16041

Western North American Boreal Mesic Black Spruce Forest and Woodland – Boreal

BpS Model/Description Version: Nov. 2024

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| --- | --- | --- | --- |
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Vegetation Type

Forest and Woodland

Map Zones

68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78

Model Splits or Lumps

Western North American Boreal Mesic Black Spruce Forest and Woodland was split into a Boreal and Boreal Transition variant for BpS modeling so that regional differences could be represented. For mapping BpS 16041 should apply in level 2 ecoregions (Nowaki et al. 2001): Intermontane Boreal, Aleutian Meadows, Arctic Tundra, Bering Taiga, Bering Tundra.

Geographic Range

This Biophysical Setting (BpS) occurs on lower to upper north-facing slopes in the boreal regions of Alaska, and northern Yukon Territory. This model applies to the boreal region of AK.

Biophysical Site Description

This system occurs on moderately well-drained sites including old alluvial fans, abandoned floodplains, and inactive terraces and is widespread on upland slopes (all aspects) and remnant alluvial deposits. On the upland slope occurrences, the slope angle is generally greater than 8°. Soils can be gravelly in abandoned floodplains and feature shallow to moderately deep organic horizons. A peat layer may be absent or well developed, but there may be an organic layer derived from non-sphagnum mosses including N-fixing *Hylocomium splendens*. Ice-rich permafrost is usually present except on shallow soils over bedrock and coarse alluvium (Viereck et al. 1992). Sites occurring on north-facing slopes can be underlain by permafrost, which retards the productivity of *Picea mariana*. Soils on these sites are moderately drained and acidic with a well-developed peat layer. Sites on lower concave slopes and toeslopes are mesic-wet, while sites on upper slopes, convex slopes and ridges are mesic. Within the southern geography of this system, *Picea mariana* dominated sites are typically restricted to peatlands (Harlow and Harrar 1968), mesic black spruce is replaced by temperate rain forests dominated by Sitka spruce in the North Pacific Coast of south-central AK.

Vegetation Description

*Picea mariana* is the dominant overstory species, but *Picea glauca* may be co-dominant on some sites. Early successional stands may be dominated by *Betula neoalaskana* or *Populus tremuloides. Populus tremuloides* replaces *Betula neoalaskana* on drier sites (Foote 1983; Chapin et al. 2006). Common understory shrubs include *Rosa acicularis, Betula nana, Ledum groenlandicum, Linnaea borealis, Vaccinium vitis-idaea, V. uliginosum,* and *Empetrum nigrum*.

Herbaceous species include *Calamagrostis canadensis, Chamerion angustifolium, Equisetum spp., Rubus chamaemorus,* and *Carex* spp. Common mosses include *Sphagnum* spp., *Hylocomium splendens*, and *Pleurozium schreberi* (NatureServe 2008). Feathermosses have a high capacity to insulate, which can lead to permafrost aggradation. Sites where permafrost is closer to the surface, and retards the infiltration of surface water will have more sphagnum. Lichens, in the *Alectoria, Bryoria, Bryocaulon, Cetraria, Flavocetraria, Masonhalea, Sphaerophorus,* and *Thamnolia* genera, fruticose lichens in the *Cladonia* genus, and N-fixing foliose lichens in the *Lobaria, Peltigera,* and *Nephroma* genera may be abundant on the drier *Picea glauca* co-dominated sites, especially in later seral stages (Flagstad et al. 2021).

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PIMA | *Picea mariana* | Black spruce |
| BEPA | *Betula neoalaskana* | Paper birch |
| POTR5 | *Populus tremuloides* | Quaking aspen |
| PIGL | *Picea glauca* | White spruce |
| BENA | *Betula nana* | Dwarf birch |
| LEGR | *Ledum groenlandicum* | Bog Labrador tea |
| SALIX | *Salix spp.* | Willow |
| VAUL | *Vaccinium uliginosum* | Bog blueberry |
| CACA4 | *Calamagrostis canadensis* | Bluejoint |
| SPGI70 | *Sphagnum girgensohnii* | Girgensohn's sphagnum |

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

Disturbance Description

Crown fires and ground fires, primarily ignited by lightning, of severity high enough to kill overstory trees are the dominant disturbance influencing black spruce forest. Moderate-severity fire sometimes occurs in a mosaic fire where black spruce is mixed with hardwoods (Lentile et al. 2007), but for a predominantly black spruce forest, fires are almost always stand-replacing crown fires or a mix of crown and lethal surface fire (see Fryer 2014a and references therein). Germination success is variable but consistently higher soon after fire, with establishment from semi-serotinous cones beginning the first year after fire and continuing for up to 10 years (Viereck 1983, Duchesne and Hawkes 2000). Fire history studies report fire frequencies from 73 to 113 years for black spruce forests in interior AK (Drury & Grissom 2008; Fastie et al. 2002; Kasischke et al. 2008; Kurkowski et al. 2008; Yarie 1981). See Fryer (2014a and 2014b) for literature reviews on black spruce including fire regime information.

The post-fire successional trajectory may be self-replacement, with black spruce following the early seral herb and shrub stages; alternatively, black spruce-hardwood may follow the early seral stages before returning to black spruce (Chapin et al. 2006). Black spruce has semi-serotinous cones and the seed bank is airborne. Fires that kill the aerial seedbank or recur before trees achieve sexual maturity can disrupt regeneration of black spruce and result in a loss of resilience (Baltzer et al. 2021; Brown and Johnstone 2012). Historically, *P. mariana* is generally successful in replacing itself after fire on moister sites and sites burned at low to moderate severity when some organic layer is left unconsumed (Johnstone et al. 2010; Hammond et al. 2019). Increased occurrence and severity of fire may lead to an increased deciduous tree component (Johnstone and Kasischke 2005; Foster et al. 2019).

The pre-burn stand composition and burn severity will influence the likely successional trajectory, with deciduous species more likely to proliferate where much of the soil organic layer is removed (Alexander and Mack 2016; Johnstone et al. 2010). *Populus tremuloides, Betula neoalaskana,* and *Populus balsamifera* are early deciduous species on mineral soils where seed stock is present. If white spruce is present in the conifer initiation, then white and black spruce can be co-dominant in the conifer canopy throughout the successional stages.

Wind and insect damage affect this type, but very little research exists to help describe or model that effect. These disturbances are also much smaller in their impacts than the dominant, stand-replacement disturbances caused by fire.

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 172 | 59 |  |  |
| Moderate (Mixed) | 251 | 41 |  |  |
| Low (Surface) |  |  |  |  |
| All Fires | 102 | 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

Matrix to large patch to small patch

Across AK fires in black spruce communities tend to be small, but a few large fires (e.g. 50,000 ha or larger) account for most of the area burn and have the most ecological impact (see Fryer 2014a and references therein).

Adjacency or Identification Concerns

In some locations, this BpS can be confused with the White Spruce BpS because black and white spruces often mix, especially on sites with transitional moisture and thermal conditions (Murphy and Witten 2006).

Issues or Problems

Native Uncharacteristic Conditions

Warmer summer temperatures and decreased precipitation in AK and northern Canada have dramatically increased wildfire disturbances in the past few decades (Overpeck et al. 1997; Stocks et al. 2000; Gillett et al. 2004; Bachelet et al. 2005). Although large fire seasons are episodic, the frequency of million-acre fire seasons in AK has increased over the past few decades, with wildfires between 2001-2020 burning 31.4 million acres, 2.5 times the acres burned during the previous 20 years (Grabinski and McFarland 2020). 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).

Resilience in black spruce forests to compositional change is threatened by predicted increases in climate moisture deficits and fire activity (Baltzer et al. 2021). Site specific elevation and aspect seem to be the most important driver in hardwood sapling density, tall shrub cover and downed woody fuel loads following the 2004 Taylor Complex fire (Hammond et al. 2019).

Comments

9/14/2022: Kori Blankenship adjusted the modeled mean fire return interval (MFRI) from 75 to 101 years based on the relative fire frequency rankings developed for boreal forest BpS during the Boreal Forest BpS Review Work Session in February 2022. The change in fire frequency increased the proportion of spruce classes (mid 2 all, late 1 open).

As of 9/2022 several Ecological Site Descriptions (ESDs) that fit within this BpS concept are under development and two are available online: Boreal Woodland Gravelly Terraces (ESD XA232X01Y262) and Boreal Woodland Loamy Frozen Terraces (ESD XA232X01Y218).

In 2021 a reviewer stated that the BpS model would benefit from incorporating “burn severity information to a greater extent. Degree of organic mat removal is a key factor in determining whether deciduous trees and shrubs are likely to seed in and dominate a site.” To date, LANDFIRE has not modeled ground fire.

During a 2016 BpS review, it was noted by a reviewer that the literature reports that fires are typically stand replacing in black spruce forest, but mixed effects are possible if hardwoods are present. Reviewer comments also suggested the possibility of adjusting the mid and late successional stage age ranges, but exact changes were not specified. Blankenship contacted the original model author, Johnston, who offered the following response: “Teresa Hollingsworth's detailed study of black spruce community composition in interior AK found no relationship between stand age and vegetation structure or composition, across an age range of 50-300+ years (Hollingsworth et al. 2006). Some recent work from my lab on moss succession dynamics suggests that the moss understory does not start to differentiate between deciduous-dominated and spruce stands until somewhere between 40-60 years old (Jean et al. 2017). On that basis, I would tend to put the break from early-mid succession at 40 years, and I think the choice between mid-late succession is probably arbitrary, as factors other than stand age appear to be driving the structural and compositional differences that we might use to define "old growth" conditions.” Based on this feedback Blankenship changed the start age of the Mid1All and Mid2All classes from 30 to 40 years and the end age of Early2Opn from 29 to 39 years. This resulted in slight changes to the succession class amounts (+ or – 5%) and fire frequency (+ or – 7yr change in MFRI).

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

In 2021 NatureServe merged Western North American Boreal Black Spruce Wet-Mesic Slope Woodland (BpS 1622) and Western North American Boreal Mesic Black Spruce Forest (BpS 1604) into one Ecological System: Western North American Boreal Mesic Black Spruce Forest and Woodland. Kori Blankenship merged the BpS description for 1622 created by Joan Foote and Colleen Ryan and reviewed by Michelle Schuman, William Putnam, and Lisa Saperstein and 16041 created by Jill Johnstone and reviewed by William Putnam to reflect the new Ecological System concept and adopted the state-and-transition model from 16041 to represent the merged system in the Boreal region.

For LANDFIRE National, this system was created for the AK Boreal region and did not receive review during LANDFIRE National for other regions in the state. This model was based on input from the experts who attended the LANDFIRE Fairbanks (Nov. 07) and Anchorage (Dec. 07) modeling meetings. During LANDFIRE National Will Putnam expressed concern that the distinction between this BpS and Western North American Boreal White Spruce-Hardwood Forest is ambiguous. They can occur on similar sites, and in many cases the relative dominance of *P. mariana* vs*. P. glauca* is mostly a function of succession and/or disturbance history.

The probability of fire in the mixed spruce-hardwood stage (Class C) relative to the spruce dominated stages (Class D and E) is unclear. It was assumed that the herb and shrub dominated stages (Class A and B) are less fire prone, and therefore have a lower fire probability, than the later seral stages. The probability and effects of insects, disease and wind/weather events in this system are unclear and are included in the old-growth stage (Class E) of the model as a place holder.

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 | B | B | B | B | B | B | B | B | B | B |
| Shrub | 0.5-1.0 | B | B | B | B | B | B | B | B | B | B |
| Shrub | 1.0-3.0 | B | B | B | B | B | B | B | B | B | B |
| Shrub | >3.0 | B | B | B | B | B | B | B | B | B | B |
| Tree | 0-5 | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf |
| Tree | 5-10 | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf |
| Tree | 10-25 | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf |
| Tree | 25-50 | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf |
| Tree | >50 | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf | C brdlf |
| Tree | 0-5 | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix |
| Tree | 5-10 | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix |
| Tree | 10-25 | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix |
| Tree | 25-50 | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix |
| Tree | >50 | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix | C mix |
| Tree | 0-5 | E con | E con | E con | E con | E con | E con | D con | D con | D con | D con |
| Tree | 5-10 | E con | E con | E con | E con | E con | E con | D con | D con | D con | D con |
| Tree | 10-25 | E con | E con | E con | E con | E con | E con | D con | D con | D con | D con |
| Tree | 25-50 | E con | E con | E con | E con | E con | E con | D con | D con | D con | D con |
| Tree | >50 | E con | E con | E con | E con | E con | E con | D con | D con | D con | D 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 2 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| CACA4 | *Calamagrostis canadensis* | Bluejoint | Upper |
| CHAN9 | *Chamerion angustifolium* | Fireweed | Upper |
| EQUIS | *Equisetum* spp, | Horsetail | Upper |

Description

Post-disturbance, herbaceous vegetation dominates. Common herbaceous species include *Calamagrostis canadensis, Chamerion angustifolium* and *Equisetum* spp. (NatureServe 2008). Black spruce seedlings and common liverwort-fire moss mats can dominate (Viereck 1983). Shrubs may sprout in areas that burned at low to moderate severity (Viereck 1983).

*Maximum Tree Size Class*  
None

Class B 14 Early Development 2 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| SAPU15 | *Salix pulchra* | Tealeaf willow | Upper |
| BENA | *Betula nana* | Dwarf birch | Upper |
| LEGR | *Ledum groenlandicum* | Bog Labrador tea | Upper |
| ROAC | *Rosa acicularis* | Prickly rose | None |

Description

Shrubs dominate as the cover of mat-forming and herbaceous species decreases (Viereck 1983). Common species include *Salix* spp., *Betula nana, Ledum* spp., *Rosa acicularis, Vaccinium uliginosum, V. vitis-idaea, Salix pulchra, S. bebbiana*, and *Empetrum nigrum*. Both hardwoods and spruce regeneration may be present.

The successional trajectory of the shrub stage will depend on the pre-burn stand composition and the degree of mineral soil exposure, which promotes deciduous seedling establishment. If hardwoods dominated the site before the burn, they are likely to vigorously resprout and gain dominance after the fire. If spruce dominated the site before a burn, they are likely to regain dominance in the post-fire stand.

One successional trajectory, possible after high severity fire, would include a hardwood phase (represented by Class C), but this class can also take an alternative successional pathway directly to a spruce dominated phase (represented by Class D).

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

Class C 17 Mid Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| BENE4 | *Betula neoalaskana* | Resin birch | Upper |
| POTR5 | *Populus tremuloides* | Quaking aspen | Upper |
| PIMA | *Picea mariana* | Black spruce | Upper |
| PIGL | *Picea glauca* | White spruce | Upper |

Description

Mixed hardwood-spruce forest. Hardwoods and spruce overtop shrubs and gain dominance. Early in this age class trees are at least 2.5 cm DBH and 4-8 m tall (Foote 1983). *Populus* *tremuloides* replaces *Betula neoalaskana* on drier sites (Foote 1983, Chapin et al. 2006). Spruce may occur as an understory, subdominant and/or co-dominant component. Tree density may be less or greater than 60% depending on site conditions. Beneath trees, shrubs, herbs and mosses exist. As the stage advances, spruce and moss become more important.

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

Class D 42 Mid Development 2 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIMA | *Picea mariana* | Black spruce | Upper |
| PIGL | *Picea glauca* | White spruce | Upper |
| HYSP70 | *Hylocomium splendens* | Splendid feather moss | Lower |
| PLSC70 | *Pleurozium schreberi* | Schreber's big red stem moss | Lower |

Description

Mid-seral black spruce/feathermoss. *Picea mariana* dominates but *Picea glauca* may be co-dominant on some sites. Spruce overtops the shrubs. Spruce canopy cover is commonly 50-70%. Increasing cover (up to 50%) of feathermosses and *Sphagnum* ssp. contributes to the development of a thick organic layer (Viereck 1983). If the organic layer increases, permafrost may aggrade (Viereck 1983).

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

Class E 25 Late Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIMA | *Picea mariana* | Black spruce | Upper |
| PIGL | *Picea glauca* | White spruce | Upper |
| BENA | *Betula nana* | Dwarf birch | Lower |
| LEGR | *Ledum groenlandicum* | Bog Labrador tea | Lower |

Description

Open, old-growth black spruce. *Picea mariana* dominates, but *Picea glauca* may be co-dominant on some sites. Spruce gains dominance over hardwoods (if previously present). Tree canopy cover is generally <60% and may be <25% (woodland) depending on site conditions. Occasional hardwoods may remain. The understory may include various combinations of tall shrubs, low shrubs, herbs, mosses and lichens. If fire is absent for long periods paludification may occur, resulting in an opening of the tree canopy to woodland conditions.

*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 | Early2:OPN | 4 |
| Early2:OPN | 5 | Mid1:ALL | 39 |
| Mid1:ALL | 40 | Late1:OPN | 119 |
| Mid2:ALL | 40 | Late1:OPN | 119 |
| Late1:OPN | 120 | 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** |
| Replacement Fire | Early1:ALL | Early1:ALL | 0.0033 | 303 | Yes | 0 |
| Alternative Succession | Early2:OPN | Mid2:ALL | 0.02 | 50 | Yes | 0 |
| Replacement Fire | Early2:OPN | Early1:ALL | 0.0033 | 303 | Yes | 0 |
| Mixed Fire | Mid1:ALL | Mid1:ALL | 0.004 | 250 | No | 0 |
| Replacement Fire | Mid1:ALL | Early1:ALL | 0.005 | 200 | Yes | 0 |
| Mixed Fire | Mid2:ALL | Mid2:ALL | 0.005 | 200 | No | 0 |
| Replacement Fire | Mid2:ALL | Early1:ALL | 0.0067 | 149 | Yes | 0 |
| Wind or Weather or Stress | Late1:OPN | Mid2:ALL | 0.01 | 100 | Yes | 0 |
| Mixed Fire | Late1:OPN | Mid2:ALL | 0.005 | 200 | Yes | 0 |
| Insects or Disease | Late1:OPN | Mid2:ALL | 0.001 | 1000 | Yes | 0 |
| Replacement Fire | Late1:OPN | Early1:ALL | 0.0067 | 149 | Yes | 0 |

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