16210

Western North American Boreal Black Spruce Bog and Dwarf-Tree Peatland

BpS Model/Description Version: Nov. 2024

Reviewer: Blaine Spellman

Vegetation Type

Woody Wetland

Map Zones

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

Geographic Range

This Biophysical Setting (BpS) is found at higher temperate and boreal latitudes of western Canada, extending into the Rocky Mountains, and in lowlands of the boreal and boreal transition regions of Alaska, including Yukon and Tanana Flats.

Biophysical Site Description

These wetlands form where the rate of peat accumulation exceeds its decomposition, resulting in ombrotrophic and acidic peatlands in which the bog surface is raised above the water table. This system is typically found on stream terraces, valley bottoms and toe-slopes up to eight percent slope, except on gravel substrates. Soils are poorly drained and acidic, often with a well-developed peat layer. Much of this vegetation 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 (perhaps, with extreme warming) deep-burning fires 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

The forest canopy is typically open to woodland and trees are generally stunted compared to adjacent more well-drained areas. The vegetation is dominated by dense to scattered trees with *Picea mariana*, and occasionally *Larix laricina* on less acidic sites. Low ericaceous shrubs are also dominant, including *Andromeda polifolia, Betula nana, Betula glandulosa, Kalmia polifolia, Ledum palustre* ssp*. decumbens, Ledum groenlandicum, Chamaedaphne calyculata, Empetrum nigrum, Myrica gale, Rubus chamaemorus, Vaccinium oxycoccos, Vaccinium vitis-idaea,* and, *Vaccinium uliginosum*. Patches of graminoids and bryophyte lawns are also common. Common graminoids include *Carex pluriflora, Carex bigelowii, Eriophorum angustifolium*, and *Calamagrostis canadensis*. *Sphagnum* species are characteristic, including *Sphagnum capillifolium, Sphagnum magellanicum, Sphagnum fuscum, Sphagnum papillosum*, and *Sphagnum cuspidatum* (DeVelice et al. 1999). Lichens include *Cladina* (several species), and *Flavocetraria cucullata*. Lichens overtop Sphagnum commonly on these thermokarst prone plots in the Yukon Flats Lowlands.

BpS Dominant and Indicator Species

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

Disturbance Description

The major disturbances in this type are fire and thermokarst collapse. Mean fire return intervals (MFRI) for black spruce communities generally range from 25 to 146 years from the 1700s to the 2000s (Fryer 2014). As of 2013, there was generally more scientific literature on fire regimes of black spruce forest types than on other black spruce communities (e.g., black spruce-lichen, black spruce scrub, and black spruce bog types; Fryer 2014). Low severity fires may simply support re-sprouting of species present prior to the fire (Bernhardt et al. 2011). A severe fire that impacts the peat layer may kill the shrub and tree rootstock, setting the system back to a wet meadow type.

In boreal wetlands, the general successional trend is from marsh to fen to treed bog. However, succession is not necessarily directional, and environmental conditions, such as nutrient content and abundance of groundwater, may prevent fens from developing into bogs (Zoltai et al. 1988). 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. Succession begins in shallow ponds or low-lying wetlands formed by processes such as glacial recession and floodplain dynamics (oxbows) or thermokarst. An organic root mat typically develops and is either anchored to the mineral soil or floating on water such as a pond's edge. In the absence of disturbance, over time, permafrost development begins, and peat-forming mosses and sedges may fill in the basin. As the peat layer develops, low and/or dwarf-shrubs become established. Dwarf-trees may establish on the well-developed peat and also around the margin of the peatland.

Many peatlands on the Kenai Lowland formed in kettles after remnant glacial ice melted. In this region there is a trend toward peatlands drying and ponds shrinking and filling in (Klein et al. 2005).

Permafrost degradation leading to collapse scars and thaw ponds is common in boreal Alaska, and studies from the Tanana Flats show areas of widespread degradation (Racine et al. 1998, Jorgenson et al. 2001a, 2001b). Thaw ponds form when ice-rich permafrost degrades and collapses forming a basin. Aquatic plants rapidly colonize the pond. Over time, marsh plants and sphagnum moss invade creating peatland conditions. This trend is leading to widespread ecosystem conversion in the Tanana Flats (Jorgenson et al. 2001b). If a collapse scar is isolated, succession follows a bog development model, whereas in an open hydrologic setting, succession follows a fen development model. Pond systems may become connected as adjacent permafrost thaws. Generally, once a forest peatland like this experiences thermokarst, it may be more prone to this in the future as well. (Myers-Smith et al. 2008).

Succession to peatlands can also occur through paludification of previously forested landscapes. Restricted drainage from permafrost development (on inactive alluvial terraces, for example) can lead to the establishment of *Sphagnum* spp. or other peat-forming mosses or sedges, and overtime, peatland plants dominate the site. Melting and impoundment can lead to an open water stage, or drainage of marshes can lead to a white spruce-*Calamagrostis canadensis* system.

Fire Frequency

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 (small patch)

Adjacency or Identification Concerns

Issues or 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 early 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 emerging climate conditions, the probability is presumably higher.

Native Uncharacteristic Conditions

Comments

This BpS concept is similar to the Boreal Woodland Peat Frozen Terraces

ecological site description: <https://edit.jornada.nmsu.edu/catalogs/esd/232X/XA232X01Y201>.

Attendees of the Boreal Forest BpS Review Work Session in February 2022 developed a relative ranking of fire frequency for boreal forest BpS and confirmed that the modeled MFRI of this BpS was appropriate relative to the other systems.

During LANDFIRE National, this BpS was described and modeled as a complex of systems including: marsh, wet meadow, low shrub peatland, black spruce forest, and tamarack fen. Further, the BpS was split to represent difference between the complex in the Boreal vs. the Sub-boreal regions. In 2021 NatureServe made significant revisions to the Ecological Systems for AK that changed how all of these types were classified. As a result, NatureServe and Kori Blankenship revised this BpS to reflect the new Ecological System concept: Western North American Boreal Black Spruce Bog and Dwarf-Tree Peatland. The Boreal/Sub-boreal split was not retained, and the tamarack fen was modeled and described separately. The revised description and model are heavily based on the Western North American Boreal Black Spruce Dwarf-tree Peatland - Boreal Complex BpS (16211) created by Jill Johnstone and Torre Jorgenson and reviewed by Michelle Schuman and Lisa Saperstein as well as the Western North American Boreal Black Spruce Dwarf-tree Peatland - Alaska Sub-boreal Complex (BpS 16212) created by Torre Jorgenson and Colleen Ryan and reviewed by Michelle Schuman.

For the state-and-transition model, it was assumed that fire would occur on the less frequent end of the range provided in the Disturbance Description 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.

Succession Classes

**Mapping Rules**

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 47 Early Development 1 - All Structures

Indicator Species

Description

Low Shrub Peatland. *Myrica gale* and *Chamaedaphne calyculata* are among the first shrubs to resprout or 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*, and *Vaccinium uliginosum*. Other common shrub species include *Salix* spp., *Betula nana* (*B. glandulosa*) and *Empetrum nigrum*. If permafrost is ice-rich in this class, it is subject to thermokarst processes. During dry periods fire can burn into the peat layer and kill the shrubs. Increased water levels as a result of thermokarst processes could kill the existing vegetation.

*Maximum Tree Size Class*  
None

Class B 53 Late Development 1 - All Structures

Indicator Species

Description

Mature, wet, black spruce woodland or forest. *Picea mariana* or *Picea mariana-Larix laricina* mix. Trees are generally stunted and pole sized although some achieve the medium (9-21") size class. The presence of *Larix laricina* can be associated with higher soil pH. Larch sawfly has reduced larch abundance in many areas. Common understory species include the same shrubs as in Class A, as well as *Calamagrostis canadensis, Carex aquatilis, C. bigelowii* and *Sphagnum* spp. Severe replacement fire will kill the shrubs. A mixed fire will kill most of the trees and top-kill the shrubs. Permafrost is well developed in this class, making it subject to thermokarst processes. Increased water levels as a result of thermokarst processes could kill the existing vegetation.

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

Model Parameters

Deterministic Transitions

Probabilistic Transitions

Optional Disturbances

Optional 1: increased water level (thermokarst processes)

References

Bernhardt, E.L., Hollingsworth, T.N. and Chapin, III, F.S., 2011. Fire severity mediates climate‐driven shifts in understorey community composition of black spruce stands of interior Alaska. Journal of Vegetation Science, 22(1):32-44.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, C. Nordman, M. Pyne, M. Reid, M. Russo, K. Schulz, K. Snow, J. Teague, and R. White. 2003-present. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA.

DeVelice, R.L., 1999. *Plant community types of the Chugach National Forest: southcentral Alaska*. US Department of Agriculture, Forest Service, Chugach National Forest, Alaska Region.

Foote, M. Joan. 1983. Classification, description, and dynamics of plant communities after fire in the Taiga of Interior Alaska. Res. Pap. PNW-307. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 108 pp.

Fryer, Janet L. 2014. Fire regimes of Alaskan black spruce communities. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: www.fs.fed.us/database/feis/fire\_regimes/AK\_black\_spruce/all.html [2021, September 21].

Gracz, M., Noyes, K, North, P., Tande, G. 2005 Wetland Mapping and Classification of the Kenai Lowland, Alaska. http://www.kenaiwetlands.net/

Jorgenson, M. T., J. E. Roth, M. D. Smith, S. Schlentner, W. Lentz, and E. R. Pullman. 2001a. An ecological land survey for Fort Greely, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. ERDC/CRREL TR-01-04. 85 pp.

Jorgenson, M.T., Racine, C.H., Walters, J.C. and Osterkamp, T.E., 2001b. Permafrost degradation and ecological changes associated with a warming climate in central Alaska. *Climatic change*, *48*(4), pp.551-579.

Jorgenson, M. T., J. E. Roth, M. Raynolds, M. D. Smith, W. Lentz, A. Zusi-Cobb, and C. H. Racine. 1999. An ecological land survey for Fort Wainwright, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. U.S. Army Cold Regions Research Engineering Laboratory, Hanover, NH CRREL Report 99-9. 83 pp.

Klein, E., Berg, E.E. and Dial, R., 2005. Wetland drying and succession across the Kenai Peninsula Lowlands, south-central Alaska. *Canadian Journal of Forest Research*, *35*(8), pp.1931-1941.

Myers-Smith, I.H., Harden, J.W., Wilmking, M., Fuller, C.C., McGuire, A.D. and Chapin Iii, F.S., 2008. Wetland succession in a permafrost collapse: interactions between fire and thermokarst. Biogeosciences, 5(5):1273-1286.

Post, R. A. 1996. Functional profile of black spruce wetlands in Alaska. US EPA, Alaska Operations Office, Seattle, WA. EPA/910/R-96/006. 170pp.

Racine, C.H., Jorgenson, M.T. and Walters, J.C., 1998, June. Thermokarst vegetation in lowland birch forests on the Tanana Flats, interior Alaska, USA. In *Proceedings of the Seventh International Conference on Permafrost* (Vol. 57, pp. 927-933). Québec: Université Laval.

Zoltai, S.C., Taylor, S., Jeglum, J.K., Mills, G.F. and Johnson, J.D., 1988. Wetlands of boreal Canada. *Wetlands of Canada, Ecological Land Classification Series*, *24*, pp.97-154.