LANDFIRE Biophysical Setting Model

Biophysical Setting 7216211 — Western North American Boreal Black Spruce Dwarf-tree Peatland - Boreal Complex

☑ *This BPS is lumped with: see below*

☐ *This BPS is split into multiple models:* *This system was created by merging several Ecological Systems: Western North American Boreal Black Spruce Dwarf-tree Peatland, Western North American Boreal Freshwater Emergent Marsh, Western North American Boreal Wet Meadow, Western North American Boreal Low Shrub Peatland and Western North American Boreal Black Spruce-Tamarack Fen*

Western North American Boreal Black Spruce-Tamarack Fen is lumped with Western North American Boreal Black Spruce Dwarf-tree Peatland because it occurs on similar sites and has a similar successional trajectory. The main difference is that the late seral stage would be dominated by Larix laricina but this is accounted for in the model by including both Picea mariana and Larix laricina in the later seral stage.

Western North American Boreal Freshwater Emergent Marsh, Western North American Boreal Wet Meadow and Western North American Boreal Low Shrub Peatland are lumped as successional stages of this model when they occur on sites with permafrost dynamics. These three systems are also lumped into the Sub-boreal Fen Complex model where they occur on non-permafrost sites in the Boreal or Sub-boreal regions.

General Information

Contributors (also see the Comments field **Date** 4/4/2008

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Vegetation Type

Wetlands/Riparian

Map Zone

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Model Zone

☑ Alaska
☐ California
☐ Great Basin
☐ Great Lakes
☐ Northeast
☐ Northern Plains
☐ N-Cent.Rockies
☐ Pacific Northwest
☐ South Central
☐ Southeast
☐ S. Appalachians
☐ Southwest

Dominant Species*

PIMA	LEGR
LALA	MYGA
SALIX	CAAQ
BENA	SPHAG2

General Model Sources

☐ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This system is found throughout boreal AK and in arctic AK, in valley bottoms and broad, poorly drained floodplains (such as Yukon and Tanana Flats).

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Biophysical Site Description

This sytem is typically found on valley bottoms and toe slopes up to 8% slope, except on gravel substrates. Soils are poorly drained and acidic, often with a well-developed peat layer (NatureServe 2008). Much of this vegetation type is likely to be underlain by near surface permafrost (active layers < 1m deep). The presence of permafrost and poor drainage of flat areas work in conjunction to keep soils cool and wet, restricting decomposition and aiding the accumulation of peat. Warming climates and deep-burning fires that occur late in the summer have the potential to disrupt the soil thermal regime and lead to permafrost thawing and subsidence (thermokarst). Thermokarst will lead to prolonged stages of wetland-marsh type vegetation. Re-establishment of black spruce forests is likely to occur when peat-reaccumulates and the permafrost develops again, leading to a rising of the surface above the water table.

Vegetation Description

Boreal Lowland Wet Black Spruce forests are typically open and trees are generally stunted. Tree rooting zones are typically within the organic layer, with low nutrient availability and low rates of growth. Forests will tend to be open and stunted compared to adjacent, more well-drained areas.

Common species include Picea mariana, Ledum groenlandicum, L. palustre ssp. decumbens, Betula nana, B. glandulosa, Empetrum nigrum, Vaccinium vitis-idaea, V. uliginosum, Chamaedaphne calyculata, Myrica gale, Carex spp., Eriophorum angustifolium, Menyanthes trifoliata and Sphagnum spp (NatureServe 2008). Larix laricina may be locally abundant, particularly on less acidic sites.

Disturbance Description

Fire and thermokarst are the most important processes influencing Boreal Lowland Wet Black Spruce. Fire return intervals for this type generally range from 80-130yrs (this is a best guess).

For the VDDT model, it was assumed that fire would occur on the less frequent end of the range provided above because the presence of moist surface fuels and the open forest canopy associated with this BpS would limit fire spread and therefore decrease the probability of any particular patch burning.

Thermokarst processes play a key role in shaping the system, but the number of possible pathways and the time scale at which they operate are beyond the limit of what can be modeled with VDDT. As a result, this model has been simplified and limited in scope. This model includes Western North American Boreal Freshwater Emergent Marsh, Western North American Boreal Wet Meadow and Western North American Boreal Low Shrub Peatland as seral stages in the Boreal Lowland Wet Black Spruce system. These four classes are linked by thermokarst processes, as well as by fire dynamics. Boreal Freshwater Emergent Marsh may maintain itself on the landscape for decades, but on sites where permafrost development is likely and under appropriate hydrologic conditions, it may begin to dry out, develop an organic layer, and succeed to Boreal Wet Meadow. In this class, permafrost development begins, as mosses and organic material accumulate. This stage will succeed to Boreal Wet Low Shrub in the absence of disturbance, and permafrost and peat development will continue. In the absence of disturbance, trees will eventually begin to invade, and around age 75, Boreal Lowland Wet Black Spruce or Black Spruce-Tamarack Fen will appear.

In any of the three stages with permafrost, there is a low probability (modeled as 0.001) that permafrost melting will set the system back to the Freshwater Emergent Marsh class. Fire is also a possibility in the shrub and forest classes. A severe fire that impacts the peat layer may kill the shrub rootstock, setting the system back to the Wet Meadow class. If such a fire is followed by flooding (as from permafrost melting), the system may transition back to the Marsh class. If the fire is less intense, the shrubs may resprout and recover quickly.

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Although it is outside of the scope of this model, the system just described is part of a larger system connected by thermokarst dynamics. Under some conditions, the Marsh class of this system may develop into a different type of Wet Meadow, with more bog characteristics, and permafrost may not develop again. This trajectory leads into the Ericaceous Dwarf Shrub Bog model, which could eventually lead to a forested bog or Wet Black Spruce-Tussock Woodland. In this forested stage, a permafrost layer would develop again. Alternatively, the Black Spruce Dwarf-tree Peatland or Black Spruce-Tamarack Fen could undergo paludification and transition to Boreal Sedge-Dwarf-Shrub Bog system. This can happen when restricted drainage from permafrost development (on inactive alluvial terraces, for example) leads to the establishment of Sphagnum spp. Or other peat forming mosses or sedges, and over time, peatland plants dominate the site.

In either of these pathways, the forested bog or Tussock Black Spruce class has the potential to undergo permafrost melting and collapse and transition back to Marsh. However, these cycles are likely to take thousands of years and are thus outside the scope of this modeling effort. Other pathways that would take the system out of this model include melting and impoundment, leading to an open water stage, or drainage of the marsh stage, leading into a white spruce-Calamagrostis canadensis system.

Another pathway into this system is paludification over thousands of years, which could move a site from the Boreal and Sub-boreal Fen Complex model into this system.

Adjacency or Identification Concerns

This type can be found adjacent to Boreal Black Spruce Wet-Mesic Slope Woodland and Boreal Mesic Black Spruce Forest - Boreal. Boreal Lowland Wet Black Spruce is typically found on valley bottoms and toe slopes up to 8% slope. As the slope increases past 8%, the vegetation typically transitions to Mesic Black Spruce Forest or, on north-facing slopes, to Black Spruce Wet-Mesic Slope Woodland. Well-drained gravel sites may support Mesic Black Spruce Forest, even in low, flat areas.

Native Uncharacteristic Conditions

Scale Description

Large patch (small patch)

Issues/Problems

Because the climate has been warming and drying over recent decades, thermokarst processes have been accelerating. At the same time, lakes and marshes have been shrinking and drying across the boreal region in recent decades. Many of the marshes in this region may be relicts of the earky Holocene post-glacial period, rather than parts of a stable cycle of disturbance and succession. As a result, the concept of equilibrium dynamics inherent in this modeling process is difficult to apply to this system. Because thermokarst processes are accelerating, it was difficult to assign a reference probability to these processes. Over the past 5000yrs, the probability of thermokarst influencing a given point on the landscape averaged about 0.000014, compared with approximately 0.0006 in the past 50yrs. Under current climate conditions, the probability is presumably higher.

Comments

This model was created for the AK boreal region and did not receive review for the arctic region.

This model was created by Torre Jorgenson and refined by Colleen Ryan based on a more narrowly focused model created by Jill Johnstone for the Boreal Lowland Wet Black Spruce system. Jill Johnstone

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reviewed the final model for the wetland complex. Information provided by Amy Larsen was used in developing this model.

Vegetation Classes

Class A 5%

Early Development 1 All Structures

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Indicator Species* and Canopy Position

TYLA	Upper
CARO6	Upper
EQFL	Upper
	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	Herbaceous	Herbaceous
Height	Herbaceous	Herbaceous
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

0-20yrs

Freshwater Emergent Marsh.

This class is characterized by herbaceous marsh vegetation such as Typha latifolia, Carex rostrata, C. aquatilis, C. utriculata, Scirpus validus, Menyanthes trifoliata, Equisetum fluviatile and Eleocharis palustris. Arctophila fulva becomes more common in the northern boreal region. Floating aquatic vegetation (Nuphar polysepalum, Potamogeton spp.) may also be present. Water level may fluctuate seasonally or between years, but is at or above the surface for most of the growing season. Areas of open water are often present seasonally. Permafrost is absent in the class.

If water levels continue to be high, with frequent large fluctuations, class A may maintain itself for decades. If the hydrologic regime begins to stabilize and dry, this class may succeed to class B (Wet Meadow) in 2yrs+.

Fire is extremely unlikely in this class.

With regular seasonal flooding and high water levels, this class maintains itself. Alternate succession to class B (probability = .12) may occur if water levels stabilize and the site begins to dry.

Class B 5%

Mid Development 1 All Structures

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Indicator Species* and Canopy Position

CACA4	Upper
CAAQ	Upper
ERAN6	Upper
	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	Herbaceous	Herbaceous
Height	Herbaceous	Herbaceous
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Distinguish from Class A for mapping by lack of aquatic plants and open water, presence of organic mat, mosses, permafrost, and/or dominance of sedges.

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Description

3-5yrs

Wet Meadow.

This class is characterized by dense sedges with a well-developed organic mat. Common and characteristic species include Calamagrostis canadensis, Carex aquatilis, C. bigelowii, Eriophorum angustifolium, E. russeolum, E. vaginatum, Equisetum arvense, Equisetum sylvaticum, Epilobium angustifolium, and the moss Ceratodon purpureus (Gracz 2005, Jorgenson et al. 1999).

Water levels are more stable in this class than in the Freshwater Emergent Marsh. Soils are saturated at some point in the growing season but do not have standing water (NatureServe 2008). Permafrost development has begun in this class, making it subject to thermokarst processes. Fire is very unlikely in this class, due to the saturated soils.

Succession to class C under typical (drying) conditions. Option 1 (probability = 0.02) represents a stable hydrologic regime that maintains class B. Option 2 (probability = 0.0006) represents increased water levels which would cause a transition to class A.

Class C **45 %**

Mid Development 2 All Structures

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Indicator Species* and Canopy Position

BENA	Upper
LEGR	Upper
SALIX	Lower
VACCI	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	Open Shrub (25-74% shrub cover)	Closed Shrub (> 75% shrub cover)
Height	Dwarf Shrub (< 20 cm)	Tall Shrub (>1.5 m)
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

6-74yrs

Low Shrub Peatland

Dwarf ericaceous, low or tall shrubs dominate this class. Myrica gale and Chamaedaphne calyculata are among the first shrubs to invade. Presence of sphagnum mosses tends to increase soil acidity which in turn favors the ericaceous shrubs such as Ledum groenlandicum, L. palustre ssp. Decumbens, Andromeda polifolia and Vaccinium uliginosum. Other common shrub species include Salix spp., Betula nana (B. glandulosa) and Empetrum nigrum.

Permafrost is well developed in this class, making it subject to thermokarst processes. Fire is possible in this class during dry periods.

Succession to class D under typical conditions. Severe replacement fire (MFRI = 175yrs) that burns into the peat layer will kill the shrubs, causing a transition to class B. Replacement fire followed by a hydrologic change that increased the water level could cause a transition to class A (probability = 0.0017). Option 2 (probability = 0.0006) represents increased water levels as a result of thermokarst processes which could kill the existing vegetation causing a transition to class A.

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Class D **45 %**

Late Development 1 All Structures

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Indicator Species* and Canopy Position

PIMA	Upper
LALA	Upper
BENA	Lower
MYGA	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	Woodland (10-24% tree cover)	Closed (60-100% tree cover)
Height	Dwarf Tree (< 3 m)	Tree (> 3m)
Tree Size Class	Pole 5–9" (swd)/5–11" (hwd)	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

75yrs+

Mature wet black spruce forest. Picea mariana or Picea mariana-Larix laricina mix. Trees are generally stunted and generally pole sized although some achieve the medium (9-21") size class. The presence of Larix laricina is associated with higher soil pH. Common understory species include the same shrubs as in class C, as well as Calamagrostis canadensis, Carex aquatilis, C. bigelowii and sphagnum.

Permafrost is well developed in this class, making it subject to thermokarst processes. The probability of fire is similar to that in the shrub class because the shrubs carry the fire.

This class persists in the absence of disturbance. Overall replacement MFRI = 130yrs. Severe replacement fire (FRI = 175yrs) will kill the shrubs, causing a transition to class B. Replacement fire followed by a hydrologic change that increased the water level could cause a transition to class A (probability = 0.0017). A mixed fire (FRI = 333yrs) that killed most of the trees and top-killed the shrubs would cause a transition to class C. Option 2 (probability = 0.0006) represents increased water levels as a result of thermokarst processes which could kill the existing vegetation causing a transition to class A.

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [ ] Tree

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover		
Height		
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

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Fire Regime Group:** IV

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	133.7			0.00748	84
Mixed	727.7			0.00137	16
Surface					
All Fires	113			0.00886	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ Native Grazing
- ☑ Other (optional 1) continued high water level
- ☐ Wind/Weather/Stress
- ☐ Competition
- ☑ Other (optional 2) increased water level (thermokarst processes)

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