USDA Natural Resources Conservation Service

Ecological site F093AY003MN
Acid Peatland

Last updated: 9/06/2024
Accessed: 11/23/2024

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): 093A–Superior and Rainy Stony and Rocky Till Plains and Moraines

The Superior Stony and Rocky Loamy Plains and Hills, Western Part is located and completely contained in northeastern Minnesota. This area has both the highest and lowest elevations in the state, as well as some of the state's most rugged topography (Ojakangas and Matsch, 1982). The MLRA was glaciated by numerous advances of the Superior, Rainy, and Des Moines glacial lobes during the Wisconsin glaciation as well as pre-Wisconsin glacial periods. The geomorphic surfaces in this MLRA are geologically very young (i.e., 10,000 to 20,000 years) and dominated by drumlin fields, moraines, small lake plains, outwash plains, and bedrock-controlled uplands (USDA-NRCS, 2022).

There are thousands of lakes scattered throughout the region that were created by these glacial events. Most of these lakes are bedrock-controlled in comparison to adjacent glaciated regions where glacial drift deposits are much thicker and the lakes occur in depressions atop the glacial drift (Ojakangas and Matsch, 1982). In contrast to adjacent MLRAs, the depth to the predominantly crystalline or sandstone bedrock in MLRA 93A is relatively shallow because the most recent glacial events were more erosional than depositional (Ojakangas and Matsch, 1982).

Classification relationships

Major Land Resource Area (MLRA): Superior Stony and Rocky Loamy Plains and Hills, Western Part (93A)

USFS Subregions: Northern Superior Uplands Section (212L); North Shore Highlands Subsection (212Lb)

Relationship to Other Established Classifications:
Minnesota Department of Natural Resources (MN DNR) APn80-Northern Spruce Bog, Acid Peatland System, Northern Floristic Region
MN DNR APn81-Northern Poor Conifer Bog, Acid Peatland System, Northern Floristic Region
MN DNR APn91-Northern Poor Fen, Acid Peatland System, Northern Floristic Region
MN DNR APn90 - Northern Open Bog, Acid Peatland System, Northern Floristic Region

NatureServe
Association: Picea mariana - (Larix laricina) / *Ledum groenlandicum* / Sphagnum spp. Swamp Forest, NatureServe Element Code, CEGL005271

Ecological site concept

The ecological site concept is a conifer-dominated acidic peatland with a sparse canopy, depauperate understory, and sphagnum hummocks. Surface water is acidic and low in minerals. Water table fluctuations are more variable than poor fens, but less variable than in forested bogs. (MN DNR, 2005).

Associated sites

F093AY001MN	**Flooded Peatland** Flooded Peatland. Typically occurs at the margin of stream and river channels. pH is greater than 5.5 at 20 inch soil depth.

Similar sites

F093AY004MN	**Peatland** Peatland. This site characterized by a shrub-graminoid plant community. The site is potentially ponded. Does not typically occurs at the margin of stream and river channels.

Table 1. Dominant plant species

Tree	(1) *Picea mariana* (2) *Larix laricina*
Shrub	(1) *Ledum groenlandicum* (2) *Chamaedaphne calyculata*
Herbaceous	(1) *Eriophorum vaginatum* (2) *Sphagnum*

Physiographic features

This site is formed in bogs, depressions on outwash plains, lake plains, moraines, and till plains. The site does not flood, and ponding varies from none to occasional.

Table 2. Representative physiographic features

Landforms	(1) Outwash plain (2) Lake plain (3) Moraine (4) Till plain (5) Bog (6) Depression
Runoff class	Negligible to very low
Flooding frequency	None
Ponding frequency	None to occasional
Elevation	274–549 m
Slope	0–1%
Water table depth	0–15 cm
Aspect	Aspect is not a significant factor

Climatic features

The average annual precipitation is 26-32 inches (66 to 81 centimeters). Measurable climatic variation (due to the lake effect) near some of Lake Superior may alter temperature and precipitation (Hillman & Nielsen, 2023). About 65 percent of the precipitation falls as rain during the growing season (May through September) and about 21 percent falls as snow. The freeze-free period averages about 130 days and ranges from 97 to 150 days (USDA-NRCS, 2022).

Table 3. Representative climatic features

Frost-free period (characteristic range)	90-109 days
Freeze-free period (characteristic range)	123-143 days
Precipitation total (characteristic range)	660-813 mm

Frost-free period (actual range)	44-114 days
Freeze-free period (actual range)	97-150 days
Precipitation total (actual range)	660-813 mm
Frost-free period (average)	93 days
Freeze-free period (average)	130 days
Precipitation total (average)	737 mm

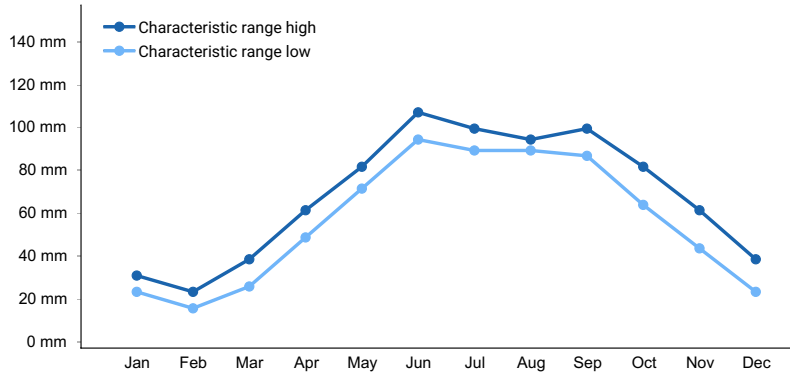


Figure 1. Monthly precipitation range

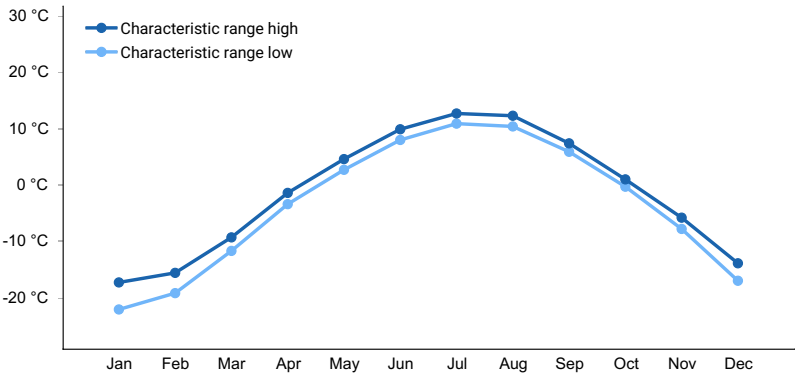


Figure 2. Monthly minimum temperature range

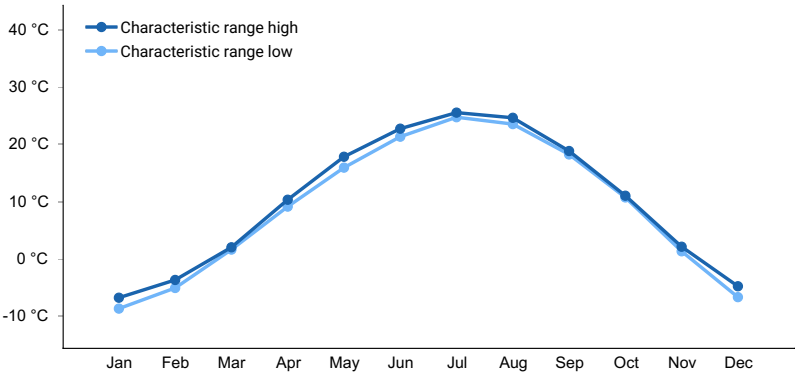


Figure 3. Monthly maximum temperature range

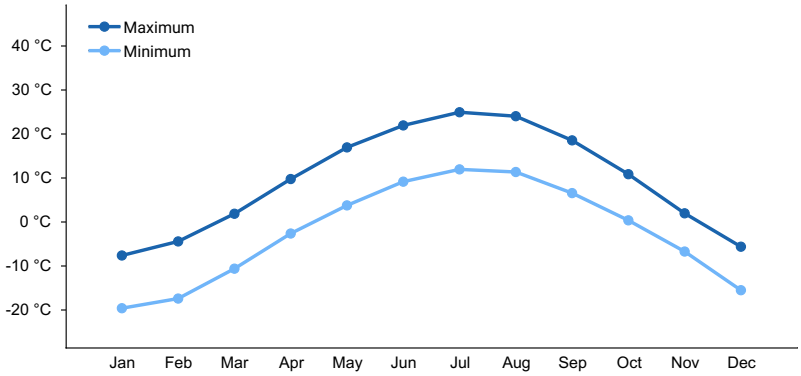


Figure 4. Monthly average minimum and maximum temperature

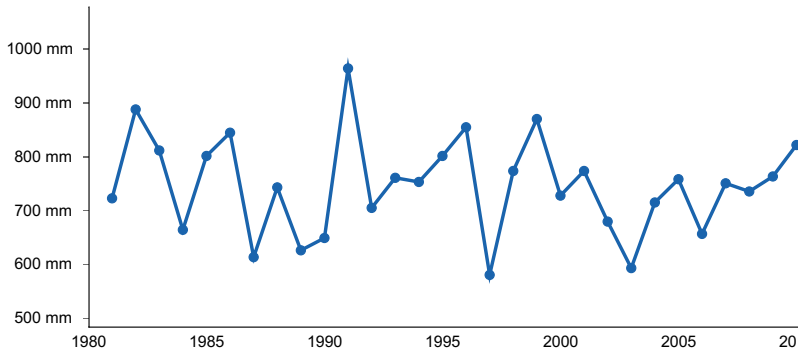


Figure 5. Annual precipitation pattern

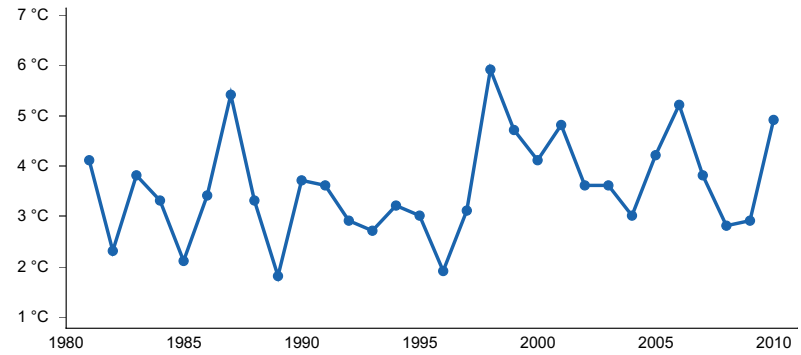


Figure 6. Annual average temperature pattern

Climate stations used

- (1) GRAND PORTAGE [USC00213296], Grand Portage, MN
- (2) WOLF RIDGE ELC [USC00219134], Finland, MN
- (3) DULUTH [USW00014913], Duluth, MN
- (4) ELY 25E [USC00212555], Ely, MN
- (5) KETTLE FALLS [USC00214306], Voyageurs Natl Park, MN
- (6) BRIMSON 2S [USC00210989], Brimson, MN
- (7) KABETOGAMA [USC00214191], Orr, MN

Influencing water features

This site is characterized by mucky peat or peat soils having a wet layer levels range from 0 - 6 inches (0 to 15 centimeters). Water is received through precipitation, runoff from adjacent uplands, and groundwater. Water exits the site through evapotranspiration, groundwater recharge, and less often, stream outflow. Groundwater movement brings in acidic water which has been exposed to acidic parent materials.

Wetland description

Under the Cowardin System of Wetland Classification, or National Wetlands Inventory (NWI), the wetlands can be classified as:
1) Palustrine, forested, needle-leaved evergreen, saturated, or
2) Palustrine, scrub-shrub, broad-leaved deciduous, saturated, or
3) Palustrine, scrub-shrub, broad-leaved evergreen, saturated, or
4) Palustrine, emergent, persistent, saturated

Under the Hydrogeomorphic Classification System (HGM), this site can be classified as:
1) Depressional, acidic, forested/organic, or
2) Depressional, acidic, scrub-shrub/organic

Hydrologic Group: A/D, B/D, C/D
Hydrogeomorphic Wetland Classification: Depressional acidic forested/organic; Depressional acidic scrub-shrub/organic

Cowardin Wetland Classification: PFO4B, PSS4B, PSS3B, PEM1B

Soil features

Soils are very deep, very poorly drained, and typic haplohemists, terric haplohemists, or hemic sphagnofibrists. Parent material is fibric and/or herbaceous organic material. Soils series include Greenwood, Lobo, and Merwin. A 3.5-5.5 pH at 20 or more inches differentiates acid peatlands from other peatland sites.

Table 4. Representative soil features

Parent material	(1) Organic material (2) Herbaceous organic material (3) Mossy organic material
Surface texture	(1) Mucky peat (2) Peat
Drainage class	Very poorly drained
Permeability class	Rapid to very rapid
Depth to restrictive layer	203 cm
Soil depth	203 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-152.4cm)	50.8–60.96 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (Depth not specified)	0 mmhos/cm
Sodium adsorption ratio (Depth not specified)	0
Soil reaction (1:1 water) (0-101.6cm)	3.5–5.5
Subsurface fragment volume <=3" (Depth not specified)	0–18%
Subsurface fragment volume >3" (Depth not specified)	0–5%

Ecological dynamics

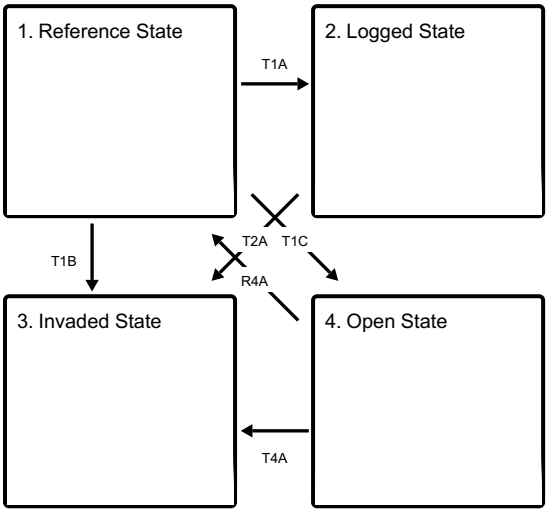
This site often occurs in peat-filled basins or depressions where surface water inputs are limited. The pH of the

surface water is acidic (<6.0) and low in minerals. Water table fluctuations are greater on this site than in poor fens, but less variable than in forested bogs (MN DNR, 2005). This site develops in peatlands where the peat surface is separated from the mineral rich groundwater. This separation is caused by peat buildup and sphagnum and results in lower pH levels.

Large-scale disturbances, such as catastrophic fires, occurred infrequently on this site. Public Land Survey records indicate that a canopy replacement event occurred every 500-1,000 years. Small-scale surface fires, localized windthrow, and seasonal drought are more common disturbance events.

State and transition model

Ecosystem states



T1A - Logging, seeding.

T1B - Impoundment or maintenance of water on-site, and/or establishment of invasive species.

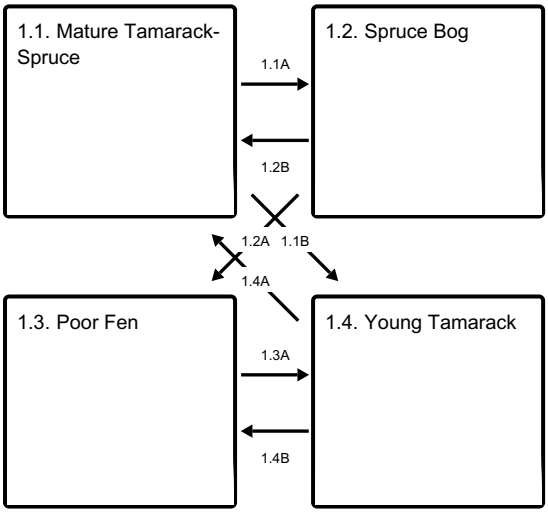
T1C - Beaver activity, roads, drainage, and other alterations in hydrology.

T2A - Non-native plant species on site

R4A - Hydrological management

T4A - Non-native species on site

State 1 submodel, plant communities



1.1A - Lack of fire, accumulation of peat, lowering of pH<5.0

1.1B - Surface fires or windthrow

1.2B - Neutralization of acids on-site raising of pH

1.2A - Frequent subsurface fires (3-5 yrs) or higher than average precipitation

1.3A - Time, accumulation of peat

1.4A - Time, accumulation of peat, acidification, establishment and growth of older trees.

State 2 submodel, plant communities

2.1. Logged Community

State 3 submodel, plant communities

3.1. Invaded Community

State 4 submodel, plant communities

4.1. Open Bog Community

State 1
Reference State

Moss cover is very indicative for this site, driving the successional dynamics and species diversity. Sphagnum sp. absorb dissolved mineral cations, and release organic acids, which lowers the pH of stagnant surface water below 5.0 (MN DNR 2003). Sphagnum tends to form carpets of hummocks, which creates an acidic environment cut off from groundwater and on-site ponding. In recently developed bogs, on sites mostly in the western range of the MLRA where soils are less continuously saturated, on sites where water table fluctuations are less variable, or on inclusions of sites where there are upwellings of groundwater, isolated minerotrophic species (i.e. creeping sedge or bluejoint) may be present. Other ground cover includes fine-leaved graminoids, and minimal presence of forbs. Occasionally, seedlings of deciduous tree species associated with adjacent sites (i.e. red maple or paper birch) may become established on Sphagnum hummocks but typically do not survive to become saplings or trees (MN DNR 2003). The overstory usually consists of scattered, stunted (<30ft [10m] tall) black spruce or tamarack (<50% cover) where Sphagum hummocks provide relief from surface flooding (MN DNR Forestry). Most vascular plants associated with Acid Peatlands have a strong association with mycorrhizal fungi, depending on them to obtain minerals and nutrients in this depauperate and harsh environment (MN DNR 2003). These fungi are more diverse on this ecological site than on other sites throughout the region.

Dominant plant species

- black spruce (*Picea mariana*), tree
- tamarack (*Larix laricina*), tree
- bog birch (*Betula pumila*), shrub
- speckled alder (*Alnus incana ssp. rugosa*), shrub
- bog Labrador tea (*Ledum groenlandicum*), shrub
- threeseeded sedge (*Carex trisperma var. trisperma*), grass
- threeleaf false lily of the valley (*Maianthemum trifolium*), other herbaceous
- sphagnum (*Sphagnum*), other herbaceous

Community 1.1
Mature Tamarack-Spruce

This site has a canopy of mature black spruce and/or tamarack. In cases where tamarack is monotypic, it is usually due to a lack of seed source for black spruce, or mortality of black spruce caused by species-specific insects or disease (MN DNR Forestry). Sphagnum dominates the moss layer. The forb layer is often sparse and includes three-leaved false lily of the valley (*Maianthemum trifolium*), stemless lady slipper (*Cypripedium acaule*), and Indian pipe (*Monotropa uniflora*). Both a tall shrub and low shrub layer may occur, but are sparser than less acid peatlands. In cases where tree growth exceeds 50% canopy cover, more shade-tolerant species can be present in the understory, including creeping snowberry (*Gaultheria hispidula*), soft-leaved sedge (*Carex disperma*) , ferns (Dryopteris spp.), clubmosses (*Lycopodium annotinum*), and bunchberry (*Cornus canadensis*) (MN DNR 2003).

Dominant plant species

- black spruce (*Picea mariana*), tree
- tamarack (*Larix laricina*), tree
- bog birch (*Betula pumila*), shrub
- speckled alder (*Alnus incana ssp. rugosa*), shrub
- bog Labrador tea (*Ledum groenlandicum*), shrub
- leatherleaf (*Chamaedaphne calyculata*), shrub
- threeseeded sedge (*Carex trisperma*), grass
- threeleaf false lily of the valley (*Maianthemum trifolium*), other herbaceous

Community 1.2
Spruce Bog

This state is characterized by a canopy dominated by black spruce, although some scattered tamarack may still remain in the overstory. Tree height is generally ranges from 15 - 35 feet (4.5 - 10.5 meters). Graminoid and forb species are usually similar to Community 1.1. Sphagnum has increased and forms large carpets with larger hummocks.

Dominant plant species

- black spruce (*Picea mariana*), tree
- blueberry (*Vaccinium*), shrub
- sedge (*Carex*), grass
- sphagnum (*Sphagnum*), other herbaceous

Community 1.3
Poor Fen

This community is characterized by a plant community dominated by sedges or low ericaceous shrubs. An elevated water table inhibits tree dominance. The shrub layer is variable in density and includes broad-leaved evergreens such as bog laurel, leatherleaf, bog rosemary and bog Labrador tea. Moss and liverwort cover is almost always near 100% and composed of Sphagnum species. Oligotrophic Sphagnum species dominant.

Dominant plant species

- leatherleaf (*Chamaedaphne calyculata*), shrub
- bog birch (*Betula pumila*), shrub
- woollyfruit sedge (*Carex lasiocarpa*), grass
- fewseed sedge (*Carex oligosperma*), grass
- sphagnum (*Sphagnum*), other herbaceous
- (*Cladopodiella fluitans*), other herbaceous
- polytrichum moss (*Polytrichum strictum*), other herbaceous
- aulacomnium moss (*Aulacomnium palustre*), other herbaceous

Community 1.4
Young Tamarack

This community is dominated by tamarack saplings and young trees and can be present post-logging or large scale disturbance.

Dominant plant species

- tamarack (*Larix laricina*), tree
- bog willow (*Salix pedicellaris*), shrub
- speckled alder (*Alnus incana ssp. rugosa*), shrub
- creeping snowberry (*Gaultheria hispidula*), shrub
- velvetleaf huckleberry (*Vaccinium myrtilloides*), shrub
- lowbush blueberry (*Vaccinium angustifolium*), shrub
- threeseeded sedge (*Carex trisperma*), grass
- tussock cottongrass (*Eriophorum vaginatum*), grass
- sphagnum (*Sphagnum*), other herbaceous
- moccasin flower (*Cypripedium acaule*), other herbaceous

Pathway 1.1A
Community 1.1 to 1.2

Lack of fire, accumulation of peat, lowering of pH<5.0

Pathway 1.1B
Community 1.1 to 1.4

Surface fires or windthrow

Pathway 1.2B
Community 1.2 to 1.1

Neutralization of acids on-site raising of pH

Context dependence. Alterations in hydrology which result in the alkalization of bogs, or fire disturbances that can result in mineral inputs from outside sources that offset depletion of cations (especially Ca++) by Sphagnum sp, (even groundwater inputs of <5% of the total water budget relative to precipitation) can revert the process of peat accumulation and acidification, and result in a community type with more minerotrophic

Pathway 1.2A
Community 1.2 to 1.3

Frequent subsurface fires (3-5 yrs) or higher than average precipitation

Context dependence. Pockets of poor fen vegetation can develop in a spruce bog where alkalization of the bog occurs on the lower flanks of the crest, where the water source can receive nutrients from surface runoff, or where the runoff is channeled into drains or water tracks. The transition of the entire site to poor fen can occur on a broader scale when catastrophic fires release nutrients and burn peat, reducing tree cover, reducing evapotranspiration and increasing water-logged conditions, resulting in even minimal groundwater and nutrient inputs to the site. Severe, catastrophic fires can result in conversion of the peatland to an open bog community dominated by fewseed sedge

Pathway 1.3A
Community 1.3 to 1.4

Time, accumulation of peat

Context dependence. This pathway usually occurs naturally with enough time for peat to accumulate and elevate the growing surface out of water-logged conditions, so that tree growth and recruitment can be more successful.

Pathway 1.4A
Community 1.4 to 1.1

Time, accumulation of peat, acidification, establishment and growth of older trees.

Pathway 1.4B
Community 1.4 to 1.3

Severe catastrophic fire or windthrow

State 2
Logged State

This state describes the removal of tamarack and black spruce through logging. The natural plant community has been severely disturbed and the site has been impacted by heavy equipment. Compositional changes in canopy cover and soil/water disturbances impact all layers of the plant community. Best management practices can help reduce site damage and the implementation of post-logging timber stand improvement practices can enhance tree regeneration.

Dominant plant species

- bog birch (*Betula pumila*), shrub
- sedge (*Carex*), grass
- cottongrass (*Eriophorum*), grass
- sphagnum (*Sphagnum*), other herbaceous

Community 2.1
Logged Community

This state describes the removal of tamarack and black spruce. With the disturbance of the site by heavy equipment. Canopy cover has been removed and shrub density will increase. Species composition will vary depending on the type, timing, and severity of disturbance.

Dominant plant species

- bog birch (*Betula pumila*), shrub
- sedge (*Carex*), grass
- cottongrass (*Eriophorum*), grass
- sphagnum (*Sphagnum*), other herbaceous

State 3
Invaded State

In this state, invasive species such as Typha sp. or reed canary grass (*Phalaris arundinacea*) are present. Water ponding for a longer than normal duration results in canopy mortality of tamarack and spruce trees and opening of the understory to light. Alder and willow shrubs often remain on edge zones. Site disturbance such as logging often allows for the introduction of non-native vegetation on these sites.

Dominant plant species

- hybrid cattail (*Typha ×glauca*), grass
- reed canarygrass (*Phalaris arundinacea*), grass
- sedge (*Carex*), grass

Community 3.1
Invaded Community

This community is characterized by the presence of invasive plant species. In some areas, ponding has resulted in canopy mortality of tamarack and spruce trees which allows for additional ground level sunlight. Alder and willow shrubs often remain on edge zones. Site disturbance, such as logging, can introduce a variety of non-native species.

Dominant plant species

- hybrid cattail (*Typha ×glauca*), grass
- reed canarygrass (*Phalaris arundinacea*), grass
- sedge (*Carex*), grass

State 4
Open State

This state is characterized by sphagnum-dominated acidic peatlands with variable microtopography that includes hummocks, deep hollows, and areas of sphagnum "carpets". This state will exhibit variability in plant community composition due to these variations in microtopography.

Dominant plant species

- leatherleaf (*Chamaedaphne calyculata*), shrub
- bog laurel (*Kalmia polifolia*), shrub
- bog Labrador tea (*Ledum groenlandicum*), shrub
- sedge (*Carex*), grass
- sphagnum (*Sphagnum*), other herbaceous

Community 4.1
Open Bog Community

Tamarack and black spruce trees are often present but sparse and stunted. Shrub cover is variable depending on the microtopography and may include bog laurel (*Kalmia polifolia*), leatherleaf (*Chamaedaphne calyculata*) and bog Labrador tea (*Ledum groenlandicum*). Moss cover in may be near 100% in some areas. Sedges are common.

Dominant plant species

- leatherleaf (*Chamaedaphne calyculata*), shrub
- bog laurel (*Kalmia polifolia*), shrub
- bog Labrador tea (*Ledum groenlandicum*), shrub
- sedge (*Carex*), grass

Transition T1A
State 1 to 2

This transition involves logging, usually clearcutting, but with reserves for seed sources, site preparation, control for disease and invasive species, and seeding, in order to maintain the site as a viable commercial timber harvesting state. This transition is only possible, or desirable, when the management is applied to phases in which radial growth has been prolific and trees have reached maturity, exhibiting taller, more commercially viable trees.

Transition T1B
State 1 to 3

Impoundment or maintenance of water on-site, and/or establishment of invasive species. Beaver activity, roads, drainage, and other alterations in hydrology can transition the Acid Peatlands out of Reference to an Impounded State, where water is ponded on site for longer durations and receives excessive nutrients from overland surface flow.

Transition T1C
State 1 to 4

Impoundment or maintenance of water on-site. Beaver activity, roads, drainage, and other alterations in hydrology can transition the Acid Peatlands out of Reference to an Open State, where water is on site for longer durations and receives excessive nutrients from overland surface flow causing stunted tree growth.

Transition T2A
State 2 to 3

Introduction and establishment of non-native invasive species.

Restoration pathway R4A
State 4 to 1

Draining or maintenance of water on-site causing alterations in hydrology that can transition the Open state back to the Reference State, where water is on site for shorter durations and receives less nutrients from overland surface flow causing increased tree growth.

Transition T4A
State 4 to 3

Introduction and establishment of non-native invasive species.

Additional community tables

Inventory data references

No field plots were established for this project. A review of the scientific literature was used to approximate the plant communities for this ecological site. Information for the state-and-transition model was obtained from the same sources. All community phases are considered provisional. Future field verification will refine the plant communities described in this project.

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Approval

Suzanne Mayne-Kinney, 9/06/2024

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	09/06/2024
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:**

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7. **Amount of litter movement (describe size and distance expected to travel):**

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):**

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):**

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):**

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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:**
