

# **Ecological site F089XY012WI**

## **Moist Siliceous Sandy Uplands**

Last updated: 9/27/2023  
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### **General information**

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

### **MLRA notes**

Major Land Resource Area (MLRA): 089X–Wisconsin Central Sands

The Wisconsin Central Sands (MLRA 89) corresponds closely to Central Sand Plains Ecological Landscape published by the Wisconsin Department of Natural Resources (WDNR, 2015). Much of the following brief overview of this MLRA is borrowed from that publication.

The Wisconsin Central Sands MLRA is entirely in Wisconsin. The total land area is 2,187,100 acres (3,420 square miles, 8858 square kilometers). It is bordered to the east by Johnstown-Hancock end moraines, which were pushed to their extent by the west side of the Green Bay Lobe (Clayton & Attig, 1999). It is bordered to the southwest by highly eroded, unglaciated valleys and ridges. The dominant feature of this MLRA is the remarkably flat, sandy plain, composed of lacustrine deposits and outwash sand, that was once the main basin of Glacial Lake Wisconsin. It also features extensive pine and oak barrens and wetland complexes.

Glacial Lake Wisconsin was fed primarily by glacial meltwater from the north and east. The lake deposited silt overlain by tens of meters of sand (Clayton & Attig, 1989). The silty layers are closer to the surface in some areas, where they impede drainage and contribute to the formation of extensive wetland complexes. It is believed that Glacial Lake Wisconsin drained within several days after a breach in the ice dam that supported it. The catastrophic flood that followed flowed to the south and carved the scattered buttes and mesas protruding from the sandy plain in the southern portion of this MLRA. Before vegetation established after glacial recession, strong winds formed aeolian sand dunes that now support xeric pine and oak stands within the Wisconsin Central Sands.

The surface of the northwestern portion is mostly undulating. The sandy surface sediment was mostly deposited by meltwater during the Wisconsin glaciation. Gentle hills are a result of underlying bedrock topography. Valleys and floodplains are formed by stream action. The underlying bedrock controls the water table elevation and contributes to the formation of numerous wetlands.

Historically, the Wisconsin Central Sands were dominated by large wetland complexes, sand prairies, and oak forests, savannas, and barrens. Some pine and hemlock forests were found in the northwest portion. The Wisconsin Central Sands was subject to frequent fires, leading to today's need for prescribed burns to maintain the area.

## **Classification relationships**

Major Land Resource Area (MLRA): Wisconsin Central Sands (89)

USFS Subregions: Central Wisconsin Sand Plain (222Ra) and Neillsville Sandstone Plateau (222Rb)

Small sections occur in the Lincoln Formation Till Plain - Mixed Hardwoods (212Qb) Subregions

Relationship to Established Framework and Classification Systems:

Habitat Types of N. & S. Wisconsin (Kotar, 2002 & 1996) and Wetland Forest Habitat Type Classification System for Northern Wisconsin (Kotar and Burger, 2017): The sites of this ES keyed out to six habitat types: *Acer rubrum*/Desmodium (ArDe); Pinus strobus-*Acer rubrum*/Vaccinium-Rubus hispidus (PArVRh); Pinus/Vaccinium-Cornus (PVCr); Pinus/Vaccinium-Gaultheria (PVG); Pinus/Vaccinium-Rubus hispidus (PVRh).

Biophysical Settings (Landfire, 2014): This ES is largely mapped as North-Central Interior Maple-Basswood Forest, North-Central Interior Dry Oak Forest and Woodland, North-Central Oak Barrens Woodland, and Laurentian Oak Barrens.

WDNR Natural Communities (WDNR, 2015): This ES is most similar to the Northern Dry-Mesic Forest community.

## **Ecological site concept**

The Moist Siliceous Sand Uplands ecological site is widespread on the western portion of MLRA 89 where sandstone bedrock is relatively shallow. These sites are characterized by very deep, somewhat poorly drained soils formed in siliceous sandy alluvium and siliceous sandy lacustrine deposits. This sand is sourced from the weathering of sandstone that was cemented by silica. Precipitation and runoff from adjacent uplands are the primary sources of water, but groundwater discharge is another significant contributor. Soils range from extremely acid to slightly acid.

Historically, this Ecological Site was dominated by a variety of plant communities,

apparently reflecting differences in historic fire regime. Prairie, Pine Barrens, Oak Barrens, Oak Savanna and mixed Pine - Oak forests were all represented. Following European settlement most of the area was cleared of forest vegetation and converted to farming, although scattered woodlots remained. Current woodlots typically consist of mixed oak, primarily northern pin oak (*Quercus ellipsoidalis*), white oak (*Q. alba*), Red oak (*Q. rubra*), white pine (*Pinus strobus*) and red maple (*Acer rubrum*). There are also considerable areas of planted red pine (*P. resinosa*).

Moist Siliceous Sand Uplands differ from other sites based on drainage and siliceous sandy material. Other somewhat poorly drained sands formed in outwash sands or have bedrock within 40 inches (100 cm). The siliceous sands tend to be less productive than the outwash sands, and the vegetative communities they support may be slightly different. The somewhat poor drainage differs this site from other sandy sites.

## Associated sites

F089XY001WI	<p><b>Acidic Poor Fen</b></p> <p>Acidic Poor Fens consist of deep herbaceous organic materials. They are very poorly drained and remain saturated throughout the year. They are strongly to extremely acidic. These sites are wetlands. These sites are found primarily in the western half of the Wisconsin Central Sands MLRA. They occur lower on the drainage sequence than Moist Siliceous Sand Uplands.</p>
F089XY007WI	<p><b>Wet Siliceous Sand Lowlands</b></p> <p>Wet Siliceous Sand Lowlands consist of deep sandy deposits sourced primarily from the weathering of sandstone high in silica. The weathered sand was deposited by rivers or glacial lakes. They are very poorly to poorly drained and remain saturated from much of the growing season. Some are subject to ponding. These sites are primarily found in the western half of the Wisconsin Central Sands MLRA. They occur lower on the drainage sequence than Moist Siliceous Sand Uplands.</p>
F089XY018WI	<p><b>Siliceous Sand Uplands</b></p> <p>Siliceous Sand Uplands consist of deep sandy deposits sourced primarily from the weathering of sandstone high in silica. The weathered sand was deposited by rivers or glacial lakes. Soils are moderately well to excessively drained. These sites are found west of the Wisconsin River. They occur much higher on the drainage sequence than Moist Siliceous Sand Uplands.</p>

## Similar sites

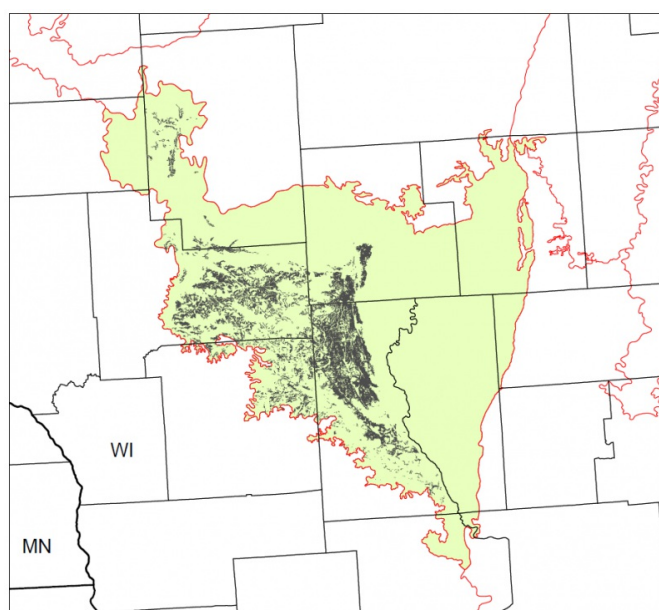
F089XY010WI	<b>Moist Sandy Bedrock Uplands</b> Moist Sandy Bedrock Uplands consist of sandy deposits derived from a mixture of outwash, alluvium, and lacustrine sources. They have contact with sandstone bedrock within 40 inches (102 cm) of the surface. These soils are somewhat poorly drained. These sites are found to the west of the Wisconsin River, mostly in Clark and Jackson counties where the depth of bedrock is shallow. Their vegetative communities are similar to those of Moist Siliceous Sand Uplands.
F089XY011WI	<b>Moist Sandy Outwash Uplands</b> Moist Sandy Outwash Uplands consist of deep sandy deposits derived from a mixture of outwash, alluvium, and lacustrine sources. They are somewhat poorly drained and are subject to neither flooding nor ponding. Their vegetative communities are similar to those of Moist Siliceous Sand Uplands.

**Table 1. Dominant plant species**

Tree	(1) <i>Pinus strobus</i> (2) <i>Quercus alba</i>
Shrub	(1) <i>Amelanchier</i>
Herbaceous	(1) <i>Pteridium aquilinum</i>

## Physiographic features

This site formed in siliceous sands on pediments and stream terraces. Slopes range from 0 to 3 percent. Elevation ranges from 705 to 1,394 feet (215 to 425 meters) above sea level. These sites are not subject to ponding or flooding. Soils have an apparent seasonally high water table (endosaturation) at depths of 18 to 48 inches (46 to 117 cm) but can drop to 60 inches (150 cm) during dry conditions. Runoff is negligible.



**Figure 1. Distribution of Moist Siliceous Sand Uplands in the Wisconsin Central Sands MLRA (89).**

**Table 2. Representative physiographic features**

Hillslope profile	(1) Toeslope (2) Footslope
Landforms	(1) Pediment (2) Terrace
Runoff class	Negligible
Flooding frequency	None
Ponding frequency	None
Elevation	215–425 m
Slope	0–3%
Water table depth	46–117 cm
Aspect	Aspect is not a significant factor

## Climatic features

The continental climate of the Wisconsin Central Sands is typical of the southern half of the state – cold winters and warm summers. Precipitation is well-distributed throughout the year with a slight peak in the summer months. Snowfall covers the ground from late fall to early spring. The soil moisture regime of MLRA 89 is udic (humid climate). The soil temperature regime is mostly frigid, with a small portion of mesic in the southern tip. Neither precipitation nor temperature vary greatly across this MLRA. More so than latitude, local topography seems to be an important predictor of growing season length, with fewer growing degree days in lower-lying areas.

The average annual precipitation for this ecological site is 34 inches. The average annual snowfall is 47 inches. The annual average maximum and minimum temperatures are 55°F and 33°F, respectively.

**Table 3. Representative climatic features**

Frost-free period (characteristic range)	89-121 days
Freeze-free period (characteristic range)	116-150 days
Precipitation total (characteristic range)	838-864 mm
Frost-free period (actual range)	77-124 days
Freeze-free period (actual range)	100-150 days
Precipitation total (actual range)	838-864 mm
Frost-free period (average)	104 days
Freeze-free period (average)	131 days

Precipitation total (average)

864 mm

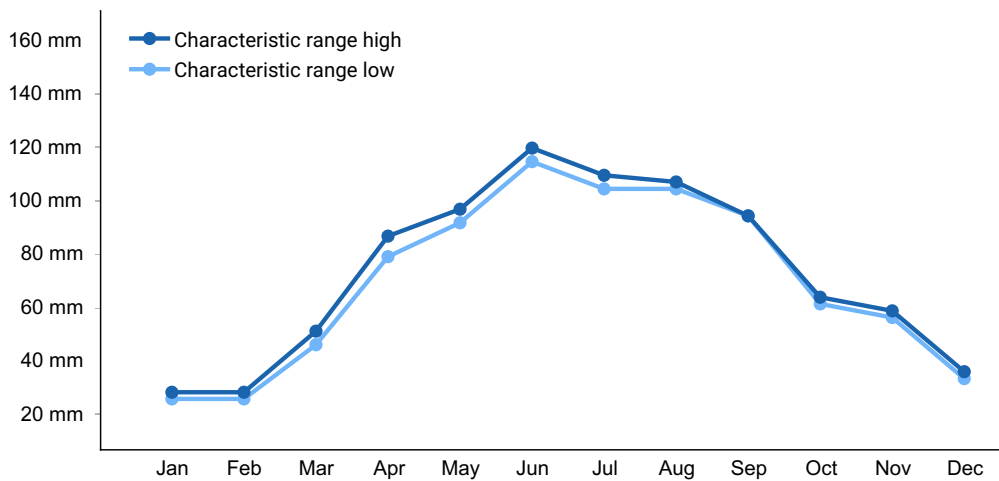


Figure 2. Monthly precipitation range

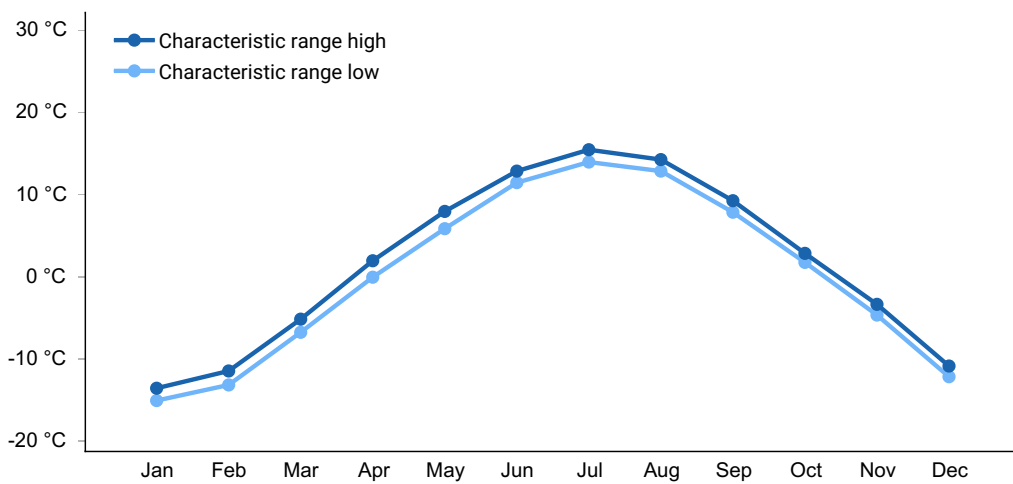


Figure 3. Monthly minimum temperature range

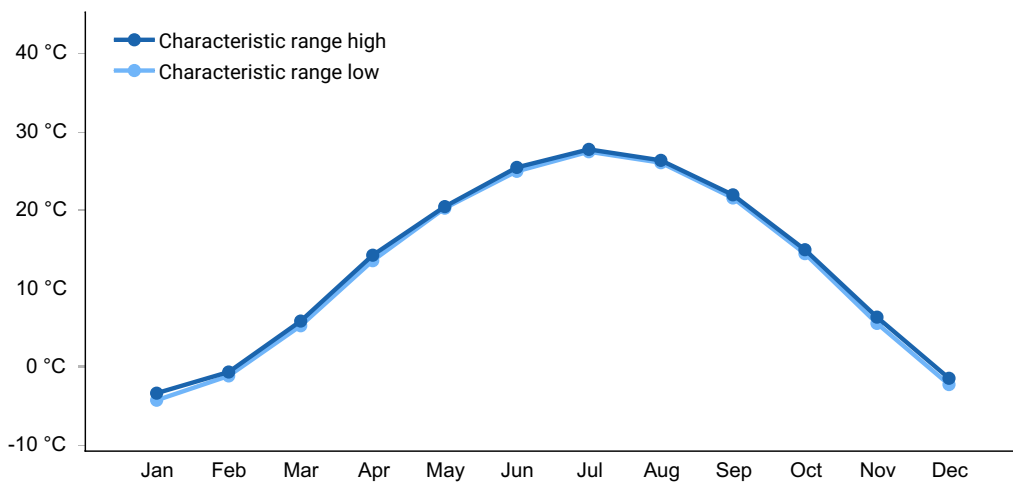
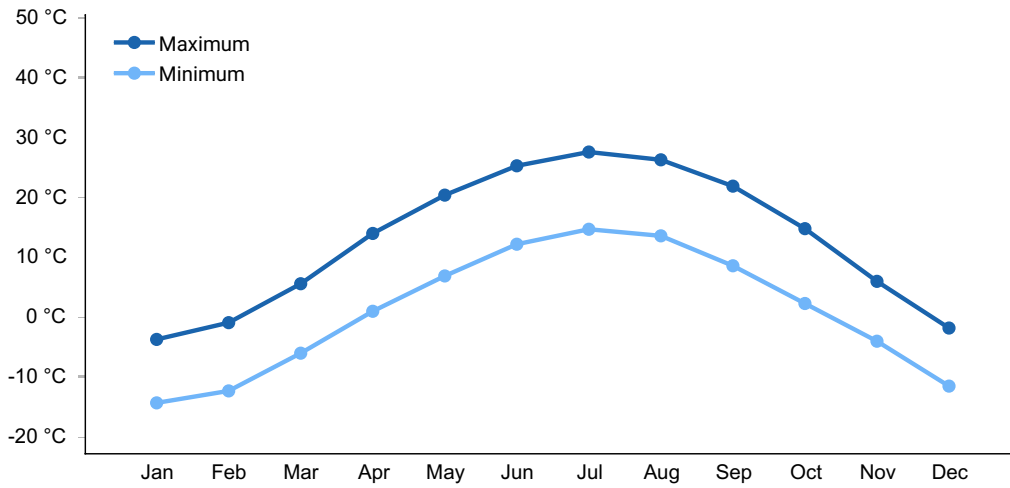
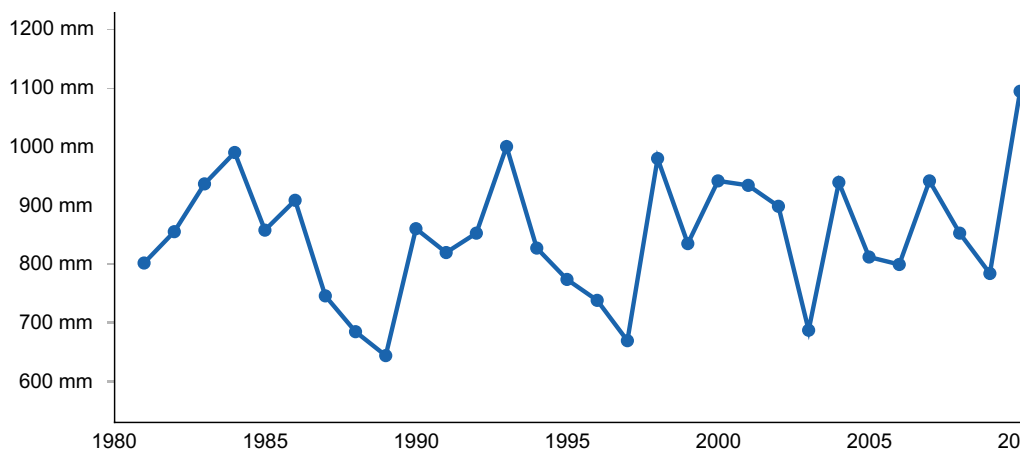


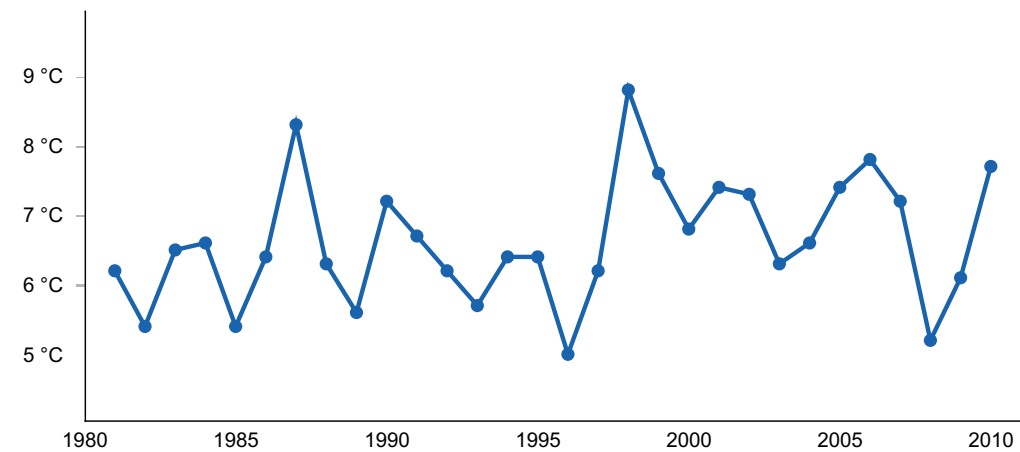
Figure 4. Monthly maximum temperature range



**Figure 5. Monthly average minimum and maximum temperature**



**Figure 6. Annual precipitation pattern**



**Figure 7. Annual average temperature pattern**

## Climate stations used

- (1) HATFIELD [USC00473471], Merrillan, WI
- (2) MATHER 3 NW [USC00475164], Warrens, WI
- (3) NECEDAH 5 WNW [USW00054903], Necedah, WI
- (4) MAUSTON 1 SE [USC00475178], Mauston, WI

## Influencing water features

Water is received through precipitation, runoff from adjacent uplands, groundwater discharge, and, rarely, stream inflow. Water levels are greatly influenced by precipitation rates and runoff from upland sites. Water leaves the site primarily through runoff, evapotranspiration, and groundwater recharge. Permeability of these sites range from slow to moderate. Hydrologic group is A or A/D.

## Soil features

These sites are represented by Ironrun and Majik soil series, classified as Typic Endoaquods and Aquic Quartzipsamments, respectively. Aquic Quartzipsamments make up 63% of the acreage of this site. These soils formed in siliceous sands from alluvial or lacustrine origin. Soils are very deep and somewhat poorly drained. They do not meet hydric requirements.

The surface of these sites is primarily sand or moderately decomposed organic materials (hemic materials). Subsurface textures are primarily sand, but also include fine sand and loamy fine sand. Soil pH ranges from extremely acid to slightly acid with values of 3.6 to 6.5. Up to 2 percent volume of surface fragments less than 3 inches may be present. Subsurface fragments less than 3 inches may be present up to 1 percent volume. Carbonates are absent.

**Table 4. Representative soil features**

Parent material	(1) Alluvium (2) Lacustrine deposits
Surface texture	(1) Sand (2) Loamy sand
Drainage class	Somewhat poorly drained
Permeability class	Slow to moderate
Soil depth	203 cm
Surface fragment cover <=3"	0–2%
Surface fragment cover >3"	0%
Available water capacity (0-152.4cm)	9.37–10.87 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Soil reaction (1:1 water) (0-101.6cm)	3.6–6.5



Subsurface fragment volume ≤3" (0-203.2cm)	0–1%
Subsurface fragment volume >3" (0-203.2cm)	0%

## Ecological dynamics

Perhaps the most important ecological characteristic of this Ecological Site, in terms of its influence on forest community dynamics, is its lack of capacity to support the high to moderate soil moisture and nutrient requiring species such as sugar maple, basswood and white ash, the shade-tolerant species, that typically dominate the more productive sites throughout Wisconsin.

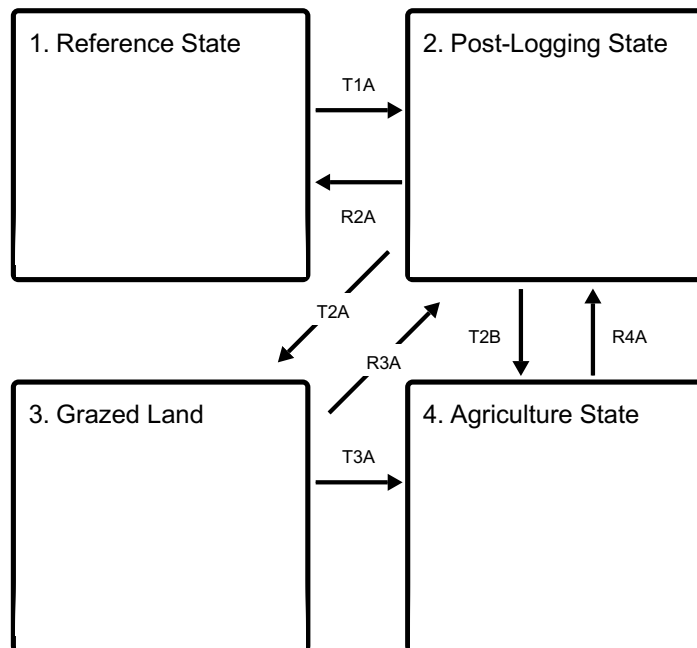
In pre-European settlement time wild fire was the main controlling factor of forest community dynamics. Following a severe, stand-replacing fire, any of the species present on the landscape could become established, depending on seed source availability and specific conditions of post-fire seedbed. The newly established young stands of any species were easily eliminated by recurring fires, but differences in fire-resisting properties among the species began to play a role in any species' survival success. White pine is best adapted for long-term success on this Ecological Site. Although vulnerable to damage or elimination by fire in early life it eventually develops thick fire-resistant bark which helps to extend its longevity, in some cases for up to four centuries or more. These survival properties assure the species' relatively continuous seed source in the region as a whole. White pine is also moderately shade-tolerant in early life which means that it can become established in some pioneer communities, such as aspen – white birch stands, or in poorly stocked oak and red maple dominated communities. Red pine had in the past been a common associate of white pine stands. It shares some of the fire-resisting properties of white pine, but it lacks shade-tolerance and does not become established in the understory. For this reason, it has not maintained its presence in current stands and its seed source has been greatly reduced throughout its natural range following the onset of fire suppression. Several species of oak are common members of forest communities on this ecological site. Northern pin oak (*Q. ellipsoidalis*) and, to a lesser degree, black oak (*Q. velutina*), are intolerant of shade and do not reproduce from seed under existing canopies. However, following fire or clear cutting they respond by sprouting from stumps. In the absence of disturbance they are replaced, through succession, by more shade-tolerant white pine, red maple (*Acer rubrum*), or white oak (*Q. alba*). Red oak (*Q. rubra*) is somewhat less shade-tolerant than the preceding species, and reproduces sporadically in larger canopy gaps and following a major stand disturbance.

Although red maple has not been identified by Finley (1976) as an important component of pre-settlement pine or oak forests, it is a prominent member in current stands. Absence of fire since the original logging era is probably the main reason. Red maple is extremely sensitive to fire damage, but is a prolific and early seed producer. Stems of 2-4 inches in diameter can produce large amounts of seed (USDA For. Serv. 1990). It is sufficiently shade-tolerant to become established in the understories of most communities on sandy

soils. On this Ecological Site it behaves similarly to white pine, but because of its much smaller size at maturity, it does not compete with white pine in the upper canopy.

## State and transition model

### Ecosystem states



**T1A** - Clear cutting or stand-replacing fire.

**R2A** - Disturbance-free period 70+ years.

**T2A** - Grazing by livestock.

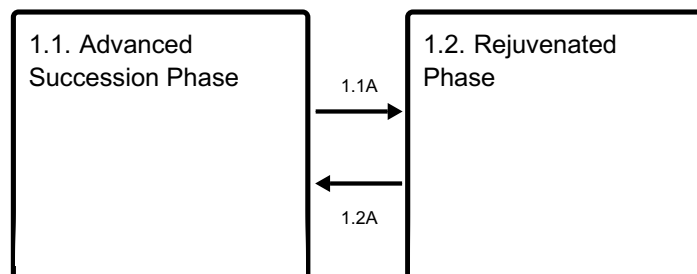
**T2B** - Removal of forest vegetation and tilling.

**R3A** - Removal of livestock grazing.

**T3A** - Removal of forest vegetation and tilling.

**R4A** - Cessation of agriculture and natural or artificial afforestation.

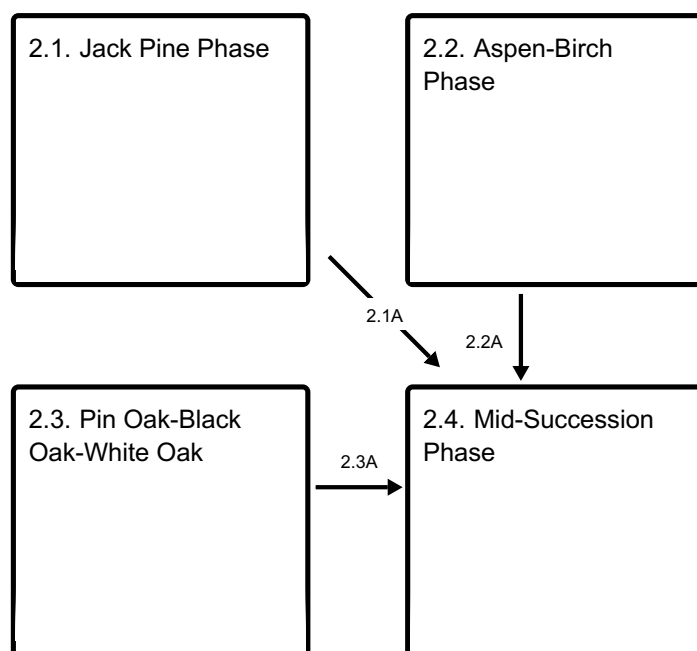
### State 1 submodel, plant communities



**1.1A** - Light to moderate intensity fires, blow-downs, snow-ice breakage.

**1.2A** - Disturbance-free period 30+ years

## State 2 submodel, plant communities

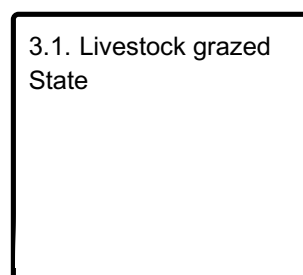


**2.1A** - Establishment of white pine and red maple.

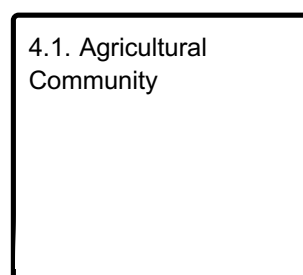
**2.2A** - Establishment of white pine and red maple.

**2.3A** - Establishment of white pine and red maple.

## State 3 submodel, plant communities



## State 4 submodel, plant communities



## State 1 Reference State

In absence of stand-leveling disturbances the Reference State Community oscillates between two easily definable community phases, a mature, or late successional, community phase and a rejuvenated community phase.

## Dominant plant species

- eastern white pine (*Pinus strobus*), tree
- white oak (*Quercus alba*), tree
- red maple (*Acer rubrum*), tree
- serviceberry (*Amelanchier*), shrub
- western brackenfern (*Pteridium aquilinum*), other herbaceous

## Community 1.1

### Advanced Succession Phase

A mature forest community contains a super-canopy, or a scattering, of large white pine trees. In pre-European settlement time such trees would have been anywhere from 80 to more than 300 years old (Sterns, 1950). Common associates have been red pine (*P. resinosa*), red oak (*Q. rubra*) and white oak (*Q. alba*). However, only white pine and white oak are moderately shade-tolerant and able to reproduce in small canopy openings and remain as permanent members of mature community in absence of moderate to severe disturbance. Red maple (*Acer rubrum*) had not been an important species in pre-settlement forests, but is today the most successful reproducing tree species in forest communities on this Ecological Site.

#### Dominant plant species

- eastern white pine (*Pinus strobus*), tree
- white oak (*Quercus alba*), tree
- red maple (*Acer rubrum*), tree
- serviceberry (*Amelanchier*), shrub
- western brackenfern (*Pteridium aquilinum*), other herbaceous

## Community 1.2

### Rejuvenated Phase

The canopy of the rejuvenated community is still dominated by original species, but the understory now also includes a well established younger cohort and perhaps a few additional seedlings and saplings of less shade tolerant species.

#### Dominant plant species

- eastern white pine (*Pinus strobus*), tree
- white oak (*Quercus alba*), tree
- red maple (*Acer rubrum*), tree
- serviceberry (*Amelanchier*), shrub
- western brackenfern (*Pteridium aquilinum*), other herbaceous

## Pathway 1.1A

### Community 1.1 to 1.2

Light intensity fires, crown breakage from ice and snow and small scale blow-downs

create canopy openings, releasing advance regeneration and stimulating new seedling establishment. Some additional less shade tolerant species such as red oak may be able to enter the community.

## **Pathway 1.2A**

### **Community 1.2 to 1.1**

A long period without major canopy disturbance allows gradual replacement of oldest canopy trees by younger cohorts. Small scale disturbances may still occur periodically, but once second or third canopies are established there is minimal new regeneration taking place and the forest gradually returns to mature state.

## **State 2**

### **Post-Logging State**

Post-logging state may consist of considerable diversity of pioneer and mid-successional community phases. Here we are describing four, most commonly found under current conditions.

#### **Dominant plant species**

- pine (*Pinus*), tree
- oak (*Quercus*), tree
- paper birch (*Betula papyrifera*), tree
- quaking aspen (*Populus tremuloides*), tree

## **Community 2.1**

### **Jack Pine Phase**

Jack pine and red pine have historically been almost entirely dependent on fire for regeneration. Jack pine is a predominantly a northern species and in southern part of Wisconsin seldom approaches its growth potential. Everywhere it occurs it is a pronounce pioneer, highly light demanding and resistant to drought and frost. It has low requirements for soil organic matter and nutrients. It is a prolific producer of seed and it often colonizes burnt over areas. Forest fires speed natural regeneration by opening the cones. However, today, jack pine is regenerated mostly by planting. Without disturbance jack pine does not regenerate and is readily succeeded by various species, even those of only moderate shade tolerance, such as white pine and red oak. Historically, red pine has often occurred in mixtures with jack pine. In terms of light, soil moisture and nutrient requirements it is intermediate between jack and white pines. In contrast to jack pine, natural red pine regeneration is often found in moderately dense pure or mixed pine stands, although not to the same extent as is white pine. Under current ecological and economic conditions red pine is regenerated almost entirely by planting.

#### **Dominant plant species**

- jack pine (*Pinus banksiana*), tree
- red pine (*Pinus resinosa*), tree

## **Community 2.2**

### **Aspen-Birch Phase**

Although a ubiquitous species, quaking aspen (*Populus tremuloides*) is far more characteristic of northern rather than southern forest regions. Its most notable ecological characteristic is the ability to rapidly invade cut-over and burned-over areas. However, its perpetuation depends entirely on recurrence of disturbance. Because of its extreme intolerance to shade, it is readily replaced by many tree species in the absence of disturbance. Once in place, aspen reproduces entirely by sprouting from extensive, superficial root systems (root suckering). Most aspen stands on this Ecological Site resulted from sprouting following clear cutting of mixed stands of pine and/or oak, in which some aspen trees were still present. Paper birch (*Betula papyrifera*) is often a member of aspen stands. It shares aspen's intolerance of shade and also produces small, winged seeds that readily disperse by wind. It does not sucker from root sprouts, but it readily sprouts from stumps upon clear cutting. It also has greater ability than does aspen of reproducing from seed under favorable seedbed conditions and in presence of large canopy openings. However in absence of disturbance it also succumbs to other species.

#### **Dominant plant species**

- quaking aspen (*Populus tremuloides*), tree
- paper birch (*Betula papyrifera*), tree

## **Community 2.3**

### **Pin Oak-Black Oak-White Oak**

On this site these three oak species occur in mixtures dominated by any of them. In some stands there also occur red oak, bur oak (*Q. macrocarpa*) or shagbark hickory (*Carya ovata*). Community composition and structure is a function of composition of the preceding, cut-over, or burned-over community and time since the disturbance. Time since disturbance is an important factor because of significant differences in sprouting abilities and success of regeneration from seed, among the participating species. Pin and black oak typically exist in current stands as multi-stem clusters resulting from stump sprouting, while white oak often reproduces from seed and gradually gains canopy dominance because of its greater shade tolerance than that of other oak species.

#### **Dominant plant species**

- pin oak (*Quercus palustris*), tree
- black oak (*Quercus velutina*), tree
- white oak (*Quercus alba*), tree

## **Community 2.4**

### **Mid-Succession Phase**

This community phase is considered a mid-successional community between the pioneering communities 2.1, 2.2, 2.3 and the Reference State. The community is characterized by canopy dominance of any of the early - succession species (i.e.: oaks, aspen - birch, jack pine) and strong presence in the understory of white pine and/or red maple seedlings and saplings.

#### **Dominant plant species**

- oak (*Quercus*), tree
- quaking aspen (*Populus tremuloides*), tree
- paper birch (*Betula papyrifera*), tree
- pine (*Pinus*), tree

### **Pathway 2.1A**

#### **Community 2.1 to 2.4**

Immigration and establishment of relatively shade tolerant white pine and red maple into shade – intolerant communities of aspen – birch, oaks or jack pine.

### **Pathway 2.2A**

#### **Community 2.2 to 2.4**

Immigration and establishment of relatively shade tolerant white pine and red maple into shade – intolerant communities of aspen – birch, oaks or jack pine.

### **Pathway 2.3A**

#### **Community 2.3 to 2.4**

Immigration and establishment of relatively shade tolerant white pine and red maple into shade – intolerant communities of aspen – birch, oaks or jack pine.

## **State 3**

### **Grazed Land**

Site phase consists of various grasses and forbs impacted by livestock grazing.

#### **Dominant plant species**

- brome (*Bromus*), grass
- tall fescue (*Schedonorus arundinaceus*), grass
- reed canarygrass (*Phalaris arundinacea*), grass

## **Community 3.1**

### **Livestock grazed State**

This community consists of various forage species utilized by livestock. Many different species may be seeded depending on the landowners goals.

#### **Dominant plant species**

- brome (*Bromus*), grass
- tall fescue (*Schedonorus arundinaceus*), grass
- reed canarygrass (*Phalaris arundinacea*), grass

## **State 4**

### **Agriculture State**

Sites phase consists of various crops being grown. Numerous species may be grown. The site may be tilled to improve drainage.

#### **Dominant plant species**

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

## **Community 4.1**

### **Agricultural Community**

This community reflects managed cropland. Various species may be grown. Common crops include corn, soybeans, wheat, and small grains.

#### **Dominant plant species**

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

## **Transition T1A**

### **State 1 to 2**

Clear cutting with initial control of competing vegetation, or stand-replacing fire, prepare the site for occupancy by shade intolerant species. This may occur through natural regeneration or by planting.

## **Restoration pathway R2A**

### **State 2 to 1**



A period of some 70-100 years without major stand disturbance, especially fire, leads to decreased presence, through natural mortality, of early successional species and the dominance of relatively shade tolerant white pine and sub-canopy of red maple, returning the community to Reference State.

### **Transition T2A**

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

Livestock grazing commenced.

### **Transition T2B**

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

Removal of forest vegetation and tilling.

### **Restoration pathway R3A**

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

Removal of livestock grazing.

### **Transition T3A**

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

Removal of forest vegetation and tilling.

### **Restoration pathway R4A**

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

Cessation of agriculture and natural or artificial afforestation.

## **Additional community tables**

### **Inventory data references**

Plot and other supporting inventory data for site identification and community phases is located on a NRCS North Central Region shared and one drive folder. University Wisconsin-Stevens Point described soils, took photographs, and inventoried vegetation data at community phases within the reference state. The data sources include WI ESD Plot Data Collection Form - Tier 2, Releve Method, NASIS pedon description, NRCS SOI 036, photographs, and Kotar Habitat Types.

### **Other references**

Clayton, L., & Attig, J. W. (1989). Glacial Lake Wisconsin (Vol. 173). Geological Society of

America.

Clayton, L., Attig, J. W., & Mickelson, D. M. (1999). Tunnel channels formed in Wisconsin during the last glaciation. *Special Papers-Geological Society of America*, 69-82.

Cleland, D.T.; Avers, P.E.; McNab, W.H.; Jensen, M.E.; Bailey, R.G., King, T.; Russell, W.E. 1997. National Hierarchical Framework of Ecological Units. Published in, Boyce, M. S.; Haney, A., ed. 1997. *Ecosystem Management Applications for Sustainable Forest and Wildlife Resources*. Yale University Press, New Haven, CT. pp. 181-200.

Curtis, J.T. 1959. *Vegetation of Wisconsin: an ordination of plant communities*. University of Wisconsin Press, Madison. 657 pp.

Finley, R. 1976. Original vegetation of Wisconsin. Map compiled from U.S. General Land Office notes. U.S. Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

NatureServe. 2018. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of 28 August 2018.

Kotar, J., J. A. Kovach, and T. L. Burger. 2002. *A Guide to Forest Communities and Habitat Types of Northern Wisconsin*. Second edition. University of Wisconsin-Madison, Department of Forest Ecology and Management, Madison.

Kotar, J., and T. L. Burger. 2017. Wetland Forest Habitat Type Classification System for Northern Wisconsin: A Guide for Land Managers and landowners. Wisconsin Department of Natural Resources, PUB-FR-627 2017, Madison.

Schulte, L.A., and D.J. Mladenoff. 2001. The original U.S. public land survey records: their use and limitations in reconstructing pre-European settlement vegetation. *Journal of Forestry* 99:5–10.

Schulte, L.A., and D.J. Mladenoff. 2005. Severe wind and fire regimes in northern forests: historical variability at the regional scale. *Ecology* 86(2):431–445.

Schulte, L.A., and D.J. Mladenoff. 2005. Severe wind and fire regimes in northern forests: historical variability at the regional scale. *Ecology* 86(2):431–445.

United States Department of Agriculture, Natural Resources Conservation Service. 2006. *Land Resource and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin*. U.S. Department of Agriculture Handbook 296.

Wisconsin Department of Natural Resources. 2015. *The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management*. Wisconsin Department of Natural Resources, PUB-SS-1131 2015,

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## Approval

Suzanne Mayne-Kinney, 9/27/2023

## 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	09/27/2023
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:

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### 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:**
-