16011

Western North American Boreal Tree-line White Spruce-Hardwood Woodland - Boreal

BpS Model/Description Version: Nov. 2024

|  |  |  |  |
| --- | --- | --- | --- |
| **Modelers** |  | **Reviewers** |  |
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| None | None | None | None |
| None | None | None | None |

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Vegetation Type

Forest and Woodland

Map Zones

67, 68, 69, 70, 71, 72, 73, 74, 76, 78

Model Splits or Lumps

This Biophysical Setting (BpS) is split into multiple models:

This BpS was split into Boreal and Boreal Transition variants so that regional differences in disturbance regimes could be modeled. The Hardwood split represent areas where hardwoods dominate. For mapping BpS 16011 should apply in level 2 ecoregions (Nowaki et al. 2001): Intermontane Boreal, Aleutian Meadows, Arctic Tundra, Bering Taiga, Bering Tundra.

Geographic Range

This BpS occurs commonly throughout the boreal region of Alaska, from the south slopes of the Brooks Range to the north slopes of the Alaska Range, west to the limit of tree growth, and near the northern and western limit of the boreal region. It extends to the limit of white spruce growth along the Alaska Peninsula, approximately coincident with the Bristol Bay Lowlands.

Biophysical Site Description

This system occurs near the elevational and latitudinal limits of white spruce tree growth. Topographies include sideslopes, rolling hills, and relatively level terrain. Soils are generally well-drained, cold, shallow, and develop on colluvial deposits, glacial till, or bedrock. High elevation sites are typically well-drained uplands with southerly aspects. At its elevational limits, the system can be conceptualized as the transition zone between boreal white spruce forest and subalpine deciduous shrub. Depending on the topography, the elevational expression of this system can occupy a narrow band just below non-forested subalpine or a broad expanse across gentle slopes and benches. This system also occurs at lower elevations at the western limit of white spruce growth where terrain is typically gentle, and permafrost is continuous.

Vegetation Description

The boreal treeline white spruce hardwood system has a short-statured canopy dominated by *Picea glauca* or co-dominated by *Picea mariana* and/or *Betula neoalaskana*. Tree cover is typically between 10 and 25%. Trees are often stunted on exposed sties (Jorgenson et al. 2003).

Dwarf ericaceous shrubs including *Empetrum nigrum, Vaccinium uliginosum,* and *Vaccinium vitis-idaea* are common and diagnostic. Other important species are *Betula nana, Betula glandulosa, Ledum palustre* ssp. *decumbens, Ledum groenlandicum, Salix pulchra, Viburnum edule, Rosa acicularis,* and *Arctostaphylos* spp. In some locations *Alnus viridis* ssp. *crispa* is the dominant understory shrub. Shrub Betula species are often matrix forming above or beyond coniferous treeline; *Betula glandulosa* dominates in the boreal with dominance transitioning to *Betula nana* in the sub-boreal region of southwest Alaska (Boucher et al. 2016).

A wide variety of herbaceous species may occur including *Calamagrostis canadensis, Pyrola* spp., and *Aconitum delphinifolium* (Viereck 1979, Jorgenson et al. 2003). Feathermosses may be common in the ground layer (NatureServe 2008). On drier or more exposed sites, *Cladina* spp. replace feathermosses as the dominant ground cover (Viereck 1979).

Lichens are often an important component of the understory. Lichen species may include *Cladina arbuscula*, *C. mitis, C. rangiferina*, and *C. stellaris*, as well as *Flavocetraria cucullata, Cetraria islandica, Cetraria nivalis, Bryoria* spp., *Alectoria nigricans,* and *Alectoria ochroleuca*.

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PIGL | *Picea glauca* | White spruce |
| PIMA | *Picea mariana* | Black spruce |
| BENA | *Betula nana* | Dwarf birch |
| BEGL | *Betula glandulosa* | Resin birch |
| VAUL | *Vaccinium uliginosum* | Bog blueberry |
| VAVI | *Vaccinium vitis-idaea* | Lingonberry |
| LEPAD | *Ledum palustre ssp. decumbens* | Marsh Labrador tea |
| EMNI | *Empetrum nigrum* | Black crowberry |
| BENE4 | *Betula neoalaskana* | Resin birch |

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

Disturbance Description

In 2014 an extensive search was done by Fire Effects Information System Staff to locate information for a synthesis on fire regimes of Alaskan white spruce communities (Abrahamson 2014). The synthesis reported mean fire-return intervals in boreal white spruce forests from about 40 to >250 years, but it is likely that fire was less frequent in treeline communities (Abrahamson 2014). As of 2014 there was no information on fire type, fire severity, fire intensity, fire pattern, or fire size in this BpS (Abrahamson 2014), however it is thought to be similar to that of lower elevation upland white spruce forests. Projections of future fire rotation periods for the boreal forest indicate that modeled climatic data of increased temperatures and reduced precipitation are likely to reduce the fire rotation periods throughout the fire-prone boreal forest (Young et al. 2017) and that high summer temperatures enhance connectivity of dry forest fuels, facilitating large fires and thus a high probability of fire occurrence across the landscape (Turner and Romme 1994).

Topographic roughness leads to lower probability of an area burning (Hammond et al. 2019, Young et al. 2017) so it is likely that those white spruce-hardwood stands at treeline in more mountainous terrain will have a longer fire return interval. In general, species dominance in the boreal forest post fire will shift along different trajectories according to variation in underlying landscape attributes (Johnstone and Chapin 2006, Kane et al. 2007, Johnstone et al. 2010, Roland et al. 2013). In the elevational version of this biophysical setting, steep slope and southern aspect are key landscape attributes that affect fire behavior and resulting plant community succession. For example, south-facing slopes are more productive (deep active layer) leading to mostly white spruce stands with mixed hardwoods at the treeline. North-facing slopes don’t receive the warmth needed for supporting treeline hardwood stands and commonly have permafrost. These communities are limited to the boreal region of the southern Brooks Range and south to southcentral Alaska, areas along treeline north of the Brooks Range do not have the white spruce component but are instead hardwoods (Balsam poplar).

A possible scenario for post-fire succession in this type is the resprouting of low shrubs from underground propagules followed by *Picea glauca* invading by seed from adjacent stands or surviving trees. *Betula neoalaskana* may invade the site if a seed source is available and site conditions are favorable. The typical succession sequence for this type does not include a hardwood sere. The rate of succession depends on severity of fire and seed source, and some sites may be shrub-dominated for long periods without spruce invasion.

Spruce bark beetle infestation affects white spruce trees at all elevations including up to treeline.

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 285 | 64 |  |  |
| Moderate (Mixed) | 511 | 36 |  |  |
| Low (Surface) |  |  |  |  |
| All Fires | 183 | 100 |  |  |

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

Scale Description

Large patch

Adjacency or Identification Concerns

Issues or Problems

Native Uncharacteristic Conditions

The frequency and severity of beetle outbreaks will likely increase under a warmer climate.

Dial et al. (2022) documented rapid advance of white spruce into arctic tundra at established treeline.

Abrahamson (2014) includes more information about the effects of climate change on white spruce treeline communities.

Comments

4/2022 - The fire frequency of this system was adjusted based on feedback from experts who attended the Boreal Forest BpS Review Work Session in February 2022. At that session, participants ranked the boreal forest BpS by relative fire frequency. Based on that ranking it was estimated that this BpS would have a mean fire return interval of approximately 200 years.

10/2021 - This description was updated by NatureServe staff and Kori Blankenship based on the updated Ecological Systems classification for Alaska. Edits focused on adjusting the Geographic Range, Biophysical Site Description, and Vegetation Description sections.

For LANDFIRE National this model was based on input from the experts who attended the LANDFIRE Fairbanks modeling meeting (Nov. 07) and refined by Tricia Wurtz. This BpS was created for the AK Boreal region and did not receive review for other regions in the state.

Succession Classes

**Mapping Rules**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Upper Layer Lifeform** | **Height (m)** | **Canopy Cover (%)** | | | | | | | | | |
| **0-10** | **11-20** | **21-30** | **31-40** | **41 - 50** | **51-60** | **61-70** | **71-80** | **81-90** | **91-100** |
| Herb | 0-0.5 | A | A | A | A | A | A | A | A | A | A |
| Herb | 0.5-1.0 | A | A | A | A | A | A | A | A | A | A |
| Herb | >1.0 | A | A | A | A | A | A | A | A | A | A |
| Shrub | 0-0.5 | A | A | A | A | A | A | A | A | A | A |
| Shrub | 0.5-1.0 | A | A | A | A | A | A | A | A | A | A |
| Shrub | 1.0-3.0 | A | A | A | A | A | A | A | A | A | A |
| Shrub | >3.0 | A | A | A | A | A | A | A | A | A | A |
| Tree | 0-5 | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf |
| Tree | 5-10 | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf |
| Tree | 10-25 | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf |
| Tree | 25-50 | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf |
| Tree | >50 | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf |
| Tree | 0-5 | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix |
| Tree | 5-10 | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix |
| Tree | 10-25 | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix |
| Tree | 25-50 | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix |
| Tree | >50 | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix |
| Tree | 0-5 | C con | C con | C con | C con | C con | C con | C con | C con | C con | C con |
| Tree | 5-10 | C con | C con | C con | C con | C con | C con | C con | C con | C con | C con |
| Tree | 10-25 | C con | C con | C con | C con | C con | C con | C con | C con | C con | C con |
| Tree | 25-50 | C con | C con | C con | C con | C con | C con | C con | C con | C con | C con |
| Tree | >50 | C con | C con | C con | C con | C con | C con | C con | C con | C con | C con |

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

**Description**

Class A 5 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| BENA | *Betula nana* | Dwarf birch | Upper |
| BEGL | *Betula glandulosa* | Resin birch | Upper |
| VAUL | *Vaccinium uliginosum* | Bog blueberry | Upper |
| VAVI | *Vaccinium vitis-idaea* | Lingonberry | Upper |

Description

This class is characterized by herbaceous and shrub vegetation. Shrubs resprout from underground propagules and then *Picea glauca* invades by seed from adjacent stands or surviving trees. The shrub layer typically features *Betula nana* or *B. glandulosa*, but other shrubs such as *Vaccinium uliginosum, Vaccinium vitis-idaea, Ledum palustre* ssp. *decumbens* and *Empetrum nigrum* may be common or dominant. In some locations *Alnus viridis* ssp. *crispa* is the dominant understory shrub. Feathermoss may be common in the in the ground layer. On drier or more exposed sites, *Cladina* spp. replace feathermosses as the dominant ground cover (Viereck 1979). The rate of succession depends on severity of fire and seed source, and some sites may be shrub-dominated for long periods without spruce invasion. Hardwoods may invade the site if a seed source is available and site conditions are favorable.

*Maximum Tree Size Class*  
Seedling/Sapling <5"

Class B 8 Mid Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| BENE4 | *Betula neoalaskana* | Resin birch | Upper |
| PIGL | *Picea glauca* | White spruce | Upper |
| PIMA | *Picea mariana* | Black spruce | Upper |

Description

This class is characterized by hardwood or white spruce-hardwood mixed forest. *Betula neoalaskana* invades with or without spruce and gain canopy dominance over the shrubs. Woodland canopy cover is generally 10-25%. Eventually hardwoods senesce and white spruce gains canopy dominance (Class C).

*Maximum Tree Size Class*  
Pole 5–9" (swd)/5–11" (hwd)

Class C 87 Late Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIGL | *Picea glauca* | White spruce | Upper |
| PIMA | *Picea mariana* | Black spruce | Upper |
| EMNI | *Empetrum nigrum* | Black crowberry | Low-Mid |
| CLADI3 | *Cladina* spp. | Reindeer lichen | Lower |

Description

This class is characterized by open white spruce woodland. Forest canopy cover is generally 10-25%. Hardwoods, if previously present in the stand, lose dominance in the overstory during this phase. The understory may include various combinations of low shrubs, herbs, and mosses. Lichens grow as the stand ages. The dominant lichen genus is typically *Cladina*; species include *C. arbuscula, C. mitis, C. rangiferina,* and *C. stellaris*. Other lichens may include *Flavocetraria cucullata, C. islandica, C. nivalis, Bryoria* spp., *Alectoria nigricans* and *Alectoria ochroleuca*. Beetles affect this class, but the rate of outbreaks is uncertain and generally not severe enough to cause a state transition.

*Maximum Tree Size Class*  
Med. 9–20" (swd)/11–20" (hwd)

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Late1:OPN | 24 |
| Mid1:OPN | 25 | Late1:OPN | 69 |
| Late1:OPN | 25 | Late1:OPN | 999 |

Probabilistic Transitions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Disturbance Type** | **Disturbance occurs In** | **Moves vegetation to** | **Disturbance Probability** | **Return Interval (yrs)** | **Reset Age to New Class Start Age After Disturbance?** | **Years Since Last Disturbance** |
| Alternative Succession | Early1:ALL | Mid1:OPN | 0.04 | 25 | Yes | 0 |
| Replacement Fire | Early1:ALL | Early1:ALL | 0.0067 | 149 | Yes | 0 |
| Mixed Fire | Mid1:OPN | Mid1:OPN | 0.002 | 500 | No | 0 |
| Replacement Fire | Mid1:OPN | Early1:ALL | 0.0033 | 303 | Yes | 0 |
| Mixed Fire | Late1:OPN | Late1:OPN | 0.002 | 500 | No | 0 |
| Replacement Fire | Late1:OPN | Early1:ALL | 0.0033 | 303 | Yes | 0 |

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