USDA Natural Resources
Conservation Service

Ecological site R108XC517IA
Wet Loess Upland Flat Savanna

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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): 108X–Illinois and Iowa Deep Loess and Drift

The Illinois and Iowa Deep Loess and Drift, West-Central Part (MLRA 108C) encompasses the eastern portion of the Southern Iowa Drift Plain and the Lake Calvin basin of the Mississippi Alluvial Plain landforms (Prior 1991). It lies entirely in one state (Iowa), containing approximately 9,805 square miles (Figure 1). The elevation ranges from approximately 1,110 feet above sea level (ASL) on the highest ridges to about 505 feet ASL in the lowest valleys. Local elevation difference is mainly 10 to 20 feet. However, some valley floors can range from 80 to 200 feet, while some upland flats and valley floors only range between 3 and 6 feet. The MLRA is underlain by Pre-Illinoian glacial till, deposited more than 500,000 years ago and since undergone extensive erosion and dissection. In the northern half of the area the till thickness ranges from 150 to 350 feet and grades to less than 150 feet thick in the southern half. The till is covered by a mantle of Peoria Loess on the hillslopes and Holocene alluvium in the drainageways. Paleozoic bedrock, comprised of limestone, shale, and mudstones, 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

USFS Subregions: Central Dissected Till Plains (251C) Section, Central Dissected Till and Loess Plain (251Cc), Mississippi River and Illinois Alluvial Plains (51Cf), Southeast Iowa Rolling Loess Hills (251Ch) Subsections (Cleland et al. 2007)

U.S. EPA Level IV Ecoregion: Rolling Loess Prairies (47f), Upper Mississippi Alluvial Plain (72d) (USEPA 2013)

National Vegetation Classification – Ecological Systems: North-Central Interior Dry-Mesic Oak Forest and Woodland (NatureServe 2015)

National Vegetation Classification - Plant Associations: Quercus bicolor – (Quercus macrocarpa, Quercus stellata) Woodland (CEGL005181) (Nature Serve 2015)

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

Natural Resources Conservation Service – Iowa Plant Community Species List: Woodland, Swamp White Oak (USDA-NRCS 2007)

Iowa Department of Natural Resources: Tallgrass Savanna (INAI 1984)

Ecological site concept

Wet Loess Upland Flat Savannas are located within the green areas on the map (Figure 1). They occur on upland flats and high stream terraces. The soils are Alfisols that are somewhat poorly to very poorly-drained and deep, formed in loess. Low hydraulic gradients create a shallow depth to an apparent water table during the growing season.

The historic pre-European settlement vegetation on this ecological site was dominated by upland and hydrophytic tallgrass savanna vegetation as the hydric/non-hydric boundary was greatly intermixed. Swamp white oak (Quercus bicolor Willd.) and bur oak (Quercus macrocarpa Michx.) are the dominant trees, and big bluestem (Andropogon gerardii Vitman) and sweet woodreed (Cinna arundinacea L.) are the dominant grasses on Wet Loess Upland Flat Savannas. Other grasses present can include switchgrass (Panicum virgatum L.), prairie cordgrass (Spartina pectinata Bosc ex Link), Canada wildrye (Elymus canadensis L.) and various sedges. The understory likely resembled that of Wet Loess Upland Flat Prairies, potentially including such conservative species as compassplant (Silphium laciniatum L.) and marsh pea (Lathyrus palustris L.) (Drobney et al 2001). Fire is the primary disturbance factor that maintains this site, while herbivory and drought are secondary factors (LANDFIRE 2009).

Associated sites

R108XC504IA	**Loess Upland Savanna** Loess parent material that is not shallow to a water table including Downs, Downs variant, Greenbush, Hedrick, Ladoga, and New Vienna soils
R108XC515IA	**Ponded Upland Depression Sedge Meadow** Loess parent material that is ponded including Sperry soils
R108XC516IA	**Wet Loess Upland Flat Prairie** Loess parent material that is shallow to the water table but classifies as a Mollisol including Garwin, Kalona, Mahaska, Muscatine, and Taintor soils

Similar sites

R108XC512IA	**Till Backslope Seep Savanna** Till Backslope Seep Savannas are lower on the landscape and are a SLOPE: stratigraphic, discharge wetland

Table 1. Dominant plant species

Tree	(1) *Quercus bicolor* (2) *Quercus macrocarpa*
Shrub	Not specified
Herbaceous	(1) *Andropogon gerardii* (2) *Cinna arundinacea*

Physiographic features

Wet Loess Upland Flat Savannas occur on upland flats and high stream terraces (Figure 2). They are situated on elevations ranging from approximately 499 to 1401 feet ASL. The site does not experience flooding, but rather allows for groundwater recharge due to low hydraulic gradients.

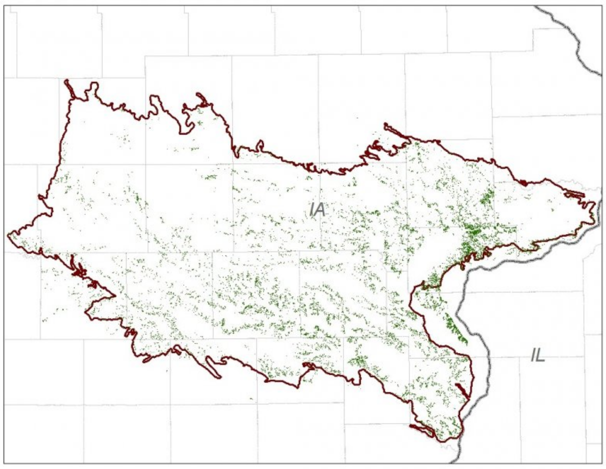


Figure 2. Figure 1. Location of Wet Loess Upland Flat Savanna ecological site within MLRA 108C.

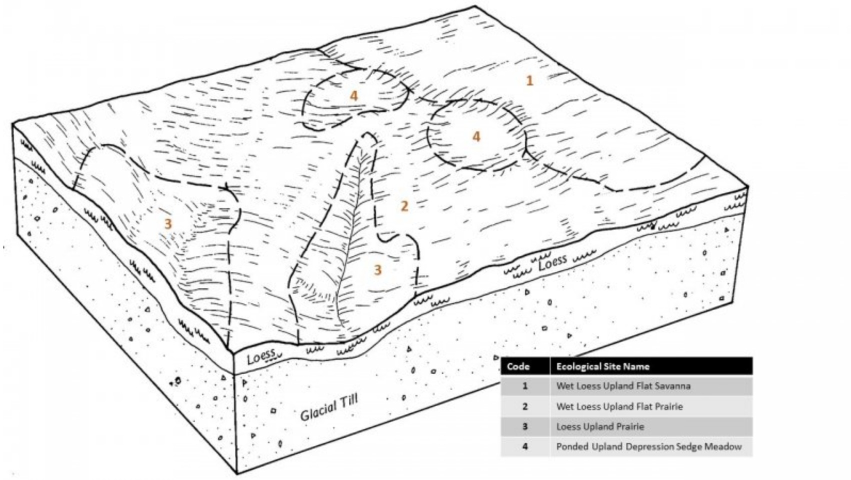


Figure 3. Figure 2. Representative block diagram of Wet Loess Upland Flat Savanna and associated ecological sites.

Table 2. Representative physiographic features

Slope shape across	(1) Concave (2) Linear
Slope shape up-down	(1) Concave (2) Linear
Landforms	(1) Upland > Flat (2) River valley > Terrace
Runoff class	Low to medium
Elevation	152–427 m
Slope	0–5%
Water table depth	0–30 cm
Aspect	Aspect is not a significant factor

Climatic features

The Illinois and Iowa Deep Loess and Drift, West-Central Part 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 108C 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 179 days, while the frost-free period is about 165 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 39 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 39 and 60°F, respectively.

Climate data and analyses are derived from 30-year averages gathered from four 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)	137-147 days
Freeze-free period (characteristic range)	165-177 days
Precipitation total (characteristic range)	914-991 mm
Frost-free period (actual range)	136-154 days
Freeze-free period (actual range)	164-181 days
Precipitation total (actual range)	914-1,016 mm
Frost-free period (average)	143 days
Freeze-free period (average)	172 days
Precipitation total (average)	965 mm

Climate stations used

- (1) BURLINGTON 2S [USC00131060], Burlington, IA
- (2) WASHINGTON [USC00138688], Washington, IA
- (3) OSKALOOSA [USC00136327], Oskaloosa, IA
- (4) TIPTON [USC00138266], Tipton, IA

Influencing water features

Wet Loess Upland Flat Savannas may be classified as a MINERAL SOIL FLATS: saturated, recharge, herbaceous wetland under the Hydrogeomorphic (HGM) classification system (Smith et al. 1995; USDA-NRCS 2008) and as a Palustrine, Persistent Emergent, Seasonally Saturated wetland under the National Wetlands Inventory (FGDC 2013). Precipitation is the main source of water for this ecological site (Smith et al. 1995). Infiltration is slow (Hydrologic Group C) for undrained soils, and surface runoff is low to medium (Figure 5).

Primary wetland hydrology indicators for an intact Wet Loess Upland Flat Savanna may include: A2 High water table and A3 Saturation. Secondary wetland hydrology indicators may include: C2 Dry-season water table and D5 FAC-neutral test (USACE 2010).

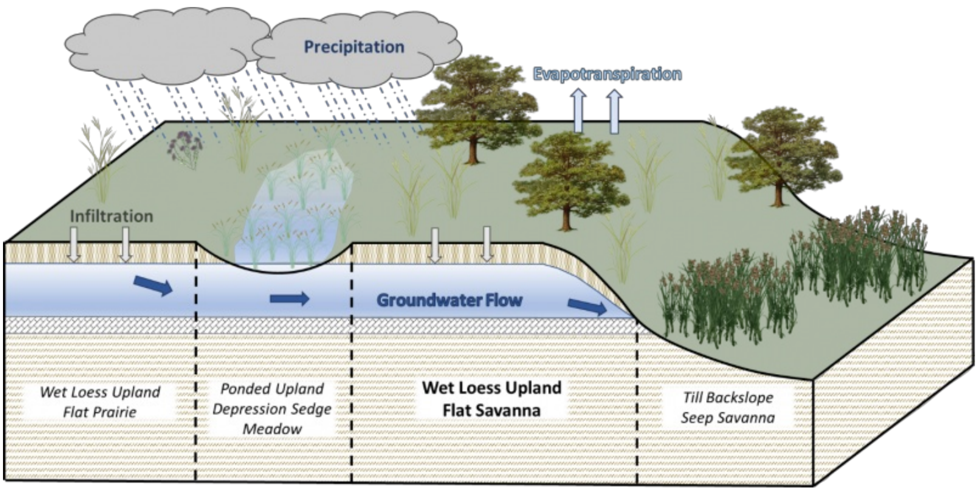


Figure 8. Figure 5. Hydrologic cycling in Wet Loess Upland Flat Savanna ecological site.

Soil features

Soils of Wet Loess Upland Flat Savannas are in the Alfisols orders, further classified as Mollic Endoaqualfs, Udollic Endoaqualfs, and Vertic Albaqualfs with slow infiltration and low to medium runoff potential. The soil series associated with this site includes Atterberry, Givin, Rubio, and Walford (Figure 6). The parent material is loess, and the soils are somewhat poorly to very poorly-drained and deep with seasonal high-water tables. Soil pH classes are strongly acid to slightly alkaline. No rooting restrictions are noted for the soils of this ecological site (Table 5).

Some soil map units in this ecological site, if not drained, may meet the definition of hydric soils and are listed as meeting criteria 2 of the hydric soils list (77 FR 12234).

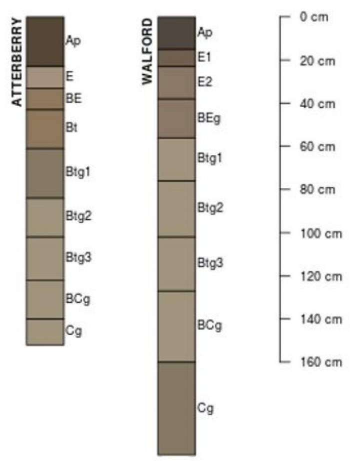


Figure 9. Figure 6. Profile sketches of soil series associated with Wet Loess Upland Flat Savanna.

Table 4. Representative soil features

Parent material	(1) Loess
Family particle size	(1) Fine (2) Fine-silty
Drainage class	Very poorly drained to somewhat poorly drained
Permeability class	Slow
Soil depth	203 cm

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 are able to support prairies, savannas, woodlands, and forests. Wet Loess Upland Flat Savannas form an aspect of this vegetative continuum. This ecological site occurs on upland flats and high stream terraces on somewhat poorly to very-poorly drained soils, spanning the hydric/non-hydric boundary. As a result, species characteristic of this ecological site consist of both upland and hydrophytic woody and herbaceous vegetation.

Fire is a critical disturbance factor that maintains Wet Loess Upland Flat Savannas. Fire intensity typically consisted of periodic 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; White 1994).

Drought and herbivory by native ungulates have also played a role in shaping this ecological site. The periodic episodes of reduced soil moisture in conjunction with the poorly to somewhat poorly--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. Bison (Bos bison) grazing, while present, served a more limited role in community composition and structure than lands further west. Prairie elk (Cervus elaphus) and white-tailed deer (Odocoileus virginianus) likely contributed to woody species reduction but are also considered to be of a lesser impact compared to the west (LANDFIRE 2009). When coupled with fire, periods of drought and herbivory can further delay the establishment of woody vegetation (Pyne et al. 1996).

Today, Wet Loess Upland Flat Savannas have been greatly reduced, if not extirpated, as most areas have been converted to agricultural production. Corn (*Zea mays* L.) and soybeans (*Glycine max* (L.) Merr.) are the dominant crops grown, but patches of forage land may be present. A return to the historic plant community may not be possible following extensive land modification, but long-term conservation agriculture or savanna 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 1 – REFERENCE STATE

The reference plant community is categorized as a wet-mesic savanna community, dominated by upland and hydrophytic vegetation. The two community phases within the reference state are dependent on periodic fire. Surface fires are the dominant fire regime, comprising approximately 96 percent of all fires and occurring every five years. Mixed and replacement fires comprise the remaining 4 percent, occurring approximately every 3 and 1 years, respectively (LANDFIRE 2009). The intensity and frequency alter species composition, cover, and extent, while regular fire intervals keep woody species from dominating. Drought and native mammal grazing have more localized impacts in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

Community Phase 1.1 Swamp White Oak – Bur Oak/Big Bluestem – Sweet Woodreed – Sites in this reference community phase are dominated by a mix of grasses and forbs with scattered trees. Swamp white oak and bur oak are the dominant trees on the site, but northern red oak (*Quercus rubra* L.) and elms (Ulmus L.) may be present. The tree canopy comprises no more than 20 percent cover and tree size class is medium (9 to 21-inch DBH). Vegetative cover is continuous (up to 100 percent) and plants can reach heights up to 3 feet tall (LANDFIRE 2009). Big bluestem, sweet woodreed, prairie cordgrass, Canada wildrye, and switchgrass are common grasses. Characteristic forbs likely resembled those of Wet Loess Upland Flat Prairies includes such species as New England aster (*Symphyotrichum novae-angliae* (L.) G.L. Nesom), Virginia mountainmint (*Pycnanthemum virginianum* (L.) T. Dur. & B.D. Jacks. ex B.L. Rob. & Fernald), sawtooth sunflower (*Helianthus grosseserratus* M. Martens), hairy hedgenettle (*Stachys pilosa* Nutt.), and giant goldenrod (*Solidago gigantea* Aiton). Surface fires every 5 years will maintain this class, but an extended fire return interval will shift the community to phase 1.2 (LANDFIRE 2009).

Pathway 1.1A – Extended fire return interval in excess of 5 years.

Community Phase 1.2 Swamp White Oak – Bur Oak/Pussy Willow – Meadow Willow/Big Bluestem – Sweet Woodreed – This reference community phase represents a successional shift following an extended fire return interval. This fire-free period allows woody shrubs to establish, including pussy willow (*Salix discolor* Muhl.) and meadow willow (*Salix petiolaris* Sm.). Tree cover increases to as much as 60 percent, and tree size class moves from medium to large (21 to 33-inch DBH). Surface fires every 5 years will maintain this class, but mixed or replacement fires will shift the community back to phase 1.1 (LANDFIRE 2009).

Pathway 1.2A – Mixed or replacement fire.

Transition 1A – Cultural treatments to enhance forage quality and yield transitions the site to the forage state (2).

Transition 1C – Tillage, seeding of agricultural crops, and non-selective herbicide transition the site to the cropland state (3).

STATE 2 – 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 (*Poa pratensis* L.), 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 Phase 2.1 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).

Pathway 2.1A – Mechanical harvesting is replaced with domestic livestock utilizing continuous grazing.

Pathway 2.1B – Mechanical harvesting is replaced with domestic livestock utilizing rotational grazing.

Community Phase 2.2 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.

Pathway 2.2A – Domestic livestock are removed, and mechanical harvesting is implemented.

Pathway 2.2B – Rotational grazing replaces continuous grazing.

Community Phase 2.3 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 orchardgrass (*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 2.3A – Continuous grazing replaces rotational grazing.

Pathway 2.3B – Domestic livestock are removed, and mechanical harvesting is implemented.

Transition 2A – Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (3).

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

STATE 3 – 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 Phase 3.1 Conventional Tillage Field – Sites in this community phase typically consist of monoculture row-cropping maintained by conventional tillage practices. They are cropped in either continuous corn or corn-soybean rotations. The frequent use of deep tillage, low crop diversity, and bare soil conditions during the non-growing season negatively 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).

Pathway 3.1A – Tillage operations are greatly reduced, crop rotation occurs on a regular interval, and crop residue remains on the soil surface.

Pathway 3.1B – Tillage operations are greatly reduced or eliminated, crop rotation occurs on a regular interval, crop residue remains on the soil surface, and cover crops are planted following crop harvest.

Community Phase 3.2 Conservation Tillage Field – This community phase is characterized by rotational crop production that utilizes various conservation tillage methods to promote soil health and reduce erosion. Conservation tillage methods include strip-till, ridge-till, vertical-till, or no-till planting systems. Strip-till keeps seedbed preparation to narrow bands less than one-third the width of the row where crop residue and soil consolidation are left undisturbed in-between seedbed areas. Strip-till planting may be completed in the fall and nutrient application either occurs simultaneously or at the time of planting. Ridge-till uses specialized equipment to create ridges in the seedbed and vegetative residue is left on the surface in between the ridges. Weeds are controlled with herbicides and/or cultivation, seedbed ridges are rebuilt during cultivation, and soils are left undisturbed from harvest to planting. Vertical-till systems employ machinery that lightly tills the soil and cuts up crop residue, mixing some of the residue into the top few inches of the soil while leaving a large portion on the surface. No-till management is the most conservative, disturbing soils only at the time of planting and fertilizer application. Compared to conventional tillage systems, 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.

Pathway 3.2A – Intensive tillage is utilized, and monoculture row-cropping is established.

Pathway 3.2B – Cover crops are implemented to minimize soil erosion.

Community Phase 3.3 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 cropland system.

Pathway 3.3A – Cover crop practices are abandoned.

Pathway 3.3B – Intensive tillage is utilized, cover crops practices are abandoned, monoculture row-cropping is established, and crop rotation is reduced or eliminated.

Transition 3A – Cultural treatments to enhance forage quality and yield transitions the site to the forage state (2).

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

STATE 4 – RECONSTRUCTED WET-MESIC OAK SAVANNA STATE

Savanna 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 savanna 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 savanna state is the result of a long-term commitment involving a multi-step, adaptive management process. 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 can help the site progress from an early successional community dominated by annuals and some weeds to a later seral stage composed of native perennial grasses, forbs, shrubs, and eventually mature oaks. Establishing a prescribed fire regime that mimics natural disturbance patterns can increase native species cover and diversity while reducing cover of non-native forbs and grasses. Light grazing alone can help promote species richness, while grazing accompanied with fire can control the encroachment of undesirable woody vegetation (Brudvig et al. 2007).

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 herbaceous seed mix utilized. If oak planting is needed, acorns should be planted shortly after harvest as acorns germinate shortly after seedfall and require no cold stratification. Browse protection may need to be installed to protect newly established seedlings from animal predation (Gucker 2011). If selective tree removal is needed, canopy reduction should encompass between 16 to 45 percent of the undesirable species in a single year (Asbjornsen et al. 2005). The seed mix should look to include a diverse mix of native cool-season and warm-season annual and perennial grasses and forbs typical of the reference state. Native, cool-season annuals can help to provide litter that promotes cool, moist soil conditions to the benefit of the other species in the seed mix. The first season following site preparation and seeding will typically result in annuals and other volunteer species forming a majority of 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.

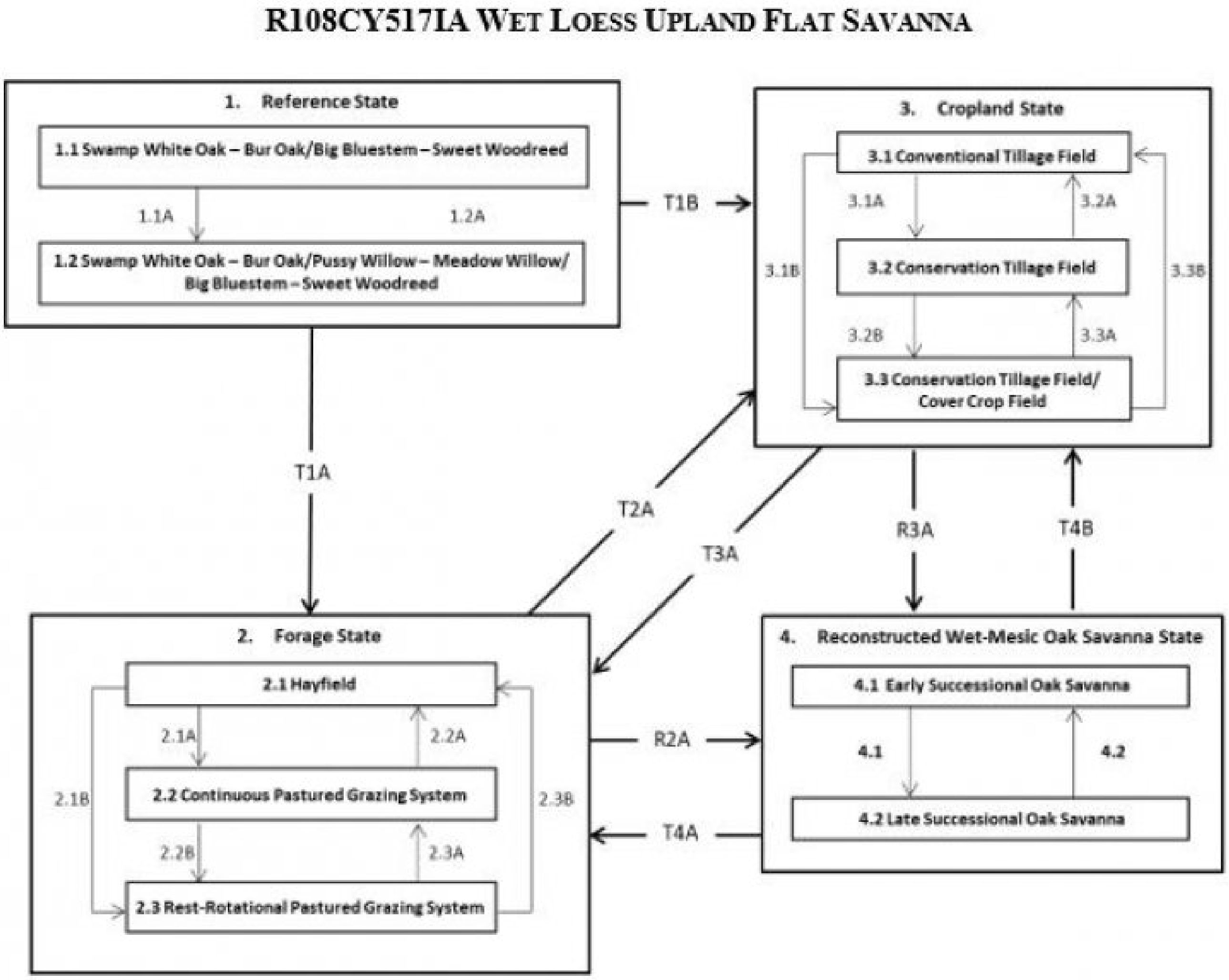
Community Phase 4.2 Late Successional Reconstructed Oak Savanna – Appropriately timed disturbance regimes (e.g., prescribed fire) applied to the early successional community phase can help increase the beta diversity, pushing the site into a late successional community phase over time. While oak savanna 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 from such tallgrasses as big bluestem and Indiangrass allows more light and nutrients to become available for forb recruitment, allowing for greater ecosystem complexity (Wilsey 2008). Prescribed fire should be used 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 – Cultural treatments to enhance forage quality and yield transition the site to the forage state (2).

Transition 4B – Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (3).

State and transition model



Code	Process
1.1A	Extended fire return interval in excess of 5 years
1.2A	Mixed or replacement fire
T1A, T3A, T4A	Cultural treatments are implemented to increase forage quality and yield
2.1A	Mechanical harvesting is replaced with domestic livestock and continuous grazing
2.1B	Mechanical harvesting is replaced with domestic livestock and rest-rotational grazing
2.2A, 2.3B	Domestic livestock grazing is replaced by mechanical harvesting
2.2B	Implementation of rest-rotational grazing
2.3A	Implementation of continuous grazing
T1B, T2A, T4B	Agricultural conversion via tillage, seeding, and non-selective herbicide
3.1A	Less tillage, residue management
3.1B	Less tillage, residue management, and implementation of cover cropping
3.2B	Implementation of cover cropping
3.2A, 3.3B	Intensive tillage, remove residue, and reinitiate monoculture row cropping
3.3A	Remove cover cropping
R2A, R3A	Site preparation, non-native 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

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.

Other references

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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	
Approved by	
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:**