USDA Natural Resources
Conservation Service

Ecological site F104XY009IA
Loamy Upland Woodland

Last updated: 5/18/2020
Accessed: 05/13/2025

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.

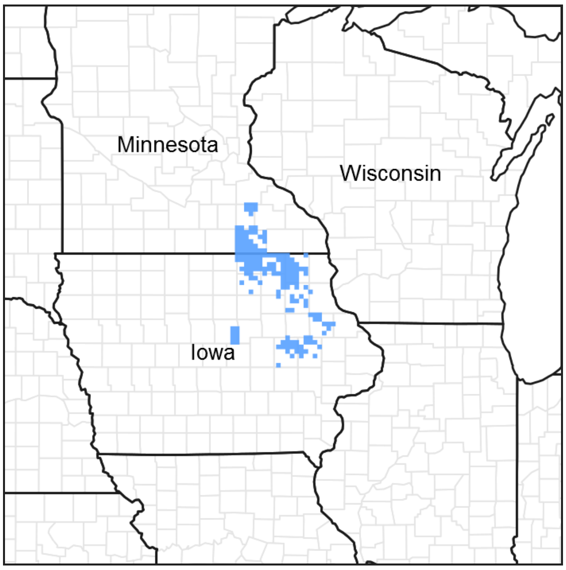


Figure 1. Mapped extent

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 System: North-Central Interior Dry-Mesic Oak Forest and Woodland (CES202.046) (NatureServe 2018)

National Vegetation Classification - Plant Associations: Quercus alba – Quercus macrocarpa – *Quercus rubra*/Corylus americana Woodland (CEGL002142 (Nature Serve 2018)

Biophysical Settings: North-Central Interior-Dry Mesic Oak Forest and Woodland (BpS 4213100) (LANDFIRE 2009)

Natural Resources Conservation Service – Iowa Plant Community Species List: Woodland, North Central Dry-Mesic Oak (USDA-NRCS 2007)

Iowa Department of Natural Resources: Upland Forest (INAI 1984)

Minnesota Department of Natural Resources: MHs37 Southern Dry-Mesic Oak Forest (MDNR 2005)

Ecological site concept

Loamy Upland Woodlands are located within the green areas on the map (Figure 1). They occur on upland summits, shoulders, and backslopes. The soils are Alfisols that are somewhat poorly to well-drained and deep, formed in loamy sediments. These sites are similar to Loamy Upland Savannas but occur in more fire-protected landscapes, such as on the east side of rivers and streams.

The historic pre-European settlement vegetation on this ecological site was dominated by an open oak woodland with a continuous understory. White oak (Quercus alba L.) and bur oak (Quercus macrocarpa Michx.) are the dominant species in the tree canopy, and hophornbeam (Ostrya virginiana (Mill.) K. Koch) is the dominant subcanopy species. Northern red oak (*Quercus rubra* L.) and hickories (Carya Nutt.) can be common canopy associates (LANDFIRE 2009; NatureServe 2018). Big bluestem (Andropogon gerardii Vitman) is a characteristic herbaceous species. Species typical of an undisturbed plant community associated with this ecological site include rosy sedge (Carex rosea Schkuhr ex Willd.), burningbush (Euonymus atropurpureus Jacq.), and Jersey tea (Ceanothus herbaceus Raf.) (Drobney et al. 2001; USDA-NRCS 2007). Shrubs can be present, including gray dogwood (Cornus racemosa Lam.) and American hazelnut (Corylus americana Walter) (NatureServe 2018). Fire is the primary disturbance factor that maintains this ecological site, while drought, windthrow, and grazing are secondary factors (LANDFIRE 2009).

Associated sites

F104XY004IA	**Bedrock Woodland** Loamy sediments over bedrock including Backbone, Dubuque, Montieth, Taopi, Whalan, Winneshiek and Winneshiek variant soils
F104XY020IA	**Loamy Floodplain Forest** Alluvial soils including Ackmore, Alluvial land, Arenzville, DuPage, Huntsville, Kennebec, Lawson, and Spillville

Similar sites

F104XY004IA	**Bedrock Woodland** Bedrock Woodlands are in a similar landscape position, but soils are shallow to bedrock

Table 1. Dominant plant species

Tree	(1) *Quercus alba* (2) *Quercus macrocarpa*
Shrub	(1) *Ostrya virginiana*
Herbaceous	(1) *Andropogon gerardii*

Physiographic features

Loamy Upland Woodlands occur on uplands (Figure 2). They are situated on elevations ranging from approximately 699 to 2001 feet ASL. The site does not experience flooding, but rather generates runoff to adjacent, downslope ecological sites.

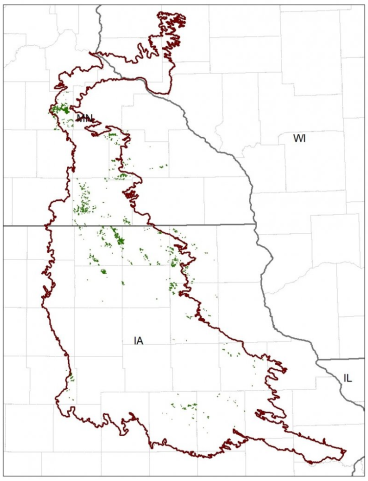


Figure 2. Figure 1. Location of Loamy Upland Woodland ecological site within MLRA 104.

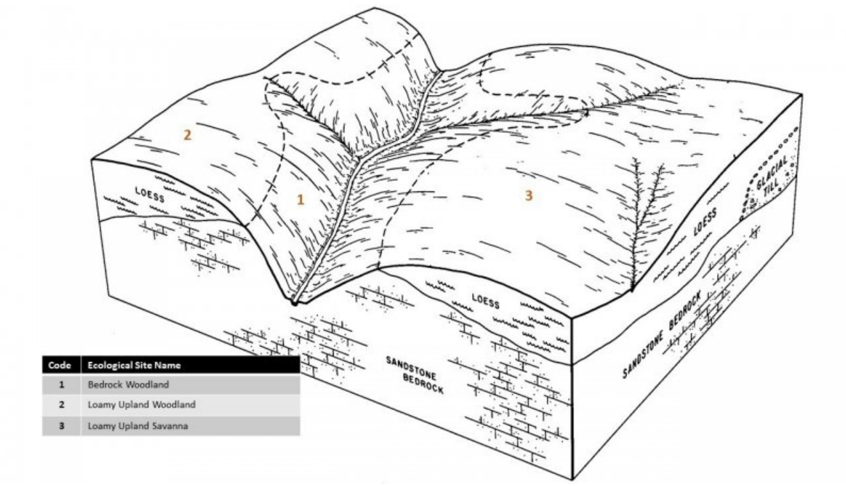


Figure 3. Figure 2. Representative block diagram of Loamy Upland Woodland and associated ecological sites.

Table 2. Representative physiographic features

Hillslope profile	(1) Summit (2) Shoulder (3) Backslope
Slope shape across	(1) Convex
Slope shape up-down	(1) Convex

Landforms	(1) Upland > Till plain
Runoff class	Low to high
Elevation	213–610 m
Slope	1–12%
Water table depth	30–203 cm
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 148 days, while the frost-free period is about 125 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 34 inches, which includes rainfall plus the water equivalent from snowfall (Table 3). The average annual low and high temperatures are 35 and 55°F, respectively.

Climate data and analyses are derived from 30-year averages gathered from three 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)	121-130 days
Freeze-free period (characteristic range)	141-153 days
Precipitation total (characteristic range)	838-889 mm
Frost-free period (actual range)	117-131 days
Freeze-free period (actual range)	141-158 days
Precipitation total (actual range)	838-914 mm
Frost-free period (average)	125 days
Freeze-free period (average)	148 days
Precipitation total (average)	864 mm

Climate stations used

- (1) FARIBAULT [USC00212721], Faribault, MN
- (2) AUSTIN WWT FAC [USC00210355], Austin, MN
- (3) OSAGE [USC00136305], Osage, IA

Influencing water features

Loamy Upland Woodlands 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 B, C, and D), and surface runoff is low to high. Surface runoff contributes some water to downslope ecological sites (Figure 5).

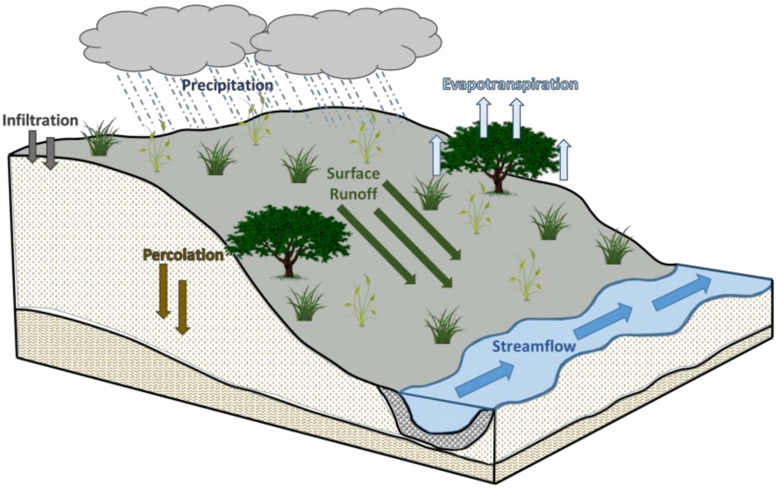


Figure 10. Figure 5. Hydrologic cycling in Loamy Upland Woodland ecological site.

Soil features

Soils of Loamy Upland Woodlands are in the Alfisols order, further classified as Aeric Endoaqualfs, Aquic Glossudalfs, Oxyaquic Hapludalfs, and Typic Hapludalfs with very slow to moderate infiltration and low to high runoff potential. The soil series associated with this site includes Coggon, Pinicon, Renova, Roseville, Sargeant, and Vlasaty. The parent material is loamy sediments, and the soils are somewhat poorly to well-drained and deep. Soil pH classes are strongly acid to moderately alkaline. No rooting restrictions are noted for the soils of this ecological site (Table 5).

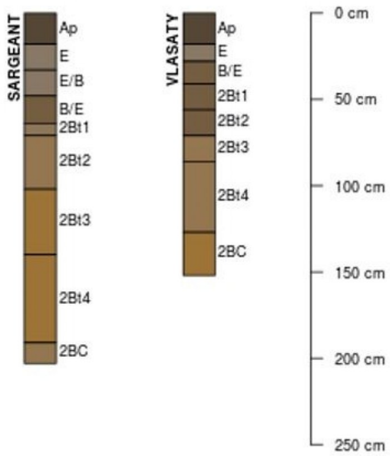


Figure 11. Figure 6. Profile sketches of soil series associated with Loamy Upland Woodland.

Table 4. Representative soil features

Family particle size	(1) Fine-loamy
Drainage class	Somewhat poorly drained to well drained
Permeability class	Very slow to moderately 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 support prairies, savannas, woodlands, and forests. Loamy Upland Woodlands form an aspect of this vegetative continuum. This ecological site occurs on uplands on somewhat poorly to well-drained soils. Species characteristic of this ecological site consist of an open oak canopy with a continuous understory of herbaceous vegetation.

Fire is a critical factor that maintains Loamy Upland Woodlands. Fire typically consisted of low- to moderate-severity surface fires every 15 to 25 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, grazing, and windthrow have also played a role in shaping this ecological site. The periodic episodes of reduced soil moisture in conjunction with the moderately well to well-drained soils have favored the proliferation of plant species tolerant of such conditions. Drought can also slow the growth of plants and result in dieback of certain species. Damage to trees from storms 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, herbivory, and high wind events can greatly delay the establishment and maturation of woody vegetation (Pyne et al. 1996).

Today, Loamy Upland 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 had fire suppressed long enough to allow the site to convert to a closed canopy, mesophytic forest. A return to the historic plant community may not be possible following extensive land modification, but long-term conservation agriculture or woodland 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 an open oak-hickory woodland community, dominated by deciduous trees and herbaceous vegetation. The two community phases within the reference state are dependent on recurring fire intervals. The severity and intensity of fire alters species composition, cover, and extent, while regular fire intervals keep the canopy from succeeding to mesophytic, fire-intolerant species. Drought, grazing, and windthrow have more localized impacts in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

Community Phase 1.1 White Oak – Bur Oak/Hophornbeam/Big Bluestem – Sites in this reference community phase are an open canopy woodland. White oak and bur oak are the dominant tree species, but northern red oak and hickories are common canopy associates. Trees are large (21 to 33 inches DBH) and cover ranges from 21 to 60 percent (LANDFIRE 2009). Hophornbeam frequently occurs as a subcanopy component. The herbaceous layer is mostly a continuous mix of graminoids and forbs including big bluestem, Pennsylvania sedge (*Carex pensylvanica* Lam.), pointedleaf ticktrefoil (*Desmodium glutinosum* (Muhl. ex Willd.) Alph. Wood), and spotted geranium (*Geranium maculatum* L.) (NatureServe 2018). Surface fires occurring approximately every 20 years will maintain this phase, but beyond 25 years the community will shift to phase 1.2 (LANDFIRE 2009).

Pathway 1.1A – Fire return interval greater than 25 years.

Community Phase 1.2 White Oak – Hickory/Hophornbeam – Gray Dogwood/Pennsylvania Sedge – American Hogpeanut – This community phase represents natural succession as a result of an extended fire return interval. The lack of disturbance allows the hickory component to mature, co-dominating with the oaks. Hophornbeam is still present in the subcanopy. Tree size class remains steady, but canopy coverage ranges from 61 to 80 percent shifting the site to a closed canopy woodland (LANDFIRE 2009). The shrub layer becomes more prominent during this phase with species such as gray dogwood, American hazelnut, and Missouri gooseberry (*Ribes missouriense* Nutt.) (NatureServe 2018). Pennsylvania sedge, American hogpeanut (*Amphicarpaea bracteata* (L.) Fernald), woodbine (*Parthenocissus vitacea* (Knerr.) Hitchc.), and other shade-tolerant species become more common in the herbaceous layer. Periodic surface fires will maintain this phase, but replacement fires occurring approximately every 20 years will shift the community back to phase 1.1 (LANDFIRE 2009).

Pathway 1.2A – Replacement fire every 20 years

Transition 1A – Long-term fire suppression in excess of 50 years transitions the site to the fire-suppressed state (2).

Transition 1B – Cultural treatments to enhance forage quality and yield transitions the site to the forage state (3).

Transition 1C – Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (4).

STATE 2 – FIRE-SUPPRESSED STATE
Long-term fire suppression can transition the reference plant community from an open woodland to a closed canopy 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 50 years from the last fire (LANDFIRE 2009).

Community Phase 2.1 Northern Red Oak – Sugar Maple/Black Cherry/Jack in the pulpit – Mayapple – This community phase represents the early stages of long-term fire suppression. White oak, bur oak, and hickory can still be present but more mesic species – e.g., northern red oak (*Quercus rubra* L.), sugar maple (*Acer saccharum* Marshall), and American basswood (*Tilia americana* L.) – begin to dominate (MDNR 2005). The tree canopy increases to 81 to 100 percent cover and basal area increases (LANDFIRE 2009). The subcanopy and shrub layer shifts to fire-intolerant species including black cherry (*Prunus serotina* Ehrh.). The herbaceous layer is increasingly dominated by spring ephemerals under the closed canopy mesophytic forest. Jack in the pulpit (*Arisaema triphyllum* (L.) Schott), mayapple (*Podophyllum peltatum* L.), bloodroot (*Sanguinaria canadensis* L.), and largeflower bellflower (*Uvularia grandiflora* Sm.) are common forbs noted in the spring.

Pathway 2.1A – Continued fire suppression.

Community Phase 2.2 Sugar Maple – American Basswood/Black Cherry/Jack in the pulpit – Mayapple – Sites falling into this community phase have a well-established, fire-intolerant sugar maple-basswood closed canopy, with hophornbeam and black cherry being common subcanopy species. Without recurring fire, downed woody debris and herbaceous and leaf litter are frequently encountered on the forest floor.

Pathway 2.2A – Severe disturbance event such as a replacement fire, severe drought, or windstorm.

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

Transition 2B – Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (4).

Restoration 2A – Site preparation, tree planting, invasive species control, and seeding native species transition this site to the reconstructed oak woodland state (5).

STATE 3 – FORAGE STATE
The forage state occurs when the site is converted to a farming system that emphasizes domestic livestock production known as grassland agriculture. Fire suppression, periodic cultural treatments (e.g., clipping, drainage, soil amendment applications, planting new species and/or cultivars, mechanical harvesting) and grazing by domesticated livestock transition and maintain this state (USDA-NRCS 2003). Early settlers seeded non-native species, such as smooth brome (*Bromus inermis* Leyss.) and Kentucky bluegrass (*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. This state is most common on the steeply sloping sites.

Community Phase 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).

Pathway 3.1A – Mechanical harvesting is replaced with domestic livestock utilizing continuous grazing.

Pathway 3.1B – Mechanical harvesting is replaced with domestic livestock utilizing rotational grazing.

Community Phase 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.

Pathway 3.2A – Domestic livestock are removed, and mechanical harvesting is implemented.

Pathway 3.2B – Rotational grazing replaces continuous grazing.

Community Phase 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 3.3A – Continuous grazing replaces rotational grazing.

Pathway 3.3B – Domestic livestock are removed, and mechanical harvesting is implemented.

Transition 3A – Land abandonment transitions the site to the fire-suppressed state (2).

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

Restoration 3A – Site preparation, tree planting, invasive species control, and seeding native species transition this site to the reconstructed oak woodland state (5).

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. This state is most common on the gently sloping sites.

Community Phase 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).

Pathway 4.1A – Tillage operations are greatly reduced, crop rotation occurs on a regular interval, and crop residue remains on the soil surface.

Pathway 4.1B – 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 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.

Pathway 4.2A – Intensive tillage is utilized, and monoculture row-cropping is established.

Pathway 4.2B – Cover crops are implemented to minimize soil erosion.

Community Phase 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 cropland system.

Pathway 4.3A – Cover crop practices are abandoned.

Pathway 4.3B – Intensive tillage is utilized, cover crops practices are abandoned, monoculture row-cropping is established, and crop rotation is reduced or eliminated.

Transition 4A – Land abandonment transitions the site to the fire-suppressed state (2).

Transition 4B – Cultural treatments to enhance forage quality and yield transitions the site to the forage state (3).

Restoration 4A – Site preparation, tree planting, invasive species control, and seeding native species transition this site to the reconstructed oak woodland state (5).

STATE 5 – RECONSTRUCTED OAK 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, permanent changes in soil hydrology, and overabundant deer populations on top of naturally-occurring disturbances (severe weather and native pests) (Flickinger 2010). 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; Flickinger 2010). Therefore, conservation of forests and 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 Loamy Upland 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 woodland state is the result of a long-term commitment involving a multi-step, adaptive management process.

Community Phase 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 woodland 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.

Pathway 5.1A – Application of stand improvement practices in line with a developed management plan.

Community Phase 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 and a well-developed shrub layer and understory.

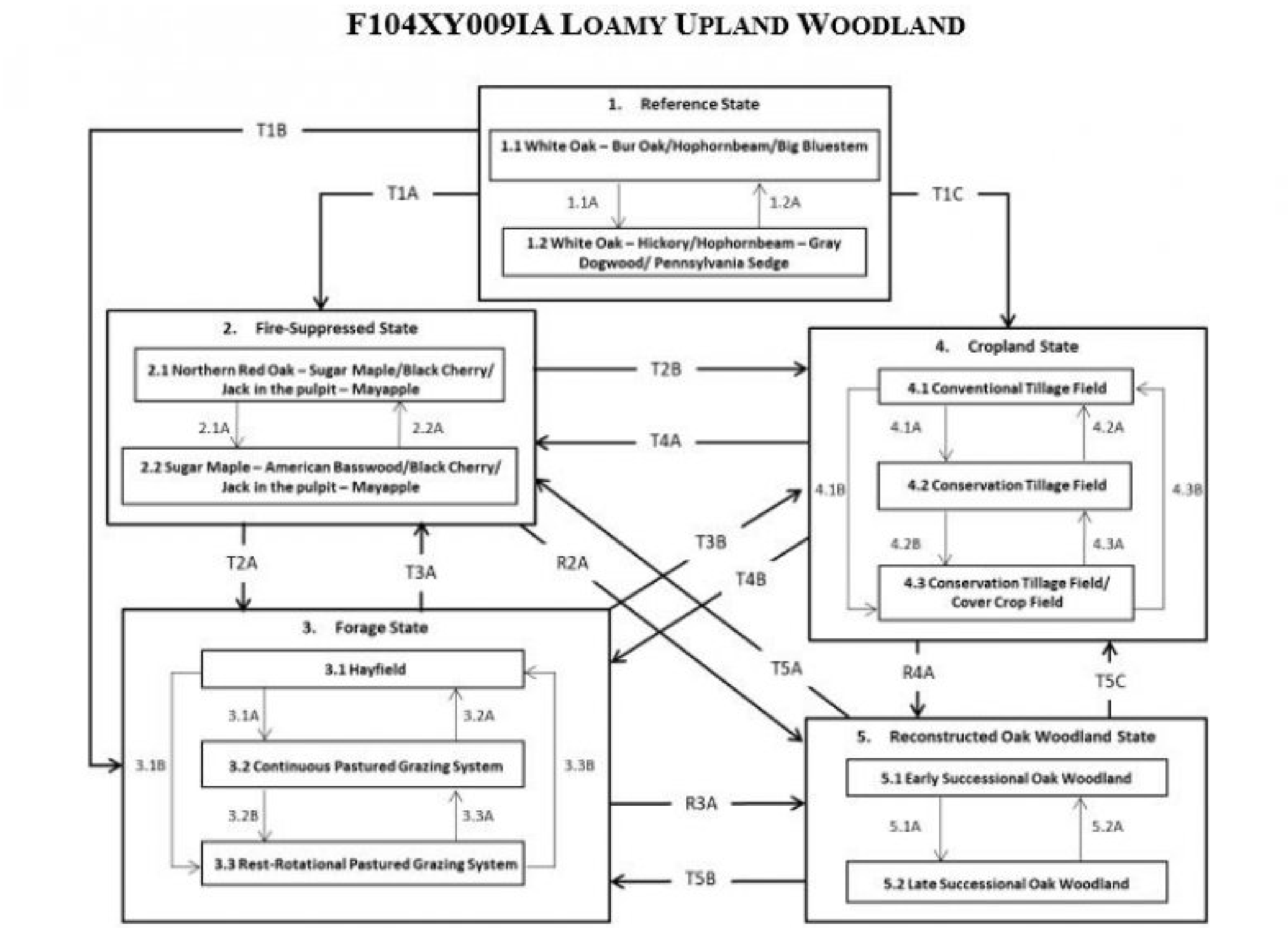
Pathway 5.2A – Reconstruction experiences a setback from extreme weather event or improper timing of management actions.

Transition 5A – Fire suppression and removal of active management transitions this site to the fire-suppressed state (2).

Transition 5B – Cultural treatments to enhance forage quality and yield transition the site to the forage state (3).

Transition 5C – Tillage, seeding of agricultural crops, and non-selective herbicide transition this site to the cropland state (4).

State and transition model



Code	Process
1.1A	Fire return interval greater than 25 years
1.2A	Replacement fire every 20 years
T1A, T3A, T4A, T5A	Long-term fire suppression and/or land abandonment
2.1A	Continued fire suppression
2.2A	Severe disturbance event such as fire, drought, or windstorm
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 an open oak-hickory woodland community, dominated by deciduous trees and herbaceous vegetation. The two community phases within the reference state are dependent on recurring fire intervals. The severity and intensity of fire alters species composition, cover, and extent, while regular fire intervals keep the canopy from succeeding to mesophytic, fire-intolerant species. Drought, grazing, and windthrow have more localized impacts in the reference phases, but do contribute to overall species composition, diversity, cover, and productivity.

Community 1.1
White Oak – Bur Oak/Hophornbeam/Big Bluestem

Sites in this reference community phase are an open canopy woodland. White oak and bur oak are the dominant tree species, but northern red oak and hickories are common canopy associates. Trees are large (21 to 33 inches DBH) and cover ranges from 21 to 60 percent (LANDFIRE 2009). Hophornbeam frequently occurs as a subcanopy component. The herbaceous layer is mostly a continuous mix of graminoids and forbs including big bluestem, Pennsylvania sedge (*Carex pensylvanica* Lam.), pointedleaf ticktrefoil (*Desmodium glutinosum* (Muhl. ex Willd.) Alph. Wood), and spotted geranium (*Geranium maculatum* L.) (NatureServe 2018). Surface fires occurring approximately every 20 years will maintain this phase, but beyond 25 years the community will shift to phase 1.2 (LANDFIRE 2009).

Community 1.2
White Oak – Hickory/Hophornbeam – Gray Dogwood/Pennsylvania Sedge – American Hogpeanut

This community phase represents natural succession as a result of an extended fire return interval. The lack of disturbance allows the hickory component to mature, co-dominating with the oaks. Hophornbeam is still present in the subcanopy. Tree size class remains steady, but canopy coverage ranges from 61 to 80 percent shifting the site to a closed canopy woodland (LANDFIRE 2009). The shrub layer becomes more prominent during this phase with species such as gray dogwood, American hazelnut, and Missouri gooseberry (*Ribes missouriense* Nutt.) (NatureServe 2018). Pennsylvania sedge, American hogpeanut (*Amphicarpaea bracteata* (L.) Fernald), woodbine (*Parthenocissus vitacea* (Knerr.) Hitchc.), and other shade-tolerant species become more common in the herbaceous layer. Periodic surface fires will maintain this phase, but replacement fires occurring approximately every 20 years will shift the community back to phase 1.1 (LANDFIRE 2009).

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

Replacement fire every 20 years

State 2
Fire-suppressed State

Long-term fire suppression can transition the reference plant community from an open woodland to a closed canopy 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 50 years from the last fire (LANDFIRE 2009).

Community 2.1
Northern Red Oak – Sugar Maple/Black Cherry/Jack in the pulpit – Mayapple

This community phase represents the early stages of long-term fire suppression. White oak, bur oak, and hickory can still be present but more mesic species – e.g., northern red oak (*Quercus rubra* L.), sugar maple (*Acer saccharum* Marshall), and American basswood (*Tilia americana* L.) – begin to dominate (MDNR 2005). The tree canopy increases to 81 to 100 percent cover and basal area increases (LANDFIRE 2009). The subcanopy and shrub layer shifts to fire-intolerant species including black cherry (*Prunus serotina* Ehrh.). The herbaceous layer is increasingly dominated by spring ephemerals under the closed canopy mesophytic forest. Jack in the pulpit (*Arisaema triphyllum* (L.) Schott), mayapple (*Podophyllum peltatum* L.), bloodroot (*Sanguinaria canadensis* L.), and largeflower bellflower (*Uvularia grandiflora* Sm.) are common forbs noted in the spring.

Community 2.2
Sugar Maple – American Basswood/Black Cherry/Jack in the pulpit – Mayapple

Sites falling into this community phase have a well-established, fire-intolerant sugar maple-basswood closed canopy, with hophornbeam and black cherry being common subcanopy species. Without recurring fire, downed woody debris and herbaceous and leaf litter are frequently encountered on the forest floor.

Pathway 2.1A
Community 2.1 to 2.2

Continued fire suppression.

Pathway 2.2A
Community 2.2 to 2.1

Severe disturbance event such as a replacement fire, severe drought, or windstorm.

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 (*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. This state is most common on the steeply sloping sites.

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 includes 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 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 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. This state is most common on the gently sloping sites.

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

4.2A – 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 Oak 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, permanent changes in soil hydrology, and overabundant deer populations on top of naturally-occurring disturbances (severe weather and native pests) (Flickinger 2010). 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; Flickinger 2010). Therefore, conservation of forests and 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 Loamy Upland 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 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 woodland 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 and a well-developed shrub layer and 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 50 years 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 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, and seeding native species transition this site to the reconstructed oak woodland 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, tree planting, invasive species control, and seeding native species transition this site to the reconstructed oak woodland 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, tree planting, invasive species control, and seeding native species transition this site to the reconstructed oak woodland state (5).

Restoration pathway T5A
State 5 to 2

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

Restoration pathway 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 ecological site description.

Other references

Baker, R.G., C.A. Chumbley, P.M. Witinok, and H.K. Kim. 1990. Holocene vegetational changes in eastern Iowa. Journal of the Iowa Academy of Science 97: 167-177.

Baker, R.G., L.J. Maher, C.A. Chumbley, and K.L. Van Zant. 1992. Patterns of Holocene environmental changes in the midwestern United States. Quaternary Research 37: 379-389.

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

Cleland, D.T., J.A. Freeouf, J.E. Keys, G.J. Nowacki, C. Carpenter, and W.H. McNab. 2007. Ecological Subregions: Sections and Subsections of the Coterminous United States. USDA Forest Service, General Technical Report WO-76. Washington, DC. 92 pps.

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

Flickinger, A. 2010. Iowa Forests Today: An Assessment of the Issues and Strategies for Conserving and Managing Iowa’s Forests. Iowa Department of Natural Resources. 329 pps.

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

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

Irland, L.C. 2000. Ice storms and forest impacts. The Science of the Total Environment 262:231-242.

LANDFIRE. 2009. Biophysical Setting 4213100 North-Central Interior Dry-Mesic Oak Forest and Woodland. In: LANDFIRE National Vegetation Dynamics Models. USDA Forest Service and US Department of Interior. Washington, DC.

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

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-Being: Current States and Trends. World Resources Institute. Island Press, Washington, D.C. 948 pages.

Minnesota Department of Natural Resources [MDNR]. 2005. Field Guide to the Native Plant Communities of Minnesota: The Eastern Broadleaf Forest Province. Ecological Land Classification Program, Minnesota County Biological Survey, Natural Heritage and Nongame Research Program, Minnesota Department of Natural Resources, St. Paul, MN.

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

NatureServe. 2018. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1 NatureServe, Arlington, VA. Available at http://explorer.natureserve.org. (Accessed 27 November 2018).

Peel, M.C., B.L. Finlayson, and T.A. McMahon. 2007. Updated world map of the Köppen-Geiger climate classification. Hydrology and Earth System Sciences 11: 1633-1644.

Peterson, C.J. 2000. Catastrophic wind damage to North American forests and the potential impact of climate change. The Science of the Total Environment 262: 287-311.

Prior, J.C. 1991. Landforms of Iowa. University of Iowa Press for the Iowa Department of Natural Resources, Iowa City, IA. 153 pps.

Pyne, S.J., P.L. Andrews, and R.D. Laven. 1996. Introduction to Wildland Fire, Second Edition. John Wiley and Sons, Inc. New York, New York. 808 pps.

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

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

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

Tomer, M.D., D.W. Meek, and L.A. Kramer. 2005. Agricultural practices influence flow regimes of headwater streams in western Iowa. Journal of Environmental Quality 34:1547-1558.

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

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

United States Department of Agriculture – Natural Resource Conservation Service (USDA-NRCS). 2006. Land

Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. 682 pps.

United States Department of Agriculture – Natural Resources Conservation Service (USDA-NRCS). 2007. Iowa NRCS Plant Community Species Lists. Des Moines, IA. Available at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ia/technical/ecoscience/bio/?cid=nrcs142p2_008160. (Accessed 19 January 2018).

U.S. Environmental Protection Agency [EPA]. 2013. Level III and Level IV Ecoregions of the Continental United States. Corvallis, OR, U.S. EPA, National Health and Environmental Effects Research Laboratory, map scale 1:3,000,000. Available at http://www.epa.gov/eco-research/level-iii-andiv-ecoregions-continental-united-states. (Accessed 1 March 2017).

Contributors

Lisa Kluesner
Ryan Dermody

Approval

Chris Tecklenburg, 5/18/2020

Acknowledgments

This project could not have been completed without the dedication and commitment from a variety of partners and staff. 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.

Drake University:
Dr. Tom Rosburg, Professor of Ecology and Botany, Des Moines, IA

Iowa Department of Natural Resources:
John Pearson, Ecologist, Des Moines, IA
Greg Schmitt, Private Lands Biologist, West Union, IA

Conservation Districts of Iowa:
Sean Kluesner, Private Lands Wetland Easement Team Specialist, New Hampton, IA

LANDFIRE (The Nature Conservancy):
Randy Swaty, Ecologist, Evanston, IL

Natural Resources Conservation Service :
Rick Bednarek, Iowa State Soil Scientist, Des Moines, IA
Scott Brady, Acting Regional Ecological Site Specialist, Havre, MT
Leland Camp, Soil Scientist, Waverly, IA
Patrick Chase, Area Resource Soil Scientist, Fort Dodge, IA
Stacey Clark, Regional Ecological Site Specialist, St. Paul, MN
James Cronin, State Biologist, Des Moines, IA
Ryan Dermody, Soil Survey Leader, Waverly, IA
Tonie Endres, Senior Regional Soil Scientist, Indianapolis, IN
Gregg Hadish, GIS Specialist, Des Moines, IA
John Hammerly, Soil Data Quality Specialist, Indianapolis, IN
Lisa Kluesner, Ecological Site Specialist, Waverly, IA
Jeff Matthias, State Grassland Specialist, Des Moines, IA
Louis Moran, Area Resource Soil Scientist, Sioux City, IA
Kevin Norwood, Soil Survey Regional Director, Indianapolis, IN
James Phillips, GIS Specialist, Des Moines, IA

Neil Sass, Area Resource Soil Scientist, West Union, IA
Jason Steele, Area Resource Soil Scientist, Fairfield, IA

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	05/13/2025
Approved by	Chris Tecklenburg
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

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

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

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

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

6. **Extent of wind scoured, blowouts and/or depositional areas:**

7. **Amount of litter movement (describe size and distance expected to travel):**

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

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

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

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant:

    Sub-dominant:

    Other:

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

14. **Average percent litter cover (%) and depth (in):**

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

17. **Perennial plant reproductive capability:**