16291

North American Arctic-Subarctic Tussock Tundra – Frequent Fire

BpS Model/Description Version: Nov. 2024

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| --- | --- | --- | --- |
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Reviewer: Phillip Barber, Robin Innes, Blaine Spellman

Vegetation Type

Herbaceous

Map Zones

68

Model Splits or Lumps

This Biophysical Setting (BpS) was split into frequent and infrequent fire variants so regional differences in fire frequency could be represented. The frequent fire variant applies to mapzone 68 within level 2 ecoregions (Nowacki et al. 2001) Intermontane Boreal and Bering Tundra. In all other areas the infrequent fire variant applies.

Geographic Range

This BpS occurs throughout arctic Alaska, from the Bristol Bay lowlands in southwestern Alaska to the North Slope on the Arctic Ocean as well as in lowland through subalpine zones of boreal and boreal transition (northern portion and higher elevation) regions of Alaska.

Biophysical Site Description

Tussock tundra is common in valleys and slopes throughout arctic Alaska. These sites are cold, poorly to very poorly drained, gleyed, and underlain by mesic, silty mineral soils often with a shallow, poorly decomposed organic horizon at the surface, which may constitute most of the active layer surrounding the tussocks (Viereck et al. 1992). Permafrost is usually present at depths of 30-55 cm. Frost scars are common. Lichens are more common on the drier tussock tundra sites in western Alaska, such as on adjacent loess covered and rounded slopes of plains, hill summits, and mountain summits (domes). Patch size is small to large. Tussock bog communities occur on lowlands of boreal and boreal transition Alaska, on filled-in sloughs on floodplains and on cold, poorly drained slopes and terraces. These sites are underlain by wet, silty mineral soils with a surface peat layer 10 to 40 cm thick surrounding the tussocks (Viereck et al. 1992).

Vegetation Description

Tussock tundra has >35% cover of sedges in a tussock growth form. The combined cover of dwarf- and low shrubs is <25%, and dwarf-shrubs may be common. Lichen cover is typically <25%. *Eriophorum vaginatum* is the primary tussock-former in most stands, but *Carex bigelowii* may dominate some sites. *Calamagrostis canadensis, Arctagrostis latifolia*, and *Chamerion latifolium (= Epilobium latifolium)* may be common (the latter, especially after fire). On wetter sites, *Vaccinium* spp. (= *Oxycoccus* spp.) and *Chamaedaphne calyculata* may be present. Shrubs include *Betula nana, Ledum palustre* ssp*. decumbens*, *Vaccinium vitis-idaea,* and *Vaccinium uliginosum*. Mosses (*Sphagnum* spp., *Polytrichum strictum*, and *Hylocomium splendens*) may form a nearly continuous mat between tussocks. Lichens may include *Flavocetraria cucullate (= Cetraria cucullata), Cetraria islandica, Cladonia* spp., *Cladonia rangiferina (= Cladina rangiferina)*, and *Thamnolia subuliformis*. There are also distinctions between acidic and non-acidic tussock tundra. Acidic sites have more ericaceous shrubs and *Sphagnum* and less *Eriophorum* spp., *Betula nana*, and *Carex bigelowii*. Acidic sites also have more organic matter build-up, and the tussocks tend to be larger.

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| ERVA4 | *Eriophorum vaginatum* | Tussock cottongrass |
| CABI5 | *Carex bigelowii* | Bigelow's sedge |
| VAOX | *Vaccinium oxycoccos* | Small cranberry |
| CHCA2 | *Chamaedaphne calyculata* | Leatherleaf |
| BENA | *Betula nana* | Dwarf birch |
| LEPAD | *Ledum palustre ssp. decumbens* | Marsh labrador tea |
| SPHAG2 | *Sphagnum spp.* | Sphagnum |
| PLSC70 | *Pleurozium schreberi* | Schreber's big red stem moss |

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

Disturbance Description

In 2013 an extensive search was done by FEIS staff to locate information for a synthesis on fire regimes of Alaskan tundra communities (Innes 2013). The literature reviewed at that time reported mean fire return interval estimates for tussock-shrub tundra ecosystems in Alaska during the late Holocene of:

* 260 years (range 30-840; Higuera et al. 2011) in Noatak National Preserve,
* 142 years (range 115-174; Higuera et al. 2011) in Noatak National Preserve,
* 263 years (range 175-374; Higuera et al. 2011) in Noatak National Preserve, and
* >5000 years on the North Slope (Jandt et al. 2008).

Jennifer Allen (personal communication) reported a fire-return interval of approximately 240yrs for tundra on the Seward Peninsula and 1,000yrs+ on the Beaufort Coastal Plain based on lake-core records. Charcoal sediment-based estimates of fire frequency for tundra in the Brook Range and to the north report fire frequencies of well over 1000 years (Sae-Lim et al. 2019).

More fires occur near the forest-tundra ecotone and spread further if trees are present (Heinselman 1981). Wein (1976) reports that July and August are the most common months for lightning fires in tundra ecosystems, while Racine et al. (1983; 1985) found that distinct fire seasons occur in both June and July in the Noatak River watershed. Subsidence and thermal erosion following fire is usually minimal in tundra ecosystems (Walker 1996).

The fire regime of tundra systems varies from one region to another, making generalizations difficult (Viereck and Schandelmeier 1980), and rapid recovery following fire makes fire frequency difficult to determine (Wein 1971). The fuel layer in sedge-shrub tussock tundra is dense and continuous and leads to large, fast spreading fires (Duchesne and Hawkes 2000; Racine et al. 1987). Racine (1979) found much variation in burn intensity on a landscape scale on the Seward Peninsula, from completely unburned to intensely burned. These patterns are related to variations in topography and the composition, moisture content, and soil organic accumulations of the plant communities. Fires in *Eriophorum* tussock tundra types tend to be light because of the wet soil profile (Wein 1971). Burns in this type usually consume all aerial woody and herbaceous plant material and litter; regeneration is vigorous via rhizomes and root sprouts. Racine (1979) found that burning was generally less severe in the tussock-shrub and sedge-shrub tundras than in the birch and ericaceous shrub tundra of the Seward Peninsula. He found that tundra burns were patchy, with unburned communities and unburned patches within burned communities.

In most areas of tussock-shrub tundra on the Seward Peninsula, less than one half of accumulated organic soil layer was removed by fire (Racine 1979). Thaw depths increased to reach into the mineral soils but were not greatly increased except where organics were removed. Frost features were made more conspicuous, and soil nutrient concentrations (K and P) increased locally.

In interior and southcentral Alaska Tussock Tundra sites, the thaw pond cycle (disturbance leads to thawing of permafrost and ponding) and paludification (Sphagnum layer buildup and saturation) are important disturbances. On the Seward Peninsula and western AK, frost action creates polygonal ground and other periglacial features and is a widespread, small-scale and continuous disturbance.

Change in the arctic and subarctic climate is another source of disturbance that is currently affecting tundra ecosystems.

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 122 | 100 |  |  |
| Moderate (Mixed) |  |  |  |  |
| Low (Surface) |  |  |  |  |
| All Fires | 122 | 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

Vegetation is found in large patches.

Wien (1976) reports many tundra fires in the 1 to 100 ha size range and few large (thousands of ha) fires. Racine (1979) reports that in 1977, lightning-caused fires burned 35,480 ha on the Seward Peninsula, with one fire burning 9,440 ha. Jandt and Meyers (2000) report that large fires (>200,000 ha) occur about every 10yrs in the Buckland Valley and surrounding highlands of the Seward Peninsula. Racine et al. (1983) found that 40 fires burned 100,000 ha (1000 km2) in the 30,000 km2 watershed of the Noatak River between 1956 and 1981. Racine et al. (1985) found a minimum fire size of .4 ha, a maximum fire size of 45,800 ha and a mean fire size of 1310 ha from 1956-1983 in the Noatak River watershed, an area dominated by tundra vegetation. Of the 79 fires analyzed by Racine et al. (1985), nearly half were between 1 and 10 ha in size. Forty-three percent of wildland fires occurring in interior Alaska occur in treeless areas, primarily tundra bogs and fens (Viereck 1975).

Adjacency or Identification Concerns

Issues or Problems

Most of the fire regime literature available for tundra ecosystems in Alaska is from the Seward Peninsula and Noatak River Watershed where fire occurs more frequently than other regions of the state (Innes 2013). Little is known about fire history in arctic tundra communities in northern and northwestern Alaska (Innes 2013).

Native Uncharacteristic Conditions

According to Innes 2013: “Because most of the area occupied by tundra in Alaska is sparsely populated and has little road access, fire regimes in tundra may not differ much from historical regimes [Chapin et al. 2000; DeWilde and Chapin 2006; Heinselman 1981]. As of 2006, about 66% of interior Alaska was considered to have an essentially "natural" fire regime, with few human ignitions, negligible suppression activity, and many large, lightning-caused fires.” Innes 2013 provides information about climate change and Alaska tundra communities.

Comments

1/2023 Kori Blankenship split the BpS model and description into frequent and infrequent fire model variants based on feedback from participants in the virtual Tundra Work Session held in the winter 2022. Jennifer Barnes suggested a fire return interval of approximately 120 years for the frequent fire model. Reviewer feedback is needed to refine the geographic range of the frequent and infrequent fire model variants.

In 2021 NatureServe merged Western North American Boreal Tussock Tundra

(BpS 1629), Alaska Arctic Tussock Tundra (BpS 16940), and Alaska Arctic Tussock-Lichen Tundra (16950) into one Ecological System: North American Arctic and Subarctic Tussock Tundra. Pat Comer and Kori Blankenship merged the BpS descriptions and used the 16290 state-and-transition model to represent the new Ecological System concept.

The 16290 BpS model and description was created by Jennifer Allen based on the Tussock Tundra 1 PNVG model description (Murphy and Witten 2006) and was reviewed by Lisa Saperstein and Stuart Chapin. The 16941 and 16942 BpS models and descriptions were created by Coleen Ryan, Kori Blankenship, and Keith Bogs with review by Janet Jorgenson. BpS 16950 was previously lumped with 16941 and 16942. Experts who attended LANDFIRE modeling meetings in Nov. 2007 and April 2008 provided input on BpS model development for all of these systems.

The 16290 state-and-transition model was originally developed with two herbaceous classes: a Mesic Graminoid Tussock and a Wet Graminoid Tussock class. When it was determined that the LANDFIRE project would not be able to distinguish these classes based on a Viereck et al. (1992) based existing vegetation map, these two classes were lumped into what is now Class A. Experts at the Fairbanks meeting indicated the need for a late seral sphagnum tussock bog stage that would develop as a result of paludification in Class B. The state-and-transition model does not include that stage because it would be hard to distinguish for mapping using LANDFIRE methods.

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 | UN | UN | UN | UN | UN | UN | UN | UN |
| Tree | 0-5 | B | B | UN | UN | UN | UN | UN | UN | UN | UN |
| Tree | 5-10 | B | B | UN | UN | UN | UN | UN | UN | UN | UN |
| Tree | 10-25 | B | B | UN | UN | UN | UN | UN | UN | UN | UN |
| Tree | 25-50 | B | B | UN | UN | UN | UN | UN | UN | UN | UN |
| Tree | >50 | B | B | UN | UN | UN | UN | UN | UN | UN | UN |

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 89 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| ERVA4 | *Eriophorum vaginatum* | Tussock cottongrass | Upper |
| CABI5 | *Carex bigelowii* | Bigelow's sedge | Upper |

Description

Mesic graminoid tussocks dominates for the first 10yrs or longer. First year following fire, *Eriophorum* (cottongrass) and *Carex* spp. (sedges) regrow via rhizomes, most vascular species begin to recover, and shrubs sprout from rootstock. Sedges often capture site 6-10yrs post fire. Grasses (*Calamagrostis* and *Arctagrostis*) are locally important following fire. A high severity fire can lead to increased shrub development, whereas a low to moderate severity fire typically leads to the development of a wet graminoid tussock stage.

Wet graminoid tussock can dominate some sites developing about 10yrs post fire. It is the most common stage after a low to moderate severity fire. Over time paludification results in the development of a sphagnum tussock bog (the model does not include the sphagnum tussock bog stage because it would be hard to distinguish for mapping using LANDFIRE methods). 4

*Maximum Tree Size Class*  
None

Class B 11 Late Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| CHCA2 | *Chamaedaphne calyculata* | Leatherleaf | Upper |
| VAOX | *Vaccinium oxycoccos* | Small cranberry | Upper |
| ERVA4 | *Eriophorum vaginatum* | Tussock cottongrass | Upper |
| CABI5 | *Carex bigelowii* | Bigelow's sedge | Upper |

Description

Dwarf shrub, tussock. Most common stage after a high severity fire. Tussocks dominated by *Eriophorum* (cottongrass) and *Carex* spp. (sedges). Common shrubs include *Oxycoccus* spp. (*Vaccinium oxycoccus*), *Chamaedaphne calyculata, Betula nana, Ledum decumbens,* and *Vaccinium* spp. Lichens begin to re-establish but do not reach former abundance until 50-120yrs following fire. Fire is difficult to detect even in the early stages of this class, however the proportions of species differs from the pre-burn community, with very few lichens, fewer shrubs and more sedges, grasses, and cottongrass. Former abundances of all species are typically reached 50-120yrs post fire.

*Maximum Tree Size Class*  
None

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Early1:ALL | 999 |
| Late1:ALL | 10 | Late1:ALL | 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 | Late1:ALL | 0.001 | 1000 | Yes | 0 |
| Replacement Fire | Early1:ALL | Early1:ALL | 0.0083 | 120 | Yes | 0 |
| Replacement Fire | Late1:ALL | Early1:ALL | 0.0083 | 120 | Yes | 0 |

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