

## Ecological site R104XY010IA Sandy Upland Prairie

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### General information

**Provisional.** A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.



Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

### MLRA notes

Major Land Resource Area (MLRA): 104X–Eastern Iowa and Minnesota Till Prairies

The Eastern Iowa and Minnesota Till Prairies (MLRA 104) includes the Iowan Surface, Oak Savanna, and Western Coulee and Ridges landforms (Prior 1991; MDNR 2005; WDNR 2015). It spans three states (Iowa, 74 percent; Minnesota, 22 percent; Wisconsin, 4 percent), encompassing approximately 9,660 square miles (Figure 1). The elevation ranges from approximately 1,310 feet above sea level (ASL) on the highest ridges to about 985 feet ASL in the lowest valleys. Local relief is mainly 10 to 20 feet. Glacial till and outwash deposits cover the uplands of the MLRA with recent alluvium located in the major river valleys. Paleozoic bedrock sediments, comprised primarily of shale and limestone, lies beneath the glacial material. The depth to limestone is shallow, resulting in karst topography across much of the area (USDA-NRCS 2006).

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

et al. 1992).

## Classification relationships

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

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

National Vegetation Classification – Ecological Systems: North-Central Interior Sand and Gravel Tallgrass Prairie (CES202.695) (NatureServe 2018)

National Vegetation Classification - Plant Associations: *Schizachyrium scoparium* – *Danthonia spicata* – *Carex pensylvanica* – (*Viola pedata*) Sand Grassland (CEGL002318) (Nature Serve 2018)

Biophysical Settings: North-Central Interior Sand and Gravel Tallgrass Prairie (BpS 4214120) (LANDFIRE 2009)

Natural Resources Conservation Service – Iowa Plant Community Species List: Prairie, Midwest Dry Sand (USDA-NRCS 2007)

Iowa Department of Natural Resources: Sand Prairie (INAI 1984)

Minnesota Department of Natural Resources: Ups13 Southern Dry Prairie (MDNR 2005)

## Ecological site concept

Sandy Upland Prairies are located within the green areas on the map (Figure 1). They occur on uplands and high stream terraces. The soils are Mollisols that are somewhat poorly to excessively-drained and deep, formed in sandy eolian deposits or outwash.

The historic pre-European settlement vegetation on this ecological site was dominated by drought-adapted herbaceous species. Little bluestem (*Schizachyrium scoparium* (Michx.) Nash) and flowering spurge (*Euphorbia corollata* L.) are the dominant and characteristic species of this site, respectively. Other grass species present can include big bluestem (*Andropogon gerardii* Vitman), Indiangrass (*Sorghastrum nutans* (L.) Nash), porcupinegrass (*Hesperostipa spartea* (Trin.) Barkworth), and Heller's rosette grass (*Dichanthelium oligosanthes* (Schult.) Gould). Species typical of an undisturbed plant community associated with this ecological site include plains muhly (*Muhlenbergia cuspidata* (Torr. ex Hook) Rydb.), candle anemone (*anemone cylindrica* A. Gray), and fourpoint evening primrose (*Oenothera rhombipetala* Nutt. ex Torr. & A. Gray). Fire and sand blowouts are the primary disturbance factors that maintain this site, while periodic drought and large mammal grazing are secondary factors (LANDFIRE 2009; NatureServe 2018).

## Associated sites

|             |  |
|-------------|--|
| R104XY011IA | <b>Sandy Upland Savanna</b><br>Sandy eolian deposits or outwash that classify as an Alfisols or Mollic subgroup of an Alfisols including Brady, Chelsea, Dunkerton, Lamont, Lilah, Oakton, Olin variant, and Sattre  |
| R104XY005IA | <b>Loamy Upland Prairie</b><br>Loamy sediment parent material on uplands and high stream terraces including Aredale, Ashdale, Atkinson, Bolan, Carmi, Cerlin, Cresco, Cresken, Dinsdale, Dinsmore, Floyd, Fort Dodge, Kenyon, Klinger, Klingmore, Marquis, Merton, Moland, Norville, Ostrander, Plano, Port Byron, Protivin, Readlyn, Tallula, Tama, Warsaw, and Winnebago |

## Similar sites

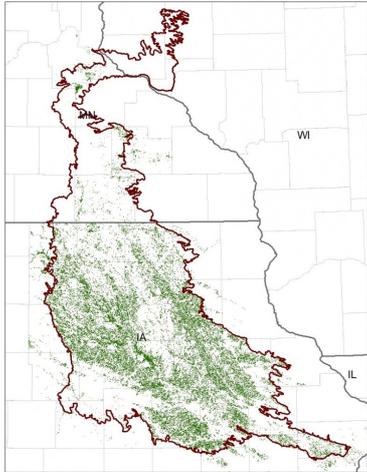
|             |   |
|-------------|---|
| R104XY005IA | <b>Loamy Upland Prairie</b><br>Loamy Upland Prairies occur on similar landscape positions, but parent material is loamy sediments |
|-------------|---|

**Table 1. Dominant plant species**

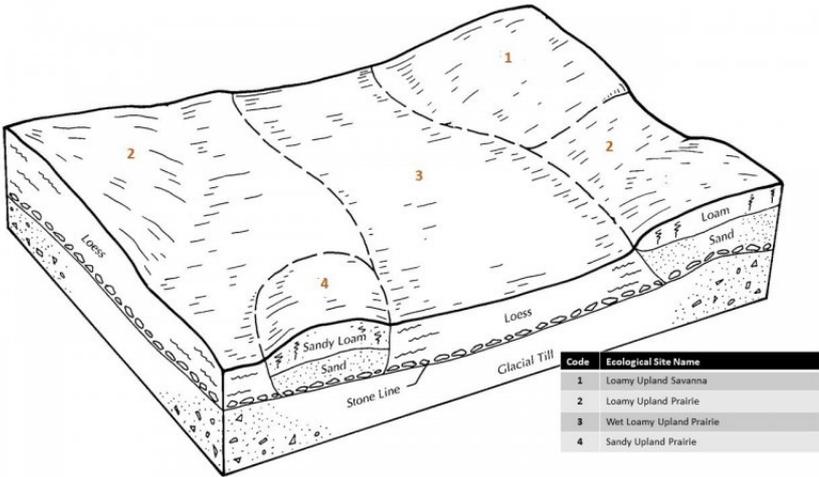
|            |  |
|------------|--|
| Tree       | Not specified  |
| Shrub      | Not specified  |
| Herbaceous | (1) <i>Schizachyrium scoparium</i><br>(2) <i>Euphorbia corollata</i> |

**Physiographic features**

Sandy Upland Prairies occur on uplands and high stream terraces (Figure 2). They are situated on elevations ranging from approximately 400 to 1499 feet ASL. The site does not experience flooding but rather, generates runoff to adjacent, downslope ecological sites (Table 1).



**Figure 2. Figure 1. Location of Sandy Upland Prairie ecological site within MLRA 104.**



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

**Table 2. Representative physiographic features**

|                     |                 |
|---------------------|-----------------|
| Slope shape across  | (1) Convex      |
| Slope shape up-down | (1) Convex      |
| Landforms           | (1) Upland      |
| Runoff class        | Very low to low |
| Elevation           | 400–1,499 ft    |

|                   |                                    |
|-------------------|------------------------------------|
| Slope             | 0–14%                              |
| Water table depth | 12–80 in                           |
| Aspect            | Aspect is not a significant factor |

## Climatic features

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

The soil temperature regime of MLRA 104 is classified as mesic, where the mean annual soil temperature is between 46 and 59°F (USDA-NRCS 2006). Temperature and precipitation occur along a north-south gradient, where temperature and precipitation increase the further south one travels. The average freeze-free period of this ecological site is about 158 days, while the frost-free period is about 133 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 36 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 36 and 56°F, respectively.

Climate data and analyses are derived from 30-year averages gathered from five 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)   | 130-135 days |
| Freeze-free period (characteristic range)  | 155-161 days |
| Precipitation total (characteristic range) | 35-37 in     |
| Frost-free period (actual range)           | 129-135 days |
| Freeze-free period (actual range)          | 152-166 days |
| Precipitation total (actual range)         | 35-37 in     |
| Frost-free period (average)                | 133 days     |
| Freeze-free period (average)               | 158 days     |
| Precipitation total (average)              | 36 in        |

## Climate stations used

- (1) NORTHWOOD [USC00136103], Northwood, IA
- (2) TRIPOLI [USC00138339], Tripoli, IA
- (3) GRUNDY CTR [USC00133487], Grundy Center, IA
- (4) INDEPENDENCE #1 [USC00134049], Independence, IA
- (5) COGGON [USC00131705], Coggon, IA

## Influencing water features

Sandy Upland Prairies are not influenced by wetland or riparian water features. Precipitation is the main source of water for this ecological site. Infiltration is moderate to very slow (Hydrologic Groups A, B, and D), and surface runoff is very low to low. Surface runoff contributes some water to downslope ecological sites (Figure 5).

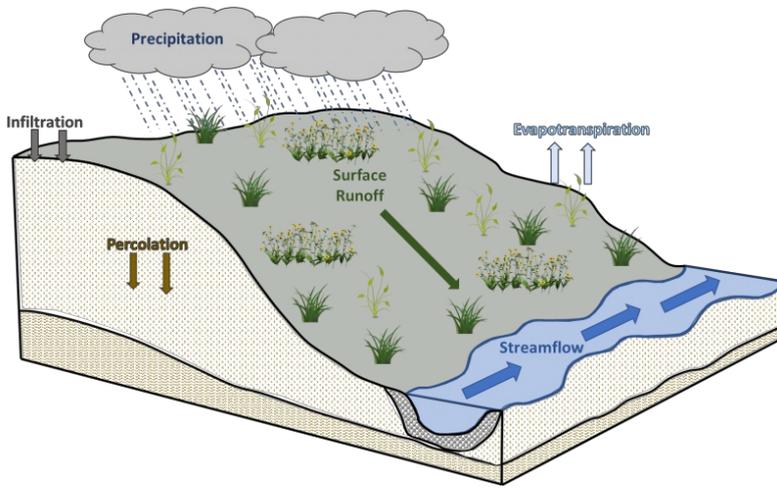


Figure 10. Figure 5. Hydrologic cycling in Sandy Upland Prairie ecological site.

### Soil features

Soils of Sandy Upland Prairies are in the Mollisols order, further classified as Aquic Hapludolls, Entic Hapludolls, Pachic Hapludolls, and Typic Hapludolls with very slow to moderate infiltration and very low to low runoff potential. The soil series associated with this site includes Burkhardt, Dickinson, Flagler, Hoopeston, Hoopeston variant, Lilah, Olin, Saude, Sparta, and Watseka and Soils that are shallow to sand. The parent material is sandy eolian deposits or outwash, and the soils are somewhat poorly to excessively-drained and deep. Soil pH classes are very strongly acid to moderately alkaline. No rooting restrictions are noted for the soils of this ecological site (Table 5).

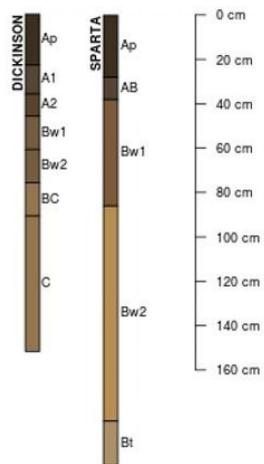


Figure 11. Figure 6. Profile sketches of soil series associated with Sandy Upland Prairie.

Table 4. Representative soil features

|                             |  |
|-----------------------------|--|
| Parent material             | (1) Eolian sands<br>(2) Outwash                |
| Family particle size        | (1) Coarse-loamy                               |
| Drainage class              | Somewhat poorly drained to excessively drained |
| Permeability class          | Slow to moderate                               |
| Depth to restrictive layer  | 80 in  |
| Soil depth                  | 80 in  |
| Surface fragment cover <=3" | 1–3%   |
| Surface fragment cover >3"  | 1%   |

## 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.

The MLRA lies within the transition zone between the eastern deciduous forests and the tallgrass prairies. The heterogeneous topography of the area results in variable microclimates and fuel matrices that in turn support prairies, savannas, woodlands, and forests. Sandy Upland Prairies form an aspect of this vegetative continuum. This ecological site occurs on uplands and high stream terraces on somewhat poorly to excessively-drained soils. Species characteristic of this ecological site consist of drought-adapted herbaceous vegetation.

Fire is a critical disturbance factor that maintains Sandy Upland Prairies. Fire intensity typically consisted of periodic, low-intensity 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).

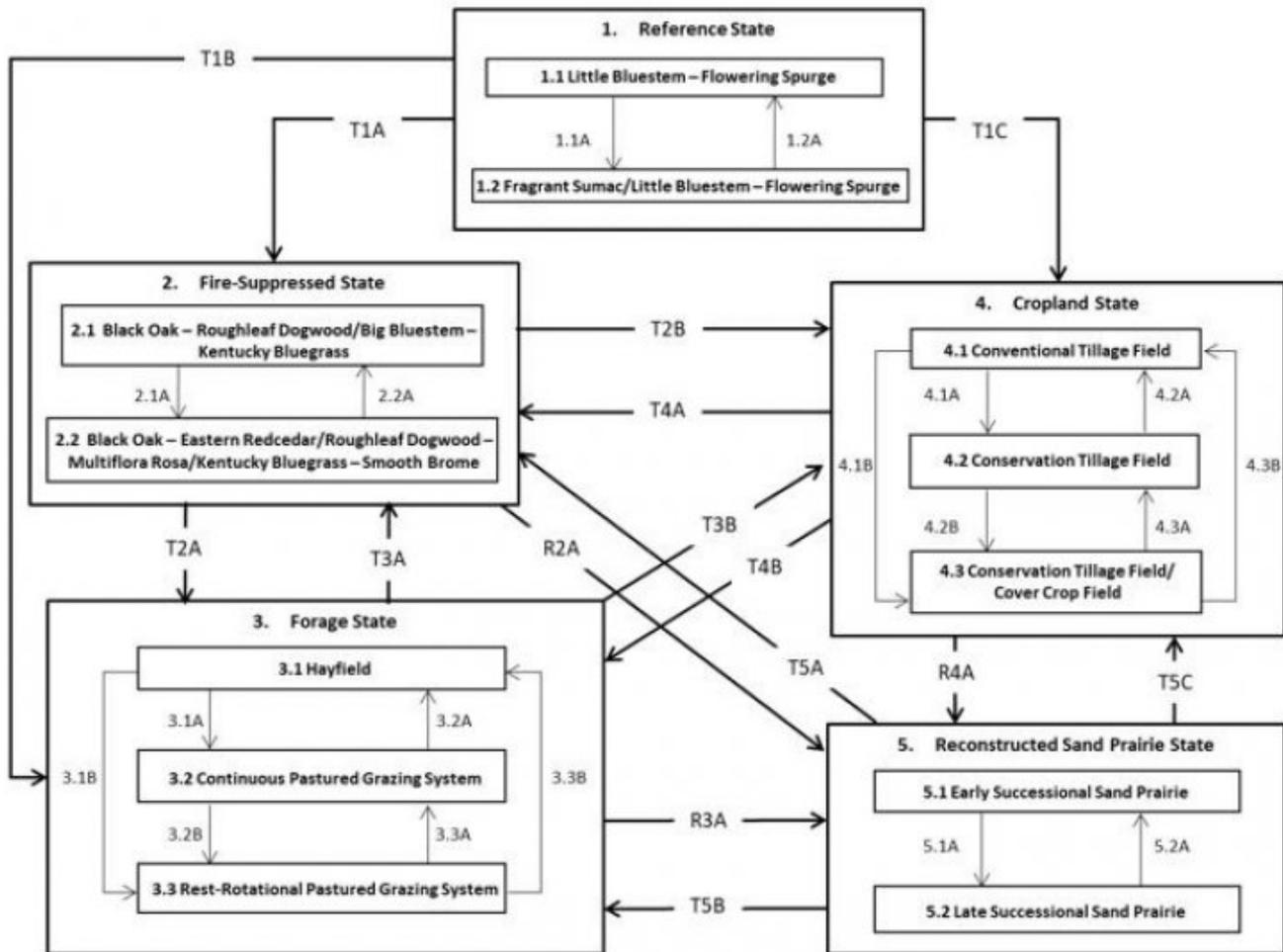
Sand blowouts are another disturbance factor that shape this ecological site. The high sand content coupled with increasing slopes allows for much erosion and shifting from high wind events or following a recent fire. The resulting substrate exposures results in a temporarily reduced vegetative canopy cover, leaving a plant community that resembles a sand barren. Over time site stability increases and the community will shift back to sand prairie (NatureServe 2018).

Drought and grazing by native ungulates have also played a role in shaping this ecological site. The periodic episodes of reduced soil moisture in conjunction with the somewhat poorly to excessively-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. Large mammals, specifically prairie elk (*Cervus elaphus*), bison (*Bos bison*), and white-tailed deer (*Odocoileus virginianus*), likely occurred in low densities resulting in limited impacts to plant composition and dominance (LANDFIRE 2009). When coupled with fire, periods of drought and herbivory can greatly delay the establishment of woody vegetation (Pyne et al. 1996).

Today, Sandy Upland Prairies are limited in their extent, having been reduced as a result of land conversion to agricultural or livestock production or having experienced long-term fire suppression allowing woody species to establish. Remnants that do exist show evidence of indirect anthropogenic influence as some non-native species are present in the community composition. A return to the historic plant community may not be possible following extensive land modification, but long-term conservation agriculture or prairie reconstruction efforts can help to restore some biotic diversity and ecological function. The state-and-transition model that follows provides a detailed description of each state, community phase, pathway, and transition. This model is based on available experimental research, field observations, literature reviews, professional consensus, and interpretations.

## State and transition model

## R104XY010IA SANDY UPLAND PRAIRIE



| Code               | Process   |
|--------------------|---|
| 1.1A               | Reduced fire return interval  |
| 1.2A               | Increased fire return interval  |
| T1A, T3A, T4A, T5A | Long-term fire suppression, land abandonment, and/or overgrazing                      |
| 2.1A               | Continued fire suppression  |
| 2.2A               | Single fire event   |
| T1B, T2A, T4B, T5B | Cultural treatments are implemented to increase forage quality and yield              |
| 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  |
| T1C, T2B, T3B, T5C | Agricultural conversion via tillage, seeding, and non-selective herbicide             |
| 4.1A               | Less tillage, residue management  |
| 4.1B               | Less tillage, residue management, and implementation of cover cropping                |
| 4.2B               | Implementation of cover cropping  |
| 4.2A, 4.3B         | Intensive tillage, remove residue, and reinitiate monoculture row cropping            |
| 4.3A               | Remove cover cropping   |
| R2A, R3A, R4A      | Site preparation, non-native species control, and native seeding                      |
| 5.1A               | Invasive species control and implementation of disturbance regimes                    |
| 5.2A               | Drought or improper timing/use of management actions                                  |

State 1  
Reference State

The reference plant community is categorized as a dry prairie community, dominated by herbaceous vegetation. The two community phases within the reference state are dependent on fire and sand blowouts. Short fire return intervals and occasional slope failures alters species composition, cover, and extent, while regular fire intervals keep woody species from dominating. Drought and grazing have more localized impacts on the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

## **Community 1.1**

### **Little Bluestem – Flowering Spurge**

Sites in this reference community phase are dominated by a mix of grasses and forbs. Vegetative cover is patchy to continuous (61 to 100 percent) and plants can reach heights greater than 3 feet tall (LANDFIRE 2009). Little bluestem, big bluestem, Indiangrass, porcupinegrass, and prairie sandreed (*Calamovilfa longifolia* (Hook.) Scribn.) are prominent grasses. Characteristic forbs include flowering spurge, prairie groundsel (*Senecio plattensis* (Nutt.) W.A. Weber & Å. Löve), whorled milkweed (*Asclepias verticillata* L.), and Cumin ragweed (*Ambrosia psilostachya* DC.) (NatureServe 2018). Replacement fires every 3 to 4 years or periodic sand blowouts will maintain this phase, but an extended fire return interval will shift the community to phase 1.2 (LANDFIRE 2009).

## **Community 1.2**

### **Fragrant Sumac/Little Bluestem – Flowering Spurge**

This reference community phase represents natural succession following an extended fire return interval, such as from drought. The lack of fire allows woody species, such as fragrant sumac (*Rhus aromatica* Aiton) and rose (*Rosa* L.), to develop in the shrub layer (Eilers and Roosa 1994). Shrubs are relatively sparse and scattered throughout the community, attaining heights up to 9 feet tall (LANDFIRE 2009). The understory remains relatively similar to community phase 1.1. Small replacement fires every 4 to 5 years maintains this phase, but a large replacement fire would shift the community back to phase 1.1 (LANDFIRE 2009).

## **Pathway 1.1A**

### **Community 1.1 to 1.2**

Natural succession following an extended fire return interval.

## **Pathway 1.2A**

### **Community 1.2 to 1.1**

Natural succession following a large replacement fire.

## **State 2**

### **Fire-suppressed State**

Long-term fire suppression can transition the reference sand prairie community into a woody-invaded shrub-prairie. This state is evidenced by a well-developed shrub layer and sparse trees (LANDFIRE 2009). Proximity to lands that have been altered provide opportunities for non-native invasive species to readily colonize this state, thereby reducing the native biodiversity and changing the vegetative community.

## **Community 2.1**

### **Black Oak – Roughleaf Dogwood/Big Bluestem – Kentucky Bluegrass**

This community phase represents the early stages of long-term fire suppression. In the absence of fire, woody species encroach into the native sand prairie. Shrubs are less than 6 feet tall and can exceed 30 percent canopy cover. Common shrubs likely to be encountered include black oak (*Quercus velutina* Lam.), roughleaf dogwood, American hazelnut, and smooth sumac (*Rhus glabra* L.). These tall shrubs can shade out midgrasses, allowing only the tall grasses – such as big bluestem and Indiangrass – to remain the dominant species in the herbaceous layer. The shade also promotes a moister soil environment, providing suitable conditions for invasion by non-native species including Kentucky bluegrass (*Poa pratensis* L.) and smooth brome (*Bromus inermis* L.) (Uchytel 1993; Howard 1996).

## **Community 2.2**

### **Black Oak – Eastern Redcedar/Roughleaf Dogwood – Multiflora Rose/Kentucky Bluegrass – Smooth Brome**

Sites falling into this community phase have a well-established shrub layer, and scattered trees begin to develop as a result of the continued lack of fire. Black oak and eastern redcedar (*Juniperus virginiana* L.) grow readily on dry, nutrient poor, sandy soils and become the dominant trees on the site (Carey 1992; Anderson 2003). The clonal roughleaf dogwood continues to expand in the shrub layer, but other native and non-native shrubs can occur including multiflora rose (*Rosa multiflora* L.).

#### **Pathway 2.1A**

##### **Community 2.1 to 2.2**

Continued fire suppression.

#### **Pathway 2.2A**

##### **Community 2.2 to 2.1**

Single fire event with enough intensity to top-kill trees.

## **State 3**

### **Forage State**

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

## **Community 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 microorganisms (Franzluebbers et al. 2000; USDA-NRCS 2003). As a result, soil biology is reduced leading to decreases in nutrient uptake by plants, soil organic matter, and soil aggregation. Frequent biomass removal can also reduce the site's carbon sequestration capacity (Skinner 2008).

## **Community 3.2**

### **Continuous Pastured Grazing**

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

## **Community 3.3**

### **Periodic-rest Pastured Grazing**

This community phase is characterized by periodic-rest grazing where the pasture has been subdivided into several smaller paddocks. Subdividing the pasture in this way allows livestock to utilize one or a few paddocks, while the remaining area is rested allowing plants to restore vigor and energy reserves, deepen root systems, develop seeds,

as well as allow seedling establishment (Undersander et al. 2002; USDA-NRCS 2003). Periodic-rest pastured grazing include deferred periods, rest periods, and periods of high intensity – low frequency, and short duration methods. Vegetation is generally more diverse and can include orchardgrass (*Dactylis glomerata* L.), timothy (*Phleum pratense* L.), red clover (*Trifolium pratense* L.), and alfalfa (*Medicago sativa* L.). The addition of native prairie species can further bolster plant diversity and, in turn, soil function. This community phase promotes numerous ecosystem benefits including increasing biodiversity, preventing soil erosion, maintaining and enhancing soil quality, sequestering atmospheric carbon, and improving water yield and quality (USDA-NRCS 2003).

### **Pathway 3.1A** **Community 3.1 to 3.2**

Mechanical harvesting is replaced with domestic livestock utilizing continuous grazing.

### **Pathway 3.1B** **Community 3.1 to 3.3**

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

### **Pathway 3.2A** **Community 3.2 to 3.1**

Domestic livestock are removed, and mechanical harvesting is implemented.

### **Pathway 3.2B** **Community 3.2 to 3.3**

Periodic-rest grazing replaces continuous grazing.

### **Pathway 3.3B** **Community 3.3 to 3.1**

Domestic livestock are removed, and mechanical harvesting is implemented.

### **Pathway 3.3A** **Community 3.3 to 3.2**

Continuous grazing replaces periodic-rest grazing.

## **State 4** **Cropland State**

The low topographic relief across the MLRA has resulted in nearly the entire area being converted to agriculture (Eilers and Roosa 1994). The continuous use of tillage, row-crop planting, and chemicals (i.e., herbicides, fertilizers, etc.) has effectively eliminated the reference community and many of its natural ecological functions in favor of crop production. Corn and soybeans are the dominant crops for the site, and oats (*Avena* L.) and alfalfa (*Medicago sativa* L.) may be rotated periodically. These areas are likely to remain in crop production for the foreseeable future.

### **Community 4.1** **Conventional Tillage Field**

Sites in this community phase typically consist of monoculture row-cropping maintained by conventional tillage practices. They are cropped in either continuous corn or alternating periods of corn and soybean crops. The frequent use of deep tillage, low crop diversity, and bare soil conditions during the non-growing season negatively impacts soil health. Under these practices, soil aggregation is reduced or destroyed, soil organic matter is reduced, erosion and runoff are increased, and infiltration is decreased, which can ultimately lead to undesirable changes in the hydrology of the watershed (Tomer et al. 2005).

## **Community 4.2**

### **Conservation Tillage Field**

This community phase is characterized by periodically alternating crops and utilizing various conservation tillage methods to promote soil health and reduce erosion. Conservation tillage methods include strip-till, ridge-till, vertical-till, or no-till planting operations. Strip-till keeps seedbed preparation to narrow bands less than one-third the width of the row where crop residue and soil consolidation are left undisturbed in-between seedbed areas. Strip-till planting may be completed in the fall and nutrient application either occurs simultaneously or at the time of planting. Ridge-till uses specialized equipment to create ridges in the seedbed and vegetative residue is left on the surface in between the ridges. Weeds are controlled with herbicides and/or cultivation, seedbed ridges are rebuilt during cultivation, and soils are left undisturbed from harvest to planting. Vertical-till operations employ machinery that lightly tills the soil and cuts up crop residue, mixing some of the residue into the top few inches of the soil while leaving a large portion on the surface. No-till management is the most conservative, disturbing soils only at the time of planting and fertilizer application. Compared to conventional tillage operations, conservation tillage methods can improve soil ecosystem function by reducing soil erosion, increasing organic matter and water availability, improving water quality, and reducing soil compaction.

## **Community 4.3**

### **Conservation Tillage with Cover Crop Field**

This community phase applies conservation tillage methods as described above as well as adds cover crop practices. Cover crops typically include nitrogen-fixing species (e.g., legumes), small grains (e.g., rye, wheat, oats), or forage covers (e.g., turnips, radishes, rapeseed). The addition of cover crops not only adds plant diversity but also promotes soil health by reducing soil erosion, limiting nitrogen leaching, suppressing weeds, increasing soil organic matter, and improving the overall soil ecosystem. In the case of small grain cover crops, surface cover and water infiltration are increased, while forage covers can be used to graze livestock or support local wildlife. Of the three community phases for this state, this phase promotes the greatest soil sustainability and improves ecological functioning within a row crop operation.

### **Pathway 4.1A**

#### **Community 4.1 to 4.2**

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

### **Pathway 4.1B**

#### **Community 4.1 to 4.3**

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

### **Pathway 4.2A**

#### **Community 4.2 to 4.1**

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

### **Pathway 4.2B**

#### **Community 4.2 to 4.3**

Cover crops are implemented to minimize soil erosion.

### **Pathway 4.3B**

#### **Community 4.3 to 4.1**

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

## **Pathway 4.3A**

### **Community 4.3 to 4.2**

Cover crop practices are abandoned.

## **State 5**

### **Reconstructed Sand 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 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 5.1**

#### **Early Successional Reconstructed Sand 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., prairie sandreed, sand dropseed, sideoats grama, large beardtongue). 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 5.2**

#### **Late Successional Reconstructed Sand 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 establishment 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 5.1A**

### **Community 5.1 to 5.2**

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

## **Pathway 5.2A**

### **Community 5.2 to 5.1**

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

### **Transition T1A**

#### **State 1 to 2**

Long-term fire suppression transitions the site to the fire-suppressed state (2).

### **Transition T1B**

#### **State 1 to 3**

Cultural treatments to enhance forage quality and yield transitions the site to the forage state (3).

### **Transition T1C**

#### **State 1 to 4**

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

### **Transition T2A**

#### **State 2 to 3**

Cultural treatments to enhance forage quality and yield transitions the site to the forage state (3).

### **Transition T2B**

#### **State 2 to 4**

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

### **Restoration pathway R2A**

#### **State 2 to 5**

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

### **Transition T3A**

#### **State 3 to 2**

Land abandonment transitions the site to the fire-suppressed state (2).

### **Transition T3B**

#### **State 3 to 4**

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

### **Restoration pathway R3A**

#### **State 3 to 5**

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

### **Transition T4A**

#### **State 4 to 2**

Land abandonment transitions the site to the fire-suppressed state (2).

### **Transition T4B**

### **State 4 to 3**

Cultural treatments to enhance forage quality and yield transitions the site to the forage state (3).

### **Restoration pathway R4A**

#### **State 4 to 5**

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

#### **Transition T5A**

##### **State 5 to 2**

Land abandonment transitions the site to the fire-suppressed state (2).

#### **Transition T5B**

##### **State 5 to 3**

Cultural treatments to enhance forage quality and yield transition the site to the forage state (3).

#### **Transition T5C**

##### **State 5 to 4**

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

### **Additional community tables**

#### **Inventory data references**

Tier 3 Sampling Plot used to develop the reference state, community phase 1.1:

State County Ownership Easting Northing

Iowa Blackhawk Cedar Hills Sand Prairie – The Nature Conservancy 536637 4715778

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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:**

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

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

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

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

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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):**

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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:**
-