



Denali National Park and Preserve

Landcover Mapping Project

Volume 2: Landcover Classes and Plant Associations

Natural Resource Technical Report NPS/DENA/NRTR—2001/002



ON THE COVER

View of cloud shrouded peak in Denali National Park and Preserve.
Photo by EarthSat Corp. and AK Natural Heritage Program.

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ABSTRACT

Boggs, K., A. Garibaldi, J. L. Stevens, J. Grunblatt, and T. Helt. 2001. Denali National Park and Preserve landcover mapping project Volume2: Landcover classes and plant associations. Natural Resource Technical Report NPS/DENA/NRTR—2001/002. National Park Service, Fort Collins, Colorado.

As part of the Inventory and Monitoring Program of the National Park Service in Alaska, the Alaska Support Office of NPS in collaboration with the Alaska Natural Heritage Program and Earth Satellite Corporation, conducted a landcover mapping project for Denali National Park and Preserve. This document provides the following information: climate and ecoregions, literature review, methods, landcover classes and plant associations. The landcover map was developed at intermediate scales (1:63,360 - 1:100,000) using Spot and Landsat Thematic Mapper multi-spectral imagery. A separate document (Stevens et al. 2001) details the production of the map.

The landcover classification system used for mapping is based primarily on vegetation structure (plant height) and form (tree, shrub or herbaceous), and to a lesser extent genera (*Picea*) and species (*Picea mariana*) information. The classification, with modifications, follows The Alaska Vegetation Classification (Viereck et al. 1992) system at levels III and IV. Development of the classification was based on a pre-fieldwork list of classes using local knowledge and a literature/data review. The classification system was field checked during July 1999 using a helicopter to reach sampling polygons. A stratified random approach—based on ecoregions, aspect, slope and unsupervised satellite imagery—was used to select polygons for field sampling both fly-over and ground data polygons. Fly-over polygons were used primarily for training the satellite imagery and describing landcover classes (life form and structure), whereas ground data was used for finer scale descriptions (species, structure and soils) of the landcover classes. Data collected for fly-over and ground data included vegetation structure, plant species, percent cover, elevation, as well as other site information. The final map classes were based on numerous iterations using the field data and image processing results.

A total of 25 landcover classes were described for Denali. The distribution of landcover types in the Denali project area is as follows: 0.8 % area in Dense-Open Spruce Forest, 9.1% area in Open-Woodland Spruce Forest, 14.2% area in Open-Woodland Stunted Spruce, 1.6% area in Broadleaf Forest, 2.5% area in Mixed Spruce-Broadleaf Forest, 4.3% area in Alder Shrub, 1.6% area in Willow Shrub, 0.9% area in Closed Low Birch Shrub, 9.5% area in Low Shrub Birch-Ericaceous-Willow, 4.6% area in Low Shrub-Sedge, 0.04% area in Peatland, 1.1% area in Herbaceous/Shrub, 5.8% area in Dwarf Shrub, 1.2% area in Dwarf Shrub-Rock, 0.8% area in Dry-Mesic Herbaceous, 0.6% area in Wet Herbaceous, 0.01% area in Aquatic Herbaceous, 4.8% area in Sparse Vegetation, 9.8% area in Bare ground, 15.5% area in Snow/Ice, 6.9% area in Shadow, 0.5% area in Silty Water, 1.0% area in Clear Water, 2.9% area in Burn, and 0.01% area in Cloud.

Plant associations were described using the ground data and a literature review. Plant associations provide a hierarchical link between the coarse scale landcover classes and finer scale species information. Plant association is the finest level of both the Viereck et al. (1992) and National Vegetation Classification System (Grossman et al. 1998) classifications. Plant associations previously described by Heebner (1982) were copied and placed under the landcover class they occur in. Plant associations not defined by Heebner (1982) but sampled during the 1999 field season were also described and placed under the proper landcover class. A total of 97 plant associations were described; 56 were based on Heebner (1982) and 41 on the 1999 field data.

Keywords: Alaska, Denali National Park and Preserve, classification, landcover class, plant association

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INTRODUCTION

This user's guide provides descriptions of the landcover classes and plant associations used to develop a landcover map for Denali National Park and Preserve (Denali; Figure 1). Additional user's guide information includes descriptions of the major landscapes and ecoregions, and methods used to develop the landcover classes and plant associations. Information pertaining to remote sensing analyses, modeling and digital map accuracy assessment are presented in Volume 1 of the Denali National Park and Preserve landcover mapping project (Stevens et al. 2001). This work was conducted by Earth Satellite Corporation (EARTHSTAT) and the Alaska Natural Heritage Program (AKNHP), Environment and Natural Resources Institute, University of Alaska Anchorage, in collaboration with the Alaska Support office of the National Park Service (NPS), as part of its Inventory and Monitoring Program.

The Inventory and Monitoring Program of NPS is designed to provide reliable and consistent information for assessing the status and trends in the condition of National Park ecosystems. Vegetation mapping is conducted under the inventory portion of the program in order to provide basic information readily useful for making resource management decisions, and to collect data that can be aggregated on a service-wide level for designing monitoring programs. The Denali landcover map can also be used to understand habitat and fuels availability, model the occurrence of archaeological sites and sensitive species, for park planning, and to provide baseline information about natural resources in the park.

The decision to use satellite imagery for the project was based on the very remote and vast project area, the level of mapping information required by NPS, the spatial, and spectral characteristics of the available sensors/data, and the time and budget costs of the project. Denali landcover was mapped at intermediate scales (1:63,360 - 1:100,000) with 25 classes, using a classification based primarily on vegetation structure (plant height) and form (tree, shrub or herbaceous), and to lesser extent genera (*Picea*) and species (*Picea mariana*) information. The mapping classification, with modifications, follows The Alaska Vegetation Classification (Viereck et al. 1992) system at levels III and IV.

The usefulness of a landcover map to land managers is increased dramatically when the landcover classes are linked to finer scale units that reflect plant species and vegetation structure, such as given in plant associations (Grossman et al. 1998). These were developed using the ground data and a literature/data review. Plant association is the finest hierarchical level of both the Alaska Vegetation Classification (Viereck et al. 1992) and the National Vegetation Classification System (Grossman et al. 1998) classification. It is defined as "a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (Flahault and Schroter 1910). Alliance is the next coarser scale within the National Vegetation Classification System and is similar to level IV of the Alaska Vegetation Classification. It is defined as "a physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation" (Grossman et al. 1998). We always attempted to define plant associations with the data available, but if data was limited then the broader scale Alliance level was described. Both Plant associations and alliances were then nested within the coarser scale landcover map classes. A total of 96 plant associations and one alliance were defined.

LITERATURE REVIEW

Vegetation/Landcover Maps

The only landcover maps that cover all of Denali were developed at a statewide scale. Viereck and Little (1972) developed a statewide map of vegetation using eight vegetation classes and one ice and snow class. An AVHRR—1-km pixel—map for Alaska was developed by Fleming (1997). The Alaska

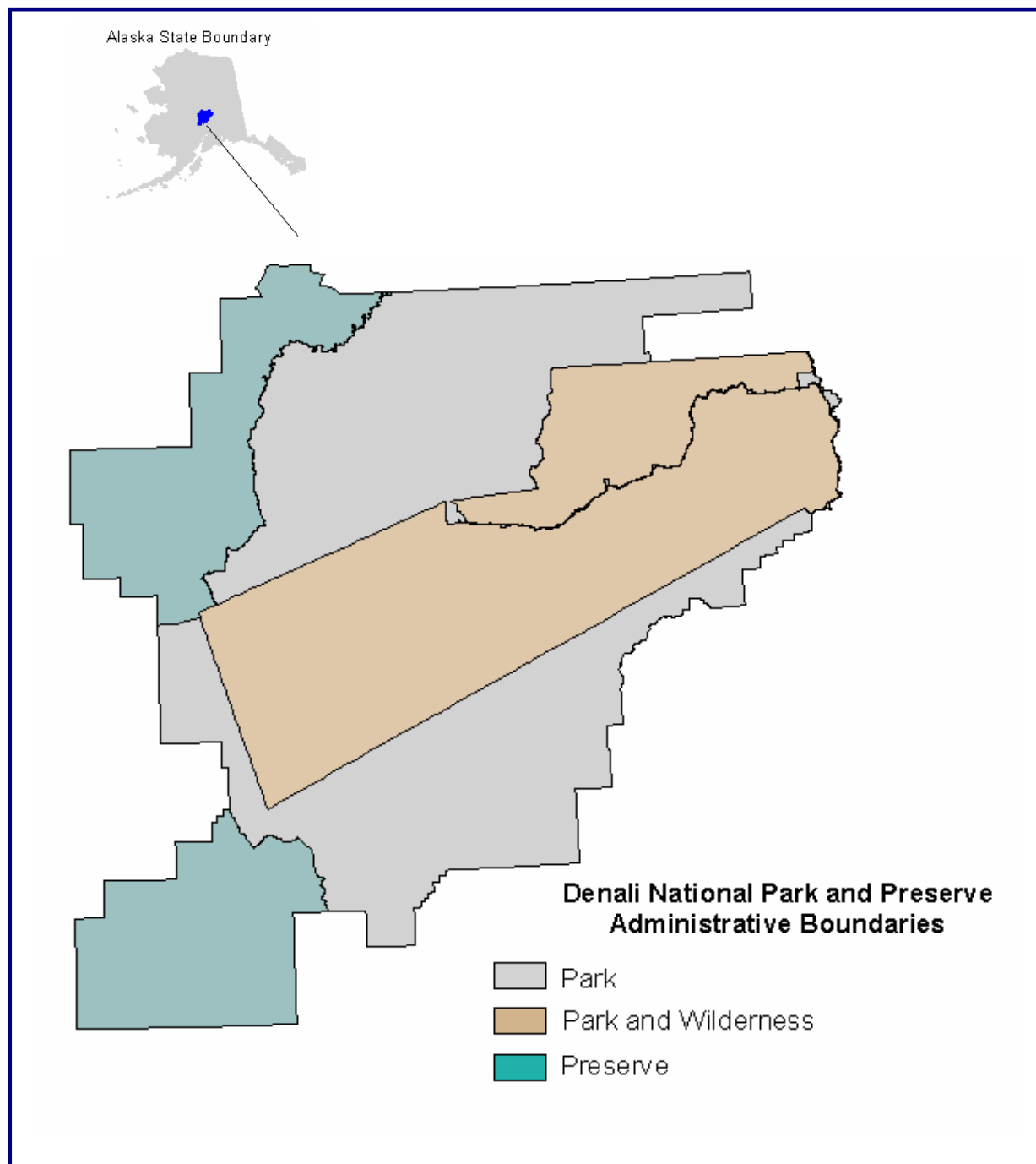


Figure 1. The location and administrative boundaries of Denali National Park and Preserve.

regional profiles, Arctic region (Selkregg 1975) also provides general maps and descriptions of the regions people, economics, wildlife, geology and vegetation.

Several landcover maps exist that cover portions of Denali. Dean and Heebner (1982) developed four vegetation maps based on 1974 and 1976 LANDSAT scenes. Heebner (1976) developed a map of Caribou habitats. A map of Reindeer habitats was developed for Denali using photo interpretation (Hanson 1950). A 1:1200 map of vegetation on Kantishna Hills mining claims was developed by the National Park Service (1987). Douglas (1994) used Advanced Very High Resolution Radiometry satellite data to predict berry productivity and availability over a broad landscape.

Plant Association Classifications

A variety of vegetation classifications—often with associated maps—have been developed that cover all or portions of Denali. For Alaska as a whole, the Alaska Vegetation Classification (Viereck et al. 1992) provides in-depth descriptions of vegetation at multiple scales. However, few vegetation description studies have been conducted in Denali. Heebner (1982) developed a plant community classification for much of Denali, based on 391 plots. The community descriptions include composition, structure and canopy cover. Shelton (1961) described Denali's vegetation zonation patterns on two mountain slopes. The study was primarily descriptive with minimal environmental measurements. Viereck (1966) described vegetation communities along the outwash of the Muldrow Glacier. Densmore (1991) described the restoration of plant communities in alpine and subalpine communities disturbed by construction and in riparian ecosystems and communities following placer mining (Densmore 1994). Densmore (1992) also developed an ongoing study to monitor plant communities in the Rock Creek watershed, and determine the role of natural change (wildfire, flooding, climatic variation).

Floristics

The floras of Alaska and floristic surveys of Denali proved valuable for understanding species distribution in Denali. The vascular plant floras of Alaska included Hulten (1968), Viereck and Little (1972), Argus (1973) and Welsh (1974). A local flora of Denali National Park (Pratt and Pratt 1993) provided color plates of the dominant flora. Numerous other floristic inventories have been conducted over the years in Denali.

Soils

Two soil maps are available for Denali (Rieger et al. 1979 and Clark 1998). The statewide soil survey (Rieger et al. 1979) provides coarse level soils information for Alaska but was too coarse to be useful for vegetation mapping and stratification purposes.

Clark (1998) is currently developing a soil/ecosite map for all of Denali. The map scale is 1:63,360 and the minimum delineation size is approximately 40 acres. Soil map units are primarily associations of two or more soils at the family level. Line symbols will be used to designate riparian areas if these areas are considered apriority. A three phase approach is being used to build the soils maps including: (1) selecting and premapping representative study sites for each subsection using air photo interpretation, (2) field investigation of premapped soil boundaries and data collection, and (3) extrapolating information obtained from the study sites to the remainder of the subsection using available tools.

Field documentation is being collected by transecting representative map unit delineations within the study sites. Transects consist of a series of data collection stops to determine the types and composition of soils and vegetation within each map unit. Multiple sampling is also used to establish the range of soil and site characteristics for each map unit and component. All data is being incorporated into a relational database for analysis and to serve as a permanent data record.

Ecoregions

Two coarse scale ecoregional maps are currently widely used in Alaska: Ecoregions of Alaska by Gallant et al. (1995) and Ecoregions and subregions of the United States by Bailey et al. (1994). They have been developed for the purposes of implementing ecosystem management, which requires working definitions of ecosystems and supporting inventories of the components that comprise ecosystems. Both ecoregional maps use similar approaches to defining and describing ecoregions. For Denali, the ecoregional maps are only available at the scale, 1:5,000,000.

Bailey et al.'s (1994) ecoregional hierarchy consists of seven levels of ecological units from the Domain, which is the most general level, to the Landtype Phase. A map of the upper four levels (Domain, Division, Province and Section), developed using a top-down approach of progressively subdividing the land surface into smaller segments, was developed for all of Alaska by Nowacki and Brock (1995). Descriptions and other data for the Section level are included in McNab and Avers (1994) and Bailey et al. (1994).

Subsection and Landtype Association levels of the hierarchy that are provided in this report are products of the Denali Park Soil Survey (Appendix 5; Clark 1998). Subsections are aggregations of Landtype Associations based on similarities in surficial geology, geomorphic processes, soil groups, and potential vegetation.

DESCRIPTION OF PROJECT AREA AND ENVIRONMENT

Denali encompasses much of the central Alaska Range and its elevation ranges from approximately 40 meters to 6,096 meters. The landcover project area includes 6,029,270 million acres within the boundaries of Denali National Park and Preserve, as well as a 16 kilometer wide buffer bordering the park that, when the park and buffer are combined, sums to 9,552,573 acres. The 'Ecoregions' section provides the reader with a general picture of the topography and vegetation within Denali. The 'Climate' section provides an overview of Denali's climate. A 'Landscape' section is provided in Appendix 1 as a guide to the major landscape units that influence vegetation in Denali. It is not, however, meant to be used as a landscape classification.

Ecoregions

The following ecoregion map (Figure 2) is directly from Clark's (1998) draft hierarchical framework of ecological units at the subsection level for Denali. Subsection descriptions are given in Appendix 5. Subsections are aggregations of Landtype Associations based on similarities in surficial geology, geomorphic processes, soil groups, and potential vegetation. The Subsections map is a link between the upper levels of the ecoregions hierarchy (Domain, Division, Province, and Section) provided by Nowacki and Brock (1995) with the lower levels (Landtype Association) provided by the detailed soil maps.

The map was made by reviewing Nowacki and Brock (1995), McNab and Avers (1994) and ECOMAP (1993), and by photo interpretation of landforms using 1:60,000 NHAP CIR photography. The map was assembled on an USGS-Denali Alaska 1984 satellite image map (1:250,000 scale). The document is updated yearly based on field data and a finalized map will be provided at the conclusion of the soils' project.

Climate

The climate of the lowlands north of the Alaska Range is subarctic-continental with short, warm summers and long, cold winters. Average annual precipitation may range from 280 millimeters to 400 millimeters, and annual snowfall from 95 centimeters to 205 centimeters (Gallant et al. 1995, McNab and Avers 1994). In winter, average daily minimum temperatures range from -33°C to -26°C , and daily maximum temperatures range from -22°C to -17°C . Summer daily temperatures have lows of about 7°C and highs

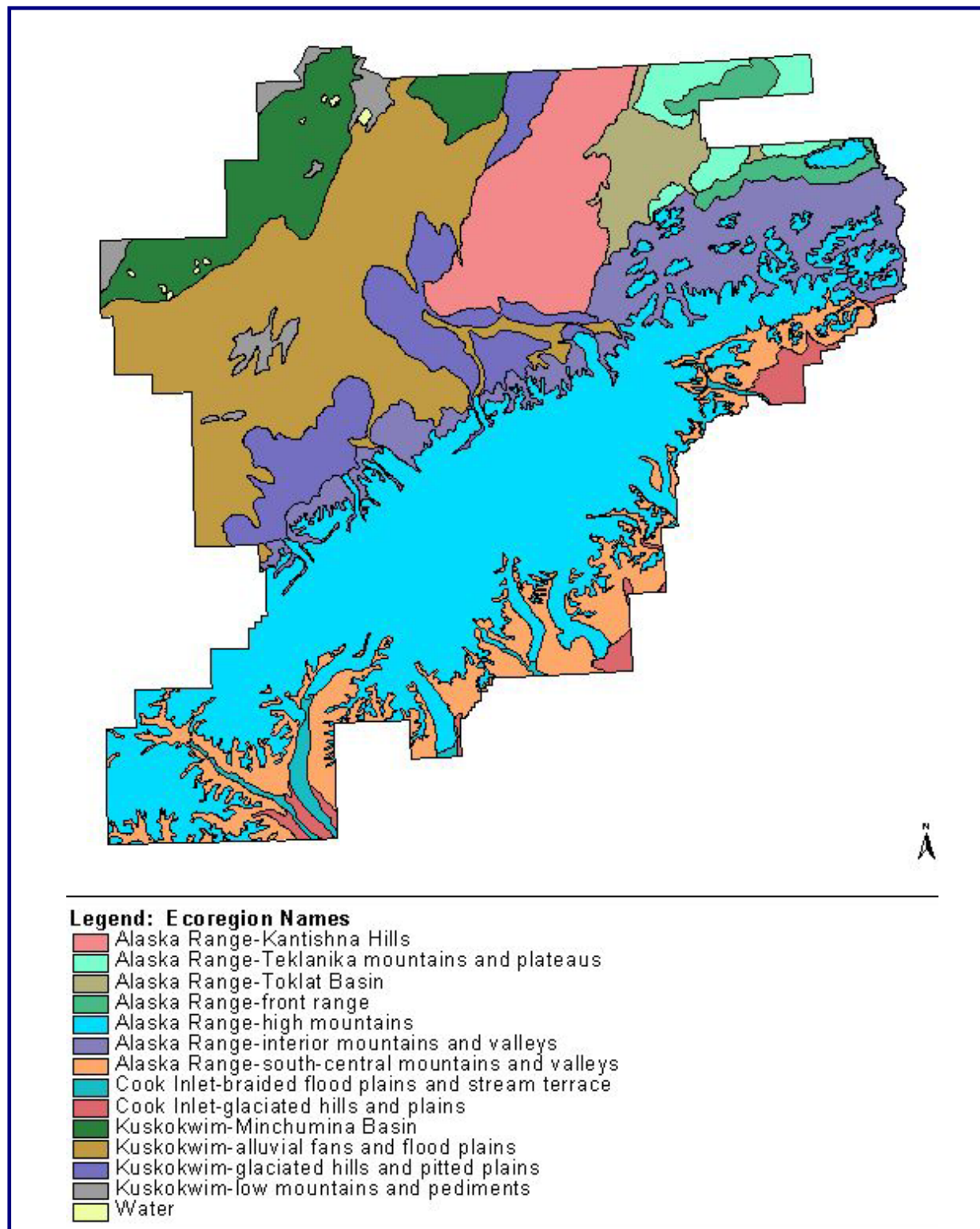


Figure 2. Ecoregion map for Denali National Park and Preserve (Clark 1998).

of 22°C. The frost-free period is usually between June and August, though they may dip below freezing during this time.

The climate in the mountains of Denali (Alaska Range and Kantishna Hills) is primarily influenced by subarctic-continental conditions. The southern half of the Alaska Range, however, is transitional between maritime and subarctic-continental climates, being warmer and moister in winter and cooler and moister in summer than the northern half of the mountain range. Within the mountains, daily winter temperatures average about -25°C with daily highs of -3°C (Gallant et al. 1995, McNab and Avers 1994). The weather stations from this region are from lower elevations. Summer daily low temperatures average 2°C and the highs about 18°C. Freezing conditions may occur year around. Mean annual precipitation at the lower elevations averages 380 millimeters, and snowfall ranges from 150 centimeters to 305 centimeters. The higher mountain peaks are estimated to receive 2,030 millimeters in annual precipitation and 1,015 centimeters of annual snowfall.

The climate of the lowlands south of the Alaska Range is affected by both maritime and subarctic-continental influences. The average annual precipitation ranges from 380 to 680 millimeters, and annual snowfall averages from 160 centimeters to 255 centimeters (Gallant et al 1995). Winter temperatures range from -15°C to -5°C. Summer temperatures vary from 5°C to about 1°C. The months of May through September are typically frost-free.

METHODS

LANDCOVER CLASSIFICATION DEVELOPMENT

Prior to the field season, the landcover classification system used to map Denali was developed from several sources, and, in general, followed The Alaska Vegetation Classification (Viereck et al. 1992) system. First, National Park Service personnel with experience in Denali provided a list of possible classes. Next, the list was expanded by reviewing Firepro data and vegetation ecology literature for Denali. A total of 52 map classes were used for in the field (Table 1). Following the field season and review of existing data, there were 55 target landcover classes that were tested for spectral mappability. However, based on satellite imagery resolution issues and ecological considerations, this list was refined to the final detailed (25) mapping classes.

The mapped classes were refined during meetings attended by NPS personnel and members of the mapping team (EARTHSAT and AKNHP). Several assumptions were made during the refinement of the classes. The group agreed that the mapping classes must be based on landcover characteristics that could be recognized by satellite imagery; and had to be flexible enough to describe potential new classes derived from satellite imagery. The mapping classes were derived from the Alaska Vegetation Classification (Viereck et al. 1992) however we did not strictly adhere to this hierarchy. This was primarily because the Alaska Vegetation Classification did not necessarily correspond well to the classes that would be detected by satellite imagery. In addition, little vegetation information was available from Denali during development of the Alaska Vegetation Classification. Consequently, classes within the Alaska Vegetation Classification hierarchy did not necessarily correlate well with vegetation classes existing within Denali.

After the field season, the landcover classification was further modified by collapsing landcover classes and revising mapped classes. These iterations were based on field observations and satellite imagery interpretation. Throughout the project, from fieldwork to final product, the image analyst, botanists, and ecologist personnel remained the same. This ensured a high level of consistency in the landcover map and classification development. Flexibility and customization in terms of landcover classes, scale of hardcopy draft products, and minimum mapping unit resulted in a more useable suite of products. A detailed review of the draft landcover map by NPS and substantial feedback resulted in significant edits to the landcover map to produce the final map product.

SAMPLING DESIGN AND 'FIELD VERIFICATION AREA' SELECTION

Field sampling consisted of selecting 33 areas to record landcover characteristics from both the air and on the ground (Table 2, Figure 3). These areas were termed field verification areas (FVAs). Individual FVAs represented the range in variability of landcover in its specific area, such as across a mountain valley. The 33 FVAs, in combination, were meant to represent the total range in variability of landcover across Denali.

The selection of field verification areas (FVA's) within Denali was based on a systematic grid followed by post-stratification using the following factors: ecoregions, landscapes, aspect, spectral signature, overlaps between scene clusters, and avoidance of Firepro sample areas. A 1:125,000 scale SPOT mosaic of Denali was used as the base map for the placement of FVA's. The systematic sampling scheme was developed by overlaying a grid over the SPOT image of Denali. The grid was large enough to ensure placement of 33 FVA's across the vegetated portion of Denali, with slight overlap into the bareground and glacier landcover classes. An FVA was then placed at the intersection of all grid lines.

Table 1. Landcover classes used during the 1999 field season.

Spruce	Low shrub
Closed White Spruce	Closed Low Willow
Closed Black Spruce	Closed Low Alder-Willow
Open White Spruce	Closed Low Shrub Birch
Open Black Spruce	Open Low Alder
Woodland Spruce (Ericaceous)	Open Low Alder-Willow
Woodland Spruce (Lichen)	Open Low Willow
Woodland Spruce (Sedge)	Open Low Mix Shrub-Sedge Tussock
	Open Low Shrub Birch-Ericaceous
	Open Low Shrub Birch-Willow
Deciduous forest	
Closed Birch	
Closed Aspen	Dwarf shrub
Closed Balsam Poplar	Dryas Dwarf Shrub
Closed Mixed Deciduous	Willow Dwarf Shrub
Open Birch	Ericaceous Bearberry/Vaccinium Dwarf Shrub
Open Aspen	Ericaceous Cassiope Dwarf Shrub
Open Balsam Poplar	
Open Mixed Deciduous	Herbaceous
Woodland Birch	Dry/Mesic Grass-Forb
Woodland Balsam Poplar	Dry/Mesic Sedge-Forb
Woodland Deciduous	Tussock Tundra
	Wet Graminoid/Forb
Mixed forest	
Closed Mixed	Other
Open Mixed	Lichen
Woodland Mixed	Sparse Vegetation
	Aquatic
Tall shrub	Bare Ground
Closed Tall Alder	Snow/Ice
Closed Tall Willow	
Closed Tall Alder-Willow	
Closed Tall Shrub Birch	
Open Tall Alder	
Open Tall Willow	
Open Tall Shrub Birch	
Open Tall Alder-Willow	

Table 2. Information used to evaluate number and placement of field verification areas.

Ecoregion	*Existing IMA's	Total area (acres)	% of total	% of total excluding Alaska-high mountains	**Idealized # of FVA's by area	New FVA's used
Alaska Range-Kantishna Hills	2	446,127	7	11	3.3	4
Alaska Range-Teklanika mtns and plateaus	1	121,175	2	3	0.9	2
Alaska Range-Toklat Basin	1	156,227	3	4	1.2	1
Alaska Range-front range	0	98,847	2	2	0.7	2
Alaska Range-high mountains	1	1,960,428	33	--	--	--
Alaska Range-interior mtns and valleys	2	536,039	9	13	4.0	4
Alaska Range-south-central mtns & valleys	9	556,426	9	14	4.1	4
Cook Inlet-braided flood plains and stream	4	55,634	1	1	0.4	1
Cook Inlet-glaciated hills and plains	4	89,819	1	2	0.7	3
Kuskokwim-Minchumina Basin	5	391,264	6	10	2.9	3
Kuskokwim-alluvial fans and flood plains	8	1,092,132	18	27	8.1	4
Kuskokwim-glaciated hills and pitted plains	1	424,958	7	10	3.1	2
Kuskokwim-low mountains and pediments	2	92,142	2	2	0.7	3

*IMA=Intensive mapping units from previous field work (Firepro)

**based on 30 FVA's and not using Alaska Range-high mountains ecoregion

FVA's that overlaid Firepro locations and contained thorough landcover information were eliminated because the Firepro information was considered adequate for spectral training. Ecoregions as defined by the USDA Natural Resources Conservation Service (Clark 1998) within Denali were overlaid on the SPOT mosaic for coarse scale stratification purposes. Movement of some of the FVA's was based upon having representative examples of FVA's within the ecoregions (Table 2).

Additional factors affected the placement of the FVA's. All aspects (north, south, east, west) on mountain slopes were included. Both large and small valleys within the Alaska Range were sampled. Alaska Native lands (including selected), hunting camps and private in-holdings were avoided. Distinct landcover signatures from the raw imagery were sampled. Sampling within scene overlap areas was maximized.

The next step was to determine where to photo interpret polygons within an FVA. Within each FVA one transect, or discontinuous transect, was laid out on the imagery mosaic to encompass the FVA's full variation of environmental factors. These environmental variables included landscape types, aspect, slope and distinct signatures. In the mountains, each transect spanned an entire valley, from ridge top to ridge top. In the remaining regions, transects that encompassed the environmental variability were often too long to fully sample. Consequently we made discontinuous transects with different transect sections falling in each distinct environment to be sampled.

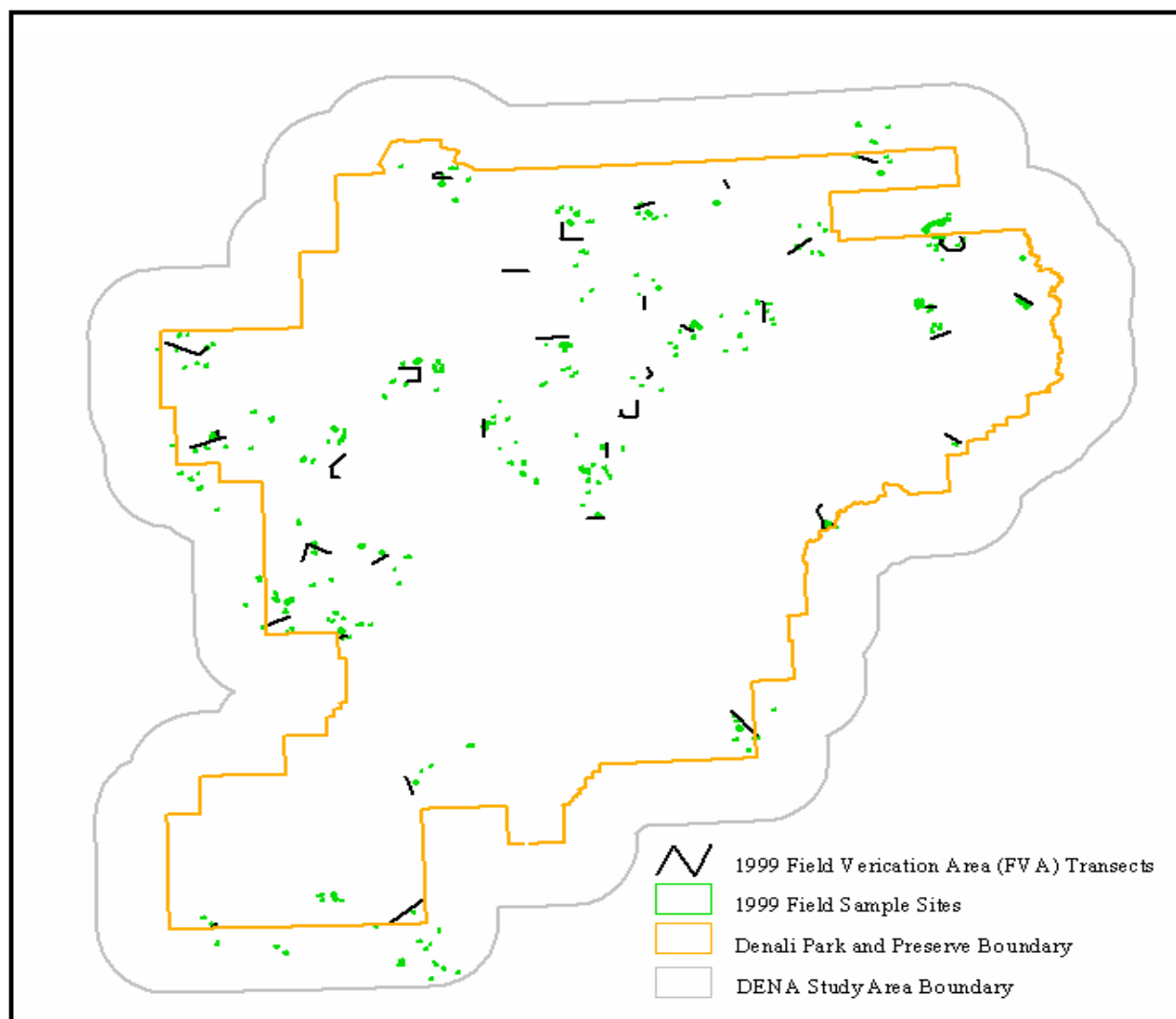


Figure 3. Locations of 1999 Field Transects and Sample Sites

FIELD DATA COLLECTION

The primary goal of the 1999 fieldwork was to collect the number of samples required to create the landcover map product. The intent of this transect-polygon sampling approach was to both collect samples that could be used to generate spectral training signatures for use in the automated image classification, and also to gain a complete picture of the occurrences of the mapping classes for areas over all slope/aspect/landform positions in the FVA. This transect "snapshot" was essential to establishing realistic parameters in the environmental and spectral models used to refine the landcover map.

Another goal during field data collection was to obtain more specific site information that could be used to describe plant associations, and to tie this more detailed vegetation information back to the landcover mapping classes. To support these objectives, field data were collected at two different levels of detail: FVA 'fly over' polygons, and 'ground site' descriptions. The field season was from July 13, 1999 to August 6, 1999.

Fly Over Polygon Data Collection

The purpose of this level of field data collection was specifically to provide additional training signatures for the automated image processing and modeling required to produce the landcover map. Information was recorded on a field form (Appendix 3) and included the data required to identify a landcover mapping class call for each sampled polygon. This information included information such as air photo number, polygon code, latitude and longitude, landcover class name and code, date, surveyors, photos, azimuth, slope, aspect, and hydrologic regime. Landcover information included percent of polygon covered by the dominant species, total percent cover for life form categories, and species height. Percent cover for life form categories included two values: aerial percent cover that always summed to 100%, and species cover that typically summed to greater than 100% due to overlapping canopies. Photographs were taken at each site.

Canopy cover was ocularly estimated (Brown 1954) for the dominant species, and defined as the percent of the ground in the polygon covered by the gross outline of an individual plant's foliage (canopy), or the outline collectively covered by all individuals of a species or life form within the polygon (Daubenmire 1959). Percent bare ground was also estimated.

When arriving at the FVA transect area, the image analyst and botanist flew a reconnaissance of the transect and landed at one end of the FVA (typically on a high vantage point). From here, the image analyst and the botanist surveyed the potential sample sites on 1:12,000 CIR (color infrared) enlargements and 1:100,000 satellite image map of the FVA. Polygons were delineated on the CIR photo to ensure that they were sufficiently large (~10 acre) and recognizable on both the CIR photo and satellite image. Each polygon was sampled by slow fly-by in the helicopter. Approximately 20 polygons were visited at each FVA for a total of 330 samples.

Another level of detail was very general observations annotated on 1:100,000 and 1:250,000 satellite image maps during transit to and from FVA transect areas. These observations typically included a general vegetation call indicating, for example, "tussock tundra" without providing any indication as to the percentages of herbaceous, low shrub, tussocks, hydrologic regime, etc. They also often represented broad landscapes rather than particular sites. Photographs were often collected for these sites, and in some cases GPS points were recorded. The purpose for collecting the information was primarily for editing the map, a qualitative assessment of its accuracy. All data was entered into an Access database developed by the National Park Service.

Ground Data Collection

The purpose for this level of data collection was primarily to provide the required information for linking the landcover classes to the finer hierarchical levels (IV and V) of the Viereck et al. (1992) classification. Ground site descriptions were also used to support classification system refinement, provide a more thorough understanding of the landcover classes, and to improve class descriptions.

One hundred ninety eight 'on the ground' site descriptions were gathered during the field season by sampling within FVA polygons or—when the ground crew could not get to the FVA polygon due to logistical restrictions—at sites similar to the FVA polygons. One or two ground personnel were let off at a FVA and visited as many polygons as time allowed. Within a polygon, selection of sample sites was similar to the approach termed "subjective sampling without preconceived bias" as described by Mueller-Dombois and Ellenberg (1974). Site selection was based on homogeneous vegetation, and sites were not chosen with regard to their position in any classification, extant or envisioned, or by applicability to specific management considerations.

The ground person walked through a polygon and recorded vegetation composition, structure, and site variables. A vegetation and physical site description form was used to record information (Appendix 2).

Vascular and nonvascular vegetation information within the polygons was collected, and six letter codes were used to abbreviate species names. In most cases a full species list was obtained, however, if time was insufficient, only the dominant species from each structural layer was recorded. The six-letter code for a species combined the first three letters from the genus and specific epithet, and was based on Hulten (1968). Canopy cover was ocularly estimated (Brown 1954) for each species and could sum to greater than 100%. Dominant plant species not identified in the field were collected and identified in the office. Canopy height was estimated for the dominant species.

Ground cover information was collected for each polygon. The categories included water, bare soil, bedrock, litter-duff, wood (>1 centimeters), large rocks (cobbles, boulders >10 centimeters), small rocks (gravel, 0.2-10 centimeters) and sand (0.1-2 millimeters). The percentages for the ground cover categories typically sum to approximately 100%. The percent of the surface within the polygon that was covered by woody debris greater than 15 centimeters in diameter was also recorded. GPS position was recorded at each polygon.

When time allowed, the following site variables were recorded within each polygon: slope, aspect, landform, hydrologic regime (dry, mesic, wet, aquatic), biome (subalpine, boreal, bog herb meadow, tussock, riparian), depth of soil peat, A, B and C horizons, depth to permafrost, and depth to water. Other recorded variables included air photo number, polygon code, landcover class name, landcover class code, date, surveyors, photos, latitude and longitude, environmental comments and disturbance comments. A photographic record was taken for each site. Vegetation information typically recorded for fly-over descriptions was also recorded for each ground description.

PLANT ASSOCIATION CLASSIFICATION DEVELOPMENT

Heebner (1982) previously described forest and shrub plant associations for the north half of the Alaska Range and further north. The 56 Heebner (1982) plant association descriptions were copied and placed under the landcover class they occur in.

Fortyone plant associations not defined by Heebner (1982) but sampled during the 1999 field season were described and placed under the proper landcover class. All field data were entered into an Access database program. Species and cover data was used to create association tables of the preliminary dominance-type groupings. A stepwise procedure of successive approximations was then used to classify the plant associations (Pfister and Arno 1980). A plant association description was prepared for each type. The descriptions are based on species lists, canopy cover, structure, and site information. Constancy-coverage tables were created for each defined plant association and are given in Appendix 4.

KEY TO LANDCOVER CLASSES

The following vegetated landcover classes are not included in the key: herbaceous/shrub and peatland.

GROWTH FORM GROUPS

1. Tree canopy cover is greater than or equal to 10% for needleleaf trees, deciduous trees, or deciduous-needleleaf mix 2
1. Tree canopy cover is less than 10% or absent 3
2. Needleleaf tree cover is greater than or equal to 75% of the total tree cover Needleleaf Forest Types
2. Needleleaf tree cover is less than 75% of the total tree cover.....Broadleaf and Mixed Forest Types
3. Shrub cover is greater than or equal to 25% Shrub Types
3. Shrub cover is less than 25% 4
4. Herbaceous cover is greater than or equal to 25%.....Herbaceous Types
4. Herbaceous cover is less than 25% 5
5. Total vegetation cover is 15-24% Sparse Vegetation
5. Total vegetation cover is less than 15%..... Bare Ground

NEEDLELEAF FOREST TYPES

1. Tree canopy cover is 45-70%..... Dense-Open Spruce Forest
1. Tree canopy cover is 10-44%..... 2
2. Average tree height is greater than or equal to 7.5 meters Open-Woodland Spruce Forest
2. Average tree height is less than 7.5 meters Open-Woodland Stunted Spruce

BROADLEAF AND MIXED FOREST TYPES

1. Greater than or equal to 75% of the total tree cover is deciduous Broadleaf forest
1. Deciduous and needleleaf trees each contribute 25-75% of the total tree cover.....
..... Mixed Spruce-Broadleaf Forest

SHRUB TYPES

1. Willow greater than 20 centimeters tall contributes 75% or more of the total shrub cover.....
..... Willow Shrub
1. Willow greater than 20 centimeters tall contributes less than 75% of the total shrub cover 2
2. Alder contributes 75% or more of total shrub cover.....Alder Shrub
2. Alder contributes less than 75% of total shrub cover 3
3. Shrub birch is greater than 75% of total shrub cover and total shrub cover is 75-100%
..... Closed Low Shrub Birch
3. Shrub birch is less than 75% of total shrub cover 4

4. Willow, shrub birch or ericaceous shrubs—all greater than 20 centimeters tall—together contribute 25-75% of the total shrub cover and total shrub cover is 25-100%..... 5
4. Willow, shrub birch or ericaceous shrubs—all greater than 20 centimeters tall—together do not contribute 25-75% of the total shrub cover 6
5. Graminoids contribute 25-75% of the total cover; tussock formation is common Low Shrub-Sedge
5. Less than 25% sedges present..... Low Shrub Birch-Ericaceous-Willow
6. Shrub height is less than 20 centimeters, and greater than 25% of the site contains rock Dwarf Shrub-Rock
6. Shrub height is less than 20 centimeters, and less than 25% of the site contains rock Dwarf Shrub

HERBACEOUS TYPES

1. Vegetation is terrestrial; not submerged, floating, or growing in permanent water..... 2
1. Vegetation is submerged, floating, or growing in permanent water Aquatic Herbaceous
2. Site is dry to mesic; little to no standing water Dry-Mesic Herbaceous
2. Dominant vegetation is emergent; semi-permanent or standing water is present..... Wet Herbaceous

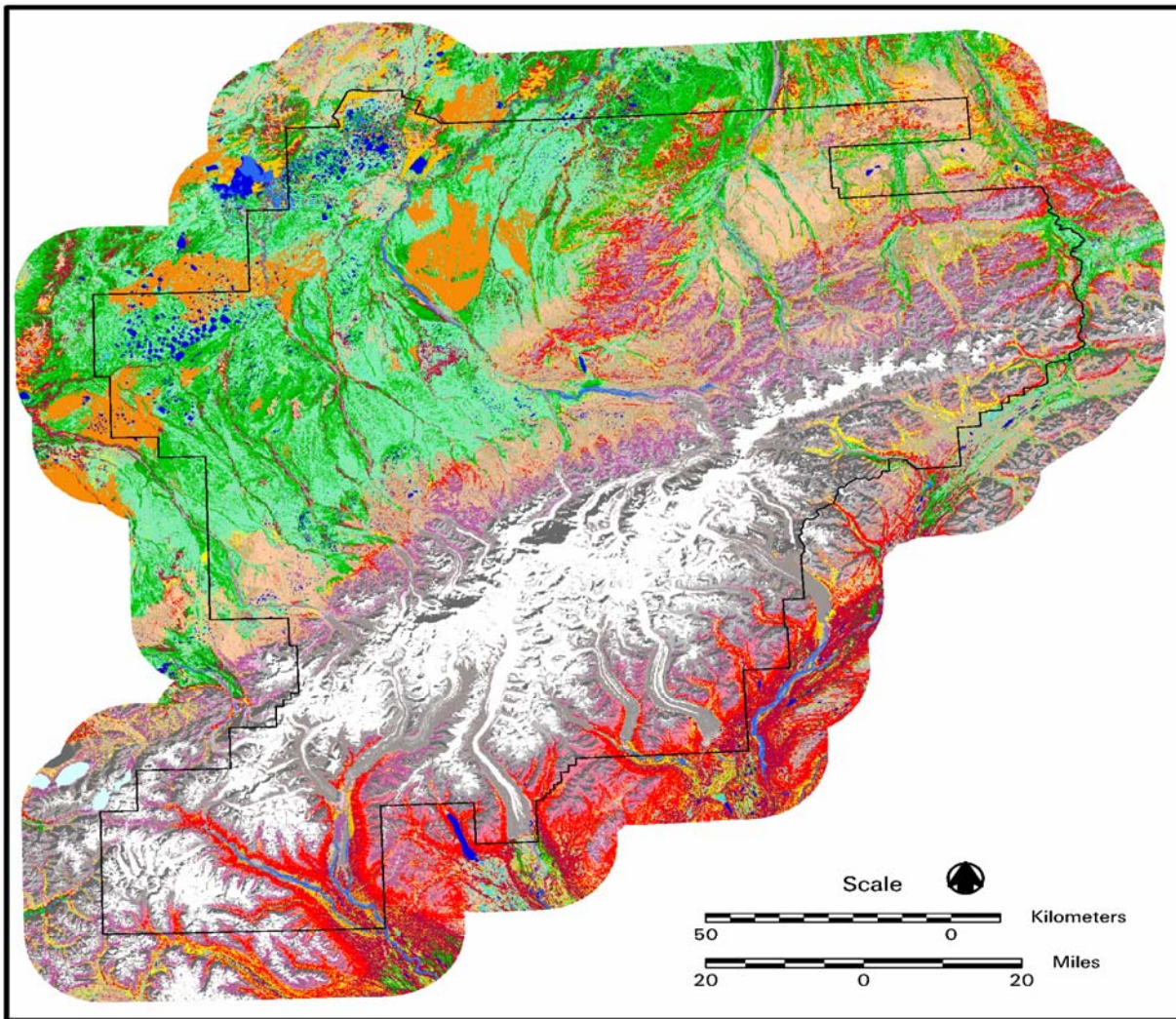
LANDCOVER CLASS DESCRIPTIONS

Full descriptions of each landcover class for the Denali landcover map (Figure 4) are provided below. Descriptions include dominant species information, physical site variables and accuracy assessment descriptions. All accuracies are based on the 25-class landcover map at a 2-acre mapping unit. Refer to Volume 1 (Stevens et al. 2001) for a complete description of the accuracy assessment and methodology. Landcover class elevation, percent landcover class per ecoregion and percent cover by landcover class in Denali are given in Tables 3, 4a-b and 5, respectively. Figure 5 provides an idealized cross section of vegetation within the park. Descriptions of plant associations follow this section.

Table 3. Elevation (meters) of landcover classes based on field polygon information and also the range in elevation from the landcover map superimposed on the digital elevation model.

Landcover class	Field polygon information				Landcover map and elevation model			
	Mean (m)	Min (m)	Max (m)	# of polygons	Mean (m)	Min (m)	Max (m)	# of pixels
Dense-Open Spruce Forest	333	107	730	108	339	46	1,450	9,597
Open-Woodland Spruce Forest	483	80	912	132	384	46	1,681	60,926
Open-Woodland Stunted Spruce	364	166	841	447	383	72	1,681	85,461
Broadleaf Forest	331	93	774	75	378	46	1,401	13,350
Mixed Spruce-Broadleaf Forest	171	91	721	184	326	46	1,687	36,231
Alder Shrub	499	191	1,124	61	631	73	1,711	7,004
Willow Shrub	582	191	1,116	64	671	67	1,544	2,791
Closed Low Birch Shrub	814	439	1,097	44	617	136	1,438	2,950
Low Shrub Birch-Ericac-Willow	756	204	1,068	58	767	91	1,808	26,292
Low Shrub-Sedge	510	168	1,052	163	645	59	1,643	12,888
Peatland	207	74	315	58	250	46	1,008	6,033
Herbaceous / Shrub	nd*	nd	nd	nd	832	106	1,461	2,222
Dwarf Shrub	856	158	1,335	42	1,059	104	2,401	5,662
Dwarf Shrub-Rock	793	185	1,335	24	1,173	91	5,490	1,216
Dry-Mesic Herbaceous	762	76	1,206	40	999	74	1,701	1,136
Wet Herbaceous	358	167	824	109	343	61	1,432	21,053
Aquatic Herbaceous	255	255	255	43	254	238	320	814
Sparse Vegetation	577	158	1,142	48	1,253	61	4,527	3,385
Bare Ground	950	274	1,620	80	1,197	46	5,536	4,640
Snow / Ice	1,500	619	2,091	58	1,868	181	6,188	5,440
Shadow / Indeterminate	nd	nd	nd	nd	1,410	53	5,916	3,787
Silty Water	272	146	1,149	261	290	46	2,355	39,535
Clear Water	366	164	753	1,304	319	60	1,380	56,615
Burn	nd	nd	nd	nd	259	149	1,006	66,812
Cloud	nd	nd	nd	nd	962	196	1,759	461

* nd = no data



Mapping Class Name	
	Dense-Open Spruce Forest (white spruce-like)
	Open - Woodland Spruce Forest
	Open - Woodland Stunted Spruce
	Broadleaf Forest
	Mixed Spruce - Broadleaf Forest
	Alder Shrub
	Willow Shrub
	Closed Low Birch Shrub
	Low Shrub Birch-Ericaceous-Willow
	Low Shrub - Sedge
	Peatland
	Herbaceous / Shrub
	Dwarf Shrub
	Dwarf Shrub - Rock
	Dry - Mesic Herbaceous
	Wet Herbaceous
	Aquatic Herbaceous
	Sparse Vegetation
	Bare Ground
	Snow / Ice
	Shadow / Indeterminate
	Silty Water
	Clear Water
	Burn
	Cloud

Figure 4. Landcover map for Denali.

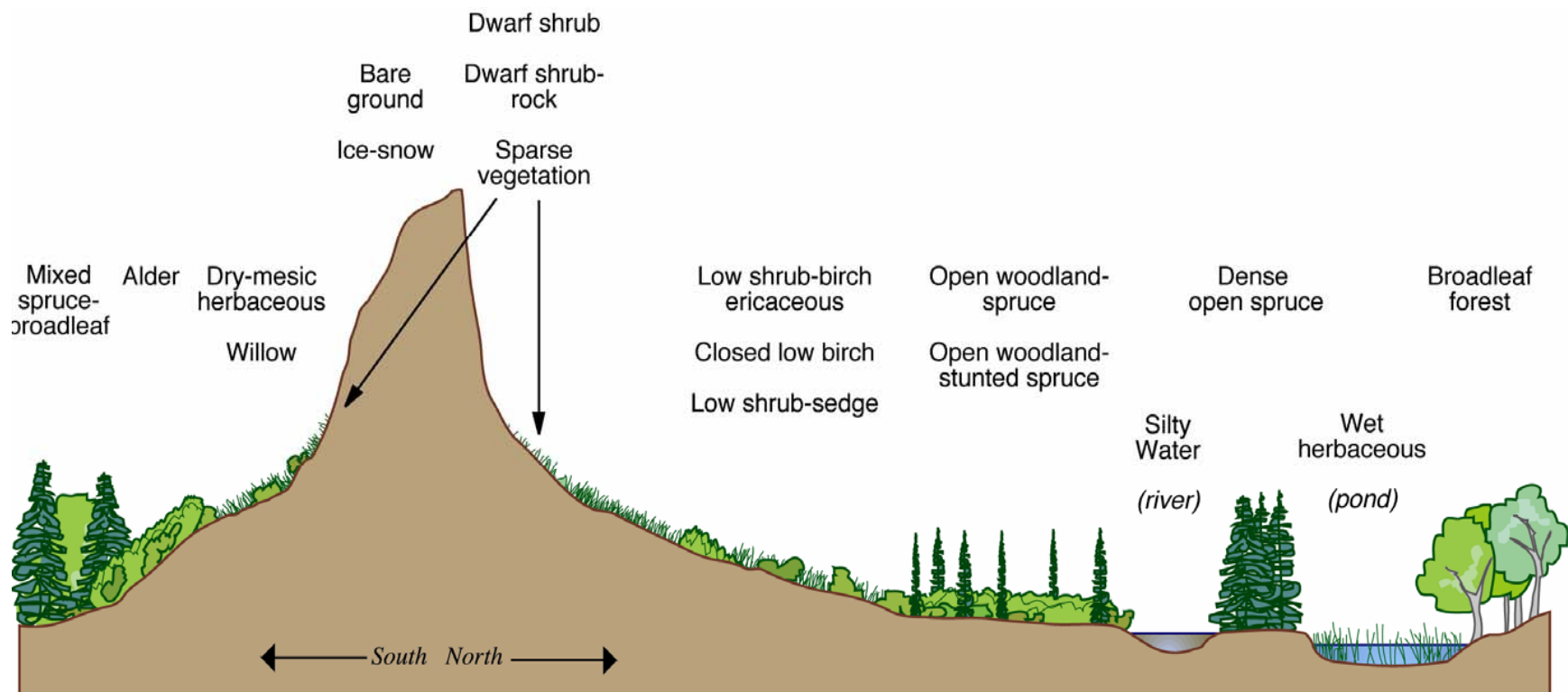


Figure 5. Idealized cross-section of landcover classes in relationship to topography within Denali.

Table 4a. Percent cover of the 25 landcover map classes by Ecoregion for Denali.

Landcover classes	Ecoregions												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Dense-Open Spruce Forest	0.44	2.36	2.01	5.52	0.23	2.07	0.20	0.00	0.40	0.39	0.77	0.87	0.14
Open-Woodland Spruce	14.50	24.57	18.35	28.67	7.03	9.25	5.28	0.00	4.23	15.27	1.89	0.56	0.29
Open-Woodland Stunt Spruce	33.51	39.23	41.12	23.07	5.33	11.59	4.51	0.01	3.69	10.57	2.19	1.11	0.35
Broadleaf Forest	1.17	0.90	2.20	20.83	3.78	1.29	4.38	0.01	0.96	4.62	5.82	12.24	0.98
Mixed Spruce-Broadleaf	4.80	3.87	5.14	9.17	0.50	0.50	0.44	0.01	0.39	1.84	25.90	13.28	2.81
Alder Shrub	2.09	0.39	0.08	0.95	5.10	0.41	13.93	0.08	6.38	13.87	13.25	2.45	20.51
Willow Shrub	1.29	0.76	0.30	0.62	6.98	1.35	3.70	0.03	2.32	4.25	4.82	1.43	5.14
Closed Low Birch Shrub	1.06	0.86	0.14	0.04	6.62	5.39	5.35	0.00	2.91	0.39	0.16	0.00	0.06
Low Shrub Birch-Ericac-Willow	25.23	5.92	1.74	3.18	41.01	18.62	25.32	0.17	22.61	27.74	27.46	0.23	2.18
Low Shrub-Sedge	8.87	3.67	4.05	2.73	18.36	40.87	10.80	0.07	7.79	5.94	5.07	4.67	1.37
Peatland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.93	0.85	0.01
Herbaceous / Shrub	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.18	0.43	12.06
Dwarf Shrub	1.09	0.52	0.00	0.05	1.99	0.31	15.49	2.34	25.26	11.08	3.92	4.93	14.61
Dwarf Shrub-Rock	0.34	0.13	0.00	0.00	0.14	0.01	2.46	1.34	4.72	0.79	0.30	3.50	1.99
Dry-Mesic Herbaceous	0.10	0.03	0.03	0.30	0.09	0.11	0.24	0.08	1.03	0.69	0.68	0.24	5.95
Wet Herbaceous	0.37	1.02	5.41	0.49	0.11	1.23	0.02	0.00	0.07	0.02	1.11	0.47	0.04
Aquatic Herbaceous	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sparse Vegetation	0.63	0.72	0.02	0.06	0.37	2.45	1.74	9.24	7.18	0.39	0.85	5.74	8.49
Bare Ground	1.07	1.42	0.04	0.03	0.04	2.96	0.75	24.41	4.34	0.12	1.52	30.33	8.27
Snow / Ice	0.03	0.00	0.00	0.00	0.00	0.00	0.00	46.79	0.07	0.00	0.00	0.01	2.69
Shadow / Indeterminate	0.11	0.07	0.05	1.16	0.43	0.14	5.34	15.31	5.42	1.78	0.56	1.41	11.93
Silty Water	0.11	1.07	1.50	0.12	0.02	1.04	0.07	0.01	0.21	0.02	0.61	15.17	0.08
Clear Water	3.02	0.76	7.96	0.27	0.03	0.08	0.00	0.01	0.02	0.16	0.79	0.07	0.04
Burn	0.18	11.74	9.72	2.75	1.84	0.33	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Cloud	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.21	0.00	0.01

Ecoregion Legend:

- 1 Kuskokwim-glaciated hills and pitted plains
- 2 Kuskokwim-alluvial fans and flood plains
- 3 Kuskokwim-Minchumina Basin
- 4 Kuskokwim-low mountains and pediments
- 5 Alaska Range-Teklanika mountains and plateaus
- 6 Alaska Range-Toklat Basin

- 7 Alaska Range-front range
- 8 Alaska Range-high mountains
- 9 Alaska Range-interior mountains and valleys
- 10 Alaska Range-Kantishna Hills
- 11 Cook Inlet-glaciated hills and plains
- 12 Cook Inlet-braided flood plains and stream terrace
- 13 Alaska Range-south-central mountains and valleys

Table 4b. Percent cover of the 25 landcover map classes found within each biome (acres of landcover class in biome/total acres in biome). The ecoregion (Clark 1998) combinations used for defining the biomes are given below.

Landcover classes	Biomes			
	Kuskokwim lowlands*	Toklat basin and plateaus	Alaska Range, Kantishna hills	Cook Inlet hills and plains
Dense-Open Spruce Forest	2.03	1.27	0.14	0.28
Open-Woodland Spruce	21.40	8.28	3.16	0.51
Open-Woodland Stunt Spruce	37.64	8.86	2.35	0.65
Broadleaf Forest	2.13	2.38	0.99	2.49
Mixed Spruce-Broadleaf	4.56	0.50	0.36	6.59
Alder Shrub	0.72	2.45	3.67	18.15
Willow Shrub	0.78	3.81	1.17	4.81
Closed Low Birch Shrub	0.72	5.93	0.75	0.06
Low Shrub Birch-Ericac-Willow	9.08	28.40	8.99	5.26
Low Shrub-Sedge	4.81	31.04	2.64	2.11
Peatland	0.00	0.00	0.00	0.32
Herbaceous / Shrub	0.00	0.00	0.04	9.62
Dwarf Shrub	0.52	1.04	8.09	12.47
Dwarf Shrub-Rock	0.14	0.07	1.89	1.90
Dry-Mesic Herbaceous	0.06	0.10	0.34	4.82
Wet Herbaceous	1.71	0.74	0.02	0.21
Aquatic Herbaceous	0.03	0.00	0.00	0.00
Sparse Vegetation	0.53	1.54	7.34	7.29
Bare Ground	1.01	1.69	16.54	9.15
Snow / Ice	0.01	0.00	30.17	2.13
Shadow / Indeterminate	0.12	0.27	11.26	9.64
Silty Water	0.91	0.59	0.05	1.34
Clear Water	2.62	0.06	0.03	0.14
Burn	8.47	0.99	0.01	0.00
Cloud	0.00	0.00	0.00	0.04

Biome	Ecoregions (Clark 1998) used to define the biome
Kuskokwim lowlands =	Kuskokwim-glaciated hills and pitted plains, Kuskokwim-alluvial fans and flood plains, Kuskokwim-Minchumina Basin, Kuskokwim-low mountains and pediments
Toklat basin and plateaus =	Alaska Range-Teklanika mountains and plateaus, Alaska Range-Toklat Basin
Alaska Range, Kantishna hills =	Alaska Range-front range, Alaska Range-high mountains, Alaska Range-interior mountains and valleys, Alaska Range-Kantishna Hills
Cook Inlet hills and plains =	Cook Inlet-glaciated hills and plains, Cook Inlet-braided flood plains and stream terrace, Alaska Range-south-central mountains and valleys

Table 5. Landcover class by acre and percent of total area within the boundaries of Denali National Park and Preserve, and also within the park's boundaries plus a 16 km buffer.

	Denali Park boundary only		Denali plus 16 km buffer	
	Acres	Percent	Acres	Percent
Dense-Open Spruce Forest	50,359	0.8	157,157	1.6
Open-Woodland Spruce Forest	551,428	9.1	931,271	9.7
Open-Woodland Stunted Spruce	853,985	14.2	1,283,661	13.4
Broadleaf Forest	97,063	1.6	253,608	2.7
Mixed Spruce-Broadleaf Forest	149,929	2.5	509,644	5.3
Alder Shrub	260,198	4.3	533,799	5.6
Willow Shrub	95,590	1.6	195,666	2.0
Closed Low Birch Shrub	54,034	0.9	87,201	0.9
Low Shrub Birch-Ericaceous-Willow	570,700	9.5	898,322	9.4
Low Shrub-Sedge	277,322	4.6	450,124	4.7
Peatland	2,304	0.0	34,475	0.4
Herbaceous / Shrub	68,872	1.1	132,299	1.4
Dwarf Shrub	346,847	5.8	517,564	5.4
Dwarf Shrub-Rock	73,894	1.2	107,686	1.1
Dry-Mesic Herbaceous	45,684	0.8	95,916	1.0
Wet Herbaceous	38,427	0.6	74,172	0.8
Aquatic Herbaceous	564	0.0	590	0.0
Sparse Vegetation	289,308	4.8	389,989	4.1
Bare Ground	592,298	9.8	710,194	7.4
Snow / Ice	932,790	15.5	1,049,706	11.0
Shadow / Indeterminate	413,260	6.9	657,181	6.9
Silty Water	30,765	0.5	67,957	0.7
Clear Water	60,764	1.0	100,880	1.1
Burn	172,528	2.9	296,214	3.1
Cloud	357	0.0	17,300	0.2
Total	6,029,270	100.0	9,552,573	100.0

DENSE-OPEN SPRUCE FOREST LANDCOVER CLASS

Classification—Tree canopy cover is between 45% to 70% with needleleaf tree cover greater than or equal to 75% of the total tree cover. The class is comparable to the Viereck et al. (1992) hierarchical levels closed needleleaf forest (IA1) and open needleleaf forest (IA2).



Distribution and Site Characteristics—The *dense-open spruce forest* class occurs on low elevation (107 to 731 meters based on field data; Table 3) floodplains, toeslopes, and valley bottoms primarily north of the Alaska Range within Denali. It generally occurs as small to medium size patches on well-drained, loamy or sandy soils. These sites have little (5 to 10 degrees) to no slope, and generally occur on South and West aspects. Disturbance is typically from alluvial and fire processes. They are commonly found in the Toklat drainage, west of the Kantishna Hills, and the toeslopes of the Alaska Range in the west-central part of the park. Although it occurs in all ecoregions, it is more prevalent in the Kuskokwim-alluvial fans and flood plains ecoregion than other ecoregions (Tables 4a and 4b; Clark 1998). The *dense-open spruce forest* class cover 0.8% (50,359 acres) of Denali (Table 5).

Vegetation—*Picea glauca* or *Picea mariana* cover ranges from 45% to 70%. Tree height can reach greater than 20 meters. *Larix laricina*, alders (such as *Alnus crispa*) and willows (such as *Salix planifolia*) occur in canopy breaks along with ericaceous shrubs such as *Arctostaphylos rubra*, *Vaccinium vitis-idaea*, and *V. uliginosum*. There frequently is a high graminoid component associated with these sites. Mosses are common as well as small amounts of lichen. The *dense-open spruce forest* class is typically interspersed with other spruce types such as the *open-woodland spruce forest* and *open-woodland stunted spruce* landcover classes.

Landcover Class Accuracy—The producer's accuracy for the *dense open spruce forest* class is 87.9%, with a user's accuracy of 69.4%. Most of the errors of commission and omission are due to confusion with the *open-woodland spruce forest* class. All accuracies are based on the 25-class landcover map at a 2-acre mapping unit prior to the digital integration of the burn mask.

OPEN-WOODLAND SPRUCE FOREST LANDCOVER CLASS

Classification—Tree canopy cover is 10% to 44% with needleleaf cover greater than or equal to 75% of the total tree cover. Needleleaf tree height is greater than or equal to 7.5 meters. The class is comparable to the Viereck et al. (1992) hierarchical levels open needleleaf forest (IA2) and needleleaf woodland (IA3).



Distribution and Site Characteristics—The *open-woodland spruce forest* class occurs primarily on lower elevation (80 to 912 meters based on field data; Table 3) landscapes north of the Alaska Range within the park. The dominant landscapes are alluvial fans and outwash-floodplains. Site conditions range from strong sunlight and well-drained soils on gentle slopes and terraces to sites with poorly drained peat and silt soils. The latter is typically dominated by *Picea mariana*. Most sites have little to no slope although a few sites reached a slope of 40 degrees. When sloping sites occur they generally occupy east aspects. This class occurs in a region of high fire frequency. This landcover class is most common on the Kuskokwim-alluvial fans and floodplains ecoregion and is also common in the Kuskokwim-Minchumina Basin ecoregion (Tables 4a and 4b; Clark 1998); in addition it is the most common type in the Kuskokwim-low mountains and pediments ecoregion. The *open-woodland spruce forest* landcover class covers 9.1% (551,428 acres) of the park (Table 5).

Vegetation—The *open-woodland spruce forest* class is dominated by *Picea mariana*, however *Picea glauca* also occurs. Average needleleaf cover is 40%, and tree height is typically greater than 7.5 meters. Ericaceous shrubs are commonly found in the understory including *Ledum decumbens*, *Vaccinium uliginosum*, *Cassiope tetragona*, and *Chamaedaphne calyculata*. Other shrubs include *Betula nana*, *Empetrum nigrum*, *Alnus* species, and *Salix* species. Mosses and lichens also occur. Some sites contain tussocks ranging up to 90% tussock cover, and average tussock cover in sites with high graminoid content is 35%. The class is typically interspersed with other spruce classes such as the *dense-open spruce forest* and *open-woodland stunted spruce* landcover classes.

Landcover Class Accuracy—The producer's accuracy for the *open-woodland spruce forest* class is 82.9%, with a user's accuracy of 79.3%. Most of the errors of commission are with the *open-woodland stunted spruce* class while most of the errors of omission are with the *dense open* class. There are also significant omission errors with the *open-woodland stunted spruce* class and the *mixed spruce broadleaf forest* class.

OPEN-WOODLAND STUNTED SPRUCE LANDCOVER CLASS

Classification—Tree canopy cover is 10% to 44% with needleleaf tree cover greater than or equal to 75% of the total tree cover. Needleleaf tree height is less than 7.5 meters. The class is comparable to the Viereck et al. (1992) hierarchical levels open needleleaf forest (IA2), needleleaf woodland (IA3), open dwarf tree scrub (IIA2), and dwarf tree scrub woodland (IIA3). The cutoff for stunted spruce in the Denali classification is 7.5 meters whereas the cutoff for dwarf tree scrub is 3 meters in Viereck et al. (1992).



Distribution and Site Characteristics—The *open-woodland stunted spruce* class is the most common vegetated class in Denali, covering 14.2% (853,985 acres) of its total area (Table 5). The class is primarily found on low to mid elevation (166 to 841 meters based on field data; Table 3) sites north of the Alaska Range. It occupies sites with poorly drained, cold soils with some peat formation, permafrost is common, and with little to no slope. This class occurs in a region of high fire frequency, although the sites have likely not recently been burned. It dominates the Kuskokwim-alluvial fans and floodplains ecoregion, the Kuskokwim-glaciated hills and pitted plains ecoregion, and the Kuskokwim-Minchumina basin ecoregion and is common in the Kuskokwim-low mountains and pediments ecoregion (Tables 4a and 4b; Clark 1998).

Vegetation—The forest canopy of the *open-woodland stunted spruce* class is dominated by *Picea mariana* although *Picea glauca* may also occur. Average needleleaf cover is 30% and tree height averages 4 meters. These sites commonly have a high percent of ericaceous shrubs and a thick graminoid layer in the understory. Tussock formation is common and its cover reaches greater than 90% in some sites and averages 40% cover. Many sites are dominated by ericaceous shrubs, whereas others are a mix of low shrubs (such as *Salix* species and *Betula* species) and ericaceous shrubs. Shrub species include *Ledum decumbens*, *Vaccinium uliginosum*, *Chamaedaphne calyculata*, *Betula nana*, *Salix* species and occasionally *Alnus* species. *Larix laricina* has been found in trace amounts on many sites, and lichens and mosses are common.

Open-woodland stunted spruce stands are commonly found adjacent to the *open-woodland spruce forest* and occasionally near the *dense-open spruce forest* map classes. Periodically, small patches of the *dry-mesic herbaceous* class are found within large patches of *open-woodland stunted spruce* often on lacustrine deposits.

Landcover Class Accuracy—The producer's accuracy for the *open-woodland stunted spruce* class is 80.1%, with a user's accuracy of 87.6%. Most of the errors of commission and omission are due to confusion with the *open-woodland spruce forest* class.

BROADLEAF FOREST LANDCOVER CLASS

Classification—*Betula papyrifera*, *Populus tremuloides* and *Populus balsamifera*, individually or combined, with a canopy cover of 10% to 100%, with needleleaf less than 25% of the total tree cover. The class is comparable to the Viereck et al. (1992) hierarchical levels closed broadleaf forest (IB1), open broadleaf forest (IB2), and broadleaf woodland (IB3).



Distribution and Site Characteristics—This class occurs at low elevations (93 to 774 meters based on field data; Table 3) primarily in the Lake Minchumina Basin, toeslopes of the Kantishna Hills, lower slope positions and rolling hills on the south side of the Alaska Range, and in localized patches on outwash plains and floodplains throughout the park. The slope ranges from relatively level on floodplains, to moderate to steep on hillsides. The class is concentrated in the Kuskokwim-low mountains and pediments ecoregion and the Alaska Range-Kantishna Hills ecoregion (Tables 4a and 4b; Clark 1998). This class does not, however, dominate any one ecoregion. These deciduous forests cover 1.6% (97,063 acres) of Denali (Table 5).

Vegetation—Forest canopy closure for the *broadleaf forest* class ranges from 10% to 100%, with an average cover of 75%. *Betula papyrifera* is the most common species dominating sites on both the north and south sides of the Alaska Range. *Populus tremuloides* often occurs as a sub-dominant to *Betula papyrifera*, but also occurs as the dominant deciduous tree species in the northeast portion of the park. *Populus balsamifera* is typically restricted to floodplains occurring as small to mid size patches, but is also found in small patches on hillsides throughout the park. From an aerial perspective, understory shrubs are typically *Alnus* and *Salix* species. Small coverage of grasses and sedges also occur. Mosses and lichens are present in varying amounts. Adjacent landcover classes include *open-woodland spruce forests* and, occasionally, *dense-open spruce forests*. Small patches of *dry-mesic herbaceous* or *wet herbaceous* often grow adjacent to this type on riparian areas.

Landcover Class Accuracy—The producer's accuracy for the *broadleaf forest* class is 80.3%, with a user's accuracy of 62.1%. Most of the errors of commission are with the *mixed spruce-broadleaf forest* class, while most of the omission errors are with the *willow shrub* and *low shrub birch-ericaceous-willow* map class.

MIXED SPRUCE-BROADLEAF FOREST LANDCOVER CLASS

Classification—Tree canopy cover is 10% to 100%, with needleleaf and deciduous trees each contributing 25% to 75% of the total tree cover. The class is comparable to the Viereck et al. (1992) hierarchical levels closed mixed forest (IC1), open mixed forest (IC2), and mixed woodland (IC3).



Distribution and Site Characteristics—The *mixed spruce-broadleaf forest* class is common on low elevation (91 to 721 meters based on field data; Table 3) foothills and floodplains south of the Alaska Range, and as scattered patches throughout the forested region—especially adjacent to floodplains—north of the Alaska Range. It is a dominant map class—along with *low shrub birch ericaceous willow*—in the Cook inlet-glaciated hills and plains ecoregion (Tables 4a and 4b; Clark 1998). Slopes range from relatively level on floodplains, to moderate or steep on hillsides, and the soils are generally mesic with no peat development. This landcover class comprises 2.5% (149,929 acres) of Denali (Table 5).

Vegetation—The dominant tree species are typically either *Picea glauca* mixed with *Betula papyrifera* or *Picea glauca* mixed with *Populus balsamifera*. The white spruce-paper birch mix is generally found on sideslopes and toeslopes. *Populus tremuloides* and *Picea mariana* may also occur, sometimes as a strong codominant. Total tree cover ranges from 30% to 75%. When the white spruce-paper birch canopy is open, the trees tend to grow in a clumped distribution. Therefore, open patches in the canopy are common and allow for other species to take advantage of the available sunlight. Low and tall shrubs, such as *Salix* species, *Alnus* species, and *Vaccinium uliginosum* dominate these patches. Mosses or lichens also occur in minor amounts.

The white spruce-balsam poplar mix occurs on disturbed, sandy soils along riparian corridors with little to no slope. It is dominated by *Picea glauca* and *Populus balsamifera*, although *Betula papyrifera* is frequently, though not always, present. Canopy cover is often patchy and the open patches are typically dominated by *Alnus* species often growing over 3.6 meters tall.

The landcover class occurs adjacent to needleleaf and deciduous classes, as well as small patches of tall shrub along riparian corridors.

Landcover Class Accuracy—The producer's accuracy for the *mixed spruce-broadleaf forest* class is 59.7%, with a user's accuracy of 88.4%. Most of the errors of commission are with the *open-woodland spruce forest* class and the *broadleaf forest* class. Most of the error of omission is with the *broadleaf forest* class. The *mixed spruce-broadleaf forest* class by definition is spectrally mixed. It is very difficult to separate from stands of open-spruce forest with a tall shrub understory that typically occur on the north side of Denali, or from mixed areas with a high proportion of broadleaf that typically occur on the south side of the park. All accuracies are based on the 25-class landcover map at a 2-acre mapping unit prior to the digital integration of the burn mask.

ALDER SHRUB LANDCOVER CLASS

Classification—Tree canopy cover is less than 10% (or absent). Total shrub cover is 25% to 100% and alder constitutes greater than 75% of the total shrub cover. The class is comparable to the Viereck et al. (1992) hierarchical levels closed tall alder (IIB1b), and open tall scrub alder (IIB2b).



Distribution and Site Characteristics—The *alder shrub* class dominates most steep slopes at low to mid elevations (191 to 1,124 meters based on field data; Table 3) on the south side of the Alaska Range and, to a lesser extent, the Kantishna Hills. It also occurs consistently in small patches on new alluvial deposits along floodplains. The steep slopes are typically colluvium and glacial drift, and slope values range from 0 to over 50% on all aspects. This class dominates the Alaska Range-south-central mountains and valleys ecoregion, and also is concentrated in the Alaska Range-interior mountains and valleys ecoregion and Alaska Range-Kantishna Hills ecoregion within Denali (Tables 4a and 4b; Clark 1998). The *alder shrub* landcover class covers 4.3% (260,198 acres) of the park (Table 5).

Vegetation—*Alnus* species or a combination of alder and tall *Salix* species (>1.5 meters in height) dominate the landcover type. *Alnus crispa* is the most common species, however, *Alnus sinuata* and *Alnus tenuifolia* dominate some sites. Alder height ranges from less than 1.5 meters at higher elevations to 4.5 meters tall downslope. Alder cover or a combination of alder and willow is also variable, ranging from 25% to 95%. Sites with a more closed canopy are more common throughout Denali than the open sites. Large homogenous patches of open alder, however, do occur and typically grade into the closed alder patches.

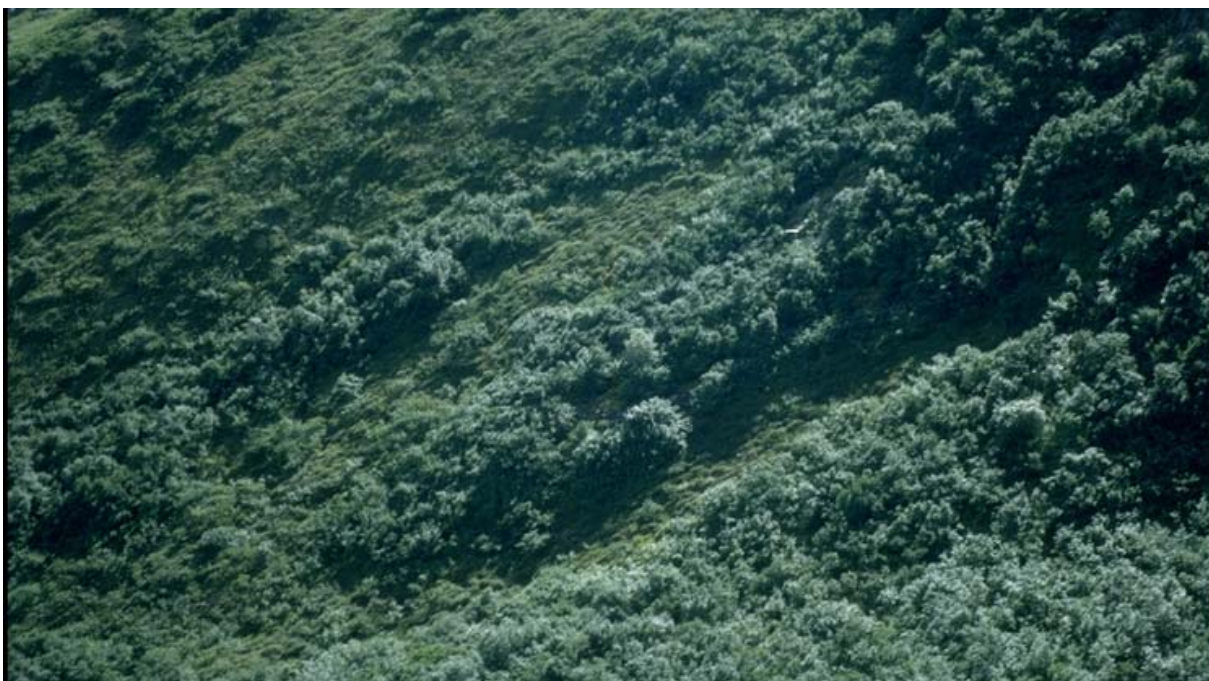
Canopy cover of understory vegetation ranges from sparse to dense. Associated understory shrubs include *Salix* species, *Echinopanax horridus*, *Sorbus scopulina*, and *Spirea beauverdiana*. A significant herbaceous layer includes *Veratrum viride*, *Epilobium angustifolium*, *Heracleum lanatum*, and small amounts of *Iris setosa*, *Petasites* species, and *Boykinia richardsonii*. High graminoid content may be present typically dominated by *Calamagrostis canadensis*. Ferns are also common including *Dryopteris dilatata*.

The *alder shrub* class grows adjacent to broadleaf forest, spruce forest, willow shrub, low shrub and dwarf shrub classes. The pure alder sites often blend into sites with willow as a co-dominant species. Alder also commonly grades into the spruce classes at times forming extensive areas of high alder cover and low spruce cover. Sites dominated by both alder and willow occur as small discontinuous patches in narrow steep draws, the wetter depressions of sideslopes, and disturbed riparian corridors. Alder-willow dominated sites generally grade into the *willow shrub* class in the drainages and pure alder sites on the steep sideslopes.

Landcover Class Accuracy—The producer's accuracy for the *alder shrub* class is 93.6%, with a user's accuracy of 92.1%. Most of the errors of commission and omission are with the *willow shrub* class.

WILLOW SHRUB LANDCOVER CLASS

Classification—Tree canopy cover is less than 10% (or absent). Total shrub cover is 25% to 100%, and willow greater than 20 centimeters tall comprises greater than 75% of the total shrub cover. The class is comparable to the Viereck et al. (1992) hierarchical levels closed tall willow (IIB1a), open tall willow (IIB2a), closed low willow (IIC1b), and open low scrub (11C2).



Distribution and Site Characteristics—The *willow shrub* class occurs on a variety of sites throughout the park. *Willow shrub* dominated by low stature (20 centimeters to 1.5 meters in height) willow is common at mid elevations (range of 191 to 1,116 meters based on field data; Table 3) mixed with other low shrub classes on flat river drainages and the rolling foothills bordering the north side of the Alaska Range. When tall willow (>1.5 meters) dominates the class, it occurs primarily in small patches on new alluvial stream/river deposits, alluvial fans, colluvial sideslopes and bordering small mountain streams. Both tall and low willows occur on upper slope positions mixed in with or above the *alder shrub* class in the Alaska Range and Kantishna Hills.

The class does not dominate any ecoregion, but is concentrated in the Alaska Range-Kantishna Hills ecoregion and the Alaska Range-south-central mountains and valleys ecoregion of the park (Tables 4a and 4b; Clark 1998). It covers 1.6% (95,590 acres) of Denali (Table 5). On the landcover map, this class is underrepresented on the south side of the Alaska Range due to its partial inclusion in the *herbaceous/shrub* class.

Vegetation—This class includes all sites dominated by willows greater than 20 centimeters tall. Willow cover ranges from 25% to 95%, and its height ranges from 20 centimeters to 4.5 meters. Sites dominated by open tall willow and closed low willow are common in the park, whereas closed tall willow is uncommon. The dominant overstory species include *Salix alaxensis*, *S. barclayi*, *S. bebbiana*, *S. glauca*, *S. lanata*, and *S. planifolia*. Other overstory and understory shrubs include *Shepherdia canadensis*, *Vaccinium uliginosum*, *Betula nana*, and *Spirea beauverdiana*. Tall alder (*Alnus* species) may also be found in isolated locations within the landcover class. Grasses, sedges, and mosses are an important

component in some sites and include *Heracleum lanatum*, *Calamagrostis canadensis*, *C. inexpansa*, *Epilobium angustifolium*, *Streptopus* species and *Veratrum viride*.

The *willow shrub* class is most commonly found next to low shrub classes on gentle toeslopes, fans, floodplains and wide valleys. It is found near needleleaf classes in narrow drainages and also in wide valleys. The *dry-mesic herbaceous* class occurs adjacent to the *willow shrub* class on sideslopes and saturated toeslopes.

Landcover Class Accuracy—The producer's accuracy for the *willow shrub* class is 55.1%, with a user's accuracy of 50.0%. Most of the errors of commission are with the *broadleaf forest* and *alder shrub* classes. Most of the omission error is with *alder shrub*.

CLOSED LOW BIRCH SHRUB LANDCOVER CLASS

Classification—Tree canopy cover is less than 10% (or absent). Greater than 75% of the total shrub cover is shrub birch, and total shrub cover is 75% to 100%. The class is comparable to the Viereck et al. (1992) hierarchical level closed low shrub birch IIC1a.



Distribution and Site Characteristics— The *closed low birch shrub* landcover class is uncommon within Denali and is concentrated in the northeast portion of the park. It typically occurs at mid elevations (439 to 1,097 meters based on field data; Table 3) on gentle to moderate slopes within the foothills and broad valleys bordering the north side of the Alaska Range and the Kantishna hills. It also occurs on floodplains. The class does not dominate any one ecoregion, but is concentrated in the Alaska Range-interior mountains and valleys ecoregion (Tables 4a and 4b; Clark 1998). It covers 0.9% (54,034 acres) of the Park (Table 5). The landcover class typically occurs adjacent to various needleleaf forest and low shrub classes.

Vegetation—*Betula glandulosa* or *B. nana* dominates this class. Average shrub cover is 75%. Tussocks are uncommon, but may be present. Associated species include low willow (*Salix* species), *Vaccinium uliginosum*, and various graminoid species. Small amounts of *Picea glauca*, *Ledum decumbens*, and moss also occur.

Landcover Class Accuracy—The producer's accuracy for the *closed low shrub birch* class is 67.3%, with a user's accuracy of 83.2%. Most of the errors of commission and omission are with the *open-woodland stunted spruce* class and the *low shrub birch-ericaceous-willow* class.

LOW SHRUB BIRCH-ERICACEOUS-WILLOW LANDCOVER CLASS

Classification—Tree canopy cover is less than 10% (or absent). Shrub birch, ericaceous shrubs and low willow (20 centimeters to 1.5 meters tall) individually contribute 25% to 75% of the total shrub cover; and total shrub cover is 25% to 100%. The class is comparable to the Viereck et al. (1992) hierarchical levels closed low scrub (IIC1), and open low scrub (IIC2).



Distribution and Site Characteristics—The *low shrub birch-ericaceous-willow* landcover class is an ecologically broad class ranging from sites dominated by open willow to *Betula nana* and ericaceous shrubs. The class is a dominant type above the boreal forest region and below alpine on gentle to moderate slopes within the foothills and broad valleys bordering the Kantishna hills, the north side of the Alaska Range, and within Broad Pass. The elevation ranges from 204 to 1,068 meters based on field data (Table 3). It dominates several ecoregions including the Cook Inlet-glaciated hills and plains, Alaska Range-front range, Alaska Range-Kantishna Hills and Alaska Range-Teklanika mountains and plateaus ecoregions (Tables 4a and 4b; Clark 1998). It covers 9.5% (570,700 acres) of Denali (Table 5). Because this class covers a wide range of site conditions across the park, it is found adjacent to numerous landcover classes. However, it is most commonly found elevationally above needleleaf classes and mixed in with other shrub classes.

Vegetation—Species composition and cover often fluctuate within and between sites. The dominant species are *Betula nana*, *Chamaedaphne calyculata*, *Salix barrattiana*, *S. glauca*, *S. planifolia*, *Ledum decumbens*, *Vaccinium uliginosum*, and *Empetrum nigrum*. Herbaceous species include *Achillea* species, *Calamagrostis lapponica*, *Epilobium angustifolium*, and *Rumex* species. Mosses are common on some sites and lichens are rare.

Landcover Class Accuracy—The producer's accuracy for the *low shrub birch ericaceous willow* class is 83.4%, with a user's accuracy of 75.3%. Most of the errors of commission and omission are with the *low shrub-sedge* class.

LOW SHRUB-SEDGE LANDCOVER CLASS

Classification—Tree canopy cover is less than 10% (or absent). Low (20 centimeters to 1.5 meters tall) mixed shrubs and graminoids each contribute 25% to 75% of the total cover, and tussock formation is common. The class is comparable to the Viereck et al. (1992) hierarchical level open low scrub (IIC2).



Distribution and Site Characteristics—The *low shrub-sedge* class is a common class occurring elevationally above the boreal forest and below alpine (168 to 1,052 meters based on field data; Table 3). It occurs on gentle to moderate slopes of foothills and broad valleys bordering the Kantishna hills and the north side of the Alaska Range, and also on the hills north of Lake Minchumina. The soils are mesic with organic tussocks over top of mineral soil. Small seasonal pools of water often occur between tussocks. The class dominates the Alaska Range-Toklat Basin ecoregion and is common in other ecoregions including the Alaska Range-Teklanika mountains and plateaus and Kuskokwim-alluvial fans and flood plains ecoregions (Tables 4a and 4b; Clark 1998). It covers 4.6% (277,322 acres) of Denali (Table 5).

The *low shrub-sedge* class commonly forms a mosaic with the *open-woodland stunted spruce* and *low shrub birch-ericaceous-willow* landcover classes.

Vegetation—Low shrubs over a lush sedge/graminoid layer that typically form tussocks characterize this class. The dominant species are *Salix* species, *Betula nana*, *Chamaedaphne calyculata*, *Ledum decumbens*, *Carex aquatilis*, *Eriophorum brachyantherum*, *E. vaginatum* and other graminoids. The combined shrub cover ranges from 25% to 74%. *Picea mariana* occurs sporadically, and *Sphagnum* species are a frequent associate along with other mosses.

Landcover Class Accuracy—The producer's accuracy for the *low shrub-sedge* class is 82.8%, with a user's accuracy of 80.3%. Most of the errors of commission and omission are with *open-woodland stunted spruce* and *low shrub birch-ericaceous-willow* map classes.

PEATLAND LANDCOVER CLASS

Classification—The *peatland* landcover class occurs on peatlands (bogs and fens) south of the Alaska Range. The peatlands north of the Alaska Range are not included in this class. The *peatland* landcover class is comprised of a variety of already defined landcover classes that occur on peat deposits including *open-woodland stunted spruce*, *willow shrub*, *dry-mesic herbaceous* and *wet herbaceous*. In addition, the *Myrica gale* plant association occurs in this landcover class. This combination class is defined because it is spectrally distinct on the south side of the Alaska Range, and the individual classes could not be spectrally separated reliably on peat deposits. The class is comparable to the Viereck et al. (1992) hierarchical levels open needleleaf forest (IA2), needleleaf woodland (IA3), open dwarf tree scrub (IIA2), dwarf tree scrub woodland (IIA3), closed tall willow (IIB1a), open tall willow (IIB2a), closed low willow (IIC1b), open low scrub (IIC2), dry graminoid herbaceous (IIIA1), mesic graminoid herbaceous (IIIA2), dry forb herbaceous (IIIB1), mesic forb herbaceous (IIIB2), wet graminoid herbaceous (IIIA3) and wet forb herbaceous (IIIB3).



Distribution and Site Characteristics—The *peatland* landcover class is found only in the lowlands (74 to 315 meters based on field data; Table 3) south of the Alaska Range. Peat deposits (i.e., peatlands, muskeg, bogs, fens) are composed of >0.5 meters of accumulated peat in areas of restricted drainage with water tables at or close to the peat surface. They occupy former lake basins and other closed depressions, alluvium along some valley floors, and are abundant on older glacial drift deposits within the boreal forest. The class covers 0.04% (2,304 acres) of Denali (Table 5). Peatlands are generally found adjacent to forested areas in Denali.

The gradient of nutrient availability and water sources in peatlands is typically divided into nutrient rich (fen) and nutrient poor (bog) peatlands. Fens are wetlands with wet organic soils, dominated by aquatic, emergent, and dwarf shrubs, or raised peat dominated by shrubs and trees. Ground water, the primary water source in a fen, is nutrient rich because of its contact with mineral soils. Waters may be acidic or

basic, but typically with a pH above 4.7. Water is lost through evapotranspiration, seepage (infiltration through the soil), and surface outflow.

Bogs are wetlands with organic soils, typically dominated by *Sphagnum* (peat moss) species, sedges, grasses, or reeds. Bogs require depressions (ponds) in level areas where precipitation exceeds evapotranspiration. Precipitation is the primary water source in a bog, with little or no ground-water flow. Consequently the sites are nutrient-poor and acidic, commonly with a pH less than 4.7. The water table is at or close to the surface most of the year. Because of the continuum of site and vegetation change within a peatland, it is often difficult to clearly separate a fen from a bog in the field.

Vegetation—In level areas, peatlands generally exhibit recognizable and consistent vegetation zonation patterns that are directly associated with different water depths. The vegetation, on a wet to dry moisture gradient, changes from aquatic (pond), to emergent and mesic herbaceous (*Calamagrostis canadensis*, *Carex rostrata*, *C. aquatilis* and *Eleocharis quinqueflora*), to shrub-dominated wetland (*Myrica gale* and *Betula nana*), to dwarf tree (*Picea mariana*). *Sphagnum* species occur in most dominance types. Not all the vegetation zones are always expressed, and the zonation may change abruptly, such as from a pond to a shrubland. Fens on ground with a slight gradient and with heavy subsurface and surface waterflow often develop a patterned ground of vegetated ridges, and vegetated or unvegetated hollows filled with water.

Landcover Class Accuracy—The producer's accuracy for the *peatland* class is 82.3%, with a user's accuracy of 80.9%. Most of the errors of commission and omission are with the *low shrub sedge* class.

HERBACEOUS/SHRUB LANDCOVER CLASS

Classification—The *herbaceous/shrub* landcover class is a mixture of three already defined landcover classes: *willow shrub*, *dwarf shrub* and *dry mesic herbaceous*. This combination class was created because of extensive over-classification of the *low shrub sedge* class on the upper slopes on the south side of the Alaska Range. The *low shrub sedge* class at this slope position was actually a combination of the *willow shrub*, *dwarf shrub* and *dry mesic herbaceous* classes. We were unable, however, to split the *low shrub sedge* class into its proper components—*willow shrub*, *dwarf shrub* and *dry mesic herbaceous*. The *low shrub sedge* class, consequently, was reclassified to a new class—*herbaceous/shrub*—at or above alder line (generally elevations of 600 m or greater) on the park's south side. For a complete description of the methods used to define this class see Stevens et al. (2001). The class is comparable to the Viereck et al. (1992) hierarchical levels closed tall willow (IIB1a), open tall willow (IIB2a), closed low willow (IIC1b), open low scrub (IIC2), dwarf scrub (IID), dry graminoid herbaceous (IIIA1), mesic graminoid herbaceous (IIIA2), dry forb herbaceous (IIIB1) and mesic forb herbaceous (IIIB2).



Distribution and Site Characteristics—The *herbaceous/shrub* class is found on mountain ridges and slopes on the south side of the Alaska Range. It occurs both above the alder zone and mixed in with the alder class moving down slope. The *willow shrub* and *dry mesic herbaceous* classes occur adjacent to this class both up and down slope. The *dwarf shrub* class typically borders the *herbaceous/shrub* class upslope. The sites are typically moist, and occur below 1,500 meters elevation (Table 3). It is a major component of the Alaska Range-south-central mountains and valleys ecoregion (Tables 4a and 4b; Clark 1998), and covers 1.1% (68,872 acres) of Denali (Table 5).

Vegetation—For species and structural information please review the individual landcover classes that make up the *herbaceous/shrub* class: *willow shrub*, *dwarf shrub* and *dry mesic herbaceous*. Note that sites dominated by *Dryas octopetala* are uncommon in the *herbaceous/shrub* class. Instead, dwarf shrub species are mixed, including *Empetrum nigrum* and *Vaccinium uliginosum*, and have a strong graminoid component. The *dry mesic herbaceous* component is typically lush and includes *Calamagrostis canadensis*, *Athyrium filix-femina*, *Epilobium angustifolium*, *Geranium erianthum*, *Heracleum lanatum* and *Sanguisorba stipulata*.

Landcover Class Accuracy—The accuracy of the *herbaceous-shrub* class was not assessed because the class is a combination of other map classes.

DWARF SHRUB LANDCOVER CLASS

Classification—Tree canopy cover is less than 10% (or absent). Shrub cover is greater than 25%, shrub height is less than 20 centimeters, and less than 25% of the site contains rock. The class is comparable to the Viereck et al. (1992) hierarchical level dwarf scrub (IID).



Distribution and Site Characteristics— The *dwarf shrub* landcover class dominates alpine areas in the Alaska Range and the Kantishna Hills. It is found on unstable to stable surfaces such as gentle to steep mountain slopes, high mountain valley floors, and rounded mountain ridges (often exposed bedrock). Slopes range from 0 to >50%. The soils are a thin layer of dry to mesic sand, litter or organic matter. Its elevation ranges up to 1,335 meters based on field data (Table 3). This class dominates the Alaska Range-interior mountains and valleys ecoregion, and is common in the Alaska Range-front range and Alaska Range-south-central mountains and valleys ecoregions (Tables 4a and 4b; Clark 1998). It covers 5.8% (346,847 acres) of Denali (Table 5). On the landcover map, this class is underrepresented on the south side of the Alaska Range due to its partial inclusion in the *herbaceous/shrub* class.

The *dwarf shrub* landcover class often grades into the *bare ground*, *sparse vegetation* or *dwarf shrub-rock* landcover classes and, on more stable sites, the *alder shrub* and *willow shrub* landcover classes.

Vegetation— The *dwarf shrub* class is comprised of vegetation that generally reaches a height of 20 centimeters or less. Most sites are a blend of dwarf shrubs with some sedge and lichen species often interspersed with exposed rock. The dominant dwarf shrubs include *Dryas octopetala*, *D. integrifolia*, *Salix reticulata*, *S. arctica*, *S. phlebophylla*, *Cassiope tetragona*, *Vaccinium uliginosum*, *Arctostaphylos rubra* and *A. alpina*. Forbs include *Epilobium angustifolium*, *Aster* species, *Heracleum lanatum*, *Veratrum viride*, *Anemone narcissiflora*, and *Campanula* species. Some sites, however, have a strong graminoid presence, or are dominated by *Dryas* species in the dwarf shrub layer.

Landcover Class Accuracy—The producer's accuracy for the *dwarf shrub* class is 78.4%, with a user's accuracy of 80.2%. Most of the errors of omission are with the *low shrub birch-ericaceous-willow* and *low shrub sedge* map classes.

DWARF SHRUB-ROCK LANDCOVER CLASS

Classification—Tree canopy cover is less than 10% (or absent). Shrub cover is greater than 25%, shrub height is less than 20 centimeters, and rock cover is greater than 25%. The class is comparable to the Viereck et al. (1992) hierarchical level dwarf scrub (IID).



Distribution and Site Characteristics—The physical site characteristics of the *dwarf shrub-rock* landcover class are similar to the *dwarf shrub* landcover class, however it has a much higher surface rock component. It is a minor class of alpine areas in the Alaska Range and the Kantishna Hills, and is found on unstable to stable surfaces such as gentle to steep mountain slopes, high mountain valley floors, and rounded mountain ridges. In addition, it occurs on sandbars and alluvial fans. The slope ranges up to >50%, and the elevation ranges up to 1,335 meters based on field data (Table 3). The soils are a thin layer of dry to mesic sand, litter or organic matter. Vegetation typically grows on the thin organic mat. This class is common in the Alaska Range-high mountains ecoregion and the Alaska Range-interior mountains and valleys ecoregion (Tables 4a and 4b; Clark 1998). It covers 1.2% (73,894 acres) of Denali (Table 5).

The *dwarf shrub-rock* class often grades into the *bare ground*, *sparse vegetation* or *dwarf shrub* landcover classes. On more stable surfaces, it grades into the *alder shrub* and *willow shrub* classes.

Vegetation—This class is dominated by dwarf shrubs, primarily *Dryas octopetala* and *D. integrifolia*, interspersed with exposed rock. Few additional species are present. Other dwarf shrubs include *Salix reticulata*, *S. arctica*, *S. phlebophylla*, *Cassiope tetragona*, *Vaccinium uliginosum*, *Arctostaphylos rubra*, and *A. alpina*. Forbs include *Epilobium angustifolium*, *Aster* species, *Heracleum lanatum*, *Veratrum viride*, *Anemone narcissiflora*, and *Campanula* species. Fruticose lichen species are common.

Landcover Class Accuracy—The producer's accuracy for the *dwarf shrub-rock* class is 54.9%, with a user's accuracy of 50.3%. Most of the errors of omission and commission are with the *dwarf shrub* and *sparse vegetation* classes. The number of *dwarf shrub-rock* signatures available for the accuracy assessment is significantly less than preferred.

DRY-MESIC HERBACEOUS LANDCOVER CLASS

Classification—Tree canopy is less than 10% (or absent), shrub cover is less than 25%, and herbaceous cover is greater than 25%. Vegetation is terrestrial (not submerged, floating, or growing in permanent water). Site is dry to mesic with little to no standing water. The class is comparable to the Viereck et al. (1992) hierarchical levels dry graminoid herbaceous (IIIA1), mesic graminoid herbaceous (IIIA2), dry forb herbaceous (IIIB1), and mesic forb herbaceous (IIIB2). The photo on the left is from the south side of the Alaska Range, and the photo on the right is a moist depression in the northwest region of Denali.



Distribution and Site Characteristics— The *dry-mesic herbaceous* class is a minor class that occurs throughout the park under a variety of site conditions. It primarily occurs as rich herbaceous meadows on mesic sideslopes ranging up to >50% slope and river terraces on the south side of the Alaska Range. The class occurs both above the alder zone up to 1,200 meters, and mixed in with alder moving down slope (Table 3). On the landcover map, it is underrepresented on the south side of the Alaska Range due to its partial inclusion in the *herbaceous/shrub* class.

It also occurs as grassy meadows, dominated by *Calamagrostis canadensis*, found on low elevation moist—and periodically wet—depressions within the boreal forest in the northwestern portion of the park. These sites are moist, however, standing water may be present in small amounts seasonally. Tussock tundra, dominated by *Eriophorum* species, also forms a portion of this class occurring as small patches on gentle to moderate slopes of foothills and broad valleys bordering the Kantishna hills and the north side of the Alaska Range, and also on hills near Lake Minchumina. Tussock tundra soils are mesic with tussocks of organic matter and live vegetation over mineral soil. Small seasonal pools of water are often found between the tussocks. The *dry-mesic herbaceous* class nearly always occurs as small patches within a mosaic of other classes. Most landcover classes occur adjacent to the class due to its wide geographic distribution and elevation range. It is uncommon in most ecoregions except the Alaska Range-south-central mountains and valleys ecoregion (Tables 4a and 4b; Clark 1998), and covers 0.8% (45,684 acres) of Denali (Table 5).

Vegetation—The *dry-mesic herbaceous* class is a grouping of plant associations that encompasses dry or mesic sites as well as lush herbaceous meadows. Herbaceous meadows contain such forbs as *Veratrum viride*, *Ligusticum scoticum*, *Geranium erianthum*, *Cicuta douglasii*, *Iris setosa*, *Athyrium filix-femina*, *Calamagrostis canadensis*, *Epilobium angustifolium*, *Heracleum lanatum* and *Sanguisorba stipulata*. Total cover often exceeds 90%. Low shrubs may also occur including *Spiraea beauverdiana* and *Salix planifolia*.

The grassy meadows in the boreal forest are dominated by *Calamagrostis canadensis* with cover values up to 95%. Other species present but uncommon are *Betula glandulosa*, *Vaccinium uliginosum*, *Athyrium filix-femina* and *Myrica gale*.

Sites that are dominated by tussocks have high levels of graminoids, predominantly *Eriophorum* species, and mosses. Surface water, *Betula nana*, and *Rubus chamaemorus* also occur. Tussock cover ranges up to 90% on sites sampled.

Landcover Class Accuracy—The producer's accuracy for the *dry-mesic herbaceous* class is 70.0%, with a user's accuracy of 85.6%. Most of the errors of omission and commission are with the *low shrub*, *herbaceous shrub* and *dwarf shrub* classes.

WET HERBACEOUS LANDCOVER CLASS

Classification—Tree canopy is less than 10% (or absent), shrub cover is less than 25%, and herbaceous cover is greater than 25%. The dominant vegetation is emergent; semi-permanent or standing water is present. The class is comparable to the Viereck et al. (1992) hierarchical levels wet graminoid herbaceous (IIIA3), and wet forb herbaceous (IIIB3).



Distribution and Site Characteristics—The *wet herbaceous* class occurs in small patches throughout the park's boreal forest zone and at higher elevations dominated by low shrubs. The sites have standing or semi-permanent water dominated by hydrophilic vegetation. It most frequently occurs on lake edges, but also on saturated river terraces, the edge of ponds, sloughs, fens, other patterned ground, and occasionally in pools of hillside streams. The sites have little to no slope. Relative to other classes, the *wet herbaceous* class is generally small in size and patchy in distribution throughout Denali. The highest elevation, based on field data, is 824 meters (Table 3). It is uncommon in all ecoregions except the Kuskokwim-alluvial fans and flood plains ecoregion and the Kuskokwim-Minchumina Basin ecoregion (Tables 4a and 4b; Clark 1998). The class covers 0.6% (38,427 acres) of Denali (Table 5).

Vegetation—Herbaceous composition is highly variable and includes *Menyanthes trifoliata*, *Potentilla palustris*, *Cnidium cnidiifolium*, *Eriophorum brachyantherum*, *E. vaginatum*, *Equisetum fluviatile*, *Carex rostrata*, *C. aquatilis* and *C. lasiocarpa*. Each species may dominate a site. Low shrubs associated with the *wet herbaceous* class include *Betula nana*, *Salix* species, *Potentilla fruticosa*, *Myrica gale*, and *Spirea beauverdiana*. *Sphagnum* species sometimes form a floating mat interspersed with the emergent vascular species.

Landcover Class Accuracy—The producer's accuracy for the *wet herbaceous* class is 68.7%, with a user's accuracy of 89.7%. Errors of omission and commission are relatively small, but scattered with a number of different mapping classes (*open-woodland stunted spruce*, *willow shrub*, *low shrubs* and *water*).

AQUATIC HERBACEOUS LANDCOVER CLASS

Classification—Tree canopy is less than 10% (or absent), shrub cover is less than 25%, and herbaceous cover is greater than 25%. Vegetation is submerged, floating, or growing in permanent water. The class is comparable to the Viereck et al. (1992) hierarchical level freshwater aquatic herbaceous (IIID1).



Distribution and Site Characteristics—The *aquatic herbaceous* class occurs in small patches of open water throughout the park's boreal forest zone and at higher elevations dominated by low shrubs. The sites are in open water of lakes, ponds, sloughs and fens. It is generally small in size and patchy in distribution throughout Denali. The *aquatic herbaceous* class is uncommon in all ecoregions (Tables 4a and 4b; Clark 1998), and covers less than 0.01% (564 acres) of Denali (Table 5).

Vegetation—A high cover of water is found in this class. Associated vegetation includes *Nymphaea tetragona*, *Nuphar polysepalum*, and a few graminoids. Other aquatic species occur but were not sampled during the field season.

Landcover Class Accuracy—The producer's accuracy for the *aquatic herbaceous* class is 100%, with a user's accuracy of 100%. The number of *aquatic herbaceous* signatures available for the accuracy assessment is significantly less than preferred. All accuracies are based on the 25-class landcover map at a 2-acre mapping unit prior to the digital integration of the burn mask.

SPARSE VEGETATION LANDCOVER CLASS

Classification—The *sparse vegetation* landcover class refers to sites with 15% to 24% total vegetation cover.



Distribution and Site Characteristics— The *sparse vegetation* class is common in alpine areas of the Alaska Range. It is generally found on unstable to stable upslope bedrock and unconsolidated rock in the mountains and high mountain valley floors. This class also occurs on sandbars, alluvial fans and the debris covered surfaces of glaciers. The physical site characteristics are similar to the *dwarf shrub-rock* class however it has a much higher surface rock and mineral soil component. The slope ranges up to >50%, and the elevation ranges up to 1,142 meters based on field data, however, the spectral map places the maximum elevation at 4,527 meters (Table 3). The soils are a thin layer of dry to mesic sand, litter or organic matter. The sparse vegetation typically occurs as patches on the organic matter interspersed with exposed rock. This class is common in the Alaska Range-high mountains, Alaska Range-interior mountains and valleys, and Alaska Range-south-central mountains and valleys ecoregions (Tables 4a and 4b; Clark 1998). The *sparse vegetation* landcover class covers 4.8% (289,308 acres) of Denali (Table 5).

The class frequently occurs next to the *bare ground*, *dwarf shrub-rock* and *dwarf shrub* classes.

Vegetation—The *sparse vegetation* class is dominated by dwarf shrubs—primarily *Dryas octopetala*—surface rock, and exposed mineral soil. Other dwarf shrubs include *Dryas integrifolia*, *Salix reticulata*, *S. arctica*, *S. phlebophylla*, *Cassiope tetragona*, *Vaccinium uliginosum*, *Arctostaphylos rubra*, and *A. alpina*. Forbs include *Epilobium angustifolium*, *Aster* species, *Heracleum lanatum*, *Veratrum viride*, *Anemone narcissiflora*, and *Campanula* species.

Landcover Class Accuracy—The producer's accuracy for the *sparse vegetation* class is 87.6%, with a user's accuracy of 45.7%. Most of the errors of omission and commission are with the *bare* and *dwarf shrub-rock* map classes.

BARE GROUND LANDCOVER CLASS

Classification—Bare ground represents areas with less than 15% vegetation cover.



Distribution and Site Characteristics— The *bare ground* class primarily occurs on steep upslope bedrock, unconsolidated rock, mountain peaks, jutting rock outcrops, and talus slopes. It also represents exposed alluvial deposits along rivers, especially those with wide outwash plains. In addition, it represents the debris-covered surfaces of glaciers, typically increasing in cover toward a glacier's terminus. *Bare ground* is often found adjacent to the *sparse vegetation*, *dwarf shrub-rock* and *dwarf shrub* landcover classes. Elevation for the class ranges up to 5,536 meters based on the spectral map (Table 3). It dominates the Alaska Range-high mountains ecoregion (Tables 4a and 4b; Clark 1998) and covers 9.8% (592,298 acres) of Denali (Table 5).

Landcover Class Accuracy—The producer's accuracy for the *bare ground* class is 70.7%, with a user's accuracy of 86.5%. Most of the errors of omission and commission are with the *sparse vegetation* class.

SNOW/ICE LANDCOVER CLASS

The *snow/ice* class refers to areas covered with snowfields, glaciers or late lying snow. Glacier surfaces have less exposed ice as one moves towards the terminus. The elevation ranges up to 6,188 meters based on the spectral map (Table 3). The *snow/ice* class dominates the Alaska Range-high mountains ecoregion, and is the most common class in Denali covering 15.5% (932,790 acres) of its total area (Table 5).



Landcover Class Accuracy—The producer’s accuracy for the *snow/ice* class is 99.7%, with a user’s accuracy of 99.5%. Most of the minor errors of omission and commission are with the *bare* class.

SHADOW INDETERMINATE LANDCOVER CLASS

The *shadow indeterminate* landcover class includes areas of severe terrain shadow where landcover could not be reliably identified. This class covers 6.9% (657,887 acres) of Denali.

Landcover Class Accuracy—Accuracies were not reported for the *shadow indeterminate* mapping class because the class was so heavily edited that the signatures were obsolete.

SILTY WATER LANDCOVER CLASS

Silty water refers to water containing moderate to high levels of glacial silt and debris. The major rivers and portions of some lakes—such as Lake Minchumina—are mapped as silty water. The *silty water* class is common in the Cook Inlet-braided flood plains and stream terrace ecoregion. The *silty water* class covers 0.5% (30,765 acres) of Denali (Table 5).



Landcover Class Accuracy—The producer’s accuracy for the *silty water* class was 91.8%, with a user’s accuracy of 97.7%. Most of the minor errors of omission and commission were with the *bare* class. This class covers 6.9% (413,260 acres) of the park.

CLEAR WATER LANDCOVER CLASS

Clear water indicates water with little to no sediment or glacial silt. Most lakes and ponds are mapped as clear water in the park. The class covers 1.0% (60,764 acres) of Denali (Table 5).



Landcover Class Accuracy—The producer’s accuracy for the *clear water* class is 100%, with a user’s accuracy of 98.8%. The minor error of commission is with the *silty water* class.

BURN LANDCOVER CLASS

Description—The *burn* landcover class represents large areas that have recently been scarred by wildfires. The class occurs predominantly in the northwest region of the park on level landscapes and rolling hills. The burns were dominated, pre-fire, by the various spruce dominated landcover classes.



Because limited air and ground information was collected within burn scars, it was not possible to accurately map the class. However, many of the more recent or very intense burns (as indicated by the scarring on the raw imagery) on the park's west side were spectrally classified as wet herbaceous. Many of the older, or less intense burns were spectrally mapped to the *willow shrub* or *low shrub-sedge* classes. See the description for the plant association *Larix laricina*, *Betula papyrifera*, *Picea mariana*, *Ledum palustre*, *B. nana*, *Rubus chamaemorus*, *Eriophorum vaginatum*, *Oxycoccus microcarpos* for a description of a post-fire community. The *burn* class is common in the Kuskokwim-alluvial fans and floodplains ecoregion (Tables 4a and 4b), and covers 2.9% (172,528 acres) of Denali (Table 5).

Burn areas were identified and mapped by establishing thresholds within the NDVI layers created from the 1994 and 1996 SPOT imagery and from the TM imagery. The thresholds for the upper and lower NDVI values for each image block were defined through an interactive review with the satellite imagery and the associated thematic NDVI layers. Once the range of NDVI values corresponding to burn areas (i.e., no or very low 'greenness') were established, a burn mask that was constrained by Park provided fire polygon coverage was developed. However, users should take note that in addition to legitimate burn areas, some areas of legitimate wet herbaceous (i.e., wet herbaceous that was not burned) as well as some areas of water and aquatic herbaceous areas fell into the threshold range of NDVI values and were included in the burn mask. To help alleviate the misclassification of legitimate water (both silty and clear) and aquatic herbaceous to burn, an additional water and aquatic herbaceous mask was also provided. See Volume 1 (Stevens et al. 2001) for a complete description of the methods used to develop the burn landcover class.

Landcover Class Accuracy—Accuracies were not reported for the *burn* landcover class.

CLOUD LANDCOVER CLASS

The *cloud* landcover class designates areas masked by cloud cover on the satellite imagery. Due to the lack of spectral data, vegetation classes could not be assigned to these sites. The *cloud* landcover class covers 0.01% (357 acres) of Denali (Table 5).

Landcover Class Accuracy—Accuracies were not reported for the *cloud* landcover class because the class was so heavily edited that the signatures were obsolete.

PLANT ASSOCIATIONS

Plant association descriptions are provided below and are organized by landcover class. As stated in the methods, Heebner (1982) previously described forest and shrub plant associations for the north half of the Alaska Range and further north. The 56 Heebner (1982) plant association descriptions were copied and placed under the landcover class they occur in.

The 41 plant associations not defined by Heebner (1982) but sampled during the 1999 field season were described and also placed under the proper landcover class. Plant association descriptions include species lists, canopy cover, structure, and site information. Constancy-coverage tables were created for each plant association defined using the 1999 field data and the tables are given in Appendix 4.

DENSE-OPEN SPRUCE FOREST LANDCOVER CLASS

Number of plant associations currently in the landcover class: 1

***Picea glauca*, *Dryas integrifolia*, *Agropyron violaceum*, *Oxytropis campestris*, Bryales C15
(from Heebner 1982)**

Vegetation—This closed *Picea glauca* community has an overstory cover value of 45%. *Picea* seedlings occur, and the age of this type is 44 years. The major species of the shrub layer are *Salix brachycarpa* ssp. *niphoclada* (10% cover), *Potentilla fruticosa* (10% cover) and *Shepherdia canadensis* (5% cover). The major species of the herbaceous layer are *Dryas integrifolia* ssp. *integrifolia* (75% cover), *Agropyron violaceum* (30% cover), *Oxytropis campestris* ssp. *gracilis* (25% cover), *Gentiana propinqua* ssp. *propinqua* (10% cover), *Arctostaphylos rubra* (5% cover), *Poa alpina* (5% cover) and *Solidago multiradiata* (5% cover).

The nonvascular layer is composed of Bryales (10% cover), *Rhytidium rugosum* (5% cover), *Distichium capillaceum* (5% cover), *Peltigera horizontalis* and *Cladonia pyxidata* var. *pocillum*.

Environmental characteristics—The altitude of this type is 732 meters with zero range. It is found on alluvial deposits. This type is similar to C14, but the overstory was more closed and composed of younger trees.

OPEN-WOODLAND SPRUCE FOREST LANDCOVER CLASS

Number of plant associations currently in the landcover class: 12

***Picea glauca*, *Alnus crispa*, *Salix* species, *Vaccinium vitis-idaea*, *Hylocomium splendens*,
Stereocaulon species C10
(from Heebner 1982)**

Vegetation—This open *Picea glauca* type is found at an average altitude of 564 meters with an average slope of 11% and a north exposure. The range in elevation is 518 to 610 meters, and the range in slope is 8% to 13%. The overstory of *Picea glauca* has 20% cover. The shrub cover is made up of *Alnus crispa* (30% cover), *Salix* species (40% cover) and *Betula nana* (20% cover). *Vaccinium vitis-idaea* (35% cover), *Carex* species and Gramineae are important to the herbaceous cover. *Hylocomium splendens* (60%) and *Stereocaulon* species (30% cover) are the most significant to the nonvascular layer.

***Picea glauca*, *Alnus crispa*, *Salix glauca*, *Equisetum arvense*, *Rubus arcticus*, feathermoss C8
(from Heebner 1982)**

Vegetation—This community has a *Picea glauca* cover in the overstory of 30% with a mean age of 139.7 years. The seedlings of this type are solely *Picea glauca*. *Picea mariana* is an occasional associate. The shrub cover is 5% *Alnus crispa*. *Picea* is approximately 15 meters in height, and the *Alnus* was 3 to 5 meters in height. *Salix glauca*, *Salix arbusculoides*, *Rosa acicularis* and *Viburnum edule* also contributed to the shrub cover. The herbaceous cover is made up of *Equisetum arvense* (35%), *Rubus arcticus* (25%), *Arctagrostis latifolia* var. *arundinacea* (10%), *Calamagrostis lapponica* (10%), *Cornus canadensis* and *Equisetum scirpoides*. The feathermosses, *Hylocomium splendens*, *Aulacomnium palustre*, *Pleurozium schreberi* and *Rhytidium rugosum* dominate the nonvascular layer with a cumulative cover of 80%. *Peltigera* species and *Cladonia* species also contribute to the nonvascular cover. This type is more variable in species composition with greater canopy closure than C6.

Environmental characteristics—The average altitude is 567 meters, and the mean slope is 6% with exposures predominantly south/southwest. The range in elevation is 198 to 1,021 meters, and the range in slope is 0% to 30%. The substrate of this type is 65% alluvial/colluvial, 30% older moraines.

***Picea glauca*, *Betula glandulosa*, *Vaccinium vitis-idaea*, *Empetrum nigrum*, feathermoss C6
(from Heebner 1982)**

Vegetation—This is an open *Picea glauca* community (15% to 20% cover); *Picea mariana* was an occasional associate. The mean age of this type is 172 years. *Betula glandulosa* is the dominant shrub with 60% cover. *Ledum palustre*, *Vaccinium uliginosum* and *Salix planifolia* ssp. *pulchra* contribute 10%, 10% and 5% to the shrub layer respectively. The herbaceous layer is composed of *Empetrum nigrum* (25% cover), *Vaccinium vitis-idaea* (25% cover), *Aster sibiricus* and *Lycopodium annotinum* var. *pungens*. The major species of the nonvascular layer are *Hylocomium splendens* (50%), *Pleurozium schreberi* (30%), *Peltigera aphthosa* var. *leucoplebia* (5%), *Nephroma arcticum* (10%), *Cladonia rangiferina* (10%) and *Cladonia* species

Environmental characteristics—This type is at an average altitude of 562 meters with a 4% slope and a south/southwest exposure. The range in elevation is 453-671 meters. The range in slope is 3% to 22%.

***Picea glauca*, *Betula nana*, *Salix planifolia*, *Carex* species C11, C7
(from Heebner 1982)**

Vegetation—This community is an open *Picea glauca* community. The shrub layer is dominated by *Betula nana* (40% cover) and *Salix planifolia* (60% cover). The herbaceous layer is dominated by *Carex* species. The data for this type was marginal and scanty which influenced the analysis. This type is an example of an outlier due to minimal information.

Environmental characteristics—This community is at an average altitude of 829 meters with a range in elevation from 820 to 838 meters.

***Picea glauca*, *Potentilla fruticosa*, *Salix planifolia*, *Festuca altaica*, Bryales, *Stereocaulon* species
C14 (from Heebner 1982)**

Vegetation—The overstory of *Picea glauca* of this plant association has a cover value of 40%. *Picea glauca* seedlings are evident. The shrub layer is composed of *Salix glauca*, *Salix barclayi* and *Salix planifolia* ssp. *pulchra*, all with an average cover of 10%. *Betula nana* (10% cover), *Potentilla fruticosa* (15% cover) and occasionally *Vaccinium uliginosum* also occur in the shrub layer. The major species found in the herbaceous layer are *Salix reticulata* (10% cover), *Arctostaphylos rubra* (10% cover), *Festuca altaica* (25% cover), *Agropyron violaceum* (25% cover), *Artemisia tilesii* (5% cover), *Carex scirpoidea* (5% cover), *Saussurea angustifolia* (5% cover), *Hedysarum alpinum* (5% cover), *Poa arctica* (10% cover) and *Senecio lugens* (5% cover). The major species of the nonvascular layer are mosses of the Bryales family (30% cover), *Stereocaulon* species (25% cover), *Peltigera canina* var. *rufescens* and *Cladonia* species. This plant association is similar to C13 although the overstory is more closed.

Environmental characteristics—The average altitude of this type is 776 meters ranging from 732 to 820 meters. The mean age is 182 years, and the type is found on alluvial deposits.

***Picea glauca*, *Salix glauca*, *Salix reticulata*, *Arctagrostis latifolia*, feathermoss, *Cladonia rangiferina*, *Cladonia amaurocrea* C12
(from Heebner 1982)**

Vegetation—This plant association has an overstory of *Picea glauca* with a cover value of 10% to 25%. Seedlings of *Picea glauca* are evident, and the mean age of this type is 120.4 years. The shrub cover is composed of *Salix alaxensis* (10% cover), *Salix glauca* (10% cover), *Salix planifolia* ssp. *pulchra* (10% cover), *Betula nana* (10% cover), *Ledum palustre* (15% cover), *Shepherdia canadensis* (5% cover) and *Vaccinium uliginosum* (10% cover). The herbaceous cover is composed of *Salix reticulata* (25% cover), *Arctagrostis latifolia* (30% cover), *Equisetum arvense* (10% cover), *Equisetum scirpoides*, *Empetrum nigrum* (10% cover), *Festuca rubra* (5% cover), *Lupinus arcticus* (10% cover), *Saussurea angustifolia* (5% cover), *Arctostaphylos rubra* (5% cover), *Senecio lugens* (5% cover), *Hedysarum alpinum* (5% cover), *Dryas integrifolia* (5% cover) and *Cassiope tetragona* (5% cover).

The nonvascular layer contained the feathermosses, *Holycomium splendens*, *Rhytidium rugosum*, *Drepanocladus uncinatus* and *Aulacomnium acuminatum* with a cumulative cover of 15%. *Cladonia rangiferina*, *Cladonia amaurocrea*, *Cladonia pyxidata* var. *pocillum* and *Peltigera canina* var. *rufescens* were also contributors to the nonvascular layer.

Environmental characteristics—This type was found at an average altitude of 695 meters with a 9% slope and a south exposure. The range in elevation is 236 to 892 meters, and the range in slope is 0% to 28%. The communities were usually disturbed with drainage gullies contributing to the variability of this type. The mean age of this type was 120.4 years, but the range in stand age was 210 years.

***Picea glauca*/Salix lanata plant association**
White spruce/Richardson willow plant association; 1 site

Vegetation—*Picea glauca* (15% cover and 7.6 meters tall) is the only tree species recorded in the *Picea glauca*/Salix lanata plant association (Appendix 4). *Salix lanata* (60% cover) dominates the shrub layer, *Equisetum arvense* (70% cover) dominates the herbaceous layer, and total moss cover is 80%. Additional species include *Vaccinium uliginosum*, *Betula glandulosa*, *Ledum groenlandicum* and lichens.



Environmental characteristics—The one site sampled for this association is located on a gentle 5-degree slope at 910 meters elevation in the foothills north of the Alaska Range.

***Picea glauca*/Salix planifolia plant association**
White spruce/diamond leaf willow; 1 site

Vegetation—*Picea glauca* (30% cover and 9 meters tall) was the only tree species recorded in the *Picea glauca*/Salix planifolia plant association (Appendix 4). The understory is dominated by *Salix planifolia* (65% cover and 1.2 meters in height). *Calamagrostis canadensis* (70% cover) dominates the herbaceous layer, along with moss (20% cover) and *Equisetum silvaticum* (20% cover). Trace amounts of low shrubs and forbs are also present.

Environmental characteristics—The *Picea glauca*/Salix planifolia plant association is found within the boreal forest zone of the park. The site sampled is located on a toeslope at an elevation of 720 meters.

***Picea glauca*, *Salix planifolia*, *Vaccinium uliginosum*, *Arctostaphylos rubra*, *Hedysarum alpinum*,
Hylocomium splendens C13
(from Heebner 1982)**

Vegetation—The overstory cover value for *Picea glauca* in this plant association is 25% to 35%. The mean age is 175.3 years. The shrub layer is composed of *Salix planifolia* ssp. *pulchra* (25% cover), *Vaccinium uliginosum* (30% cover), *Potentilla fruticosa* (10% cover) and *Shepherdia canadensis* (10% cover). *Salix hastata* and *Salix barclayi* are occasional associates. The herbaceous cover is *Arctostaphylos rubra* (30% cover), *Salix reticulata* (25% cover), *Elymus innovatus* (10% cover), *Vaccinium vitis-idaea* (10% cover), *Empetrum nigrum* (10% cover), *Pyrola grandiflora* (25% cover), *Astragalus alpinus* (25% cover), *Hedysarum alpinum* (30% cover), *Solidago multiradiata* (10% cover), *Aster sibiricus* (10% cover), *Dryas integrifolia* (5% cover) and *Tofieldia coccinea* (10% cover). The nonvascular layer is dominated by *Hylocomium splendens* with 75% cover.

Environmental characteristics—This type is found at an average altitude of 712 meters with an average slope of 2% and an average aspect of 230 degrees. The substrate is alluvial and predominantly river bars. This plant association has a greater closure of overstory than C12.

***Picea glauca*, *Salix planifolia*, *Vaccinium uliginosum*, *Empetrum nigrum*, *Hylocomium splendens*
C9 (from Heebner 1982)**

Vegetation—The community has an overstory of *Picea glauca* that has a mean cover value of 30%. The shrub layer is composed of *Salix* species (usually *Salix planifolia* ssp. *pulchra*), *Vaccinium uliginosum*, *Betula nana* and *Ledum palustre* with cover values of 30%, 30%, 20%, and 10% respectively. *Rosa acicularis*, *Spiraea beauverdiana* are occasionally associates. The herbaceous cover is made up of *Empetrum nigrum* (75%), *Polygonum bistorta* (30%), *Equisetum arvense* (25%), *Cornus canadensis* (20%), *Festuca altaica* (25%), *Trisetum spicatum* (10%), *Poa arctica* (10%), *Anemone parviflora* (5%), *Petasites frigida* (5%), *Vaccinium vitis-idaea* (10%), *Carex bigelowii* (5%), and *Salix reticulata*. The nonvascular layer is composed of *Hylocomium splendens* (75% cover), *Stereocaulon* species (5% cover), *Nephroma arcticum* (5% cover), *Peltigera aphthosa* (5% cover), *Cladonia* species (5% cover) and *Polytrichum* species. The mean age of this type is 124.9 years.

Environmental characteristics—This type is found at a mean altitude of 804 meters with an average slope of 8% with a south exposure. The range in elevation is 328 to 1,000 meters.

***Picea mariana*/*Equisetum silvaticum* plant association
Black spruce/horsetail plant association; 1 site**

Vegetation—*Picea mariana* (80% cover and an average height of 9.1 meters) is the only tree species recorded in this association (Appendix 4). *Equisetum silvaticum* (80% cover) dominates the understory with 80% cover and the moss *Hylocomium splendens* (90% cover) dominates the groundcover.

Environmental characteristics—This association is found within the boreal forest zone of the park. The one site sampled is located on a gentle 2-degree slope adjacent to a stream. The soil profile consisted of 20 centimeters of peat over silt interspersed with small angular stones. The water table was reached at 20 centimeters.

***Picea mariana* – *Larix laricina*, *Ledum palustre*, *Vaccinium uliginosum*, *Rubus chamaemorus*,
feathermoss C5
(from Heebner 1982)**

Vegetation—*Picea mariana* and *Larix laricina* are codominant in the overstory of this community with a cumulative cover of 20%. The seedlings are predominantly *Picea mariana* and the average age is 186 years. The 65% shrub layer cover is contributed by *Ledum palustre* ssp. *groenlandicum* (30%), *Vaccinium uliginosum* (25%), *Salix planifolia* ssp. *pulchra* (5%), *Salix lanata* ssp. *richardsonii* (5%), and *Betula glandulosa* (5%). The herbaceous layer is composed of *Rubus chamaemorus*, *Vaccinium vitis-idaea*, *Empetrum nigrum*, *Arctagrostis latifolia* var. *arundinacea*, *Carex bigelowii*, *Equisetum arvense*, *Arctostaphylos alpina*, *Eriophorum vaginatum* and *Oxycoccus microcarpus*. The first three species each contribute 10% to the herbaceous cover. The remaining species contribute 5% to the cover value.

The feathermosses *Pleurozium schreberi*, *Hylocomium splendens* and *Aulacomnium* ssp. contribute 45% to the nonvascular cover and *Sphagnum* species contribute 5%. *Cladonia rangiferina* (30%), *Cladonia multiformis*, *Cladonia* species and *Peltigera aphthosa* var. *leucoplebia* are also contributing nonvascular species.

Environmental characteristics—This type is found in the Tanana lowland at an average altitude of 261 meters on alluvial/colluvial deposits. The range in elevation is 198 to 317 meters. *Sphagnum* species have less cover value, and the *Larix* seedlings and *Alnus crispa* are absent as compared to C4.

OPEN-WOODLAND STUNTED SPRUCE LANDCOVER CLASS

Number of plant associations currently in the landcover class: 11

***Larix laricina* plant association
Tamarack plant association; 1 site**

Vegetation—The overstory of the *Larix laricina* plant association is dominated by *Larix laricina* (30% cover), with *Betula papyrifera* as a minor subdominant (Appendix 4). Both *Larix laricina* and *Betula papyrifera* are low in stature reaching 3 meters and 0.9 meters, respectively. Understory species include *Chamaedaphne calyculata* (50% cover), *Sphagnum* species (50% cover), *Equisetum fluviatile* (10% cover) and *Betula papyrifera* (5% cover).



Environmental characteristics—The one site sampled was found on wet organic soils within a large wetland complex at low elevation in the northwest portion of the park.

***Larix laricina*, *Picea mariana*, *Andromeda polifolia*, *Eriophorum vaginatum*, *Sphagnum* species C1
(from Heebner 1982)**

Vegetation—The average overstory of this community is 10 to 15%, predominantly composed of *Larix laricina*. *Picea mariana* is associated. This is an early successional type of wet areas with an average stand age of 74 years. The ground surface is hummocky, being too wet to form tussocks. *Andromeda polifolia* is the dominant shrub with an average cover of 50-75%. *Betula nana*, *Ledum palustre*, and *Chamedaphne calyculata* are associated all with an average cover of 10%. *Salix fuscescens* and *Vaccinium uliginosum* are rare associates.

The herbaceous layer is dominated by *Eriophorum vaginatum* or *Equisetum fluviatile* with an average cover of 80%. Other herbs include *Drosera rotundifolia*, *Carex rhynchophylla*, *Sparganium angustifolium*, *Menyanthes trifoliata*, and *Potentilla palustris*. The nonvascular cover is 80% composed solely of *Sphagnum* species

Environmental characteristics—This community is found in the Tanana lowland on eolian deposits at an average altitude of 217 meters (elevation range is 198 to 236 meters).

***Picea glauca*/*Salix glauca* plant association
White spruce/grayleaf willow plant association; 1 site**

Vegetation—The overstory of the *Picea glauca*/*Salix glauca* plant association consists of widely spaced *Picea glauca* (15% cover), and an understory of *Salix glauca* (60% cover; Appendix 4). Tree height is 6 meters and the shrubs average 1.5 meters tall. *Calamagrostis canadensis* (50% cover) dominates the herbaceous layer. Other common species include *Salix lanata* and *Alnus crispa*. Trace amounts of *Mertensia paniculata*, *Zygadenus elegans*, *Boykinia richardsonii*, and *Vaccinium uliginosum* occur.

Environmental characteristics—This association is found within the subalpine zone on the north side of the Alaska Range and the Kantishna Hills. The one site sampled is located on a 40-degree sideslope.

***Picea mariana*/*Betula glandulosa* plant association
Black spruce/resin birch; 1 site**

Vegetation—*Picea mariana* (20% cover) is the only tree species in the association, and *Betula glandulosa* dominates the understory with 40% cover (Appendix 4). Black spruce and resin birch reach 3.7 meters and 0.9 meters in height, respectively. Additional species with greater than 10% cover include *Sphagnum* species, *Hylocomium splendens*, *Carex bigelowii*, *Eriophorum brachyantherum*, and *Vaccinium uliginosum*. *Carex bigelowii* and *Eriophorum brachyantherum* increase in cover on wet microsites, and *Ledum decumbens* and *Vaccinium uliginosum* increase on the drier sites.

Environmental characteristics—This association occurs on floodplains within the boreal forest zone of the park. The one site sampled occurs on a floodplain with a 2-degree slope and mesic soil.

***Picea mariana*/*Carex bigelowii* plant association**
Black spruce/Bigelow sedge plant association; 1 site

Vegetation—*Picea mariana* (80% cover and 1.2 meters tall) is the only tree species in the association, and the tussocky understory is dominated by *Carex bigelowii* (60% cover) (Appendix 4). In the low shrub strata, both *Ledum groenlandicum* and *Vaccinium uliginosum* have a strong presence with 20% and 30% cover, respectively. In the dwarf shrub strata *Vaccinium vitis-idaea* has 10% total cover. The moss layer has a total cover of 40% and is codominated by *Hylocomium splendens* and *Sphagnum* species. Trace amounts of forbs occur.



Environmental characteristics—This association occurs in the subalpine zone and the higher elevation boreal forests of the park. The one site sampled is located on a colluvial slope with a 10-degree slope facing northwest. Soil on this site is mesic and tussock formation is common.

***Picea mariana*/*Eriophorum vaginatum* plant association**
Black spruce/tussock cottongrass plant association; 5 sites

Vegetation—The *Picea mariana*/*Eriophorum vaginatum* plant association is dominated by *Picea mariana*—and occasionally *Picea glauca*—in the overstory with cover reaching 20% and a height ranging from 1.5 to 6.0 meters (Appendix 4). Tussocks of *Eriophorum vaginatum* dominate the understory with cover values reaching 80%, and tussock height averaging 20 centimeters. *Ledum decumbens* or *L. groenlandicum* also has significant cover (50%) in some sites. Additional species include *Vaccinium uliginosum*, *Betula glandulosa*, *Betula nana* and *Salix bebbiana*. Mosses, such as *Hylocomium splendens* and *Sphagnum fuscum*, exceed 30% cover on some sites.



Environmental characteristics—This plant association is common on level (up to 2 degrees) slopes of floodplains, terraces and ice-core hills within the boreal forest predominantly on the north side of the Alaska Range. The elevation ranges from 339 to 700 meters. The tussocks average 20 centimeters tall and the hollows contain water during wet periods. Soils are mesic and have a layer of peat, averaging 25 centimeters deep, over a thin layer of mineral soil. Permafrost is reached at a depth of 25 to 50 centimeters. The one-pH value measures 7.0.

***Picea mariana* – *Larix laricina*, *Betula nana*, *Ledum palustre*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Carex bigelowii*, *Sphagnum* species C4
(from Heebner 1982)**

Vegetation—*Picea mariana* and *Larix laricina* are codominant and compose an overstory of 20%. *Picea* are the oldest trees, and the average age of this type is 194 years. Both *Larix* and *Picea* seedlings occur. The shrub stratum has a cover of 65% composed of *Betula nana* (25% cover), *Salix planifolia* ssp. *pulchra* (5% cover), *Ledum palustre* (30% cover) and *Vaccinium uliginosum* (25% cover). *Chamaedaphne calyculata*, *Alnus crispa* and *Spiraea beauverdiana* are occasional associates. *Empetrum nigrum*, *Carex bigelowii* and *Vaccinium vitis-idaea* each have 25% cover in the herbaceous stratum. *Equisetum silvaticum* and *Rubus chamaemorus* have 10% cover values. *Arctagrostis latifolia* var. *arundinacea* and *Eriophorum vaginatum* ssp. *vaginatum* are occasional associates. *Sphagnum* species, *Pleurozium schreberi*, *Polytrichum strictum*, *Nephroma arcticum* and *Cladonia rangiferina* have 75%, 10%, 10%, 5%, and 10% cover values respectively in the nonvascular layer.

Environmental characteristics—This type C4 is found in the Tanana lowland at an average altitude of 309 meters. It most commonly occurs on alluvial/colluvial deposits (46%) but may also occur on glacial/fluviol substrates (26%), older moraines (17%), eolian deposits (5%) or lacustrine deposits (5%). The average slope is 2% with an exposure of 195 degrees. The slope ranges from 0% to 6%. The elevation of plots ranges from 198 to 479 meters, and the mean elevation is 309 meters.

***Picea mariana* – *Larix laricina*, *Ledum palustre*, *Empetrum nigrum*, *Sphagnum* species C2
(from Heebner 1982)**

Vegetation—This community has an overstory closure of 20% codominated by *Picea mariana* and *Larix laricina* with an average age of 145 years. The shrub layer, with an average cover of 60%, is composed of *Ledum palustre*, *Betula nana*, and *Vaccinium uliginosum* with covers of 30%, 10%, and 20% respectively. *Salix glauca* and *S. planifolia* spp. *pulchra* occur occasionally. The herbaceous cover is 75%. *Empetrum nigrum* (60% cover) is the most abundant herb. *Rubus chamaemorus*, *Oxycoccus microcarpus*, *Vaccinium vitis-idaea*, *Carex bigelowii* each have 15% cover. *Sphagnum* species is dominant in the nonvascular layer with 70% cover. *Cladonia rangiferina* (20% cover), *Cladonia alpestris*, *Cladonia* species, *Cetraria* species, and *Polytrichum strictum* also add to the nonvascular layer.

Environmental characteristics—This type is found on a glacial/fluviol or alluvial/colluvial substrate at an average altitude of 460 meters in the Tanana lowland (elevation range is 329 to 506 meters).

***Picea mariana*, *Larix laricina*, *Ledum palustre*, *Eriophorum vaginatum*, *Sphagnum* species C3
(from Heebner 1982)**

Vegetation—The overstory of this community is dominated by *Picea mariana* with a cover of 20%. *Larix laricina* is occasionally associated and is generally older than the *Picea*. No *Larix* seedlings are present. The average age of this type is 123 years. *Ledum palustre* is the dominant shrub with a 30% cover. *Vaccinium uliginosum*, *Betula nana*, and *Andromeda polifolia* have cover values of 15%, 10% and 5% respectively. *Eriophorum vaginatum* forms tussocks 30 centimeters high and has a cover of 70%. *Vaccinium vitis-idaea*, *Empetrum nigrum*, *Oxycoccus microcarpus* and *Rubus chamaemorus* are also frequent with cover values of 25%, 10%, 10%, and 10% respectively.

Sphagnum species dominates the nonvascular layer with a cover of 50%. *Cladonia rangiferina* (20% cover), *Cladonia alpestris* (5% cover), *Cetraria cucullata*, *Nephroma arcticum* and *Pleurozium schreberi* (5% cover) and *Tomenthypnum nitens* also compose the nonvascular layer.

Environmental characteristics—C3 is found at an average altitude of 288 meters in the Tanana lowland with plots at altitudes ranging from 198 to 572 meters. In comparison to C2 this type is of younger age, contains less *Larix*, more *Eriophorum*, no *Salix* species and is of lower altitude. C3 is found most commonly on eolian or lacustrine substrates but also occurs on glacial/fluviol and alluvial/colluvial.

***Picea mariana*/*Ledum* species plant association
Black spruce/Labrador tea plant association; 7 sites**

Vegetation—This plant association is dominated by *Picea mariana* with at least 25% cover, and either *Ledum groenlandicum* or *Ledum decumbens* with 20% cover (Appendix 4). Cover for *Ledum* species reaches over 90% in some sites. *Picea mariana* averages 1.5 to 6 meters in height. Associated species include *Betula glandulosa*, *Betula nana*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Chamaedaphne calyculata*, *Rubus chamaemorus*, and *Eriophorum vaginatum*. Small amounts of *Larix laricina* and *Betula papyrifera* may be present. Moss cover ranges from 60% to 90%, and *Sphagnum* species commonly dominate.



Environmental characteristics—This association is a common component of the boreal forest on the north side of the Alaska Range within the park. It occurs at mid to low elevations (199 to 554 meters) on level low slope (<3 degree slope) landscapes including floodplains, pleistocene outwash deposits, and ice-core hills. Permafrost is generally found within 0.5 to 0.8 meters of the soil surface. A significant layer of peat occurs on most sites and, occasionally, peat moss is found overlaying the peat. The one pH value recorded was 4.9.

***Picea mariana*/Vaccinium uliginosum plant association**
Black spruce/Bog blueberry plant association; 2 sites

Vegetation—*Picea mariana* (greater than 40% cover and 3 to 5 meters in height) is the only tree species in the association (Appendix 4). *Vaccinium uliginosum* (average 30% cover) dominates the shrub layer. Other associated species include *Ledum decumbens*, *Alnus crispa*, *Betula glandulosa*, *Betula nana*, and *Vaccinium vitis-idaea*. Moss (25% to 90% cover) includes *Hylocomium splendens*, *Sphagnum* species, and *Pleurozium* species.



Environmental characteristics—This plant association is a component of the boreal forest north of the Alaska Range in Denali. It most frequently occurs on rounded ridgetops and gentle sideslopes (<10 degree slope) of rolling hills. The soils are mesic and well drained often with a thin layer of organic matter (20 centimeters) overlaying mineral soil and bedrock.

BROADLEAF FOREST LANDCOVER CLASS

Number of plant associations currently in the landcover class: 8

***Betula papyrifera*, *Alnus crispa*, *Rosa acicularis*, *Vaccinium vitis-idaea*, *Hylocomnium splendens*
M10 (from Heebner 1982)**

Vegetation—This is a closed overstory plant association dominated by *Betula papyrifera*. The average closure of the tree strata is 55%. *Betula papyrifera* has an average cover value of 40%. *Populus tremuloides* and *Picea glauca* are occasional associates in a subdominant position with cover values of 5% each. All three-tree species are regenerating. The major species of the shrub layer are *Alnus crispa* (10% cover) and *Rosa acicularis* (10% cover). *Ribes triste*, *Spiraea beauverdiana*, *Salix bebbiana* and *Ledum palustre* ssp. *groenlandicum* are occasional associates.

The herbaceous species list includes *Vaccinium vitis-idaea* (25% cover), *Cornus canadensis* (5% cover), *Linnaea borealis* (5% cover), *Calamagrostis inexpansa* (5% cover) and *Pyrola secunda* (2% cover). The nonvascular layer is dominated by *Hylocomium splendens* (20% cover), *Peltigera* species and *Cladonia* species

Environmental characteristics—This type is found at a mean altitude of 291 meters on a 15% slope with a south exposure. The range in altitude is 198 to 622 meters and the range in slope is 0% to 33%. Plots within this type had a fire 20 years ago. This type is found in the Tanana lowland.

***Populus balsamifera*-*Alnus crispa*, *Dryas drummondii*, *Shepherdia canadensis*, *Agropyron violaceum* M3
(from Heebner 1982)**

Vegetation—The overstory of this type is 30% *Alnus crispa* and 10% *Populus balsamifera*. The overstory height is 3 meters. *Populus balsamifera* regeneration is important to the understory with a cover value of 20%. The major species of the shrub layer are *Shepherdia canadensis* (10% cover) and *Salix setchelliana* (3% cover). The herbaceous cover is composed of *Dryas drummondii* (75%), *Agropyron violaceum* (5% cover) *Oxytropis* species (5% cover), *Carex aurea* and *Senecio pauperculus*.

Environmental characteristics—This community is found at an altitude of 232 meters on alluvial/colluvial deposits. The ground surface is 30% unvegetated sand. This is a younger successional type than M2 which is also found on gravel bars. *Alnus crispa* is more important to the overstory than in M2. *Salix alaxensis* was important in the understory, and *Alnus crispa* was absent from M2. The type M3 is found at a lower altitude than M2 and is found in the Tanana lowland as opposed to M1 and M2 which are found in the northern foothills. This type was not aged.

***Populus balsamifera*, *Larix laricina*, *Picea glauca*, *Salix alaxensis*, *Hedysarum alpinum*, *Epilobium angustifolium* M6
(from Heebner 1982)**

Vegetation—The overstory of this community is dominated by *Populus balsamifera* with a cover value of 35%. *Larix laricina* and *Picea glauca* occur in the subdominant strata both with cover values of 5%. *Populus balsamifera* is the oldest species with an average age of 80 years. The average age of *Larix laricina* is 50 years while *Picea glauca* is 38 years. Both *Picea glauca* and *Populus balsamifera* regeneration is evident. *Alnus crispa* (10% cover) and *Salix alaxensis* (10% cover) are important to the shrub overstory. Major species of the shorter shrub layer are *Shepherdia canadensis* (5% cover), *Rosa acicularis* (3% cover), *Vaccinium uliginosum* (3% cover) and *Potentilla fruticosa* (2% cover). Major species of the herbaceous layer are *Epilobium angustifolium*, *Hedysarum alpinum*, *Aster sibiricus* and *Arctostaphylos rubra*, all of 5% cover. The major species of the nonvascular layer is *Hylocomium splendens* with 5% cover.

Environmental characteristics—This type is found at an average altitude of 457 meters on alluvial/colluvial deposits (80% of plots) and glacial/fluvial deposits (20% of plots). The range in elevation was 227 to 640 meters. The soil was sandy, and this is a flood plain successional type.

***Populus balsamifera*, *Picea glauca*, *Alnus crispa*, *Rosa acicularis*, *Calamagrostis lapponica*, *Equisetum silvaticum*, *Polytrichum* species M9
(from Heebner 1982)**

Vegetation—The closed overstory of this plant association is 5% *Picea glauca* and 35% *Betula papyrifera* or *Populus balsamifera*. The regeneration was predominantly deciduous. The shrub cover was *Alnus crispa* (20% cover), *Salix alaxensis* (5% cover), *Salix arbusculoides* (5% cover), *Salix* species (10% cover), *Rosa acicularis* (10% cover), *Ribes triste* (1% cover) and *Viburnum edule* (3% cover).

Spiraea beauverdiana and *Ledum palustre* ssp. *groenlandicum* are occasional associates. The herbaceous species composition is *Calamagrostis lapponica* (30% cover), *Equisetum silvaticum* (20% cover), *Vaccinium vitis-idaea* (5% cover), *Cornus canadensis* (5% cover) and *Epilobium angustifolium* (10% cover). The major species of the nonvascular layer are *Polytrichum* species (50% cover), *Cladonia* species (10% cover), *Peltigera* species, *Aulacomnium* species and *Hylocomium splendens* (10% cover).

This type has an overstory of *Betula papyrifera* or *Populus balsamifera*. The under stories are similar. The *Betula papyrifera* overstory subtype was disturbed by a 1968 fire which left evidence in fire-charred *Picea glauca* and *Betula papyrifera*.

Environmental characteristics—The overstory of this subtype was found at a mean altitude of 404 meters with an elevation range of 198 to 610 meters. The *Populus balsamifera* overstory subtype was found on a 39% slope of south exposure with an altitude of 610 meters.

***Populus balsamifera*, *Picea glauca*, *Alnus crispa*, *Salix alaxensis*, *Calamagrostis inexpansa*,
Tommenhypnum nitens M5
(from Heebner 1982)**

Vegetation—This plant association is predominantly deciduous, although *Picea glauca* occurs occasionally in the overstory (5% cover). *Picea glauca* seedlings occur. *Populus balsamifera* has a cover value of 25%. *Alnus crispa* and *Salix alaxensis* both have cover values of 40%. The major species of the lower shrub layer are *Salix arbusculoides* (15% cover), *Salix barclayi* (15% cover) and *Salix planifolia* ssp. *pulchra* (10% cover). *Salix scouleriana* and *Potentilla fruticosa* are occasional associates. The herbaceous layer contains *Arctostaphylos rubra* (15% cover), *Cornus canadensis* (10% cover), *Rubus arcticus* (15% cover), *Calamagrostis inexpansa* (15% cover), *Anemone richardsonii* (5% cover) and *Parnassia kotzebuei*.

The major species of the nonvascular layer is *Tommenhypnum nitens* with 25% cover. This community is found at a mean altitude of 281 meters on alluvial/colluvial deposits (60% of plots) or eolian deposits (40% of plots).

Environmental characteristics—The range in elevation is 213 to 323 meters. This is also a successional flood plain type of older age than M1, M2, M3, and M4. It is exposed to occasional flooding which accounts for the relative poor development of the herbaceous and nonvascular layer. This type is found in the Tanana lowland.

***Populus balsamifera*, *Picea glauca*, *Salix alaxensis*, *Alnus crispa*, *Salix planifolia*, *Empetrum*
nigrum, *Epilobium angustifolium*, *Hylocomium splendens* M8
(from Heebner 1982)**

Vegetation—The overstory of this type has a closure of 45% that is predominantly *Populus balsamifera*. *Picea glauca* occurs in the understory. The seedlings are predominantly *Picea glauca*. The average age of this type is 99 years with the *Populus balsamifera* being the oldest trees. *Salix alaxensis* (30% cover) and *Alnus crispa* (30% cover) are important to the understory. The shrub layer also contains *Salix planifolia* ssp. *pulchra* (30% cover), *Salix barclayi* (20% cover), *Salix glauca* (20% cover) and *Potentilla fruticosa* (25% cover). *Rosa acicularis*, *Juniperus communis*, *Shepherdia canadensis*, and *Vaccinium uliginosum* are occasional associates.

The major species of the herbaceous layer are *Empetrum nigrum* (50% cover), *Aster sibiricus* (35% cover), *Dryas integrifolia* (35% cover), *Epilobium angustifolium* (35% cover), *Rubus arcticus* (25% cover), *Arctostaphylos rubra* (25% cover), *Carex* species (*C. podocarpa* or *C. scirpoidea*, 20% cover), *Hedysarum alpinum* (20% cover), *Salix arctica* (20% cover), *Equisetum* species (20% cover), *Parnassia palustris* (10% cover) and *Festuca rubra* (8% cover). Occasional associates are *Hierochloa odorata*, *Calamagrostis inexpansa*, *Linnaea borealis* and *Arctagrostis latifolia*. Major species of the nonvascular layer are *Hylocomium splendens* (60% cover), *Sphagnum* species (10% cover), *Ceratodon purpureus*, *Drepanocladus uncinatus* and *Aulacomium palustre*.

Environmental characteristics—This type is found at an average altitude of 664 meters with a 12% slope at an aspect of 68 degrees. The range in elevation is 485 to 914 meters, and the range in slope is 0% to 39%. This is an older successional type than M7 being found on more stable riverbanks. The higher cover values and more species in the understory are evidence of this comparison to M7. This type is found in the northern foothills.

***Populus balsamifera*, *Salix alaxensis*, *Salix glauca*, *Shepherdia canadensis*, *Senecio lugens* M2
(from Heebner 1982)**

Vegetation—The overstory of this community is *Populus balsamifera* with a closure of 25%. The age of this community is 62 years and *Populus balsamifera* regeneration is evident.

The major species of the shrub layer are *Salix* species. *Salix alaxensis* has a cover value of 30%. *Salix arbusculoides*, *Salix glauca*, and *Salix barclayi* have cumulative cover of 60%. *Shepherdia canadensis* (15% cover) and *Betula nana* (5% cover) are common associates.

The major species in the herbaceous layer are *Senecio lugens* (60% cover), *Solidago multiradiata* (15% cover), *Delphinium glaucum* (20% cover), *Aster sibiricus* (30% cover), *Hedysarum alpinum* (10% cover), *Pedicularis verticillata* (5% cover), *Elymus innovatus* (5% cover), *Festuca altaica* (5% cover), *Epilobium latifolium* (5% cover) and *Poa glauca* (5% cover). The nonvascular layer has a 10% cover value with major species being *Hylocomium splendens* and *Stereocaulon* species

Environmental characteristics—The soils of this type are sandy, and 40% of the ground surface is unvegetated. The altitude is 649 meters, and the type is found on alluvial deposits. This type is a younger gravel bar successional type than M1. There is a higher percentage of unvegetated mineral soil and decaying wood in the plots of this type.

***Populus balsamifera*, *Salix alaxensis*, *Salix planifolia*, *Shepherdia canadensis*, *Arctostaphylos rubra*, *Senecio lugens*, *Hylocomium splendens* M1
(from Heebner 1982)**

Vegetation—The overstory of this plant association is *Populus balsamifera* and has a cover value of 25%. The shrub layer is made up of *Salix alaxensis* (10% cover), *Salix barrattiana* (5% cover), *Salix barclayi* (5% cover), *Salix brachycarpa* ssp. *niphoclada* (5% cover), *Salix planifolia* ssp. *pulchra* (10% cover), *Shepherdia canadensis* (25% cover), *Betula nana* (10% cover), *Festuca altaica* (25% cover), *Arctostaphylos rubra* (20% cover), *Arctostaphylos uva-ursi* (20% cover), *Senecio lugens* (20% cover), *Parnassia palustris* (20% cover), *Pedicularis verticillata* (10% cover), *Pyrola secunda* (10% cover), *Empetrum nigrum* (10% cover), *Salix reticulata* (10% cover), *Carex scirpoidea* (10% cover), *Epilobium latifolium* (5% cover) and *Hedysarum alpinum* (5% cover).

The major species of the nonvascular layer are the feathermosses (75% cover), *Hylocomium splendens* and *Pleurozium schreberi*. The lichens *Cladonia rangiferina*, *Cladonia pyxidata*, *Cladonia chlorophaea*, *Peltigera aphthosa*, *Peltigera canina* var. *rufescens*, *Cetraria ericetorum* and *Stereocaulon* species also occur. The average age of this type is 86 years with *Populus balsamifera* regeneration occurring.

Environmental characteristics—The communities are found at an altitude of 741 meters on alluvial deposits.

MIXED SPRUCE-BROADLEAF FOREST LANDCOVER CLASS

Number of plant associations currently in the landcover class: 4

***Picea glauca*, *Betula papyrifera*, *Vaccinium uliginosum*, *Betula nana*, *Calamagrostis lapponica*,
Carex nesophila, *Peltigera aphthosa* M11
(from Heebner 1982)**

Vegetation—The tree strata of this type has a cover value of 20% to 30%. The overstory is dominated by *Picea glauca* (10% to 20% cover). *Betula papyrifera* (20% cover) or *Populus balsamifera* (1% cover) are complimentary associates. The average age of the type is 39 years, and the regeneration is *Picea glauca*. The plant association is similar to M9. The under stories are similar, but the overstories appear to be subtypes dominated by *Picea glauca*. The *Picea glauca*-*Populus balsamifera* subtype is found at an altitude of 930 meters on a 22% slope and southwest exposure. The *Picea glauca*-*Betula papyrifera* subtype is found at an altitude of 325 meters and was disturbed by a 1969 fire. The *Betula papyrifera* and *Picea glauca* are generating in this subtype.

The major species of the shrub layer are *Betula nana* (10% cover), *Vaccinium uliginosum* (10% cover), *Ledum palustre* (5% cover) and *Rosa acicularis* (5% cover), *Spiraea beauverdiana*, *Salix glauca* and *Salix planifolia* ssp. *pulchra* are occasional associates. The major species of the herbaceous layer are *Carex nesophila* (5% cover) and *Calamagrostis lapponica*, (5% cover). The *Picea* -*Betula* subtype contains *Epilobium latifolium* in the herbaceous layer with 10% cover. The *Picea* -*Populus* subtype contains *Vaccinium vitis-idaea* (25% cover), *Empetrum nigrum* (25% cover) and *Poa arctica* (20% cover).

The major species of the nonvascular layer are *Peltigera aphthosa* (10% cover), *Cladonia* species (5% cover) and *Stereocaulon* species (5% cover). *Polytrichum* species (35% cover) is associated with the fire-charred subtype whereas *Hylocomium splendens* (35% cover) is important in the *Picea* -*Populus* slope subtype.

Environmental characteristics—The community has a mean altitude of 628 meters with a range from 325 to 930 meters. The average slope is 12% ranging from 1 to 22%. The exposure is south, and the type is found on sedimentary bedrock and alluvial/colluvial surficial deposits.

***Picea glauca*, *Populus balsamifera*, *Vaccinium uliginosum*, *Ledum palustre*, *Empetrum nigrum*,
Pyrola grandiflora, *Hylocomium splendens* M7
(from Heebner 1982)**

Vegetation—The average overstory of this type is 15% and is dominated by *Picea glauca*. *Populus balsamifera* and *Larix laricina* are associates in the subdominant layer with a 10% cover and 3% cover

respectively. The average age of *Picea glauca* is 125 years. The average age of *Populus balsamifera* and *Larix laricina* was 135 years and 50 years respectively. The regeneration is predominantly *Picea glauca*, but young trees of *Populus balsamifera* and *Larix laricina* of 1 to 2 meters in height occur. *Alnus crispa* (5% cover), *Salix arbusculoides* (5% cover), *Salix barclayi* (5% cover), *Ledum palustre* (45% cover), *Vaccinium uliginosum* (45% cover), *Shepherdia canadensis* (5% cover) and *Potentilla fruticosa* (5% cover) are the major species of the shrub layer. *Rosa acicularis* and *Viburnum edule* are occasional associates.

The major species of the herbaceous layer are *Empetrum nigrum* (20% cover), *Pyrola grandiflora* (20% cover), *Cornus canadensis* (5% cover), *Arctagrostis latifolia* (3% cover), *Arctostaphylos rubra* (5% cover) and *Vaccinium vitis-idaea* (5% cover). *Mertensia paniculata*, *Saussurea angustifolia* and *Rubus arcticus* are occasional associates. The major species of the nonvascular layer are *Hylocomium splendens* (60% cover) and *Polytrichum strictum* (3% cover).

Environmental characteristics—This type is found at an average altitude of 410 meters with an average slope of 5% with south exposure. The range in elevation is 213 to 930 meters, and the range in slope is 0% to 32%. It is found predominantly on alluvial/colluvial deposits in the Tanana lowland. It is a flood plain successional type of older age than M6.

***Picea mariana*, *Betula papyrifera*, *Larix laricina*, *Ledum palustre*, *Vaccinium uliginosum*,
Vaccinium vitis-idaea, *Empetrum nigrum*, feathermoss M12
(from Heebner 1982)**

Vegetation—This community has a tree strata closure of 20% to 35%. The overstory is dominated by *Picea mariana* (20% average cover). *Larix laricina* and *Betula papyrifera* each have 10% cover values in the understory. All three species are regenerating. The average age of the *Picea mariana* is 93 years. The average age of the *Larix laricina* is 31 years. Important species in the shrub stratum are *Salix arbusculoides* (5% cover), *Salix barclayi* (5% cover), *Salix glauca* (5% cover), *Ledum palustre* (25% cover), *Vaccinium uliginosum* (25% cover) and *Betula nana* (5% cover). *Spiraea beauverdiana*, *Potentilla fruticosa*, *Salix bebbiana* and *Salix planifolia* ssp. *pulchra* are occasional associates.

The major species of the herbaceous layer are *Vaccinium vitis-idaea* (25% cover), *Empetrum nigrum* (20% cover), and *Equisetum sylvaticum* (5% cover). *Saussurea angustifolia* (10% cover), *Rubus chamaemorus* (10% cover), *Festuca rubra* (5% cover) and *Eriophorum vaginatum* (or *Carex bigelowii*) are important occasional associates. The major species of the nonvascular layer are *Hylocomium splendens* (50% cover), *Pleurozium schreberi* (5% cover), *Sphagnum* species (10% cover), *Polytrichum* species, *Cladonia rangiferina* (10% cover), *Cladonia* species and *Peltigera aphthosa* var. *leucoplebia*.

Environmental characteristics—This type is found in the Tanana lowland at an average altitude of 264 meters the range in elevation is 198 to 334 meters. The substrate is predominately alluvial/colluvial deposits (67% of plots). Eolian (17% of plots), glacial (8% of plots) and lacustrine (8% of plots) deposits underlie this type also.

***Populus balsamifera*-*Picea glauca*, *Salix glauca*, *Juniperus communis*, *Elymus innovatus*,
Arctostaphylos uva-ursi, *Hylocomium splendens* M4
(from Heebner 1982)**

Vegetation—This plant association has an overstory closure of 35% with *Populus balsamifera* and *Picea glauca* codominant. The mean age of the *Populus balsamifera* is 96 years. *Picea glauca* seedlings are

evident. The major species of the shrub layer are *Salix glauca* (10% cover), *Salix brachycarpa* ssp. *niphoclada* (10% cover), *Juniperus communis* (10% cover) and *Shepherdia canadensis* (3% cover). The major species of the herbaceous layer are *Elymus innovatus* (20% cover), *Arctostaphylos uva-ursi* (10% cover), *Calamagrostis inexpansa* (10% cover), *Oxytropis campestris* ssp. *gracilis* (5% cover) and *Hedysarum alpinus* (5% cover). *Geocaulon lividum*, *Carex coccinea* and *Pyrola secunda* are of scattered occurrence. The major nonvascular species are *Hylocomium splendens* (33% cover), *Cladonia* species (10% cover), *Peltigera aphthosa*, *Cetraria cucullata* and *Polytrichum* species

Environmental characteristics—This type was found at an average altitude of 275 meters on alluvial/colluvial deposits in the Tanana lowland.

ALDER SHRUB LANDCOVER CLASS

Number of plant associations currently in the landcover class: 7

***Alnus crispa* plant association**
American green alder plant association; 5 sites

Vegetation—*Alnus crispa* dominates the overstory (80% to 100% cover), and the understory is sparse with less than 20% vascular plant cover (Appendix 4). The average height of *Alnus crispa* is 2.7 meters and other tall shrubs rarely occur in this plant association. Understory species include *Ribes triste*, *Linnaea borealis*, *Rosa acicularis*, *Dryopteris dilatata*, *Athyrium filix-femina* and *Equisetum sylvaticum*. Moss cover is less than 10%. The *Calamagrostis canadensis* and *Vaccinium uliginosum*/low shrub plant associations are typically found mixed with this type and on higher slope positions.



Environmental characteristics—This is a dominant shrub association within Denali, especially on the south side of the Alaska Range. It occurs on mountain sideslopes typically starting on the lower slope position and extending up to subalpine or alpine. In forested regions, it occupies avalanche chutes. On sampled sites, the slope ranges from 5 to 35% and the elevation ranges up to 900 meters. The soils are typically mesic with litter over mineral soil.

***Alnus crispa*/Calamagrostis canadensis plant association**
American green alder/Bluejoint plant association; 4 sites

Vegetation—*Alnus crispa* (50% to 100% cover and average height of 2.4 meters) dominates the overstory (Appendix 4). *Calamagrostis canadensis* (20% to 75% cover) is the dominant understory species. Species diversity is low. Other species include *Salix lanata*, *Salix alaxensis*, *Rosa acicularis* and *Carex bigelowii*. Sapling *Populus balsamifera* occasionally occurs on floodplain sites. Moss cover ranges from 0% to 10%.



Environmental characteristics—This association occurs on both mountain side slopes and floodplains within the boreal forest and subalpine zone. On sampled sites, the slope was 0% on floodplains and up to 40% on sideslopes. Elevations range up to 900 meters

***Alnus crispa*/Ericaceous shrub plant association**
American green alder/Ericaceous shrub plant association; 4 sites

Vegetation—The *Alnus crispa*/Ericaceous shrub plant association is comprised of patches of thick *Alnus crispa* interspersed within a matrix of ericaceous shrubs. The *Alnus crispa* patches typically occupy 30% to 50% of the matrix and ericaceous shrubs the remainder. *Betula glandulosa* and *Vaccinium uliginosum* typically dominate the ericaceous patches. *Empetrum nigrum*, *Vaccinium vitis-idaea* and *Ledum decumbens* also occur. Other tall shrubs within the alder patches include *Salix lanata* and *Salix glauca*. The average height of *Alnus crispa* is 1.8 meters. Moss cover ranges from 10% to 80%.



Environmental characteristics—This association occurs on mountain sideslopes and river cut sideslopes extending from the boreal forest zone up through subalpine and, occasionally, the alpine zone. Adjacent types found up slope are typically low or dwarf shrub map classes. On sampled sites, the slope ranges from 15% to 30% and the elevation ranges up to over 900 meters. The soils are typically mesic with litter over mineral soil.

***Alnus crispa*, *Salix planifolia*, *Betula nana*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Hylocomium splendens* S6**
(from Heebner 1982)

Vegetation—*Alnus crispa* is dominant in the shrub overstory of this plant association. The height of *Alnus crispa* varies from 1.2 to 2 meters, and the cover varies from 5% to 75%. *Salix planifolia* ssp. *pulchra* and *Betula nana* both with average heights of 0.9 meters and average cover values of 10% are codominant in the second shrub layer. Other associates in the shrub layer are *Vaccinium uliginosum* and *Ledum palustre* with average cover values of 30% and 10% respectively. *Spiraea beauverdiana* is an occasional associate.

The major species of the herbaceous layer are *Empetrum nigrum* (25% cover), *Vaccinium vitis-idaea* (25% cover), *Carex bigelowii* (10% cover) and *Arctagrostis latifolia* var. *latifolia* (8% cover). Important occasional associates are *Petasites hyperboreus* (10% cover), *Polygonum bistorta* (8% cover), *Polemonium acutiflorum* (2% cover) and *Poa arctica* (3% cover). The major species of the nonvascular layer are *Hylocomium splendens* (25% cover), *Polytrichum* species (3% cover) and *Stereocaulon* species (2% cover).

***Alnus crispa*, *Salix planifolia* ssp. *pulchra*, *Equisetum arvense*, *Arctagrostis latifolia*, *Carex bigelowii* S3
(from Heebner 1982)**

Vegetation—*Alnus crispa*, 2.5 meters tall, dominates the shrub overstory with 67% cover. *Salix planifolia* ssp. *pulchra* (10% cover, height 1.2 meters) dominates the shrub understory with frequent associates being *Alnus crispa* (10% cover), *Betula nana* (5% cover), *Viburnum edule* (10% cover), *Vaccinium uliginosum* (3% cover) and *Spiraea beauverdiana* (10% cover). The herbaceous layer contains the major species *Equisetum arvense* (75% cover), *Carex bigelowii* (25% cover), *Arctagrostis latifolia* (25% cover), *Poa arctica* (25% cover) and *Polemonium acutiflorum* (15% cover). Occasional associates in the herbaceous layer are *Vaccinium vitis-idaea* (2% cover), *Rubus arcticus* (25% cover), *Equisetum sylvaticum* (50% cover) and *Petasites hyperboreus* (25% cover).

The nonvascular layer contains the following major species with their associated mean cover values: *Polytrichum commune* (2% cover) and *Hylocomium splendens*. Occasional associates were *Sphagnum* species (5% cover), *Rhytidium rugosum* (2% cover) and *Rhacomitrium lanuginosum*.

Environmental characteristics—This plant association is found with an average slope of 9% and an aspect of 316 degrees. The slope ranges from 0% to 17%. The average altitude is 780 meters ranging from 703 to 817 meters. It is a stream valley with wet rocky soil. Rock was hit at an average depth of 15 centimeters. The ground surface is 205 unvegetated covered with humus.

***Alnus crispa*, *Salix planifolia*, *Lycopodium annotinum*, *Calamagrostis inexpansa*, *Spiraea beauverdiana*, feathermoss S4
(from Heebner 1982)**

Vegetation—The overstory of this type is dominated by *Alnus crispa* (2.5 meters tall, 75% cover). The shrub understory is dominated by *Salix planifolia* ssp. *pulchra* (1.2 meters tall, 60% cover). Important associates in the shrub understory are *Spiraea beauverdiana* (30% cover), *Betula nana* (5% cover), *Vaccinium uliginosum* (5% cover) and *Ledum palustre* (1% cover).

The major species of the herbaceous layer are *Lycopodium annotinum* (20% cover), *Calamagrostis inexpansa* (5% cover), *Poa arctica* (5% cover), *Rubus arcticus* (5% cover), *Vaccinium vitis-idaea* (5% cover), *Empetrum nigrum* (5% cover), *Polemonium acutiflorum* (10% cover), *Petasites hyperboreus* (10% cover), *Epilobium angustifolium* (10% cover), *Artemisia arctica*, *Linnaea borealis* (5% cover) and *Petasites hyperboreus* (3% cover). Important occasional associates are *Equisetum* species (10% cover), *Galium boreale* (5% cover), *Sanguisorba officinalis* (8% cover), *Cornus canadensis* (10% cover) and *Heracleum lanatum* (8% cover). The major species of the nonvascular layer are *Hylocomium splendens* (35% cover), *Drepanocladus uncinatus* (8% cover), *Polytrichum* species (5% cover), *Cetraria* species (5% cover) and *Cladonia* species (2% cover).

Environmental characteristics—This plant association is found at an average altitude of 838 meters with an average slope of 16% and an average aspect of 237 degrees. The range in elevation is 762 to 975 meters, the range in slope is 0% to 39%, and the range in aspect is 86 to 296 degrees. The ground surface has an unvegetated humus cover of 25%. This type is found on the lower half of the slope with 25% of the plots being found in stream valleys.

***Alnus sinuata* alliance
Sitka alder alliance; 3 sites**

Vegetation—This type was defined at the alliance hierarchical level—the next coarser scale above plant association—because the sampled plots could not be reliably defined into separate plant associations. *Alnus sinuata* dominates (20% to 85% cover) the tall shrub layer of the alliance and the understory species composition is highly variable between sites. Other overstory shrubs include *Vaccinium uliginosum*, *Salix alaxensis* and *Salix lanata*. *Alnus sinuata* averages 1.8 meters in height. A variety of herbaceous species occur including *Calamagrostis canadensis*, *Equisetum pratense* and *Sanguisorba stipulata*. Moss cover varies from 1 to 60%.



Environmental characteristics—This alliance is uncommon but widespread throughout the subalpine region of the park. Elevations range from 777 to 1,085 meters. It occurs on floodplains and mountain sideslopes (ranging from 5% to 22%), and the hydrologic regime ranges from moist to wet with limited standing water.

WILLOW SHRUB LANDCOVER CLASS

Number of plant associations currently in the landcover class: 17

***Alnus crispa*, *Salix alaxensis*, *Calamagrostis inexpansa*, *Rubus arcticus*, feathermoss S1
(from Heebner 1982)**

Vegetation—This tall shrub plant association is characterized by the dominance of *Salix alaxensis* in the shrub overstory of height 11 meters. *Alnus crispa* is dominant in the understory. The oldest age is 54 years for *Salix alaxensis* and 42 years for *Alnus crispa*. The average cover values for *Salix alaxensis* and *Alnus crispa* were 50% and 60% respectively.

The major species of the herbaceous layer are *Calamagrostis inexpansa* (50% cover), *Arabis lyrata* ssp. *kamchatica* (6% cover), *Rubus arcticus* (35% cover), *Artemisia tilesii* ssp. *elatior* (35% cover), *Oxyria digyna* (35% cover), and *Galium boreale* (25% cover). The major species of the nonvascular layer are *Hylocomium splendens* (35% cover), *Polytrichum juniperum* (25% cover), *Polytrichum strictum* (10%

cover), *Mnium thomsonii* (5% cover), *Peltigera polydactyla* (8% cover), *Peltigera canina* var. *rufescens* (8% cover) and *Sphagnum* species (1% cover).

Environmental characteristics—This type is found at 460 meters mean elevation on alluvial deposits. There is zero range in elevation. The ground surface is 30% unvegetated covered with humus, and the type is located in stream valleys.

***Salix alaxensis*, *Alnus crispa*, *Salix arbusculoides*, *Artemisia tilesii* S16
(from Heebner 1982)**

Vegetation—The dominant species in the shrub overstory of this type is *Salix alaxensis* which is 4 meters tall with a cover value of 35%. *Alnus crispa* (2 meters tall, 40% cover), *Salix arbusculoides* (1.5 meters tall, 10% cover) and *Viburnum edule* (5% cover) are the other major shrub species. The major species of the herbaceous layer are *Artemisia tilesii* (30% cover), *Epilobium latifolium* (8% cover), *Epilobium angustifolium* (8% cover), *Calamagrostis lapponica* (5% cover), *Parnassia kotzebui* (3% cover), *Salix reticulata* (2% cover), *Aconitum delphinifolium* (3% cover), *Solidago multiradiata* (3% cover), *Erigeron acris* ssp. *politus* (1% cover), *Dryas octopetala* (5% cover), *Oxytropis maydelliana* (3% cover), *Pedicularis capitata* (3% cover) and *Poa arctica* (3% cover). The major species of the nonvascular layer is *Hylocomium splendens* (4% cover).

Environmental characteristics—This type is found at an average altitude of 579 meters with a 50% slope. There is zero range in elevation. It is a creek bank community found on alluvial deposits. The ground surface is 30% unvegetated, covered with humus, mineral soil and rock. The aspect is 156 degrees.

***Salix alaxensis*, *Betula nana*, *Festuca altaica*, *Salix reticulata*, *Dryas integrifolia* S13
(from Heebner 1982)**

Vegetation—This shrub community has an overstory dominated by *Salix alaxensis* (height of 2 meters, 15% cover). The major species of the shrub understory are *Salix glauca* (height 1.5 meters, 10% cover) and *Betula nana* (height 1 meter, 10% cover). Frequent associates with the shrub layer are *Shepherdia canadensis* (3% cover) and other *Salix* species. The major species of the herbaceous layer are *Festuca altaica* (10% cover), *Salix reticulata* (10% cover), *Parnassia kotzebui* (6% cover), *Hedysarum alpinum* (8% cover), *Dryas integrifolia* (10% cover), *Arctostaphylos rubra* (10% cover), *Pedicularis capitata* (10% cover) and *Solidago multiradiata* (10% cover).

The nonvascular layer is composed of *Hylocomium splendens* (3% cover), *Polytrichum* species (2% cover), and *Stereocaulon* species (2% cover). Occasional associates in the nonvascular layer are *Thamnia vermicularis*, *Pleurozium schreberi*, *Rhytidium rugosum*, *Cetraria cucullata*, *Cetraria richardsonii*, *Cetraria islandica*, and *Distichium* species

Environmental characteristics—This type is found at an average altitude of 951 meters with an average slope of 5%, and an average aspect of 275 degrees. The range in elevation is 762 to 1,082 meters, the range in slope is 0% to 22% and the range in aspect is 146 to 356 degrees. The bedrock geology is 67% sedimentary/metasedimentary, 22% basalt/gabbroic and 11% volcanic. The surficial geology is 100% alluvial deposits. This is a gravel bar community, and the ground surface is 5% to 10% unvegetated.

**Salix alaxensis, Salix barclayi, Shepherdia canadensis, Epilobium angustifolium S11
(from Heebner 1982)**

Vegetation—The shrub overstory is dominated by *Salix alaxensis* with a height of 2 meters and an average cover of 35%. The shrub understory of this type is composed of *Salix barclayi* (1m tall, 35% cover) and *Shepherdia canadensis* (0.6 meters tall, 35% cover). The major species of the herbaceous layer are *Epilobium angustifolium* (25% cover), *Salix reticulata* (5% cover), *Solidago multiradiata* (5% cover), *Angelica lucida* (5% cover), *Rubus arcticus* (5% cover), *Empetrum nigrum* (2% cover) and *Heracleum lanatum* (1% cover). Occasional associates were *Cornus canadensis* (5% cover), *Mertensia paniculata* (2% cover), *Dryas octopetala* (2% cover), *Saxifraga tricuspidata* (2% cover), *Aster sibiricus* (5% cover) and *Stellaria monantha* (2% cover).

The major species of the nonvascular layer are *Pleurozium schreberi* (5% cover) and *Peltigera aphthosa* var. *leucoplebia* (2% cover). *Polytrichum* species, *Cetraria islandica* and *Lobaria linita* were occasionally found in this type also.

Environmental characteristics—The average altitude was 803 meters, and it is a stream valley type found on alluvial deposits. The range in elevation is 701 to 866 meters. The ground surface was 10% unvegetated covered with humus.

**Salix alaxensis, Salix glauca, Rosa acicularis, Petasites hyperboreus, Calamagrostis inexpansa S2
(from Heebner 1982)**

Vegetation—This shrub community has an overstory of 3.2 meters which is *Salix alaxensis* with an average cover value of 5%. The understory is composed of 1.5 meters *Salix glauca* (60% cover), *Salix planifolia* ssp. *pulchra* (5% cover) and *Rosa acicularis* (12% cover). The herbaceous layer is composed of *Petasites hyperboreus* (30% cover), *Mertensia paniculata* (10% cover), *Calamagrostis inexpansa* (10% cover), *Festuca altaica* (10% cover), *Artemisia tilesii* (10% cover), *Equisetum arvense* (10% cover), *Carex saxatilis* ssp. *laxa* (2% cover), *Carex podocarpa* (2% cover) and *Heracleum lanatum* (5% cover). The major species of the nonvascular layer are *Hylocomium splendens* (5% cover) and *Stereocaulon* species (1% cover).

Environmental characteristics—The altitude of this type is 1,030 meters with a 9% slope and a northeast exposure. There is zero range in elevation. It is found on volcanic sediments. The ground surface is 40% unvegetated covered with humus.

**Salix alaxensis, Salix planifolia, Shepherdia canadensis, Festuca altaica, Hylocomium splendens S12
(from Heebner 1982)**

Vegetation—The shrub overstory of this community is dominated by *Salix alaxensis* (4 meters in height, 10% cover). The shrub understory was also dominated by *Salix* species averaging 1.2 meters in height with an average cover value of 35%. The *Salix* species are most frequently *Salix planifolia* ssp. *pulchra*, *Salix glauca*, and *Salix barclayi*. Other species of the shrub layer are *Shepherdia canadensis* (5% cover), and occasionally *Vaccinium uliginosum* (1% cover). The herbaceous cover is composed of *Festuca altaica* (20% cover), *Mertensia paniculata* (6% cover), *Parnassia kotzebui* (5% cover), *Anemone parviflora* (5% cover), *Artemisia tilesii* (5% cover), and *Dryas octopetala* (5% cover). Important occasional associates in the herbaceous layer are *Arctostaphylos rubra* (10% cover), *Aconitum delphinifolium* (5% cover), *Senecio lugens* (5% cover), *Carex* species (5% cover), *Aster sibiricus* (2% cover), *Salix arctica* (2% cover), *Cnidium cnidifolium* (1% cover) and *Vaccinium vitis-idaea* (2% cover).

The major species of the nonvascular layer are *Hylocomium splendens* (25% cover), *Pleurozium schreberi* (5% cover), *Peltigera aphthosa* (2% cover) and *Polytrichum* species (1% cover). Occasional associates are *Peltigera venosa*, *Lobaria linita*, *Thamnolia vermicularis*, *Stereocaulon* species, *Dactylina ramulosa*, *Drepanocladus uncinatus*, and *Dicranum* species

Environmental characteristics—This type is found at an average altitude of 970 meters, with an average slope of 9% and an average aspect of 117 degrees. The range in elevation is 728 to 1,059 meters, the range in slope is 0% to 17%, and the range in aspect is 26 to 176 degrees. The bedrock geology in 82% of the plots is sedimentary/metasedimentary, in 9% of the plots is schist/gneiss and in 9% of the plots is unknown. The surficial geology in 55% of the plots is bedrock, in 27% of the plots is alluvial, in 9% of the plots is glacial/fluviol and in 9% of the plots is lacustrine deposits. The ground surface is 10% unvegetated and covered with humus or mineral soil.

***Salix alaxensis*, *Salix planifolia*, *Sanguisorba officinalis*, *Petasites hyperboreus*, *Delphinium glaucum* S9
(from Heebner 1982)**

Vegetation—This shrub community has an overstory dominated by 2 meters *Salix alaxensis* (30% cover) while the major species of the understory are *Salix planifolia* ssp. *pulchra* var. *pulchra* (30% cover) and *Sanquisorba officinalis* (10% cover). The major species of the herbaceous layer are *Petasites hyperboreus* (30% cover), *Delphinium glaucum* (25% cover), *Calamagrostis inexpectans* (5% cover), *Festuca* species (8% cover), *Mertensia paniculata* (8% cover) and *Rubus arcticus* (5% cover).

Environmental characteristics—This type has a ground surface which was 25% unvegetated and covered with humus. The bedrock geology is sedimentary, and the surficial geology is alluvial/colluvial deposits. It is the lower half of a slope community found at an altitude of 519 meters. There is zero range in elevation. This type is found in the Tanana-Kuskokwim lowland section (Talkeetna quadrangle).

***Salix alaxensis*, *Shepherdia canadensis*, *Dryas octopetala*, *Arctostaphylos rubra* S15
(from Heebner 1982)**

Vegetation—The shrub overstory of this type is composed of *Salix alaxensis* with a height of 2.5 meters and 20% cover. The other major species of the shrub layer are *Shepherdia canadensis* (5% cover), *Salix glauca* (5% cover) and *Potentilla fruticosa* (2% cover). Species occasionally found in this type are *Salix arbusculoides* (5% cover), *Salix barrattiana* (2% cover) and *Betula nana* (10% cover).

The major species of the herbaceous layer are *Dryas octopetala* (30% cover), *Aster sibiricus* (10% cover), *Anemone parviflora* (10% cover), *Arctostaphylos rubra* (30% cover), *Salix reticulata* (10% cover), *Festuca altaica* (10% cover), *Hedysarum alpinum* (5% cover), *Anemone parviflora* (5% cover), and *Epilobium latifolium* (5% cover). Species that occur occasionally in this type were *Oxytropis borealis*, *Draba alpina*, and *Carex sciropoidea*. The major species of the nonvascular layer are *Hylocomium splendens* (5% cover), *Pleurozium schreberi* (1% cover), *Stereocaulon* species (1% cover), and *Peltigera scabrosa*.

Environmental characteristics—This is a gravel bar community, and the ground surface is 25% unvegetated. The type is found at an average altitude of 1,060 meters on alluvial deposits. The range in elevation is 1,038 to 1,082 meters. The average slope is 7%, and the range is 0% to 13%. The aspect is 296 degrees.

Salix barclayi/Calamagrostis canadensis plant association
Barclay willow/Bluejoint plant association; 1 site

Vegetation—In the *Salix barclayi/Calamagrostis canadensis* plant association, *Salix barclayi* is the only tall shrub (50% cover; 1.8 meters tall) and *Calamagrostis canadensis* (80% cover, 1.5 meters tall on average) dominates the understory (Appendix 4). *Athyrium filix-femina* and *Equisetum arvense* are common herbaceous associates. Few other shrub or herbaceous species occur.



Environmental characteristics—The one site sampled occurred south of the Alaska Range at 231 meters elevation, on the drier portions of a broad floodplain that had heavy beaver activity.

Salix barclayi, Equisetum palustre, Carex podocarpa, Hylocomium splendens S10
(from Heebner 1982)

Vegetation—The major species of the shrub layer are *Salix barclayi* (70% cover, 1.8 meters height), *Salix planifolia* ssp. *pulchra* (5% cover, 1 meters height), *Salix alaxensis* (1% cover, 3 meters height) and *Sanquisorba officinalis* (5% cover). Occasional associates are *Vaccinium uliginosum* and *Potentilla fruticosa*. The major species of the herbaceous layer are *Rubus arcticus* (6% cover), *Carex podocarpa* (25% cover), *Achillea borealis* (10% cover), *Equisetum palustre* (25% cover), *Epilobium angustifolium* (5% cover) and *Arctagrostis latifolia* (10% cover). Occasional associates are *Sedum rosea* (1% cover), *Petasites hyperboreus* (5% cover), *Anemone* species (5% cover), *Polygonum bistorta* (5% cover), *Artemisia arctica* (5% cover) and *Angelica lucida* (5% cover).

The nonvascular layer was composed of *Hylocomium splendens* (10% cover), *Polytrichum strictum* (2% cover), and *Aulacomium palustre* (5% cover). Occasional associates were *Sphagnum* species, *Tomenhypnum nitens* and *Cladonia* species

Vegetation—This type is found at an average altitude of 868 meters with a 2% slope and an average aspect of 276 degrees. The range in elevations is 735 to 936 meters, the range in slope is 0% to 7% and there is zero range in aspect. It is found in the Cook Inlet-Susitna lowland physiographic region. The type is found on alluvial deposits in stream valleys. The ground surface is 10% unvegetated with humus cover.

**Salix bebbiana/Equisetum arvense plant association
Bebb willow/Horsetail plant association; 1 site**

Vegetation—*Salix bebbiana* dominates (40% cover and 3 meters tall) the overstory and *Equisetum arvense* (90% cover) the understory (Appendix 4). *Epilobium angustifolium*, *Betula nana* and seedlings of *Populus balsamifera* are common associates. Few other species occur.

Environmental characteristics—The one site sampled occurred on a 20% sideslope above a floodplain.

**Salix glauca, Shepherdia canadensis, Dryas integrifolia, Artemisia frigida, Festuca rubra T1
(from Heebner 1982)**

Vegetation—The major species of the shrub layer are *Salix alaxensis* (1.5 meters tall, 5% cover), *Salix glauca* (1 meter tall, 15% cover), *Salix barclayi* (0.8 meters tall, 15% cover) and *Shepherdia canadensis* (0.6 meters tall, 10% cover). The major species of the herbaceous layer are *Dryas integrifolia* (25% cover), *Artemisia frigida* (20% cover), *Solidago multiradiata* (10% cover), *Festuca rubra* (10% cover) and *Poa glauca* (3% cover). Species that occur occasionally in this type were *Potentilla fruticosa*, *Agropyron violaceum*, *Minuartia macrocarpa*, *Pyrola secunda* and *Parnassia kotzebui*. The nonvascular layer is composed of *Rhacomitrium canescens* (5% cover), *Polytrichum juniperinum* (5% cover), *Cladonia pyxidata* (2% cover), *Peltigera aphthosa* (2% cover), *Cetraria cucullata* (2% cover) and *Cladonia* species (2% cover).

Environmental characteristics—This type is found at an altitude of 953 meters with a 17% slope and an average aspect of 226 degrees. The elevation ranges from 945 to 960 meters, the slope ranges from 6% to 28%, and the aspect ranges from 116 to 336 degrees. It is found on older glacial moraines. The ground surface is 45% unvegetated. Of the unvegetated surface, 35% is rocky glacial debris and 10% is humus.

**Salix lanata/Calamagrostis canadensis plant association
Richardson willow/Bluejoint plant association; 1 site**

Vegetation—*Salix lanata* dominates (90% cover) the overstory and *Calamagrostis canadensis* (30% cover) dominates the understory (Appendix 4). *Salix lanata* averages 1.5 meters tall. *Boykinia richardsonii* and *Mertensia paniculata* are common herbaceous associates, and *Salix planifolia* and *Salix reticulata* also occur.



Environmental characteristics—The one site sampled was a stringer of vegetation running down a mountain sideslope following the course of a depression. This association likely occurs throughout the park as small patches within the subalpine zone. The elevation of the sampled site was 1,034 meters.

***Salix lanata*/*Equisetum variegatum* plant association**
Richardson willow/Bluejoint plant association; 1 site

Vegetation—*Salix lanata* (50% cover) dominates the overstory and *Equisetum variegatum* (90% cover) dominates the understory (Appendix 4). *Salix lanata* averages 0.9 meters tall, and *Equisetum variegatum* less than 0.3 meters. *Carex membranacea* and *Equisetum arvense* are common herbaceous associates, and *Salix alaxensis* and *Salix glauca* also occur in the overstory.



Environmental characteristics—The one site sampled occurred on a recently deposited and frequently flooded portion of a floodplain at low elevations within the boreal forest zone of the park. The *Carex aquatilis* plant association occurs on wetter sites, and *Picea glauca* invades the drier sites.

Salix planifolia plant association
Diamondleaf willow plant association; 1 site

Vegetation—*Salix planifolia* (50% cover and on average 1.5 meters tall) dominates the overstory (Appendix 4). A variety of low shrubs occur including *Spiraea beauverdiana*, *Betula nana* and *Empetrum nigrum*. *Eriophorum brachyantherum* (20% cover) is the dominant herbaceous species and few other herbaceous species occur. Moss forms a carpet on the ground. *Salix planifolia* increases on drier areas and *Eriophorum brachyantherum* is more common on wetter-level sites.



Environmental characteristics—The one site sampled was found on floodplain at low elevation within the boreal forest zone of the park. The surface is muck and peat, and gravel occurs at 0.3 meters deep.

Salix planifolia/Carex bigelowii plant association
Diamondleaf willow /Carex bigelowii plant association; 1 site

Vegetation—*Salix planifolia* (70% cover) is the only shrub species in the overstory and averages 0.6 meters in height (Appendix 4). *Carex bigelowii* (40% cover) is the dominant herbaceous species. Other vascular species include *Salix reticulata*, *Cassiope tetragona* and *Petasites frigidus*. *Hylocomium splendens* is the dominant moss.



Environmental characteristics—The one site sampled occurred adjacent to a mountain stream on a 10% slope. The association within the park likely occurs as small stringers along mountain streams at higher elevations.

***Salix planifolia*, *Vaccinium uliginosum*, *Salix reticulata*, *Carex podocarpa*, *Hylocomium splendens*
S8 (from Heebner 1982)**

Vegetation—The dominant species of the shrub overstory in this type is *Salix planifolia* ssp. *pulchra* (65% cover, 1.5 meters height). *Vaccinium uliginosum* (25% cover) is the major species of the shrub understory. Occasional associates are *Potentilla fruticosa* (50% cover) and *Salix barclayi* (10% cover). The major species of the herbaceous layer are *Salix reticulata* (25% cover), *Carex podocarpa* (35% cover), *Equisetum arvense* (10% cover), *Vaccinium vitis-idaea* (10% cover), *Poa arctica* (10% cover), *Sedum rosea* (5% cover) and *Polemonium acutiflorum* (5% cover).

The major species of the nonvascular layer are *Hylocomium splendens* (15% cover) and *Pleurozium schreberi* (5% cover). Occasional associates are *Stereocaulon* species, *Cladonia* species, *Cetraria cucullata*, *Aulacomnium palustre* and *Drepanocladus uncinatus*.

Environmental characteristics—This type is found at an average altitude of 852 meters and is on the lower half of the slope. The range in elevation is 754 to 1,052 meters. The bedrock geology is 60% sedimentary, 20% volcanic and 20% schist/gneiss. The surficial geology in 40% of the plots is alluvial deposits, in 40% of the plots is glacial moraines, and in 20% of the plots is bedrock. Other important characteristics of this type are the hummocks and uneven ground which caused differential moisture regimes within the plots of this type. The percentage of ground surface unvegetated varied from 0% to 40%.

CLOSED LOW BIRCH SHRUB LANDCOVER CLASS

Number of plant associations currently in the landcover class: 1

***Betula nana*, *Salix barrattiana*, *Potentilla fruticosa*, *Festuca rubra*, *Hylocomium splendens* S5
(from Heebner 1982)**

Vegetation—This low shrub community is dominated by 1 meter *Betula nana* in the shrub overstory (65% cover). *Salix barrattiana* (20% cover), *Salix planifolia* ssp. *pulchra* (10% cover) and *Potentilla fruticosa* (10% cover) are important understory species. The herbaceous layer contains the following major species: *Festuca rubra* (15% cover), *Dryas integrifolia* ssp. *sylvatica* (8% cover), *Empetrum nigrum* (5% cover), *Saussurea angustifolia* (5% cover), *Poa arctica* (5% cover), *Arctostaphylos rubra* (5% cover), and *Senecio lugens* (5% cover). The major species of the nonvascular layer are *Hylocomium splendens* (60% cover), *Stereocaulon* species (8% cover), *Cetraria islandica* (6% cover), *Peltigera aphthosa* var. *typica* (2% cover), *Cladonia amaurocrea* (2% cover), *Dactylina ramulosa* (1% cover) and *Polytrichum juniperum* (2% cover).



Environmental characteristics—This low shrub community is a gravel bar community with an average vegetated cover value of 90%. The average altitude is 1,038 meters, and the type is found on alluvial deposits. There is zero range in elevation. This type is found at higher altitude and appears to be better drained than the previous vegetation type (S4). Five percent of the ground surface is unvegetated and covered with humus.

LOW SHRUB BIRCH-ERICACEOUS-WILLOW LANDCOVER CLASS

Number of plant associations currently in the landcover class: 9

**Carex microglochin, Salix reticulata, Juncus castaneus, Hedysarum alpinum, Potentilla fruticosa, Sphagnum species T14
(from Heebner 1982)**

Vegetation—The major species of the shrub layer are *Salix lanata* ssp. *richardsonii* (1 meter height, 5% cover), *Salix barclayi* (0.5 meters height, 5% cover), *Potentilla fruticosa* (0.5 meters height, 10% cover), and *Vaccinium uliginosum* (0.3 meters height, 5% cover) and *Sanguisorba officinalis* (1% cover). The major species of the herbaceous layer are *Hedysarum alpinum* (25% cover), *Dryas integrifolia* ssp. *integrifolia* (10% cover), *Vaccinium vitis-idaea* (5% cover), *Carex sciropoidea* (10% cover), *Carex microglochin* (10% cover), *Carex membranacea* (10% cover), *Salix reticulata* (10% cover), *Juncus castaneus* ssp. *castaneus* (5% cover), *Kobresia simpliciuscula* (2% cover), *Parnassia kotzebui* (5% cover), *Polygonum viviparum* (5% cover), *Tofieldia pusilla* (5% cover), *Saussurea angustifolia* (2% cover) and *Pedicularis verticillata* (2% cover). The nonvascular layer is composed of *Sphagnum* species (25% cover).

Environmental characteristics—This type is found at an altitude of 610 meters on alluvial deposits. There is zero range in elevation. This type is very similar to T13, but there is 3% standing water in this type and not in T13. *Salix reticulata* has less cover value in T14 and *Juncus castaneus* appears in this type.

Chamaedaphne calyculata plant association Leatherleaf plant association; 2 sites

Vegetation—*Chamaedaphne calyculata* is the dominant species in this association often with 100% cover (Appendix 4). Other species are uncommon, but *Ledum palustre* and *Vaccinium uliginosum* may occur. *Sphagnum* species may dominate the moss layer in some sites.



Environmental characteristics—This association occurs as small patches (sometimes microsites) on wet sites at the edge of wetlands within the boreal forest zone of the park.

***Larix laricina*, *Betula papyrifera*, *Picea mariana*, *Ledum palustre*, *Betula nana*, *Rubus chamaemorus*, *Eriophorum vaginatum*, *Oxycoccus microcarpus* M13
(from Heebner 1982)**

Vegetation—This plant association has standing charred *Larix laricina* and *Picea mariana*. Presently the tree stratum has a closure of 5% to 10%. *Larix laricina*, *Picea mariana* and *Betula papyrifera* are regenerating in approximately equal proportions. The major species of the shrub layer are *Salix* species (5% cover), *Betula nana* (15% cover), *Ledum palustre* (25% cover), *Chamaedaphne calyculata* (10% cover), *Andromeda polifolia* (5% cover) and *Vaccinium uliginosum* (10% cover). The *Salix* species included *Salix bebbiana*, *Salix monticola*, and *Salix brachycarpa* ssp. *niphoclada*.

The major species of the herbaceous layer were *Oxycoccus microcarpus* (15% cover), *Rubus chamaemorus* (20% cover), *Vaccinium vitis-idaea* (15% cover), *Eriophorum vaginatum* ssp. *vaginatum* (20% cover), *Epilobium angustifolium* (5% cover) and *Carex rotundata* (5% cover). *Tofieldia pusilla*, *Calamagrostis lapponica*, *Spiranthes romanzoffiana*, *Stellaria calycantha* ssp. *interior*, *Cicuta mackenzieana*, *Luzula rufescens* and *Drosera rotundifolia* were occasional associates. The major species of the nonvascular layer are *Polytrichum* species (10% cover), *Sphagnum* species (10% cover), *Marchantia polymorpha* (2% cover) and *Cladonia* species (2% cover).

Environmental characteristics—This type is found in the Tanana lowland at an average altitude of 198 meters on lacustrine deposits. There is zero range in elevation. All plots which compose this type were burned within the previous eight years.

***Salix barrattiana*, *Betula nana*, *Dryas integrifolia*, *Gentiana propinqua*, *Pleurozium schreberi* S14
(from Heebner 1982)**

Vegetation—The shrub layer is dominated by *Salix barrattiana* (0.8 meters height, 50% cover). *Betula nana* (25% cover) and occasionally *Shepherdia canadensis* and *Salix brachycarpa* ssp. *niphoclada* (10% cover) also contribute to the shrub layer. The major species of the herbaceous layer are *Festuca altaica* (10% cover), *Gentiana propinqua* (10% cover), *Aconitum delphinifolium* (5% cover), *Dryas integrifolia* (25% cover), *Arctostaphylos uva-ursi* (6% cover), *Elymus innovatus* (5% cover), *Astragalus nutzotinensis* (5% cover), *Carex sciropoidea* (10% cover), *Pedicularis verticillata* (8% cover), *Pyrola grandiflora* (5% cover) and *Zigadenus elegans* (10% cover). The major species of the nonvascular layer are *Pleurozium schreberi* (25% cover), *Dicranum* species (5% cover), *Stereocaulon* species (2% cover), *Peltigera canina* var. *rufescens*, *Peltigera aphthosa* var. *leucoplebia*, *Cladonia chlorophaea*, *Cladonia pyxidata*, *Cladonia cyanipes/bacilliformis*, *Cladonia coccifera*, *Cetraria cucullata*, *Cetraria islandica*, *Ceratodon purpureus*, and *Drepanocladus uncinatus*.

Environmental characteristics—This type is found at an average altitude of 735 meters, and this type is found on alluvial deposits. The range in elevation is 725 to 754 meters. It is a valley association with very sandy soils. The depth of sandy penetrable soil was 6 centimeters average. The ground surface is 20% unvegetated covered with 10% humus and 10% mineral soil.

**Salix glauca, Shepherdia canadensis, Vaccinium uliginosum, Dryas integrifolia, Saxifraga tricuspidata, Polytrichum commune T2
(from Heebner 1982)**

Vegetation—The major species of the shrub layer are *Salix glauca* (10% cover, 1 meter height), *Salix monticola* (5% cover, 1 meter height), *Shepherdia canadensis* (5% cover, 1 meter height) and *Vaccinium uliginosum* (5% cover, 8 meter height). The major species of the herbaceous layer are *Dryas integrifolia* (10% cover), *Saxifraga tricuspidata* (10% cover), *Festuca altaica* (5% cover), *Salix reticulata* (5% cover), *Astragalus alpinus* ssp. *alpinus* (5% cover), *Artemisia tilesii* (5% cover), *Solidago multiradiata* (5% cover), *Poa arctica* ssp. *arctica* (2% cover), *Stellaria monatha* (1% cover) and *Epilobium angustifolium* (2% cover).

The major species of the nonvascular layer are *Polytrichum commune* (10% cover), *Rhytidium rugosum* (8% cover), *Racomitrium canescens* (6% cover), *Cetraria islandica* (3% cover), *Cetraria cucullata* (3% cover), *Dactylina ramulosa* (1% cover), *Cladonia* species (2% cover) and *Pertusaria* species (1% cover).

Environmental characteristics—This type is found on older glacial moraines at altitude of 884 meters. There is zero range in elevation. The average slope is 22% with an aspect of 156 degrees. The ground surface is 35% unvegetated of which 25% is covered with rocky glacial moraines and 10% covered with dark soil and humus.

**Salix planifolia, Betula nana, Salix glauca, Vaccinium uliginosum, Arctagrostis latifolia, feathermoss T12
(from Heebner 1982)**

Vegetation—The major species of the shrub layer are *Salix planifolia* ssp. *pulchra* (1.2 meters height, 25% cover), *Salix glauca* (1.2 meters height, 10% cover), *Betula nana* (1 meters height, 35% cover), *Potentilla fruticosa* (0.2 meters height, 5% cover) and *Vaccinium uliginosum* (0.2 meters height, 10% cover). The major species of the herbaceous layer are *Poa arctica* ssp. *arctica* (5% cover), *Linnaea borealis* (2% cover), *Mertensia paniculata* (3% cover), *Arctagrostis latifolia* (25% cover), *Delphinium glaucum* (3% cover) and *Festuca brachyphylla* (5% cover).

The major species of the nonvascular layer are *Pleurozium schreberi* (25% cover), *Dicranum* species (5% cover), *Hylocomium splendens* (25% cover), *Peltigera aphthosa* var. *leucoplebia* (3% cover), *Polytrichum* species (3% cover), *Aulacomium palustre* (5% cover), *Cetraria laevigata*, *Stereocaulon* species (2% cover) and *Cladonia* species.

Environmental characteristics—This type is found at an altitude of 984 meters with a 15% slope and an average aspect of 176 degrees. The range in elevation is 716 to 1,091 meters, the range in slope is 3% to 22%, and the range in aspect is zero. The bedrock geology in 50% of the plots is volcanic, in 25% of the plots is metasedimentary and in 25% of the plots is schist/gneiss. The surficial geology is bedrock.

**Salix planifolia, Betula nana, Calamagrostis lapponica, Petasites hyperboreus, feathermoss T11
(from Heebner 1982)**

Vegetation—The major species of the shrub layer are *Salix planifolia* ssp. *pulchra* (30% cover, 1 meter height), *Betula nana* (0.8 meters height, 10% cover) and *Spiraea beauverdiana* (0.7 meters height, 10% cover). The major species of the herbaceous layer are *Calamagrostis lapponica* (50% cover), *Polemonium acutiflorum* (5% cover), *Rubus arcticus* (10% cover), *Aconitum delphinifolium* (5% cover),

Epilobium angustifolium (5% cover) and *Petasites hyperboreus* (20% cover). Important species that occasionally occur in this type are *Vaccinium vitis-idaea* (15% cover), *Empetrum nigrum* (15% cover), *Luzula tundricola* (5% cover), *Heracleum lanatum* (5% cover) and *Sanguisorba officinalis* (3% cover).

The major species of the nonvascular layer are *Hylocomium splendens* (30% cover), *Politrachium* species (10% cover), *Rhytidium rugosum* (5% cover), *Cetraria* species (10% cover), *Cladonia* species (10% cover), *Peltigera* species (5% cover), *Nephroma* species (5% cover) and *Pleurozium schreberi* (5% cover).

Environmental characteristics—This type is found at an average altitude of 844 meters with a slope of 8% and an average aspect of 198 degrees. The range in elevation is 732 meters, the range in slope is 1% to 33%, and the range in aspect is 166 to 296 degrees. The bedrock geology in 89% of the plots is sedimentary/metasedimentary and in 11% of the plots is volcanic. The surficial geology in 56% of the plots is bedrock, in 33% of the plots is glacial moraines and in 11% of the plots is alluvial deposits.

***Vaccinium uliginosum*, *Betula nana*, *Salix arctica*, *Salix reticulata*, *Ledum decumbens*, *Dryas octopetala*, feathermoss T10
(from Heebner 1982)**

Vegetation—The major species of the shrub layer are *Betula nana* (0.5 meters height, 25% cover), *Vaccinium uliginosum* (0.3 meters height, 10% cover) and *Ledum palustre* (0.2 meters height, 10% cover). Species occasionally occurring with the shrub layer of this type are *Salix planifolia* ssp. *pulchra* (0.8 meters height, 10% cover) and *Salix glauca* (0.8 meters height, 10% cover). The major species of the herbaceous layer are *Empetrum nigrum* (10% cover), *Vaccinium vitis-idaea* (10% cover), *Salix arctica* (10% cover), *Salix reticulata* (10% cover), *Carex microchaeta* (5% cover), *Festuca altaica* (10% cover), *Dryas octopetala* ssp. *octopetala* (20% cover), *Artemisia arctica* (10% cover) and *Arctostaphylos arctica* (5% cover). Important species that occur frequently in this type are *Diapensia lapponica* (5% cover), *Poa arctica* (5% cover), *Tofieldia coccinea* (3% cover), *Arctagrostis latifolia* (5% cover), *Epilobium latifolium* (5% cover), *Petasites hyperboreus* (5% cover) and *Polygonum bistorta* (5% cover).

The major species of the nonvascular layer are *Hylocomium splendens* (10% cover), *Polytrichum juniperinum* (4% cover), *Rhytidium rugosum* (4% cover), *Pleurozium schreberi* (4% cover), *Rhacomitrium lanuginosum* (3% cover), *Drepanocladus uncinatus*, *Cetraria nivalis*, *Cladonia arbuscula*, *Cladonia rangiferina*, *Cladonia* species, *Stereocaulon* species, *Dactylina ramulosa*, *Thamnolia vermicularis*, *Peltigera aphthosa* var. *leucoplebia*, *Nephroma arcticum*, *Cetraria islandica*, *Lobaria linita* and *Asahinea chrysantha*.

Environmental characteristics—This type is found at an average altitude of 939 meters with a 10% slope and an average aspect of 162 degrees. The range in elevation is 579 to 1,167 meters, the range in slope is 0% to 39%, and the range in aspect is 16 to 356 degrees. The bedrock geology in 60% of the plots is sedimentary/metasedimentary, in 10% of the plots is volcanic/metavolcanic, in 10% of the plots is schist/gneiss, in 6% of the plots is basalt/gabbroic and in 5% of the plots is unknown. The surficial geology in 35% of the plots is glacial moraines, in 44% of the plots is bedrock, in 18% of the plots is alluvial and in 2% of the plots is unknown. This type is 5% unvegetated weathered rock and mineral soil. Frost boils and patterned (pyramidal formation) ground due to solifluction are evident in this type.

Vaccinium uliginosum/low shrub plant association
Bog blueberry/low shrub plant association; 3 sites

Vegetation—*Vaccinium uliginosum* (75% to 90% cover) is the dominant species. Other species are uncommon although *Betula nana*, *Calamagrostis canadensis* and *Epilobium angustifolium* may be present (Appendix 4). This plant association is distinct from the *Vaccinium uliginosum*/dwarf shrub plant association in both species composition and that its average height exceeds 20 centimeters



Environmental characteristics—This association occurs as small patches in the subalpine and boreal forest of the park. It occupies well-drained colluvial slopes, bedrock outcrops and glacial drift.

LOW SHRUB-SEDGE LANDCOVER CLASS

Number of plant associations currently in the landcover class: 3

Betula nana/Carex aquatilis plant association
Dwarf arctic birch/Water sedge plant association; 1 site

Vegetation—*Betula nana* (30% cover) is the dominant shrub, and *Carex aquatilis* (50% cover) dominates the understory (Appendix 4). Other species include *Andromeda polifolia*, *Vaccinium vitis-idaea*, *Larix laricina*, *Picea mariana* and *Carex limosa*. *Sphagnum* species (90% cover) dominate the bryophyte layer.



Environmental characteristics—The one site sampled occurred on a low elevation (273 meters) peatland bordering a lake in the northwest corner of the park. The soil was organic and the water at the soil surface.

Betula nana/Eriophorum brachyantherum plant association
Dwarf arctic birch/ Eriophorum brachyantherum plant association; 3 sites

Vegetation—*Eriophorum brachyantherum* (60% to 80% cover) is the dominant species in this type. *Carex bigelowii* (0-30% cover) is commonly a strong codominant in the herbaceous layer. *Betula nana* or *Betula glandulosa*, often in combination with *Salix planifolia*, *Vaccinium uliginosum* and *Vaccinium vitis-idaea*, make up the shrub layer. Other species include *Empetrum nigrum*, *Ledum groenlandicum* and *Equisetum sylvaticum*.

Environmental characteristics—*Eriophorum brachyantherum* and other herbaceous species form tussocks that typically dominate the sites. The sites are moist on level to moderate (10%) slopes. The soils are organic often over permafrost.

Betula nana/Eriophorum vaginatum plant association
Dwarf arctic birch/Hare's tail grass plant association; 4 sites

Vegetation— *Betula nana*, often in combination with *Vaccinium uliginosum*, *Empetrum nigrum* and *Ledum decumbens*, make up the shrub layer (Appendix 4). Their combined cover ranges from 35% to 65%. *Eriophorum vaginatum* (40% to 75% cover) dominates the herbaceous layer and other herbaceous species include *Carex microchaeta*, *C. bigelowii* and *Rubus chamaemorus*.



Environmental characteristics—This association occurs in the subalpine and boreal forest zone of the park, often forming a mosaic with various spruce forest associations. It occurs at mid elevations (598 to 770 meters) on slopes of less than 10% on outwash terraces and rounded ridges. *Eriophorum vaginatum* and other herbaceous species form tussocks that typically dominate the moist sites. The soils are organic often over permafrost.

PEATLAND LANDCOVER CLASS

Number of plant associations currently in the landcover class: 1

**Myrica gale plant association
Sweet gale plant association; 3 sites**

Vegetation—*Myrica gale* (greater than 50% cover) dominates the shrub layer (Appendix 4). *Betula nana*, *Chamaedaphne calyculata*, and *Ledum groenlandicum* are other common shrubs. A variety of sedges may form the herbaceous layer including *Carex microglochin*, *C. rotundata* and *C. williamsii*. *Sphagnum* species (60% to 90% cover) dominate the moss layer.



Environmental characteristics—This is a wet site typically found in peatlands on the south side of the Alaska Range. It occurs as patches within a larger mosaic of dwarf tree, shrub and herbaceous types. Water depth ranges from 8 centimeters below to 8 centimeters above the surface of the peat.

DWARF SHRUB LANDCOVER CLASS, AND DWARF SHRUB-ROCK LANDCOVER CLASS

Number of plant associations currently in the landcover class: 10

Arctostaphylos alpina plant association Alpine blueberry plant association; 1 site

Vegetation—*Arctostaphylos alpina* (25% cover) codominates this association with *Vaccinium uliginosum* (15%), *Cornus canadensis* (20%) and *Empetrum nigrum* (20%, Appendix 4). Few other shrub or herbaceous species occur. Lichen cover is 20%.

Environmental characteristics—This association occurs in alpine areas and forms small patches within a mosaic of other dwarf shrub associations. It commonly occurs on well-drained colluvial slopes. The soil of the one site sampled had a 3-centimeter thick organic mat over silt and sand.

Cassiope tetragona plant association Four-angled cassiope plant association; 2 sites

Vegetation—*Cassiope tetragona* (30% cover) codominates this association with *Arctostaphylos alpina* (20% cover), *Diapensia lapponica* and *Vaccinium uliginosum* (5% cover). Other shrub species include *Empetrum nigrum* and *Dryas octopetala* (Appendix 4). Herbaceous species include *Arnica lessingii*, *Carex bigelowii* and *Hierochloa alpina*. Lichen cover averages 40% and moss cover is less than 10%. *Hylocomium splendens* has 30% cover.



Environmental characteristics—This association occurs in alpine areas and forms small patches within a mosaic of other dwarf shrub associations. The soils are well drained and rocky on colluvial and bedrock slopes.

***Dryas octopetala*, *Cassiope tetragona*, *Vaccinium uliginosum*, *Salix reticulata*, *Salix arctica*,
feathermoss, *Stereocaulon* species T8
(from Heebner 1982)**

Vegetation—The major shrub species of this type are *Vaccinium uliginosum* (0.08 meters height, 15% cover) and *Rhododendron lapponicum* (0.05 meters height, 5% cover). Species that occur occasionally in the shrub layer are *Salix glauca* (0.4 meters height, 2% cover), *Salix barrattiana* (0.1 meters height, 2% cover), *Salix planifolia* ssp. *pulchra* (0.4 meters height, 2% cover), *Potentilla fruticosa* (0.1 meters height, 1% cover), and *Betula nana* (0.1 meters height, 2% cover).

The major species of the herbaceous layer are *Cassiope tetragona* (25% cover), *Salix reticulata* (10% cover), *Salix arctica* (10% cover), *Dryas octopetala* ssp. *octopetala* (25% cover), *Carex microchaeta* (5% cover), *Anemone parviflora* (5% cover), *Festuca altaica* (8% cover) and *Silene acaulis* (2% cover). Important species that occur frequently in this type are *Arctostaphylos rubra* (5% cover), *Astragalus umbellatus* (5% cover), *Pedicularis capitata* (2% cover), *Hierochloa alpina* (5% cover), *Poa arctica* (5% cover), *Diapensia lapponica* (2% cover), *Lupinus arcticus* (3% cover), *Minuartia arctica* (2% cover) and *Polygonum bistorta* (2% cover).

The major species of the nonvascular layer are *Hylocomium splendens* (10% cover), *Cetraria cucullata* (3% cover), *Stereocaulon* species (5% cover), *Thamnia vermicularis* (2% cover), *Aulacomnium turgidum*, *Polytrichum juniperinum*, *Distichium capillaceum*, *Rhytidium rugosum*, *Aulacomnium palustre*, *Lobaria linita*, *Cetraria islandica*, *Dactylina ramulosa*, *Peltigera aphthosa* var. *leucoplebia*, *Cornicularia divergens*, *Cetraria nivalis*, *Sphaerophorus globosus* and *Cladonia* species

Environmental characteristics—This type is found at an average altitude of 1,135 meters on a 15% slope with an average aspect of 183 degrees. The range in elevation is 823 to 1,341 meters, the range in slope is 1% to 33%, and the range in aspect is 026 to 306 degrees. The bedrock geology in 50% of the plots is sedimentary/metasedimentary, in 20% of the plots is basalt/gabbroic, in 10% of the plots is volcanic, in 10% of the plots is schist/gneiss and in 10% of the plots is unknown. The surficial geology in 90% of the plots is bedrock and in 10% of the plots is older glacial moraines. The ground surface is 12% unvegetated. This type is found at a lower altitude than T4-T7. It is a moister type than T5, T6, and T7.

***Dryas octopetala*, *Salix arctica*, *Carex microchaeta*, *Oxytropis nigrescens*, *Hylocomium splendens*
T6 (from Heebner 1982)**

Vegetation—The major species of this herbaceous plant association are *Dryas octopetala* ssp. *octopetala* (50% cover), *Salix arctica* (25% cover), *Oxytropis nigrescens* ssp. *bryophila* (5% cover), *Carex microchaeta* (10% cover), *Senecio lugens* (3% cover), *Minuartia arctica* (2% cover), *Anemone parviflora* (3% cover), *Ligusticum mutellinoides* ssp. *alpinum* (3% cover), *Castilleja elegans* (3% cover), *Poa arctica* (3% cover), *Trisetum spicatum* (3% cover), *Silene acaulis* (1% cover), *Saxifraga reflexa* (2% cover) and *Campanula lasiocarpa* (2% cover). Other species which occur frequently in this type are *Festuca brachyphylla*, *Luzula tundricola*, *Luzula confusa*, *Diapensia lapponica*, *Saxifraga flagellaris* ssp. *setigera*, *Polygonum viviparum*, *Pedicularis capitata*, *Artemisia arctica*, *Polygonum bistorta*, *Draba nivalis*, *Potentilla uniflora*, *Antennaria monocephala* ssp. *monocephala* and *Senecio residifolius*.

The major species of the nonvascular layer are *Hylocomium splendens* (5% cover), *Thamnia vermicularis*, *Cetraria islandica*, *Cetraria cucullata*, *Cetraria nivalis*, *Peltigera aphthosa*, *Stereocaulon* species, *Lobaria linita*, *Rhytidium rugosum*, *Rhacomitrium canescens*, *Distichium capillaceum*, *Pertusaria* species, *Asahinea chrysantha*, *Alectoria nigricans*, *Polytrichum juniperinum*, *Drepanocladus uncinatus*, *Sphaerophorus globosus* and *Cladonia* species.

Environmental characteristics—This type is found at an altitude of 1,285 meters with a 16% slope and aspect of 201 degrees. The range in elevation is 1,068 to 1,494 meters, the range in slope is 2% to 41% and the range in aspect is 26 to 356 degrees. The bedrock geology in 46% of the plots is basalt/gabbroic, in 30% of the plots is sedimentary/metasedimentary, in 12% of the plots is volcanic and in 12% of the plots is schist/gneiss. The surficial geology in 81% of the plots is bedrock, in 15% of the plots is older glacial moraines and in 4% of the plots is alluvial. This type when compared to T5 has no *Vaccinium uliginosum* and a higher cover of *Dryas octopetala* and *Salix arctica*. The species composition is similar, but there are species exclusive to either type as *Hierochloe alpina* (in T5) and *Senecio residifolius* (in T6). T6 is found on steeper slopes with a more southwestern exposure. The ground surface is 36% unvegetated weathered rock and mineral soil in T6. This value was 28% in T5. The ground surface of T6 is terraced as a result of solifluction.

***Dryas octopetala*, *Vaccinium uliginosum*, *Salix arctica*, *Carex microchaeta*, *Hierochloe alpina*,
Hylocomium splendens T5
(from Heebner 1982)**

Vegetation—The major species of this plant association are *Dryas octopetala* (35% cover), *Vaccinium uliginosum* (0.1 meters height, 10% cover), *Salix arctica* (10% cover), *Hierochloe alpina* (8% cover), *Anemone parviflora* (8% cover), *Senecio lugens* (8% cover), *Oxytropis nigrescens* (8% cover), *Carex microchaeta* (10% cover), *Diapensia lapponica* (2% cover) and *Ligusticum mutellinoides* ssp. *alpinum* (5% cover). Other species which occur frequently in this type are *Poa arctica* (3% cover), *Campanula lasiocarpa* (5% cover), *Carex sciopoidea* (5% cover), *Luzula confusa* (5% cover), *Arenaria chamissonis*

(2% cover), *Polygonum bistorta* (2% cover), *Pedicularis capitata* (3% cover), *Cassiope tetragona* (2% cover), *Gentiana algida* (2% cover), *Primula tschuktschorum* ssp. *tschuktschorum* (2% cover), *Castilleja elegans* (2% cover), *Geum rossii* (1% cover), *Antennaria friesiana* ssp. *friesiana* and *Saxifraga eschscholtzii*.

The major species of the nonvascular layer are *Hylocomium splendens* (10% cover), *Stereocaulon* species (2% cover), *Rhacomitrium canescens* (5% cover), *Polytrichum juniperinum* (4% cover), *Rhytidium rugosum* (3% cover), *Dactylina ramulosa* (1% cover), *Cetraria nivalis* (1% cover), *Sphaerophorus globosus*, *Cetraria islandica*, *Peltigera pratexta*, *Thamnolia vermicularis*, *Asahinea chrysantha*, *Cetraria cucullata*, *Alectoria* species *Parmelia* species and *Cladonia* species

Environmental characteristics—This type is found at an altitude of 1,200 with an 8% slope and an aspect of 165 degrees. The range in elevation is 1,073 to 1,311 meters, the range in slope is 0% to 44%, and the range in aspect is 026 to 326 degrees. The bedrock geology in 33% of the plots is sedimentary/metasedimentary, in 33% of the plots is basalt/gabbroic, in 17% of the plots is volcanic, in 11% of the plots is schist/gneiss and in 6% of the plots is granitic. The surficial geology in 72% of the plots is bedrock, in 22% of the plots is alluvial deposits and in 6% of the plots is older glacial moraines. The ground surface is 28% unvegetated weathered rock and mineral soil.

***Salix brachycarpa*, *Dryas octopetala*, *Salix reticulata*, *Cassiope tetragona*, feathermoss T4 (from Heebner 1982)**

Vegetation—The shrub layer if it exists in this type is occasionally composed of the following species: *Salix glauca* (1 meter height, 1% cover), *Salix brachycarpa* ssp. *niphoclada* (0.3 meters height, 30% cover), and *Salix barrattiana* (0.2 meters height, 5% cover). The major species of the herbaceous layer are *Salix arctica* (10% cover), *Salix reticulata* (25% cover), *Anemone parviflora* (5% cover), *Festuca rubra* (10% cover), *Dryas octopetala* (30% cover), *Silene acaulis* (3% cover), *Poa alpina* (6% cover), *Epilobium latifolium* (4% cover), *Trisetum spicatum* (6% cover) and *Saxifraga hieracifolia*. Occasional associates in the herbaceous layer are *Cassiope tetragona* (10% cover), *Androsace chamaejasme* ssp. *lehmanniana* (5% cover), *Aster alpinus* (3% cover) and *Cnidium cnidifolium* (5% cover).

The major species of the nonvascular layer are *Hylocomium splendens* (5% cover), *Rhacomitrium canescens* (5% cover), *Aulacomium palustre* (5% cover), *Distichium capillaceum* (3% cover), *Polytrichum* species (2% cover), *Peltigera aphthosa* var. *leucoplebia* (2% cover), *Cetraria islandica* (1% cover), *Stereocaulon* species (2% cover), *Thamnolia vermicularis* (2% cover) and *Dactylina ramulosa*. Other nonvascular species that occur frequently in this type are *Pertusaria* species, *Peltigera canina* var. *rufescens*, *Lobaria linita*, *Cladonia chlorophaea*, *Rhytidium rugosum* and *Cetraria cucullata*.

Environmental characteristics—This plant association is found at an average altitude of 1,265 meters with a 28% slope and average aspect of 205 degrees. The range in elevation is 1,052 to 1,654 meters, the range in slope is 2% to 50%, and the range in aspect is 056 to 326 degrees. The bedrock geology in 88% of the plots is sedimentary/metasedimentary, in 6% of the plots is volcanic and in 6% of the plots is granitic. The surficial geology in 76% of the plots is bedrock, in 12% of the plots is glacial moraines and in 12% of the plots is alluvial deposits. The ground surface of this type is 35% unvegetated weathered rock and mineral soil.

**Salix glauca, Salix reticulata, Festuca altaica, Dryas octopetala T3
(from Heebner 1982)**

Vegetation—The major species of the shrub layer of this type are *Salix glauca* (10% cover, 1 meter height). Species that occur occasionally in this type are *Salix barrattiana* and *Potentilla fruticosa*. The major species of the herbaceous layer are *Salix reticulata* (25% cover), *Dryas octopetala* (30% cover), *Festuca altaica* (25% cover), *Artemisia arctica* (10% cover), *Hedysarum alpinum* (5% cover), *Anemone parviflora* (8% cover) and *Gentiana propinqua* (3% cover). Important occasional associates in the herbaceous layer are *Salix arctica* (10% cover), *Festuca rubra* (10% cover), *Senecio lugens* (5% cover), *Solidago multiradiata* (5% cover), *Epilobium latifolium* (5% cover), *Polygonum bistorta* (5% cover), *Equisetum scirpoides*, *Poa arctica* (5% cover), *Carex* species (5% cover), *Aster sibiricus* (2% cover) and *Silene acaulis*.

The major species of the nonvascular layer are *Hylocomium splendens* (10% cover), *Peltigera canina* var. *rufescens* (2% cover), *Stereocaulon* species (2% cover), *Rhytidium rugosum*, *Tortula mucronifolia*, *Rhacomitrium canescens*, and *Cetraria cucullata*.

Environmental characteristics—This type occurs at an average altitude of 1,163 meters with 14% slope and an aspect of 158 degrees. The range in elevation is 920 to 1,305 meters, the range in slope is 0% to 37%, and the range in aspect is 026 to 356 degrees. The bedrock geology is 62% sedimentary/metasedimentary, 23% basalt/gabbroic, 8% schist/gneiss and 8% volcanic. The surficial geology is 38% alluvial/colluvial deposits, 31% glacial moraines and 31% bedrock. The ground surface is 5% weathered rock.

**Salix polaris plant association
Polar willow plant association; 1 site**

Vegetation—The association is dominated by *Salix Polar* (20% cover), *Cassiope tetragona* (15% cover) and *Dryas octopetala* (10% cover, Appendix 4). Over 40% moss cover occurs dominated by *Hylocomium splendens*. A variety of forbs and graminoids occur in trace amounts including *Arnica lessingii*, *Geum rossii*, *Petasites frigidus* and *Saxifraga reflexa*.



Environmental characteristics—This association occurs in alpine areas and forms small patches within a mosaic of other dwarf shrub associations. The one site sampled had soil with a 5-centimeter thick organic mat over gravel and sand on a well-drained colluvial slope.

***Salix reticulata*, *Carex membranacea*, *Eriophorum angustifolium*, *Dryas integrifolia*, *Sphagnum*
species T13
(from Heebner 1982)**

Vegetation—The major species of the shrub layer are *Salix lanata* spp. *richardsonii* (1.5 meters height, 5% cover), *Salix barclayi* (0.6 meters height, 5% cover) and *Potentilla fruticosa* (0.4 meters height, 5% cover). The major species of the herbaceous layer are *Salix reticulata* (30% cover), *Dryas integrifolia* ssp. *integrifolia* (25% cover), *Carex aquatilis* (15% cover), *Carex membranacea* (15% cover), *Eriophorum angustifolium* ssp. *subarcticum* (10% cover), *Vaccinium vitis-idaea* (10% cover), *Hedysarum alpinum* (10% cover), *Anemone parviflora* (5% cover), *Equisetum scirpoides* (2% cover), *Parnassia kotzebui* (2% cover) and *Tofieldia pusilla* (5% cover). The major species of the nonvascular layer are *Sphagnum* species (35% cover).

Environmental characteristics—This type is found at an altitude of 610 meters on alluvial deposits. The soil is sandy. There is zero range in elevation.

***Vaccinium uliginosum*/Dwarf shrub plant association
Bog blueberry/Dwarf shrub plant association; 7 sites**

Vegetation—*Vaccinium uliginosum* is the dominant species ranging from 30% to 80% and its height is typically less than 20 centimeters tall (Appendix 4). Other common dwarf shrub species include *Cornus suecica*, *Arctostaphylos rubra*, *Empetrum nigrum* and *Betula nana*. Herbaceous species are uncommon and includes *Carex microchaeta* and *Calamagrostis canadensis*. Lichen and moss cover are typically less than 20% and 60%, respectively.



Environmental characteristics—This is a common association of alpine and subalpine areas that forms small patches within a mosaic of other dwarf shrub or low shrub associations. It typically occurs on well-drained colluvial slopes, including moraines. The soil is a thin organic mat over mineral soil. Sorted circles are common, and the slope varies from 0% to 20%.

DRY-MESIC HERBACEOUS LANDCOVER CLASS

Number of plant associations currently in the landcover class: 4

***Calamagrostis canadensis* plant association**
Bluejoint plant association; 8 sites

Vegetation—*Calamagrostis canadensis* dominates this association with cover up to 95% sometimes forming a monoculture (Appendix 4). Other species are uncommon and include *Betula glandulosa*, *Vaccinium uliginosum*, *Athyrium filix-femina* and *Myrica gale*.



Environmental characteristics—This is a common association within the park occurring under a wide variety of site conditions. In the mountains, it is found on mid-elevation colluvial slopes. It is commonly bordered upslope by dwarf shrub associations, downslope by either alder or low shrub associations, or forms a mosaic with alder associations. In wetlands or stream banks, it is found on drier sites and on old beaver dams. In the boreal forest it occupies large oval moist to wet depressions and some burn sites. The soils are a thin organic mat of roots over mineral soil.

Calamagrostis canadensis-Mixed herbaceous plant association
Bluejoint-Mixed herbaceous plant association; 7 sites

Vegetation—This association forms lush herbaceous meadows dominated by two or more of the following species: *Athyrium filix-femina*, *Calamagrostis canadensis*, *Epilobium angustifolium*, *Geranium erianthum*, *Heracleum lanatum* and *Sanguisorba stipulata* (Appendix 4). Total cover often exceeds 90% and herbaceous height ranges from 0.3 to 1.0 meters tall. Low shrubs may also occur including *Spiraea beauverdiana* and *Salix planifolia*.



Environmental characteristics—This association typically occurs on moist sites in alpine and subalpine areas on the south side of the Alaska Range. It is typically found on mid to lower slope colluvial deposits, and the soils are a thin organic mat of roots over mineral soil. It is commonly bordered upslope by dwarf shrub classes, and downslope by either alder or low shrub types.

Carex canescens, Carex rhynchophylla, Agropyron violaceum, Rorippa islandica, Sphagnum species T9
(from Heebner 1982)

Vegetation—This type is a seasonal *Carex* meadow with a seasonal receding water level. The major species are *Carex canescens* (20% cover), *Carex rhynchophylla* (20% cover), *Agropyron violaceum* (10% cover), *Rorippa islandica* (10% cover), *Ranunculus gmelini* (10% cover), *Hippuris vulgaris* (5% cover), *Equisetum fluviatile* (5% cover) and *Sphagnum* species (50% cover).

Environmental characteristics—This type is found at an average altitude of 572 meters. The bedrock is sedimentary and the surficial geology is glacial/fluvial.

Epilobium latifolium plant association
River beauty plant association; 1 site

Vegetation—In the one site sampled, *Epilobium latifolium* (30% cover) was the only species that occurred (Appendix 4).



Environmental characteristics—This association occupies well-drained newly formed sand/gravel bars of floodplains and outwash plains. Much of the ground cover is exposed alluvium.

WET HERBACEOUS LANDCOVER CLASS

Number of plant associations currently in the landcover class: 9

***Betula papyrifera*, *Salix planifolia*, *Calamagrostis inexpansa*, *Carex aquatilis*, *Potentilla palustris*
M14 (from Heebner 1982)**

Vegetation—This plant association has an overstory of *Betula papyrifera* with a 5% cover value. There is standing water with 25% cover and senescent *Betula papyrifera* (5% cover). The shrub layer is composed of *Salix planifolia* ssp. *pulchra* (10% cover), *Salix bebbiana* (3% cover), and *Salix barclayi* (5% cover). There is standing dead *Salix* with a cover value of 5%. The major species of the herbaceous layer are *Calamagrostis inexpansa* (50% cover), *Carex aquatilis* ssp. *aquatilis* (10% cover), *Hippuris vulgaris* (5% cover), and *Potentilla palustris* (5% cover). *Glyceria pulchella*, *Beckmannia erucaeformis*, *Ranunculus pennsylvanicus*, *Ranunculus confervoides*, *Rubus arcticus* spp. *acaulis*, *Potamogeton epihydrus* var. *ramosus*, *Utricularia vulgaris* ssp. *macrorhiza* and *Utricularia intermedia* also occur.

Environmental characteristics—This is the wettest forest plant association sampled. It is found in the Tanana lowland at an altitude of 198 meters on lacustrine deposits. There is zero range in elevation.

Carex aquatilis plant association
Water sedge plant association; 5 sites

Vegetation—*Carex aquatilis* (60% to 90% cover) is the dominant species in the association (Appendix 4). Other species are uncommon but may include *Potentilla palustris* and *Vaccinium microcarpos*. *Sphagnum* species often form a floating mat interspersed with the emergent *Carex aquatilis*.



Environmental characteristics—This association occurs in the shallow zones of ponds, the borders of large lakes, and the borders of some small streams. The ponds typically occur on floodplains, kettle-kame topography and thermokarst throughout Denali. Water depth ranges up to 30 centimeters above the soil surface. Elevation ranges from 200 to 583 meters.

Carex lasiocarpa plant association
1 site

Vegetation—*Carex lasiocarpa* is the dominant species in the association, and other species are uncommon but may include *Carex rostrata* and *Eriophorum vaginatum* (Appendix 4).



Environmental characteristics—This association is found in shallow water on the edge of ponds that occur on floodplains and other systems. The one site sampled occurred at 333 meters elevation, and had 20 centimeters of standing water.

Carex rostrata plant association
Beaked sedge plant association; 5 sites

Vegetation—*Carex rostrata* (60% to 90% cover) is the dominant species in the association, often forming monocultures. Other species are rare but may include *Potentilla palustris*, *Carex aquatilis* and *Sphagnum* species.



Environmental characteristics—This association is uncommon yet wide spread occurring in shallow ponds throughout the boreal forest portions of the park. The ponds occur on floodplains, kettle-kame topography and thermokarst topography. Water depth ranges from 15 centimeters above the soil surface to 15 centimeters below. The elevation ranges from 215 to 945 meters.

***Eleocharis quinqueflora* plant association**
Spike rush plant association; 1 site

Vegetation—*Eleocharis quinqueflora* (80% cover) dominates this association (Appendix 4). Other species are uncommon but may include *Carex rotundata* (20% cover) and *Betula glandulosa* (trace cover).



Environmental characteristics—The association is found on low elevation peatlands south of the Alaska Range. It occurs as small patches within the peatland mosaic of dwarf tree, shrub and herbaceous map classes. The water table was at the soil surface on the one site sampled.

***Equisetum fluviatile* plant association**
Water horsetail plant association; 2 sites

Vegetation—*Equisetum fluviatile* is the dominant species ranging up to 50% cover (Appendix 4). Other species are uncommon but may include *Potentilla palustris* and *Menyanthes trifoliata*. *Sphagnum* species often occur as floating mats within the *Equisetum fluviatile*.



Environmental characteristics—This plant association is found as small to large patches in wet depressions, ponds, sloughs and lakes. The ecosystems include floodplains, kettle-kame and thermokarst topography. Water depth above the soil surface commonly exceeds 20 centimeters.

***Eriophorum brachyantherum* plant association**
2 sites

Vegetation—*Eriophorum brachyantherum* (80% to 90% cover) is the dominant species often forming a monoculture (Appendix 4). Other species are uncommon but may include *Salix fuscescens* (40% cover) and floating mats of *Sphagnum* species (50% cover).



Environmental characteristics—This association occurs on the shallow portions of ponds and slow moving streams. Water depth above ground level ranges from 6 to 25 centimeters.

***Eriophorum vaginatum* plant association**
Hare's-tail grass plant association; 1 site

Vegetation—*Eriophorum vaginatum* is the dominant species (90% cover) and may form monocultures (Appendix 4). Other species are uncommon but may include *Carex rotundata* and floating mats of moss.



Environmental characteristics—The association occurs on the shallow portions of ponds. The one site sampled was on a floodplain but the association, also, likely occurs as small patches in ponds on kettle-kame and thermokarst topography.

***Menyanthes trifoliata* plant association**
Buckbean plant association; 1 site

Vegetation—*Menyanthes trifoliata* (90% cover) is the dominant species in the association (Appendix 4). Other species are uncommon but may include *Cicuta mackenzieana*, *Potentilla palustris* and *Equisetum fluviatile*.



Environmental characteristics—The one site sampled occurred on a floodplain pond in 20-centimeter deep water. It also likely occurs as small to large patches at low elevations on the northern and southern edges of the park.

LITERATURE CITED

- Bailey, R. G., P. E. Avers, T. King, and W. H. McNab. 1994. Ecoregions and subregions of the United States. United States Department of Agriculture, Forest Service.
- Ballard, T. M. 1973. Soil physical properties in a sorted stripe field. *Arctic and Alpine Research*. 5:127-131.
- Brown, D. 1954. Methods of surveying and measuring vegetation. Commonwealth Agricultural Bureau, Bucks, England. Bull. 42.
- Clark, M. 1998. Denali Park - Ecoregions and the National Hierarchical Framework of Ecological Units. Department of Agriculture, Natural Resources Conservation Service.
- Daubenmire, R. D. 1959. A canopy coverage method of vegetation analysis. *Northwest Science*. 33:43-66.
- Densmore, R. 1991. Restoration of alpine and subalpine plant communities in areas disturbed by construction. Report for Denali National Park and Preserve.
- Densmore, R. 1992. Vegetation monitoring protocol development. Report for Denali National Park and Preserve.
- Densmore, R.V. 1994. Succession and regraded placer mine spoil in Alaska, U.S.A., in relation to initial site characteristics. *Arctic and Alpine Research*. 26(4):354-363.
- Douglas, D. 1994. Remote sensing to assess vegetation phenology and berry production/availability. In Densmore, R. 1994. Production and availability of berries important to Grizzly bears. Progress report for Denali National Park and Preserve.
- ECOMAP. 1993. National hierarchical framework of ecological units. ECOMAP, USDA Forest Service, Washington, DC. October 29, 1993. National hierarchical framework of ecological units.
- Flahault, C., and C. Schroter. 1910. Rapprt sur la nomenclature phytogeographique. Proceedings of the Third International Botanical Congress, Brussels 1:131-164.
- Fleming, M. D. 1997. Alaska vegetation landcover classification. Department of Integrative Biology, University of California Berkeley.
- Gallant, A. L., E. F. Binnian, J. M. Omernik, and M. B. Shasby. 1995. Ecoregions of Alaska. Geological Survey Professional Paper 1567. US Geological Survey, Reston.
- Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I. The National Vegetation Classification System: development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA.
- Hamilton, T. D. 1999. Surficial geologic map of Gates of the Arctic National Park and Preserve, Alaska: U. S. Geological Survey, digital map, scale 1:250,000.

- Hanson, Herbert C. 1950. Vegetation and soil profiles in some solifluction and mound areas in Alaska. *Ecology*. 31(4):606-630.
- Heebner, D. 1976. Collections for vegetation analysis of the park for caribou range mapping project. Report for Denali National Park and Preserve.
- Heebner, Deborah K. 1982. The numerical analysis of vegetation plots in Denali National Park and Preserve. Fairbanks, AK: University of Alaska. 243 p. M.S. thesis.
- Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, CA. 1008 p.
- Kreig, R. A. and R. D. Reger. 1982. Air-photo analysis and summary of landform soil properties along the route of the trans-Alaska pipeline system. Alaska Department of Natural Resources. Division of Geological and Geophysical Surveys, Geologic Report 66.
- McNab, H.W. and P. E. Avers. 1994. Ecological Subregions of the United States: Section Descriptions. Publication WO-WSA-5. Department of Agriculture, Forest Service. Washington, D.C.
- Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York, NY. 547 p.
- Nowacki, G. and T. Brock. 1995. ALASKA-ECOMAP version 2.0. United States Department of Agriculture-Forest Service.
- Pfister, R.D. and S.F. Arno. 1980. Classifying forest habitat types based on potential climax vegetation. *Forest Science*. 26(1): 52-70.
- Pratt, V.E. and F.G. Pratt. 1993. Wildflowers of Denali National Park. Alaskakrafts, Inc. Anchorage, AK. 166p.
- Rieger, S., D.B. Schoephorster, and C.E. Furbush. 1979. Exploratory soil survey of Alaska: U. S. Department of Agriculture, Soil Conservation Service, 213 p.
- Ritter, D. F. 1986. Process geomorphology. Wm. C. Brown Publishers, Dubuque, Iowa. 579 p.
- Selkregg, L. L. 1975. Alaska regional profiles, Arctic Region. The University of Alaska, Arctic Environmental Information and Data Center, Anchorage, AK.
- Shelton, N. 1962. Vegetation differences related to slope and aspect on Cathedral Mountain. M.S. Thesis. Duke University.
- USDI National Park Service. 1987. Kantishna Hills vegetation mapping for EIS. 1:1200 maps of vegetation.
- Viereck, Leslie A. 1966. Plant succession and soil development on gravel outwash of the Muldrow Glacier, Alaska. *Ecological Monographs*. 36(3):181-199.
- Viereck L.A., and E.L. Little, Jr. 1972. Alaska trees and shrubs. Agriculture Handbook No. 410 Forest Service, reprinted by the University of Alaska Press, Fairbanks, Alaska.

Viereck, L. A.; C.T. Dyrness, A.R. Batten, K.J. Wenzlick. 1992. The Alaska vegetation classification. Pacific Northwest Research Station, U. S. Forest Service, Portland, OR. Gen. Tech. Rep. PNW-GTR286. 278 p.

Washburn, A. L. 1956. Classification of patterned ground and review of suggested origins. Geological Society America Bulletin 67:823-66.

Welsh, S. L. 1974. Anderson's flora of Alaska and adjacent parts of Canada. Brigham Young University Press, Provo, Utah.

GLOSSARY

Most of the ecological terms below are from Hamilton (1999), Gallant et al. (1995), Anderson et al. (1998), Viereck et al. (1992) and Gabriel and Talbot (1984).

Albedo—Same as reflectivity. The percentage of incoming radiation that is reflected by a natural surface such as a ground, ice, snow, water, clouds, or particulates in the atmosphere.

Alliance—A physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation (Grossman et al. 1998).

Alluvial fans—Erosional-depositional system in which rock and sediment are transported down-valley and deposited where it emerges from the confines of the valley into a larger valley or plain. They tend to be fan-shaped in plan view; a segment of a cone radiating away from a single point source.

Alluvial—Characterized by the deposition of sediment by a stream or other running water at any point along its course.

Alpine—The zone on mountain tops between permanent snow and the cold limits of trees.

Annual—Plant species that complete their life-cycle within a single growing season.

Aquatic—Refers to sites with vegetation that is submerged, floating, or growing in permanent water.

Bare-ground—Refers to (1) a landcover class with less than 15 percent vegetation cover, or (2) a soil surface devoid of vegetation.

Bedrock—Refers to exposed rock typically at higher elevations and includes all the jagged rocky ridges, peaks, cirque headwalls and cirque basins. It has little or no soil development.

Biennial—Plant species that complete their life-cycle within two growing seasons.

Boreal—Northern biogeographical region typically referring to subpolar and cold temperate areas.

Brackish—Tidal water with a salinity of 0.5-30 parts per thousand.

Broad-leaved—Describes a plant with leaves that have well-defined leaf blades and are relatively wide in outline (shape) as opposed to needle-like or linear; leaf area is typically greater than 500 square millimeters or 1 square inch.

Bryophyte—Nonvascular, terrestrial green plant, including mosses, hornworts, and liverworts.

Bunch grass—Multi-stemmed (caespitose) life form of grasses characterized by clumps of erect shoots that slowly spread horizontally by tillers, generally creating distinct individual plants spaced across the ground; often applied to sedges and other graminoids with similar life forms.

Caespitose (cespitoso)—Describes a low branching pattern from near the base that forms a multi-stemmed or a bunched appearance.

Canopy cover—The percent of the ground in the polygon covered by the gross outline of an individual plant's foliage (canopy), or the outline collectively covered by all individuals of a species or life-form within the polygon (Daubenmire 1959).

Classification—Process of assigning individual pixels of an image to categories, generally on the basis of spectral reflectance characteristics.

Cliff—Any high, very steep to perpendicular, or overhanging face of a rock outcrop.

Cold-deciduous—Describes a plant that sheds its leaves as a strategy to avoid seasonal periods of low temperature, often initiated by photoperiod; applied to vegetation adapted to seasonal cold season influences (temperate).

Colluvium—Unconsolidated surface materials that have been transported downslope and deposited on the lower slopes. Colluvium is moved by landslides, flow slides, talus rubble, rock-glaciers, solifluction and unconsolidated runoff.

Creeping—Describes the pattern of stems growing at or just beneath the surface of the ground and usually producing roots at nodes.

Crustose lichen—Lichen life form that grows in intimate contact with its substrate, lacks a lower cortex and rhizoids (root-like structures), and is impossible to separate from the substrate without destroying the thallus; lichen with an unlobed, flattened thallus, growing adnate (joined) to the substrate.

Cushion plant—A low, woody, plant life form so densely branched that it forms a compact canopy that is pad- or bolster-like in appearance; usually with microphyllous foliage; characteristic of alpine and tundra plants.

Deciduous—Describes a woody plant that seasonally loses all of its leaves and becomes temporarily bare-stemmed.

Digital image processing—computer manipulation of the digital-number values of an image.

Digital image—an image where the property being measured has been converted from a continuous range of analogue values to a range expressed by a finite number of integers, usually recorded as binary codes from 0 to 255, or as one byte.

Dominant—An organism, group of organisms, or taxon that by its size, abundance, or coverage exerts considerable influence upon an association's biotic (such as structure and function) and abiotic (such as shade and relative humidity) conditions.

Dwarf shrub—Shrub life form growing less than 0.2 meters tall.

Ecoregions—Landscape units defined based on similar patterns in potential natural communities, soils, hydrologic function, landform, topography, lithology, climate, and natural processes such as nutrient cycling, productivity, succession, and natural disturbance regimes associated with flooding, wind, or fire. Climate, as modified by topography, is the dominant criterion at the scale mapped for Denali.

Eolian—Wind blown sand and silt deposits.

Ephemeral forb vegetation—Annual vegetation that, during favorable periods, dominate areas that are usually sparsely vegetated or unvegetated for most of the year.

Epiphyte—Vascular plant that grows by germinating and rooting on other plants or other perched structures; sometimes called "air plants."

Evergreen—Describes a plant that has green leaves all year round.

Field verification area—An area sampled during the field season composed of multiple polygons.

Floodplain—A fluvial plain formed by non-glacial fed rivers.

Foliose lichen—Lichen life form that is leafy in appearance and loosely attached to its substrate; lichen with a lobed, flattened thallus growing loosely attached to the substrate, the lobes are flattened or inflated with distinctly differentiated upper and lower surfaces; umbilicate lichens are included.

Forb—A broad-leaved herbaceous plant.

Fresh water—Water with a salinity of less than 0.5 parts per thousand.

Frost boils—Areas of bare soil that are sufficiently disturbed by frost action to prevent plant colonization. On slopes, fine material in unsorted circles moves slowly downslope producing banked or "stepped" frost boils (from Gabriel and Talbot. 1984).

Frost Scar—Exposed bare mineral soil formed by frost action in the soil.

Fruticose lichen—Lichen life form that is bunched, shrubby or "hairy" in appearance and loosely attached to its substrate; lichen with the thallus branched, the branches solid, or hollow and round, or flattened without distinctly differentiated upper and lower surfaces; squamulose lichens are included.

Geographic Information System (GIS)—A data-handling and analysis system based on sets of data distributed spatially in two dimensions. The data sets may be map oriented, when they comprise qualitative attributes of an area recorded as lines, points, and areas often in vector format, or image oriented, when the data are quantitative attributes referring to cells in a rectangular grid usually in raster format. It is also known as a geobased or geocoded information system.

Geomorphic process—Refers to the mechanical transport of organic and inorganic material such as mass movement, surface erosion, the transport of material (silt) by water, and biogenic soil movement by root throw and animals.

Glacial drift—The material transported by a glacier and then deposited either directly from the ice or from the melt water. Numerous types of glacial drift occur including moraines, kettle-kame topography, eskers, drumlins, glacial till and outwash.

Glacial outwash—Fluvial plains formed when glacially fed rivers deposit their sediment in stream channels and the associated plain. Due to continual channel shifting the sediment is spread across an area called an outwash plain. Outwash plains typically have braided rivers consisting of multiple, wide, shallow channels characterized by rapid erosion, deposition and channel shifts.

Glacial till—A surface formed by sediment originating directly from glacial ice and typically has no discernible sediment stratification.

Global Positioning System (GPS)—The GPS is a worldwide satellite navigation system that is funded and supervised by the U.S. Department of Defense. GPS satellites transmit specially coded signals. These signals are processed by a GPS receiver that computes extremely accurate measurements, including 3-dimensional position, velocity, and time on a continuous basis.

Graminoid—Grasses and grass-like plants, including sedges and rushes.

Grassland—Vegetation dominated by perennial graminoid plants.

Ground layer—Applies to the herbaceous layer.

Growth form—The shape or appearance of a plant; it primarily reflects the influence of growing conditions.

Herbaceous—A vascular plant without significant woody tissue above or at the ground; an annual, biennial, or perennial plant lacking significant thickening by secondary woody growth, with perennating buds borne at or below the ground surface (hemicryophytes, geophytes, helophytes, and therophytes of Raunkier).

Ice wedge polygons—Refers to patterned ground with polygons typically connected in a polygonal pattern that is similar to the pattern produced by mud cracks. They are formed by large masses of ice—called ice wedges—that grow in thermal contraction cracks in permafrost.

Image—pictorial representation of a scene recorded by a remote sensing system. Although image is a general term, it is commonly restricted to representations acquired by non-photographic methods.

Interpretation—The process in which a person extracts information from an image.

Infra Red (IR) color photograph—Color photograph in which the red-imaging layer is sensitive to photographic IR wavelengths, the green-imaging layer is sensitive to red light, and the blue-imaging layer is sensitive to green light. Also known as camouflage detection photographs and false-color photographs.

Krumholtz—Growth form assumed by tree species at the upper treeline or in the alpine zone; characterized by a creeping and multi-stemmed growth pattern due to desiccation and physical damage caused by wind and blowing ice crystals near the upper treeline; the same species grows as an erect, single-stemmed tree at lower elevation.

Lacustrine deposits—derived from materials deposited in lake water and exposed when the water level is lowered or the land is raised.

Landsat (formerly ERTS)—The Landsat program, first known as the Earth Resources Technology Satellite (ERTS) Program, is a development of the National Aeronautics and Space Administration (NASA) in association with NOAA, USGS, and Space Imaging. The activities of these combined groups led to the concept of dedicated Earth-orbiting satellites, the defining of spectral and spatial requirements for their instruments, and the fostering of research to determine the best means of extracting and using information from the data. The first satellite, ERTS 1, was launched on July 23, 1972. The second satellite was launched on January 22, 1975. Concurrently, the name of the satellites and program was changed to emphasize its prime area of interest (land resources). The first two satellites were designated as Landsats 1 and 2. Landsat 3 was launched on March 5, 1978. Landsat 4 was launched on July 16,

1982. Landsat 5 (launched March 1, 1984) is currently in service providing selected data to worldwide researchers.

Lichen—An organism generally recognized as a single plant that consists of a fungus and an alga or cyanobacterium living in symbiotic association.

Life form—The shape or appearance of a plant that mostly reflects inherited or genetic influences.

Low shrub—Low-growing shrub life form between 0.1 and 1 meter tall.

Matted—Describes a creeping plant that by reiterative growth has overlapping stems and forms a low, dense ground cover.

Mesic—Sites are moist and tussocks may dominate. Permanent standing water is not present.

Mixed forest—Describes vegetation in which evergreen and deciduous species each generally contribute 25-75% to the total canopy cover.

Montane—Describes the zone in mountainous regions where the influence of altitude (vertical relief) results in local climatic regimes that are sufficiently different from those in the adjacent lowlands as to cause a complex vertical climate-vegetation-soil zonation; includes vegetation at the base of a mountain when it is different from lowland vegetation.

Mosaic—Composite image or photograph made by piecing together individual images or photographs covering adjacent areas.

Nonvascular plant—A plant without specialized water or fluid conductive tissue (xylem and phloem); includes bryophytes, lichens, and algae.

Patterned ground—Refers to regions with perennially frozen ground that often have their surface materials arranged into distinct geometric shapes. The features, collectively known as patterned ground, include polygons, nets, circles and stripes.

Pavement—A relatively flat surface of consolidated material, generally exposed bedrock.

Perennial—Plant species with a life-cycle that characteristically lasts more than two growing seasons and persists for several years.

Pingo—These are ice-filled conical hills or mounds, 20 to 400 meters in diameter and 10 to 70 meters high.

Pixel—The term for a processed signal of a remotely sensed area of ground. Contraction of picture element.

Plant association—The finest level of both the Viereck et al. (1992) and National Vegetation Classification System (Grossman et al. 1998) classifications. It is defined as "a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (Flahault and Schroter 1910).

Pulvinate mosses—Mosses growing in cushion-like mats or clumps.

Remote sensing—Collection and interpretation of information about an object without being in physical contact with the object.

Resolution—Ability to separate closely spaced objects on an image or photograph. Resolution is commonly expressed as the most closely spaced line-pairs per unit distance that can be distinguished. Also called spatial resolution.

Rock glacier—Tongue-shaped or lobate masses of unsorted, angular frost-rived material with interstitial ice. They typically originate in cirques or in high, steep-walled recesses.

Saltwater—Water with a salinity of greater than 30 parts per thousand.

Satellite—An object in orbit around a celestial body.

Scene—Area on the ground that is covered by an image or photograph.

Scree—A sheet of coarse rock debris covering a mountain slope without an adjacent cliff.

Scrub—Vegetation dominated by shrubs, including thickets.

Seasonal—Showing periodicity related to the seasons; applied to vegetation exhibiting pronounced seasonal periodicity marked by conspicuous physiognomic changes.

Shrub—A perennial woody species that typically has several stems arising from or near the ground.

Solifluction (or gelifluction)—The flow of soil in association with frozen ground. During the spring and summer thaw, water in the active layer cannot penetrate below the permafrost table. Soils are often saturated, and the loss of friction and cohesion causes them to behave like viscous fluids. The soil thus slowly ‘flows.’ The downslope fronts of the solifluction lobes are marked by near-vertical scarps as high as 2 meters.

Sorted circles—Similar to sorted polygons but circular in outline.

Sorted polygons—Refers to patterned ground where sorting separates the coarse from the fine soil particles, and typically produces a surface feature of fine materials bordered by stones in a variety of geometric shapes; polygons, circles, nets and stripes.

Sorted stripes—Refers to patterned ground that consists of linear alignments of soil, vegetation and stones on slopes. Often strips of stone separated by broad zones of finer sediment and vegetation. The strips are up to several meters in width and 100 meters in length.

Sparsely vegetated—Describes vegetation with low total plant cover (between 15 and 25%) that is scattered; areas with high cover of crustose lichen and no other vegetation are included here.

Spectral reflectance—Reflectance of electromagnetic energy at specified wavelength intervals.

Stomata—Pores or openings for gas exchange that are generally concentrated on leaf surfaces.

Subalpine—Upper mountain vegetation immediately below the cold limits of tree and tall shrub growth.

Supervised classification—Digital-information extraction technique in which the operator provides training-site information that the computer uses to assign pixels to categories.

Tall shrub—Tall-growing shrub life form greater than 1 meter tall.

Talus—A sloping accumulation of coarse rock fragments at the base of a cliff.

Temperate—Geographically, the region between the polar and tropical regions; climatically, the region is moderate with distinct seasons of alternating long, warm summers and short, cold winters.

Terraces—Floodplains and outwash plains removed from frequent flooding due to down-cutting of the river.

Texture—Frequency of change and arrangement of tones on an image.

Thematic Data—Thematic data layers in a data set are layers of information that deal with a particular theme. These layers are typically related information that logically go together. Examples of thematic data would include a data layer whose contents are roads, railways, and river navigation routes.

Thematic Mapper (TM)—A cross-track scanner deployed on Landsat that records seven bands of data from the visible through the thermal IR regions.

Thermokarst—Refers to the collapse of the soil surface due to the thawing of ice rich permafrost, resulting in ponds and hills.

TM—Thematic mapper.

Topographic Map—Map that presents the horizontal and vertical positions of the features represented; distinguished from a planimetric map by the addition of relief in measurable form.

Topography—Configuration (relief) of the land surface; the graphic delineation or portrayal of that configuration in map form, as by contour lines; in oceanography the term is applied to a surface such as the sea bottom or a surface of given characteristics within the water mass.

Training area—A sample of the Earth's surface with known properties; the statistics of the imaged data within the area are used to determine decision boundaries in classification.

Training site—Area of terrain with known properties or characteristics that is used in supervised classification.

Treeline—A zone where the normal growth of trees is limited; cold temperatures often combined with drought form the upper or arctic treeline, and drought combined with hot temperatures form lower or arid treeline.

Tundra—The treeless region north of the Arctic Circle (arctic tundra) or above the treeline of high mountains (alpine tundra) and on some sub-Antarctic islands; characterized by very low winter temperatures, short cool summers, permafrost below a surface layer subject to summer melt, short growing season, and low precipitation.

Tussock—Graminoid life form consisting of bunch-like tufts, sometimes more than 1 meter or 3 feet tall, in which the hard, old, withered leaves are intermingled with the fresh, young, green leaves.

Understory—General term that in these descriptions applies to the shrub and herbaceous layers of a vegetation type, as well as the tree regeneration layer. We have tried to use "shrub layer" or "herbaceous layer" in most cases, but understory is used in some places. "Undergrowth" is the more specific term used for shrub and herbaceous layers in forests or woodland vegetation types, and has been little used in these descriptions.

Unsupervised classification—Digital information extraction technique in which the computer assigns pixels to categories with no instructions from the operator.

Vascular plant—Plant with water and fluid conductive tissue (xylem and phloem); includes seed plants, ferns, and fern allies.

Wet—Refers to sites where the dominant vegetation is emergent—not submerged or floating—and semi-permanent or standing water is present.

Woody plant—Plant species life form with woody tissue and buds on that woody tissue near or at the ground surface or above; plants with limited to extensive thickening by secondary woody growth and with perennating buds; includes phanerophytes and chamaephytes of Raunkier.

Woody—Containing lignified plant tissue.

Xeromorphic—Describes plants with morphological and physiological characters that tolerate persistently low water availability, such as succulence, specialized leaf surfaces for light reflectance or water retention, opportunistic leaf growth, leaf-size reduction with increased thickness and sunken stomata, revolute margins, or stem and leaf modification to form thorns or spines.

Appendix 1. Descriptions of some of the major landscapes that influence landcover in Denali National Park and Preserve.

The following are some of the major landscapes that often influence landcover in Denali National Park and Preserve. Landscape units are considered in developing the classification system because some units strongly affect the distribution and pattern of landcover on a time and space scale pertinent to the products being produced. For example, the floodplain landscape strongly influences the type of vegetation and the pattern of landcover classes on floodplains, and exist at a spatial scale that can be recognized using Landsat imagery. This is not to imply that all landscape units delineated strongly influence or reflect vegetation distribution.

BEDROCK

Bedrock occurs at higher elevations and includes all the jagged rocky ridges, peaks, cirque headwalls and cirque basins in Denali (Figure 6). Bedrock has little or no soil development, and colluvium, alluvial fans and glacial drift all occur downslope. Glaciation has shaped and exposed the bedrock. Frost action and weathering continue to fracture rock, causing continued rock fall and erosional landforms such as altoplanation terraces (mountain terraces), scarps, cliffs, and tors. Most precipitation runs off the surface because of shallow soils or a lack of soils, and relatively steep slopes.

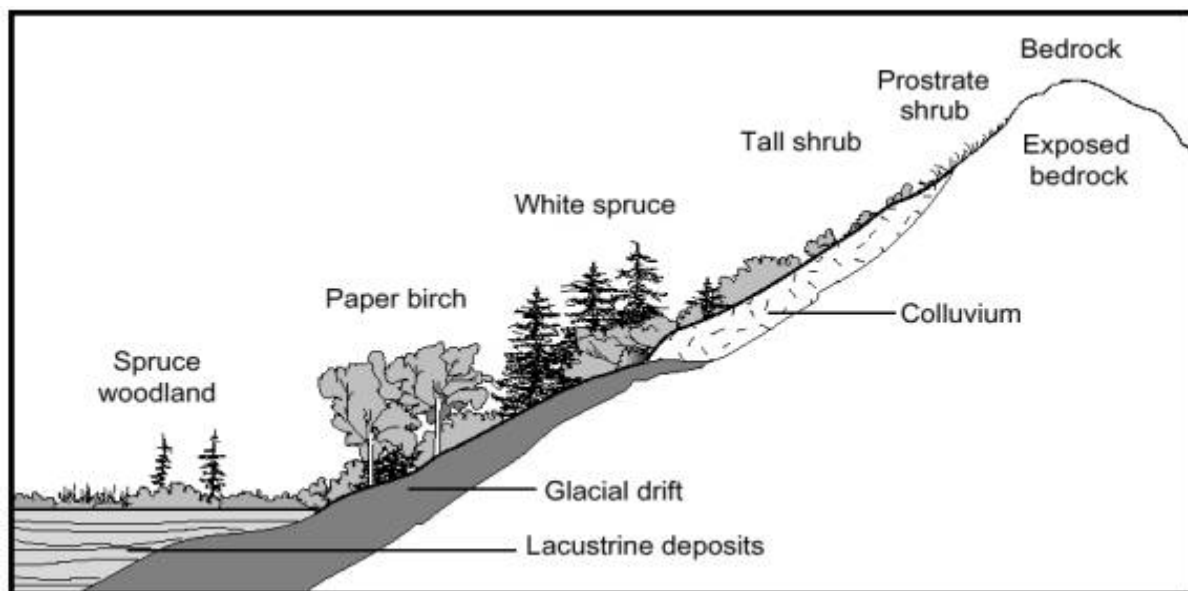


Figure 6. Idealized cross-section of a mountain valley in Denali National Park and Preserve showing various surficial geology deposits and landcover types.

Vegetation on bedrock is generally absent in the higher elevations or is sparse due to the harsh climatic conditions, and shallow or no soils. On stable areas the vegetation often forms continuous mats of low growing vegetation (lichen, prostrate shrub), and, moving downslope, shrubs and trees occur.

COLLUVIUM

Colluvial deposits are unconsolidated surface materials that have been transported downslope and deposited on the lower slopes (Figure 6). Colluvium is moved by landslides, flow slides, talus rubble, rock-glaciers, solifluction and unconsolidated runoff; solifluction is described below.

Solifluction

Solifluction (or gelifluction) is the flow of soil in association with frozen ground, and is a type of colluvium (Ritter 1986; Figure 7). During the spring and summer thaw, water in the active layer cannot penetrate below the permafrost table. Soils are often saturated, and the loss of friction and cohesion causes them to behave like viscous fluids. The soil thus slowly ‘flows.’ The downslope fronts of the solifluction lobes are marked by near-vertical scarps as high as 1.8 meters. This form of mass wasting commonly occurs on slopes between 5 and 20%. Steeper slopes tend to drain off excess water. Silty soils are the most susceptible to solifluction, whereas gravelly and sandy soils are so permeable and easily drained that they rarely flow. Solifluction commonly occurs on various colluvial and glacial drift deposits.

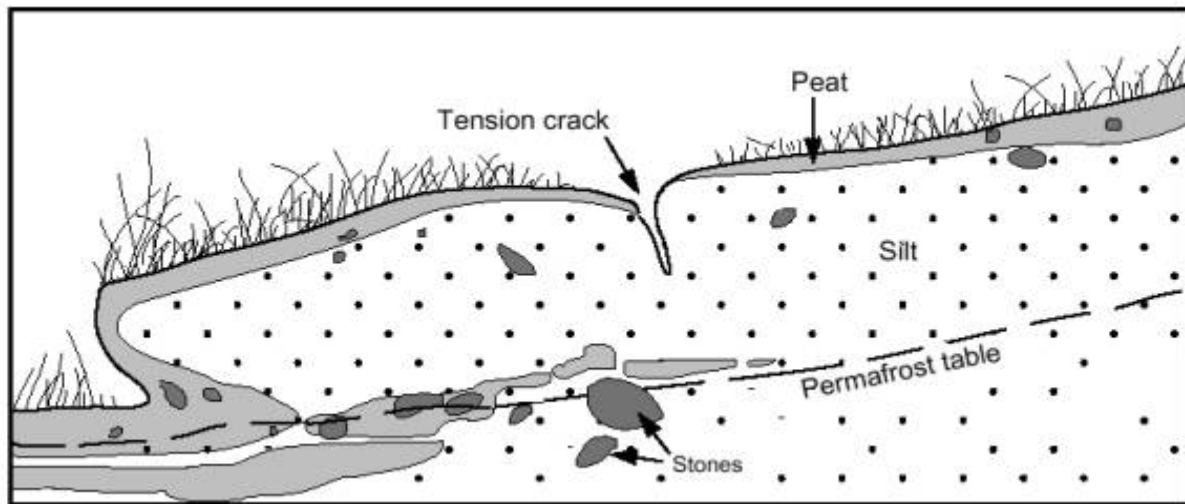


Figure 7. Idealized cross-section of a solifluction lobe.

ALLUVIAL FAN

Alluvial fans are common throughout the mountainous ecoregion of Denali. Alluvial fans are an erosional-depositional system in which rock and sediment are transported down-valley and deposited where it emerges from the confines of a narrow valley into a larger valley or plain. They tend to be fan-shaped in plan view; a segment of a cone radiating away from a single point source. The point of deposition can shift away from the mountain front to well down the original fan surface if the stream has become entrenched. The stream emerges down-fan and deposits its material forming a new fan on top of the older deposits. On an alluvial fan, some areas are actively forming whereas other areas are inactive.

Fan morphology is relatively consistent. The slope of an alluvial fan decreases as you move down fan. Near the mountain front, fans are relatively steep although rarely exceeding 10% (Ritter 1986). They gradually flatten at their lower extremity. The steepest gradients are usually associated with coarse-grained materials. The presence of boulders strewn across fan surfaces suggests periodic slush flow activity.

Vegetation on fans reflects the differences in active versus inactive fan areas, and different vegetation successional stages are evident. Disturbance species—such as willows (*Salix* species) and alder (*Alnus* species)—prefer the active areas, just as they colonize recently deposited floodplain materials. The inactive older deposits tend to reflect the vegetation found on stable surfaces adjacent to the fans such as on colluvium and glacial drift.

GLACIAL DRIFT

This landscape type is somewhat of an agglomeration of different deposits that dominate the valley bottoms and mountain sideslopes (Figure 6). Glacial drift is defined as material transported by a glacier and then deposited either directly from the ice or from the melt water. In Denali, these deposits are predominantly of late Pleistocene age. Numerous types of glacial drift occur including moraines, kettle-kame topography, eskers, drumlins, glacial till and outwash. Glacial till is the dominant feature and is formed by sediment originating directly from glacial ice and typically has no discernible sediment stratification. Inactive glacial outwash is included—active outwash is placed in the floodplain landscape unit.

Various processes and other landscape types occur on the glacial drift type. These include thermokarst, frost scarring, polygonal ground and pingos. Alluvial fans and colluvial slopes often cover glacial drift, and glacial drift is subjected to solifluction—a type of colluvial process. Rivers can also rework glacial deposits forming floodplains.

TERRACES

Terraces are floodplains and outwash plains that have been horizontally and vertically removed from the regular flooding of a river. The ultimate cause of this removal from the river's influence is down-cutting by the river. These surfaces are typically gravel and sandy gravel, capped by floodplain deposits of silt, sand, or peat up to 0.9 to 1.8 meters thick. Older surfaces may be also covered by thicker eolian silt, peatland, and thaw-lake deposits.

SAND-SILT DEPOSITS

Sand and silt deposits occur in a variety of forms within Denali, and a few examples follow. Some silt and sand is deposited initially by slow-moving streams within basins partly dammed by end moraines. These deposits commonly grade downward into lacustrine deposits and are often dissected by postglacial streams. Other sand-silt deposits are formed by loess, and now are poorly stratified sandy silt, organic silt, and silty peat. Abundant ice often occurs in the form of lenses, wedges, and interstitial grains. Another example is upland silt deposits formed from loess and the layers are subsequently mixed by frost action with local organic matter and weathering products (Hamilton, 1999).

LACUSTRINE DEPOSITS

Lacustrine deposits occupy the valley bottoms, as do glacial drift and floodplains (Figure 6). This deposit is derived from materials deposited in lake water and exposed when the water level is lowered or the land is raised. Lacustrine deposits have a high percentage of thermokarst formed lakes.

FLOODPLAINS

Floodplains are composed of glacial and non-glacial rivers, sandbars and low terraces that are still actively flooded (Figure 8). The soils include both poorly-drained permafrost rich soils, lake silts and clays, and well-drained alluvial loams, sands and gravels.

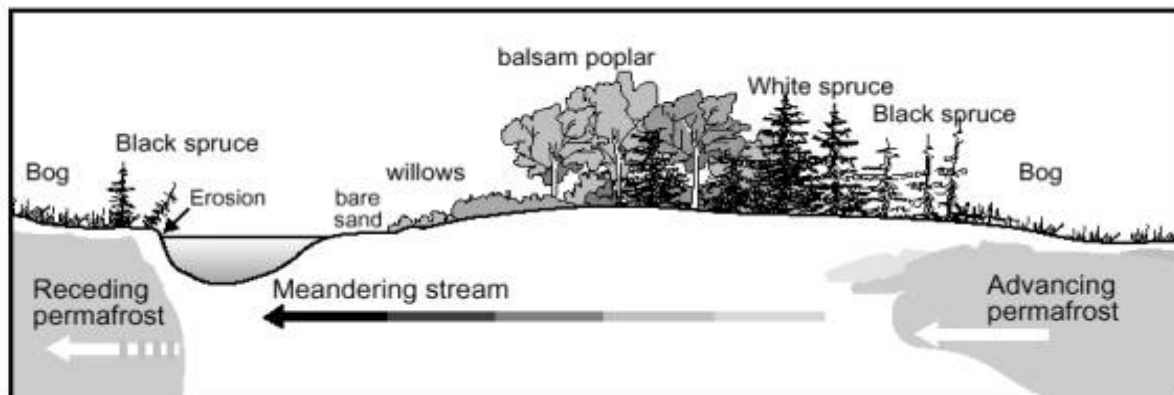


Figure 8. Idealized cross-section of geomorphic and vegetation succession on a floodplain (adapted from Krieg and Reger 1982).

Active glacial outwash plain is included in this section due to its similarity to floodplains—inactive glacial outwash is included in the glacial drift description. Glacial outwash forms when glacially fed rivers deposit their sediment in stream channels and the associated plain. Due to continual channel shifting the sediment is spread across an area called an outwash plain. Outwash plains typically have braided rivers consisting of multiple, wide, shallow channels characterized by rapid erosion, deposition and channel shifts. Outwash plains are common in Denali.

Floodplains are formed by non-glacial fed rivers. In Denali, they often rework lacustrine and glacial drift deposits. The formation of new land on floodplains is well documented. Along a meandering river—meandering rivers have one or two main channels—alluvium is deposited on convex curves in the river channel. The opposing concave bank is cut, providing sediment for deposition on convex curves downstream and creating a series of similar bands of alluvial deposits. The channel thus meanders laterally across the floodplain. Vegetation growing on new deposits near the river may be contrasted with that on older deposits inland to recognize and measure successional processes.

ORGANIC DEPOSITS

Organic deposits (i.e., peatlands, muskeg, bogs, fens) are composed of three to 1.8 meters of accumulated peat in areas of restricted drainage with water tables at or close to the peat surface. Organic deposits are generally found adjacent to forested areas in Denali. They occupy former lake basins and other closed depressions, alluvium along some valley floors, and are abundant on older glacial drift deposits within the boreal forest.

The gradient of nutrient availability and water sources for organic deposits is typically divided into nutrient rich (fen) and nutrient poor (bog) peatlands. Fens are wetlands with wet organic soils, dominated by aquatic, emergent, and dwarf shrubs, or raised peat dominated by shrubs and trees. Ground water, the primary water source in a fen, is nutrient rich because of its contact with mineral soils. Waters may be acidic or basic, but typically with a pH above 4.7. Water is lost through evapotranspiration, seepage (infiltration through the soil), and surface outflow.

Bogs are wetlands with organic soils, typically dominated by *Sphagnum* (peat moss) species, sedges, grasses, or reeds. Bogs require depressions (ponds) in level areas where precipitation exceeds evapotranspiration. Precipitation is the primary water source in a bog, with little or no ground-water flow. Consequently the sites are nutrient-poor and acidic, commonly with a pH less than 4.7. The water

table is at or close to the surface most of the year. Because of the continuum of site and vegetation change within a peatland, it is often difficult to clearly separate a fen from a bog in the field.

In level areas, bogs and fens generally exhibit recognizable and consistent vegetation zonation patterns that are directly associated with different water depths. The vegetation, on a wet to dry moisture gradient, typically changes from aquatic (pond), to emergent, to mesic herbaceous, to carr (shrub-dominated wetland), to dwarf tree. Not all the vegetation zones are always expressed, and the zonation may change abruptly, such as from a pond to a carr. Fens on ground with a slight gradient and with heavy subsurface and surface waterflow often develop a patterned ground of vegetated ridges, and vegetated or unvegetated hollows filled with water.

PINGO

Pingos are uncommon in Denali. They are ice-filled conical hills or mounds, 20 to 400 meters in diameter and 10 to 70 meters high. Closed-system pingos form in nearly level areas when unfrozen ground water migrates under hydrostatic pressure to a site where the permafrost is domed up to form a mound. An open-system type is generally smaller and forms on sloping ground where water beneath or within the permafrost penetrates the permafrost under high hydraulic pressure, which heaves the overlying material to form a mound. Radiometric dating indicates that most pingos in Alaska are less than 4,000 to 7,000 years old, however, many are less than 1,000 and even 100 years old.

PATTERNED GROUND

Patterned ground is found predominantly on the north side of the Alaska Range in Denali. Regions with perennially frozen ground often have their surface materials arranged into distinct geometric shapes. The features, collectively known as patterned ground, include polygons, nets, circles and stripes (Washburn 1956). In general, the geometric pattern changes with increasing slope from polygons and circles on level ground, to nets and then stripes on steeper surfaces. Whether the geometric shape is formed by sorting or not has an effect on the type and size of patterned ground and its vegetation (Ritter 1986). Two types of patterned ground are described below: sorted polygons and ice wedge polygons.

Sorted Polygons

For sorted polygons, sorting separates the coarse from the fine soil particles, and typically produces a surface feature of fine materials bordered by stones in a variety of geometric shapes; polygons, circles, nets and stripes. Sorted polygons are bounded by straight segments composed of stones that surround a central core of finer material. They range up to 10 meters in diameter. One general theory behind the formation of sorted polygons is that soil heaving separates the coarse and fine sediments, and repeated freezing and thawing moves the stones upward and outward. The smaller grains with greater cohesion contract farther inward and downward during thawing. The process continues until the adjacent polygons meet. The coarse materials form circular or polygonal rims with finer materials in the center (Ballard 1973).

Sorted Circles

Sorted circles are similar to sorted polygons but circular in outline. Sorted stripes are linear alignments of soil, vegetation and stones on slopes. They are strips of stone separated by broad zones of finer sediment and vegetation. The strips are up to several meters in width and 100 meters in length. Sorted polygons and circles occur on glacial drift, rounded foothills and on mountain slopes.

Ice Wedge Polygons

Ice wedge polygons are typically connected in a polygonal pattern that is similar to the pattern produced by mud cracks. They are formed by large masses of ice—called ice wedges—that grow in thermal

contraction cracks in permafrost. Thermal tension on the ground surface leads to frost fractures only millimeters wide that penetrate the active layer and permafrost. The ground cracking typically occurs in winter when ground temperatures reach their annual minimum. In spring, water from melting snow freezes in these cracks and produces a vertical vein of ice. During the summer months the permafrost warms and horizontal compression caused by re-expansion of the permafrost results in the upturning of permafrost, forming elevated perimeters of the polygon. In winter, renewed thermal tension reopens the vertical crack that is presumed to be a zone of weakness. Another sliver of ice is added when the spring melt water enters the renewed crack and freezes. Over the centuries, these incremental cracks produce ice wedges that may be 2 meters wide at the top. Troughs often form the boundaries between polygons and generally indicate ice wedges that are 1 to 2 meters wide at the top. The diameter of ice wedge polygons ranges from several to more than 30 meters.

THERMOKARST

Thermokarst is found predominantly on the north side of the Alaska Range in Denali. It is the collapse of the soil surface due to the thawing of ice rich permafrost. The ground around thermokarst is supersaturated—often with ice lenses and layers—because it contains more water in the solid state than the ground could possibly hold if the water is in the liquid state. The melting of ground ice is due to either vertical soil degradation when the surface thermal properties are altered, or lateral degradation such as where lake water laterally erodes its banks, including ground ice. Many of the processes that lead to thermokarst are initiated by broad climate changes, but minor events such as fires, clearing of forest vegetation, shifting stream channels, and removal of the peat surface will upset the thermal balance and produce thermokarst.

Thermokarst is a common feature in areas with low relief and level land such as in mountain valleys and the regions north of the Alaska Range. It occurs on a variety of landscape deposits—sand, lacustrine, glacial drift, and floodplain—throughout Denali.

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1999 DENALI LANDCOVER MAPPING PROJECT; FVA "FLY-OVER" DATA FORM

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Appendix 4. The following tables list the constancy, range in cover, average cover and average height of all species that occur in plant associations that were defined using the 1999 field data. The plant associations are listed in alphabetical order. Constancy is the percentage of sample plots on which the species occurs across all plots sampled for the plant association. Average cover is calculated based on the sample plots on which the species occurs. For example, if a plant occurs on two out of ten sample plots within a plant association, and the cover of that species is 50 percent and 70 percent on the plots, cover equals 60 percent (i.e., $50+70/2 = 60$) and constancy equals 20 percent (i.e., $100 \times 2/10 = 20$). The range in cover is based on the sample plots on which the species occurs.

***Alnus crispa* plant association** Number of plots = 5

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)				
<i>Alnus crispa</i>	100	90 -- 100	97	2.8
Shrub Low (>0.2m and <1.5m)				
<i>Ribes triste</i>	60	1 -- 20	7	0.2
<i>Rosa acicularis</i>	40	1 -- 2	1	0.3
<i>Spiraea beauverdiana</i>	20	1 -- 1	1	0.2
Shrub Dwarf (<0.2m)				
<i>Cornus canadensis</i>	20	1 -- 1	1	0.1
<i>Dryas octopetala</i>	20	1 -- 1	1	--
<i>Linnaea borealis</i>	40	1 -- 5	3	0.0
<i>Rubus arcticus</i>	20	1 -- 1	1	0.1
<i>Rubus idaeus</i>	20	1 -- 1	1	0.2
Graminoid				
<i>Calamagrostis canadensis</i>	20	15 -- 15	15	0.3
Forb				
<i>Aconitum delphiniifolium</i>	20	1 -- 1	1	0.3
<i>Artemisia arctica</i>	40	1 -- 1	1	--
<i>Aster sibiricus</i>	20	--	--	--
<i>Boykinia richardsonii</i>	20	5 -- 5	5	--
<i>Equisetum sylvaticum</i>	40	5 -- 10	8	0.2
<i>Lycopodium annotinum</i>	20	1 -- 1	1	--
<i>Mertensia paniculata</i>	20	1 -- 1	1	0.2
Moss				
<i>Hylocomium splendens</i>	20	10 -- 10	10	--
bryophytes-mosses and liverworts	40	5 -- 10	8	--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	80	80 -- 99	90	--

***Alnus crispa*/Calamagrostis canadensis plant association**

Number of plots = 4

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea glauca</i>	50	1 -- 3	2	0.9
<i>Populus balsamifera</i>	75	1 -- 5	2	2.2
Shrub Tall (>1.5m)				
<i>Alnus crispa</i>	100	50 -- 90	75	2.6
<i>Salix alaxensis</i>	50	20 -- 25	23	2.3
Shrub Low (>0.2m and <1.5m)				
<i>Potentilla fruticosa</i>	25	1 -- 1	1	0.6
<i>Ribes triste</i>	25	1 -- 1	1	0.3
<i>Rosa acicularis</i>	25	2 -- 2	2	--
<i>Salix lanata</i>	25	10 -- 10	10	1.2
<i>Salix</i>	25	5 -- 5	5	--
<i>Spiraea</i>	25	5 -- 5	5	0.6
Shrub Dwarf (<0.2m)				
<i>Cornus suecica</i>	25	--		--
<i>Linnaea borealis</i>	25	--		--
Graminoid				
<i>Arctagrostis latifolia</i>	25	1 -- 1	1	--
<i>Carex bigelowii</i>	25	1 -- 1	1	--
<i>Calamagrostis canadensis</i>	100	20 -- 75	51	0.8
Moss				
bryophytes-mosses and liverworts	50	5 -- 10	8	--
<i>Ptilium</i>	25	--		--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	75	70 -- 90	83	--
mineral-surface rock fragments	25	20 -- 20	20	--

***Alnus crispa*/Ericaceous shrub plant association**

Number of plots = 4

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea glauca</i>	25	1 -- 1	1	0.6
<i>Picea mariana</i>	25	1 -- 1	1	3.0
Shrub Tall (>1.5m)				
<i>Alnus crispa</i>	75	40 -- 50	47	2.1
<i>Salix glauca</i>	25	20 -- 20	20	1.8
<i>Salix lanata</i>	25	5 -- 5	5	1.8
Shrub Low (>0.2m and <1.5m)				
<i>Alnus crispa</i>	25	30 -- 30	30	0.6
<i>Betula glandulosa</i>	50	25 -- 50	38	0.9
<i>Betula nana</i>	25	5 -- 5	5	0.3
hybrid <i>Betula</i>	25	1 -- 1	1	1.2
<i>Ledum decumbens</i>	75	1 -- 10	4	--
<i>Ribes triste</i>	25	2 -- 2	2	--
<i>Salix glauca</i>	25	1 -- 1	1	0.6
<i>Salix planifolia</i>	50	1 -- 1	1	0.8
<i>Spiraea beauverdiana</i>	50	1 -- 10	5	0.3
<i>Vaccinium uliginosum</i>	100	10 -- 75	50	0.3
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos alpina</i>	25	10 -- 10	10	--
<i>Arctostaphylos rubra</i>	25	1 -- 1	1	--
<i>Cornus suecica</i>	25	1 -- 1	1	--
<i>Empetrum nigrum</i>	50	5 -- 10	8	0.0
<i>Salix arctica</i>	25	1 -- 1	1	0.1
<i>Vaccinium vitis-idaea</i>	25	5 -- 5	5	--
Graminoid				
<i>Calamagrostis canadensis</i>	75	-- 15	5	--
<i>Carex</i>	25	5 -- 5	5	--
<i>Festuca altaica</i>	25	20 -- 20	20	--
<i>Festuca</i>	25	--	--	--
graminoid group	25	10 -- 10	10	--
<i>Hierochloe alpina</i>	25	--	--	--
<i>Poa alpigena</i>	25	1 -- 1	1	--
Forb				
<i>Artemisia arctica</i>	50	1 -- 1	1	--
<i>Epilobium angustifolium</i>	50	1 -- 1	1	--
<i>Sedum rosea</i>	25	1 -- 1	1	--
Lichen				
<i>lichens</i>	25	5 -- 5	5	--
Moss				
<i>Hylocomium</i>	25	--	--	--
<i>Hylocomium splendens</i>	25	60 -- 60	60	--
bryophytes-mosses and liverworts	75	30 -- 80	57	--
<i>Polytrichum</i>	25	--	--	--
<i>Ptilium</i>	25	--	--	--

Alnus sinuata alliance

Number of plots = 3

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)	33	85 -- 85	85	3.7
<i>Sorbus scopulina</i>				
<i>Alnus sinuata</i>	33	1 -- 1	1	1.8
Shrub Low (>0.2m and <1.5m)				
<i>Alnus sinuata</i>	67	20 -- 50	35	1.2
<i>Salix alaxensis</i>	33	20 -- 20	20	1.2
<i>Salix brachycarpa</i>	33	1 -- 1	1	0.9
<i>Salix lanata</i>	33	10 -- 10	10	1.2
<i>Vaccinium uliginosum</i>	33	40 -- 40	40	--
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos alpina</i>	33	5 -- 5	5	--
<i>Cassiope tetragona</i>	33	1 -- 1	1	--
<i>Dryas</i>	67	1 -- 10	5	--
<i>Rubus arcticus</i>	33	1 -- 1	1	--
<i>Salix arctica</i>	33	10 -- 10	10	--
<i>Salix reticulata</i>	67	20 -- 30	25	--
<i>Vaccinium uliginosum</i>	33	20 -- 20	20	0.1
Graminoid				
<i>Calamagrostis canadensis</i>	33	35 -- 35	35	0.9
<i>Carex membranacea</i>	33	5 -- 5	5	--
<i>Carex podocarpa</i>	33	5 -- 5	5	--
<i>Carex scirpoidea</i>	33	--	--	--
<i>Festuca</i>	33	5 -- 5	5	--
graminoid group	33	1 -- 1	1	--
Forb				
<i>Anemone narcissiflora</i>	33	1 -- 1	1	--
<i>Anemone parviflora</i>	33	1 -- 1	1	--
<i>Artemisia</i>	33	--	--	--
<i>Aster sibiricus</i>	33	1 -- 1	1	--
<i>Athyrium filix-femina</i>	33	65 -- 65	65	0.9
<i>Boykinia richardsonii</i>	67	1 -- 5	3	--
<i>Epilobium angustifolium</i>	33	1 -- 1	1	--
<i>Epilobium latifolium</i>	33	--	--	--
<i>Equisetum pratense</i>	33	60 -- 60	60	--
<i>Gentiana algida</i>	33	1 -- 1	1	--
<i>Geum rossii</i>	33	1 -- 1	1	--
<i>Hedysarum alpinum</i>	33	1 -- 1	1	--
<i>Heracleum lanatum</i>	33	1 -- 1	1	--
<i>Lycopodium</i>	33	1 -- 1	1	--
<i>Mertensia paniculata</i>	33	1 -- 1	1	--
<i>Parnassia kotzebuei</i>	33	1 -- 1	1	--
<i>Papaver</i>	33	--	--	--
<i>Petasites frigidus</i>	33	1 -- 1	1	--
<i>Polygonum bistorta</i>	33	1 -- 1	1	--
<i>Saxifraga hirculus</i>	33	1 -- 1	1	--
<i>Saxifraga hieraciifolia</i>	33	1 -- 1	1	--
<i>Sanguisorba stipulata</i>	33	5 -- 5	5	--
<i>Streptopus amplexifolius</i>	33	1 -- 1	1	--
<i>Valeriana capitata</i>	33	1 -- 1	1	--
Lichen				
<i>Cetraria</i>	33	--	--	--
lichens	33	1 -- 1	1	--
Moss				
bryophytes-mosses and liverworts	67	50 -- 60	55	--

Arctostaphylos alpina plant association Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos alpina</i>	100	25 -- 25	25	--
<i>Cornus canadensis</i>	100	20 -- 20	20	--
<i>Empetrum nigrum</i>	100	20 -- 20	20	--
<i>Linnaea borealis</i>	100	1 -- 1	1	--
<i>Vaccinium uliginosum</i>	100	15 -- 15	15	--
Forb				
<i>Lycopodium annotinum</i>	100	1 -- 1	1	--
Lichen				
<i>Cetraria</i>	100	--		--
<i>Cladina</i>	100	--		--
lichens	100	20 -- 20	20	--

Betula nana/Carex aquatilis plant association Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Larix laricina</i>	100	1 -- 1	1	0.2
<i>Picea mariana</i>	100	1 -- 1	1	--
Shrub Low (>0.2m and <1.5m)				
<i>Betula nana</i>	100	30 -- 30	30	0.3
Shrub Dwarf (<0.2m)				
<i>Andromeda polifolia</i>	100	5 -- 5	5	--
<i>Vaccinium microcarpos</i>	100	1 -- 1	1	--
Graminoid				
<i>Carex aquatilis</i>	100	50 -- 50	50	--
<i>Carex limosa</i>	100	50 -- 50	50	--
Moss				
<i>Sphagnum</i>	100	90 -- 90	90	--
Water				
water	100	10 -- 10	10	--

Betula nana/Eriophorum brachyantherum plant association Number of plots = 3

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)				
<i>Alnus crispa</i>	33	20 -- 20	20	1.5
<i>Salix brachycarpa</i>	33	2 -- 2	2	1.8
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	33	2 -- 2	2	--
<i>Betula nana</i>	67	15 -- 25	20	0.3
<i>Ledum groenlandicum</i>	33	3 -- 3	3	--
<i>Salix brachycarpa</i>	33	10 -- 10	10	0.6
<i>Salix planifolia</i>	67	5 -- 10	8	0.3
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos alpina</i>	33	1 -- 1	1	--
<i>Betula</i>	33	25 -- 25	25	0.2
<i>Empetrum nigrum</i>	33	1 -- 1	1	--
<i>Ledum decumbens</i>	67	20 -- 25	23	0.2
<i>Vaccinium uliginosum</i>	67	10 -- 15	13	0.2
<i>Vaccinium vitis-idaea</i>	100	5 -- 10	8	--
Graminoid				
<i>Carex bigelowii</i>	67	20 -- 30	25	--
<i>Carex</i>	33	80 -- 80	80	--
<i>Eriophorum brachyantherum</i>	100	-- 70	43	--
Forb				
<i>Epilobium palustre</i>	33	1 -- 1	1	--
<i>Equisetum sylvaticum</i>	33	10 -- 10	10	--
<i>Petasites frigidus</i>	67	1 -- 2	2	--
Lichen				
lichens	33	1 -- 1	1	--
Moss				
bryophytes-mosses and liverworts	33	25 -- 25	25	--

Betula nana/Eriophorum vaginatum plant association

Number of plots = 4

Strata/Species	Constancy	Range	Cover %		Average Ht (m)
			Average		
Tree Stunted (<7.5m)					
<i>Picea mariana</i>	75	1 -- 5	3		1.4
Shrub Low (>0.2m and <1.5m)					
<i>Betula glandulosa</i>	25	20 -- 20	20		0.6
<i>Betula nana</i>	50	10 -- 40	25		0.6
<i>Ledum decumbens</i>	50	10 -- 35	23		0.2
<i>Vaccinium uliginosum</i>	75	10 -- 10	10		0.3
Shrub Dwarf (<0.2m)					
<i>Betula glandulosa</i>	25	40 -- 40	40		0.1
<i>Empetrum nigrum</i>	100	1 -- 15	8		0.1
<i>Ledum decumbens</i>	50	5 -- 20	13		--
<i>Rubus chamaemorus</i>	75	1 -- 5	4		--
<i>Vaccinium uliginosum</i>	25	20 -- 20	20		--
<i>Vaccinium vitis-idaea</i>	100	1 -- 10	5		0.1
Graminoid					
<i>Carex bigelowii</i>	25	20 -- 20	20		--
<i>Carex micropoda</i>	25	20 -- 20	20		0.3
<i>Carex microchaeta</i>	25	1 -- 1	1		--
<i>Eriophorum vaginatum</i>	100	40 -- 75	63		0.3
Lichen					
<i>Cetraria cucullata</i>	25	--			--
lichens	75	5 -- 20	10		--
<i>Stereocaulon</i>	25	--			--
Moss					
<i>Hylocomium splendens</i>	25	30 -- 30	30		--
bryophytes-mosses and liverworts	75	25 -- 60	38		--
<i>Polytrichum</i>	25	--			--
<i>Sphagnum</i>	50	--			--

Calamagrostis canadensis plant association Number of plots = 8

Strata/Species	Constancy	Range	Cover %		Average Ht (m)
			Average		
Tree Stunted (<7.5m)					
<i>Betula papyrifera</i>	13	1 -- 1	1		1.8
<i>Larix laricina</i>	13	2 -- 2	2		3.7
<i>Picea glauca</i>	13	2 -- 2	2		3.0
Shrub Tall (>1.5m)					
<i>Alnus tenuifolia</i>	13	2 -- 2	2		4.6
<i>Salix arbusculoides</i>	13	20 -- 20	20		1.8
Shrub Low (>0.2m and <1.5m)					
<i>Betula glandulosa</i>	25	1 -- 5	3		0.8
<i>Myrica gale</i>	13	20 -- 20	20		0.6
<i>Salix planifolia</i>	13	1 -- 1	1		0.9
<i>Spiraea beauverdiana</i>	13	1 -- 1	1		--
<i>Vaccinium uliginosum</i>	13	10 -- 10	10		--
Graminoid					
<i>Carex aquatilis</i>	13	10 -- 10	10		--
<i>Calamagrostis canadensis</i>	100	50 -- 100	83		1.2
<i>Carex</i>	25	1 -- 40	20		--
Forb					
<i>Athyrium filix-femina</i>	13	10 -- 10	10		0.9
<i>Epilobium latifolium</i>	13	5 -- 5	5		0.9
<i>Potentilla palustris</i>	38	1 -- 10	4		--
<i>Veratrum viride</i>	13	5 -- 5	5		0.3
Moss					
<i>Hylocomium splendens</i>	13	3 -- 3	3		--
bryophytes-mosses and liverworts	13	10 -- 10	10		--
Barren					
litter-herbaceous, mulch, and woody debris <2.5 cm	75	90 -- 100	95		--
Water					
water	13	10 -- 10	10		--

Calamagrostis canadensis-Mixed herbaceous plant association Number of plots = 7

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)				
<i>Alnus sinuata</i>	14	20 -- 20	20	3.7
Shrub Low (>0.2m and <1.5m)				
<i>Betula nana</i>	14	1 -- 1	1	--
<i>Potentilla fruticosa</i>	14	1 -- 1	1	--
<i>Salix barclayi</i>	14	5 -- 5	5	1.2
<i>Salix planifolia</i>	14	10 -- 10	10	1.2
<i>Spiraea beauverdiana</i>	71	1 -- 20	5	0.5
<i>Vaccinium uliginosum</i>	29	1 -- 5	3	0.5
Shrub Dwarf (<0.2m)				
<i>Cornus canadensis</i>	14	20 -- 20	20	0.1
<i>Cornus suecica</i>	14	10 -- 10	10	--
<i>Empetrum nigrum</i>	14	1 -- 1	1	--
<i>Rubus arcticus</i>	14	2 -- 2	2	--
<i>Rubus chamaemorus</i>	14	1 -- 1	1	0.1
<i>Salix reticulata</i>	14	10 -- 10	10	--
Graminoid				
<i>Calamagrostis canadensis</i>	100	10 -- 80	30	0.8
<i>Carex podocarpa</i>	14	10 -- 10	10	--
<i>Carex</i>	14	30 -- 30	30	--
<i>Phleum pratense</i>	29	1 -- 1	1	0.3
<i>Poa</i>	14	10 -- 10	10	--
<i>Trisetum spicatum</i>	14	3 -- 3	3	--
Forb				
<i>Aconitum delphinifolium</i>	43	1 -- 5	2	0.5
<i>Achillea millefolium</i>	14	1 -- 1	1	--
<i>Aconitum</i>	14	1 -- 1	1	--
<i>Angelica lucida</i>	43	2 -- 10	7	--
<i>Anemone narcissiflora</i>	43	1 -- 2	1	0.3
<i>Anemone parviflora</i>	14	1 -- 1	1	--
<i>Armeria arctica</i>	14	1 -- 1	1	0.2
<i>Artemisia arctica</i>	14	1 -- 1	1	--
<i>Athyrium filix-femina</i>	57	1 -- 70	43	0.6
<i>Boykinia richardsonii</i>	14	10 -- 10	10	--
<i>Dryopteris dilatata</i>	14	10 -- 10	10	--
<i>Epilobium angustifolium</i>	71	3 -- 40	20	0.7
<i>Epilobium latifolium</i>	14	10 -- 10	10	--
<i>Equisetum arvense</i>	29	1 -- 10	5	--
<i>Gentiana algida</i>	14	1 -- 1	1	--
<i>Geranium erianthum</i>	43	5 -- 20	12	0.5
<i>Gymnocarpium dryopteris</i>	14	1 -- 1	1	--
<i>Heracleum lanatum</i>	14	10 -- 10	10	--
<i>Mertensia paniculata</i>	14	1 -- 1	1	--
<i>Mertensia</i>	14	5 -- 5	5	--
<i>Petasites frigidus</i>	14	1 -- 1	1	--
<i>Petasites sagittatus</i>	14	10 -- 10	10	--
<i>Sanguisorba stipulata</i>	71	1 -- 15	8	0.3
<i>Sedum rosea</i>	14	1 -- 1	1	--
<i>Senecio triangularis</i>	43	1 -- 10	4	0.8
<i>Solidago multiradiata</i>	14	1 -- 1	1	--
<i>Streptopus amplexifolius</i>	14	1 -- 1	1	0.3
<i>Thelypteris phegopteris</i>	14	80 -- 80	80	0.2
<i>Veratrum viride</i>	14	1 -- 1	1	0.1

Carex aquatilis plant association

Number of plots = 5

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Low (>0.2m and <1.5m)				
<i>Chamaedaphne calyculata</i>	20	1 -- 1	1	--
Shrub Dwarf (<0.2m)				
<i>Vaccinium microcarpos</i>	20	3 -- 3	3	--
Graminoid				
<i>Carex aquatilis</i>	100	60 -- 90	78	0.3
<i>Carex rostrata</i>	20	20 -- 20	20	0.3
Forb				
<i>Potentilla palustris</i>	20	30 -- 30	30	--
Moss				
bryophytes-mosses and liverworts	20	2 -- 2	2	--
<i>Sphagnum girgensohnii</i>	20	90 -- 90	90	--
<i>Sphagnum</i>	20	99 -- 99	99	--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	20	5 -- 5	5	--
mineral-bare soil	20	90 -- 90	90	--
Water				
water	80	5 -- 95	50	--

Carex lasiocarpa plant association Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Graminoid				
<i>Carex lasiocarpa</i>	100	60 -- 60	60	--
<i>Carex</i>	100	1 -- 1	1	--
<i>Carex rostrata</i>	100	10 -- 10	10	--
<i>Eriophorum vaginatum</i>	100	1 -- 1	1	--
Forb				
<i>Drosera rotundifolia</i>	100	1 -- 1	1	--
Water				
water	100	99 -- 99	99	--

Carex rostrata plant association Number of plots = 5

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Graminoid				
<i>Carex aquatilis</i>	20	40 -- 40	40	0.6
<i>Carex rostrata</i>	100	60 -- 90	80	0.5
Forb				
<i>Potentilla palustris</i>	20	1 -- 1	1	--
Moss				
<i>Sphagnum girgensohnii</i>	20	60 -- 60	60	--
Water				
water	60	20 -- 95	52	--

Cassiope tetragona plant association Number of plots = 2

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea glauca</i>	100	-- 1	1	0.5
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos alpina</i>	50	20 -- 20	20	--
<i>Betula nana</i>	50	1 -- 1	1	--
<i>Cassiope tetragona</i>	100	30 -- 40	35	0.0
<i>Diapensia lapponica</i>	50	10 -- 10	10	0.0
<i>Dryas octopetala</i>	50	5 -- 5	5	--
<i>Empetrum nigrum</i>	50	5 -- 5	5	--
<i>Ledum decumbens</i>	100	5 -- 5	5	--
<i>Vaccinium uliginosum</i>	100	5 -- 10	8	0.0
<i>Vaccinium vitis-idaea</i>	100	3 -- 5	4	0.0
Graminoid				
<i>Carex bigelowii</i>	50	10 -- 10	10	--
<i>Carex micropoda</i>	50	10 -- 10	10	--
<i>Hierochloa alpina</i>	50	2 -- 2	2	--
Forb				
<i>Artemisia arctica</i>	50	1 -- 1	1	--
<i>Arabis lemmonii</i>	50	1 -- 1	1	0.0
<i>Campanula lasiocarpa</i>	50	1 -- 1	1	0.0
<i>Lupinus</i>	50	1 -- 1	1	--
Lichen				
<i>Cetraria</i>	50	20 -- 20	20	--
<i>Cladonia rangiferina</i>	50	40 -- 40	40	--
lichens	50	20 -- 20	20	--
Moss				
<i>Hylocomium splendens</i>	50	30 -- 30	30	--
bryophytes-mosses and liverworts	50	10 -- 10	10	--
Barren				
mineral-surface rock fragments	50	10 -- 10	10	--

Chamaedaphne calyculata plant association Number of plots = 2

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea mariana</i>	50	1 -- 1	1	0.3
Shrub Low (>0.2m and <1.5m)				
<i>Chamaedaphne calyculata</i>	100	70 -- 100	85	0.5
<i>Ledum decumbens</i>	50	10 -- 10	10	0.3
<i>Vaccinium uliginosum</i>	50	10 -- 10	10	--
Graminoid				
<i>Carex aquatilis</i>	50	10 -- 10	10	--
Moss				
<i>Sphagnum fuscum</i>	50	50 -- 50	50	--

Eleocharis quinqueflora plant association Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	100	1 -- 1	1	--
Graminoid				
<i>Carex rostrata</i>	100	20 -- 20	20	--
<i>Eleocharis quinqueflora</i>	100	80 -- 80	80	--
Water				
water	100	5 -- 5	5	--

***Epilobium latifolium* plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Forb				
<i>Epilobium latifolium</i>	100	30 -- 30	30	0.2

***Equisetum fluviatile* plant association** Number of plots = 2

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Forb				
<i>Equisetum fluviatile</i>	100	50 -- 50	50	--
<i>Menyanthes trifoliata</i>	50	30 -- 30	30	--
<i>Potentilla palustris</i>	50	30 -- 30	30	--
Moss				
<i>Sphagnum</i>	100	30 -- 95	63	--
Water				
water	50	50 -- 50	50	--

***Eriophorum brachyantherum* plant association** Number of plots = 2

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Dwarf (<0.2m)				
<i>Salix fuscescens</i>	50	40 -- 40	40	0.2
Graminoid				
<i>Eriophorum brachyantherum</i>	100	80 -- 90	85	0.3
Moss				
<i>Sphagnum</i>	50	50 -- 50	50	--
Water				
water	100	10 -- 50	30	--

***Eriophorum vaginatum* plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Graminoid				
<i>Carex rostrata</i>	100	20 -- 20	20	--
<i>Eriophorum vaginatum</i>	100	60 -- 60	60	--
Moss				
bryophytes-mosses and liverworts	100	50 -- 50	50	--
Water				
water	100	50 -- 50	50	--

***Larix laricina* plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Betula papyrifera</i>	100	5 -- 5	5	0.9
<i>Larix laricina</i>	100	30 -- 30	30	3.0
Shrub Low (>0.2m and <1.5m)				
<i>Chamaedaphne calyculata</i>	100	50 -- 50	50	0.6
Forb				
<i>Equisetum fluviatile</i>	100	10 -- 10	10	--
Moss				
<i>Sphagnum</i>	100	50 -- 50	50	--

Menyanthes trifoliata plant association Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Graminoid				
<i>Calamagrostis canadensis</i>	100	1 -- 1	1	--
Forb				
<i>Cicuta mackenzieana</i>	100	2 -- 2	2	--
<i>Equisetum fluviatile</i>	100	10 -- 10	10	--
<i>Menyanthes trifoliata</i>	100	90 -- 90	90	--
<i>Potentilla palustris</i>	100	5 -- 5	5	--

Myrica gale plant association Number of plots = 3

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Low (>0.2m and <1.5m)				
<i>Betula nana</i>	33	10 -- 10	10	1.2
<i>Chamaedaphne calyculata</i>	33	5 -- 5	5	0.3
<i>Ledum groenlandicum</i>	33	3 -- 3	3	--
<i>Myrica gale</i>	100	20 -- 90	53	0.4
<i>Spiraea beauverdiana</i>	33	1 -- 1	1	--
Graminoid				
<i>Carex aquatilis</i>	67	1 -- 20	10	--
<i>Calamagrostis canadensis</i>	67	1 -- 5	3	--
<i>Carex micropoda</i>	33	50 -- 50	50	--
<i>Carex rostrata</i>	33	10 -- 10	10	--
<i>Carex williamsii</i>	33	40 -- 40	40	--
<i>Eleocharis quinqueflora</i>	33	1 -- 1	1	--
<i>Eriophorum angustifolium</i>	33	10 -- 10	10	--
Forb				
<i>Potentilla palustris</i>	33	1 -- 1	1	--
Moss				
<i>Sphagnum fuscum</i>	33	60 -- 60	60	--
<i>Sphagnum girgensohnii</i>	67	40 -- 60	50	--
<i>Sphagnum</i>	33	75 -- 75	75	--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	33	30 -- 30	30	--
Water				
water	33	70 -- 70	70	--

Picea glauca/Salix glauca plant association Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea glauca</i>	100	15 -- 15	15	6.1
Shrub Tall (>1.5m)				
<i>Alnus crispa</i>	100	10 -- 10	10	2.4
Shrub Low (>0.2m and <1.5m)				
<i>Potentilla fruticosa</i>	100	1 -- 1	1	0.3
<i>Salix glauca</i>	100	60 -- 60	60	1.2
<i>Salix lanata</i>	100	10 -- 10	10	1.2
<i>Vaccinium uliginosum</i>	100	1 -- 1	1	--
Graminoid				
<i>Calamagrostis canadensis</i>	100	50 -- 50	50	0.6
Forb				
<i>Gentiana propinqua</i>	100	1 -- 1	1	--
<i>Mertensia paniculata</i>	100	1 -- 1	1	--
<i>Parnassia palustris</i>	100	1 -- 1	1	--
<i>Zigadenus elegans</i>	100	1 -- 1	1	--
unknown-forbs	100	1 -- 1	1	--

***Picea glauca*/Salix lanata plant association**

Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Tall (>7.5m)				
<i>Picea glauca</i>	100	15 -- 15	15	7.6
Shrub Tall (>1.5m)				
<i>Salix alaxensis</i>	100	1 -- 1	1	1.8
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	100	10 -- 10	10	0.6
<i>Potentilla fruticosa</i>	100	10 -- 10	10	1.2
<i>Salix lanata</i>	100	60 -- 60	60	--
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos rubra</i>	100	5 -- 5	5	--
<i>Ledum groenlandicum</i>	100	10 -- 10	10	0.2
<i>Vaccinium uliginosum</i>	100	20 -- 20	20	0.2
Forb				
<i>Equisetum arvense</i>	100	70 -- 70	70	--
Lichen				
lichens	100	10 -- 10	10	--
Moss				
bryophytes-mosses and liverworts	100	80 -- 80	80	--

***Picea glauca*/Salix planifolia plant association**

Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Tall (>7.5m)				
<i>Picea glauca</i>	100	30 -- 30	30	9.1
Shrub Low (>0.2m and <1.5m)				
<i>hybrid Betula</i>	100	1 -- 1	1	0.6
<i>Ribes triste</i>	100	1 -- 1	1	0.6
<i>Salix lanata</i>	100	1 -- 1	1	1.2
<i>Salix planifolia</i>	100	65 -- 65	65	1.2
<i>Vaccinium uliginosum</i>	100	1 -- 1	1	0.3
Shrub Dwarf (<0.2m)				
<i>Cornus canadensis</i>	100	1 -- 1	1	--
<i>Rubus arcticus</i>	100	1 -- 1	1	--
<i>Vaccinium vitis-idaea</i>	100	1 -- 1	1	--
Graminoid				
<i>Calamagrostis canadensis</i>	100	70 -- 70	70	0.9
Forb				
<i>Aconitum delphinifolium</i>	100	1 -- 1	1	--
<i>Epilobium angustifolium</i>	100	1 -- 1	1	--
<i>Equisetum sylvaticum</i>	100	20 -- 20	20	0.3
<i>Mertensia paniculata</i>	100	1 -- 1	1	--
Moss				
<i>Hylocomium splendens</i>	100	--		--
bryophytes-mosses and liverworts	100	20 -- 20	20	--
<i>Ptilium</i>	100	--		--

***Picea mariana*/Betula glandulosa plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea mariana</i>	100	20 -- 20	20	3.7
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	100	40 -- 40	40	0.9
<i>Salix planifolia</i>	100	5 -- 5	5	0.9
<i>Vaccinium uliginosum</i>	100	10 -- 10	10	--
Shrub Dwarf (<0.2m)				
<i>Vaccinium vitis-idaea</i>	100	2 -- 2	2	--
Graminoid				
<i>Carex bigelowii</i>	100	20 -- 20	20	--
<i>Calamagrostis canadensis</i>	100	5 -- 5	5	--
<i>Eriophorum brachyantherum</i>	100	30 -- 30	30	--
Moss				
<i>Hylocomium splendens</i>	100	20 -- 20	20	--
<i>Sphagnum</i>	100	50 -- 50	50	--

***Picea mariana*/Carex bigelowii plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea mariana</i>	100	80 -- 80	80	1.2
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	100	1 -- 1	1	--
<i>Ledum groenlandicum</i>	100	20 -- 20	20	0.3
<i>Rubus spectabilis</i>	100	5 -- 5	5	--
<i>Vaccinium uliginosum</i>	100	30 -- 30	30	--
Shrub Dwarf (<0.2m)				
<i>Empetrum nigrum</i>	100	1 -- 1	1	--
<i>Vaccinium vitis-idaea</i>	100	10 -- 10	10	--
Graminoid				
<i>Carex bigelowii</i>	100	60 -- 60	60	--
Forb				
<i>Equisetum sylvaticum</i>	100	1 -- 1	1	--
<i>Petasites sagittatus</i>	100	1 -- 1	1	--
Moss				
<i>Hylocomium splendens</i>	100	20 -- 20	20	--
<i>Sphagnum</i>	100	20 -- 20	20	--

***Picea mariana*/Equisetum sylvaticum plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Tall (>7.5m)				
<i>Picea mariana</i>	100	80 -- 80	80	9.1
Shrub Low (>0.2m and <1.5m)				
<i>Spiraea beauverdiana</i>	100	1 -- 1	1	--
Shrub Dwarf (<0.2m)				
<i>Cornus canadensis</i>	100	20 -- 20	20	--
Forb				
<i>Equisetum sylvaticum</i>	100	80 -- 80	80	--
Moss				
<i>Hylocomium splendens</i>	100	90 -- 90	90	--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	100	5 -- 5	5	--

***Picea mariana*/Eriophorum vaginatum plant association**

Number of plots = 5

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea glauca</i>	20	10 -- 10	10	1.5
<i>Picea mariana</i>	80	15 -- 20	19	3.1
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	40	10 -- 25	18	0.6
<i>Betula nana</i>	40	5 -- 40	23	0.5
<i>Ledum decumbens</i>	80	5 -- 50	29	0.2
<i>Potentilla fruticosa</i>	20	1 -- 1	1	--
<i>Rubus spectabilis</i>	40	1 -- 5	3	--
<i>Salix bebbiana</i>	20	20 -- 20	20	0.9
<i>Salix planifolia</i>	20	2 -- 2	2	0.3
<i>Vaccinium uliginosum</i>	60	1 -- 10	5	0.3
Shrub Dwarf (<0.2m)				
<i>Betula nana</i>	20	5 -- 5	5	--
<i>Empetrum nigrum</i>	20	5 -- 5	5	--
<i>Rubus chamaemorus</i>	20	1 -- 1	1	--
<i>Salix reticulata</i>	20	5 -- 5	5	--
<i>Vaccinium uliginosum</i>	20	3 -- 3	3	--
<i>Vaccinium vitis-idaea</i>	80	1 -- 5	3	--
Graminoid				
<i>Carex lugens</i>	40	1 -- 20	11	--
<i>Eriophorum vaginatum</i>	80	50 -- 80	63	0.3
Lichen				
<i>Cladina</i>	20	10 -- 10	10	--
<i>Cladina rangiferina</i>	40	5 -- 10	8	--
<i>lichens</i>	20	1 -- 1	1	--
Moss				
<i>Hylocomium splendens</i>	60	10 -- 20	13	--
bryophytes-mosses and liverworts	60	10 -- 30	20	--
<i>Sphagnum fuscum</i>	40	10 -- 20	15	--
<i>Sphagnum</i>	20	1 -- 1	1	--
Water				
water	20	2 -- 2	2	--

***Picea mariana*/Ledum species plant association**

Number of plots = 7

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Tall (>7.5m)				
<i>Picea mariana</i>	14	25 -- 25	25	9.1
Tree Stunted (<7.5m)				
<i>Betula papyrifera</i>	14	5 -- 5	5	3.0
<i>Larix laricina</i>	71	1 -- 5	3	3.5
<i>Picea mariana</i>	100	5 -- 40	26	4.1
Shrub Tall (>1.5m)				
<i>Alnus crispa</i>	14	10 -- 10	10	1.8
Shrub Low (>0.2m and <1.5m)				
<i>Alnus crispa</i>	14	1 -- 1	1	0.9
<i>Betula glandulosa</i>	29	2 -- 5	4	0.3
<i>Betula nana</i>	29	10 -- 20	15	0.5
<i>Chamaedaphne calyculata</i>	43	3 -- 5	4	0.3
<i>Ledum decumbens</i>	43	20 -- 40	28	0.3
<i>Ledum groenlandicum</i>	43	40 -- 90	60	0.6
<i>Rosa acicularis</i>	14	1 -- 1	1	--
<i>Rubus spectabilis</i>	71	5 -- 10	7	--
<i>Spiraea beauverdiana</i>	14	1 -- 1	1	0.3
<i>Vaccinium uliginosum</i>	71	5 -- 15	9	0.3
Shrub Dwarf (<0.2m)				
<i>Empetrum nigrum</i>	43	5 -- 50	22	--
<i>Ledum decumbens</i>	14	20 -- 20	20	0.2
<i>Oxycoccus microcarpos</i>	29	1 -- 5	3	--
<i>Rubus chamaemorus</i>	14	15 -- 15	15	0.1
<i>Vaccinium uliginosum</i>	14	10 -- 10	10	0.2
<i>Vaccinium vitis-idaea</i>	71	2 -- 20	8	--
Graminoid				
<i>Carex lugens</i>	14	1 -- 1	1	--
<i>Carex</i>	14	10 -- 10	10	--
<i>Eriophorum vaginatum</i>	29	10 -- 20	15	0.3
graminoid group	14	5 -- 5	5	0.2
Forb				
<i>Equisetum sylvaticum</i>	29	1 -- 2	2	--
Lichen				
<i>Cladina</i>	29	5 -- 10	8	--
<i>Cladonia</i>	14	5 -- 5	5	--
<i>Cladina rangiferina</i>	29	5 -- 10	8	--
lichens	29	5 -- 5	5	--
Moss				
<i>Hylocomium</i>	14	--	--	--
<i>Hylocomium splendens</i>	43	10 -- 20	17	--
bryophytes-mosses and liverworts	71	10 -- 90	46	--
<i>Polytrichum</i>	14	--	--	--
<i>Sphagnum fuscum</i>	57	3 -- 20	13	--
<i>Sphagnum girgensohnii</i>	14	80 -- 80	80	--
<i>Sphagnum</i>	57	-- 60	25	--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	29	10 -- 10	10	--
Water				
water	14	--	--	--

***Picea mariana/Vaccinium uliginosum* plant association**

Number of plots = 2

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea mariana</i>	100	40 -- 50	45	3.8
Shrub Tall (>1.5m)				
<i>Alnus crispa</i>	100	2 -- 5	4	1.1
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	50	10 -- 10	10	0.9
<i>Betula nana</i>	50	10 -- 10	10	0.0
<i>Ledum decumbens</i>	50	15 -- 15	15	0.6
<i>Vaccinium uliginosum</i>	100	30 -- 30	30	0.3
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos alpina</i>	50	5 -- 5	5	--
<i>Empetrum nigrum</i>	100	1 -- 1	1	0.0
<i>Rubus spectabilis</i>	50	5 -- 5	5	0.0
<i>Vaccinium vitis-idaea</i>	50	10 -- 10	10	--
Forb				
<i>Geocaulon lividum</i>	50	5 -- 5	5	--
Lichen				
<i>Cetraria</i>	50	--		--
<i>Cladina</i>	50	--		--
lichens	50	5 -- 5	5	--
Moss				
<i>Hylocomium splendens</i>	50	70 -- 70	70	0.0
bryophytes-mosses and liverworts	100	20 -- 90	55	0.0
<i>Pleurozium</i>	50	--		--
<i>Sphagnum</i>	50	5 -- 5	5	0.0

***Salix barclayi/Calamagrostis canadensis* plant association**

Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)				
<i>Salix barclayi</i>	100	50 -- 50	50	1.8
Shrub Low (>0.2m and <1.5m)				
<i>Viburnum edule</i>	100	2 -- 2	2	0.6
Graminoid				
<i>Calamagrostis canadensis</i>	100	80 -- 80	80	1.5
Forb				
<i>Athyrium filix-femina</i>	100	20 -- 20	20	0.9
<i>Equisetum arvense</i>	100	10 -- 10	10	0.6

***Salix bebbiana/Equisetum arvense* plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Populus balsamifera</i>	100	3 -- 3	3	1.8
Shrub Tall (>1.5m)				
<i>Salix bebbiana</i>	100	40 -- 40	40	3.0
Shrub Low (>0.2m and <1.5m)				
<i>Betula nana</i>	100	5 -- 5	5	0.3
<i>Elaeagnus commutata</i>	100	1 -- 1	1	--
Forb				
<i>Epilobium angustifolium</i>	100	5 -- 5	5	--
<i>Equisetum arvense</i>	100	90 -- 90	90	--

Salix polaris plant association

Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Dwarf (<0.2m)				
<i>Cassiope tetragona</i>	100	15 -- 15	15	--
<i>Diapensia lapponica</i>	100	1 -- 1	1	--
<i>Dryas octopetala</i>	100	10 -- 10	10	--
<i>Minuartia macrocarpa</i>	100	1 -- 1	1	--
<i>Salix polaris</i>	100	20 -- 20	20	--
Graminoid				
<i>Arctophila fulva</i>	100	1 -- 1	1	--
graminoid group	100	5 -- 5	5	--
Forb				
<i>Antennaria monocephala</i>	100	1 -- 1	1	--
<i>Arabis lemmonii</i>	100	1 -- 1	1	--
<i>Geum rossii</i>	100	1 -- 1	1	--
<i>Ligusticum mutellinoides</i>	100	1 -- 1	1	--
<i>Lycopodium selago</i>	100	1 -- 1	1	--
<i>Oxytropis deflexa</i>	100	1 -- 1	1	--
<i>Pedicularis capitata</i>	100	1 -- 1	1	--
<i>Petasites frigidus</i>	100	1 -- 1	1	--
<i>Pedicularis kanei</i>	100	1 -- 1	1	--
<i>Polygonum viviparum</i>	100	1 -- 1	1	--
<i>Saxifraga punctata</i>	100	1 -- 1	1	--
<i>Saxifraga reflexa</i>	100	1 -- 1	1	--
<i>Senecio atropurpureus</i>	100	1 -- 1	1	--
Lichen				
<i>Stereocaulon</i>	100	1 -- 1	1	--
Moss				
<i>Hylocomium</i>	100	40 -- 40	40	--
Barren				
mineral-surface rock fragments	100	10 -- 10	10	--

Salix lanata/Calamagrostis canadensis plant association

Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)				
<i>Salix lanata</i>	100	90 -- 90	90	1.5
Shrub Low (>0.2m and <1.5m)				
<i>Potentilla fruticosa</i>	100	1 -- 1	1	0.6
<i>Salix planifolia</i>	100	1 -- 1	1	0.9
Shrub Dwarf (<0.2m)				
<i>Rubus idaeus</i>	100	1 -- 1	1	--
<i>Salix reticulata</i>	100	1 -- 1	1	--
Graminoid				
<i>Calamagrostis canadensis</i>	100	10 -- 10	10	--
Forb				
<i>Boykinia richardsonii</i>	100	15 -- 15	15	--
<i>Epilobium angustifolium</i>	100	2 -- 2	2	--
<i>Mertensia paniculata</i>	100	15 -- 15	15	--
<i>Sedum rosea</i>	100	1 -- 1	1	--
Moss				
bryophytes-mosses and liverworts	100	1 -- 1	1	--

***Salix lanata*/Equisetum variegatum plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)				
<i>Salix alaxensis</i>	100	5 -- 5	5	1.8
<i>Salix glauca</i>	100	5 -- 5	5	--
Shrub Low (>0.2m and <1.5m)				
<i>Salix lanata</i>	100	50 -- 50	50	0.9
Graminoid				
<i>Carex membranacea</i>	100	5 -- 5	5	--
Forb				
<i>Equisetum arvense</i>	100	10 -- 10	10	--
<i>Equisetum variegatum</i>	100	90 -- 90	90	--
Moss				
bryophytes-mosses and liverworts	100	90 -- 90	90	--
Barren				
mineral-bare soil	100	10 -- 10	10	--

***Salix planifolia* plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Tree Stunted (<7.5m)				
<i>Picea mariana</i>	100	1 -- 1	1	1.8
Shrub Tall (>1.5m)				
<i>Salix planifolia</i>	100	50 -- 50	50	1.5
Shrub Low (>0.2m and <1.5m)				
<i>Betula nana</i>	100	10 -- 10	10	--
<i>Rubus spectabilis</i>	100	5 -- 5	5	--
<i>Spiraea beauverdiana</i>	100	10 -- 10	10	0.3
Shrub Dwarf (<0.2m)				
<i>Empetrum nigrum</i>	100	15 -- 15	15	--
Graminoid				
<i>Eriophorum brachyantherum</i>	100	20 -- 20	20	--
Moss				
bryophytes-mosses and liverworts	100	90 -- 90	90	--
<i>Sphagnum</i>	100	5 -- 5	5	--

***Salix planifolia*/Carex bigelowii plant association** Number of plots = 1

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Low (>0.2m and <1.5m)				
<i>Salix planifolia</i>	100	70 -- 70	70	0.6
Shrub Dwarf (<0.2m)				
<i>Cassiope tetragona</i>	100	20 -- 20	20	--
Graminoid				
<i>Carex bigelowii</i>	100	40 -- 40	40	--
Forb				
<i>Aconitum delphinifolium</i>	100	1 -- 1	1	--
<i>Petasites frigidus</i>	100	1 -- 1	1	--
Moss				
<i>Hylocomium splendens</i>	100	60 -- 60	60	--

Vaccinium uliginosum/dwarf shrub plant association

Number of plots = 7

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Low (>0.2m and <1.5m)				
<i>Betula glandulosa</i>	14	10 -- 10	10	0.2
<i>Betula nana</i>	57	5 -- 15	10	0.3
<i>Salix</i>	14	1 -- 1	1	0.9
<i>Salix planifolia</i>	14	5 -- 5	5	0.3
<i>Spiraea beauverdiana</i>	29	1 -- 2	1	--
<i>Vaccinium uliginosum</i>	43	30 -- 60	42	0.2
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos alpina</i>	29	2 -- 10	6	0.1
<i>Arctostaphylos</i>	14	20 -- 20	20	--
<i>Arctostaphylos rubra</i>	43	10 -- 10	10	--
<i>Cassiope tetragona</i>	14	20 -- 20	20	--
<i>Cornus canadensis</i>	43	2 -- 20	9	--
<i>Diapensia lapponica</i>	43	1 -- 10	4	--
<i>Dryas octopetala</i>	14	10 -- 10	10	0.1
<i>Empetrum nigrum</i>	100	1 -- 30	13	0.1
<i>Ledum decumbens</i>	43	1 -- 20	9	--
<i>Linnaea borealis</i>	29	1 -- 2	1	--
<i>Loiseleuria procumbens</i>	14	1 -- 1	1	--
<i>Minuartia obtusiloba</i>	14	--	--	--
<i>Rubus chamaemorus</i>	14	1 -- 1	1	--
<i>Salix arctica</i>	29	1 -- 3	2	0.1
<i>Salix reticulata</i>	14	5 -- 5	5	0.2
<i>Vaccinium uliginosum</i>	57	50 -- 80	60	0.2
<i>Vaccinium vitis-idaea</i>	43	1 -- 10	4	0.1
Graminoid				
<i>Calamagrostis canadensis</i>	29	2 -- 5	4	0.5
<i>Carex micropoda</i>	14	2 -- 2	2	--
<i>Carex podocarpa</i>	14	10 -- 10	10	--
<i>Eriophorum</i>	14	1 -- 1	1	0.3
<i>Festuca altaica</i>	14	10 -- 10	10	--
<i>Hierochloe alpina</i>	14	1 -- 1	1	--
Forb				
<i>Angelica lucida</i>	14	1 -- 1	1	--
<i>Anemone narcissiflora</i>	29	1 -- 5	3	--
<i>Anemone parviflora</i>	14	1 -- 1	1	--
<i>Arnica alpina</i>	14	--	--	--
<i>Artemisia alaskana</i>	14	5 -- 5	5	--
<i>Artemisia arctica</i>	14	1 -- 1	1	--
<i>Arnica frigida</i>	14	--	--	--
<i>Artemisia</i>	14	--	--	--
<i>Castilleja elegans</i>	14	--	--	--
<i>Cardamine microphylla</i>	14	10 -- 10	10	0.2
<i>Dryopteris dilatata</i>	14	1 -- 1	1	--
<i>Epilobium angustifolium</i>	14	1 -- 1	1	--
<i>Ligusticum mutellinoides</i>	14	1 -- 1	1	--
<i>Lycopodium alpinum</i>	14	1 -- 1	1	--
<i>Lycopodium annotinum</i>	29	1 -- 2	1	--
<i>Lycopodium</i>	14	1 -- 1	1	--
<i>Petasites frigidus</i>	14	--	--	--
<i>Pedicularis labradorica</i>	14	1 -- 1	1	--
<i>Polemonium</i>	14	1 -- 1	1	--
<i>Sanguisorba stipulata</i>	14	1 -- 1	1	--
<i>Thelypteris phegopteris</i>	14	5 -- 5	5	--
<i>Veratrum viride</i>	14	5 -- 5	5	--
<i>Viola</i>	14	1 -- 1	1	--
Lichen				
<i>Cetraria</i>	14	--	--	--
<i>Cladina rangiferina</i>	14	5 -- 5	5	--
lichens	43	5 -- 40	17	--
<i>Masonhalea richardsonii</i>	14	20 -- 20	20	--
<i>Stereocaulon</i>	29	-- 1	--	--
<i>Thamnolia</i>	14	--	--	--
Moss				
<i>Hylocomium</i>	14	15 -- 15	15	--
<i>Hylocomium splendens</i>	14	5 -- 5	5	--

bryophytes-mosses and liverworts	43	30 -- 60	50	--
<i>Pleurozium</i>	29	-- 15	8	--
<i>Polytrichum</i>	14	--		--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	14	30 -- 30	30	--
mineral-surface rock fragments	14	5 -- 5	5	--
mineral-bare soil	14	1 -- 1	1	--

***Vaccinium uliginosum*/low shrub plant association**

Number of plots = 3

Strata/Species	Constancy	Cover %		Average Ht (m)
		Range	Average	
Shrub Tall (>1.5m)				
<i>Salix planifolia</i>	33	2 -- 2	2	2.1
Shrub Low (>0.2m and <1.5m)				
<i>Betula nana</i>	33	15 -- 15	15	0.4
<i>Salix planifolia</i>	33	5 -- 5	5	--
<i>Spiraea beauverdiana</i>	33	1 -- 1	1	0.7
<i>Vaccinium uliginosum</i>	67	90 -- 90	90	0.3
Shrub Dwarf (<0.2m)				
<i>Arctostaphylos rubra</i>	33	1 -- 1	1	--
<i>Cornus canadensis</i>	33	1 -- 1	1	--
<i>Empetrum nigrum</i>	67	2 -- 5	4	--
<i>Vaccinium uliginosum</i>	33	75 -- 75	75	0.2
<i>Vaccinium vitis-idaea</i>	67	1 -- 10	5	--
Graminoid				
<i>Calamagrostis canadensis</i>	33	20 -- 20	20	0.6
Forb				
<i>Epilobium angustifolium</i>	33	20 -- 20	20	0.6
Lichen				
lichens	33	1 -- 1	1	--
Moss				
<i>Hylocomium splendens</i>	33	70 -- 70	70	--
bryophytes-mosses and liverworts	33	--		--
Barren				
litter-herbaceous, mulch, and woody debris <2.5 cm	33	99 -- 99	99	--
mineral-bare soil	33	1 -- 1	1	--

Appendix 5. Hierarchical framework of ecological units to the subsection level for Denali National Park and Preserve (Clark 1998).

100 - Polar Domain

130 - Subarctic Division

131 - Yukon Intermontane Taiga Province

131B - Kuskokwim Plain Section

(1) 131B.G1 - Glaciated Hills and Pitted Plains Subsection

(2) 131B.V1 - Alluvial Fans and Flood Plains Subsection

(3) 131B.V2 - Minchumina Basin Subsection

M131C - Kuskokwim Mountains Section

(4) M131C.M1 - Low Mountains and Pediments Subsection

135 - Alaska Range Taiga Province

M135C - Alaska Range Section

(5) M135C.M1 - Front Range Subsection

(6) M135C.M2 - High Mountains Subsection

(7) M135C.M3 - Interior Mountains and Glaciated Valleys Subsection

(8) M135C.M4 - Kantishna Hills Subsection

(9) M135C.M5 - Southcentral Mountains

(10) M135C.M6 - Teklanika Mountains and Plateaus Subsection

(11) M135C.M7 - Toklat Basin Subsection

200 - Humid Temperate Domain

210 - Warm Continental Division

213 - Alaska Mixed Forest Province

213B - Cook Inlet Lowlands Section

(12) 213B.G1 - Glaciated Hills and Plains Subsection

(13) 213B.V1 - Braided Flood Plains and Stream Terraces Subsection

Section and subsection descriptions for Denali National Park and Preserve

131B - Kuskokwim Plain Section

(1) 131B.G1 - Kuskokwim-Glaciated Hills and Pitted Plains Subsection

Location: Interior valleys (northwest)

Extent: 424957 acres

Climate: Subarctic continental

Elevation: ???

*Geology*²: Quaternary glacial deposits

Landform: Pitted outwash plains, glacial hills, and moraines

Slope: 0 to 60%

Parent Materials: loess over glacial drift

*Vegetation*³: Dwarf shrub and spruce/shrub woodland

Processes: Acidification, podzolization, hydromorphism, and cryoturbation

*Major Soils*⁴: Typic and Pergelic Haplocryods and Histic

Pergelic Cryaquepts

Criteria for Separating: Glacial hills with dendritic drainage patterns or distinctive pitted ablation features lacking significant drainage outlets. North-central polygon may be ice mounded topography (Yedoma) which would suggest combining this polygon with unit 3.

(2) 131B.V1 - Kuskokwim-Alluvial Fans and Flood Plains Subsection

Location: Interior Valleys (west central)

Extent: 1109803 acres

Climate: Subarctic continental

Elevation: ???

*Geology*²: Quaternary glaciofluvial deposits

Landforms: Alluvial fans, pitted fan terraces, flood plains and terraces

Slope: 0 to 20%

Parent Materials: glaciofluvial deposits and loess over glaciofluvial deposits

*Vegetation*³: Open and closed spruce forest; minor- Open spruce forest/shrub/bog mosaic

Processes: Fans and flood plains-alkalinization and fluvial processes; Fan terraces and stream terraces-acidification, podzolization, hydromorphism, and cryoturbation.

*Major Soils*⁴: Fans and flood plains-Typic Cryofluvents, Aquic Cryofluvents, and Typic Cryaquepts
Fan terraces and stream terraces-Histic Pergelic Cryaquepts, Pergelic Haplocryods, and Typic Cryochrepts.
Proximal end is well drained and distal end is very poorly drained.

Criteria for Separating: Distinctive alluvial fan photo signature with none to moderate pitting. This unit has a normal radial drainage net compared to unit (1). At lower elevations, this unit grades to a broad alluvial plain which serves as a large groundwater discharge area for unit (3).

(3) 131B.V2 - Minchumina Basin Subsection

Location: Interior Valleys (northwest)

Extent: 391263 acres

Climate: Subarctic continental

Elevation: ???

*Geology*²: Quaternary alluvium with linear eolian features

Landform: Closed and open basins, ice mounded topography (Yedoma) probable in the NE delineation.

Slope: 0 to 10%

Parent Materials: loess over medium textured alluvium and organic materials
*Vegetation*³: Open spruce forest/shrub/bog mosaic; closed sheath cottongrass woodland
Processes: Acidification, hydromorphism and cryoturbation
*Major Soils*⁴: Histic Pergelic Cryaquepts, Typic Cryofibrists, Pergelic Cryohemists (IQ6)
Criteria for Separating: Apparent ground water discharge areas with little local relief, pond and lake density is high and evidence of ice mounded topography in the northeastern polygon

M131C - Kuskokwim Mountains Section

(4) M131C.M1 - Kuskokwim-Low Mountains and Pediments

Subsection

Location: Northwestern Preserve
Extent: 92142 acres
Climate: Subarctic continental
Elevation: ???
*Geology*²: Lower Paleozoic (Cambrian through Devonian) sedimentary, metasedimentary and metamorphic rocks (Ipz)
Landform: Low mountains including extended toe slopes (northcentral polygons) and pediment slopes (northwest polygon)
Slope: 0 to 60%
Parent Materials: loess, colluvium, and bedrock on backslopes through summits. Toeslopes likely consist of silty colluvial materials
*Vegetation*³: Spruce and broadleaf forest; Open spruce and closed mixed forest mosaic
Processes: acidification, podzolization, colluviation, cryoturbation and frost shatter
*Major Soils*⁴: Histic Pergelic Cryaquepts and Typic Haplocryods
Criteria for Separating: distinctive hills, low mountains, and pediment footslopes within the Kuskokwim Basin

M135 - Alaska Range Section

(5) M135.M1 - Alaska Range-Front Range Subsection

Location: Northeastern Park and Preserve
Extent: 450217 acres
Climate: Subarctic continental
Elevation: ?

*Geology*⁵: Pelitic and quartose schist sequence (PzpCp) and Totatlanika schist (MDt).

Landform: Mountains

Associated Micro-relief: Altiplanation terrace, nonsorted circles, nonsorted stripes

Slope: 0 to over 90%

Parent Materials: Colluvium, congeliturbate, and bedrock derived from schist; locally mantled with a thin loess mantle

*Vegetation*³: Shrub; Dwarf shrub; Spruce forest/shrub; Nonvegetated

Processes: Colluviation, cryoturbation, and frost shatter on mountains and fluvial processes on alluvial fans and flood plains

Major Soils: Dysic Cryochrepts, Typic Cryochrepts; Aquic Cryochrepts on mountains; Typic Haplocryods and Typic Cryochrepts on fan terraces and Typic Cryofluvents, Typic Cryofluvents, and Oxyaquic Cryorthents on flood plains

Criteria for Separating: Vegetated Interior Alaska Range mountains below about 1,350 meters elevation. Distinctive lithology, primarily schist bedrock, and climate that is likely drier than more southerly mountains of the Alaska Range.

(6) M135.M2 - Alaska Range-High Mountains Subsection

Location: Central Park and Preserve

Extent: 1960423 acres

Climate: Subarctic continental

Elevation: Above about 1,500 meters

*Geology*²: Mesozoic and Paleozoic - argillite, shale, graywache, conglomerate, and sandstone (KJ, TxC) and Tertiary felsic intrusives (Tif)

Landform: Mountains-backslopes, shoulders and crests; Glaciers and icefields

Slope: 45 to over 150%

Parent Materials: colluvium and bedrock

*Vegetation*³: Nonvegetated

Processes: colluviation, cryoturbation, and frost shatter

*Major Soils*⁴: None- mostly miscellaneous land types including rock outcrops, talus, and ice

Criteria for Separating: Nonvegetated mountains consisting primarily of rock and ice above about 1,350 meters elevation.

(7) M135.M3 - Alaska Range-Interior Mountains and Glaciated Valleys Subsection

Location: Central Park and Preserve

Extent: 142879 acres

Climate: Subarctic continental

Elevation: &&&

Geology^{5&6}: Tcv-Cantwell Formation -volcanic rocks subunit; Tcs-Cantwell Formation-sedimentary rocks subunit; Tkcs-Late Triassic sedimentary rocks; KJf-Flysch Sequence; Tn-Nenana Gravels

Landform: Mountains, glacial till plains and hills, and flood plains

Slope: 0 to 90%

Parent Materials: Mountains consist of colluvium derived from a variety of sedimentary and volcanic rocks. Valleys consists of alluvium and glacial drift

*Vegetation*³: Flood plains-shrub; Mountains-dwarf shrub and barren ground; occasionally spruce forest on lower mountain slopes and high flood plains;

Processes: Mountains-colluviation, cryoturbation, and frost shatter; Valleys-fluvial processes, podzolization and acidification, cryoturbation and hydromorphism

Major Soils: Mountains-Pergelic Cryoborolls, Pergelic Cryochrepts (shallow to very deep). Fan terraces-Typic Haplocryods and Typic Histihaplels; Glacial plains and Hills-Typic Histihaplels, Ruptic-Histic Aquiturbels, Typic Halplocryods

Criteria for Separating: Vegetated Interior Alaska Range mountains below about 1,350 meters elevation. Unit generally consists of glaciated valleys and bedrock controlled mountains. Parent materials in high mountains consist of a wide assemblage of sedimentary, and to a lesser extent, volcanic rocks.

(8) M135.M4 - Alaska Range-Kantishna Hills Subsection

Location: Northcentral Park and Preserve

Extent: 446125 acres

Climate: Subarctic continental

Elevation: &&&

*Geology*²: Lower Paleozoic-metamorphic (schist and quartzite) and varied metasedimentary (IPzpC and IpC)

Landform: Mountain slopes- all positions

Slope: 15 to 60%

Parent Materials: Loess and colluvium over bedrock

*Vegetation*³: Tall shrub; Herbaceous/shrub; Spruce

/shrub woodland

Processes: Acidification, colluviation, cryoturbation, and frost shatter

*Major Soils*⁴: Pergelic Cryaquepts, Typic Cryochrepts and Pergelic Cryorthents

Criteria for Separating: Vegetated mountains with all exposures represented and interior climate. Mountains on the southern edge of this unit have appearance that is somewhat similar to unit 10 and may warrant separating and including with that unit. Fieldwork will verify this possible separation.

(9) M135.M5 - Alaska Range-Southcentral Mountains Subsection

Location: Southern Park and Preserve

Extent: 556425 acres

Climate: Transitional maritime and subarctic continental

Elevation: &&&

*Geology*²: Lower Paleozoic-metamorphic (schist and quartzite) and varied metasedimentary (IPzpC and IpC)

Landform: Mountain footslopes

Slope: 15 to 60%

Parent Materials: Loess and volcanic ash over glacial drift, colluvium, and bedrock

*Vegetation*³: Dwarf shrub; Tall shrub

Processes: Acidification, podzolization, colluviation, cryoturbation, and frost shatter

*Major Soils*⁴: Andic Humicryods and Typic Cryaquands

Criteria for Separating: Vegetated mountain footslopes with all exposures represented

(10) M135.M6 - Alaska Range-Teklanika Mountains and Plateaus Subsection

Location: Northeastern Park and Preserve

Extent: 156227 acres

Climate: Subarctic continental

Elevation: &&&

*Geology*⁵: Tn-Nenana Gravels, Tcb-coal bearing rocks and Quaternary sediments

Landform: Plateaus, broad mountain toeslopes and flood plains

Slope: 0 to 65%

Parent Materials: Loess of mixed mineralogy over colluvium and residuum derived primarily from the Nenana Gravels

*Vegetation*³: Dwarf shrub, shrub, eriophorum tussock and

spruce woodland
Processes: Cryoturbation, hydromorphism, and fluvial processes
Major Soils: Plateaus and broad mountain toeslopes - Typic Histohaplels, Typic Histurbels, and Ruptic-Histic Aquiturbels; Flood plains-Typic Cryofluvents, Typic Cryorthents and Oxyaquic Cryorthents
Criteria for Separating: Unique plateau-plateau escarpment landform assemblage.

(11) M135.M7 - Alaska Range-Toklat Basin Subsection

Location: Northeastern Park and Preserve
Extent: 162962 acres
Climate: Subarctic continental
Elevation: ??? meters
*Geology*²: Quaternary alluvium
Landform: Fan terraces and flood plains
Slope: 0 to 45%
Parent Materials: Fan terraces and hills-loess over valley fill; flood plains-alluvium
*Vegetation*³: Open spruce/shrub/bog mosaic; spruce woodland shrub
Processes: Acidification, podzolization, cryoturbation, and colluviation
*Major Soils*⁴: Fan terraces - Histic Pergelic Cryaquepts, and Typic Cryochrepts; flood plains - Typic Cryaquepts and Typic Cryofluvents
Criteria for Separating: Large intermontane basin

213B - Cook Inlet Lowlands Section

(12) 213B.G1 - Cook Inlet-Glacial Hills and Plains Subsection

Location: South-side of Alaska Range along the southern and southeastern Park boundary
Extent: 89818 acres
Climate: Transitional maritime and subarctic continental
Elevation: ???
Geology: Quaternary glacial deposits
Landforms: Hills, moraines, and till and outwash plains
Slope: 0 to 45%
Parent Materials: loess and volcanic ash over glacial drift; organic materials
*Vegetation*³: Closed broadleaf forest; Tall shrub
Processes: Acidification, podzolization, and adisolization
*Major Soils*⁴: Andic Humicryods, Typic Haplocryands, Typic Fulvicryands

Criteria for Separating: Linear features between
mountain toeslopes and valley bottoms

(13) 213B.V1 - Cook Inlet-Braided Flood Plains and Stream

Terraces Subsection

Location: South side of Alaska Range along the southern
and southeastern Park boundary

Extent: 55634 acres

Climate: Transitional maritime and subarctic continental

Elevation: ???

Geology: Holocene alluvial deposits

Landforms: Flood plains and terraces

Slope: 0 to 10%

Parent Materials: Alluvium

*Vegetation*³: Closed broadleaf forest; Tall shrub

Processes: Flood plains - alkalization and fluvial
processes; Stream terraces - acidification

*Major Soils*⁴: Typic Cryofluvents, Aquic Cryofluvents, and
Typic Cryaquents

Criteria for Separating: Distinctive valley bottoms and
braided flood plains

Appendix 6. Vascular and nonvascular species list and codes for plants collected during the 1999 field season (Hultén 1968).

Scientific names	4 letter codes
Deciduous Trees	
<i>Populus tremuloides</i> Michx.	POTR5
<i>Betula papyrifera</i> Marsh.	BEPA
<i>Populus balsamifera</i> L.	POBA2
Evergreen Trees	
<i>Larix laricina</i> (Du Roi) K. Koch	LALA
<i>Picea glauca</i> (Moench) Voss	PIGL
<i>Picea mariana</i> (P. Mill.) B.S.P.	PIMA
Shrubs Tall	
<i>Alnus crispa</i> (Ait.) Pursh	ALCR6
<i>Alnus sinuata</i> (Regel) Rydb.	ALSI3
<i>Alnus tenuifolia</i> Nutt.	ALTE2
<i>Salix alaxensis</i> (Anderss.) Coville	SAAL
<i>Salix barclayi</i> Anderss.	SABA3
<i>Salix bebbiana</i> Sarg.	SABE2
<i>Salix glauca</i> L.	SAGL
<i>Sorbus scopulina</i> Greene	SOSC2
Shrubs Low	
<i>Betula glandulosa</i> Michx.	BEGL
<i>Betula nana</i> L.	BENA
<i>Chamaedaphne calyculata</i> (L.) Moench	CHCA2
<i>Elaeagnus commutata</i> Bernh. ex Rydb.	ELCO
<i>Betula hybrid</i>	BETULX
<i>Ledum groenlandicum</i> Oeder	LEGR
<i>Myrica gale</i> L.	MYGA
<i>Potentilla fruticosa</i> auct. non L.	POFR4
<i>Ribes triste</i> Pallas	RITR
<i>Rosa acicularis</i> Lindl.	ROAC
<i>Rosa woodsii</i> Lindl.	ROWO
<i>Rubus spectabilis</i> Pursh	RUSP
<i>Salix brachycarpa</i> Nutt.	SABR
<i>Salix exigua</i> Nutt.	SAEX
<i>Salix lanata</i> L.	SALA4
<i>Salix planifolia</i> Pursh	SAPL2
<i>Shepherdia canadensis</i> (L.) Nutt.	SHCA
<i>Spiraea</i> L.	SPIRA
<i>Spiraea beauverdiana</i> auct. non Schneid.	SPBE
<i>Vaccinium uliginosum</i> L.	VAUL
<i>Viburnum edule</i> (Michx.) Raf.	VIED

Scientific names	4 letter codes
Shrubs Dwarf	
<i>Andromeda polifolia</i> L.	ANPO
<i>Antennaria friesiana</i> (Trautv.) Ekman	ANFR
<i>Arctostaphylos</i> Adans.	ARCTO3
<i>Arctostaphylos alpina</i> (L.) Spreng.	ARAL2
<i>Arctostaphylos rubra</i> (Rehd. & Wilson) Fern.	ARRU
<i>Cassiope tetragona</i> (L.) D. Don	CATE11
<i>Cornus</i> L.	CORNU
<i>Cornus canadensis</i> L.	COCA13
<i>Cornus suecica</i> L.	COSU4
<i>Diapensia lapponica</i> L.	DILA
<i>Dryas integrifolia</i> Vahl	DRIN4
<i>Dryas octopetala</i> L.	DROC
<i>Empetrum nigrum</i> L.	EMNI
<i>Ledum decumbens</i> (Ait.) Lodd. ex Steud.	LEDE5
<i>Linnaea borealis</i> L.	LIBO3
<i>Loiseleuria procumbens</i> (L.) Desv.	LOPR
<i>Rhododendron lapponicum</i> (L.) Wahlenb.	RHLA2
<i>Rubus arcticus</i> L.	RUAR
<i>Rubus chamaemorus</i> L.	RUCH
<i>Rubus idaeus</i> L.	RUID
<i>Salix arctica</i> R. Br. ex Richards.	SAAR16
<i>Salix fuscescens</i> Anderss.	SAFU
<i>Salix phlebophylla</i> Anderss.	SAPH
<i>Salix polaris</i> Wahlenb.	SAPO
<i>Salix reticulata</i> L.	SARE2
<i>Vaccinium microcarpos</i> (Turcz. ex Rupr.) Schmalh.	VAMI
<i>Vaccinium oxycoccus</i> L.	VAOX
<i>Vaccinium vitis-idaea</i> L.	VAVI
Graminoids	
<i>Agropyron</i> Gaertn.	AGROP2
<i>Arctagrostis latifolia</i> (R. Br.) Griseb.	ARLA2
<i>Calamagrostis canadensis</i> (Michx.) Beauv.	CACA4
<i>Carex aquatilis</i> Wahlenb.	CAAQ
<i>Carex bigelowii</i> Torr. ex Schwein.	CABI5
<i>Carex lasiocarpa</i> Ehrh.	CALA11
<i>Carex limosa</i> L.	CALI7
<i>Carex lugens</i> Holm	CALU2
<i>Carex membranacea</i> Hook.	CAME4
<i>Carex microchaeta</i> Holm	CAMI4
<i>Carex micropoda</i> C.A. Mey.	CAMI16
<i>Carex misandra</i> R. Br.	CAMI10
<i>Carex podocarpa</i> R. Br.	CAPO
<i>Carex rostrata</i> Stokes	CARO6
<i>Carex rotundata</i> Wahlenb.	CARO7
<i>Carex scirpoidea</i> Michx.	CASC10
<i>Carex williamsii</i> Britt.	CAWI3
<i>Eleocharis quinqueflora</i> (F.X. Hartmann) Schwarz	ELQU2

Scientific names	4 letter codes
Eriophorum L.	ERIOP
Eriophorum angustifolium Honckeney	ERAN6
Eriophorum brachyantherum Trautv. & C.A. Mey.	ERBR6
Eriophorum russeolum Fries ex Hartman	ERRU2
Eriophorum vaginatum L.	ERVA4
Festuca altaica Trin.	FEAL
Festuca rubra L.	FERU2
Hierochloe alpina (Sw. ex Willd.) Roemer & J.A. Schultes	HIAL3
Phleum pratense L.	PHPR3
Poa alpigena (Fries ex Blytt) Lindm. f.	POAL
Trisetum spicatum (L.) Richter	TRSP2
Forbs	
Achillea millefolium L.	ACMI2
Aconitum L.	ACONI
Aconitum delphiniifolium DC.	ACDE2
Anemone narcissiflora L.	ANNA
Anemone parviflora Michx.	ANPA
Angelica lucida L.	ANLU
Antennaria monocephala DC.	ANMO9
Arabis lemmonii S. Wats.	ARLE
Arenaria capillaris Poir.	ARCA7
Armeria arctica (Cham.) Wallr.	ARAR12
Arnica L.	ARNIC
Arnica alpina (L.) Olin	ARAL4
Arnica frigida C.A. Mey. ex Iljin	ARFR2
Artemisia alaskana Rydb.	ARAL5
Artemisia arctica Less.	ARAR9
Artemisia L.	ARTEM
Artemisia tilesii Ledeb.	ARTI
Aster sibiricus L.	ASSI
Astragalus polaris Benth.	ASPO
Athyrium filix-femina (L.) Roth	ATFI
Boschniakia rossica (Cham. & Schlecht.) Fedtsch.	BORO
Boykinia richardsonii (Hook.) Rothrock	BORI2
Campanula lasiocarpa Cham.	CALA7
Campanula uniflora L.	CAUN2
Cardamine microphylla M.F. Adams	CAMI3
Castilleja elegans Malte	CAEL6
Chrysosplenium wrightii Franch. & Savigny	CHWR2
Cicuta mackenzieana Raup	CIMA
Claytonia L.	CLAYT
Drosera anglica Huds.	DRAN
Drosera rotundifolia L.	DRRO
Dryopteris dilatata auct. non (Hoffmann) Gray	DRDI2
Epilobium angustifolium L.	EPAN2
Epilobium latifolium L.	EPLA
Epilobium palustre L.	EPPA
Equisetum L.	EQUIS

Scientific names	4 letter codes
Equisetum arvense L.	EQAR
Equisetum fluviatile L.	EQFL
Equisetum pratense Ehrh.	EQPR
Equisetum sylvaticum L.	EQSY
Equisetum variegatum Schleich. ex F. Weber & D.M.H. Mohr	EQVA
Galium boreale L.	GABO2
Gentiana algida Pallas	GEAL2
Gentiana propinqua Richards.	GEPR7
Gentiana prostrata Haenke	GEPR3
Geocaulon lividum (Richards.) Fern.	GELI2
Geranium erianthum DC.	GEER2
Geum rossii (R. Br.) Ser.	GERO2
Gymnocarpium dryopteris (L.) Newman	GYDR
Hedysarum alpinum L.	HEAL
Heracleum lanatum Michx.	HELA4
Ligusticum L.	LIGUS
Ligusticum mutellinoides ssp. alpinum auct. non (Ledeb.) Thellung	LIMUA
Lupinus L.	LUPIN
Lycopodium L.	LYCOP2
Lycopodium alpinum L.	LYAL3
Lycopodium annotinum L.	LYAN2
Lycopodium complanatum L.	LYCO3
Lycopodium selago L.	LYSE99
Menyanthes trifoliata L.	METR3
Mertensia paniculata (Ait.) G. Don	MEPA
Minuartia arctica (Stev. ex Ser.) Graebn.	MIAR3
Minuartia macrocarpa (Pursh) Ostenf.	MIMA4
Minuartia obtusiloba (Rydb.) House	MIOB2
Pyrola asarifolia Michx.	PYAS
Pyrola secunda L.	PYSE
Oxycoccus microcarpos Turcz. ex Rupr.	OXMI3
Oxytropis campestris (L.) DC.	OXCA4
Oxytropis deflexa (Pallas) DC.	OXDE2
Oxytropis nigrescens (Pallas) Fisch. ex DC.	OXNI
Oxytropis viscida Nutt.	OXVI2
Papaver L.	PAPAV
Parnassia L.	PARNA
Parnassia kotzebuei Cham. ex Spreng.	PAKO3
Parnassia palustris L.	PAPA8
Parrya nudicaulis (L.) Boiss.	PANU5
Pedicularis capitata M.F. Adams	PECA2
Pedicularis kanei Dur.	PEKA7
Pedicularis labradorica Wirsing	PELA
Petasites frigidus (L.) Fries	PEFR5
Petasites sagittatus (Banks ex Pursh) Gray	PESA5
Polemonium L.	POLEM
Polygonum bistorta L.	POBI5
Polygonum viviparum L.	POVI3
Potentilla palustris (L.) Scop.	POPA14

Scientific names	4 letter codes
Rubus pedatus Sm.	RUPE
Sanguisorba canadensis L.	SACA14
Sanguisorba stipulata Raf.	SAST11
Saussurea angustifolia (Willd.) DC.	SAAN3
Saussurea viscida var. yukonensis (Porsild) Hultén	SAVIY
Saxifraga hieraciifolia Waldst. & Kit. ex Willd.	SAHI5
Saxifraga hirculus L.	SAHI3
Saxifraga oppositifolia L.	SAOP
Saxifraga punctata L. p.p.	SAPU6
Saxifraga reflexa Hook.	SARE8
Saxifraga tricuspidata Rottb.	SATR5
Sedum rosea var. alaskanum (Rose) Berger	SEROA
Senecio atropurpureus (Ledeb.) Fedtsch.	SEAT2
Senecio lugens Richards.	SELU
Senecio triangularis Hook.	SETR
Silene acaulis (L.) Jacq.	SIAC
Solidago multiradiata Ait.	SOMU
Streptopus amplexifolius (L.) DC.	STAM2
Synthyris borealis Pennell	SYBO
Thalictrum sparsiflorum Turcz. ex Fisch. & C.A. Mey.	THSP
Thelypteris phegopteris (L.) Slosson	THPH
Tofieldia coccinea Richards.	TOCO
Triglochin maritimum L.	TRMA4
Urtica gracilis Ait.	URGR3
Valeriana capitata Pallas ex Link	VACA3
Veratrum viride Ait.	VEVI
Viola L.	VIOLA
Woodsia ilvensis (L.) R. Br.	WOIL
Zigadenus elegans Pursh	ZIEL2
Mosses	
Hylocomium Schimp. in B.S.G.	HYLOC2
Hylocomium splendens (Hedw.) Schimp. in B.S.G.	HYSP70
Mnium Hedw.	MNIUM2
Pleurozium Mitt.	PLEUR10
Polytrichum commune Hedw.	POCO
Polytrichum Hedw.	POLYT5
Ptilium De Not.	PTILI3
Sphagnum L.	SPHAG2
Sphagnum fuscum (Schimp.) Klinggr.	SPFU70
Sphagnum girgensohnii Russ.	SPGI70

Scientific names	4 letter codes
Lichen	
Cetraria Ach.	CETRA2
Cetraria cuculatta (Bell.) Ach.	CECU99
Cladina (Nyl.) Nyl.	CLADI3
Cladina rangiferina (L.) Nyl.	CLRA60
Cladonia P. Browne	CLADO3
Masonhalea richardsonii (Hook.) Karnefelt	MARI60
Nephroma Ach.	NEPHR3
Peltigera Willd.	PELTI2
Stellaria longifolia Muhl. ex Willd.	STLO
Stereocaulon Hoffm.	STERE2
Thamnolia Ach. ex Schaerer	THAMN3

Appendix 7. Cross walk of hierarchical levels between the Denali National Park and Preserve landcover map classification (adapted from Viereck et al. 1992) and the National Vegetation Classification System (Grossman et al. 1998). The Denali landcover classes *peatland* and *herbaceous/shrub* are not included because they do not correspond to a single physiognomic unit.

Denali landcover classes			National Vegetation Classification System landcover classes			Comment
II	III	IV	Formation	Alliance*	Code	
Needleleaf forest	Closed/Open needleleaf forest	Dense-open spruce	Cylindrical-crowned temperate or subpolar needle-leaved evergreen forest	<i>Picea glauca</i> forest*	I.A.8.N.d.	Denali uses 50-70% trees; NVCS uses >25%. Both use >75% evergreen
			Temporarily flooded temperate or subpolar needle-leaved evergreen forest	<i>Picea glauca</i> forest*	I.A.8.N.e.	
			Cylindrical-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Picea glauca</i> woodland*	II.A.4.N.c.	
			Temporarily flooded temperate or subpolar needle-leaved evergreen woodland	<i>Picea glauca</i> woodland*	II.A.4.N.d.	
Needleleaf forest	Open needleleaf forest/ Needleleaf woodland	Open-woodland spruce	Cylindrical-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Picea glauca</i> woodland*	II.A.4.N.c.	Denali uses tree height >7.5 m, 10-49% trees; NVCS uses 25-60%. Both use >75% evergreen
			Cylindrical-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.c.	
			Temporarily flooded temperate or subpolar needle-leaved evergreen woodland	<i>Picea glauca</i> woodland*	II.A.4.N.d.	
			Temporarily flooded temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.d.	
			Seasonally flooded temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.e.	
			Saturated temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.f.	
			Lichen vegetation with a sparse tree layer	---	VI.B.1.N.c.	

Needleleaf forest/ Dwarf tree	Open needleleaf forest/ Needleleaf woodland/ Open dwarf tree scrub/Dwarf tree scrub woodland	Stunted spruce	Needle-leaved evergreen shrubland (group)	<i>Picea glauca</i> shrubland*	III.A.3.	Denali uses tree height <7.5 m, cover 10-49%; NVCS uses 25-60%, height described as Krumholtz
			Cylindrical-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.c.	
			Cylindrical-crowned temperate or subpolar needle-leaved evergreen woodland	<i>Picea glauca</i> woodland*	II.A.4.N.c.	
			Temporarily flooded temperate or subpolar needle-leaved evergreen woodland	<i>Picea glauca</i> woodland*	II.A.4.N.d.	
			Temporarily flooded temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.d.	
			Seasonally flooded temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.e.	
			Saturated temperate or subpolar needle-leaved evergreen woodland	<i>Picea mariana</i> woodland*	II.A.4.N.f.	
			Saturated mixed needle-leaved evergreen - cold-deciduous forest	<i>Picea mariana</i> - <i>Larix laricina</i> saturated forest	I.C.3.N.d.	
Broadleaf forest	Closed broadleaf/ Open broadleaf/ Broadleaf woodland	Broadleaf	Montane or boreal cold-deciduous forest	<i>Betula papyrifera</i> forest	I.B.2.N.b.	Denali uses >10% trees; NVCS uses >25% trees; both use >75% broadleaf
			Montane or boreal cold-deciduous forest	<i>Populus tremuloides</i> forest	I.B.2.N.b.	
			Montane or boreal cold-deciduous forest	<i>Populus balsamifera</i> forest*	I.B.2.N.b.	
			Temporarily flooded cold-deciduous forest	<i>Populus balsamifera</i> forest*	I.B.2.N.	
			Cold-deciduous woodland	<i>Populus tremuloides</i> woodland	II.B.2.N.a.	
			Cold-deciduous woodland	<i>Populus balsamifera</i> woodland*	II.B.2.N.a.	
			Cold-deciduous woodland	<i>Betula papyrifera</i> woodland	II.B.2.N.a.	

			Temporarily flooded cold-deciduous woodland	<i>Populus balsamifera</i> woodland*	II.B.2.N.b.	
Mixed forest	Closed mixed forest/ Open mixed forest/ Mixed woodland	Spruce-broadleaf	Mixed needle-leaved evergreen - cold-deciduous forest	<i>Picea glauca-Betula papyrifera</i> forest*	I.C.3.N.a.	Denali uses >10% trees; NVCS uses >25% trees; both use 25-75% mix of broadleaf & evergreen
			Temporarily flooded mixed needle-leaved evergreen - cold-deciduous forest	<i>Picea glauca-Populus balsamifera</i> forest*	I.C.3.N.b.	
			Mixed needle-leaved evergreen - cold-deciduous woodland	<i>Picea mariana-Betula papyrifera</i> woodland*	II.C.3.N.a.	
			Mixed needle-leaved evergreen - cold-deciduous woodland	<i>Picea glauca-Betula papyrifera</i> woodland*	II.C.3.N.a.	
Tall Scrub/ Low Scrub	Closed tall scrub/ Open tall scrub/ Closed low scrub/ Open low scrub	Alder	Subalpine or subpolar cold-deciduous shrubland	<i>Alnus viridis</i> ssp. <i>crispa</i> *	III.B.2.N.b	Denali uses Alder >25%; NVCS uses Alder >25%
			Subalpine or subpolar cold-deciduous shrubland	<i>Alnus viridis</i> ssp. <i>sinuata</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Alnus tenuifolia</i> *	III.B.2.N.b	
			Intermittently flooded cold-deciduous shrubland	---	III.B.2.N.c	
			Temporarily flooded cold-deciduous shrubland	<i>Alnus viridis</i> ssp. <i>crispa</i> *	III.B.2.N.d	
			Seasonally flooded cold-deciduous shrubland	---	III.B.2.N.e	
			Semipermanently flooded cold-deciduous shrubland	---	III.B.2.N.f.	
Tall Scrub/ Low Scrub	Closed tall scrub/ Open tall scrub/ Closed low scrub/ Open low scrub	Willow	Subalpine or subpolar cold-deciduous shrubland	<i>Salix lanata</i> ssp. <i>richardsonii</i> *	III.B.2.N.b	Denali uses Willow >25% and >20 cm tall; NVCS uses Willow >25% and >45 cm tall
			Subalpine or subpolar cold-deciduous shrubland	<i>Salix barclayi</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Salix barrattiana</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Salix brachycarpa</i> *	III.B.2.N.b	

			Intermittently flooded cold-deciduous shrubland	---	III.B.2.N.c	
			Temporarily flooded cold-deciduous shrubland	<i>Salix alaxensis</i> *	III.B.2.N.d	
			Temporarily flooded cold-deciduous shrubland	<i>Salix lanata</i> ssp. <i>richardsonii</i> *	III.B.2.N.d	
			Temporarily flooded cold-deciduous shrubland	<i>Salix planifolia</i> ssp. <i>pulchra</i>	III.B.2.N.d	
			Temporarily flooded cold-deciduous shrubland	<i>Salix bebbiana</i>	III.B.2.N.d	
			Temporarily flooded cold-deciduous shrubland	<i>Salix glauca</i>	III.B.2.N.d	
			Seasonally flooded cold-deciduous shrubland	---	III.B.2.N.e	
			Semipermanently flooded cold-deciduous shrubland	---	III.B.2.N.f.	
			Caespitose cold-deciduous dwarf-shrubland (possible crosswalk)	---	IV.B.2.N.a.	
			Caespitose needle-leaved or microphyllous evergreen dwarf-shrubland	---	IV.A.1.N.a.	
Low Scrub	Closed low scrub	Closed low shrub birch	Subalpine or subpolar cold-deciduous shrubland	<i>Betula nana</i> *	III.B.2.N.b	Denali uses 0.2-1.5 m tall and >75% shrub; NVCS uses >45 cm tall and >25% shrub
			Subalpine or subpolar cold-deciduous shrubland	<i>Betula glandulosa</i> *	III.B.2.N.b	
Low Scrub	Closed low scrub/ Open low scrub	Low shrub-sedge	Temporarily flooded cold-deciduous shrubland	---	III.B.2.N.d	Denali uses 0.2-1.5 m tall, >25 shrub; NVCS uses >45 cm tall, >25% shrub
			Seasonally flooded cold-deciduous shrubland	---	III.B.2.N.e	
			Semipermanently flooded cold-deciduous shrubland	---	III.B.2.N.f.	
			Saturated cold-deciduous shrubland	<i>Salix lanata</i> ssp. <i>richardsonii</i> *	III.B.2.N.g	
			Saturated cold-deciduous shrubland	<i>Salix planifolia</i> ssp. <i>pulchra</i> *	III.B.2.N.g	
			Saturated cold-deciduous shrubland	<i>Betula nana</i> *	III.B.2.N.g	
			Saturated cold-deciduous shrubland	<i>Ledum decumbens</i> *	III.B.2.N.g	
			Caespitose cold-deciduous dwarf-shrubland (possible crosswalk)	---	IV.B.2.N.a.	

			Saturated cold-deciduous dwarf-shrubland	---	IV.B.2.N.d.	
Low Scrub	Closed low scrub/ Open low scrub	Low shrub birch-ericaceous-willow	Subalpine or subpolar cold-deciduous shrubland	<i>Vaccinium uliginosum</i> *	III.B.2.N.b	Denali uses 0.2-1.5 m tall, >25% shrub; NVCS uses >45 cm tall, >25% shrub
			Subalpine or subpolar cold-deciduous shrubland	<i>Betula glandulosa</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Ledum groenlandicum</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Ledum decumbens</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Salix planifolia</i> ssp. <i>pulchra</i>	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Salix barrattiana</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Salix brachycarpa</i> *	III.B.2.N.b	
			Subalpine or subpolar cold-deciduous shrubland	<i>Salix glauca</i> *	III.B.2.N.b	
			Intermittently flooded cold-deciduous shrubland	---	III.B.2.N.c	
			Temporarily flooded cold-deciduous shrubland	<i>Salix planifolia</i> ssp. <i>pulchra</i>	III.B.2.N.d	
			Seasonally flooded cold-deciduous shrubland	---	III.B.2.N.e	
			Semipermanently flooded cold-deciduous shrubland	<i>Chamaedaphne calyculata</i> *	III.B.2.N.f.	
			Saturated cold-deciduous shrubland	<i>Vaccinium uliginosum</i> *	III.B.2.N.g	
			Saturated cold-deciduous shrubland	<i>Myrica gale</i> *	III.B.2.N.g	
			Caespitose cold-deciduous dwarf-shrubland (possible crosswalk)	---	IV.B.2.N.a.	
			Saturated cold-deciduous dwarf-shrubland (possible crosswalk)	---	IV.B.2.N.d.	
Dwarf scrub	Dryas dwarf scrub/ Ericaceous dwarf scrub/ Willow dwarf scrub	Dwarf shrub-rock	Creeping or matted needle-leaved or microphyllous evergreen dwarf-shrubland	<i>Dryas octopetala</i> *	IV.A.1.N.b.	Denali uses <20 cm tall, >25% shrub (bareground >25%); NVCS uses <45 cm tall, >25% shrub
			Creeping or matted needle-leaved or microphyllous evergreen dwarf-shrubland	<i>Cassiope tetragona</i>	IV.A.1.N.b.	

			Creeping or matted cold-deciduous dwarf-shrubland	---	IV.B.2.b.	
			Mixed evergreen - cold-deciduous dwarf-shrubland	---	IV.C.2.a.	
Dwarf scrub	Dryas dwarf scrub/ Ericaceous dwarf scrub/ Willow dwarf scrub	Dwarf shrub	Caespitose cold-deciduous dwarf-shrubland	<i>Vaccinium uliginosum</i> *	IV.B.2.a.	Denali uses <20 cm tall, >25% shrub (bareground <25%); NVCS uses <45 cm tall, >25% shrub
			Caespitose cold-deciduous dwarf-shrubland	<i>Arctostaphylos alpina</i> *	IV.B.2.a.	
			Caespitose needle-leaved or microphyllous evergreen dwarf-shrubland	<i>Dryas octopetala</i> *	IV.A.1.N.a.	
			Caespitose needle-leaved or microphyllous evergreen dwarf-shrubland	<i>Dryas integrifolia</i> *	IV.A.1.N.a.	
			Creeping or matted needle-leaved or microphyllous evergreen dwarf-shrubland	<i>Cassiope tetragona</i> *	IV.A.1.N.b.	
			Creeping or matted cold-deciduous dwarf-shrubland	<i>Salix rotundifolia</i> = <i>S. dodgeana</i>	IV.B.2.b.	
			Creeping or matted cold-deciduous dwarf-shrubland	<i>Salix reticulata</i>	IV.B.2.b.	
			Creeping or matted cold-deciduous dwarf-shrubland	<i>Salix polaris</i> *	IV.B.2.b.	
			Mixed evergreen - cold-deciduous dwarf-shrubland	---	IV.C.2.a.	
			Lowland lichen vegetation	---	VI.B.1.N.a.	
			Montane/submontane temperate or subpolar lichen vegetation dominate the nonvascular cover	---	VI.B.1.N.b.	
			Lichen vegetation with a sparse dwarf-shrub layer	---	VI.B.1.N.d.	
Graminoid herb/ Forb herb	Dry graminoid/ Mesic graminoid/ Dry forb/ Mesic forb	Dry-mesic herbaceous	Medium-tall sod temperate or subpolar grassland	<i>Calamagrostis canadensis</i> *	V.A.5.N.c	Denali and NVCS both use herbaceous >25% cover
			Short alpine or subalpine dry bunchgrass grassland	<i>Festuca altaica</i> *	V.A.5.N.h	
			Seasonally flooded temperate or subpolar grassland	---	V.A.5.N.k	
			Semipermanently flooded temperate or subpolar grassland	---	V.A.5.N.l.	

			Saturated temperate or subpolar grassland	---	V.A.5.N.m	
			Medium-tall temperate or subpolar grassland with a sparse cold-deciduous shrub layer	---	V.A.7.N.g	
			Short temperate or subpolar grassland with a sparse cold-deciduous shrub layer	---	V.A.7.N.l.	
			Saturated temperate or subpolar grassland with a sparse cold-deciduous shrub layer	---	V.A.7.N.p	
			Short temperate or subpolar lowland grassland with a sparse cold-deciduous shrub layer	---	V.A.8.N.b	
			Low temperate or subpolar perennial forb vegetation	---	V.B.2.N.b	
			Temporarily flooded temperate or subpolar perennial forb vegetation	<i>Epilobium latifolium*</i>	V.B.2.N.d	
Graminoid herb/ Forb herb	Wet graminoid/ Wet forb	Wet herbaceous	Semipermanently flooded temperate or subpolar grassland	<i>Carex aquatilis</i>	V.A.5.N.l.	Denali and NVCS both use herbaceous >25% cover
			Semipermanently flooded temperate or subpolar grassland	<i>Carex lasiocarpa</i>	V.A.5.N.l.	
			Semipermanently flooded temperate or subpolar grassland	<i>Carex rostrata</i>	V.A.5.N.l.	
			Semipermanently flooded temperate or subpolar grassland	<i>Eriophorum angustifolium</i>	V.A.5.N.l.	
			Saturated temperate or subpolar grassland	<i>Eleocharis palustris*</i>	V.A.5.N.m.	
			Saturated temperate or subpolar grassland	<i>Eriophorum russeolum</i>	V.A.5.N.m.	
			Saturated temperate or subpolar grassland	<i>Eriophorum vaginatum</i>	V.A.5.N.m.	
			Saturated temperate or subpolar grassland	<i>Eriophorum brachyantherum</i>	V.A.5.N.m.	
			Saturated temperate or subpolar grassland	<i>Carex aquatilis</i>	V.A.5.N.m.	
			Saturated temperate or subpolar grassland	<i>Carex lasiocarpa</i>	V.A.5.N.m.	
			Saturated temperate or subpolar grassland	<i>Carex rostrata</i>	V.A.5.N.m.	
			Semipermanently flooded temperate perennial forb vegetation	<i>Menyanthes trifoliata</i>	V.B.2.N.e.	

			Semipermanently flooded temperate perennial forb vegetation	<i>Equisetum fluviatile</i>	V.B.2.N.e	
			Saturated temperate perennial forb vegetation	<i>Menyanthes trifoliata</i>	V.B.2.N.f.	
			Saturated temperate perennial forb vegetation	<i>Equisetum fluviatile</i>	V.B.2.N.f.	
Aquatic herb	Freshwater aquatic herbaceous	Aquatic herbaceous	Permanently flooded temperate or subpolar hydromorphic rooted vegetation	<i>Nuphar polysepalum</i>	V.C.2.N.a	
		Sparsely vegetated	Sparse vegetation (Subclass)	---	VII.	Denali uses 15-24% total cover; NVCS uses 0.1-25%
		Bare ground				Denali uses <15% total cover; NVCS uses 0%

* Alliance names followed by * indicate the alliance was not defined in NVCS. The name was given by the authors of this report and corresponds to the name that most likely will be assigned by NVCS in the future.

--- means no alliance was defined or could be assigned.

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