Ecological site F092XY008WI
Sandy Sandstone Uplands

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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): 092X–Superior Lake Plain

The Wisconsin portion of the Superior Lake Plain (MLRA 92) corresponds very closely to the Superior Coastal Plain Ecological Landscape published by Wisconsin Department of Natural Resources (WDNR 2015). The following brief overview of this MLRA is borrowed from that publication.

The Superior Coastal Plain is bordered on the north by Lake Superior and on the south by the Northwest Sands, Northwest Lowlands, and North Central Forest Ecological Landscapes. The total land area is approximately 1.2 million acres, which mostly consists of privately-owned forestland. The climate is strongly influenced by Lake Superior, resulting in cooler summers, warmer winters, and greater precipitation compared to more inland locations. The most extensive landform in this ecological landscape is a nearly level plain of lacustrine clays that slopes gently northward toward Lake Superior. The coastal plain is cut by deeply incised stream drainages and interrupted by the comparatively rugged Bayfield Peninsula.

During the Late Wisconsin glacial period, this area was covered with the advancing and retreating lobes of Superior and Chippewa. The landscape was rippled with moraines, but they were subdued by deposition of lacustrine materials. As the glaciers receded, glacial lakes riddled the landscape—most notably, Glacial Lake Duluth. The glacier receded eastward, exposing the western Lake Superior Basin. The ice covered the eastern basin, blocking the outlet of the lake, and continued to recede and contribute meltwaters that filled the glacial lake. The deep, red clays were deposited during this period of glacial lakes. The meltwaters from the glacier also contained sands which were deposited along the edge of the glacial lakes as beach deposits. Deep, narrow valleys have since been carved by rivers and streams flowing north into Lake Superior.

Historically, the Superior Coastal Plain was almost entirely forested. Various mixtures of eastern white pine (*Pinus strobus*), white spruce (Picea glauca), balsam fir (*Abies balsamea*), white birch (Betula papyrifera), balsam poplar (Populus balsamifera), quaking aspen (Populus tremuloides), and northern white-cedar (Thuja occidentalis) occurred on the fine-textured glacio-lacustrine deposits bordering much of the Lake Superior coast. Sandy soils, sometimes interlayered with clays, occur in some places. Such areas supported forests dominated by eastern white pine and red pine (Pinus resinosa). Eastern white pine was strongly dominant in some areas, according to mid-19th century notes left by surveyors of the federal General Land Office (Finley, R. 1976). Dry-mesic to wet-mesic northern hardwoods or hemlock-hardwood forests were prevalent on the glacial tills of the Bayfield Peninsula. Large peatlands occurred along the Lake Superior shoreline, associated with drowned river mouths.

Classification relationships

Habitat Types of N. Wisconsin (Kotar, 2002): This ES keys out to two habitat types: *Pinus strobus* - *Acer rubrum* / Vaccinium angustifolium - Apocynum androsaemifolium [PArVAa-Po]; and Acer saccharum – Tsuga canadensis / Maianthemum candense. [ATM]

Biophysical Setting (Landfire, 2009): This ES is mapped as Laurentian-Acadian Northern Hardwoods Forest-

Hemlock; and Laurentian – Acadian Sub-boreal Mesic Balsam Fir-Spruce Forest – Coastal. This ES is more similar to the Norther Hardwoods Hemlock Forest.

WDNR Natural Communities (WDNR, 2015): This ES is most similar to the Northern Dry Forest, though some sites may be more similar to the Northern Dry-Mesic Forest.

USFS Subregions: Superior-Ashland Clay Plain Subsection (212Ya); May contain small areas of Ewen Dissected Lake Plain Subsection (212Jo), Winegar Moraines Subsection (212Jc), Gogebic-Penokee Iron Range Subsection (212Jb), and NorthShore Highlands Subsection (212Lb)*

Major Land Resource Area (MLRA): Superior Lake Plain (92)

Ecological site concept

The Sandy Sandstone Uplands has a small extent in MLRA 92 and occurs along the shore of Lake Superior and on the Apostle Islands. These sites occur on shallow to moderately deep sandy soils overlying sandstone outcrops. The soils associated with this ES are excessively drained and parent materials include sandy-skeletal beach deposits and sandstone residuum. The soils differ in their depth to bedrock, but are all underlain by sandstone within 100 cm. Water is received through precipitation, but quickly drains. Soils do not remain saturated for any time during the year. These soils are strongly acidic.

Historically this Ecological Site was occupied by forest communities dominated by various mixtures of pine and oak species. The mixtures were largely dependent on frequency and severity of disturbances, particularly fire and subsequent seed-bed conditions and availability of seed sources. White pine was the most constant species in forest communities due to its 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 white pine, red pine, aspen, red oak and red maple. White birch, balsam fir and white spruce are common associates.

This ES is distinguished by its truncated soil and excessive drainage. Other sandy sites have a deeper solum, may be underlain by finer material, and often have more saturation during the year. Loamy Sandstone Uplands has a finer soil texture.

Sandy Sandstone Uplands are uniquely along lake shore bluffs or close to Lake Superior as a result they have a unique climate yielding some variability in their vegetation namely whether Sugar maple is strongly expressed or only an uncommon associate.

Associated sites

F092XY006WI	**Wet Sandy Lowlands** Wet Sandy Depressions are poorly or very poorly drained sandy soils that have formed in outwash and lake plains. The sites are seasonally ponded depressions that remain saturated for sustained periods, allowing for hydric conditions to occur. Primarily associated with Kinross soil series. HGM criteria: recharge; Depressional. These sites are located lower in the drainage sequence than Sandy Sandstone Uplands, and remain saturated much longer during the year.
F092XY010WI	**Moist Sandy Lowlands** Moist Sandy Lowlands have a sandy mantle overlying finer glaciofluvial materials. The finer materials can cause episaturation in spring and fall, allowing the site to remain moist for some of the growing season, but does not remain saturated, nor does it have hydric conditions. These sites are located lower in the drainage sequence than Sandy Sandstone Uplands, and remain saturated longer during the year.

Similar sites

F092XY013WI	**Sandy Uplands** While vegetatively similar, Sandy Uplands also contains the PArVAa-Po habitat type, the Sandy Sandstone Uplands have a restricted rooting depth and are less likely to support large trees. Sandy Uplands sites are formed primarily in sandy deposits, and some are underlain by finer glaciofluvial material. Sites are moderately well to excessively drained, but sites with underlying finer materials may have extended saturation in spring and fall. Sites range from strongly acid to neutral and may contain carbonates. These sites can be located in the drainage sequence with Sandy Sandstone Uplands. These sites have a deeper solum, and often have an additional parent material beneath the sandy materials on top.
F092XY009WI	**Loamy Sandstone Uplands** These sites are shallow loamy soils that overly sandstone bluffs along the shore of Lake Superior. They are moderately well drained soils, but have a seasonally high water table. The soils range from strongly acid to neutral. These sites are nearby on similar landscape to Sandy Sandstone Uplands, but differ in having a finer texture.

Table 1. Dominant plant species

Tree	(1) *Pinus strobus* (2) *Quercus rubra*
Shrub	(1) *Corylus cornuta*
Herbaceous	(1) *Eurybia macrophylla*

Physiographic features

This site occurs on knolls, ridges, hillslopes, interfluves, and terraces located on bedrock-controlled hills. Landform shape ranges from linear to convex. Elevation of the landforms range from 185 to 400 meters above sea level. Slopes range from 0 to 15 percent. This site occurs on all slope aspects.

Table 2. Representative physiographic features

Landforms	(1) Hills > Knoll (2) Hills > Ridge (3) Hills > Hillslope (4) Hills > Interfluve
Runoff class	Negligible to very high
Elevation	607–1,312 ft
Slope	0–15%
Ponding depth	39 in
Aspect	Aspect is not a significant factor

Climatic features

Sandy Sandstone Uplands are located along the shore of Lake Superior on the Bayfield Peninsula, and the Apostle Islands. The annual average precipitation is 29-33 inches, with an average snowfall range of 72-132 inches (PRISM, 19881-2010). The annual average maximum and minimum temperatures are 51oF and 31oF, respectively (PRISM, 19881-2010). Being mostly located directly on the lake, the Sandy Sandstone Uplands sites tend to have a lower maximum temperature and a higher minimum temperature than some of the PESDs located inland of the Lake Superior. The length of the freeze-free period ranges from 162 to 194, with an average of 179 days (Table 2). The length of the frost-free period ranges from 138 to 166, with an average of 152 days (Table 2). These ranges occur because this PESD has sites located all around the Bayfield Peninsula that are subject to different wind and precipitation patterns. A few sites even occur further inland from the lake, and others are located on the small Apostle Islands, with various aspects.

Table 3. Representative climatic features

Frost-free period (characteristic range)	96-114 days
Freeze-free period (characteristic range)	126-138 days

Precipitation total (characteristic range)	31-33 in
Frost-free period (actual range)	87-114 days
Freeze-free period (actual range)	121-138 days
Precipitation total (actual range)	31-33 in
Frost-free period (average)	104 days
Freeze-free period (average)	131 days
Precipitation total (average)	32 in

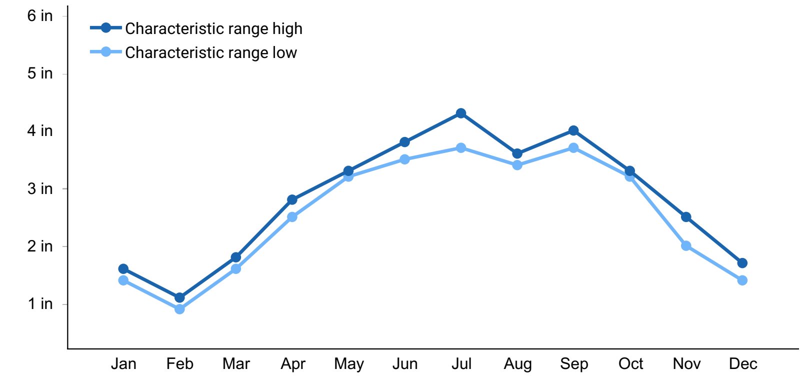


Figure 1. Monthly precipitation range

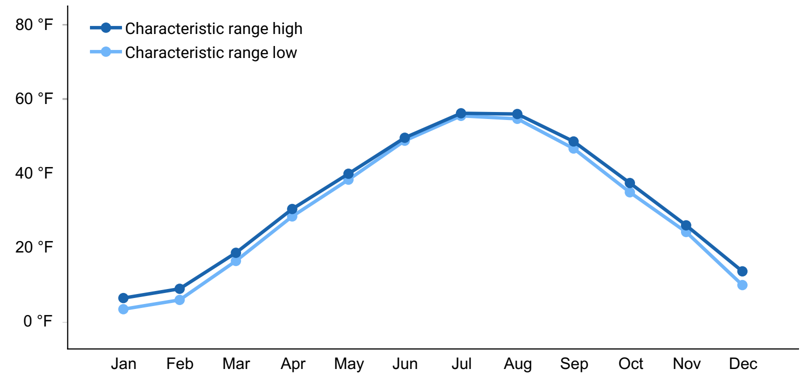


Figure 2. Monthly minimum temperature range

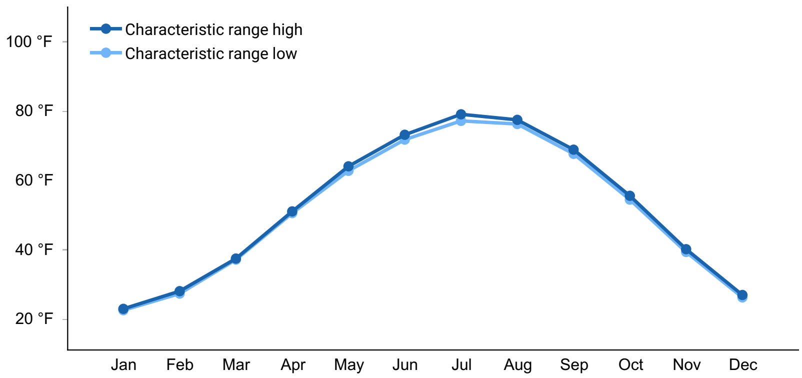


Figure 3. Monthly maximum temperature range

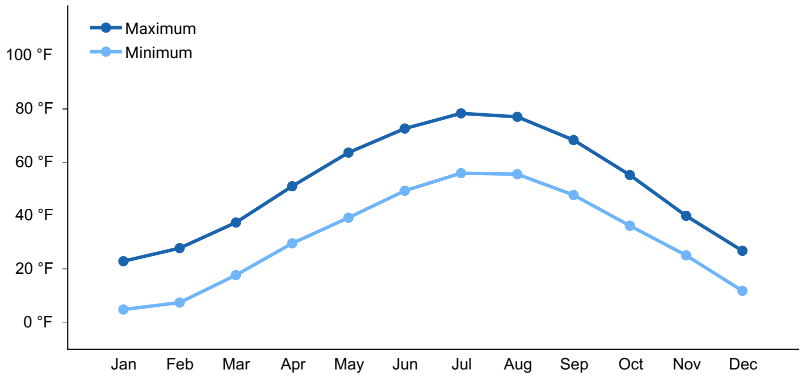


Figure 4. Monthly average minimum and maximum temperature

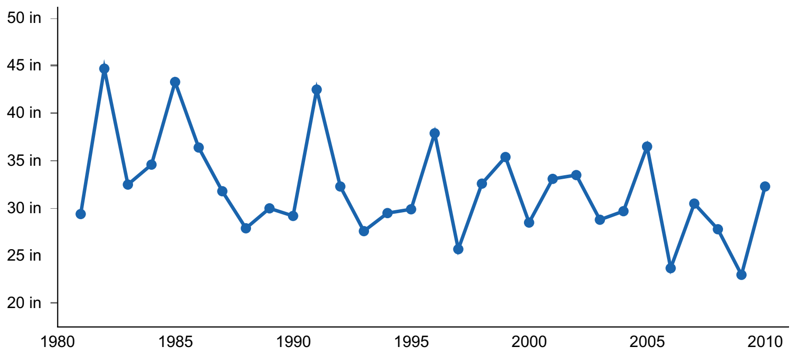


Figure 5. Annual precipitation pattern

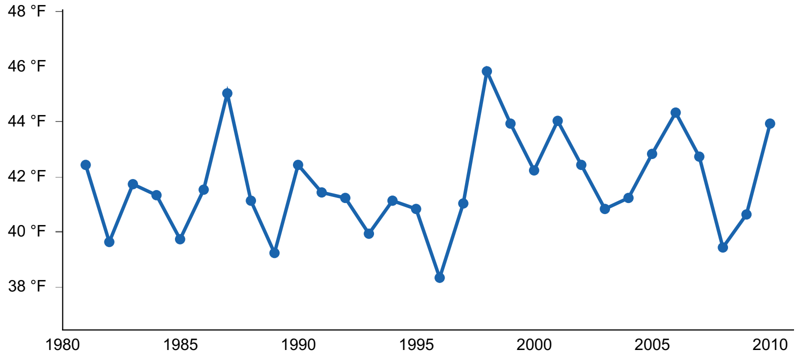


Figure 6. Annual average temperature pattern

Climate stations used

- (1) ASHLAND EXP FARM [USC00470349], Ashland, WI
- (2) BAYFIELD 6 N [USC00470603], Bayfield, WI
- (3) MADELINE ISLAND [USC00474953], La Pointe, WI

Influencing water features

Water is received primarily through precipitation. Water is discharged from the site primarily through runoff, subsurface outflow, or evapotranspiration.

Permeability of the soil is rapid. Runoff potential is negligible to very high. The hydrologic group of this site is either A or B.

The soils of this site do not exhibit any significant saturation at any depth for any significant period. Water that percolates into the soil is generally lost through plant uptake and evapotranspiration, or through subsurface outflow. The sandstone bedrock restricts ground water recharge.

Soil features

The soils of this site are represented by the Brownstone, Deerton, and Redrim soil series. These soils are classified as Haplorthods.

This ecological site is characterized by shallow to moderately deep, excessively drained and well drained soils formed in sandy to sandy-skeletal beach deposits or residuum weathered from sandstone, all underlain by sandstone within 100 cm.

The average gravel content within the soil can be as much as 35 percent, while the average content of cobbles and stones can be as much as 35 percent. Surface stones average about 2 percent. Soil reaction (pH) in the upper 100 cm is very strongly acid. Carbonates are absent.

Table 4. Representative soil features

Parent material	(1) Residuum–sandstone (2) Beach sand
Surface texture	(1) Very cobbly sand
Drainage class	Well drained to excessively drained
Permeability class	Rapid
Soil depth	10–39 in
Surface fragment cover >3"	0–3%
Available water capacity (0-60in)	2.63–3.04 in
Soil reaction (1:1 water) (0-40in)	4.6–5
Subsurface fragment volume <=3" (0-40in)	10–35%
Subsurface fragment volume >3" (0-40in)	3–35%

Ecological dynamics

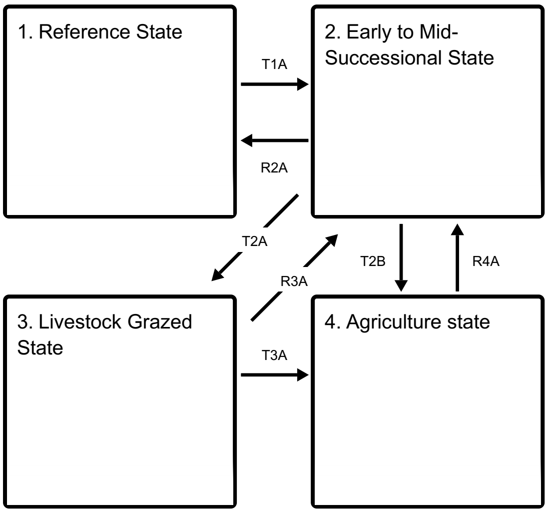
Perhaps the most important ecological characteristic of this Ecological Site, in terms of influence on forest community dynamics, is its limited capacity to support the high to moderate soil moisture and nutrient requiring species such as sugar maple, basswood and white ash, the shade-tolerant species,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

Red maple (*Acer rubrum*) has not been identified by Finley (1976) as a component of pre-settlement pine forests, but 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, 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 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 ad 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.

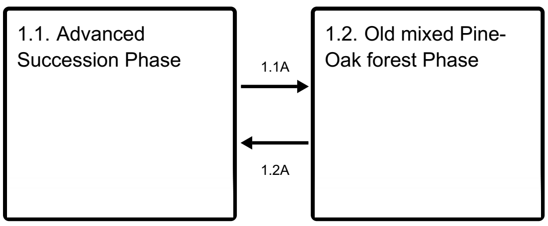
T2B - Removal of natural vegetation, plowing, fertilizing, irrigating, planting agricultural crops.

R3A - Removing livestock from stands.

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

R4A - Cessation of agricultural crop cultivation, replanting trees.

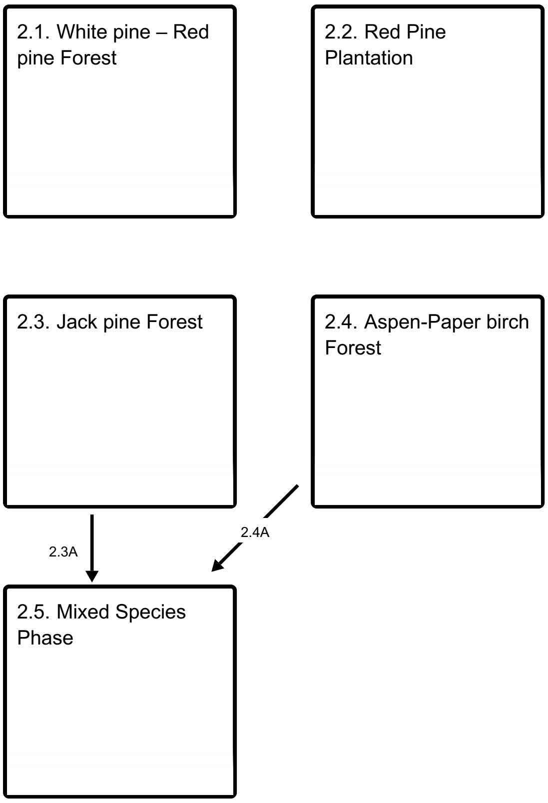
State 1 submodel, plant communities



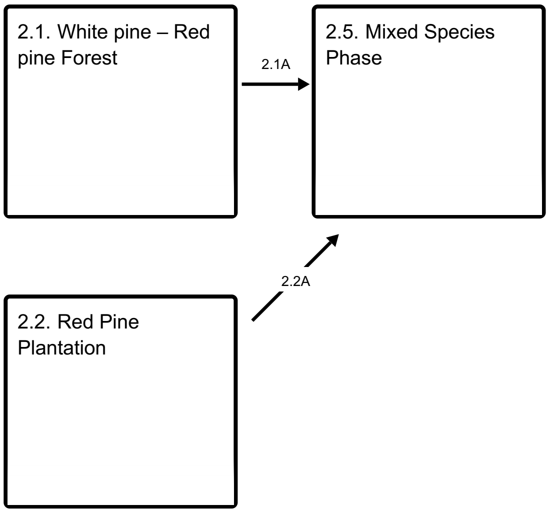
1.1A - Light to moderate intensity fires, reducing, or eliminating fire sensitive species such as red maple, balsam fir, and white spruce.

1.2A - Time, natural succession.

State 2 submodel, plant communities



Communities 1, 5 and 2 (additional pathways)



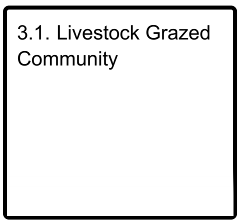
2.1A - White pine regeneration in mixed stand of white, red, and sometimes Jack pine.

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

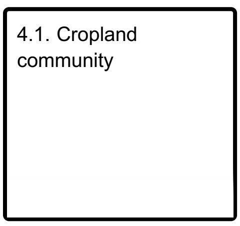
2.3A - White pine seeding in from natural seed source, or under-planted.

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

State 3 submodel, plant communities



State 4 submodel, plant communities



State 1
Reference State

In the long-term absence of stand replacing disturbance, the tree species composition of forest communities on this ecological site fluctuates among a relatively large number of species such as white pine (*Pinus strobus*), red pine (P. Resinosa), Jack pine (*P. banksiana*), red oak (*Quercus rubra*), red maple (*Acer rubrum*), balsam for (*Abies balsamea*) and white spruce (Picea alba). This fluctuation is the result of a range of common, but less severe, disturbances, natural mortality and species differences in regeneration requirements and tolerance of understory conditions. While 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.

Community 1.1
Advanced Succession Phase

White pine, with varying admixtures of red pine and red oak, constitutes the dominant over-story. The sub-canopy is a mixture of balsam fir, white spruce and red maple. The shrub layer typically is well-developed and is dominated by beaked hazel, *Corylus cornuta*. Other important species are juneberry, Amalenchier spp., blueberries, Vaccinium angustifolum, blackberries/raspberries, Rubus spp.. Herbaceous layer typically is dominated by high cover of bracken fern (*Pteridium aquilinum*) and large-leaf aster (Aster macrophyllus). Other well represented species include wintergreen (*Gaultheria procumbens*), wild lily of-the valley (*Maianthemum canadense*) and starflower (*Trientalis borealis*).

Community 1.2
Old mixed Pine-Oak forest Phase

A mixture of mature and over-mature white and red pine and red oak, containing sporadic seedlings and saplings of white pine and red oak sprouts. Successful reproduction of red pine is rare. The shrub and herb layers are same as described in Community Phase 1.1.

Pathway 1.1A
Community 1.1 to 1.2

Periodic moderate intensity fires, eliminating or reducing balsam fir and white spruce, but leaving at least the oldest and fire-resistant white and red pine trees.

Pathway 1.2A
Community 1.2 to 1.1

Slow encroachment of balsam fir and white spruce into stands, as part of common succession process on these sites.

State 2
Early to Mid-Successional State

Intermediate disturbance or large scale disturbance can lead to this early to mid-successional forest state, The tree species composition of forest communities in this state is dependent on disturbance type and seed source available. This state represents a continuum from a pioneer type community of aspen-paper birch to Jack pine forest to mixed white and red pine forests. Red pine plantations are also common on this ecological site. Eventually this state will progress to a mixed species forest that will mature toward the reference state. The major difference will be remnants of the aspen or paper birch that might have dominated earlier and a younger age of the later dominant overstory pines, red oak, and red maple.

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.

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, together with balsam fir and white spruce, becomes common. Herbaceous layer also increases, often dramatically, with bracken fern (*Pteridium aquilinum*) and large-leaf aster (Aster macrophyllus) attaining strong dominance.

Community 2.3
Jack pine Forest

Unless planted, this community develops only if fire was included in the destruction of preceding community and 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.

Community 2.4
Aspen-Paper birch Forest

Like the naturally developed jack pine forest, the aspen-paper birch forest community 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 that that in conifer stands.

Community 2.5
Mixed Species Phase

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-paper birch. This cohort is in the process of being replaced by more shade tolerant white pine and red maple. Red oak is also frequent associate. In absence of major disturbance this community phase transitions into Reference State Community.

Pathway 2.1A
Community 2.1 to 2.5

Invasion of pioneer, or early successional communities by white pine where seed source is present.

Pathway 2.2A
Community 2.2 to 2.5

Invasion of pioneer, or early successional communities by white pine where seed source is present.

Pathway 2.3A
Community 2.3 to 2.5

Invasion of pioneer, or early successional communities by white pine where seed source is present.

Pathway 2.4A
Community 2.4 to 2.5

Aspen-Paper birch Forest

Mixed Species Phase

Invasion of pioneer, or early successional communities by white pine where seed source is present.

State 3
Livestock Grazed State

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.

Community 3.1
Livestock Grazed Community

Open forest with few trees or grassland state due to cattle grazing. In this phase most tree regeneration is sparse if any due to livestock browsing and grazing. With time this phase tends toward grassland or a savannah type of vegetation.

State 4
Agriculture state

Production of agricultural crops, most often potatoes, corn or hay.

Community 4.1
Cropland community

Agricultural phase that consists of row crops, such as potatoes, corn, or hay.

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. Natural succession by shade-tolerant species e.g.: red maple, balsam fir, white spruce and white pine.

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 and/or irrigation.

Restoration pathway R3A
State 3 to 2

Removal of livestock, natural succession.

Transition T3A
State 3 to 4

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

Restoration pathway R4A
State 4 to 2

Cessation of agricultural practices, natural conversion to forest communities, or planting.

Additional community tables

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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	05/12/2025
Approved by	Chris Tecklenburg
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:**

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

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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:**