USDA Natural Resources Conservation Service

Ecological site F091XY010WI
Acidic Sandy Upland

Last updated: 9/27/2023
Accessed: 06/30/2024

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): 091X–Wisconsin and Minnesota Sandy Outwash

The Wisconsin and Minnesota Sandy Outwash MLRA is the most extensive glacial outwash system in the northern half of Wisconsin. The total land area of the Wisconsin portion is just under 1.4 million acres (2,170 sq miles). The northern half is a former spillway for Glacial Lake Duluth. The flowing meltwater from the draining lake has left behind thick deposits of drift and carved a terraced river valley now occupied by the St. Croix and Bois Brule Rivers.

The northeastern section – the Bayfield hills – is a collapsed outwash plain where drift deposits are thick. Lacustrine materials from Glacial Lake Duluth line the northeastern tip. Moving southwest, the landscape transitions into a large pitted outwash plain. This is an area of extensive kettle holes, and, where the underlying till is less permeable, kettle lakes with some interspersed morainic hills and ridges. The glacial drift deposits are thinner in the southwestern section, although there is still no documented surface bedrock within this MLRA.

The St. Croix and Bois Brule rivers share a channel that lines much of the northwestern border of this MLRA. In some places, the underlying reddish-brown sandy loam till of the Copper Falls Formation is exposed along cut riverbanks, though most of it is covered by a mantle of outwash. Glacial lakes deposited pockets of fine-textured lacustrine materials, most of which were washed away or buried by glacial outwash and meltwater flowing through the channel. East of the channel, some of the silty and clayey lakebed deposits are found near the surface, where they impede drainage and contribute to the formation of extensive wetlands.

Historically, the area supported extensive jack pine (Pinus banksiana), scrub, and oak forests and barrens. The northern portion also supported stands of red pine (Pinus resinosa) and eastern white pine (*Pinus strobus*) as well. Marsh and sedge meadow, wet prairies, and lowland shrubs dominated the extensive wetland complexes in the southern tip of this MLRA (Finley, R., 1976).

Classification relationships

Relationship to Established Framework and Classification Systems:
Biophysical Settings (Landfire, 2014): This ES is largely mapped as Laurentian-Acadian Northern Hardwoods Forest, Boreal White Spruce-Fir Forest, Boreal White Spruce-Fir-Hardwood Forest, Boreal Hardwood Forest, Laurentian Pine Barrens, and Laurentian Oak Barrens

Habitat Types of N. Wisconsin (Kotar, 2002): The sites of this ES keyed out to three habitat types: *Pinus strobus-Acer rubrum*/Vaccinium. Uvularia variant (PArV-U); *Pinus strobus-Acer rubrum*/Vaccinium-Aralia, Polygonatum variant (PArVAa-Po); and a combo of *Acer saccharum*/Vaccinium-Clintonia (AVCl) and *Acer saccharum*/Clintonia (ACl). The two Acer habitat types observed (AVCl and ACl) are unlikely to represent this ES.

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

Hierarchical Framework Relationships:
Major Land Resource Area (MLRA): Wisconsin and Minnesota Sandy Outwash (91X)

USFS Subregions: Bayfield Sand Plains (212Ka)
Small sections occur in the Mille Lacs Uplands (212Kb) subregion

Wisconsin DNR Ecological Landscapes: Northwest Sands, North Central Forest

Ecological site concept

The Acidic Sandy Uplands ecological site is located primarily in the northern portion of MLRA 91X on outwash and lake plains, stream and lake terraces, dunes, and ground moraines. These sites are characterized by very deep, moderately well to well drained soils formed primarily in sandy outwash. Some sites have a thin loamy mantle. Precipitation and runoff from adjacent uplands are the primary sources of water. Soils range from extremely acid to neutral.

Historically this Ecological Site was occupied by forest communities dominated by various mixtures of pine and oak species. Specific mixtures were largely dependent on frequency and severity of disturbances, particularly fire and subsequent seed-bed conditions and availability of seed sources. White pine (*Pinus strobus*) was the most persistent species in forest communities due to its biological and ecological characteristics of great longevity, resistance of old trees to fire damage and moderate tolerance to shade by seedlings and saplings. Red oak was often present as an associate species. Virtually all stands on this Ecological Site were harvested during the late 19th and early 20th centuries and post-logging fires were almost universal. Today's forests are dominated by any mixture of, aspen, red maple (*Acer rubrum*), red oak (*Quercus rubra*), white oak (Q. alba), white pine (*Pinus strobus*) and red pine (Pinus resinosa). White birch (Betula papyrifera) and balsam fir (Abies balsamea) are common associates.

Acidic Sandy Uplands is distinguished from from its sandy upland counterparts with its extremely low pH. The low pH indicates low nutrient availability and limits vegetative growth. The sandy materials also have a lower available water capacity than loamy or clayey materials found in other upland sites. The moderately well to well drainage differs this site from other sandy sites.

Associated sites

F091XY005WI	**Wet Sandy and Loamy Lowland** These sites occur on depressions and drainageways on outwash plains and lake plains. They primarily form in sandy outwash are subject to some flooding. Soils are very deep and poorly or very poorly drained. They are saturated for much of the year. They are much wetter and occur lower on the drainage sequence than Acidic Sandy Uplands.
F091XY007WI	**Moist Sandy and Loamy Lowland** These soils formed in sandy outwash, sandy lacustrine deposits, sandy eolian deposits, or loess that is sometimes underlain by sandy or loamy till. Soils are very deep and somewhat poorly drained. They are wetter and occur lower on the drainage sequence than Acidic Sandy Uplands.
F091XY014WI	**Acidic Dry Upland** These soils formed in sandy and gravelly outwash. Soils are very deep and are excessively drained. They are characterized by the presence of a spodic horizon. They may occur higher on the drainage sequence than Acidic Sandy Uplands.

Similar sites

F091XY014WI	**Acidic Dry Upland** Like Acidic Sandy Upland soils, these soils formed in sandy outwash and are characterized by the presence of a spodic horizon. Unlike the moderately well to somewhat excessively drained Acidic Sandy Uplands, these soils are exclusively excessively drained. The vegetative communities they support are very similar to those found on Acidic Sandy Uplands.

Table 1. Dominant plant species

Tree	(1) *Pinus strobus* (2) *Acer rubrum*
Shrub	(1) *Corylus cornuta*
Herbaceous	(1) *Eurybia macrophylla*

Physiographic features

These sites formed on outwash and lake plains, stream and lake terraces, dunes, and ground moraines. Slopes range from 0 to 45 percent. Sites are on summit, shoulder, backslope, and footslope positions.

Sites are not subject to ponding or flooding. Sites have an apparent seasonally high water table (endosaturation) at depths of 24 to 36 inches below the soil surface. The water table can drop to greater than 60 inches during dry conditions. Runoff is primarily negligible to low, but some sites on steep slopes have high runoff potential.

Table 2. Representative physiographic features

Landforms	(1) Lake plain (2) Outwash plain (3) Lagoon (4) Lake terrace (5) Stream terrace (6) Dune (7) Ground moraine
Runoff class	Negligible to high
Flooding frequency	None
Ponding frequency	None
Elevation	180–610 m
Slope	0–45%
Water table depth	61–91 cm
Aspect	Aspect is not a significant factor

Climatic features

The continental climate of the Wisconsin and Minnesota Sandy Outwash MLRA is typical of northern Wisconsin – colder winters and warmer summers. In general, the northern latitudes have cooler summers, colder winters, lower precipitation, and shorter growing seasons than the south; however, neither average annual precipitation nor average annual minimum and maximum temperatures vary greatly within this MLRA. The climate of the northernmost tip is somewhat affected by Lake Superior and receives higher annual precipitation in the form of lake effect snow.

The average annual precipitation for this site is 32 inches. The average annual snowfall is 65 inches. The average annual maximum and minimum temperatures are 52°F and 30°F, respectively. The average length of the freeze-free period within this site ranges from 121 to 143 days. The average length of the frost-free period ranges from 97 to 121 days.

Table 3. Representative climatic features

Frost-free period (characteristic range)	77-88 days
Freeze-free period (characteristic range)	107-116 days
Precipitation total (characteristic range)	787-813 mm
Frost-free period (actual range)	75-90 days
Freeze-free period (actual range)	105-118 days

Precipitation total (actual range)	787-813 mm
Frost-free period (average)	83 days
Freeze-free period (average)	112 days
Precipitation total (average)	813 mm

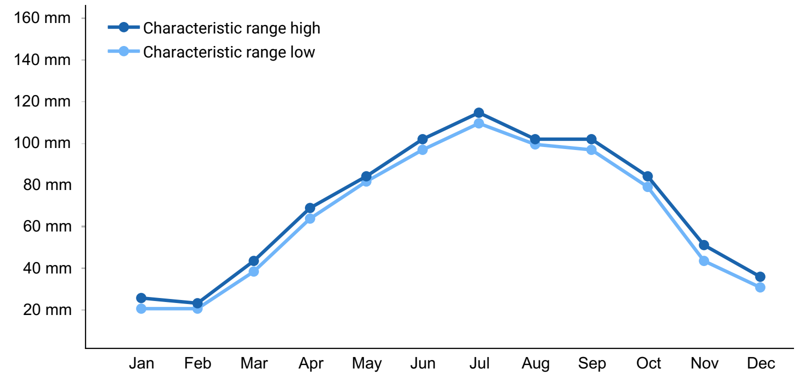


Figure 1. Monthly precipitation range

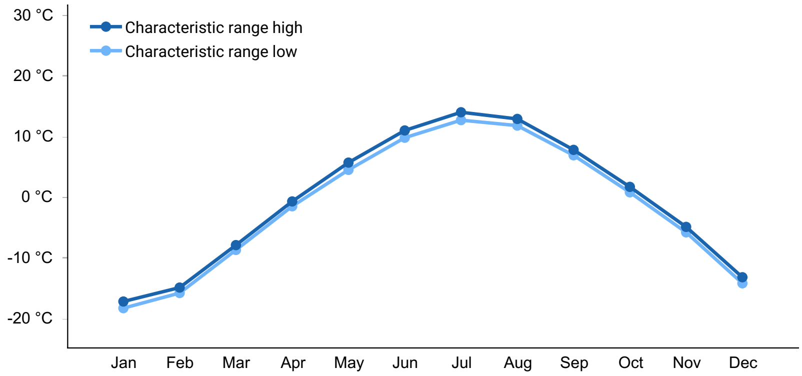


Figure 2. Monthly minimum temperature range

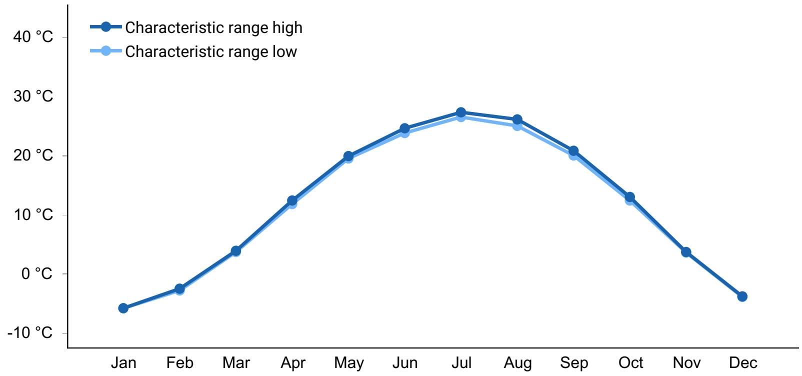


Figure 3. Monthly maximum temperature range

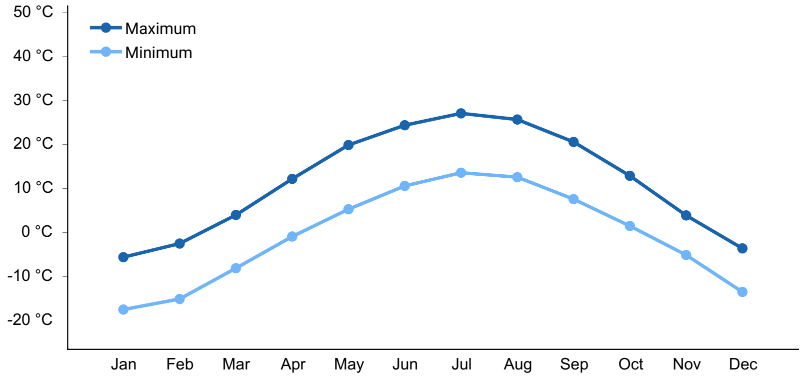


Figure 4. Monthly average minimum and maximum temperature

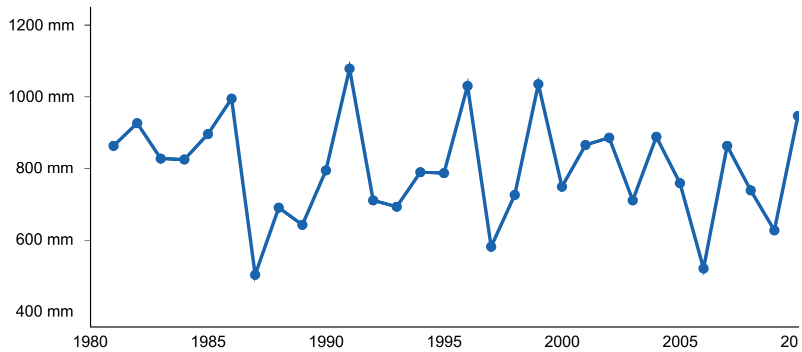


Figure 5. Annual precipitation pattern

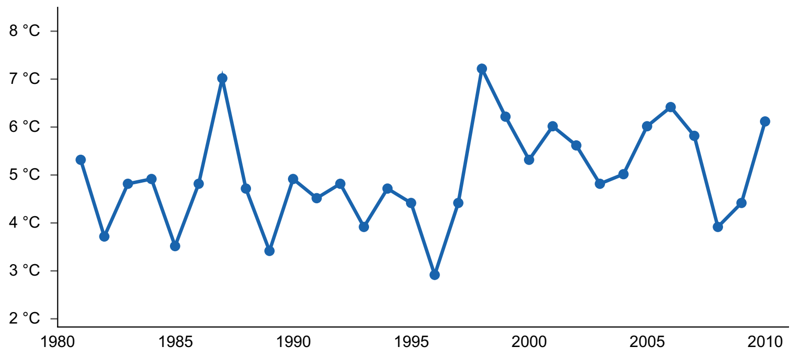


Figure 6. Annual average temperature pattern

Climate stations used

- (1) GORDON [USC00473186], Gordon, WI
- (2) SOLON SPRINGS [USC00477892], Solon Springs, WI
- (3) BRULE RS [USC00471131], Brule, WI

Influencing water features

Water is received primarily through precipitation, runoff from adjacent uplands, and groundwater discharge. Water is discharged from the site primarily through runoff, evapotranspiration, and groundwater recharge.

Permeability of these sites is very slow to rapid. Hydrologic group is A.

Wetland description

Hydrogeomorphic Wetland Classification: None
Cowardin Wetland Classification: None

Soil features

These sites are represented by the Croswell, Cublake, Karlin, Lindquist, Neconish, Omega, Pence, Rousseau, Springstead, and Sultz soil series. The Croswell, Cublake, Neconish, and Springstead soils are classified as Oxyaquic Haplorthods; Karlin, Rousseau, and Sultz are Entic Haplorthods; Omega and Pence are Typic Haplorthods; Lindquist is a Lamellic Haplorthod.

These soils formed primarily sandy outwash. Some sites formed in loamy alluvium over sandy outwash, and other sites are sandy outwash underlain by lacustrine deposits. Few sites formed in sandy glaciofluvial or sandy eolian deposits. Soils are very deep and are moderately well to somewhat excessively drained. Soils do not meet hydric soil requirements.

Surface textures include sand, loamy sand, and sandy loam, and some sites have organic material with varying degrees of decomposition. Subsurface textures are similar to surface textures but can have gravelly and coarse modifiers. The soil pH ranges from extremely acid to slightly acid with values of 4.2 to 6.7. Carbonates are absent.

Figure 7. Croswell Soil Series sampled on 06/18/2019 in Douglas County, WI. Image courtesy of UWSP.

Table 4. Representative soil features

Parent material	(1) Till (2) Outwash (3) Lacustrine deposits (4) Eolian deposits (5) Alluvium
Surface texture	(1) Sand (2) Loamy sand (3) Sandy loam (4) Moderately decomposed plant material
Drainage class	Moderately well drained to somewhat excessively drained
Permeability class	Very slow to rapid
Soil depth	203 cm
Surface fragment cover <=3"	0–8%
Surface fragment cover >3"	0–5%
Available water capacity (0-152.4cm)	10.16–16.41 cm
Soil reaction (1:1 water) (0-101.6cm)	4.2–6.7
Subsurface fragment volume <=3" (0-101.6cm)	7–24%

Subsurface fragment volume >3" (0-101.6cm)	0–5%

Ecological dynamics

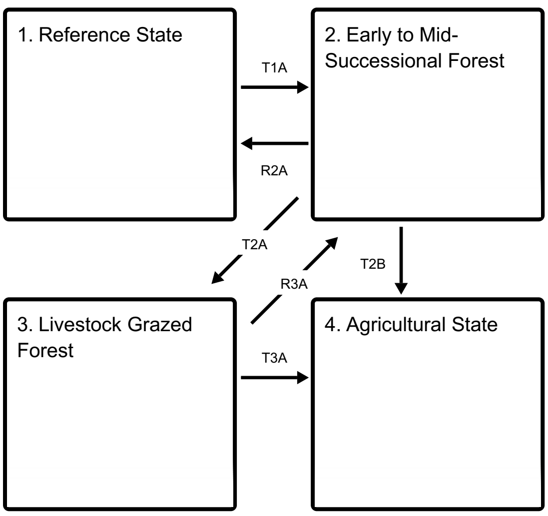
Perhaps the most important ecological characteristic of this Ecological Site, in terms of influence on forest community dynamics, is its limited capacity to support the high to moderate soil moisture and nutrient requiring species such as sugar maple (*Acer saccharum*), basswood (*Tilia americana*) and white ash (Fraxinus Americana). These are the shade-tolerant species, commonly known as the northern hardwoods, that typically dominate the more productive sites throughout northern Wisconsin. Although some of these species do occur sporadically on this Ecological Site, their regeneration capacity and growth rates are sub-optimal, thus precluding their canopy dominance.

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 naturally occurring species could become established, depending on the seed source 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 unset of fire suppression.

In his reconstruction of pre-European settlement vegetation of Wisconsin, Finley (1976), did not identify red maple (*Acer rubrum*) as a prominent component of pine forests, but the species is a prominent member of current stands. Absence of fire since the end of the original logging era is probably the main reason. Red maple is extremely sensitive to fire, but is a prolific and early seed producer. Stems of 2-4 inches in diameter can produce large amounts of seed (USDA Forest Service, 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 stature at maturity, it does not compete with white pine in the upper canopy.

State and transition model

Ecosystem states



T1A - Stand replacing disturbance e.g., blow-down and fire, or clear-cutting followed by fire. Regeneration by natural seeding or planting.

R2A - Fire control, time, natural succession.

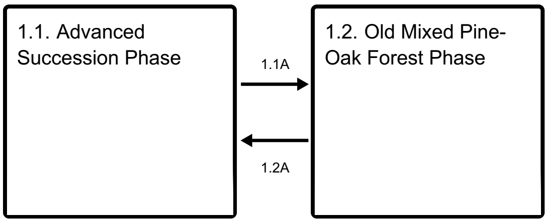
T2A - Grazing by livestock. Disruption of tree regeneration and ground vegetation.

T2B - Removal of natural vegetation, plowing, fertilizing, irrigating, planting agricultural crops.

R3A - Removal of livestock from stands.

T3A - Removal of natural vegetation, plowing, fertilizing, irrigating, planting agricultural crops.

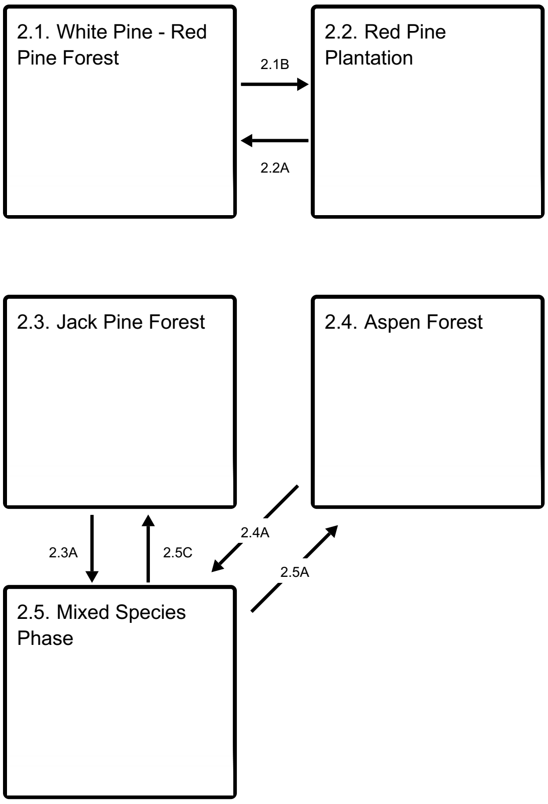
State 1 submodel, plant communities



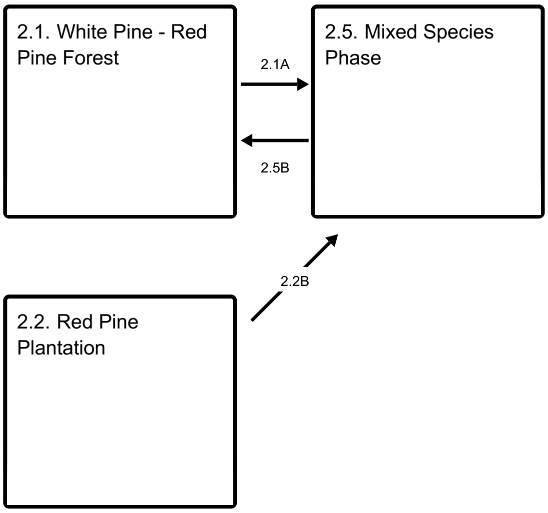
1.1A - Light to moderate intensity fires, reducing or eliminating advance tree regeneration.

1.2A - White pine and red oak regeneration re-establishes.

State 2 submodel, plant communities



Communities 1, 5 and 2 (additional pathways)



2.1B - Removal of White Pine

2.1A - White pine regeneration in mixed stand of white, red, and sometimes Jack pine.

2.2A - White pine seeding in from natural seed source or under-planted.

2.2B - White pine seeding in from natural seed source or under-planted.

2.3A - White pine seeding in from natural seed source or under-planted.

2.4A - White pine seeding in from natural seed source or under-planted.

2.5B - Time without disturbance, natural succession

2.5C - This pathway occurs with fire when Jack pine seed sources is available or when planted

2.5A - Repetitive clearcutting and burning of earlier stands

State 1
Reference State

In the long-term absence of stand replacing disturbance, tree species composition of forest communities on this ecological site fluctuates among white pine (*Pinus strobus*), red pine (P. Resinosa), red oak (*Quercus rubra*) and red maple (*Acer rubrum*). This fluctuation is due to many factors. There is a differential response to a range of common, but not stand-replacing disturbances, such as light fire, snow and ice brakeage and natural mortality in the canopy. There are differences in regeneration requirements among the species and in seedling tolerance of understory conditions. While the resulting community species composition and structure can be viewed as a continuum, two distinct community phases can be described as representing the opposite ends of a continuum.

Dominant plant species

- eastern white pine (*Pinus strobus*), tree
- red pine (*Pinus resinosa*), tree
- northern red oak (*Quercus rubra*), tree

Community 1.1
Advanced Succession Phase

Figure 8. Image courtesy of UWSP taken on 06/18/2019 in Douglas County, WI.

White pine, with varying admixtures of red pine and red oak, constitutes the dominant overstory. The shrub layer typically is well-developed and is dominated by beaked- and american hazel, (*Corylus cornuta* and *C. americana*)). Other important species are juneberry (Amalenchier spp.) and blueberry, (Vaccinium angustifolum). Herbaceous layer typically is dominated by high cover of bracken fern (*Pteridium aquilinum*) and large-leaf aster (*Eurybia macrophylla*). Other well represented species include wild lily of-the valley (*Maianthemum canadense*), wood anemone (*Anemone quinquefolia*) and starflower (*Trientalis borealis*).

Community 1.2
Old Mixed Pine-Oak Forest Phase

Pathway 1.1A
Community 1.1 to 1.2

Periodic moderate intensity fires, eliminating or reducing advance regeneration, but leaving at least the oldest and fire-resistant pines and oaks.

Pathway 1.2A
Community 1.2 to 1.1

Canopy species re-establish regeneration layer.

State 2
Early to Mid-Successional Forest

Community 2.1
White Pine - Red Pine Forest

Even-aged, naturally regenerated, mixed pine forest, some times with admixture of red oak of sprout origin. These stands often contain considerable amount of white pine regeneration, but with only sporadic presence of young red pine in locations with large canopy openings and absence of other competing vegetation.

Dominant plant species

- eastern white pine (*Pinus strobus*), tree
- red pine (*Pinus resinosa*), tree

Community 2.2
Red Pine Plantation

Planted red pine with varying spacing. Plantations with close spacing e.g. less than 8 x 8 feet typically are devoid of significant understory vegetation. However, if thinning is applied the shrub component, dominated by beaked hazelnut (*Corylus cornuta*), increases significantly. Other common shrubs may include blackberries and raspberries (Rubus spp.), juneberry (Amelanchier spp.) and blueberries (Vaccinium spp.). Depending on the proximity of seed sources, white pine regeneration may be common. Herbaceous layer also increases, often dramatically, with bracken fern (*Pteridium aquilinum*) and large-leaf aster (*Eurybia macrophylla*) attaining strong dominance.

Dominant plant species

- red pine (*Pinus resinosa*), tree

Community 2.3
Jack Pine Forest

Unless planted, this community develops only if fire was included in the destruction of preceding community and mature Jack pine trees were present to provide seed source. Young jack pine communities often are very dense. Over time, natural mortality thins the stand and shrub and herb layers develop similarly as described for Community Phase 2.2.

Dominant plant species

- jack pine (*Pinus banksiana*), tree

Community 2.4
Aspen Forest

Like the naturally developed jack pine forest, the aspen forest community most often requires fire disturbance for establishment. Once in place it can be perpetuated by clear cutting. Understory communities develop in a similar way as described in communities 2.2 and 2.3, but more quickly, because aspen mortality leads to faster self-thinning of stands and light penetration in aspen canopy is greater that that in conifer stands.

Dominant plant species

- quaking aspen (*Populus tremuloides*), tree
- bigtooth aspen (*Populus grandidentata*), tree

Community 2.5
Mixed Species Phase

Figure 9. Image courtesy of UWSP taken on 06/18/2019 in Douglas County, WI.

This is a mid-successional community. The oldest tree cohort is made up of remnants of the pioneer communities of either Jack pine, red pine, or aspen. This cohort is in the process of being replaced by more shade tolerant white pine. Red oak is also frequent associate. In absence of major disturbance this community phase transitions into Reference State Community.

Dominant plant species

- jack pine (*Pinus banksiana*), tree
- red pine (*Pinus resinosa*), tree
- quaking aspen (*Populus tremuloides*), tree
- eastern white pine (*Pinus strobus*), tree
- northern red oak (*Quercus rubra*), tree

Pathway 2.1B
Community 2.1 to 2.2

Stand replacing disturbance e.g., blow-down and fire, or logging of white pine followed by fire. Regeneration by natural seeding or planting.

Pathway 2.1A
Community 2.1 to 2.5

White pine regeneration in mixed stand of white, red, and sometimes Jack pine.

Pathway 2.2A
Community 2.2 to 2.1

White pine seeding in from natural seed source or under-planted.

Pathway 2.2B
Community 2.2 to 2.5

White pine seeding in from natural seed source or under-planted.

Pathway 2.3A
Community 2.3 to 2.5

White pine seeding in from natural seed source or under-planted.

Pathway 2.4A
Community 2.4 to 2.5

White pine seeding in from natural seed source or under-planted.

Pathway 2.5B
Community 2.5 to 2.1

Elimination of repetitive clearcutting and burning of stands. Lack of disturbance over time will cause this transition.

Pathway 2.5C
Community 2.5 to 2.3

This pathway occurs with fire when Jack pine seed sources is available or when planted

Pathway 2.5A
Community 2.5 to 2.4

Aspen becomes established following repetitive clearcutting and burning of early stages of pine and oak. These stands are being perpetuated through clear cutting.

State 3
Livestock Grazed Forest

Livestock grazed forests are more often referred to as woodlands rather than forests because this long-term land use significantly changes some soil characteristics and nature of vegetative community. Species composition is altered by selective browsing and grazing as well as by distribution of seeds and other propagules by grazing animals. In addition, soil compaction differentially affects germination and establishment of plant species, including trees.

State 4
Agricultural State

Production of agricultural crops, most often oats or hay. Routine usage of tillage, fertilizer, and other field practices.

Transition T1A
State 1 to 2

Stand-replacing disturbance, such as blow-down, or ice storm, followed by fire, or clear-cut logging, followed by natural regeneration or site preparation and planting.

Restoration pathway R2A
State 2 to 1

Time (50-100 years) and natural succession by white pine will lead back to the reference state. Minimal disturbance during the successional period.

Transition T2A
State 2 to 3

Prolonged grazing by livestock

Transition T2B
State 2 to 4

Elimination of forest cover and introduction of tilling, fertilizing an/or irrigation.

Restoration pathway R3A
State 3 to 2

Removal of livestock, natural succession. Results may be sped up by planting and initial outcomes will be heavily influenced by seed source and adjacent plant communities.

Transition T3A
State 3 to 4

Elimination of forest cover and introduction of tilling, fertilizing an/or irrigation.

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

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.

County Soil Surveys from Douglas, Bayfield, Washburn, Burnett, Polk, and Sawyer.

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.

Hvizdak, David. Personal knowledge and field experience.

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

Kotar, J. 1986. Soil – Habitat Type relationships in Michigan and Wisconsin. J. For. and Water Cons. 41(5): 348-350.

Kotar, J., J.A. Kovach and G. Brand. 1999. Analysis of the 1996 Wisconsin Forest Statistics by Habitat Type. U.S.D.A. For. Serv. N.C. Res. Stn. Gen. Tech. Rept. NC-207.

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 sur¬vey 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.

Soil Survey Staff. Input based on personal experience. Tim Miland, Scott Eversoll, Ryan Bevernitz, and Jason Nemecek.

United States Department of Agriculture, Natural Resources Conservation Service. 2022. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture, 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, Madison.

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Approval

Suzanne Mayne-Kinney, 9/27/2023

Acknowledgments

NRCS contracted UWSP to write ecological sites for MLRA 91. Completed in 2021.

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:**

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:

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

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

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

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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:**

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17. **Perennial plant reproductive capability:**
