USDA Natural Resources Conservation Service

Ecological site F110XY003IL
Limestone Woodland

Last updated: 4/22/2020
Accessed: 05/18/2024

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.

MLRA notes

Major Land Resource Area (MLRA): 110X–Northern Illinois and Indiana Heavy Till Plain

The Northern Illinois and Indiana Heavy Till Plain (MLRA 110) encompasses the Northeastern Morainal, Grand Prairie, and Southern Lake Michigan Coastal landscapes (Schwegman et al. 1973, WDNR 2015). It spans three states – Illinois (79 percent), Indiana (10 percent), and Wisconsin (11 percent) – comprising about 7,535 square miles (Figure 1). The elevation is about 650 feet above sea level (ASL) and increases gradually from Lake Michigan south. Local relief varies from 10 to 25 feet. Silurian age fractured dolomite and limestone bedrock underlie the region. Glacial drift covers the surface area of the MLRA, and till, outwash, lacustrine deposits, loess or other silty material, and organic deposits are common (USDA-NRCS 2006).

The vegetation in the MLRA has undergone drastic changes over time. At the end of the last glacial episode – the Wisconsinan glaciation – the evolution of vegetation began with the development of tundra habitats, followed by a phase of spruce and fir forests, and eventually spruce-pine forests. Not until approximately 9,000 years ago did the climate undergo a warming trend which prompted the development of deciduous forests dominated by oak and hickory. As the climate continued to warm and dry, prairies began to develop approximately 8,300 years ago. Another shift in climate that resulted in an increase in moisture prompted the emergence of savanna-like habitats from 8,000 to 5,000 years before present (Taft et al. 2009). Forests maintained footholds on steep valley sides, morainal ridges, and wet floodplains. Fire, droughts, and grazing by native mammals helped to maintain the prairies and savannas until the arrival of European settlers, and the forests were maintained by droughts, wind, lightning, and occasional fire (Taft et al. 2009; NatureServe 2018).

Classification relationships

USFS Subregions: Southwestern Great Lakes Morainal (222K) and Central Till Plains and Grand Prairies (251D) Sections; Kenosha-Lake Michigan Plain and Moraines (222Kg), Valparaiso Moraine (Kj), and Eastern Grand Prairie (251Dd) Subsections (Cleland et al. 2007)

U.S. EPA Level IV Ecoregion: Kettle Moraines (53b), Illinois/Indiana Prairies (54a), and Valparaiso-Wheaton Morainal Complex (54f) (USEPA 2013)

National Vegetation Classification – Ecological Systems: North-Central Interior Oak Savanna (CES202.698) (NatureServe 2018)

National Vegetation Classification – Plant Associations: Quercua macrocarpa – (Quercus alba, Quercus velutina)/Andropogon gerardii Wooded Grassland (CEGL002020) (Nature Serve 2018)

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

Illinois Natural Areas Inventory: Dry-mesic barren (White and Madany 1978)

Wisconsin Natural Communities: Oak opening (WDNR 2015)

Ecological site concept

Limestone Woodlands are located within the green areas on the map (Figure 1). They occur on bedrock-controlled uplands. The soils are Alfisols that are well drained and moderately deep, formed in till or drift over dolostone.

The historic pre-European settlement vegetation on this ecological site was dominated by an open oak canopy and sparse herbaceous layer. Bur oak (Quercus macrocarpa Michx.) and white oak (Quercus alba L.) are the dominant tree species on the site, and little bluestem (Schizachyrium scoparium (Michx.) Nash) is the dominant grass. The moderately deep soils over bedrock result in a less productive plant community with smaller, stunted trees and an herbaceous layer that is generally less than 3 feet tall (White and Madany 1978). The site is not as acidic as the sandstone communities, resulting in slightly more herbaceous diversity. Fire is the primary disturbance that maintains this ecological site, and drought, storm damage, and periodic pest influences are secondary disturbances (LANDFIRE 2009).

Associated sites

R110XY001IL	**Dry Limestone Prairie** Sites that moderately deep to limestone bedrock on fire-prone landscapes including Channahon, Elizabeth, Plattville, and Rockton soils
R110XY002IL	**Wet Limestone Prairie** Sites that are moderately deep to limestone bedrock and shallow to a high-water table including Calamine, Faxon, Joliet, Millsdale, Romeo, and Tallmadge soils

Similar sites

F110XY005IL	**Sandstone Woodland** Sandstone Woodlands are a similar vegetation type, but site is shallow to sandstone bedrock

Table 1. Dominant plant species

Tree	(1) *Quercus macrocarpa* (2) *Quercus alba*
Shrub	Not specified
Herbaceous	(1) *Schizachyrium scoparium*

Physiographic features

Limestone Woodlands occur on bedrock-controlled uplands. They are situated on elevations ranging from approximately 476 to 1020 feet ASL. The site does not experience flooding but rather generates runoff to adjacent, downslope ecological sites.

Figure 1.

Table 2. Representative physiographic features

Slope shape across	(1) Convex
Slope shape up-down	(1) Convex
Landforms	(1) Upland
Runoff class	High
Elevation	145–311 m
Slope	0–12%
Water table depth	203 cm
Aspect	Aspect is not a significant factor

Climatic features

The Northern Illinois and Indiana Heavy Till Plain falls into the hot-summer humid continental climate (Dfa) and warm-summer humid continental climate (Dfb) Köppen-Geiger climate classifications (Peel et al. 2007). The two main factors that drive the climate of the MLRA are latitude and weather systems. Latitude, and the subsequent reflection of solar input, determines air temperatures and seasonal variations. Solar energy varies across the seasons, with summer receiving three to four times as much energy as opposed to winter. Weather systems (air masses and cyclonic storms) are responsible for daily fluctuations of weather conditions. High-pressure systems are responsible for settled weather patterns where sun and clear skies dominate. In fall, winter, and spring, the polar jet stream is responsible for the creation and movement of low-pressure systems. The clouds, winds, and precipitation associated with a low-pressure system regularly follow high-pressure systems every few days (Angel n.d.).

The soil temperature regime of MLRA 110 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 181 days, while the frost-free period is about 148 days (Table 2). The majority of the precipitation occurs as rainfall in the form of convective thunderstorms during the growing season. Average annual precipitation is 38 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 40.4 and 60°F, respectively.

Table 3. Representative climatic features

Frost-free period (characteristic range)	145-152 days
Freeze-free period (characteristic range)	174-187 days
Precipitation total (characteristic range)	940-991 mm
Frost-free period (actual range)	143-154 days
Freeze-free period (actual range)	174-193 days
Precipitation total (actual range)	940-991 mm
Frost-free period (average)	148 days
Freeze-free period (average)	181 days
Precipitation total (average)	965 mm

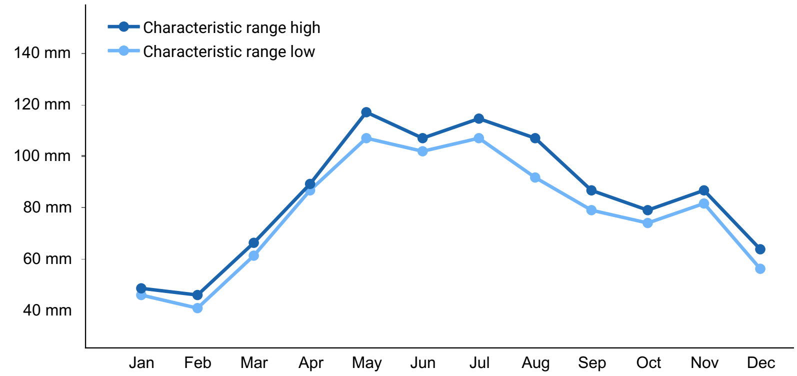


Figure 2. Monthly precipitation range

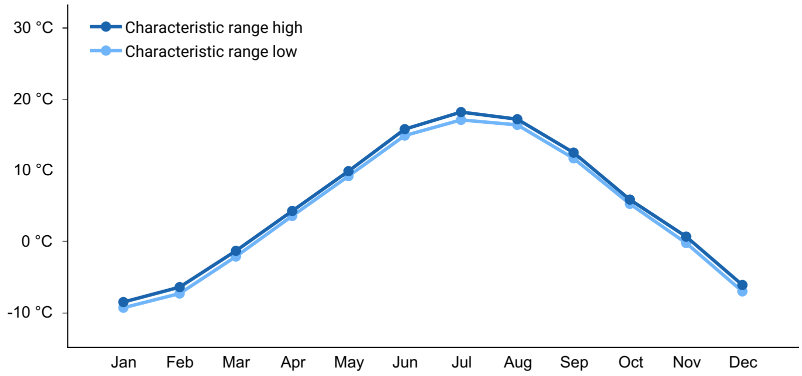


Figure 3. Monthly minimum temperature range

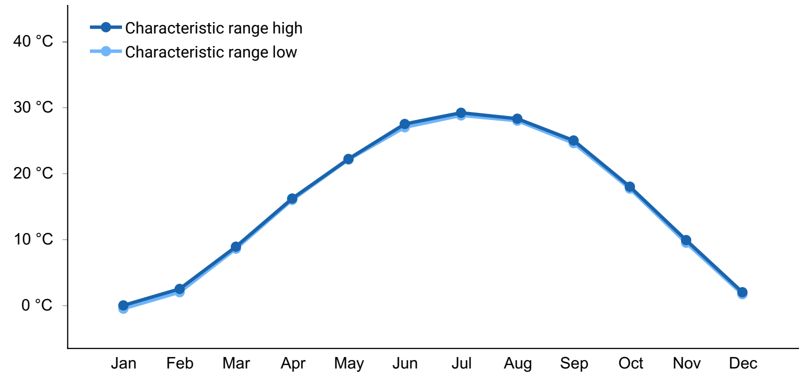


Figure 4. Monthly maximum temperature range

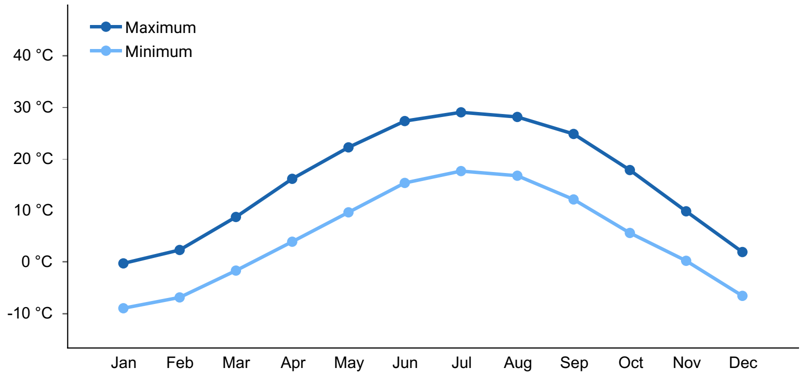


Figure 5. Monthly average minimum and maximum temperature

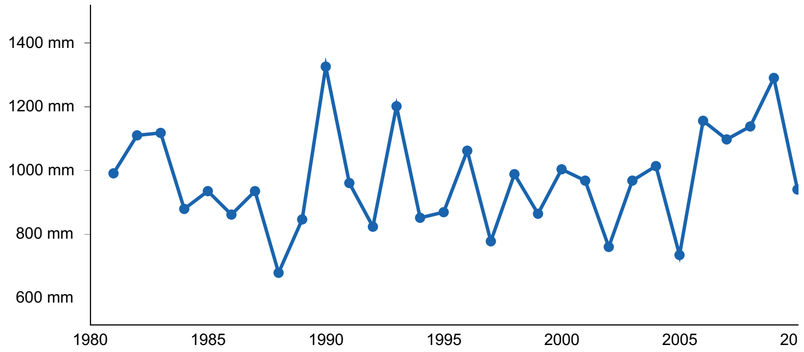


Figure 6. Annual precipitation pattern

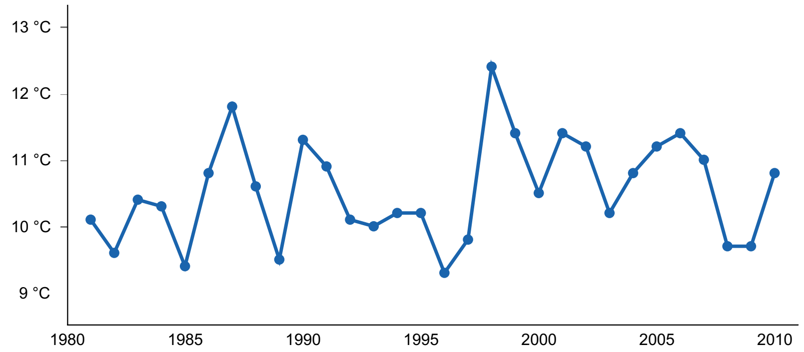


Figure 7. Annual average temperature pattern

Climate stations used

- (1) MARSEILLES LOCK [USC00115372], Marseilles, IL
- (2) KANKAKEE WASTEWATER [USC00114603], Kankakee, IL
- (3) JOLIET BRANDON RD DAM [USC00114530], Joliet, IL

Influencing water features

Limestone Woodlands are not influenced by wetland or riparian water features. Precipitation is the main source of water for this ecological site. Infiltration is very slow to slow (Hydrologic Groups C and D), and surface runoff is high. Surface runoff contributes some water to downslope ecological sites.

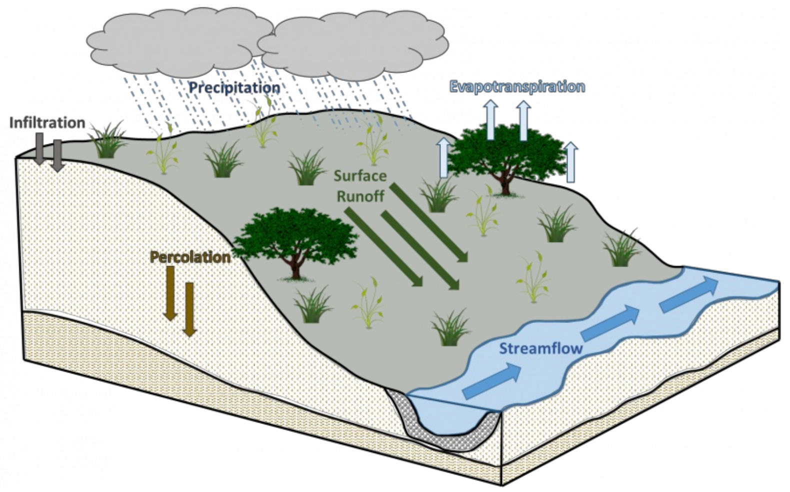


Figure 8. Hydrologic cycling in Limestone Woodland ecological site

Soil features

Soils of Limestone Woodlands are in the Alfisols order, further classified as Lithic Hapludalfs and Typic Hapludalfs with very slow to slow infiltration and high runoff potential. The soil series associated with this site includes Ritchey and Whalan. The parent material is till or drift over dolostone, and the soils are well drained and moderately deep. Soil pH classes are moderately acid to moderately alkaline. A paralithic contact is noted as a rooting restriction for the soils of this ecological site

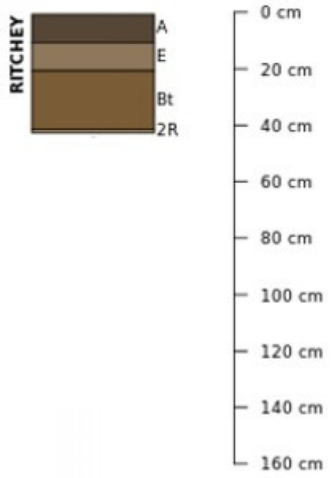


Figure 9. Profile sketches of soil series associated with Limestone Woodland

Table 4. Representative soil features

Parent material	(1) Till (2) Drift
Family particle size	(1) Fine-loamy (2) Loamy (3) Loamy-skeletal
Drainage class	Well drained
Permeability class	Very slow
Depth to restrictive layer	41–81 cm
Soil depth	41–81 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (Depth not specified)	7.62–15.24 cm
Calcium carbonate equivalent (Depth not specified)	0–20%
Electrical conductivity (Depth not specified)	0 mmhos/cm
Sodium adsorption ratio (Depth not specified)	0
Soil reaction (1:1 water) (Depth not specified)	5.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	3–7%
Subsurface fragment volume >3" (Depth not specified)	1–2%

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.

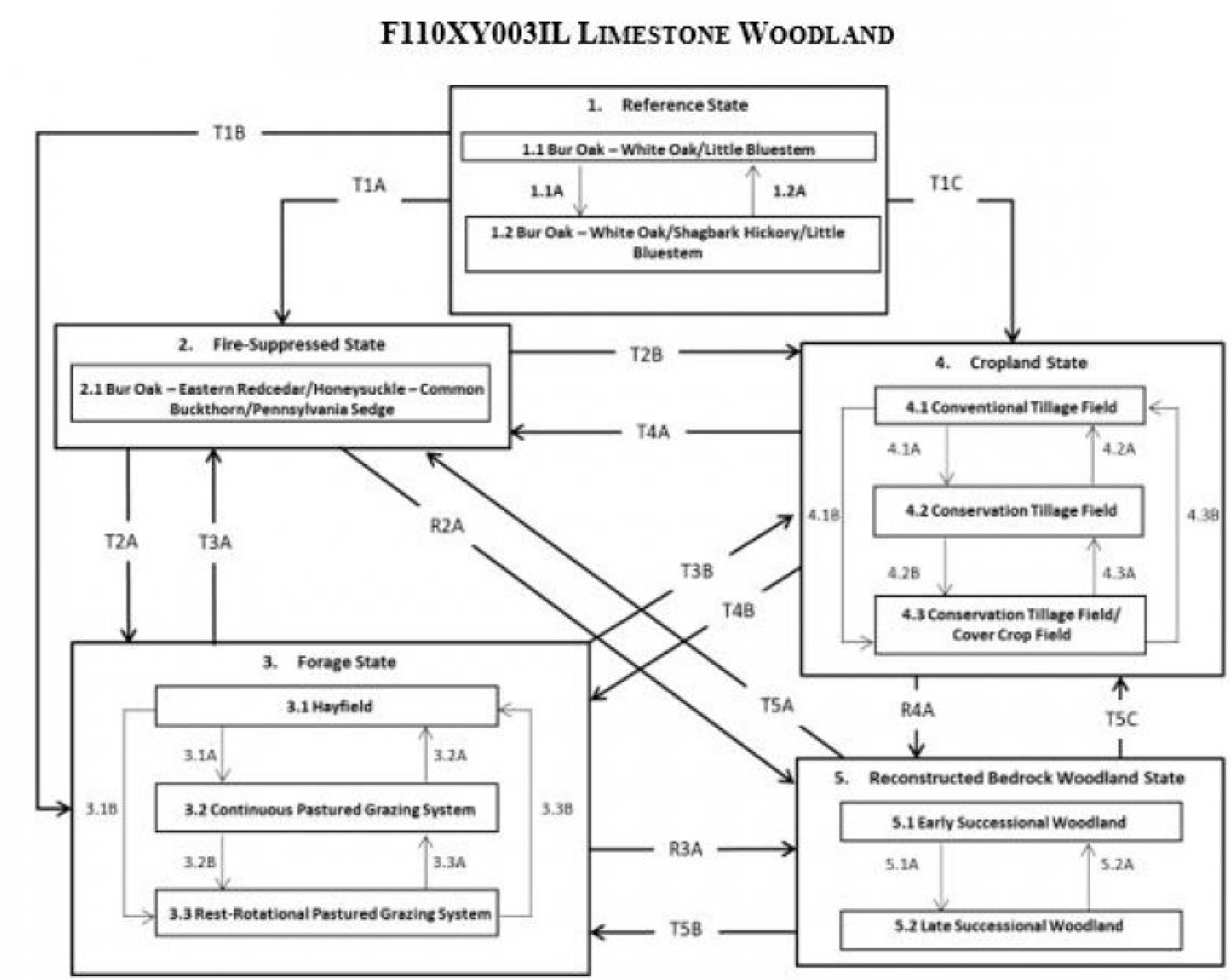
The MLRA lies within the tallgrass prairie ecosystem of the Midwest, but a variety of environmental and edaphic factors resulted in landscape that historically supported prairies, savannas, forests, and various wetlands. Limestone Woodlands form an aspect of this vegetative continuum. This ecological site occurs on bedrock-controlled uplands on well drained soils. Species characteristic of this ecological site consist of a scrubby, open oak canopy and sparse herbaceous vegetation.

Fire is a critical factor that maintains Limestone Woodlands. Fire typically consisted of low-severity surface fires every 10 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, drive large game, improve grazing and browsing habitat, agricultural clearing, and enhance vital ethnobotanical plants (Barrett 1980; LANDFIRE 2009).

Drought and storm damage have also played a role in shaping this ecological site. The periodic episodes of reduced soil moisture in conjunction with the moderately deep 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. Damage to trees from storms and pest outbreaks can vary from minor, patchy effects of individual trees to stand effects that temporarily affect community structure and species richness and diversity (Irland 2000; Peterson 2000). When coupled with fire, periods of drought and catastrophic storm damage can greatly delay the establishment and maturation of woody vegetation (Pyne et al. 1996).

Today, Limestone Woodlands have been reduced from their pre-settlement extent. Low to moderate slopes have been converted to cropland, while steeper slopes have been converted to forage land. Remnants that do exist have experienced long-term fire suppression and overbrowsing resulting in significant changes to the forest structure. A return to the historic plant community may not be possible following extensive land modification, but long-term conservation agriculture or forest 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



Code	Process
T1A, T3A, T4A, T5A	Long-term fire suppression and/or land abandonment
1.1A	Fire return interval greater than 25 years
1.2A	Mixed-severity fire
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, tree planting, 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 barren community, dominated by scrubby woody and herbaceous vegetation. The two community phases within the reference state are dependent on a combination of surface, mixed, and replacement fires. Low intensity surface fires are the dominant fire regime, comprising more than 80 percent of all fires and occurring every 2 to 7 years. Mixed and replacement fires comprise the remaining 20 percent, occurring approximately every 88 and 37 years, respectively (LANDFIRE 2009). Fire intensity and return intervals alter species composition, cover, and extent, while regular fire intervals keep woody species from closing the canopy. Episodic droughts and storm damage have more localized impacts in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

Community 1.1
Bur Oak - White Oak/Little Bluestem

Sites in this reference community phase are an open canopy woodland. Bur oak and white oak are the dominant trees on the site. Trees are medium (9 to 21-inch DBH), and heights are less than 30 feet tall (LANDFIRE 2009). The herbaceous layer can be sparse with grasses and forbs less than 3 feet tall, including little bluestem, poverty oatgrass (*Danthonia spicata* (L.) P.Beauv. ex Roem. & Schult.), bastard toadflax (*Comandra umbellata* (L.) Nutt. ssp. umbellata), and wild quinine (*Parthenium integrifolium* L.) (White and Madany 1978). Surface fires every 10 years will maintain this community phase, but an extended fire return interval will shift the community to phase 1.2 (LANDFIRE 2009).

Dominant plant species

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

Community 1.2
Bur Oak - White Oak/Shagbark Hickory/Little Bluestem

This reference community phase represents a fire return interval greater than 25 years. Bur oak and white oak remain the canopy dominant, but shagbark hickory (*Carya ovata* (Mill.) K. Koch) can begin to become prominent in the subcanopy. Tree size class remains medium due to stunting from the shallow rooting depth and acidic soil conditions. Surface fires every 10 years will maintain this community phase, but a mixed-severity fire will shift the community back to phase 1.1 (LANDFIRE 2009).

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- white oak (*Quercus alba*), tree
- shagbark hickory (*Carya ovata*), shrub
- little bluestem (*Schizachyrium scoparium*), grass

Pathway 1.1A
Community 1.1 to 1.2

Fire return interval greater than 25 years.

Pathway 1.2A
Community 1.2 to 1.1

Mixed-severity fire event.

State 2
Fire-Suppressed Forest State

Fire suppression can transition the reference plant community from an oak forest to an oak-maple mesophytic forest. As the natural fire regime is removed from the landscape, encroachment and dominance by shade-tolerant, fire-intolerant species ensues. This results in a positive feedback loop of mesophication whereby plant community succession continuously creates cool, damp shaded conditions that perpetuate a closed canopy ecosystem

(Nowacki and Abrams 2008). Succession to this forested state can occur in as little as 80 years from the last fire (LANDFIRE 2009).

Community 2.1
Bur Oak - Eastern Redcedar/Honeysuckle - Common Buckthorn/Pennsylvania Sedge

This community phase represents the early stages of long-term fire suppression. Mature, scrubby oaks and shagbark hickory are still present, but the fire-intolerant eastern redcedar (*Juniperus virginiana* L.) begins to co-dominate in the prolonged absence of fire. The tree canopy closes to 100 percent cover and basal area increases (LANDFIRE 2009). Non-native shrubs, such as honeysuckle (Lonicera L.) and common buckthorn (*Rhamnus cathartica* L.), can rapidly colonize. The herbaceous layer shifts to shade-tolerant species, and diversity is reduced.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- eastern redcedar (*Juniperus virginiana*), tree
- honeysuckle (*Lonicera*), shrub
- common buckthorn (*Rhamnus cathartica*), shrub
- Pennsylvania sedge (*Carex pensylvanica*), other herbaceous

State 3
Forage State

The forage state occurs when the reference state 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. 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 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 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 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 rotational 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

Rotational 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 rotational grazing.

State 4
Cropland State

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 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).

Community 4.2
Conservation Tillage Field

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

Community 4.3
Conservation Tillage Field/Alternative 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 4.1A
Community 4.1 to 4.2

Tillage operations are greatly reduced, crop rotation 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, crop rotation 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 crop practices are abandoned, monoculture row-cropping is established, and crop rotation is reduced or eliminated.

Pathway 4.3A
Community 4.3 to 4.2

Cover crop practices are abandoned.

State 5
Reconstructed Bedrock Woodland State

The combination of natural and anthropogenic disturbances occurring today has resulted in numerous forest health issues, and restoration back to the historic reference condition may not be possible. Woodlands are being stressed by non-native diseases and pests, habitat fragmentation, changes in soil conditions, and overabundant deer populations on top of naturally occurring disturbances (severe weather and native pests) (IFDC 2018). However, these habitats provide multiple ecosystem services including carbon sequestration; clean air and water; soil conservation; biodiversity support; wildlife habitat; timber, fiber, and fuel products; as well as a variety of cultural activities (e.g., hiking, camping, hunting) (Millennium Ecosystem Assessment 2005; IFDC 2018). Therefore, conservation of woodlands should still be pursued. Woodland reconstructions are an important tool for repairing natural ecological functioning and providing habitat protection for numerous species associated with Limestone Woodlands. 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 ranges of stress and disturbance, and create and maintain positive biotic and abiotic interactions (SER 2002). The reconstructed bedrock woodland state is the result of a long-term commitment involving a multi-step, adaptive management process.

Community 5.1
Early Successional Reconstructed Woodland

This community phase represents the early community assembly from woodland reconstruction. It is highly dependent on the current condition of the site based on past and current land management actions, invasive species, and proximity to land populated with non-native pests and diseases. Therefore, no two sites will have the same early successional composition. Technical forestry assistance should be sought to develop suitable conservation management plans.

Community 5.2
Late Successional Reconstructed Woodland

Appropriately timed management practices (e.g., prescribed fire, hazardous fuels management, forest stand improvement, continuing integrated pest management) applied to the early successional community phase can help increase the stand maturity, pushing the site into a late successional community phase over time. A late successional reconstructed woodland will have an uneven-aged canopy with a sparse, short herbaceous understory.

Pathway 5.1A
Community 5.1 to 5.2

Application of stand improvement practices in line with a developed management plan.

Pathway 5.2A
Community 5.2 to 5.1

Reconstruction experiences a setback from extreme weather event or improper timing of management actions.

Transition T1A
State 1 to 2

Long-term fire suppression in excess of 80 years transitions the site to the fire-suppressed forest 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 this 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, tree planting, invasive species control, seeding native species, and deer management transition this site to the reconstructed bedrock woodland state (5).

Transition T3A
State 3 to 2

Land abandonment transitions the site to the fire-suppressed forest 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, tree planting, invasive species control, and seeding native species transition this site to the reconstructed bedrock woodland state (5).

Transition T4A
State 4 to 2

Land abandonment transitions the site to the fire-suppressed forest 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, tree planting, invasive species control, and seeding native species transition this site to the reconstructed bedrock woodland state (5).

Transition T5A
State 5 to 2

Fire suppression and removal of active management transitions this site to the fire-suppressed forest 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

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 this ecological site description.

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Contributors

Lisa Kluesner
Kristine Ryan
Sarah Smith
Tiffany Justus

Approval

Chris Tecklenburg, 4/22/2020

Acknowledgments

This project could not have been completed without the dedication and commitment from a variety of staff members. Team members supported the project by serving on the technical team, assisting with the development of state and community phases of the state-and-transition model, providing peer review and technical editing, and conducting quality control and quality assurance reviews.

Table 6. List of primary contributors and reviewers.
Organization Name Title Location
Natural Resources Conservation Service Ron Collman State Soil Scientist Champaign, IL
Tonie Endres Senior Regional Soil Scientist Indianapolis, IN
Tiffany Justus Soil Scientist Aurora, IL
Lisa Kluesner Ecological Site Specialist Waverly, IA
Rick Neilson State Soil Scientist Indianapolis, IN
Jason Nemecek State Soil Scientist Madison, WI
Kevin Norwood Soil Survey Regional Director Indianapolis, IN
Kristine Ryan MLRA Soil Survey Leader Aurora, IL
Stanley Sipp Resource Inventory Specialist Champaign, IL
Sarah Smith Soil Scientist Aurora, IL
Chris Tecklenberg Acting Regional Ecological Site Specialist Hutchinson, KS

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	05/18/2024
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:**

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:**