

Ecological site F091XY014WI Acidic Dry Upland

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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): 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 Pine Barrens, Laurentian Oak Barrens, Laurentian-Acadian Northern Hardwoods Forest, Laurentian-Acadian Northern Pine Forest, Laurentian-Acadian Northern Oak Forest, and Boreal White Spruce-Fir Forest

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); *Pinus strobus-Quercus/Gaultheria* (PQG)

WDNR Natural Communities (WDNR, 2015): This ES is most similar to the Northern Dry Forest and 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) and Hayward Stagnation Moraines (212Xf) subregions

Wisconsin DNR Ecological Landscapes: Northwest Sands, North Central Forest

Ecological site concept

The Acidic Dry Uplands ecological site dominates the northern portion of MLRA 91X. Sites are found on outwash plains, eskers, and moraines. These sites are characterized by very deep, excessively drained soils formed primarily in acidic sandy outwash. Some sites have thin loamy mantles over the outwash or formed in sandy eolian deposits. Precipitation and runoff are the primary sources of water. Soils range from very strongly acid to slightly acid.

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 (*Quercus rubra*) 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 trembling or big-tooth aspen (*Populus tremuloides* and *P. grandidentata*), red oak, red maple (*Acer rubrum*), white pine and red pine (*Pinus resinosa*). White birch (*Betula papyrifera*), balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*) are common associates.

The excessive drainage of Acidic Dry Uplands differs it from other sandy sites. The low pH differs this site from Dry Uplands, which are also sandy and excessively drained.

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 wetter and occur lower on the drainage sequence than Acidic Dry 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 Dry Uplands.
F091XY010WI	Acidic Sandy Upland These soils formed primarily sandy outwash, but some sites formed in loamy alluvium over sandy outwash, and other sites are sandy outwash underlain by lacustrine deposits. Soils are very deep and are moderately well to somewhat excessively drained. These soils are characterized by the presence of a spodic horizon. They are slightly wetter and occur lower on the drainage sequence than Acidic Dry Uplands.

Similar sites

F091XY010WI	Acidic Sandy Upland These soils formed primarily sandy outwash, but some sites formed in loamy alluvium over sandy outwash, and other sites are sandy outwash underlain by lacustrine deposits. Like Acidic Dry Uplands, these soils are very deep and are characterized by the presence of a spodic horizon, but they are somewhat wetter.
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F091XY015WI	<p>Dry Upland</p> <p>These sites formed in sandy outwash or eolian deposits. Soils are very deep and excessively drained. They occupy the same positions on the landscape and have the same particle sizes and drainage class as Acidic Sandy Uplands but lack a spodic horizon.</p>
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Table 1. Dominant plant species

Tree	(1) <i>Pinus strobus</i> (2) <i>Quercus rubra</i>
Shrub	(1) <i>Acer rubrum</i> (2) <i>Pinus strobus</i>
Herbaceous	(1) <i>Vaccinium</i> (2) <i>Pteridium aquilinum</i>

Physiographic features

These sites formed on outwash plains, eskers, and moraines. Slopes range from 0 to 45 percent. Sites are on summit, shoulder, and backslope positions.

Sites are not subject to ponding or flooding. The depth to water table exceeds 80 inches below the soil surface. Runoff is negligible to medium.

Table 2. Representative physiographic features

Hillslope profile	(1) Summit (2) Shoulder (3) Backslope
Slope shape across	(1) Convex
Slope shape up-down	(1) Linear
Landforms	(1) Outwash plain (2) Esker (3) Moraine
Runoff class	Negligible to medium
Flooding frequency	None
Ponding frequency	None
Elevation	180–595 m
Slope	0–45%
Water table depth	203 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 northern portion of the Acidic Dry Uplands PES is climatically-affected by its proximity to Lake Superior. The average annual snowfall is 69 inches, more than any other site and 11 inches more than the average for this MLRA. It also has a longer growing season than other ecological sites in the northern section of this MLRA. The average annual precipitation for this site is 32 inches. 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)	87-98 days
Freeze-free period (characteristic range)	119-127 days
Precipitation total (characteristic range)	787-838 mm
Frost-free period (actual range)	85-102 days
Freeze-free period (actual range)	119-131 days
Precipitation total (actual range)	787-864 mm
Frost-free period (average)	93 days
Freeze-free period (average)	123 days
Precipitation total (average)	813 mm

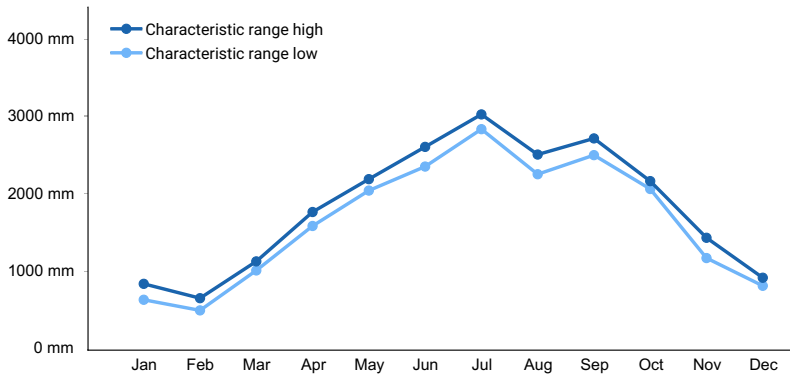


Figure 1. Monthly precipitation range

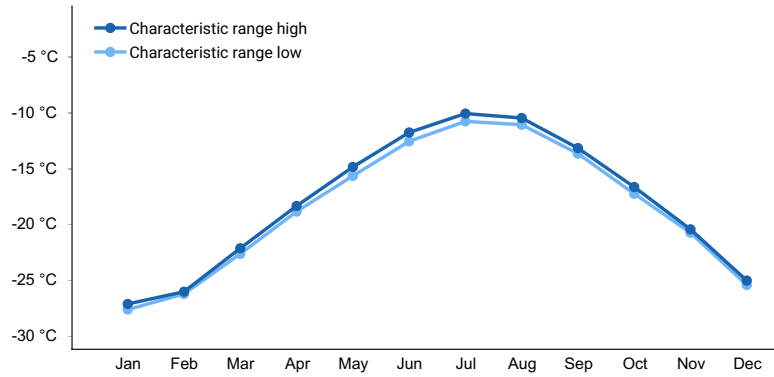


Figure 2. Monthly minimum temperature range

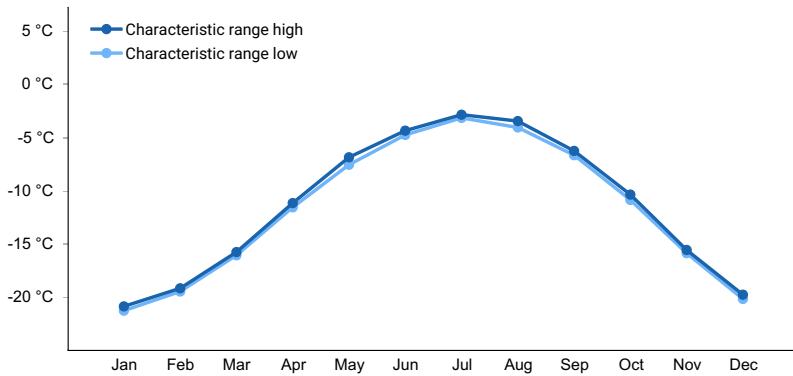


Figure 3. Monthly maximum temperature range

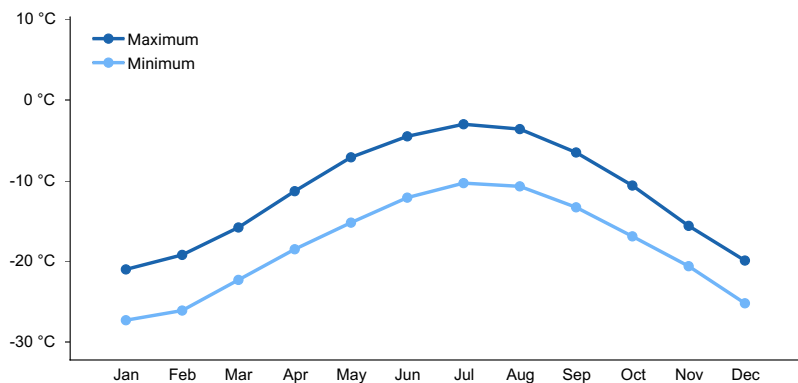


Figure 4. Monthly average minimum and maximum temperature

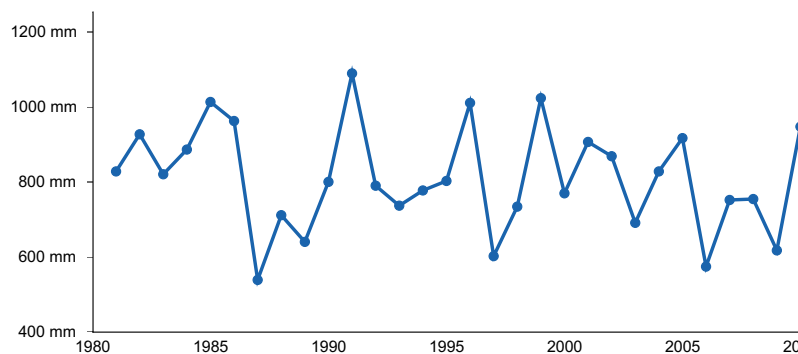


Figure 5. Annual precipitation pattern

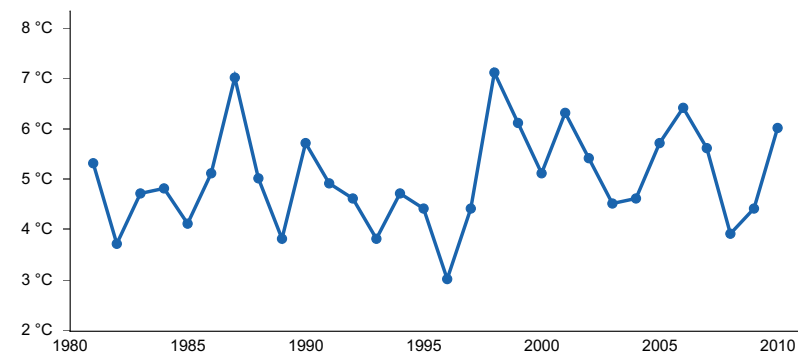


Figure 6. Annual average temperature pattern

Climate stations used

- (1) BRULE RS [USC00471131], Brule, WI
- (2) SOLON SPRINGS [USC00477892], Solon Springs, WI
- (3) ASHLAND EXP FARM [USC00470349], Ashland, WI
- (4) DRUMMOND [USC00472240], Drummond, 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 moderate to rapid. Hydrologic group is A.

Wetland description

Hydrogeomorphic Wetland Classification: None
 Cowardin Wetland Classification: None

Soil features

These sites are represented by the Rubicon, Sayner, and Vilas soil series, all classified as Entic Haplorthods.

These soils formed in sandy and gravelly outwash. Soils are very deep and are excessively drained. Soils do not meet hydric soil requirements.

Surface textures of these sites is primarily loamy sand and sand, but few sites may have moderately decomposed organic material at the surface. Subsurface textures include sand, loamy sand, gravelly sand, and gravelly coarse sand. Soil pH ranges from very strongly acid to slightly acid with values of 4.8 to 6.3.



Figure 7. Rubicon Soil Series sampled on 06/19/2019 in Douglas County, WI.

Table 4. Representative soil features

Parent material	(1) Outwash
Surface texture	(1) Moderately decomposed plant material (2) Loamy sand (3) Sand
Drainage class	Excessively drained
Permeability class	Moderate to rapid
Soil depth	201 cm
Surface fragment cover <=3"	0–7%
Surface fragment cover >3"	0–5%
Available water capacity (0-150.1cm)	2.21–4.29 cm
Soil reaction (1:1 water) (0-100.1cm)	4.8–6.3
Subsurface fragment volume <=3" (0-100.1cm)	2–25%
Subsurface fragment volume >3" (0-100.1cm)	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

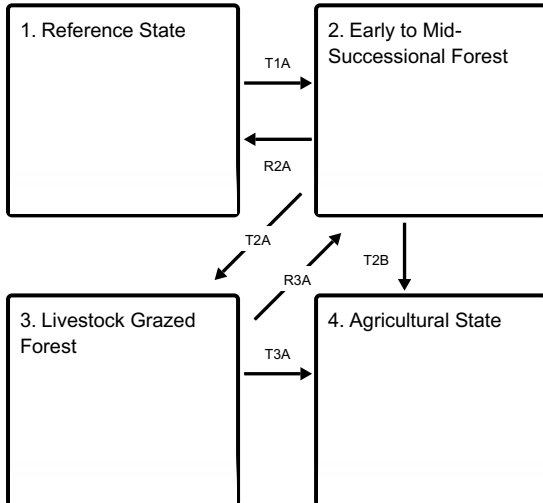
Ecological Site, their regeneration capacity and growth rates are sub-optimal, thus precluding their canopy dominance.

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 onset 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 natural, 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.

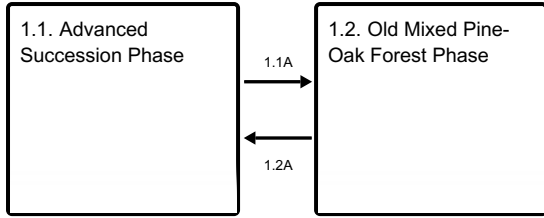
T2A - Grazing by livestock. Disruption of tree regeneration and ground vegetation.

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.

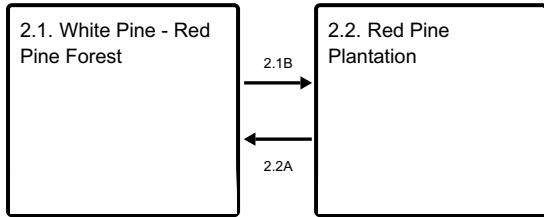
State 1 submodel, plant communities



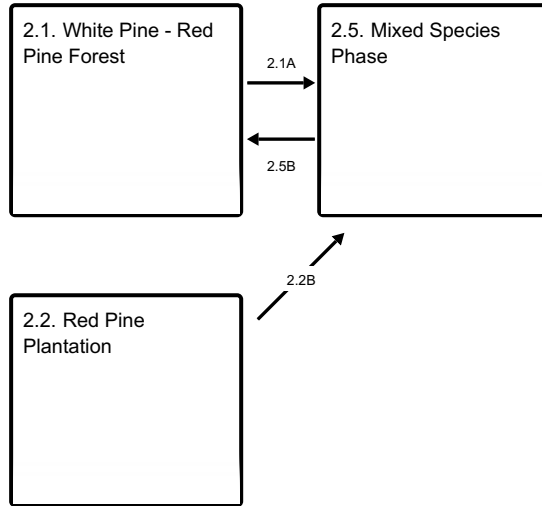
1.1A - Light to moderate intensity fires, reducing or eliminating fire sensitive species, such as red maple, balsam fir, and white spruce.

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

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 (*Amelanchier* spp.) and blueberry, (*Vaccinium angustifolium*). 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*).

Dominant plant species

- eastern white pine (*Pinus strobus*), tree
- red pine (*Pinus resinosa*), tree
- northern red oak (*Quercus rubra*), tree
- balsam fir (*Abies balsamea*), tree
- beaked hazelnut (*Corylus cornuta*), shrub
- blueberry (*Vaccinium*), shrub
- western brackenfern (*Pteridium aquilinum*), other herbaceous

Community 1.2

Old Mixed Pine-Oak Forest Phase

Dominant plant species

- eastern white pine (*Pinus strobus*), tree
- red pine (*Pinus resinosa*), tree
- northern red oak (*Quercus rubra*), tree
- beaked hazelnut (*Corylus cornuta*), shrub
- blueberry (*Vaccinium*), shrub
- brackenfern (*Pteridium*), other herbaceous
- bigleaf aster (*Eurybia macrophylla*), other herbaceous

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



Figure 9. Image courtesy of UWSP taken on 06/25/2017 in Bayfield County, WI.

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
- beaked hazelnut (*Corylus cornuta*), shrub
- western brackenfern (*Pteridium aquilinum*), other herbaceous
- bigleaf aster (*Eurybia macrophylla*), other herbaceous

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-Paper Birch Forest



Figure 10. Image courtesy of UWSP taken on 06/26/2019 in Douglas County, WI.

Like the naturally developed jack pine forest, the aspen-paper birch forest community most often requires fire disturbance for establishment. Once in place it can be perpetuated by clear cutting, but paper birch presence drops off dramatically due to very dense stocking of aspen sprouts. 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 than that in conifer stands.

Dominant plant species

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

Community 2.5 Mixed Species Phase



Figure 11. 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



Red Pine Plantation



Mixed Species Phase

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



Aspen-Paper Birch Forest



Mixed Species Phase

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.

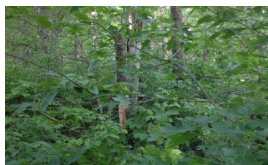
Pathway 2.5C Community 2.5 to 2.3

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

Pathway 2.5A Community 2.5 to 2.4



Mixed Species Phase



Aspen-Paper Birch Forest

Repetitive clearcutting and burning of earlier stands

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 Standard: Terrestrial Ecological Classifications. NatureServe Central 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 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.
- 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.

Contributors

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Approval

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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:

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:**
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17. **Perennial plant reproductive capability:**
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