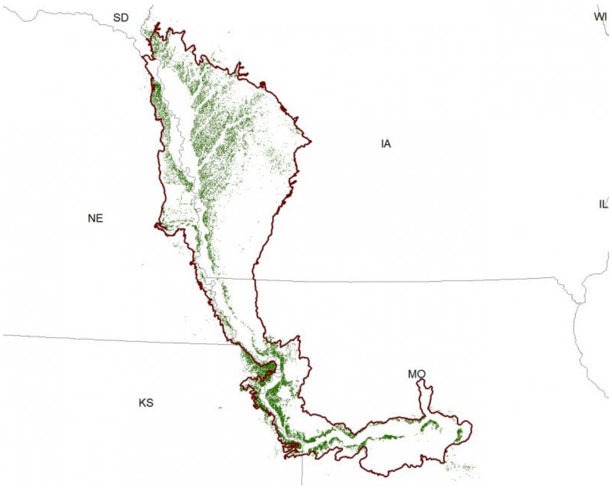


Figure 2. Figure 1. Location of Deep Loess Exposed Backslope Savanna ecological site within MLRA 107B.

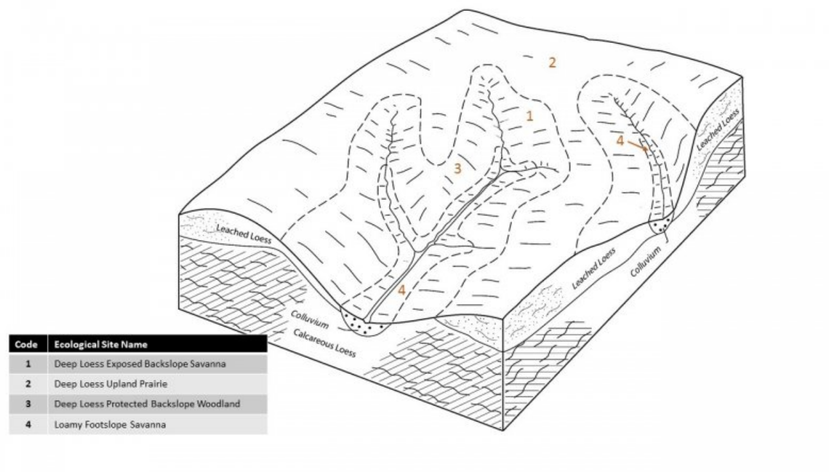


Figure 3. Figure 2. Representative block diagram of Deep Loess Exposed Backslope Savanna and associated ecological sites.

Table 2. Representative physiographic features

Hillslope profile	(1) Backslope
Slope shape across	(1) Linear (2) Convex
Slope shape up-down	(1) Concave (2) Convex
Landforms	(1) Hillslope
Flooding frequency	None
Ponding frequency	None
Slope	14–35%
Water table depth	80 in
Aspect	W, S, SW

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 186 days, while the frost-free period is about 160 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 36 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 40 and 62°F, respectively.

Climate data and analyses are derived from 30-year average gathered from seven 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)	134-156 days
Freeze-free period (characteristic range)	159-188 days
Precipitation total (characteristic range)	32-38 in
Frost-free period (actual range)	128-163 days
Freeze-free period (actual range)	153-193 days
Precipitation total (actual range)	32-41 in
Frost-free period (average)	146 days
Freeze-free period (average)	176 days
Precipitation total (average)	35 in

Climate stations used

- (1) MAPLETON NO.2 [USC00135123], Mapleton, IA
- (2) SIDNEY [USC00137669], Sidney, IA
- (3) LEXINGTON 3E [USC00234904], Lexington, MO
- (4) KANSAS CITY INTL AP [USW00003947], Kansas City, MO
- (5) CASTANA EXP FARM [USC00131277], Mapleton, IA
- (6) LOGAN [USC00134894], Logan, IA
- (7) OREGON [USC00236357], Oregon, MO

Influencing water features

Deep Loess Exposed Backslope Savannas are not influenced by wetland or riparian water features. Precipitation is the main source of water for this ecological site. Infiltration is moderate to slow (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).

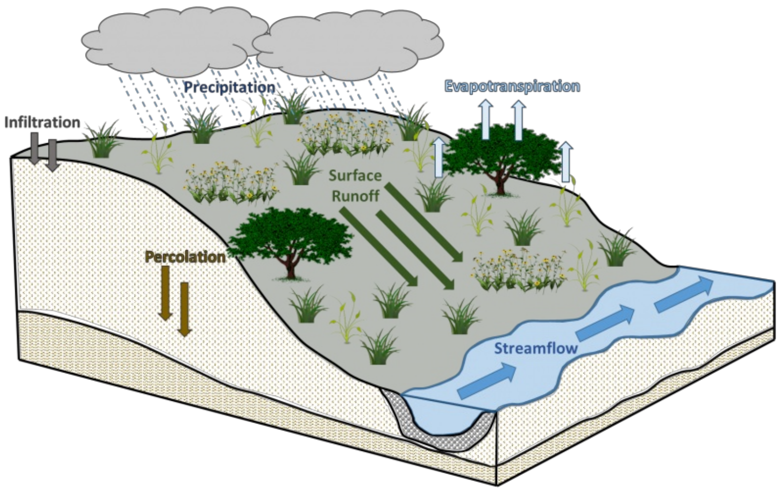


Figure 10. Figure 5. Hydrologic cycling in Deep Loess Exposed Backslope Savanna.

Soil features

Soils of Deep Loess Exposed Backslope Savannas are in the Alfisol, Entisol, Inceptisol, and Mollisol orders, further classified as Mollic Hapludalfs, Typic Hapludalfs, Dystric Eutrudepts, and Typic Hapludolls. The soil series associated with this site includes Knox, Marshall, Monona, Udarents, and Udorthents. The parent material is loess, and the soils are well-drained and very deep with no coarse fragments. Soil pH classes are strongly acid to moderately alkaline. No rooting restrictions are noted for the soils of this ecological site.

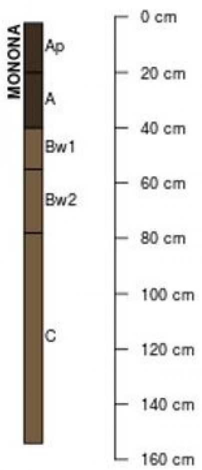


Figure 11. Figure 6. Profile sketch of soil series associated with Deep Loess Exposed Backslope Savanna.

Table 4. Representative soil features

Parent material	(1) Loess
Surface texture	(1) Silt loam (2) Silty clay loam
Family particle size	(1) Fine-silty
Drainage class	Well drained
Permeability class	Slow to moderately slow
Soil depth	80 in
Available water capacity (0-40in)	8–9 in
Calcium carbonate equivalent (0-40in)	0–20%

Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	5.1–8.4

Ecological dynamics

Deep Loess Exposed Backslope Savannas form a vegetative continuum throughout the prairie-woodland borders of the Loess Hills (NatureServe 2015). This ecological site occurs on south- and west-facing backslopes on well-drained loess soils. Species characteristic of this ecological site are scattered bur and white 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, Deep Loess Exposed Backslope Savannas are limited in their extent, having been significantly reduced as a result of conversion to cool-season grassland and continuous grazing (Nelson 2010). Areas where slopes are less than twenty percent may have been converted to cropland, but these comprise a small portion of the landscape. Sites where reference community savannas occur have experienced a shift in species composition and cover due to a successful long-term fire suppression policy. The current savannas exhibit a more closed-canopy forest community that has limited oak regeneration (LANDFIRE 2009). In addition, invasive species are rapidly threatening the remaining native community. A return to the historic plant community may not be possible, but efforts to recover ecological functioning can improve savanna ecosystem services.

STATE 1 – REFERENCE STATE

The reference plant community is categorized as an oak savanna, defined by a continuous ground layer of grasses and forbs, a ten to 30 percent canopy of oaks, and a sparse layer of shrubs (Asbjornsen et al. 2005; Nelson 2010; NatureServe 2015). 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 community. Grazing and drought disturbances have less impact in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

Community Phase 1.1 Bur Oak – White Oak/Leadplant/Little Bluestem – White Prairie Clover – This reference community phase supports sparse, widely-scatted bur and white oaks with a canopy coverage up to fifteen percent. Mean fire return interval is less than five years (LANDFIRE 2009). Oaks are approximately 30 to 60 feet tall and medium-sized (9 to 21 inch DBH) (LANDFIRE 2009; Nelson 2010). Shagbark hickory (*Carya ovata* (Mill.) K. Koch) may be present in low abundance (NatureServe 2015). Shrubs are limited and generally consist of small patches of leadplant. The understory supports a variety of dry prairie species including little bluestem and white prairie clover.

Pathway 1.1A – Natural succession as a result of a fire-free period between 5 and 10 years.

Community Phase 1.2 Bur Oak – White Oak/Wild Plum – Leadplant/Little Bluestem – This reference community phase can occur when fire frequency is reduced to no more than ten years. The bur and white oak component matures, reaching large size classes (21 to 33 inches DBH) and canopy coverage up to 30 percent (LANDFIRE 2009). The native prairie grasses continue to form the dominant herbaceous component, but the reduced fire interval allows perennial grass thatch to increase and shade out some of the smaller-statured forbs. Leadplant increases its cover in the shrub canopy with wild plum (*Prunus americana* Marshall) becoming co-dominant.

Pathway 1.2A – Natural succession as a result of a fire-free period less than five years.

Transition 1A – Fire suppression transitions this site to the fire-suppressed woodland state (2).

Transition 1B – 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).

STATE 2 – FIRE-SUPPRESSED STATE

Long-term fire suppression can transition the reference savanna community into a fire-suppressed closed-canopy state. As the natural fire regime is removed from the landscape, encroachment by shade-tolerant species ensues as the overstory canopy becomes denser (Asbjornsen et al 2005). Succession to this state can occur in as little as 25 years from the last fire (LANDFIRE 2009).

Community Phase 2.1 Bur Oak – White Oak/Shagbark Hickory – Eastern Redcedar/Roughleaf Dogwood/Eastern Woodland Sedge – This community phase represents the early stages of long-term fire-suppression of the native savanna. Bur oak and white oak are still the dominant canopy species, but shagbark hickory (*Carya ovata* (Mill.) K. Koch) and eastern redcedar (*Juniperus virginiana* L.) arise in the sub-canopy. Green ash (*Fraxinus pennsylvanica* Marshall) and common hackberry (*Celtis occidentalis* L.) may occur infrequently as well (Steinauer and Rolfsmeier 2010). Canopy coverage ranges between 60 and 80 percent and tree size class is very large (greater than 33 inches DBH) (LANDFIRE 2009). Roughleaf dogwood increases in the shrub canopy with scattered patches of coralberry (*Symphoricarpos orbiculatus* Moench). As the overstory becomes denser, the herbaceous layer shifts to dominance by more shade-tolerant species such as eastern woodland sedge (*Carex blanda* Dewey) (Rosburg 1994; Steinauer and Rolfsmeier 2010).

Pathway 2.1A – Fire is removed from the landscape in excess of 30 years.

Restoration 2A – Mechanical or chemical control of undesirable woody species and non-native species and reintroduction of a historic fire regime restore the site back to the reference state (1).

Community Phase 2.2 Oak – Shagbark Hickory/Eastern Redcedar – Black Cherry/Roughleaf Dogwood/Eastern Woodland Sedge – Sites falling into this community phase are still dominated by oaks, but shagbark hickory becomes a co-dominant. Canopy coverage can reach 100 percent (LANDFIRE 2009). Eastern redcedar continues to inhabit the subcanopy along with black cherry (*Prunus serotina* Ehrh.), and the shrub component becomes dense with roughleaf dogwood and coralberry. The understory persists but is very sparse with only shade-tolerant species (LANDFIRE 2009; Steinauer and Rolfsmeier 2010).

Pathway 2.2A – Fire is restored to the landscape within 25 years of initial encroachment.

Restoration 2B – Site preparation, invasive species control (native and non-native), and seeding native species transition this site to the reconstructed savanna state (4).

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.

Community Phase 3.1 Smooth Brome – Kentucky Bluegrass – Species characteristic of this community phase include smooth brome and Kentucky bluegrass. While some native prairie species persist, 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).

Restoration 3A – Site preparation, invasive species control (native and non-native), and seeding native species transition this site to the reconstructed savanna state (4).

STATE 4 – 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. Bur 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 will 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 bur 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 Phase 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 seed mix utilized. If bur 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.

Pathway 4.1A – 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.

Community Phase 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 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).

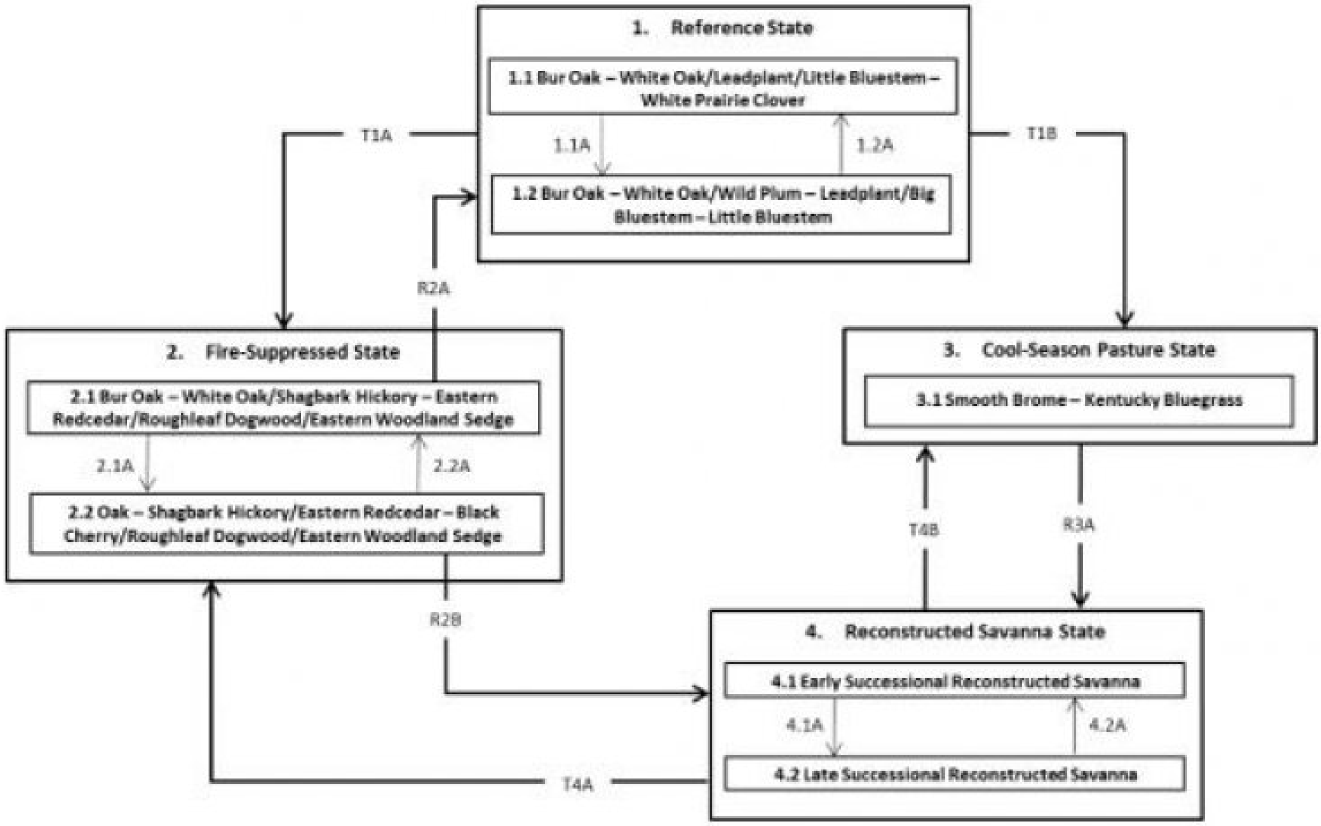
Pathway 4.2B – Reconstruction experiences a decrease in native species diversity from drought or improper timing of management actions (e.g., reduced fire frequency, use of non-selective herbicides).

Transition 4A – Fire suppression and removal of active management transitions this site to the fire-suppressed woodland state (2).

Transition 4B – 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).

State and transition model

R107BY003MO Deep Loess Exposed Backslope Savanna



Code	Process
T1A, T4A	Fire suppression
T1B, T4B	Woody species reduction, fire suppression, non-selective herbicide, interseeding of non-native cool-season grasses, and continuous grazing
1.1A	Fire-free period, 5-10 years
1.2A	Fire-free period, less than 5 years
R2A	Selective tree removal, non-native species control, and reintroduction of historic fire regime
2.1A	Fire-free period, >25 years
2.2A	Fire-free period, <25 years
R2B,R3A	Site preparation, invasive species control, and seeding native species
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 an oak savanna, defined by a continuous ground layer of grasses and forbs, a ten to 30 percent canopy of oaks, and a sparse layer of shrubs (Asbjornsen et al. 2005; Nelson 2010; NatureServe 2015). 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 community. 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

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

- leadplant (*Amorpha canescens*), shrub
- little bluestem (*Schizachyrium scoparium*), grass

Community 1.1
Bur Oak – White Oak/Leadplant/Little Bluestem – White Prairie Clover

This reference community phase supports sparse, widely-scatted bur and white oaks with a canopy coverage up to fifteen percent. Mean fire return interval is less than five years (LANDFIRE 2009). Oaks are approximately 30 to 60 feet tall and medium-sized (9 to 21 inch DBH) (LANDFIRE 2009; Nelson 2010). Shagbark hickory (*Carya ovata* (Mill.) K. Koch) may be present in low abundance (NatureServe 2015). Shrubs are limited and generally consist of small patches of leadplant. The understory supports a variety of dry prairie species including little bluestem and white prairie clover.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- white oak (*Quercus alba*), tree
- leadplant (*Amorpha canescens*), shrub
- little bluestem (*Schizachyrium scoparium*), grass

Community 1.2
Bur Oak – White Oak/Wild Plum – Leadplant/Little Bluestem

This reference community phase can occur when fire frequency is reduced to no more than ten years. The bur and white oak component matures, reaching large size classes (21 to 33 inches DBH) and canopy coverage up to 30 percent (LANDFIRE 2009). The native prairie grasses continue to form the dominant herbaceous component, but the reduced fire interval allows perennial grass thatch to increase and shade out some of the smaller-statured forbs. Leadplant increases its cover in the shrub canopy with wild plum (*Prunus americana* Marshall) becoming co-dominant.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- white oak (*Quercus alba*), tree
- leadplant (*Amorpha canescens*), shrub
- little bluestem (*Schizachyrium scoparium*), grass

Pathway P1.1A
Community 1.1 to 1.2

Natural succession as a result of a fire-free period between 5 and 10 years.

Pathway P1.2A
Community 1.2 to 1.1

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

State 2
Fire Suppressed State

Long-term fire suppression can transition the reference savanna community into a fire-suppressed closed-canopy state. As the natural fire regime is removed from the landscape, encroachment by shade-tolerant species ensues as the overstory canopy becomes denser (Asbjornsen et al 2005). Succession to this state can occur in as little as 25 years from the last fire (LANDFIRE 2009).

Dominant plant species

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

- shagbark hickory (*Carya ovata*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- roughleaf dogwood (*Cornus drummondii*), shrub
- eastern woodland sedge (*Carex blanda*), grass

Community 2.1
Bur Oak – White Oak/Shagbark Hickory – Eastern Redcedar/Roughleaf Dogwood/Eastern Woodland Sedge

This community phase represents the early stages of long-term fire-suppression of the native savanna. Bur oak and white oak are still the dominant canopy species, but shagbark hickory (*Carya ovata* (Mill.) K. Koch) and eastern redcedar (*Juniperus virginiana* L.) arise in the sub-canopy. Green ash (*Fraxinus pennsylvanica* Marshall) and common hackberry (*Celtis occidentalis* L.) may occur infrequently as well (Steinauer and Rolfsmeier 2010). Canopy coverage ranges between 60 and 80 percent and tree size class is very large (greater than 33 inches DBH) (LANDFIRE 2009). Roughleaf dogwood increases in the shrub canopy with scattered patches of coralberry (*Symphoricarpos orbiculatus* Moench). As the overstory becomes denser, the herbaceous layer shifts to dominance by more shade-tolerant species such as eastern woodland sedge (*Carex blanda* Dewey) (Rosburg 1994; Steinauer and Rolfsmeier 2010).

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- white oak (*Quercus alba*), tree
- roughleaf dogwood (*Cornus drummondii*), shrub
- eastern woodland sedge (*Carex blanda*), grass

Community 2.2
Oak – Shagbark Hickory/Eastern Redcedar – Black Cherry/Roughleaf Dogwood/Eastern Woodland Sedge

Sites falling into this community phase are still dominated by oaks, but shagbark hickory becomes a co-dominant. Canopy coverage can reach 100 percent (LANDFIRE 2009). Eastern redcedar continues to inhabit the subcanopy along with black cherry (*Prunus serotina* Ehrh.), and the shrub component becomes dense with roughleaf dogwood and coralberry. The understory persists but is very sparse with only shade-tolerant species (LANDFIRE 2009; Steinauer and Rolfsmeier 2010).

Dominant plant species

- oak (*Quercus*), tree
- shagbark hickory (*Carya ovata*), tree
- roughleaf dogwood (*Cornus drummondii*), shrub
- eastern redcedar (*Juniperus virginiana*), shrub
- black cherry (*Prunus serotina*), 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

Fire is restored to the landscape within 25 years of initial encroachment.

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 smooth brome and Kentucky bluegrass. While some native prairie species persist, 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

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

State 4
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. Bur 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 will 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 bur 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 seed mix utilized. If bur 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 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 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 P4.1A
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 P4.2A
Community 4.2 to 4.1

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 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).

Transition T1A
State 1 to 2

Fire suppression transitions this site to the fire-suppressed woodland 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).

Restoration pathway R2A
State 2 to 1

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

Restoration pathway R2B
State 2 to 4

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

Restoration pathway R3A
State 3 to 4

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

Transition T4A
State 4 to 2

Transition 4A – Fire suppression and removal of active management transitions this site to the fire-suppressed woodland state (2).

Transition T4B
State 4 to 3

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

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.

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, Northern Bobwhite

Medium Vegetation Height (0.5 – 1 meter, moderate litter levels, some bare ground visible): Eastern Meadowlark, Dickcissel, Field Sparrow, Northern Bobwhite, Bobolink, Eastern Kingbird

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

Amphibian and reptile species associated with this ecological site's reference state condition: Ornate Box Turtle (Terrapene ornata ornata), Western Slender Glass Lizard (Ophisaurus attenuatus attenuatus), Great Plains Skink (Eumeces obsoletus), Northern Prairie Skink (E. septentrionalis septentrionalis), Prairie Kingsnake (Lampropeltis calligaster calligaster), and Bullsnake (Pituophis catenifer sayi).

Small mammals associated with this ecological site's reference state condition:
Prairie Vole (Microtus ochrogaster), Meadow Jumping Mouse (Zapus hudsonius), Plains Pocket Gopher (Geomys bursarius), Franklin's Ground Squirrel (Spermophilus franklinii), and Thirteen-lined Ground Squirrel (Spermophilus tridecemlineatus).

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 include: Prairie Meadow Katydid (Conocephalus saltans), Packard's Grasshopper (Melanoplus packardii), Mermiria Grasshopper (Mermiria picta), Black-margined Shield-back Katydid (Pediodectes nigromarginata), Ottoe Skipper butterfly (Hesperia ottoe) and two native bees (Tetraloniella albata, Diadasia enavata).

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 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 can support the Eastern Tiger Salamander (Ambystoma tigrinum tigrinum).

Small mammals 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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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):**

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

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

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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):**

---

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:**
