

Ecological site F231XY169AK Boreal Woodland Peat Frozen Flats

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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): 231X–Interior Alaska Highlands

The Interior Alaska Uplands (MLRA 231X) is in the Interior Region of Alaska and includes the extensive hills, mountains, and valleys between the Tanana River to the south and the Brooks Range to the north. These hills and mountains surround the Yukon Flats Lowlands (MLRA 232X). MLRA 231X makes up about 69,175 square miles. The hills and mountains of the area tend to be moderately steep to steep resulting in high-relief slopes. The mountains are generally rounded at lower elevations and sharp-ridged at higher elevations. Elevation ranges from about 400 feet in the west, along the boundary with the Interior Alaska Lowlands (MLRA 229X), to 6,583 feet at the summit of Mt. Harper, in the southeast. Major tributaries include large sections of the Yukon, Koyukuk, Kanuti, Charley, Coleen, and Chatanika Rivers. This area is traversed by several major roads, including the Taylor Highway in the east and the Steese, Elliott, and Dalton Highways north of Fairbanks. The area is mostly undeveloped wild land that is sparsely populated. The largest community along the road system is Fairbanks with smaller communities like Alatna, Allakaket, Chicken, Eagle, Eagle Village, Hughes, and Rampart occurring along the previously mentioned rivers and highways.

The vast majority of this MLRA was unglaciated during the Pleistocene epoch with the exceptions being the highest mountains and where glaciers extended into the area from the Brooks Range. For the most part, glacial moraines and drift are limited to the upper elevations of the highest mountains. Most of the landscape is mantled with bedrock colluvium originating from the underlying bedrock. Valley bottoms are filled with Holocene fluvial deposits and colluvium from the adjacent mountain slopes. Silty loess, which originated from unvegetated flood plains in and adjacent to this area, covers much of the surface. On hill and mountain slopes proximal to major river valleys (e.g., Tanana and Yukon Rivers), the loess is many feet thick. As elevation and distance from major river valleys increases, loess thickness decreases significantly. Bedrock is commonly exposed on the highest ridges.

This area is in the zone of discontinuous permafrost. Permafrost commonly is close to the surface in areas of the finer textured sediments throughout the MLRA. Isolated masses of ground ice occur in thick deposits of loess on terraces and the lower side slopes of hills. Solifluction lobes, frost boils, and circles and stripes are periglacial features common on mountain slopes in this area. Pingos, thermokarst pits and mounds, ice-wedge polygons, and earth hummocks are periglacial features common on terraces, lower slopes of hills and mountains, and in upland valleys in the area.

The dominant soil orders in this area are Gelisols, Inceptisols, Spodosols, and Entisols. The soils in the area have a subgelic or cryic soil temperature regime, an aquic or udic soil moisture regime, and mixed mineralogy. Gelisols are common on north facing slopes, south facing footslopes, valley bottoms, and stream terraces. Gelisols are typically shallow or moderately deep to permafrost (10 to 40 inches) and are poorly or very poorly drained. Wildfires can disturb the insulating organic material at the surface, lowering the permafrost layer, eliminating perched water tables from Gelisols, and thus changing the soil classification. Inceptisols and Spodosols commonly form on south facing hill and mountain slopes. Entisols are common on flood plains and high elevation mountain slopes. Miscellaneous (non-soil) areas make up about 2 percent of this MLRA. The most common miscellaneous areas are rock outcrop and rubble land. In many valleys placer mine tailings are common.

Short, warm summers and long, cold winters characterize the subarctic continental climate of the area. The mean annual temperature of the area ranges from 22 to 27 degrees F. The mean annual temperature of the southern half of the area is approximately 3 degrees warmer compared to the northern half (PRISM 2018). The warmest months span June through August with mean monthly temperatures ranging from 50 to 56 degrees F. The coldest months span November through February with mean monthly temperatures ranging from -5 to 3 degrees F. When compared to the high-elevation alpine and subalpine life zones, the lower elevation boreal life zone tends to be 2-3 degrees F colder during the coldest months and 1-2 degrees F warmer during the warmest months (PRISM 2018). The freeze-free period at the lower elevations averages about 60 to 100 days, and the temperature usually remains above freezing from June through mid-September.

Precipitation is limited across this area, with the average annual precipitation ranging from 12 to 19 inches. The southern half of the areas receives approximately 2.5 inches more annual precipitation than the northern half (PRISM 2018). The lower elevation boreal life zone receives approximately 2.5 inches less annual precipitation than the high-elevation alpine and subalpine life zones (PRISM 2018). Approximately 3/5th of the annual precipitation occurs during the months of June through September with thunderstorms being common. The average annual snowfall ranges from about 45 to 100 inches. The ground is consistently covered with snow from November through March.

Most of this area is forested below an elevation of about 2500 feet. Dominant tree species on slopes are white spruce and black spruce. Black spruce stands are most common on north-facing slopes, stream terraces, and other sites with poor drainage and permafrost. White spruce stands are most common on warm slopes with dry soils. At lower elevations, lightning-caused wildfires are common, often burning many thousands of acres during a single fire. Following wildfires, forbs, grasses, willow, ericaceous shrubs, paper birch, and quacking aspen communities are common until they are eventually replaced by stands of spruce. Tall willow and alder scrub is extensive on low flood plains. White spruce and balsam poplar are common on high flood plains.

With increasing elevation, the forests and woodlands give way to subalpine communities dominated by krummholz spruce, shrub birch, willow, and ericaceous shrubs. At even higher elevations, alpine communities prevail which are characterized by diverse forbs, dwarf ericaceous shrubs, and eightpetal mountain-avens. Many of these high elevation communities have a considerable amount of lichen cover and bare ground.

LRU notes

This area supports three life zones defined by the physiological limits of plant communities along an elevational gradient: boreal, subalpine, and alpine. The boreal life zone is the elevational band where forest communities dominate. Not all areas in the boreal life zone are forest communities, however, particularly in places with too wet or dry soil to support tree growth (e.g., bogs or river bluffs). Above the boreal band of elevation, subalpine and alpine vegetation dominate. The subalpine zone is typically a narrow transitional band between the boreal and the alpine life zones, and is characterized by sparse, stunted trees. In the subalpine, certain types of birch and willow shrub species grow at ≥ 1 m in height (commonly *Betula glandulosa* and *Salix pulchra*). In the alpine, trees no longer occur, and all shrubs are dwarf or lay prostrate on the ground. In this area, the boreal life zone occurs below 2500 feet elevation on average. The transition between boreal and alpine vegetation can occur within a range of elevations, and is highly dependent on slope, aspect, and shading from adjacent mountains.

Within each life zone, there are plant assemblages that are typically associated with cold slopes and warm slopes. Cold slopes and warm slopes are created by the combination of the steepness of the slope, the aspect, and shading from surrounding ridges and mountains. Warm slope positions typically occur on southeast to west facing slopes that are moderate to very steep ($>10\%$ slope) and are not shaded by the surrounding landscape. Cold slopes typically occur on northwest to east facing slopes, occur in shaded slope positions, or occur in low-lying areas that are cold air sinks. Examples of shaded positions include head slopes, low relief backslopes of hills, and the base of hills and mountains shaded by adjacent mountain peaks. Warm boreal slope soils have a cryic soil temperature regime and lack permafrost. In this area, white spruce forests are an indicator of warm boreal slopes. Cold boreal slope soils typically have a gelic soil temperature regime and commonly have permafrost. In this area, black spruce forests and woodlands are an indicator of cold boreal slopes. The boreal life zone can occur at higher elevations on warm slopes, and lower elevations on cold slopes.

Classification relationships

Landfire BPS – 7416211 – Western North American Boreal Black Spruce Dwarf-tree Peatland – Boreal Complex (Landfire 2009)

Ecological site concept

This boreal site occurs on stream terraces and loess plains with wet, peaty and frozen soils that are prone to thermokarst. Thermokarst is common which results from the thawing of ice rich permafrost, subsequent setting of ground, and formation of thermokarst depressions. This site is occasionally associated with peat plateaus. Because of the unique associated soil and site properties, thermokarst depressions, palsa, and peat plateau result in alternate states. Reference state soils pond frequently, have a high-water table throughout the growing season, and are considered very poorly drained. These soils have permafrost at shallow to moderately deep depths. Mineral soil horizons have minimal to no rock fragments and are commonly cryoturbated. A typical soil profile is a very thick layer of organic material over a thick layer of silty parent material.

The thermokarst and peat plateau states have unique soil and site properties resulting in different kinds and amounts of vegetation. The thermokarst state has soils that lack permafrost and have a water table at or above the soil surface for the entire growing season. Thermokarst vegetation is commonly characterized as open low scrub (Vioreck et al. 1992) with common species including leatherleaf, bog rosemary, water sedge, and Sphagnum. A peat plateau is a generally flat-topped expanse of peat, elevated above the general surface of a peatland (Schoeneberger and Wysocki 2017). Peat plateaus have much drier soils that do not pond. Peat plateau are believed to have more productive black spruce stands with larger amounts of lichen cover.

Fire has highly variable impacts to the soils associated with this site. This site has a thick organic mat that insulates its cold soils, which is a key factor in maintaining the depth and presence of permafrost. Fire can significantly reduce the thickness of that organic mat, which can in turn increase soil temperature. These increases in soil temperature can thaw frozen soils and result in thermokarst. Field data in areas without thermokarst show that fire has negligible impacts to the depth and presence of permafrost. Field data in areas with thermokarst show a complete loss of permafrost within the soil profile (0-60 inches).

Multiple plant communities occur within the reference state and the vegetation in each community differs in large part due to fire. When the reference state vegetation burns, the post-fire plant community is dominantly ericaceous shrubs, graminoids, and mosses. With time and lack of another fire event, the post-fire vegetation goes through multiple stages of succession. For this site, the reference plant community is the most stable with the longest time since the vegetation was burned. This community is typically characterized as dwarf tree scrub woodland (Vioreck et al. 1992) with black spruce the dominant tree. For this ecological site to progress from the earliest stages of post-fire succession to the oldest stages of succession, data suggest that 70-100 years or more must elapse without another fire event (Johnstone et al. 2010a).

The reference plant community understory commonly has marsh Labrador tea, bog rosemary, dwarf birch, bog blueberry, lingonberry, leatherleaf, tussock cottongrass, Bigelow's sedge, cloudberry, various Sphagnum, various reindeer lichen, and curled snow lichen. Tree cover primarily occurs in the stunted tree stratum (greater than 50 years of age and less than 15 feet). The understory vegetative strata that characterize this community are low shrubs (between 8 and 36 inches), mosses, and lichens.

Associated sites

F231XY118AK	Boreal Woodland Organic Frozen Slopes Occurs upslope of site 169, on valley sides, toeslopes, and footslopes.
F231XY131AK	Boreal Forest Gravelly Floodplain Occurs on flood plains with productive white spruce forests.
R231XY137AK	Boreal Sedge Peat Depressions Occurs on abandoned channels of stream terraces commonly with sedge meadows.
F231XY171AK	Boreal Woodland Loamy Frozen Terraces Occurs on adjacent stream terraces often closer to the active stream channel.

F231XY193AK	Boreal Woodland Loamy Frozen Drainageways Occurs adjacent to site 169 in drainageways with black spruce woodlands.
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Similar sites

F231XY118AK	Boreal Woodland Organic Frozen Slopes Both sites have similar soils, vegetation, and are prone to thermokarst. Site 169 occurs on flat landforms like valley bottoms and stream terraces, while site 118 occurs on toeslopes and footslopes of hills and low-elevation mountains.
F231XY171AK	Boreal Woodland Loamy Frozen Terraces Both sites have similar vegetation and occur on stream terraces. Site 171 generally occurs closer to the active flood plain and has comparatively thinner organic horizons. Site 169 is more prone to thermokarst.

Table 1. Dominant plant species

Tree	(1) <i>Picea mariana</i>
Shrub	(1) <i>Ledum palustre ssp. decumbens</i> (2) <i>Ledum palustre ssp. decumbens</i>
Herbaceous	(1) <i>Sphagnum</i> (2) <i>Cladina</i>

Physiographic features

This boreal site occurs on nearly level surfaces and/or depressions of stream terraces and loess plains. On occasion, this site is associated with thermokarst depressions and peat plateau. Slope is negligible and occurs on all aspects. This site is associated with the boreal life zone which typically occurs below 2500 feet in this area. On rare occasion, elevation can range up to 2950 feet.

This site no longer floods. Reference state and thermokarst state soils ponds frequently for long to very long periods of time and a water table occurs at very shallow depth throughout the growing season. Peat plateau soils do not pond and have a water table at deep depths during the growing season. This site generates limited runoff to adjacent ecological sites.

Table 2. Representative physiographic features

Geomorphic position, flats	(1) Talf (2) Dip
Geomorphic position, terraces	(1) Tread
Landforms	(1) Stream terrace (2) Plain (3) Depression (4) Thermokarst depression (5) Peat plateau
Runoff class	Negligible to low
Flooding frequency	None
Ponding duration	Long (7 to 30 days) to very long (more than 30 days)
Ponding frequency	Frequent
Elevation	67–762 m
Slope	0–3%
Ponding depth	0–15 cm
Water table depth	0–25 cm
Aspect	W, NW, N, NE, E, SE, S, SW

Table 3. Representative physiographic features (actual ranges)

Runoff class	Not specified
Flooding frequency	Not specified
Ponding duration	Very long (more than 30 days)
Ponding frequency	None to frequent
Elevation	61–899 m
Slope	0–10%
Ponding depth	30 cm
Water table depth	0–102 cm

Climatic features

Short, warm summers and long, cold winters characterize the subarctic continental climate associated with this boreal site. The mean annual temperature of the site ranges from 22 to 27 degrees F. The warmest months span June through August with mean normal maximum monthly temperatures ranging from 60 to 66 degrees F. The coldest months span November through February with mean normal minimum temperatures ranging from -3 to -12 degrees F. The freeze-free period for the site ranges from 80 to 120 days, and the temperature usually remains above freezing from late May through mid-September.

The area receives minimal annual precipitation with the summer months being the wettest. Average annual precipitation across the area typically ranges between 12 to 18 inches. Approximately 3/5th of the annual precipitation occurs during the months of June through September with thunderstorms common. The average annual snowfall ranges from about 45 to 100 inches. The ground is consistently covered with snow from November through March.

Table 4. Representative climatic features

Frost-free period (characteristic range)	16-78 days
Freeze-free period (characteristic range)	76-114 days
Precipitation total (characteristic range)	305-457 mm
Frost-free period (actual range)	4-87 days
Freeze-free period (actual range)	48-120 days
Precipitation total (actual range)	229-508 mm
Frost-free period (average)	53 days
Freeze-free period (average)	90 days
Precipitation total (average)	381 mm

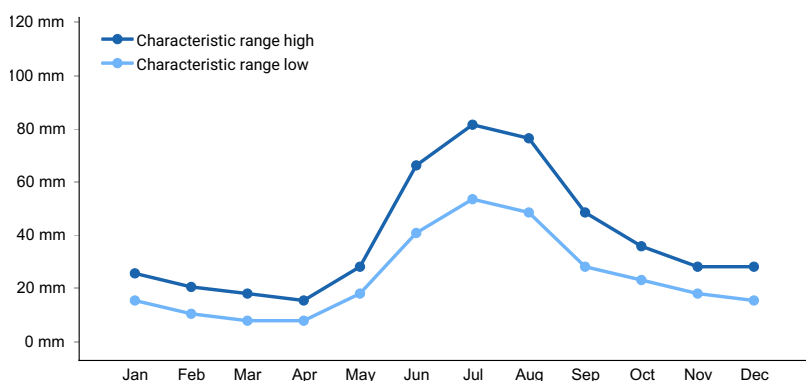


Figure 1. Monthly precipitation range

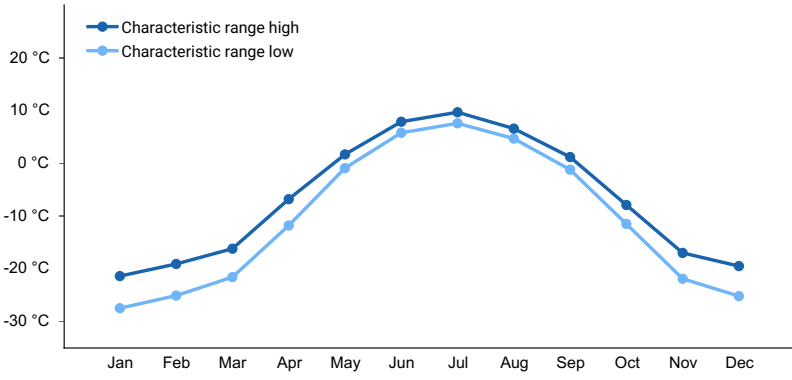


Figure 2. Monthly minimum temperature range

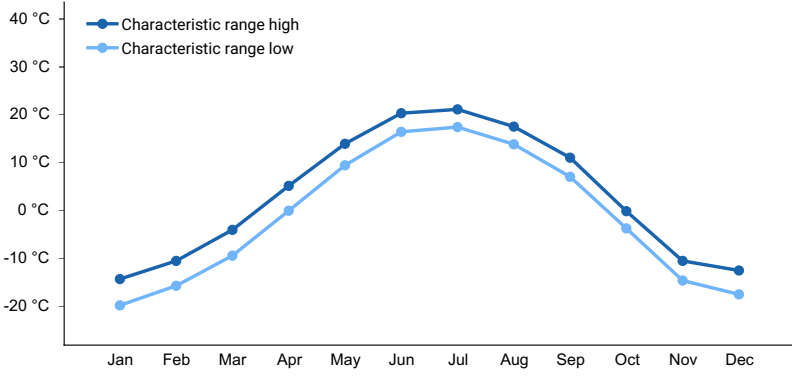


Figure 3. Monthly maximum temperature range

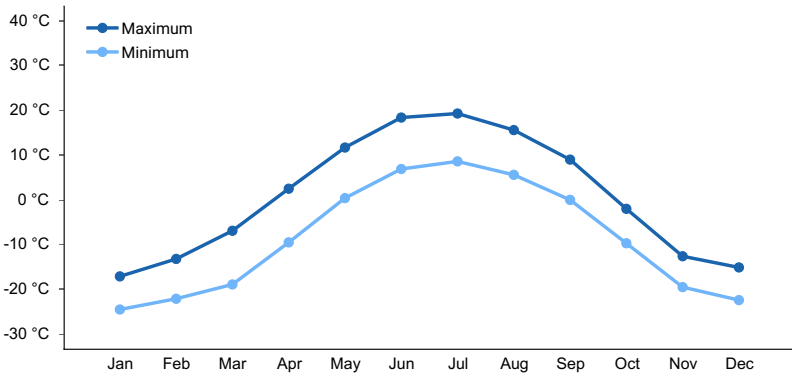


Figure 4. Monthly average minimum and maximum temperature

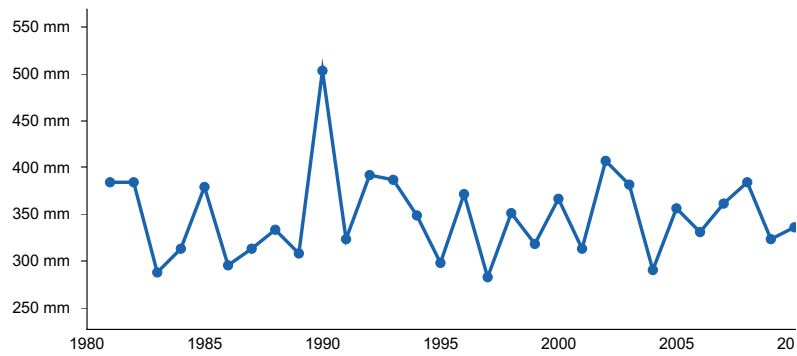


Figure 5. Annual precipitation pattern

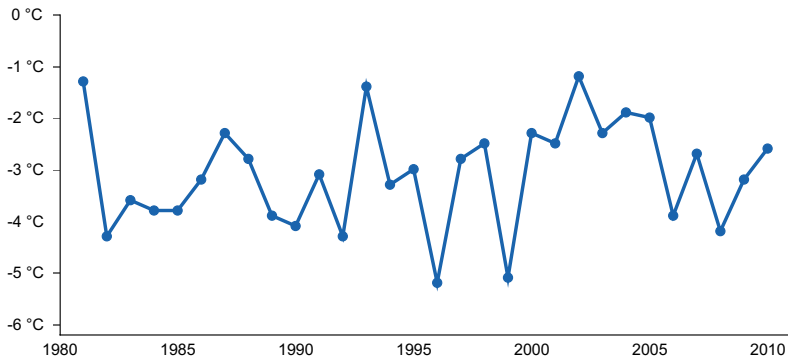


Figure 6. Annual average temperature pattern

Climate stations used

- (1) EAGLE AP [USW00026422], Tok, AK
- (2) CHICKEN [USC00501684], Tok, AK
- (3) MILE 42 STEESE [USC00505880], Fairbanks, AK
- (4) BETTLES AP [USW00026533], Bettles Field, AK
- (5) CIRCLE HOT SPRINGS [USC00501987], Central, AK
- (6) FT KNOX MINE [USC00503160], Fairbanks, AK
- (7) GILMORE CREEK [USC00503275], Fairbanks, AK
- (8) FOX 2SE [USC00503181], Fairbanks, AK
- (9) ESTER DOME [USC00502868], Fairbanks, AK
- (10) ESTER 5NE [USC00502871], Fairbanks, AK
- (11) COLLEGE 5 NW [USC00502112], Fairbanks, AK
- (12) COLLEGE OBSY [USC00502107], Fairbanks, AK
- (13) KEYSTONE RIDGE [USC00504621], Fairbanks, AK

Influencing water features

This site is classified as an organic soil flats wetland under the Hydrogeomorphic (HGM) classification system (Smith et al. 1995; USDA-NRCS 2008). Precipitation is the main source of water (Smith et al. 1995).

Depth to the water table may decrease following summer storm events or spring snowmelt and increase during extended dry periods.

Wetland description

n/a

Soil features

Soils formed in organic material, windblown silts, and silty alluvium and commonly have permafrost at shallow to moderate depth. Rock fragments do not occur on the soil surface. These are peaty soils commonly capped with 15 to 25 inches of saturated organic material. The mineral soil below the organic material is most commonly silt loam derived from alluvium that is often capped with wind-blown loess, which generally lacks rock fragments and has high water holding capacity. All soils are very deep but reference state and peat plateau state soils are commonly cryoturbated and have permafrost at shallow to moderate depths (16 to 25 inches). Thermokarst state soils have no permafrost. The pH of the soil profile typically ranges from very strongly acidic to slightly acidic. The reference state and thermokarst state soils are wet for long portions of the growing season and are considered very poorly drained. The peat plateau soils are dry for much of the growing season and are considered well drained.



Figure 7. A typical soil profile associated with the reference state of this site.

Table 5. Representative soil features

Parent material	(1) Organic material (2) Eolian deposits (3) Loess (4) Alluvium
Surface texture	(1) Peat
Drainage class	Very poorly drained
Permeability class	Moderately rapid to very rapid
Depth to restrictive layer	41–64 cm
Soil depth	152 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	21.34–42.93 cm
Calcium carbonate equivalent (25.4-101.6cm)	0%
Clay content (0-50.8cm)	0%
Electrical conductivity (25.4-101.6cm)	0–3 mmhos/cm
Sodium adsorption ratio (25.4-101.6cm)	0
Soil reaction (1:1 water) (25.4-101.6cm)	4.5–6.5
Subsurface fragment volume <=3" (0-152.4cm)	0%
Subsurface fragment volume >3" (0-152.4cm)	0%

Table 6. Representative soil features (actual values)

Drainage class	Very poorly drained to well drained
Permeability class	Very slow to very rapid
Depth to restrictive layer	41 cm

Soil depth	Not specified
Surface fragment cover <=3"	Not specified
Surface fragment cover >3"	Not specified
Available water capacity (0-101.6cm)	5.08–42.93 cm
Calcium carbonate equivalent (25.4-101.6cm)	Not specified
Clay content (0-50.8cm)	0–5%
Electrical conductivity (25.4-101.6cm)	Not specified
Sodium adsorption ratio (25.4-101.6cm)	Not specified
Soil reaction (1:1 water) (25.4-101.6cm)	3–7.4
Subsurface fragment volume <=3" (0-152.4cm)	0–5%
Subsurface fragment volume >3" (0-152.4cm)	0–5%

Ecological dynamics

Fire

In the Interior Alaska Uplands area, fire is a common and natural event that has a significant control on the vegetation dynamics across the landscape. A typical fire event in the lands associated with this ecological site will reset plant succession and alter dynamic soil properties (e.g., soil organic matter and depth of permafrost). For this ecological site to progress from the earliest stages of post-fire succession to the oldest stages of succession, data suggest that 70-100 years or more must elapse without another fire event (Johnstone et al. 2010a).

Within this area, fire is considered a natural and common event that typically is unmanaged. Fire suppression is limited, and generally occurs adjacent to Fairbanks and the various villages spread throughout the area or on allotments with known structures, all of which have a relatively limited acre footprint. Most fires are caused by lightning strikes. From 2000 to 2020, 596 known fire events occurred in the Interior Alaska Uplands area and the burn perimeter of the fires totaled about 13.8 million acres (AICC 2022). Fire-related disturbances are highly patchy and can leave undisturbed areas within the burn perimeter. During this time frame, 80% of the fire events were smaller than 20,000 acres but 18 fire events were greater than 200,000 acres in size (AICC 2022). These burn perimeters cover approximately 30% of the Interior Alaska Uplands area.

The fire regime within Interior Alaska follows two general scenarios—low-severity burns and high-severity burns. It should be noted, however, that the fire regime in Interior Alaska is generally thought to be much more complex (Johnstone et al. 2008). Burn severity refers to the proportion of the vegetative canopy and organic material consumed in a fire event (Chapin et al. 2006). Fires in cool and moist habitat tend to result in low-severity burns, while fires in warm and dry habitat tend to result in high-severity burns. Because the soils have a thick organic cap and are very poorly to poorly drained, the typical fire scenario for this ecological site is considered to result in a low-severity burn.

Reference State Soil and Vegetation Dynamics

The low-severity fire regime associated with this site has modest impacts to soil organic matter thickness, depth of permafrost, and soil drainage. While a low-severity fire can consume the bulk of above ground vegetation, minimal proportions of the organic mat are typically removed. Organic matter continues to insulate these cold soils. Field data support that each plant community has permafrost and that the associated low-severity fire event had a negligible impact on the depth of permafrost. If permafrost remains at similar depths after a fire event, then soil

drainage is unlikely to improve post-fire.

In areas prone to low-severity fire events, the pre-fire vegetative community generally reestablishes quickly and there is minimal long-term alteration to community composition (Johnstone et al. 2010; Bernhardt et al. 2011). When minimal proportions of the organic mat are consumed, many species regenerate asexually using below ground root systems and rhizomes. Species known to regenerate after low-severity fire events include various graminoids (e.g., *Carex* spp. and *Eriophorum* spp.), forbs (e.g., *Equisetum* sp.), and shrubs (e.g., *Ledum groenlandicum*, *Vaccinium uliginosum*, *Salix* sp.) (Johnstone et al. 2010). Black spruce is the Interior Alaska tree species best adapted to a low-severity fire regime. Black spruce have semi-serotinous cones and a low-severity fire often results in a flush of black spruce seedlings at the burned location.

The later stages of succession have an overstory that is a mix of broadleaf and immature needleleaf trees (community 1.2) or mature needleleaf trees (community 1.1). The recruitment of trees species during the early stages of post-fire succession largely controls the composition of the stand of trees in the later stages of post-fire succession (Johnstone et al. 2010a). During these later stages of succession, the slower growing black spruce seedlings mature and eventually replace the shade-intolerant broadleaf tree species. The typical fire return interval for black spruce stands in the boreal forest is 70-130 years (Johnstone et al. 2010a).

Lands associated with this site may be burning more frequently than in the past, which may result in alternative pathways of succession. The historic fire return interval for black spruce stands in Interior Alaska occurs approximately once per century. Due to global climate change, stands of spruce in certain portions of the Alaskan boreal forest are burning more frequently than these historic averages (Kelly et al. 2013). Increases to burn frequency favors forested stands dominated by quick growing deciduous trees. A major reason being that increased fire frequency decreases the presence and abundance of mature, cone-bearing trees. Less mature trees result in less spruce seedlings post-fire and an overall decreased abundance of spruce in the developing forest canopy. Increased burn frequency in the boreal forest may result in alternative pathways of post-fire succession with stands of deciduous trees persisting for longer than normal durations of time (Johnstone et al. 2010b).

Field Observations of Reference State Soils

Field data indicate the low severity fires associated with this site have minimal impacts to soil organic matter, depth to permafrost, and drainage. From 2009 to 2013, two field observations were collected in areas that burned 5 to 8 years before sampling occurred (AICC 2022) and resemble the earliest stage of fire-related succession for this ecological site (community 1.3). When comparing soils between the more recently burned plots and plots not recently burned, there were negligible differences in soil mean organic matter thickness (24 inches [burned] vs. 21 inches [not burned]) and mean depth of permafrost (21 inches vs. 22 inches). Since this site is associated with a perched water table and permafrost remained at similar depths, soil drainage is not likely improved in recently burned plots. From these data and for this site, it appears that low-severity fire events typically have minimal impacts to the soil organic matter thickness, depth of permafrost, and soil drainage. For this site, additional plots and environmental co-variate data will help clarify the variability in fire severity (e.g., timing of fire, soil organic matter moisture content, and pre-fire vegetation) and its effects to soil organic thickness, depth to permafrost, and drainage.

Thermokarst State

Thermokarst occurs due to the thaw of ice-rich permafrost in soil after disturbances such as fire events or land clearing. For this site, thermokarst depressions are common landforms associated with this site on stream terraces and loess plains. From 2008 to 2015, seven field observation were collected in areas that had undergone various degrees of thermokarst. When compared to reference state soils, all four observations had comparatively wetter soils that pond for longer durations of time. Five of these observations no longer had permafrost in the soil profile (0-60 inches).

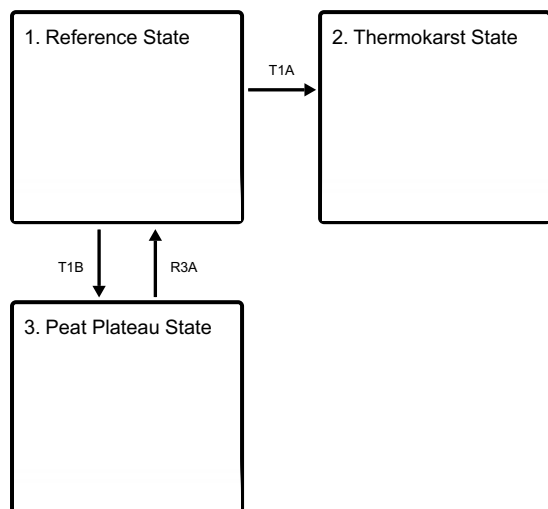
Peat Plateau and Palsa State

Palsa and peat plateau develop from the soils associated with the reference state (personnel observations of NRCS staff). A palsa is a much smaller landform feature compared to a peat plateau. A palsa is an elliptical dome-like permafrost mound containing alternating layers of ice lenses and peat or mineral soil, commonly 10-30 feet in height and 6 to 80 feet long (Schoeneberger and Wysocki 2017). A peat plateau is a generally flat-topped expanse

of peat, elevated above the general surface of a peatland, and containing segregated ice that may or may not extend downward into the underlying mineral soil (Schoeneberger and Wysocki 2017). These landforms can raise significantly above the water table and their peaty soils can become well drained. If these landforms raise high enough above the water table, soil temperature increases, ice-lens melt, and these landforms collapse.

State and transition model

Ecosystem states

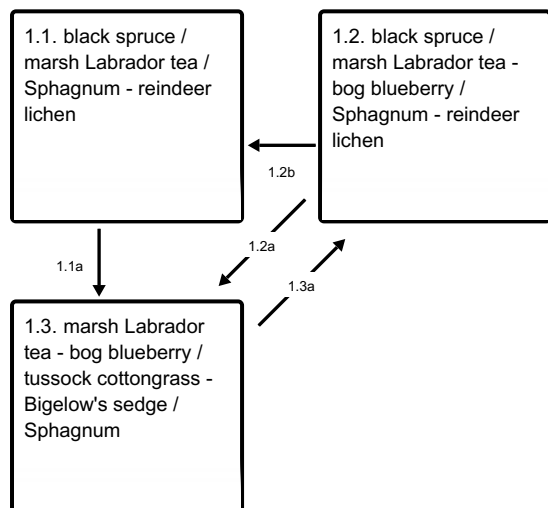


T1A - Disturbance leads to the thermal erosion of ground ice and the subsidence of soil resulting in formation of thermokarst depressions.

T1B - Thick lens of ice form in the soil and lift the bog above the surrounding area forming a peat plateau.

R3A - Collapse of peat plateau.

State 1 submodel, plant communities



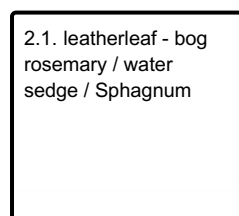
1.1a - A low-severity fire sweeps through and incinerates much of the above ground vegetation.

1.2b - Time without fire.

1.2a - A low-severity fire sweeps through and incinerates much of the above ground vegetation.

1.3a - Time without fire.

State 2 submodel, plant communities



State 3 submodel, plant communities

3.1. Black spruce /
marsh Labrador tea /
curled snow lichen -
reindeer lichen

State 1 Reference State

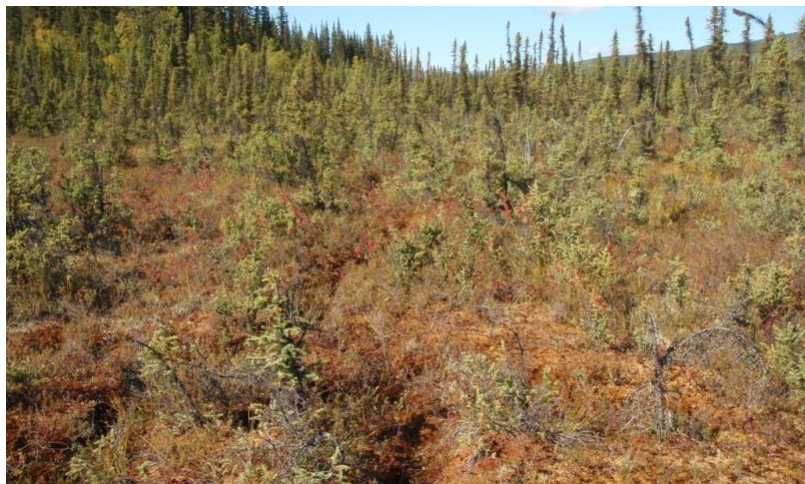


Figure 8. Stunted black spruce woodland on a stream terrace in the area.

The reference plant community is dwarf tree scrub woodland (Vioreck et al. 1992) with the dominant tree being black spruce. There are three plant communities within the reference state related to fire.

Dominant plant species

- black spruce (*Picea mariana*), tree
- marsh Labrador tea (*Ledum palustre ssp. decumbens*), shrub
- sphagnum (*Sphagnum*), other herbaceous
- reindeer lichen (*Cladina*), other herbaceous

Community 1.1

black spruce / marsh Labrador tea / Sphagnum - reindeer lichen



Figure 9. A typical plant community associated with community 1.1.

The reference plant community is characterized as dwarf tree scrub woodland (Vioreck et al. 1992) with black spruce as the dominant tree. Black spruce tree cover primarily occurs in the stunted tree stratum (greater than 50 years of age and less than 15 feet). Live deciduous trees, primarily resin birch, occasionally occur in the tree canopy. The soil surface is primarily covered with herbaceous litter, moss, and lichen. Common understory species

include marsh Labrador tea, bog rosemary, dwarf birch, bog blueberry, lingonberry, leatherleaf, tussock cottongrass, Bigelow's sedge, cloudberry, various Sphagnum, various reindeer lichen, and curled snow lichen (*Flavocetraria cucullata*). The understory vegetative strata that characterize this community are low shrubs (between 8 and 36 inches), mosses, and lichens.

Forest overstory. Cover from seedlings and saplings (tree regeneration) were not included in the overstory canopy cover values but are included in the cover percent values for individual tree species.

Forest understory. Sphagnum was typically identified to genus. Sphagnum angustifolium, S. fuscum, S. magellanicum, and S. warnstorffii were species occasionally identified in plots.

Dominant plant species

- black spruce (*Picea mariana*), tree
- resin birch (*Betula neoalaskana*), tree
- marsh Labrador tea (*Ledum palustre* ssp. *decumbens*), shrub
- bog rosemary (*Andromeda polifolia*), shrub
- dwarf birch (*Betula nana*), shrub
- bog blueberry (*Vaccinium uliginosum*), shrub
- lingonberry (*Vaccinium vitis-idaea*), shrub
- leatherleaf (*Chamaedaphne calyculata*), shrub
- tussock cottongrass (*Eriophorum vaginatum*), grass
- Bigelow's sedge (*Carex bigelowii*), grass
- cloudberry (*Rubus chamaemorus*), other herbaceous
- sphagnum (*Sphagnum*), other herbaceous
- reindeer lichen (*Cladina*), other herbaceous

Community 1.2

black spruce / marsh Labrador tea - bog blueberry / Sphagnum - reindeer lichen



Figure 10. A typical plant community associated with community 1.2.

Community 1.2. is in the late stage of fire-induced secondary succession for this ecological site. It is characterized as dwarf tree scrub woodland (Vioreck et al. 1992). Black spruce seedlings are abundant and tree cover primarily occurs in regenerative tree stratum. The soil surface is primarily covered with mosses, lichen, and herbaceous litter. Common understory species include marsh Labrador tea, crowberry, lingonberry, bog blueberry, red fruit bearberry, dwarf birch, tussock cottongrass, Bigelow's sedge, cloudberry, various Sphagnum, and various reindeer lichen. The understory vegetative strata that characterize this community are tree regeneration, low shrubs (between 8 and 36 inches), dwarf shrubs (less than 8 inches), mosses, and foliose and fruticose lichens.

Dominant plant species

- black spruce (*Picea mariana*), tree
- resin birch (*Betula neoalaskana*), tree
- marsh Labrador tea (*Ledum palustre* ssp. *decumbens*), shrub
- black crowberry (*Empetrum nigrum*), shrub

- lingonberry (*Vaccinium vitis-idaea*), shrub
- bog blueberry (*Vaccinium uliginosum*), shrub
- red fruit bearberry (*Arctostaphylos rubra*), shrub
- dwarf birch (*Betula nana*), shrub
- small cranberry (*Vaccinium oxycoccos*), shrub
- bog rosemary (*Andromeda polifolia*), shrub
- tussock cottongrass (*Eriophorum vaginatum*), grass
- Bigelow's sedge (*Carex bigelowii*), grass
- cloudberry (*Rubus chamaemorus*), other herbaceous
- sphagnum (*Sphagnum*), other herbaceous
- reindeer lichen (*Cladina*), other herbaceous

Community 1.3

marsh Labrador tea - bog blueberry / tussock cottongrass - Bigelow's sedge / Sphagnum



Figure 11. A typical plant community associated with community 1.3.

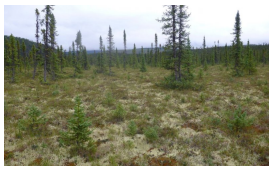
Community 1.3 is in the early stage of fire-induced secondary succession for this ecological site. This community is characterized as open low scrub (Vioreck et al. 1992). Seedlings of black spruce are common but have limited cover. Common species include bog blueberry, dwarf birch, bog rosemary, marsh Labrador tea, red fruit bearberry, lingonberry, Bigelow's sedge, various sedges, tussock cottongrass, and Sphagnum. The strata that characterize this community are low shrubs (between 8 and 36 inches), medium graminoids (between 4 and 24 inches), and mosses.

Dominant plant species

- bog blueberry (*Vaccinium uliginosum*), shrub
- dwarf birch (*Betula nana*), shrub
- bog rosemary (*Andromeda polifolia*), shrub
- marsh Labrador tea (*Ledum palustre ssp. decumbens*), shrub
- red fruit bearberry (*Arctostaphylos rubra*), shrub
- lingonberry (*Vaccinium vitis-idaea*), shrub
- Bigelow's sedge (*Carex bigelowii*), grass
- tussock cottongrass (*Eriophorum vaginatum*), grass
- mud sedge (*Carex limosa*), grass
- water sedge (*Carex aquatilis*), grass
- cloudberry (*Rubus chamaemorus*), other herbaceous
- sphagnum (*Sphagnum*), other herbaceous

Pathway 1.1a

Community 1.1 to 1.3



black spruce / marsh Labrador tea / Sphagnum - reindeer lichen

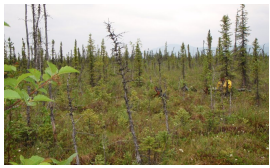


marsh Labrador tea - bog blueberry / tussock cottongrass - Bigelow's sedge / Sphagnum

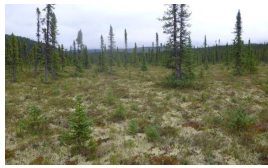
A fire sweeps through and incinerates much of the above ground vegetation. Because of the associated cold and wet soils, this site commonly experiences low-severity fires. Minimal proportions of the organic mat are typically removed. The pre-fire vegetation generally reestablishes quickly from below ground root systems and rhizomes.

Pathway 1.2b

Community 1.2 to 1.1



black spruce / marsh Labrador tea - bog blueberry / Sphagnum - reindeer lichen



black spruce / marsh Labrador tea / Sphagnum - reindeer lichen

Time without fire. Black spruce seedlings and saplings mature into a stunted woodland.

Pathway 1.2a

Community 1.2 to 1.3



black spruce / marsh Labrador tea - bog blueberry / Sphagnum - reindeer lichen



marsh Labrador tea - bog blueberry / tussock cottongrass - Bigelow's sedge / Sphagnum

A fire sweeps through and incinerates much of the above ground vegetation. Because of the associated cold and wet soils, this site commonly experiences low-severity fires. Minimal proportions of the organic mat are typically removed. The pre-fire vegetation generally reestablishes quickly from below ground root systems and rhizomes.

Pathway 1.3a

Community 1.3 to 1.2



marsh Labrador tea - bog blueberry / tussock cottongrass - Bigelow's sedge / Sphagnum



black spruce / marsh Labrador tea - bog blueberry / Sphagnum - reindeer lichen

Time without fire. Black spruce seedlings and sapling start to become a characteristic component of the plant community.

State 2

Thermokarst State



Figure 12. Vegetation in a thermokarst pit in the area.

Thermokarst occurs due to the thermal erosion of ice-rich permafrost in soil after disturbances such as fire events or land clearing. While thermokarst can be readily observed, details related to thermokarst succession are poorly understood. After an unknown timeframe, thermokarst depressions could theoretically revert back to plant communities associated with the reference state (Myers-Smith et al. 2008). However, the timeframe for recovery is likely outside the scope of typical land management priorities. At this time, restoration back to reference conditions is not considered within the state-and-transition model. The thermokarst plant community is open low scrub (Viereck et al. 1992). Associated soils pond and have a persistent high water table. The thermokarst state has one documented plant community. Future data collection efforts and research would likely enhance information about existing plant communities within this state and allow for better understanding of the potential transitions from one community or state to another.

Dominant plant species

- leatherleaf (*Chamaedaphne calyculata*), shrub
- bog rosemary (*Andromeda polifolia*), shrub
- water sedge (*Carex aquatilis*), grass
- sphagnum (*Sphagnum*), other herbaceous

Community 2.1

leatherleaf - bog rosemary / water sedge / Sphagnum



Figure 13. A typical plant community associated with community 2.1.

Community 2.1 develops after thermokarst for this ecological site. This community is characterized as open low scrub (Viereck et al. 1992). Seedlings of black spruce and white spruce occasionally occur and have limited cover. Common species include leatherleaf, bog rosemary, sweetgale, marsh Labrador tea, dwarf birch, tealeaf willow, small cranberry, bog blueberry, water sedge, purple marshlocks, and Sphagnum. The vegetative strata that characterize this community are low shrubs (between 8 and 36 inches), tall graminoids (greater than 2 feet), medium graminoids (between 4 and 24 inches), and mosses.

Dominant plant species

- leatherleaf (*Chamaedaphne calyculata*), shrub
- sweetgale (*Myrica gale*), shrub
- bog rosemary (*Andromeda polifolia*), shrub
- marsh Labrador tea (*Ledum palustre* ssp. *decumbens*), shrub
- dwarf birch (*Betula nana*), shrub
- tealeaf willow (*Salix pulchra*), shrub
- small cranberry (*Vaccinium oxycoccos*), shrub
- bog blueberry (*Vaccinium uliginosum*), shrub
- water sedge (*Carex aquatilis*), grass
- purple marshlocks (*Comarum palustre*), other herbaceous
- sphagnum (*Sphagnum*), other herbaceous

State 3

Peat Plateau State

Palsa and peat plateau develop from the soils associated with the reference state (personnel observations of NRCS staff). A palsa is a much smaller landform feature compared to a peat plateau. A palsa is an elliptical dome-like permafrost mound containing alternating layers of ice lenses and peat or mineral soil, commonly 10-30 feet in height and 6 to 80 feet long (Schoeneberger and Wysocki 2017). A peat plateau is a generally flat-topped expanse of peat, elevated above the general surface of a peatland, and containing segregated ice that may or may not

extend downward into the underlying mineral soil (Schoeneberger and Wysocki 2017). Palsa and peat plateau can raise significantly above the water table and their peaty soils can become well drained. If these landforms raise high enough above the water table, soil temperature increases and eventually ice-lens melt. Palsa (Pielou 1994) and peat plateau (personnel observations of NRCS staff) are both prone to collapse. After collapse, the soils are thought to revert back to reference state conditions. The alternate state community is dwarf tree scrub woodland (Viereck et al. 1992) with black spruce as the dominant tree. The plant community associated with this state has limited data (USDA NRCS 2016) and is provisional.

Dominant plant species

- black spruce (*Picea mariana*), tree
- marsh Labrador tea (*Ledum palustre* ssp. *decumbens*), shrub
- bog rosemary (*Andromeda polifolia*), shrub
- small cranberry (*Vaccinium oxycoccos*), shrub
- (*Flavocetraria cucullata*), other herbaceous
- reindeer lichen (*Cladina*), other herbaceous
- sphagnum (*Sphagnum*), other herbaceous

Community 3.1

Black spruce / marsh Labrador tea / curled snow lichen - reindeer lichen

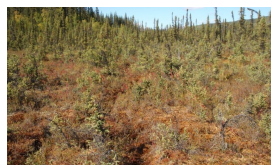
Community 3.1 develops after the formation of peat plateau for this ecological site. The reference plant community is characterized as dwarf tree scrub woodland (Viereck et al. 1992) with black spruce as the dominant tree. Black spruce tree cover primarily occurs in the stunted tree stratum (greater than 50 years of age and less than 15 feet). Common understory species include marsh Labrador tea, various Sphagnum, various reindeer lichen, and curled snow lichen.

Dominant plant species

- black spruce (*Picea mariana*), tree
- marsh Labrador tea (*Ledum palustre* ssp. *decumbens*), shrub
- sphagnum (*Sphagnum*), other herbaceous
- reindeer lichen (*Cladina*), other herbaceous
- (*Flavocetraria cucullata*), other herbaceous

Transition T1A

State 1 to 2



Reference State



Thermokarst State

Land clearing or fire can thaw permafrost and the thermal erosion of ground ice results in the settling of soil, which is thermokarst. Subsidence can be significant with collapsed pits going down and spanning across several feet.

Transition T1B

State 1 to 3

A peat plateau is a generally flat-topped expanse of peat, elevated above the general surface of a peatland, and containing segregated ice that may or may not extend downward into the underlying mineral soil (Schoeneberger and Wysocki 2017). These landforms can raise significantly above the water table and their peaty soils can become well drained.

Restoration pathway R3A

State 3 to 1

If these landforms raise high enough above the water table, soil temperature increases, ice-lens melt, and these landforms collapse.

Additional community tables

Table 7. Community 1.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
black spruce	PIMA	<i>Picea mariana</i>	Native	0.6–10.4	5–45	2.5–12.7	–
resin birch	BENE4	<i>Betula neoalaskana</i>	Native	–	0–1	–	–

Table 8. Community 1.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
Bigelow's sedge	CAB15	<i>Carex bigelowii</i>	Native	0.1–0.6	0–30
tussock cottongrass	ERVA4	<i>Eriophorum vaginatum</i>	Native	0.1–0.6	0–15
Forb/Herb					
cloudberry	RUCH	<i>Rubus chamaemorus</i>	Native	0–0.1	0.1–25
Labrador lousewort	PELA	<i>Pedicularis labradorica</i>	Native	0–0.1	0–3
Shrub/Subshrub					
marsh Labrador tea	LEPAD	<i>Ledum palustre ssp. decumbens</i>	Native	0.2–0.9	0–40
bog rosemary	ANPO	<i>Andromeda polifolia</i>	Native	0–0.1	0–30
bog blueberry	VAUL	<i>Vaccinium uliginosum</i>	Native	0.2–0.9	0–20
leatherleaf	CHCA2	<i>Chamaedaphne calyculata</i>	Native	0.2–0.9	0–20
black crowberry	EMNI	<i>Empetrum nigrum</i>	Native	0–0.1	0–15
lingonberry	VAVI	<i>Vaccinium vitis-idaea</i>	Native	0–0.1	0–15
dwarf birch	BENA	<i>Betula nana</i>	Native	0.2–0.9	0–15
small cranberry	VAOX	<i>Vaccinium oxycoccos</i>	Native	0–0.1	0.1–7
Nonvascular					
sphagnum	SPHAG2	<i>Sphagnum</i>	Native	0–0.1	15–95
	FLCU	<i>Flavocetraria cucullata</i>	Native	0–0.1	0–30
star reindeer lichen	CLST60	<i>Cladina stellaris</i>	Native	0–0.1	0–25
reindeer lichen	CLMI60	<i>Cladina mitis</i>	Native	0–0.1	0–18
reindeer lichen	CLST5	<i>Cladina stygia</i>	Native	0–0.1	0–17
cup lichen	CLADO3	<i>Cladonia</i>	Native	0–0.1	0–15
peppermint drop lichen	ICER	<i>Imadophila ericetorum</i>	Native	0–0.1	0–5

Table 9. Community 1.2 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
black spruce	PIMA	<i>Picea mariana</i>	Native	–	15–35	–	–

Table 10. Community 2.1 forest overstory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)	Diameter (Cm)	Basal Area (Square M/Hectare)
Tree							
black spruce	PIMA	<i>Picea mariana</i>	Native	–	0–4	–	–
white spruce	PIGL	<i>Picea glauca</i>	Native	–	0–2	–	–

Table 11. Community 2.1 forest understory composition

Common Name	Symbol	Scientific Name	Nativity	Height (M)	Canopy Cover (%)
Grass/grass-like (Graminoids)					
water sedge	CAAQ	<i>Carex aquatilis</i>	Native	0.6–1.2	8–65
Forb/Herb					
purple marshlocks	COPA28	<i>Comarum palustre</i>	Native	0.1–0.6	0–15
Shrub/Subshrub					
sweetgale	MYGA	<i>Myrica gale</i>	Native	0.2–0.9	0–60
marsh Labrador tea	LEPAD	<i>Ledum palustre ssp. decumbens</i>	Native	0.2–0.9	0–50
leatherleaf	CHCA2	<i>Chamaedaphne calyculata</i>	Native	0.2–0.9	0.1–25
bog rosemary	ANPO	<i>Andromeda polifolia</i>	Native	0–0.1	0–8
tealeaf willow	SAPU15	<i>Salix pulchra</i>	Native	0.9–1.5	0–8
small cranberry	VAOX	<i>Vaccinium oxycoccos</i>	Native	0–0.1	0–8
bog blueberry	VAUL	<i>Vaccinium uliginosum</i>	Native	0.2–0.9	0–6
dwarf birch	BENA	<i>Betula nana</i>	Native	0.2–0.9	0–3
Nonvascular					
sphagnum	SPHAG2	<i>Sphagnum</i>	Native	0–0.1	0–85

Animal community

n/a

Hydrological functions

n/a

Recreational uses

n/a

Wood products

n/a

Other products

n/a

Other information

n/a

Inventory data references

Tier 2 sampling plots used to develop the reference state. Plot numbers as recorded in NASIS with associated

community phase.

Community 1.1

08CS02903, 09NP02801, 09NP02802, 09NP02903, 09TC02603, 09TC03501, 09TC03504, 09TC03506, 09TC04401, 10NP03803, 10TC04704, 2015AK290508, 2015AK290516, 2015AK290518, 2015AK290904, 2016AK290406, 2016AK290410, 2016AK290416, 2016AK290417

Community1.2

08CS00301, 09NP02803, 10TC00502

Community 1.3

09TC01402, 13NR00805

Community 2.1

08CS02904, 08CS03402, 08TC03101, 09TC02602, 10NP03802, 10TC04701, 2015AK290984,

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Approval

Kirt Walstad, 2/13/2024

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	11/24/2024

Approved by	Kirt Walstad
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:**
-

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