16281

North American Arctic-Subarctic Shrub-Tussock Tundra – Frequent Fire

BpS Model/Description Version: Nov. 2024

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

Shrubland

Map Zones

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

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. For mapping BpS 16281 should apply in level 2 ecoregions (Nowacki et al. 2001): Intermontane Boreal and Bering Tundra.

Geographic Range

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

Biophysical Site Description

Tussock communities occur on gentle slopes, terraces, and old alluvial deposits. These sites are cold, poorly drained, and underlain by mesic, silty mineral soils with a surface peat layer 10 to 40 cm thick surrounding the tussocks. Soils may be neutral to slightly acidic, poorly drained, gleyed, and often with a poorly decomposed organic horizon at the surface, which may constitute most of the active layer. Permafrost is usually present at depths of 30-65 cm. Frost scars are common (Viereck et al 1992). See [Gushdoiman](https://soilseries.sc.egov.usda.gov/OSD_Docs/G/GUSHDOIMAN.html) soil series description.

Vegetation Description

This is a common lowland system dominated by tussock sedges and low shrubs. Tussock shrub tundra is common in valleys and slopes throughout arctic Alaska. Tussock shrub tundra has >35% cover of sedges in a tussock growth form, and the combined cover of dwarf- and low shrubs is >25%. *Eriophorum vaginatum* is the primary tussock-former in most stands, but *Carex bigelowii* may be the dominant tussock sedge on some sites. *Betula nana*, *Betula glandulosa*, *Salix pulchra*, and *Chamaedaphne calyculata* can dominate the low-shrub layer. Other species include *Ledum palustre* ssp. *decumbens*, *Ledum groenlandicum*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, *Empetrum nigrum*, and *Carex* spp. Grasses, including *Calamagrostis canadensis* and *Arctagrostis* spp. may also be present. Lichens are scarce (with the possible exception of *Peltigera canina*). There are also distinctions between acidic and non-acidic tussock tundra. Acidic sites have more ericaceous shrubs and *Sphagnum*, less *Eriophorum* spp., *Betula nana*, and *Carex bigelowii*, and have more organic matter buildup and the tussocks tend to be larger. *Aulacomnium palustre* and other moss species may be more common on less acid sites.

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| ERVA4 | *Eriophorum vaginatum* | Tussock cottongrass |
| CABI5 | *Carex bigelowii* | Bigelow's sedge |
| BENA | *Betula nana* | Dwarf birch |
| SAPU15 | *Salix pulchra* | Tealeaf willow |
| CHCA2 | *Chamaedaphne calyculata* | Leatherleaf |
| LEPAD | *Ledum palustre ssp. decumbens* | Marsh labrador tea |
| VACCI | *Vaccinium* | Blueberry |
| CACA4 | *Calamagrostis canadensis* | Bluejoint |
| ARCTA | *Arctagrostis spp.* | Polargrass |

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 in the Brook Range and to the north report fire frequencies of well over 1000 years (Sae-Lim et al. 2019). In the Yukon Flats, 13 of 31 sample plots were thought to be in some stage of fire succession, and the presence of *Betula neoalaska* in the plots was interpreted as a fire sere (Spellman pers. comm. 2022).

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.

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). Fires typically burn-off the shrub layer resulting in an herbaceous-dominated tussock system, but the shrubs often recover to their pre-fire cover within 15-20 years. The fuel layer in sedge-shrub tussock tundra is dense and continuous and leads to large, fast-spreading fires (Racine et al. 1987; Duchesne and Hawkes 2000). Racine (1979) found much variation in burn intensity on a landscape scale on the Seward Peninsula, from completely unburned to intensely burned, that tundra burns were patchy, with unburned communities and unburned patches within burned communities, and that burning was generally less severe in the tussock-shrub and sedge-shrub tundra than in the birch and ericaceous shrub tundra of the Seward Peninsula. Differences in topography, moisture, vegetation composition, and organic matter depth cause variation in burn severity and lead to a patchy burn pattern (Racine 1979). Fire severity in *Eriophorum* tussock tundra types tends to be light because of the wet soil profile (Wein 1976). Burns in this type usually consume all aerial woody and herbaceous plant material and litter; regeneration is vigorous via rhizomes and root sprouts. 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 soil 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. Subsidence and thermal erosion following fire are usually minimal in tundra ecosystems (Walker 1996).

On 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 Alaska, 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 | 178 | 99 |  |  |
| Moderate (Mixed) | 12755 | 1 |  |  |
| Low (Surface) |  |  |  |  |
| All Fires | 176 | 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 found in large patches to matrix forming.

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 in 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. Reviewer feedback is needed to refine the geographic range of the frequent and infrequent fire model variants.

This BpS is similar to the [Boreal Tussock Loamy Frozen Terraces Ecological Site Description](https://edit.jornada.nmsu.edu/catalogs/esd/232X/XA232X01Y209) (ESD XA232X01Y209).

In 2021 NatureServe merged Western North American Boreal Low Shrub-Tussock Tundra (BpS 1628) and Alaska Arctic Shrub-Tussock Tundra (BpS 1693) into one Ecological System: North American Arctic and Subarctic Shrub-Tussock Tundra. BpS 1693 was not previously modeled as a distinct system (it was lumped with 16941 and 16942). Pat Comer and Kori Blankenship revised the 1628 description to reflect the new Ecological System concept.

During LANDFIRE National, this model was based on the FRCC Guidebook PNVG model for Tussock Tundra 1 (TT1; Murphy and Witten 2006) and input from the experts who attended the LANDFIRE Fairbanks (Nov. 07) modeling meeting and was refined by Jennifer Allen. Much of the text in the Disturbance Description and Scale Description portion of this report were taken from the TT1 description (Murphy and Witten 2006). This model was created for the boreal region of AK and did not receive review for other parts of 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 | C | C | C | C | C | C | C | C | C | C |
| 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 7 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 |
| CACA4 | *Calamagrostis canadensis* | Bluejoint | Upper |
| ARCTA | *Arctagrostis* spp, | Polargrass | Upper |

Description

Mesic herbaceous-graminoid-tussock-sedge. 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.

*Maximum Tree Size Class*  
None

Class B 77 Mid Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| BENA | *Betula nana* | Dwarf birch | Upper |
| SALIX | *Salix* spp*.* | Willow | Upper |
| ERVA4 | *Eriophorum vaginatum* | Tussock cottongrass | Upper |
| CABI5 | *Carex bigelowii* | Bigelow's sedge | Upper |

Description

Low shrub-tussock. Tussocks are dominated by *Eriophorum* (cottongrass) and *Carex* spp. (sedges). Common shrub species include *Betula nana*, *Salix* spp., and *Vaccinium uliginosum*. 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 differ 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. Lichens, if present, have < 25% cover.

*Maximum Tree Size Class*  
None

Class C 16 Mid Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| BENA | *Betula nana* | Dwarf birch | Upper |
| SALIX | *Salix* spp*.* | Willow | Upper |
| ERVA4 | *Eriophorum vaginatum* | Tussock cottongrass | Upper |
| PECA60 | *Peltigera canina* | Felt lichen | Upper |

Description

Dwarf shrub-lichen-tussock. Tussocks are dominated by shrubs and lichens. Species composition is similar to that in Class B, but lichen cover is >25%.

References.

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.

Duchesne L. C. and B.C. Hawkes. 2000Fire in northern ecosystems. In: Brown, J.K. and J.K. Smith (eds.) Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol 2. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 257 p.

Heinselman, M.L. 1981. Fire and succession in the conifer forests of northern North America. In: West, D.C., H.H. Shugart, and D.B. Botkin. Forest succession: concepts and application. Springer-Verlag, New York. Chapter 23.

Higuera, P.E., M. Chipman, J. Allen, S. Rupp and F.S. Hu. 2008. Preliminary data provided by Jenifer Allen from a study of tundra fire regimes in the Noatak National Preserve since 6000 years before present.

Higuera, Philip E., Barnes, Jennifer L.; Chipman, Melissa L.; Urban, Michael; Hu, Feng Sheng. 2011. The burning tundra: a look back to the last 6,000 years of fire in the Noatak National Preserve, northwestern Alaska. Alaska Park Science. 10(1): 37-41.

Higuera, Philip E.; Chipman, Melissa L.; Barnes, Jennifer L.; Urban, Michael A.; Hu, Feng Sheng. 2011. Variability of tundra fire regimes in Arctic Alaska: millennial-scale patterns and ecological implications. Ecological Applications. 21(8): 3211-3226.

Innes, Robin J. 2013. Fire regimes of Alaskan tundra communities. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us

/database/feis/fire\_regimes/AK\_tundra/all.html [2016, June 28].

Jandt, R.J. and R.C. Meyers. 2000. Recovery of lichen in tussock tundra following fire in Northwestern Alaska. USDOI BLM-Alaska Open File Report 82.

Jandt, Randi; Joly, Kyle; Meyers, C. Randy; Racine, Charles. 2008. Slow recovery of lichen on burned caribou winter range in Alaska tundra: potential influences of climate warming and other disturbance factors. Arctic, Antarctic, and Alpine Research. 40(1): 89-95.

Murphy, K.A. and E. Witten. 2006. Tussock Tundra 1. In Fire Regime Condition Class (FRCC) Interagency Guidebook Reference Conditions. Available at www.frcc.gov.

Payette, S., C. Morneau, L. Sirois, M. Desponts. 1989. Recent fire history of the northern Quebec biomes. Ecology. 70:656-673.

Personal communication experts’ workshop, March 2-4 2004. Fire Regime Condition Class (FRCC) interagency experts’ workshop to develop and review Potential Natural Vegetation (PNV) groups for Alaska. Anchorage, Alaska.

Racine, C.H., L.A. Johnson, L.A. Viereck. 1987. Patterns of vegetation recovery after tundra fires in northwestern Alaska, USA. Arctic and Alpine Research. 19:461-469.

Racine. 1979. Climate of the Chucki-Imuruk area. Pages 32-37 in H. R. Melchior, ed., Biological Survey of the Bering Land Bridge National Monument. Alaska Cooperative Park Studies Unit, University of Alaska Fairbanks, Fairbanks, AK.

Racine, C. H., W. A. Patterson III, and J. G. Dennis. 1983. Permafrost thaw associated with tundra fires in northwest Alaska. Pages 1024-1029 in Proceedings, Permafrost, Fourth International Conference. National Academy Press, Washington, D.C.

Racine, C.H.; J.G. Dennis and W.A. Patterson III. 1985. Tundra fire regimes in the Noatak River Watershed, Alaska: 1956-83. Arctic 38:194-200.

Racine, C; J.L. Allen and J.G. Dennis. 2006. Long-term monitoring of vegetation change following tundra fires in Noatak National Preserve, Alaska. Arctic Network of Parks inventory and monitoring program, National Park Service, Alaksa Region. Report no. NPS/AKRARCN/NRTR-2006/02.

Sae-Lim, J., Russell, J. M., Vachula, R. S., Holmes, R. M., Mann, P. J., Schade, J. D., and Natali, S. M. 2019. Temperature-controlled tundra fire severity and frequency during the last millennium in the Yukon-Kuskokwim Delta, Alaska. The Holocene. 29(7): 1223-1233.

Viereck, L.A. 1975. Forest ecology of the Alaska Taiga. In: Proceedings of the circumpolar conference on northern ecology; 1975 September; Ottawa, ON. National Research Council of Canada: I-1 to I-22.

Viereck et al. 1992. The Alaska vegetation classification. Pacific Northwest Research Station, USDA Forest Service, Portland, OR. Gen. Tech. Rep. PNW-GTR286. 278 p.

Viereck, L.A.; Schandelmeier, L.A. 1980. Effects of fire in Alaska and adjacent Canada--a literature review. BLM-Aalska Tech. Rep. No. 6. Anchorage, Alaska: U.S. Department of the Interior, Bureau of Land Management. 124 p

Walker, D.A. 1996. Disturbance and Recovery of Arctic Alaskan Vegetation. In: JF Reynolds and JD Tenhunen eds, Landscape function and disturbance in arctic tundra. Ecological studies vol. 120, Springer Verlag Berlin Heidleberg

Wein, R.W. 1971. Panel discussion: In: Slaughter, C.W., Barney, Richard J., and Hansen, G.M. (editors). 1971. Fire in the Northern Environment – A Symposium. Sponsors: Alaska Forest Fire Counc il and Society of American Foresters. Held at: The University of Alaska, Fairbanks. April 13-14, 1971. Published by: Pacific.

Wein, R.W. 1976. Frequency and characteristics of arctic tundra fires. Arctic 29: 213-222.