Ecological site R107XA203IA
Calcareous Till Exposed Backslope Prairie

Last updated: 5/21/2020
Accessed: 04/25/2024

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 Minnesota Loess Hills (MLRA 107A) includes the Northwest Iowa Plains, Inner Coteau, and Coteau Moraines landforms (Prior 1991; MDNR 2005). It spans two states (Iowa, 89 percent; Minnesota, 11 percent), encompassing approximately 4,470 square miles (Figure 1). The elevation ranges from approximately 1,700 feet above sea level (ASL) on the highest ridges to about 1,115 feet ASL in the lowest valleys. Local relief is mainly 10 to 100 feet. However, some valley floors can range from 80 to 200 feet, while some upland flats only range between 3 and 6 feet. The eastern half of the MLRA is underlain by Wisconsin-age till, deposited between 20,000 and 30,000 years ago and is known as the Sheldon Creek Formation. The western half is underlain by Pre-Illinoian glacial till, deposited more than 500,000 years ago and has since undergone extensive erosion and dissection. Both surfaces are covered by approximately 4 to 20 feet of loess on the hillslopes, and Holocene alluvium covers the till in the drainageways. Cretaceous bedrock, comprised of sandstone and shale, lies beneath the glacial material (USDA-NRCS 2006).

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

Classification relationships

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

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

National Vegetation Classification – Ecological Systems: Northern Tallgrass Prairie (CES205.686) (NatureServe 2015)

National Vegetation Classification - Plant Associations: Andropogon gerardii – Hesperostipa spartea – Sporobolus

heterolepis Grassland (CEGL002202) (NatureServe 2015)

Biophysical Settings: Northern Tallgrass Prairie (BpS 4214200) (LANDFIRE 2009)

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

Iowa Department of Natural Resources: Blacksoil Tallgrass Prairie (INAI 1984)

Minnesota Department of Natural Resources: Ups13d Dry Hill Prairie (Southern) (MDNR 2005)

Ecological site concept

Calcareous Till Exposed Backslope Prairies are located within the green areas on the map (Figure 1). They occur on south and west-facing upland backslopes on slopes greater than 20 percent. The soils are Mollisols and Entisols that are well drained and deep, formed in calcareous glacial till. These fine-loamy soils experience moisture deficits during the growing season most years and frequent deficits during times of droughts (MDNR 2005; NatureServe 2015).

The historic pre-European settlement vegetation on this site was dominated by herbaceous species typical of a midgrass prairie. Little bluestem (Schizachyrium scoparium (Michx.) Nash) and sideoats grama (Bouteloua curtipendula (Michx.) Torr.) are the dominant grass species of Calcareous Till Exposed Backslope Prairies. Other grasses that may occur include composite dropseed (Sporobolus compositus (Poir.) Merr. var. compositus), big bluestem (Andropogon gerardii Vitman), and Indiangrass (Sorghastrum nutans (L.) Nash) (MDNR 2005). Forbs typical of an undisturbed plant community associated with this ecological site include purple prairie clover (Dalea purpurea Vent.), blacksamson echinacea (Echinacea angustifolia DC.), and tall blazing star (Liatris aspera Michx.) (Drobney et al. 2001; MDNR 2005). Shrub cover is sparse, with western snowberry (Symphoricarpos occidentalis Hook.) and leadplant (Amorpha canescens Pursh.) the most commonly encountered species (MDNR 2005). Fire is the primary disturbance factor that maintains this site, while drought and herbivory are secondary factors (MDNR 2005; LANDFIRE 2009).

Associated sites

R107XA202IA	**Calcareous Till Upland Prairie** Glacial till on uplands that are shallow to calcium carbonates including Moneta and Steinauer
R107XA204IA	**Calcareous Till Protected Backslope Savanna** Glacial till on north and east facing upland backslopes with slopes greater than 20 percent that are shallow to calcium carbonates including Cornell, Moneta, Steinauer, and Soils that are moderately deep to carbonates

Similar sites

R107XA211IA	**Footslope Prairie** Footslope Prairies are derived from colluvium and occur at the bottom of Calcareous Till backslope ecological sites
R107XA204IA	**Calcareous Till Protected Backslope Savanna** Calcareous Till Protected Backslope Savannas are similar in parent material but occur on north and east aspects on upland backslopes
R107XA206IA	**Outwash Upland Prairie** Outwash Upland Prairies are derived from glacial outwash and have a lower soil fertility resulting in a similar, but sparser, plant community.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified

Herbaceous	(1) *Schizachyrium scoparium* (2) *Bouteloua curtipendula*

Physiographic features

Calcareous Till Exposed Backslope Prairies occur on south and west-facing upland backslopes on slopes greater than 20 percent (Figure 2). They are situated on elevations ranging from approximately 649 to 1801 feet ASL. The site does not experience flooding but rather generates runoff to adjacent, downslope ecological sites.

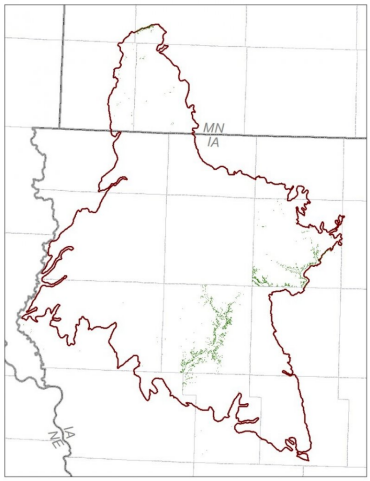


Figure 2. Figure 1. Location of Calcareous Till Exposed Backslope Prairie ecological site within MLRA 107A.

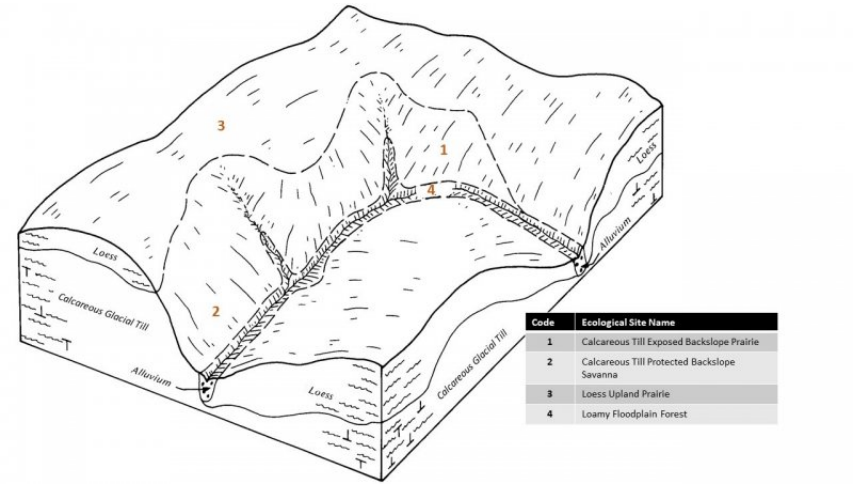


Figure 3. Figure 2. Representative block diagram of Calcareous Till Exposed Backslope Prairie and associated ecological sites.

Table 2. Representative physiographic features

Hillslope profile	(1) Backslope
Slope shape across	(1) Convex
Slope shape up-down	(1) Convex
Landforms	(1) Upland > Hillslope
Runoff class	High to very high
Elevation	649–1,801 ft
Slope	15–45%
Water table depth	60–80 in
Aspect	W, NW, S, SW

Climatic features

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

The soil temperature regime of MLRA 107A is classified as mesic, where the mean annual soil temperature is between 46 and 59°F (USDA-NRCS 2006). Temperature and precipitation occur along a north-south gradient, where temperature and precipitation increase the further south one travels. The average freeze-free period of this ecological site is about 157 days, while the frost-free period is about 134 days (Table 2). The majority of the precipitation occurs as rainfall in the form of convective thunderstorms during the growing season. Average annual precipitation is approximately 32 inches, which includes rainfall plus the water equivalent from snowfall. The average annual low and high temperatures are 36 and 58°F, respectively (Table 3).

Climate data and analyses are derived from 30-year averages gathered from two 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)	126 days
Freeze-free period (characteristic range)	147-149 days
Precipitation total (characteristic range)	31 in
Frost-free period (actual range)	126 days
Freeze-free period (actual range)	147-149 days
Precipitation total (actual range)	31-32 in
Frost-free period (average)	126 days
Freeze-free period (average)	148 days
Precipitation total (average)	31 in

Climate stations used

- (1) CHEROKEE [USC00131442], Cherokee, IA
- (2) SIOUX RAPIDS 4 E [USC00137726], Sioux Rapids, IA

Influencing water features

Calcareous Till Exposed Backslope Prairies 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, C) for undrained soils, and surface runoff is high to very high. Precipitation infiltrates the soil surface and percolates downward through the horizons unimpeded by any restrictive layer. The Dakota bedrock aquifer underlying this ecological site is typically deep and confined, leaving it generally unaffected by recharge (Prior et al. 2003). Surface runoff contributes some water to downslope ecological sites (Figure 5).

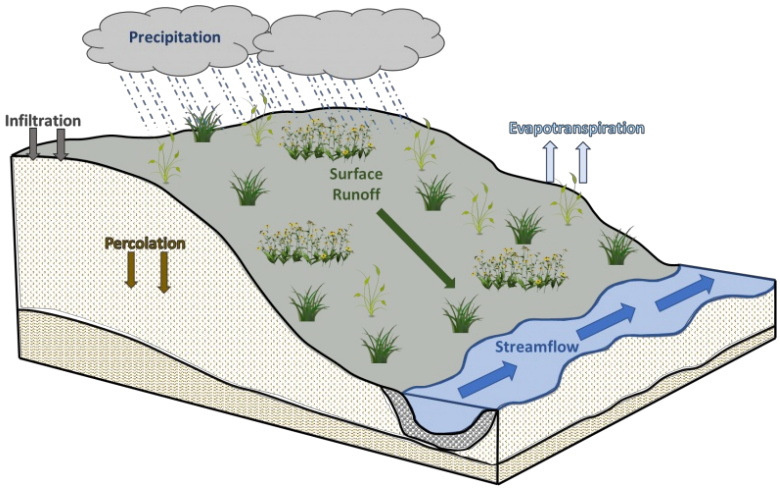


Figure 8. Figure 5. Hydrologic cycling in Calcareous Till Exposed Backslope Prairie ecological site.

Soil features

Soils of Calcareous Till Exposed Backslope Prairies are in the Mollisols and Entisols orders, further classified as Entic Hapludolls, Oxyaquic Vertic Argiudolls, Typic Hapludolls, Udorthentic Haplustolls, and Typic Udorthents with slow to moderate infiltration and high to very high runoff potential. The soil series associated with this site includes Cornell, Moneta, Steinauer, Steinauer variant, and Soils that are moderately deep to carbonates (Figure 6). The parent material is calcareous glacial till and the soils are well-drained and deep. Soil pH classes are slightly to moderately alkaline. No rooting restrictions are noted for the soils of this ecological site (Table 5).

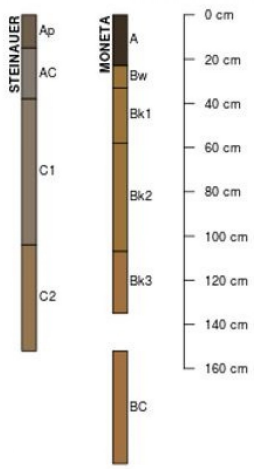


Figure 9. Figure 6. Profile sketches of soil series associated with Calcareous Till Exposed Backslope Prairie.

Table 4. Representative soil features

Parent material	(1) Till
Family particle size	(1) Fine-loamy
Drainage class	Well drained
Permeability class	Slow
Soil depth	80 in

Ecological dynamics

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

ecological processes are described to inform land management decisions.

MLRA 107A is defined by a relatively low relief landscape that experiences lower rainfall amounts and available moisture compared to other MLRAs occurring to the south and east. As a result, prairie vegetation communities dominate the uplands, while forested communities are restricted to medium and large streams (Prior 1991; Eilers and Roosa 1994; MDNR 2017a, b). Calcareous Till Exposed Backslope Prairies form an aspect of this vegetative continuum. This ecological site occurs on south and west-facing upland backslopes on well drained soils. Species characteristic of this ecological site consist of drought-tolerant, midgrass herbaceous vegetation (Figure 7).

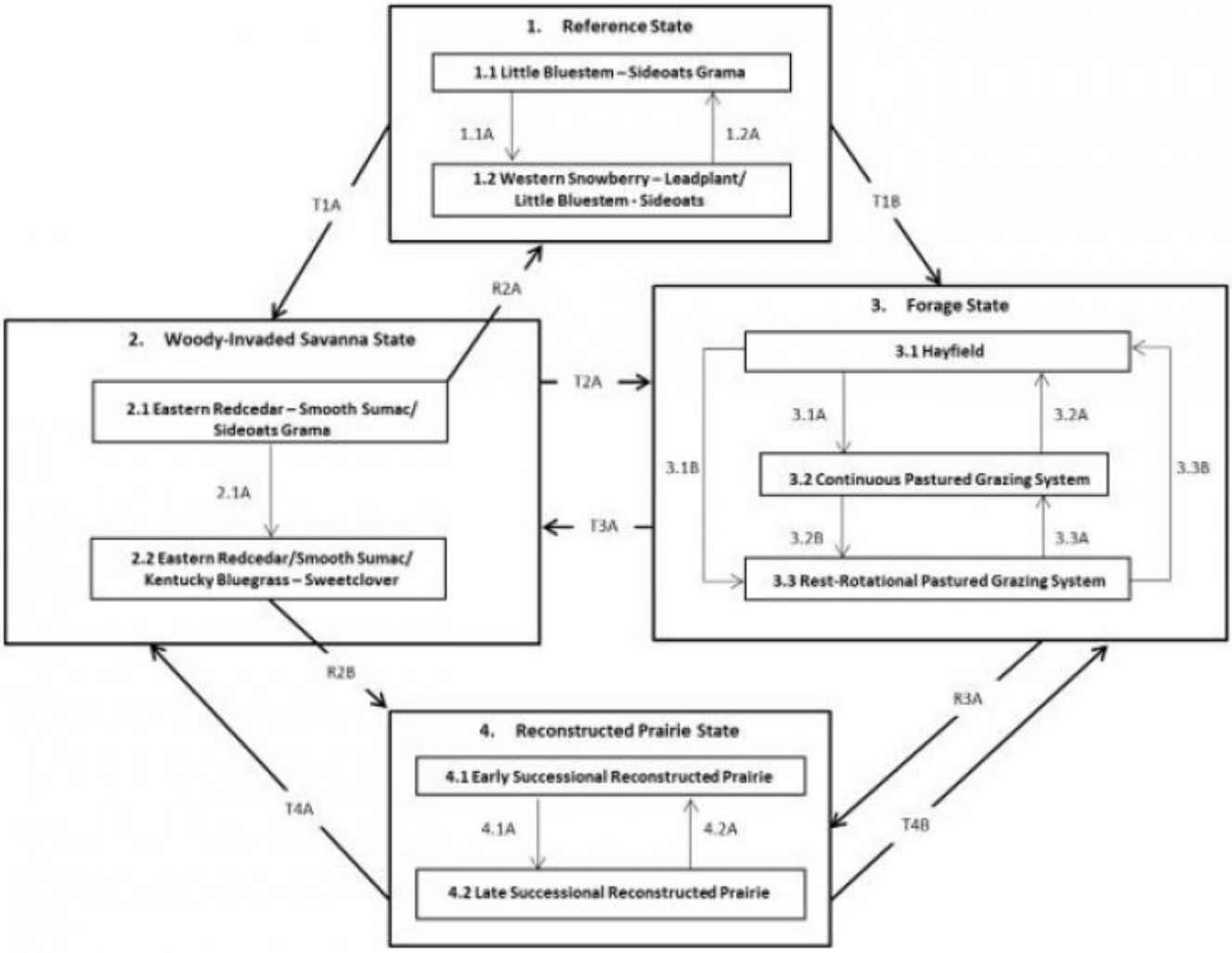
Fire is the dominant ecosystem driver for maintaining the vegetation of Calcareous Till Exposed Backslope Prairies. Fire intensity typically consisted of periodic, high severity surface fires occurring every 1 to 5 years (LANDFIRE 2009). Ignition sources included summertime lightning strikes from convective storms and bimodal, human ignitions during the spring and fall seasons. Native Americans regularly set fires to improve sight lines for hunting, driving large game, improving grazing and browsing habitat, agricultural clearing, and enhancing vital ethnobotanical plants (Barrett 1980).

Drought and herbivory have also played a role in shaping this ecological site. 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. Drought can also slow the growth of plants and result in dieback of certain species. The steep slopes of this ecological site likely deterred extensive grazing, however some grazing could be expected from bison (Bos bison) and possibly prairie elk (Cervus elaphus), the main herbivores in northern tallgrass prairies (LANDFIRE 2009). When coupled with fire, periods of drought and herbivory can greatly delay the establishment of woody vegetation (Pyne et al. 1996).

Today, Calcareous Till Exposed Backslope Prairies are limited in their extent, having been reduced as a result of eastern redcedar (*Juniperus virginiana* L.) encroachment from long-term fire suppression or having been converted to pasture. Remnants that do exist show evidence of indirect anthropogenic influence as some non-native species are present in the species composition. A return to the historic plant community is highly challenging, but long-term reconstruction efforts can help to restore some the natural diversity and ecological function. The state-and-transition model that follows provides a detailed description of each state, community phase, pathway, and transition. This model is based on available experimental research, field observations, literature reviews, professional consensus, and interpretations.

State and transition model

R107AY203IA Calcareous Till Exposed Backslope Prairie



Code	Process
T1A, T3A, T4A	Long-term fire suppression, land abandonment, and/or overgrazing
T1B, T2A, T4B	Cultural treatments are implemented to increase forage quality and yield
R2A	Woody species removal and reintroduction of fire
1.1A	Reduced fire return interval
1.2A	Increased fire return interval
2.1A	Fire suppression in excess of 20 years
3.1A	Mechanical harvesting is replaced with domestic livestock and continuous grazing
3.1B	Mechanical harvesting is replaced with domestic livestock and rest-rotational grazing
3.2A, 3.3B	Domestic livestock grazing is replaced by mechanical harvesting
3.2B	Implementation of rest-rotational grazing
3.3A	Implementation of continuous grazing
R2B, R3A	Site preparation, invasive species control, and native seeding
4.1A	Invasive species control and implementation of disturbance regimes
4.2A	Drought or improper timing/use of management actions

State 1
Reference State

The reference plant community is categorized as a dry midgrass community, dominated by herbaceous vegetation. The two community phases within the reference state are dependent on fire. Regular fire intervals alter species composition, cover, and extent, as well as keep woody species from dominating. Drought and episodic grazing have more localized impacts in the reference phases, but do contribute to overall species composition, diversity, cover,

and productivity.

Dominant plant species

- leadplant (*Amorpha canescens*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- little bluestem (*Schizachyrium*), other herbaceous
- sideoats grama (*Bouteloua curtipendula*), other herbaceous

Community 1.1
Little Bluestem-Sideoats Grama

Sites in this reference community phase are dominated by grasses and forbs. Vegetative cover is continuous (75 to 100 percent) and grass heights are approximately 1.5 feet tall (MDNR 2005; LANDFIRE 2009). Little bluestem and sideoats grama are the dominant midgrasses, and composite dropseed, big bluestem, and Indiangrass are the dominant tallgrasses. Characteristic forbs include stiff goldenrod (*Oligoneuron rigidum* (L.) Small var. rigidum), prairie groundsel (*Packera plattensis* (Nutt.) W.A. Weber & Á. Löve), and white heath aster (*Symphyotrichum ericoides* (L.) G.L. Nesom var. ericoides). Shrub cover is generally less than five percent. Fire return intervals every 1 to 5 years will maintain this phase, but a reduced fire return interval will shift the community to phase 1.2.

Dominant plant species

- little bluestem (*Schizachyrium*), other herbaceous
- sideoats grama (*Bouteloua curtipendula*), other herbaceous

Community 1.2
Western Snowberry-Leadplant/Little Bluestem-Sideoats Grama

This reference community phase represents the vegetative community when the fire interval has been reduced, allowing low shrubs to establish in the prairie. Western snowberry and leadplant are the most common shrubs, but smooth sumac (*Rhus glabra* L.) can also be present. A resumption of regular fire return intervals (every 1 to 5 years) will shift the community back to phase 1.1.

Dominant plant species

- leadplant (*Amorpha canescens*), shrub
- western snowberry (*Symphoricarpos occidentalis*), shrub
- little bluestem (*Schizachyrium*), other herbaceous
- sideoats grama (*Bouteloua curtipendula*), other herbaceous

Pathway 1.1A
Community 1.1 to 1.2

Reduced fire interval

Pathway 1.2A
Community 1.2 to 1.1

Increased fire return interval

State 2
Woody-Invaded Savanna State

Fire suppression can transition the reference plant community into a semi-natural woodland state dominated by eastern redcedar (Briggs et al. 2002; Anderson 2003). Eastern redcedar is a species native to the eastern half of North America with a range spanning from Ontario east to Nova Scotia, south across the Great Plains into eastern Texas, and east to the Atlantic coast (Lawson 1990; Lee 1996). It is a long-lived (450+ years), slow-growing, fire-intolerant dioecious conifer historically found in areas that were protected from fire (e.g., bluffs, rocky hillsides, sandstone cliffs, granite outcrops, etc.) (Ferguson et al. 1968; Anderson 2003). Today, however, decades of fire

suppression have allowed this species to spread, and it can now be found occupying sites with highly variable aspects, topography, soils, and formerly stable plant communities (Anderson 2003).

Dominant plant species

- eastern redcedar (*Juniperus virginiana*), tree
- smooth sumac (*Rhus glabra*), shrub
- sideoats grama (*Bouteloua curtipendula*), other herbaceous
- Kentucky bluegrass (*Poa pratensis*), other herbaceous
- sweetclover (*Melilotus*), other herbaceous

Community 2.1
Eastern Redcedar-Smooth Sumac/Sideoats Grama

This community phase represents the early stages of eastern redcedar and smooth sumac invasion into the prairie. In the absence of fire, these woody species become highly aggressive invaders. Eastern redcedar seeds are readily eaten and transplanted by birds, while smooth sumac typically spreads by rhizomes from adjacent ecotones (MDNR 2005). Native grasses can persist, however sideoats grama is the only species known to increase its cover under some overstory shading (Gehring and Bragg 1992).

Dominant plant species

- eastern redcedar (*Juniperus virginiana*), tree
- smooth sumac (*Rhus glabra*), shrub
- Kentucky bluegrass (*Poa pratensis*), other herbaceous
- sweetclover (*Melilotus*), other herbaceous

Community 2.2
Eastern Redcedar/Smooth Sumac/Kentucky Bluegrass-Sweetclover

Sites falling into this community phase have an established eastern redcedar tree canopy following numerous years of fire suppression. As the canopy increases, light availability is greatly reduced to the ground layer and soil moisture increases, allowing more shade tolerant species, such as Kentucky bluegrass (*Poa pratensis* L.), to replace the heliophytic prairie grasses (Gehring and Bragg 1992; Brantley and Young 2010; Pierce and Reich 2010). Other non-native species that may occur include sweetclover (Meliltous officinalis (L.) Lam.), smooth brome (*Bromus inermis* L.), Canada bluegrass (*Poa compressa* L.), and redtop (*Agrostis gigantea* Roth). The continued absence of fire will allow this community to expand its range.

Dominant plant species

- eastern redcedar (*Juniperus virginiana*), tree
- smooth sumac (*Rhus glabra*), shrub
- Kentucky bluegrass (*Poa pratensis*), other herbaceous

Pathway 2.1A
Community 2.1 to 2.2

Fire suppression in excess of 20 years

State 3
Forage State

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

function.

Community 3.1
Hayfield

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

Community 3.2
Continuous Pastured Grazing System

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

Community 3.3
Rest-Rotation Pastured Grazing System

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

Pathway 3.1A
Community 3.1 to 3.2

Mechanical harvesting is replaced with domestic livestock and continuous grazing

Pathway 3.1B
Community 3.1 to 3.3

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

Pathway 3.2A
Community 3.2 to 3.1

Domestic livestock is replaced by mechanical harvesting

Pathway 3.2B
Community 3.2 to 3.3

Implementation of rest-rotational grazing

Pathway 3.3B
Community 3.3 to 3.1

Domestic livestock grazing is replaced by mechanical harvesting

Pathway 3.3A
Community 3.3 to 3.2

Implementation of continuous grazing

State 4
Reconstructed Prairie State

Prairie reconstructions have become an important tool for repairing natural ecological functions and providing habitat protection for numerous grassland dependent species. Because the historic plant and soil biota communities of the tallgrass prairie were highly diverse with complex interrelationships, historic prairie replication cannot be guaranteed on landscapes that have been so extensively manipulated for extended timeframes (Kardol and Wardle 2010; Fierer et al. 2013). Therefore, ecological restoration should aim to aid the recovery of degraded, damaged, or destroyed ecosystems. A successful restoration will have the ability to structurally and functionally sustain itself, demonstrate resilience to the natural ranges of stress and disturbance, and create and maintain positive biotic and abiotic interactions (SER 2002). The reconstructed hill prairie state is the result of a long-term commitment involving a multi-step, adaptive management process. Diverse, species-rich seed mixes are important to utilize as they allow the site to undergo successional stages that exhibit changing composition and dominance over time (Smith et al. 2010). On-going management via prescribed fire and/or light grazing can help the site progress from an early successional community dominated by annuals and some weeds to a later seral stage composed of native, perennial grasses, forbs, and a few shrubs. Establishing a prescribed fire regimen that mimics natural disturbance patterns can increase native species cover and diversity while reducing cover of non-native forbs and grasses. Light grazing alone can help promote species richness, while grazing accompanied with fire can control the encroachment of woody vegetation (Brudvig et al. 2007).

Community 4.1
Early Successional Reconstructed Prairie

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

Community 4.2
Late Successional Reconstructed Prairie

Appropriately timed disturbance regimes (e.g., prescribed fire) applied to the early successional community phase can help increase the beta diversity, pushing the site into a late successional community phase over time. While prairie communities are dominated by grasses, these species can suppress forb establi8shment and reduce overall diversity and ecological function (Martin and Wilsey 2006; Williams et al. 2007). Reducing accumulated plant litter from perennial bunchgrasses allows more light and nutrients to become available for forb recruitment, allowing greater ecosystem complexity (Wilsey 2008).

Pathway 4.1A
Community 4.1 to 4.2

Invasive species control and implementation of disturbance regimes

Pathway 4.2A
Community 4.2 to 4.1

Drought or improper timing/use of management actions

Transition T1A
State 1 to 2

Long-term fire suppresion, land abandonment, and/or overgrazing

Transition T1B
State 1 to 3

Cultural treatments are implemented to increase forage quality and yield

Transition T2A
State 2 to 3

Cultural treatments are implemented to increase forage quality and yield

Transition R2B
State 2 to 4

Site preparation, invasive species control and native seeding

Restoration pathway T3A
State 3 to 2

Long term fire suppression, land abandonment, and/or overgrazing

Transition R3A
State 3 to 4

Site preparation, invasive species control, and native seeding

Restoration pathway T4A
State 4 to 2

Long-term fire suppression, land abandonment, and/or overgrazing

Restoration pathway T4B
State 4 to 3

Cultural treatments are implemented to increase forage quality and yield

Additional community tables

Inventory data references

Tier 3 Sampling Plot used to develop the reference state, community phase 1.1:
State County Ownership Legal Description Easting Northing
Iowa O'Brien Waterman Prairie Wildlife Area – Iowa Department of Natural Resources T94N R39W S23 302976 4758029

Other references

Anderson, M.D. 2003. *Juniperus virginiana*. In: Fire Effects Information System [Online]. U.S. Department of

Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available at: https://www.feis-crs.org/feis/. (Accessed 12 February 2018).

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.

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

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

Brantley, S. and D. Young. 2010. Linking light attenuation, sunflecks, and canopy architecture in mesic shrub thickets. Plant Ecology 206: 225-236.

Briggs, J.M., A.K. Knapp, and B.L. Brock. 2002. Expansion of woody plants in tallgrass prairie: a fifteen-year study of fire and grazing-interactions. The American Midland Naturalist 147: 287-294.

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

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.

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

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

Ferguson, E.R. E.R. Lawson, W.R. maple, and C. Mesavage. 1968. Managing Eastern Redcedar. Research paper SO-37. U.S. Department of Agriculture, Forest Service, Southern Forest Experimental Station, New Orleans, LA. 14 pps.

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

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

Gehrig, J.T. and T.B. Bragg. 1992. Changes in prairie vegetation under eastern redcedar (*Juniperus virginiana* L.) in an eastern Nebraska bluestem prairie. The American Midland Naturalist 128: 209-271.

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

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

LANDFIRE. 2009. Biophysical Setting 4214200 Northern Tallgrass Prairie System. In: LANDFIRE National Vegetation Dynamics Models. USDA Forest Service and US Department of Interior. Washington, DC.

Lawson, E.R. 1990. *Juniperus virginiana* L. eastern redcedar. In: R.M. Burns and B.H. Honkala, technical coordinators. Silvics of North America, Volume I: Conifers. Agricultural Handbook 654. Washington, DC: U.S. Department of Agriculture, Forest Service.

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

Lee, S.A. 1996. Propagation of Juniperus for conservation plantings in the Great Plains. M.S. Thesis. University of Nebraska, Lincoln, NE. 91 pps.

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

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

Minnesota Department of Natural Resources [MDNR]. 2005. Field Guide to the Native Plant Communities of Minnesota: The Prairie Parkland and Tallgrass Aspen Parklands Provinces. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. Minnesota Department of Natural Resources, St. Paul, Minnesota.

Minnesota Department of Natural Resources [MDNR]. 2017a. Coteau Moraines Subsection. Minnesota Department of Natural Resources: Ecological Classification System. Available at: http://www.dnr.state.mn.us/ecs/251Bb/index.html. (Accessed 10 October 2017).

Minnesota Department of Natural Resources [MDNR]. 2017b. Inner Coteau Subsection. Minnesota Department of Natural Resources: Ecological Classification System. Available at: http://www.dnr.state.mn.us/ecs/251Bc/index.html. (Accessed 10 October 2017).

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

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).

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.

Pierce, A.M. and P.B. Reich. 2010. The effects of eastern redcedar (*Juniperus virginiana*) invasion and removal on a dry bluff prairie ecosystem. Biological Invasions 12: 241-252.

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.

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

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

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

Society for Ecological Restoration [SER] Science & Policy Working Group. 2002. The SER Primer on Ecological Restoration. Available at: http://www.ser.org/. (Accessed 28 February 2017).

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

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

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

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

United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS). 2007. Iowa NRCS Plant Community Species Lists. Des Moines, IA. Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/technical/ecoscience/bio/?cid=nrcs142p2_008160. (Accessed 1 February 2018).

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).

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

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

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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)	
Contact for lead author	
Date	04/25/2024
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:**