

Ecosystems of Northern Alaska

ABSTRACT

Torre Jorgenson, ABR, Inc., Fairbanks, AK, tjorgenson@abrinc.com
Michael Heiner, The Nature Conservancy, Seattle, WA, mheiner@tnc.org

In response to a need for a unified ecological map for ecoregional planning in northern Alaska by the Nature Conservancy, we developed a map of local-scale ecosystems (ecotypes) that encompasses the Brooks Range, foothills, and Beaufort Coastal Plain ecoregions. Our approach to ecological land classification and mapping combined vegetation structure associated with existing landcover maps derived from satellite image processing, with physiography (i.e., coastal, floodplain, alpine), topography (DEM modeling), and bedrock characteristics to model ecotypes that best partition geomorphic, hydrologic, pedologic, and vegetative characteristics. We developed a classification that included 7 alpine, 9 upland, 5 lowland, 10 riverine, 4 coastal, and 1 human-modified ecotypes that encompass a broad diversity of ecological characteristics ranging from boreal forests in the southern Brooks Range to brackish meadows along the Beaufort Sea coast. As input to map development, we used four existing landcover maps for the North Slope by Muller et al. (1999), Gates of the Arctic National Park and Preserve by the Earth Satellite Corporation and Alaska Natural Heritage Program (1999), northwest Alaska parks by the National Park Service (1999), and the Arctic National Wildlife Refuge by Markon (1986). For physiography, we manually delineated floodplains and coastal areas at 1:100,000-scale on NASA Geocover satellite imagery, and differentiated alpine, upland and lowland areas by using a digital elevation model to characterize elevation, slope, moisture index, and land position (concavity/convexity index). Bedrock geology was adapted from Moore et al. (1994). Glacial extent was obtained from USGS maps, as compiled by Manley (pers. comm.). Rule-based models were developed to recode the map classes from the individual landcover maps into ecotypes. In the resulting map of the 308,208-km² area, 57% of the area has upland, 18% has alpine, 17% has lowland, 5% has riverine, 3% has coastal, and <0.1% has human-modified ecotypes. Each ecotype typically is associated with 2–4 geomorphic units, 2–4 climatically related soil types, 1–3 plant associations, and differing permafrost conditions. For ecoregional planning, the map was used to identify rare ecosystems and high-value wildlife habitats deserving priority protection.



ECOTYPE DESCRIPTIONS

Alpine Glaciers: Perennially frozen snow and ice at high elevations, typically on north-facing slopes.

Alpine Non-carbonate Barrens: Barren (<5% plant cover) to partially vegetated (5–30%) alpine non-carbonate bedrock and talus slopes above treeline in the Brooks Range. Bedrock includes felsic intrusive (e.g., granite), noncarbonate metamorphic (e.g., schist), and noncarbonate sedimentary (e.g., sandstone, shale) rocks that generally have low calcium and sodium and high aluminum concentrations that lead to acidic soils. Soils are rocky, excessively drained, lacking in surface organic accumulations, and strongly acidic (pH < 5.5). At high elevations, common species include *Carex bigelowii*, *Saxifraga bronchialis*, *S. rigida*, *S. rivularis*, *S. eschscholtzii*, and crustose and fruticose lichens.

Alpine Carbonate Barrens: Barren (<5% plant cover) to partially vegetated (5–30%) alpine carbonate bedrock and talus slopes in the Brooks Range. Bedrock includes both sedimentary (limestone, dolostone) and metamorphic (marble) carbonate rocks. Soils are rocky, excessively drained, lacking in surface organic, and alkaline (pH > 7.3). Common pioneering plants include *Dryas integrifolia*, *D. octopetala*, *Saxifraga oppositifolia*, *Potentilla uniflora*, *Oxytropis nigrescens*, *O. arctica*, and *Carex rupestris*.

Alpine Mafic Barrens: Barren areas on intermediate, mafic, and ultramafic plutonic rocks above treeline that typically have dark-colored mineral assemblages with abundant iron and magnesium. Soils are rocky, excessively drained, lacking in surface organic accumulations, and are neutral to alkaline.

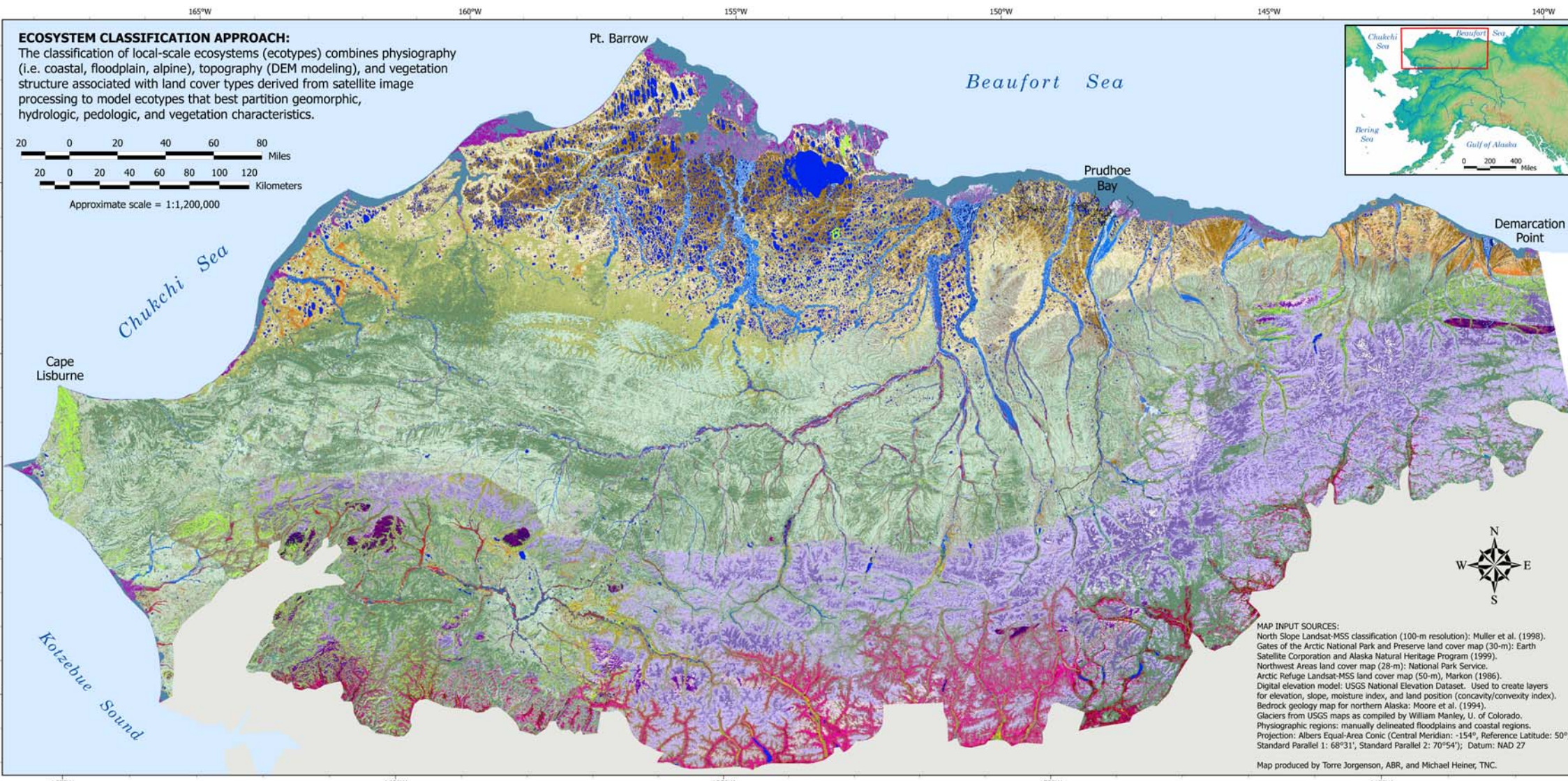
Alpine Non-carbonate Dwarf Shrub: Areas on carbonate bedrock and talus slopes above treeline in the Brooks Range with dwarf shrub vegetation. Soils are rocky, excessively drained, rich in iron and magnesium, and are neutral to alkaline. Vegetation is poorly described for this type but is probably similar to that described for Alpine Noncarbonate Dwarf Shrub Tundra.

Alpine Carbonate Dwarf Shrub: Areas on carbonate bedrock and talus slopes above treeline in the Brooks Range with dwarf shrub vegetation. Soils are rocky, excessively drained, rich in iron and magnesium, and are neutral to alkaline. Some areas have high levels of trace metals. Vegetation is poorly described for this type but is probably similar to that described for Alpine Noncarbonate Dwarf Shrub Tundra.

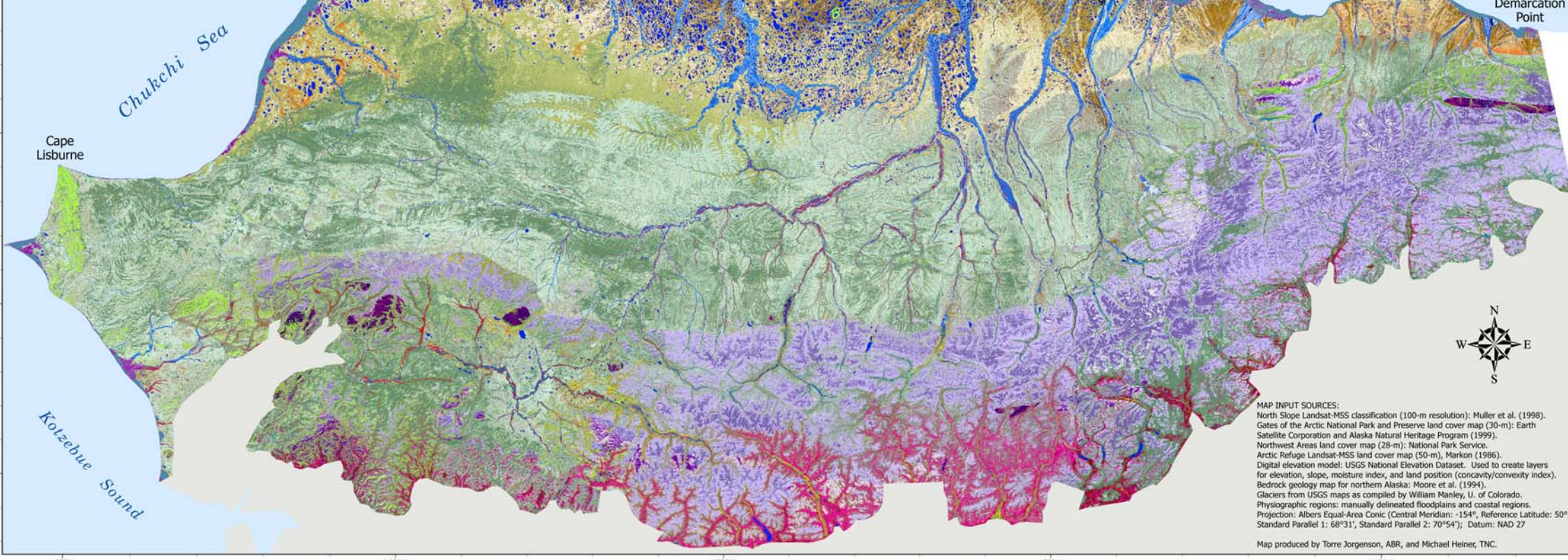
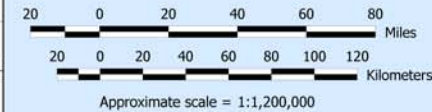
Alpine Mafic Dwarf Shrub: Areas on intermediate, mafic, and ultramafic plutonic rocks at high elevations with dwarf shrub vegetation. Rocks have dark-colored mineral assemblages with abundant iron and magnesium. Soils are rocky, excessively drained, lacking in surface organic accumulations, and are neutral to alkaline. Some areas have high levels of trace metals. Vegetation is poorly described for this type but is probably similar to that described for Alpine Noncarbonate Dwarf Shrub Tundra.

Upland Shrubby Tussock Tundra: Gently sloping uplands and ridges on loess and colluvium (primarily <120 m elev.), with vegetation dominated by low shrubs, usually having moderately thick surface organic, and are underlain by ice-rich permafrost. The open tree canopy is closed canopy of *Betula papyrifera* and *Picea mariana*. The understorey includes *Alysicarpus*, *Vaccinium vitis-idaea*, *Ledum*, *Empetrum nigrum*, *Rosa acicularis*, *Shepherdia canadensis*, *Spiraea beauverdrana*, *Liriodendron boreale*, *Calluna vulgaris*, *Hylocomium splendens*, and *Cladonia rangiferina*.

Upland Spruce Forest: Upland areas on mid- to upper slopes on weathered bedrock, colluvium, and glacial till with needletree forests. Soils are loamy to rocky, well-drained, have thin organic horizons, and are circumneutral to acidic. Dwarf shrubs include *Dryas octopetala* (mostly south slopes), *D. integrifolia*, *Saxifraga oppositifolia*, *Saxifraga arctica*, and *Arctostaphylos alpina*. Other species include *Carex rupestris*, *C. bigelowii*, *Najas*, *Saxifraga oppositifolia*, *Potentilla uniflora*, *Oxytropis nigrescens*, *O. arctica*, *Nephraria arctica*, *Rhizidium nigricans*, *Flavocetraria pallidula*, and *Arthmia vermicularis*.



ECOSYSTEM CLASSIFICATION APPROACH: The classification of local-scale ecosystems (ecotypes) combines physiography (i.e. coastal, floodplain, alpine), topography (DEM modeling), and vegetation structure associated with land cover types derived from satellite image processing to model ecotypes that best partition geomorphic, hydrologic, pedologic, and vegetation characteristics.



MAP INPUT SOURCES:
North Slope Landsat-MSS classification (100-m resolution): Muller et al. (1998), Gates of the Arctic National Park and Preserve land cover map (30-m): Earth Satellite Corporation and Alaska Natural Heritage Program (1999). Northwest Areas land cover map (28-m): National Park Service. Arctic Refuge Landsat-MSS land cover map (50-m): Markon (1986). Digital elevation model: USGS National Elevation Database. Used to create layers for elevation, slope, moisture index, and land position (concavity/convexity index). Bedrock geology map for northern Alaska: Moore et al. (1994). Glaciers from USGS maps as compiled by William Manley, U. of Colorado. Physiographic regions: manually delineated floodplains and coastal regions. Projection: Albers Equal-Area Conic (Central Meridian: -154°, Reference Latitude: 50°, Standard Parallel 1: 68°31', Standard Parallel 2: 70°54'); Datum: NAD 27

Map produced by Torre Jorgenson, ABR, and Michael Heiner, TNC.

MODELING APPROACH

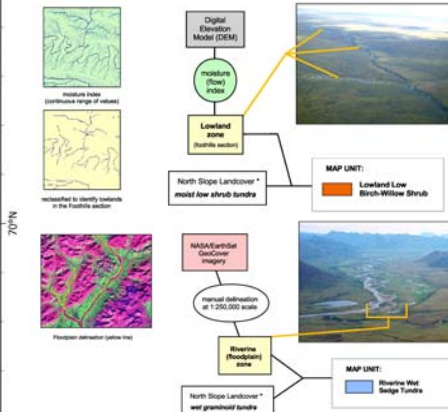


Table 1. Areal extent of ecotypes in northern Alaska.

	Beaufort Coastal Plain Area (%)	Brooks Foothills Area (%)	Brooks Range Area (%)	Total Area km ²	%
Alpine Glaciers	0.0	0.2	234	0.1	
Alpine Noncarbonate Barrens	0.0	12.7	16016	5.2	
Alpine Carbonate Barrens	0.0	1.0	1281	0.4	
Alpine Mafic Barrens	0.0	0.4	568	0.2	
Alpine Noncarbonate Dwarfs Dwarf Shr.	0.3	26.8	34188	11.1	
Alpine Carbonate Dwarfs Dwarf Shrub	0.0	1.4	1732	0.6	
Alpine Mafic Dwarfs Dwarf Shrub	0.0	0.4	479	0.2	
Upland Spruce Forest	4.9	6252	2.0		
Upland Birch-Aspen-Spruce Forest	0.2	0.2	216	0.1	
Upland Tall Alder Scrub	0.1	3.0	3926	1.3	
Upland Low Birch-Willow Scrub	0.0	28.3	22.8	61876	20.1
Upland Shrubby Tussock Tundra	0.3	46.0	8.5	58117	18.9
Upland Tussock Tundra	12.2	8.0	0.0	17336	5.6
Upland Dwarf Dryas Scrub Tundra	1.5	1.0	4.3	7533	2.4
Upland Moist Sedge-Shrub Tundra	0.5	10.1	6.3	20711	6.5
Lowland Spruce Forest	1.4	171	0.6		
Lowland Birch Forest	0.2	2.2	0.1		
Lowland Birch-Willow Scrub	1.9	0.8	0.8	3217	1.0
Lowland Moist Sedge-Shrub Tundra	25.0	3.0	0.0	19792	6.4
Lowland Wet Sedge Tundra	20.1	2.1	0.3	16034	5.2
Lowland Water	14.1	0.6	0.5	10556	3.4
Riverine Spruce Forest	0.4	521	0.2		
Coastal Wet Sedge Tundra	0.2	29	0.0		
Riverine Balsam Poplar Forest	0.0	29	0.0		
Riverine Tall Alder-Willow Scrub	0.1	109	0.0		
Riverine Low Willow Scrub Tundra	0.3	0.9	0.3	1585	0.5
Riverine Dry Dwarfs Dwarf Shrub	3.7	2.0	0.8	630	0.2
Riverine Moist Sedge-Shrub Tundra	2.2	0.5	0.1	2104	0.7
Riverine Wet Sedge Tundra	1.3	0.7	0.3	1985	0.6
Riverine Waters	1.4	0.3	0.2	1558	0.5
Coastal Wet Sedge Tundra	10.8	0.3	0.2	7380	2.4
Coastal Grass & Dwarf Shrub Tundra	2.1	0.2	0.2	1550	0.5
Coastal Wet Sedge Tundra	2.0	0.0	0.0	1353	0.4
Coastal Barrens	0.8	0.0	0.0	546	0.2
Clouds, Ice, Snow	0.0	0.2	1.1	1556	0.5
Total (less Coastal Water & Clouds)	64683	115407	126316	308208	

Coastal Grass and Dwarf Shrub Tundra: Low-lying, salt-affected areas along the coast with vegetation dominated by either grasses or dwarf shrubs. Soils are well-drained, slightly saline, and alkaline. On active dunes and beaches, vegetation includes *Elymus arvensis*, *Chrysanthemum bipinnatum*, *Puccinellia* spp., *Artemisia tiliifolia*, and *Salix ovalifolia*. Well-drained inactive tidal flats dominated by dwarf shrub vegetation have *S. ovalifolia*, *Stellaria humifusa*, *E. arvensis*, *Deschampsia caespitosa*, *DuRoiia fisheri*, *Carex subsubspicata*, and *A. tiliifolia*. Inactive dunes with slightly saline sandy soils have dwarf shrub vegetation dominated by *Empetrum nigrum*, *S. ovalifolia*, *E. arvensis*, *Lathyrus maritimus*, *C. subspicata*, and lichens. Substantial areas of this class include Lowland Moist Sedge-Shrub Tundra.

Coastal Wet Sedge Tundra: Low-lying, salt-affected areas on tidal flats, deltas, and muddy beaches along the coast that are frequently flooded. Soils are poorly drained, clayey to loamy, usually lack surface organic, and are brackish and alkaline. The soils are underlain by ice-poor permafrost. Vegetation is dominated by *Carex subsubspicata*, *Carex usina*, and *Puccinellia phryganeae*, with *DuRoiia fisheri*, *Puccinellia andersonii*, *Cochlearia officinalis*, and *Stellaria humifusa* also common. Nonvascular plants usually are absent. Substantial areas of Lowland Wet Sedge Tundra are included in these mapped areas but could not be adequately differentiated.

Coastal Barrens: Barren or partially vegetated areas on tidal flats, deltas, and muddy beaches along the coast that are frequently flooded. Soils are poorly drained, clayey to loamy, usually lack surface organic, brackish, acidic to alkaline, and are underlain by ice-poor permafrost. Common colonizing plants include *Deschampsia caespitosa*, *Elymus arvensis*, *Salix ovalifolia*, *Stellaria humifusa*, and *Cochlearia officinalis* in well-drained areas, and *Puccinellia phryganeae*, *DuRoiia fisheri*, and *Carex subsubspicata* in wet areas. This class includes tundra that has been killed by salinizer intrusions from storm surges and partly colonized by salt-tolerant plants.

Coastal Water: Shallow (<2 m) estuaries, lagoons, embayments, and tidal ponds along the coast of the Beaufort and Chukchi Seas. Winds, tides, river discharge, and likely create dynamic changes in physical and chemical characteristics. Salinity ranges widely from brackish near rivers to saline in unprotected areas. Tidal ranges normally are small (<0.2 m) along the Beaufort and moderate (0.5–1 m) along the Chukchi Seas, but storm surges produced by winds may raise sea level as much as 2–3 m. The ice-free period extends from July until October.

Marine Water (not mapped): Deep (>2 m) marine waters of the Beaufort and Chukchi Seas outside of lagoons and barrier islands. Coverage is highly variable from permanent pack ice to seasonally ice free areas. Small areas of Marine Water included in Coastal Water for mapping purposes.

Human Modified: Barren or partially vegetated areas resulting from human disturbance. As mapped, the areas are predominantly roads, pads, and mine pits and overburden.

Cloud, Snow and Ice: Areas with clouds, snow, and ice. The Clouds and Ice Class was combined with the Shadow classes for the final map. Most of the original shadow classes in the Brooks Range were recoded to alpine classes based on modeling. Remaining shadow areas are mostly due to clouds. Auefs on rivers was classified as Riverine Barrens.

References: Earth Satellite Corporation. 1999. Gates of the Arctic National Park and Preserve Landcover Map and User's Guide. Final Report prepared for the National Park Service, Anchorage, AK, by Earth Satellite Corporation and Alaska Natural Heritage Program.

