USDA Natural Resources Conservation Service

Ecological site R103XY021MN
Clayey Upland Savannas

Last updated: 10/04/2023
Accessed: 05/05/2024

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): 103X–Central Iowa and Minnesota Till Prairies

MLRA 103 is in Minnesota (56 percent) and Iowa (44 percent) and consists of approximately 18 million acres. It is in the Western Lake Section of the Central Lowland Province of the Interior Plains in an area known as the "Des Moines Lobe" of the Wisconsin-age ice sheet. The MLRA is mostly on a young, nearly level to gently rolling, glaciated till plain that has moraines and glacial lake plains in some areas. The plain is covered with glacial till, outwash, and glacial lake deposits. Recent alluvium consisting of clay, silt, sand, and gravel fill the bottoms of most of the major river valleys. Paleozoic bedrock sediments, primarily shale and limestone, underlie the glacial deposits in most of the area.

The annual precipitation increases from northwest to southeast. Most of the rainfall occurs as high-intensity, convective thunderstorms during the summer. Two-thirds or more of the precipitation falls during the freeze-free period. Snowfall is common in winter. Ground water supplies are adequate for the domestic, livestock, municipal, and industrial needs. Nearly all of this area is farmland, and about four-fifths is cropland.

Classification relationships

Major Land Resource Area (MLRA): Central Iowa and Minnesota Till Prairies (103) (USDA Handbook 296, 2006)

USFS Subregions: North Central Glaciated Plains Section (251B); Upper Minnesota River-Des Moines Lobe (251BA) and Southern Des Moines Lobe (251Be) Subsections (Cleland et al. 2007)

Relationship to Other Established Classifications:
The reference state is similar to the Minnesota Department of Natural Resources UPs24 Southern Mesic Savanna.

Ecological site concept

The Clayey Upland Savannas are characterized by a savanna plant community on fine-textured soils. These soils developed under a native grasses and scattered fire-tolerant trees. This site was historically subject to intermittent fire events. Soil attributes that characterize this concept are fine textured mollic epipedons and argillic horizons.

Associated sites

R103XY023MN	**Clayey Wet Savannas** The Clayey Wet Savannas ecological site occurs on poorly drained, silty-textured soils located in depressions, on low gradient linear slopes, or on toeslopes. This site has a seasonal high water table at or very near the surface.

Similar sites

R103XY020MN	**Loamy Upland Savannas** The Loamy Upland Savannas ecological site is characterized by a savanna plant community on soils derived from medium-textured till and lacustrine materials. Drainage class ranges from well to somewhat poorly drained.

Table 1. Dominant plant species

Tree	(1) *Quercus macrocarpa* (2) *Quercus ellipsoidalis*
Shrub	(1) *Corylus americana* (2) *Amorpha canescens*
Herbaceous	(1) *Andropogon gerardii*

Physiographic features

The Clayey Upland Savannas ecological site occurs on lake plains (Glacial Lake Minnesota) and ground, end, and lateral moraines. Although widespread, the central concept for this site resides adjacent to the Big Woods ecoregion in Minnesota. The most common landform positions are backslopes, summits, and shoulders that are linear to slightly convex both vertically and horizontally.

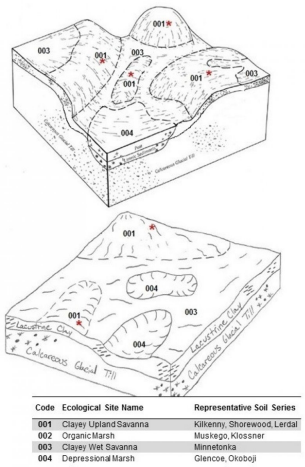


Figure 1. Block diagrams of the representative Clayey Upland Savannas and associated ecological sites.

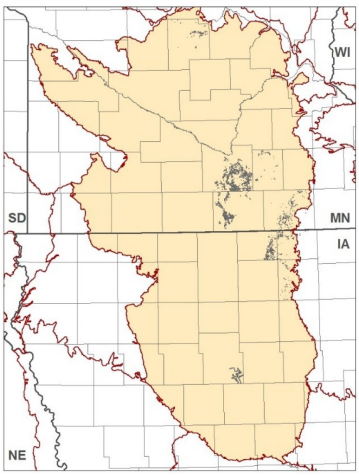


Figure 2. Distribution of the Clayey Upland Savannas ecological site within MLRA 103. In many cases, the data set is not spatially consistent across political boundaries due to the method by which soils were mapped; e.g. due to county subsets.

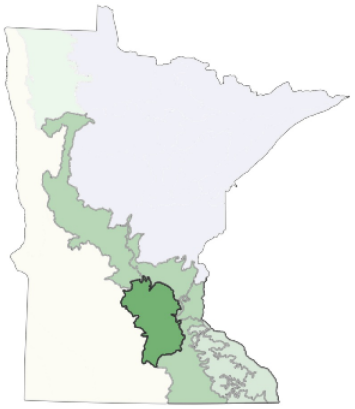


Figure 3. The state of Minnesota with the Big Woods Region in dark green. (MN DNR)

Table 2. Representative physiographic features

Hillslope profile	(1) Backslope (2) Summit (3) Shoulder
Landforms	(1) Ground moraine (2) Lava plain (3) End moraine (4) Lateral moraine
Runoff class	Low to very high
Elevation	688–1,837 ft
Slope	0–35%
Water table depth	30–80 in
Aspect	W, NW, N, NE, E, SE, S, SW

Climatic features

The soil temperature regime of MLRA 103 is classified as “mesic” (i.e., mean annual soil temperature between 46 and 59°F). The average freeze-free period of this site is 154 days, while the frost-free period is 127 days. The average mean annual precipitation is 32 inches, which includes rainfall plus the water equivalent from snowfall. Cold air drainage, a lower water table and the fact that dry soils are generally warmer than wet soils make this site warmer than adjacent, downslope sites.

Table 3. Representative climatic features

Frost-free period (characteristic range)	124-129 days
Freeze-free period (characteristic range)	150-156 days
Precipitation total (characteristic range)	31-33 in
Frost-free period (actual range)	123-130 days
Freeze-free period (actual range)	149-160 days
Precipitation total (actual range)	31-33 in
Frost-free period (average)	127 days
Freeze-free period (average)	154 days
Precipitation total (average)	32 in

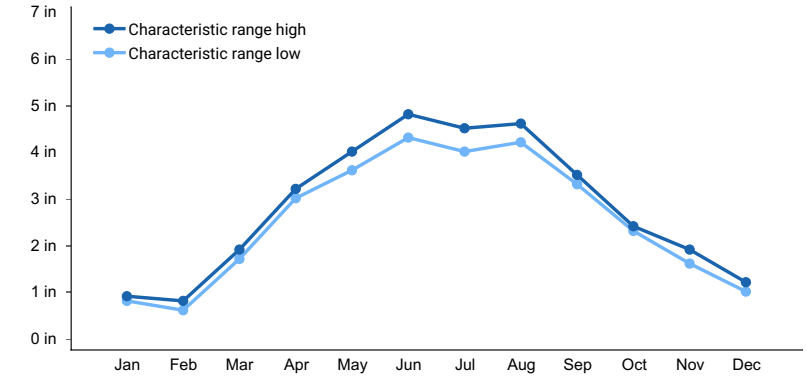


Figure 4. Monthly precipitation range

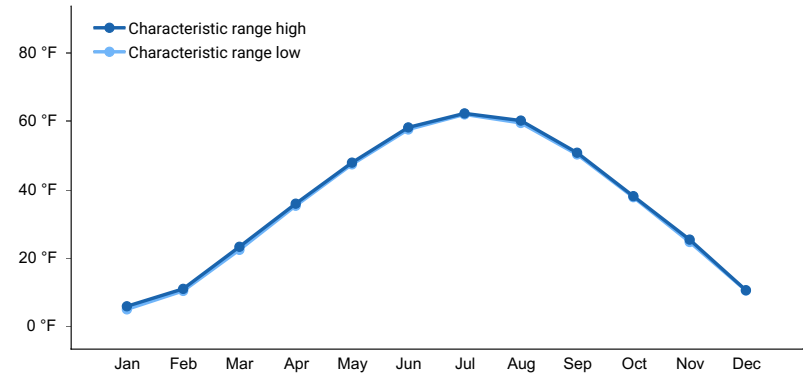


Figure 5. Monthly minimum temperature range

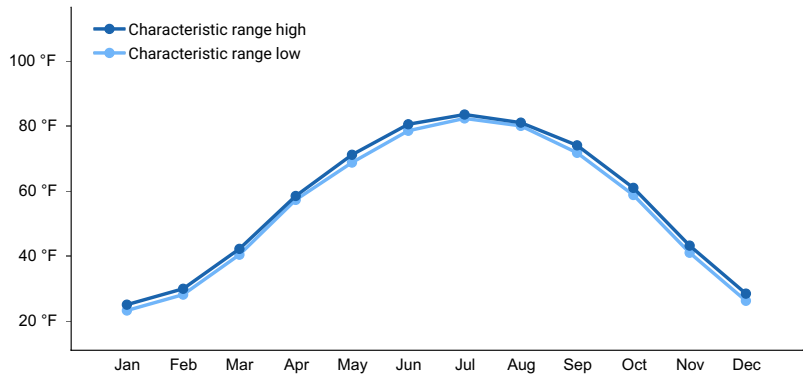


Figure 6. Monthly maximum temperature range

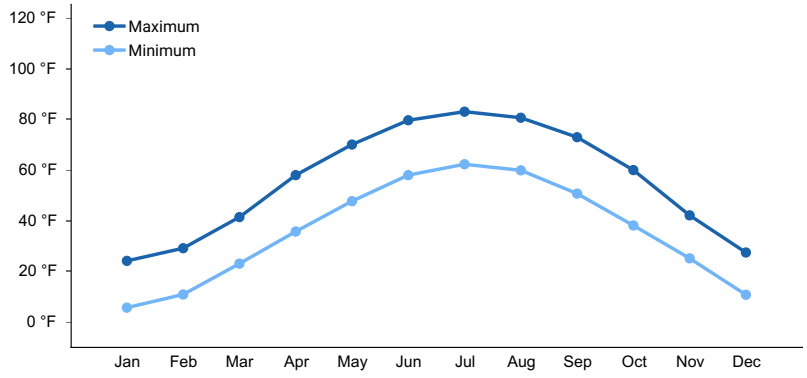


Figure 7. Monthly average minimum and maximum temperature

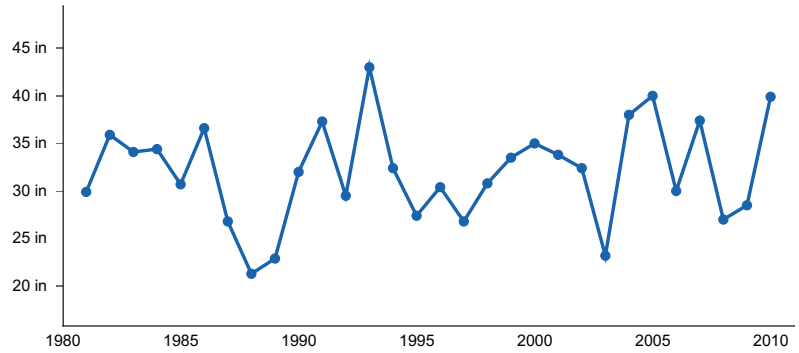


Figure 8. Annual precipitation pattern

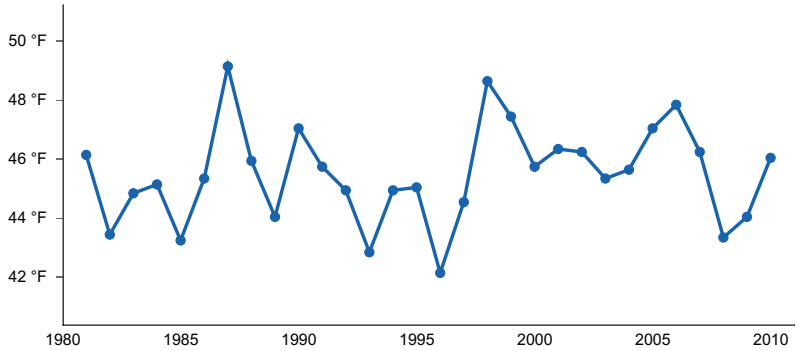


Figure 9. Annual average temperature pattern

Climate stations used

- (1) CHANHASSEN WSFO [USC00211448], Chanhassen, MN
- (2) AMBOY [USC00210157], Amboy, MN
- (3) OWATONNA [USC00216287], Owatonna, MN
- (4) WELLS [USC00218808], Wells, MN

Influencing water features

The Clayey Upland Savannas ecological site may receive water from precipitation, lateral subsurface flow, and to a lesser extent from runoff. Since some of these soil components have little for contributing area, direct precipitation may be the only water source that some of them receive. Spring is the wettest time of the year in the region. This site is endosaturated. The depth to saturation for most of the included soil series is 30-50 cm depth during the spring months and may drop to as low 200cm later in the growing season during dry periods.

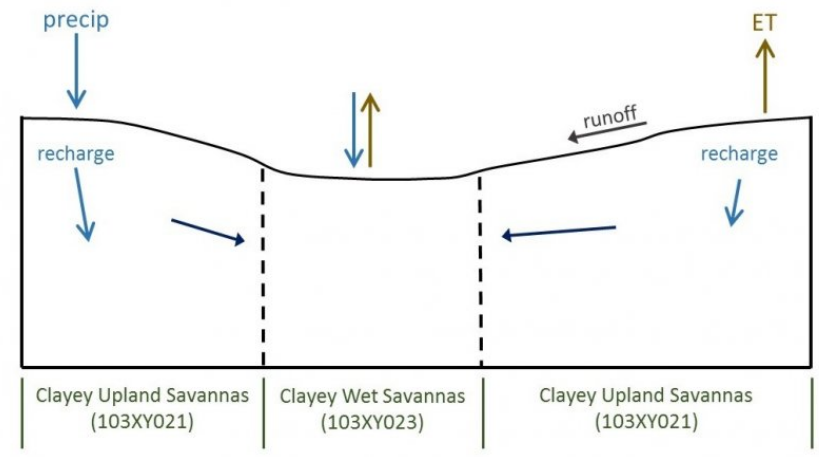


Figure 10. Representation of hydrological factors in a typical area of the Clayey Upland Savannas and associated ecological sites on the Des Moines Lobe (MLRA 103).

Soil features

The Clayey Upland Savannas ecological site occurs on soils that developed under a savanna landscape of scattered trees and native grasses. Soils are classified as Vertic Hapludalfs, Epiaqualfs, or Aquertic Argiudolls. Clay particles were illuviated from horizons higher in the soil profile and accumulated deeper. Argillic horizons form readily in Des Moines Lobe materials after leaching of all carbonates from the upper portion of the soil takes place (Grimm, 1984).

The dominant soil series associated with this ecological site are Kilkenny, Lerdal, Shorewood, and Good Thunder. The parent material is fine glacial till and/or lacustrine deposits. Many of the included soils have a loamy glacial till substratum within 2 meters of the surface. These soils are very deep (>60 inches to bedrock). Drainage class is somewhat poorly drained to moderately well drained, and the seasonal high depth to saturation is between 12 and 20 inches. The epipedon textures includes clay loam, silty clay loam, and silty clay. The soil family particle size class is fine. Course fragments range from 0 to 14 percent by volume. Soil pH classes are very strongly acid to moderately alkaline throughout the series control section.

Table 4. Representative soil features

Parent material	(1) Till (2) Lacustrine deposits
Surface texture	(1) Clay loam (2) Silty clay loam (3) Silty clay
Drainage class	Somewhat poorly drained to moderately well drained
Permeability class	Slow to rapid
Soil depth	80 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-60in)	9–10.5 in
Calcium carbonate equivalent (0-40in)	0–30%
Soil reaction (1:1 water) (0-40in)	4.5–8.4
Subsurface fragment volume <=3" (0-40in)	0–14%
Subsurface fragment volume >3" (0-40in)	0–3%

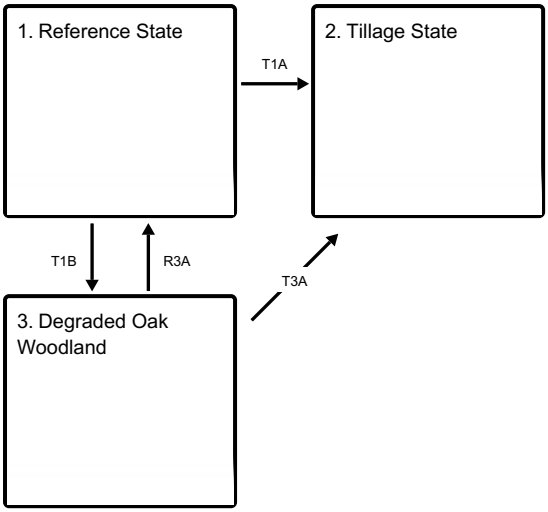
Ecological dynamics

The Clayey Upland Savanna ecological site plant community is a mesic to wet mesic savanna with includes scattered oaks and native, warm-season grassses. This site is primarily located in areas adjacent to the Big Woods region of Minnesota adjacent to lakes, rivers, and streams. Natural fire disturbance was suppressed but not eliminated in these areas resulting in a savanna landscape.

The state and transition model (STM) consists of three states: Reference State, Tillage State, and the Degraded Oak Woodland State. The Reference State describes a mesic savanna with native grasses and scattered oaks. State 2 is the Tillage State which describes land transitioned to row crops. This is the most common state in MLRA 103 for this site. A few tilled areas have been reseeded to native warm season or cool-season grasses, so this community is included in the model. State 3 is a Degraded Oak Woodland State in which disturbances have modified the plant community composition and structure. Lack of natural fire, unmanaged grazing, and invasive species are common triggers transitioning a site to State 3.

State and transition model

Ecosystem states



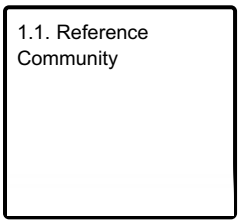
T1A - Tillage, planting

T1B - Absence of natural fire regime, increase in woody vegetation, and invasion of non-native species

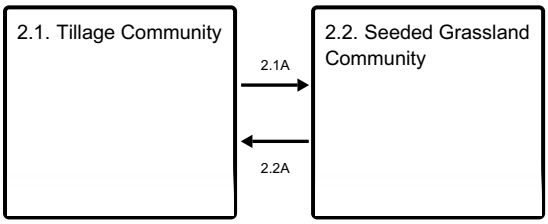
R3A - Restoration activities

T3A - Tillage, planting

State 1 submodel, plant communities



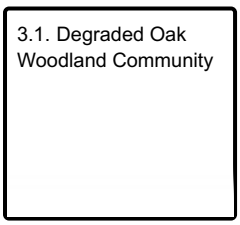
State 2 submodel, plant communities



2.1A - Establishment of grasses

2.2A - Transition to row crop agriculture

State 3 submodel, plant communities



State 1
Reference State

The reference state is a mesic to wet-mesic savanna community on clayey soils that exhibits a diversity of native grasses and forbs along with scattered oak species. Plant community structure and composition within are variable and dependent upon the impacts of drought, grazing, and fire events. Fire was historically present on these sites but

to a lesser degree than the prairie ecological sites. This reduced occurrence of fire resulted in a plant community that included woody shrubs and scattered trees. A secondary trigger for maintenance or conversion of this ecological site is grazing. Intensive grazing can reduce the extent of highly palatable species thereby allowing the growth of less desirable plants to increase. Fire frequency, periods of drought, and grazing will create variability in the plant community. A high fire frequency will create a shrubby prairie with a reduction in woody species. A longer fire free interval will allow trees to increase and the community will exhibit a bur oak-northern red oak savanna structure. An absence of natural fire will transition the site closer to a mixed oak woodland. Characteristic vegetation in the reference savanna state includes bur oak, northern pin oak, American hazelnut, leadplant, and big bluestem. Other prairie grasses and native forbs will also be present within the reference plant community. High-quality, untilled areas of the Clayey Upland Savannas ecological site are uncommon in MLRA 103 as most sites have been transitioned to agricultural production.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- northern pin oak (*Quercus ellipsoidalis*), tree
- American hazelnut (*Corylus americana*), shrub
- leadplant (*Amorpha canescens*), shrub
- big bluestem (*Andropogon gerardii*), grass

Community 1.1
Reference Community

The reference community is characterized by a savanna plant community with a diversity of native grasses, forbs, and scattered oak trees. Common reference species include bur oak, northern pin oak, American hazelnut, leadplant, big bluestem, and an array of forbs. The vegetative composition is influenced primarily by drought, grazing and fire. A mosaic of plant structure and composition will occur on these sites depending on the disturbance regime.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- northern pin oak (*Quercus ellipsoidalis*), tree
- American hazelnut (*Corylus americana*), shrub
- leadplant (*Amorpha canescens*), shrub
- big bluestem (*Andropogon gerardii*), grass

State 2
Tillage State

Soil tillage is the primary mechanism to transition a site to the Tillage State. In this state, dynamic soil properties such as bulk density, structure, organic carbon content, and saturated hydraulic conductivity are altered by agricultural practices. Certain practices can mitigate the impacts of traditional agricultural practices on soil health. Conservation tillage minimizes soil disturbance and can improve soil structure and overall soil health. Corn or soybean plantings and a cover crop rotation can build soil structure, improve infiltration rates, reduce runoff and erosion, and protect water quality. Some areas in this ecological site are not appropriate for intensive crop production due to slope. Where the gradient exceeds 20 percent row crop production is not feasible due to limitations on farm machinery. A few areas have been seeded back to warm-season or cool-season grasses. Under conservation programs such as the NRCS Conservation Reserve Program (CRP), previously tilled areas have been converted to warm-season grasslands. Native forbs are commonly included in seed mixes to benefit wildlife and pollinators. Although highly beneficial to wildlife, these sites generally lack the diversity of native plant species that occurs in the Reference State. Cool-season grasses are also feasible. Species selection will depend on the landowner’s objectives and site specifics. Most areas in this state will remain in use for crop production in the foreseeable future – primarily in an intensive corn and soybean rotation.

Dominant plant species

- corn (*Zea mays*), grass
- soybean (*Glycine max*), other herbaceous

Community 2.1
Tillage Community

The Tillage Community typically consists of intensively produced, traditional row crops. Tillage and intentional plant establishment (crop seeding) are the primary triggers for this community. The most common crops are corn and soybeans on an annual rotation. This community is feasible for lower slope areas.

Dominant plant species

- corn (*Zea mays*), grass
- soybean (*Glycine max*), other herbaceous

Community 2.2
Seeded Grassland Community

The primary mechanism of change to this community is the seeding of desired grass species. This pathway is commonly triggered in conjunction with a conservation program such as the NRCS Conservation Reserve Program (CRP). The site is taken out of crop production and seeded with warm-season grasses to benefit wildlife, soil health, and water quality. A few areas within this ecological site may be seeded to cool-season grasses. Species selection depends on landowner goals.

Resilience management. Resilience management practices for warm-season grasslands include prescribed fire, brush management, and herbaceous weed treatment. Resilience management practices for cool-season grass sites include planned grazing, invasive plant management, and appropriate disturbance/harvest management.

Dominant plant species

- big bluestem (*Andropogon gerardii*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- smooth brome (*Bromus inermis*), grass
- Kentucky bluegrass (*Poa pratensis*), grass

Pathway 2.1A
Community 2.1 to 2.2

The mechanism of change is the seeding of grass species. Warm season or cool season grasses may be planted depending on the landowner's objectives. Warm season grasses may be established as part of a conservation program.

Conservation practices

Forage and Biomass Planting

Pathway 2.2A
Community 2.2 to 2.1

The site is transitioned back to cropland through tillage and seeding.

State 3
Degraded Oak Woodland

The Degraded Oak Woodland is characterized by a disturbed woodland condition. Characteristics of this site include the dominance of trees (no longer a true savanna community) and the presence of invasive plant species. Bur oak and other hardwood species have increased. Invasives, such as Kentucky bluegrass and common buckthorn, are often dominant the understory. As the tree and shrub density increases, the ground layer plant diversity transitions to more shade-tolerant forest species.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- American hazelnut (*Corylus americana*), shrub
- chokecherry (*Prunus virginiana*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- common buckthorn (*Rhamnus cathartica*), grass

Community 3.1
Degraded Oak Woodland Community

This plant community exhibits and increase in woody species and invasive plants. Native plant diversity is decreasing. Due to the increasing shade levels, ground flora are transitioning to more shade-tolerant species. The community is no longer a savanna but transitioning to a woodland.

Dominant plant species

- bur oak (*Quercus macrocarpa*), tree
- chokecherry (*Prunus virginiana*), shrub
- American hazelnut (*Corylus americana*), shrub
- Kentucky bluegrass (*Poa pratensis*), grass
- common buckthorn (*Rhamnus cathartica*), grass

Transition T1A
State 1 to 2

The site is transitioned to agricultural production through tillage and seeding of desired crops.

Transition T1B
State 1 to 3

Transition mechanisms include absence of a natural fire regime, invasion of non-native plant species, and a continual increase in woody species. Native plant diversity will decrease as the community transitions from a open savanna to a closed, shaded woodland.

Restoration pathway R3A
State 3 to 1

Restoration of the site to include non-native vegetation control, woody vegetation removal, introduction of prescribed fire, establishment of desired native species.

Transition T3A
State 3 to 2

Site is transitioned to agricultural production via tillage and seeding of desired crops.

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

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Contributors

Clayton Johnson (Clayton.Johnson@usda.gov), Soil Survey Office Leader, USDA-NRCS, Albert Lea, MN
Myles Elsen (Myles.Elsen@usda.gov), Soil Scientist, USDA-NRCS, Albert Lea, MN
Anita Arends (Anita.Arends@usda.gov), USDA-NRCS, Springfield, IL

Approval

Suzanne Mayne-Kinney, 10/04/2023

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	05/05/2024
Approved by	Suzanne Mayne-Kinney
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:**