National Park Service
U.S. Department of the Interior

Natural Resource Program Center

An Ecological Land Survey and Landcover Map of the Arctic Network

Natural Resource Technical Report NPS/ARCN/NRTR—2009/270

ON THE COVER

Top to Bottom:

Noatak River in the Noatak National Preserve, Kobuk Valley National Park, and Arrigetch Peaks in Gates of the Arctic National Park and Preserve.
PHOTOGRAPHS COURTESY ABR, INC.

An Ecological Land Survey and Landcover Map of the Arctic Network

Natural Resource Technical Report NPS/ARCN/NRTR—2009/270

M. Torre Jorgenson
Joanna E. Roth
Patricia F. Miller
Matthew J. Macander
Michael S. Duffy
Aaron F. Wells
Gerald V. Frost
Erik R. Pullman

ABR, Inc.–Environmental Research & Services
P.O. Box 80410
Fairbanks, Alaska 99708

October 2009

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center, publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report is available from ABR, Inc.–Environmental Research & Services Web site (www.abrinc.com) and from the Natural Resource Publications Management Web site (http://www.nature.nps.gov/publications/NRPM) on the Internet.

Please cite this publications as:

Jorgenson, M. T., J. E. Roth, P. F. Miller, M. J. Macander, M. S. Duffy, A. F. Wells, G. V. Frost, and E. R. Pullman. An ecological land survey and landcover map of the Arctic Network. Natural Resource Technical Report NPS/ARCN/NRTR—2009/270. National Park Service, Fort Collins, Colorado.

NPS/953/100695, October 2009

Contents

Figures

Tables

Appendices

Acknowledgments

We thank Jim Lawler and Diane Sanzone of the National Park Service for their support and management of this project. Jennifer Mitchell, Tara Whitesell, Kumi Rattenbury and Eric Miller provided excellent assistance in the field. We appreciate the safe helicopter flying provided by Troy Cambier and Stan Hermans, and fixed wing support provided by Bettles Air and Brooks Range Aviation. We thank Carolyn Parker, Misha Zhurbenko and Olga Afonina for their plant identification skills. We appreciate the helpful review of Janet Kidd, Sue Bishop, Dave Swanson, Peter Neitlich, and Beth Koltun. We give Pam Odom a special thanks for producing this report.

Introduction

An ecological land survey (ELS) and classification in conjunction with landcover mapping improves the ability of resource managers to evaluate land resources and develop management strategies that are appropriate to the varying conditions of the landscape. An ELS can be used to efficiently allocate inventory and monitoring efforts, to partition ecological information for analysis of ecological relationships, to develop predictive ecological models, and to improve techniques for assessing and mitigating impacts. The Arctic Network (ARCN) of the National Park Service (NPS) adopted this integrated approach of inventorying and classifying ecological characteristics from the “bottom up” and using satellite image processing and environmental modeling to better differentiate the distribution of ecosystems from the “top down.”

This report provides the results of a eight-year effort (2002–2009) by ABR, Inc. –Environmental Research & Services to survey, compile, analyze, and map ecosystems across the five parks of the Arctic Network, including Gates of the Arctic National Park and Preserve (GAAR), Noatak National Preserve (NOAT), Kobuk Valley National Park (KOVA), Cape Krusenstern National Monument (CAKR), and Bering Land Bridge National Preserve (BELA). Initial ecological surveys and mapping were done for CAKR and BELA during 2002–2003 (Jorgenson et al. 2004). Subsequent field surveys were done in NOAT (2005–2006), KOVA (2007), and GAAR (2008). We compiled existing vegetation and soils data from a variety of sources and included them in a standardized database for analysis. We used satellite image processing and rule-based modeling incorporating the landscape analysis of the large dataset to produce a new landcover map for NOAT and KOVA, taking advantage of extraordinarily clear and comprehensive Landsat imagery from 2002. Using the new mapping, we then developed an integrated, seamless landcover map for the entire network by integrating our previous BELA-CAKR mapping and the existing landcover map for GAAR (Boggs et al. 1999). Finally, the analysis of geomorphology-soils-vegetation relationships allowed us to develop a map of soil landscapes across the network.

The structure and function of natural ecosystems are regulated largely along gradients of energy, moisture, nutrients, and disturbance. These gradients are affected several ecological components including climate, physiography, geomorphology, soils, hydrology, vegetation, and fauna, and have been referred to as state factors (Barnes et al. 1982, ECOMAP 1993, Bailey 1996). We used the state-factor approach (Jenny 1941, Van Cleve et al. 1990, Vitousek 1994, Bailey 1996, Ellert et al. 1997) to evaluate relationships among individual ecological components and to develop a reduced set of ecotypes (Figure 1a).

An ecological land classification also involves organizing ecological components within a hierarchy of spatial and temporal scales (Wiken 1981, Allen and Starr 1982, Driscoll et al. 2004, O’Neil et al. 1986, Delcourt and Delcourt 1988, Klijn and Udo de Haes 1994, Forman 1995, Bailey 1996). Local-scale features (e.g., vegetation) are nested within regional-scale components, (e.g., climate and physiography) (Figure 1b). Climate, particularly temperature and precipitation, accounts for the largest proportion of global variation in ecosystem structure and function (Walter 1979, Vitousek 1994, Bailey 1998). Within a given climatic zone, physiography (characteristic geologic substrate, surface shape, and relief) controls the rates and spatial arrangements of geomorphic

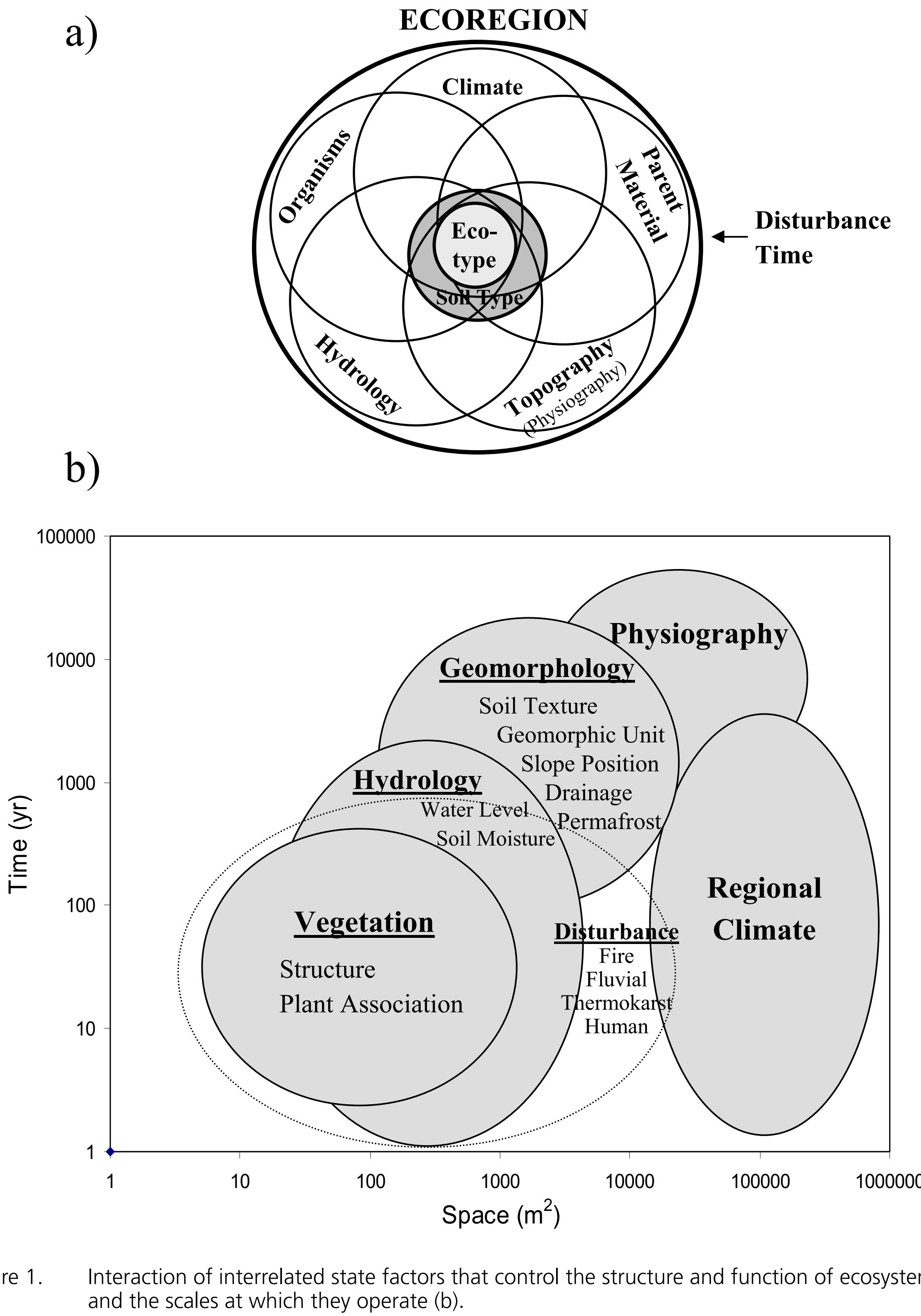


Figure 1. Interaction of interrelated state factors that control the structure and function of ecosystems (a) and the scales at which they operate (b).

processes and energy flow. These processes result in the formation of geomorphic units with characteristic lithologies, textures, and surface forms, which in turn affect soil properties and the movement of water (Wahrhaftig 1965, Swanson et al. 1988, Bailey 1996). Water movement through soil is a critical factor in determining the distribution of vegetation (Fitter and Hay 1987, Oberbauer et al. 1989), due to its influence on both water balance and nutrient availability for plants. Finally, vegetation provides structure and energy that affect the distribution of many wildlife species. The interrelated processes that operate across these components at the various scales can also be sources of disturbance that greatly influence the timing and development of ecosystems (Watt 1947, Pickett et al. 1989, Walker and Walker 1991, Forman 1995). Official systems for classifying ecosystems across scales have been developed for both the United States (Cleland et al. 1997) and Canada (Wiken and Ironside 1977), while the proposed system for Europe incorporates elements of both the U.S. and Canadian systems (Klijn and Udo de Haes 1994).

A hierarchical approach to mapping vegetation and landcover was developed for northern Alaska by Everett and Walker (Everett 1978; Walker 1981, 1983, 1999). They also applied an integrated geobotanical approach to mapping ecosystem components in the Prudhoe Bay region, but did not group the integrated units hierarchically (Walker et al. 1980). Recently, an integrated-terrain-unit (ITU) approach was developed for large-scale mapping of ecosystems on the Arctic Coastal Plain (Jorgenson et al. 1997, Jorgenson et al. 2003a), the entire North Slope (Walker 1999, Jorgenson and Heiner 2003), Wrangell–St. Elias National Park and Preserve (Jorgenson et al., 2008), Cape Krusenstern National Monument and Bering Land Bridge National Preserve (Jorgenson et al., 2004), Yukon-Kuskokwim Delta (Jorgenson 2000), interior Alaska (Jorgenson et al. 1999, Jorgenson et al. 2001), and south-central Alaska (Jorgenson et al. 2003b). The ITU approach also has been used for mapping circumpolar arctic vegetation (Walker et al. 2002).

To implement the ecological land classification portion of the overall mapping effort, we used a simplified ITU approach that incorporates physiography, surface form, and vegetation; these features are readily mapped or modeled. The physiographic units are derived from the existing landscape-level ecological subsection maps for northern Alaska (Jorgenson et al. 2002) and are closely related to surficial geology and geomorphology. The surface forms are derived from the digital elevation model (DEM) (primarily slope-related features). The vegetation classes are derived from the landcover spectral classification. This ITU approach, along with the landscape relationships developed from the analysis of the field survey information, allows us to develop an enhanced set of ecosystem types from remote sensing that essentially differentiate ecosystems at the site level (“ecotypes”) of ecological land classification. This integrated approach has several benefits. First, it incorporates the important effects of geomorphic processes on natural disturbance regimes (e.g., flooding, thermokarst) and the flow of energy and material. Second, it preserves the diversity of environmental characteristics. Finally, it uses a systematic approach to classifying landscape features for applied analyses. To demonstrate one application of this approach, we analyzed the relationships among soil and ecotypes and used these relationships to develop a map of soil landscapes. Thus, the maps can serve as the spatial database with differing ecological components to aid resource managers evaluating ecological impacts and develop land management strategies appropriate for a diversity of landscape conditions.

Specific objectives of the project were to:

1. conduct field inventories of vegetation, soils and environmental characteristics in NOAT, KOVA and GAAR,
2. compile pre-existing field-survey data with data collected by ABR for use in classification and mapping,
3. input the comprehensive data set into analysis of terrain-soil-vegetation for all parks to classify ecotypes based on analysis of vegetation characteristics and relationships among ecological components,
4. classify soil types based on field soil descriptions,
5. develop a spectral database to map ecotypes and soil-landscape maps through processing Landsat ETM+ satellite imagery and rule-based modeling,
6. document survey results for the users of the map, and
7. integrate the landcover maps for the five parks into one seamless map.

Methods

Field Surveys

We conducted field work over a four-year period (Figure 2). Surveys focused on NOAT during 23–31 July 2005 and 19–23 July 2006. Surveys in KOVA were conducted from 25 July- 4 August 2007, and surveys in GAAR were completed during 1–10 August 2008. We used a gradient-directed sampling scheme (Austin and Heyligers 1989) to sample the range of ecological conditions and to provide the spatially-related data needed to interpret ecosystem development. Intensive sampling was done along toposequences (transects) located within major physiographic units, including riverine, lacustrine, lowland, upland, subalpine and alpine areas using the ecological subsection mapping for ARCN (Swanson 2001, Jorgenson 2001, Jorgenson et al. 2002). Data were collected at 763 plots along 91 toposequences. Along each transect, 1–20 plots were sampled, each in a distinct vegetation type or spectral signature identifiable on aerial photographs. All sample locations were located on aerial photographs and coordinates (including approximate elevations) were obtained with a Global Positioning System (GPS) receiver (accuracy ±15 m). At each plot (~10-m radius), descriptions or measurements of geology, hydrology, soil stratigraphy, soil chemistry and vegetation structure and cover were recorded (Appendix 1). Photos were taken at all sample locations. Data and photos are archived at ABR and NPS.

Geologic and surface-form variables recorded include physiography, surface geomorphic unit, slope, aspect, surface form, and height of microrelief. Hydrologic variables measured at each sampling site included depth of water above or below ground surface, depth to saturated soil, pH, and electrical conductivity (EC). Water quality measurements (pH and EC) were made with Oakton or Cole-Palmer portable meters that were calibrated daily with standard solutions.

To assess differences in bedrock chemistry, we collected soils from the C horizon at 39 sites; these samples were sent to the Soil, Plant and Water Testing Laboratory at Colorado State University, Boulder, Co for analysis. Laboratory

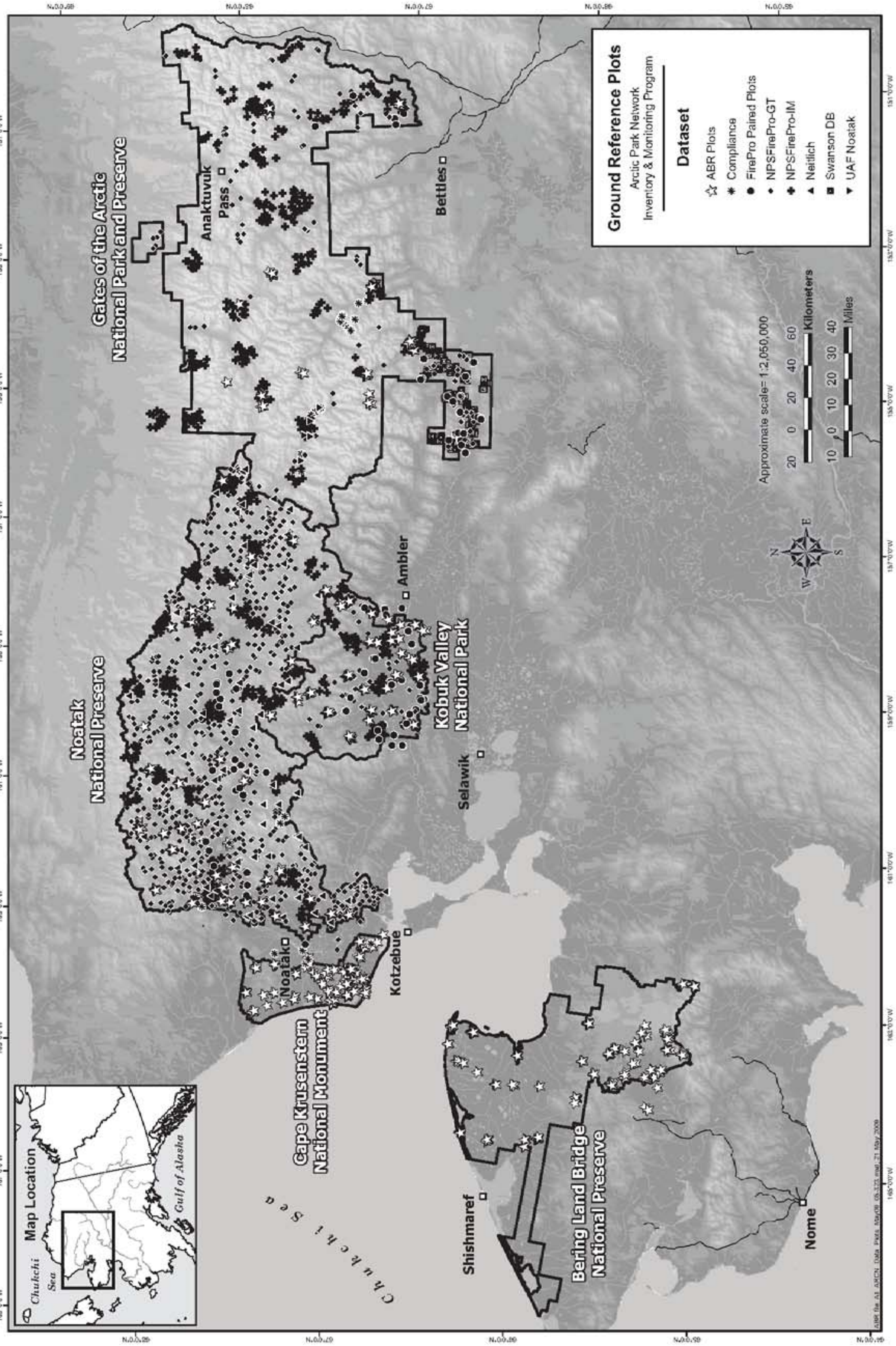


Figure 2. Sampling locations for the ecological land survey and landcover map for the Arctic Network (ARCN) of the National Park Service.

analyses included: (1) routine analyses for pH (paste), EC, organic matter (OM), lime, and extractable (AB-DTPA: NH4HCO3-Ammonium bicarbonate-diethylene triamine pentaacetic acid) NO_3, P, K, Zn, Fe, Cu, Mn; (2) total N and C; and (3) Inductively Coupled Plasma (ICP) analysis after total soil digestion (EPA 3050 Nitric Acid, Perchloric Acid) for Ca, Mg, Na, K, P, Al, Fe, Mn, Ti, Cu, Zn, Ni, Mo, Cd, Sr, Se, Ba, Pb, and V.

Soil stratigraphy was described from a shallow soil core or soil pit at each plot. Most soil profiles were limited to the seasonally thawed layer (~0.5–1 m) above the permafrost and were described from soil plugs dug with a shovel. For all plots, the dominant mineral texture, the depth of surface organic matter, cumulative thickness of all organic horizons, depth to rock (>15% by volume), and depth of thaw were recorded. When water was not present, EC and pH were measured from a saturated soil paste. A single simplified texture (i.e., loamy, sandy, organic) was assigned to characterize the dominant texture in the top 40 cm at each plot for ecotype classification. A more complete soil stratigraphy was described at 322 plots using standard methods (SSS 2003). Detailed soil horizon descriptions were summarized into more general lithofacies classes for the purposes of consolidating sites by depositional setting.

Vegetation composition and structure were assessed semiquantitatively. If cover was <10% or >90%, then cover of each species was visually estimated to the nearest 1%; for cover of 10–90%, it was estimated to the nearest 5%. Isolated individuals or species with very low cover were assigned a cover value of 0.1%. A species list was compiled that included most vascular plants and the dominant nonvascular plants observed in the plot. Although we searched for infrequently occurring and rare species, this project was designed as a field survey and not a comprehensive plant inventory. Total cover of each plant growth form (e.g., tall shrub, dwarf shrub, lichens) was estimated independently of the cover estimates for individual species. Data were cross-checked to ensure that the summed cover of individual species within a growth form category was comparable to the total cover estimated for that growth form. Taxonomic nomenclature is based on Viereck & Little (1972) for trees and shrubs, and Hultén (1968) for all other taxa, with references to currently accepted synonyms throughout the text. We also used floristic data complied by the park for guidance (Parker 2006). Unknown dominant vascular species were identified by Dave Murray and Carolyn Parker, University of Alaska Museum of the North Herbarium (ALA), Fairbanks. Nomenclature for bryophytes and lichens followed the USDA PLANTS National Database (USDA 2008). Identification of mosses and lichens during field sampling was limited to dominant, readily identifiable species. Dominant cryptogams that could not be identified in the field were collected and sent to Mikhail Zhurbenko and Olga Afonina, Komarov Botanical Institute, Russia, for identification. Plant species identified are listed in Appendix 2. The ranking and status of rare plants follows guidelines of the Alaska Natural Heritage Program, which monitors rare and endemic species in Alaska (AKNHP 2007). Notable plant species, including taxa that are rare within Alaska (Rank S3 or less) or that were newly documented within NOAT, KOVA and GAAR, are listed in Appendices 3–6.

Supplementary Data

In order to increase the accuracy of the landcover map, we acquired ecological datasets from several additional sources throughout the duration of the project. These were used for mapping, except for one dataset, which was used for floristic analysis (Table 1). Several datasets

Table 1. Auxilliary datasets used for mapping and analysis purposes. Values in parentheses are number of plots that met the minimal criteria for mapping.

Data Set	Source	Location	Description	Data collection Range	Used for floristic analysis	Used for mapping	Number of Plots
Cooper Arrigetch Data	D. Cooper's PHD thesis	GAAR	Floristic analysis in the Arrigetch Peaks Region.	1980	Yes	No	376 (0) (releves)
GAAR Compliance & Bear Surveys	NPS- BRIM database (J. Chakuchin); Bear Survey photo points (S. Miller)	GAAR	Photo points only	-	No	Yes	53 (49)
NPS Firepro-GT	NPS	GAAR, KOVA, NOAT	Fire Program ground truth data- mixed collection methods, aerial and ground.	1984-1988	No	Yes	1048 (932)
NPS Firepro-IM	NPS	GAAR, KOVA, NOAT	Fire Program intensive mapping data- mostly aerial data.	1985-1992	No	Yes	822 (531)
NPS Firepro-Paired Plots	NPS- J. Allen	GAAR, KOVA, NOAT	Fire Program paired burned and non-burned plot data. High quality location and vegetation data.	1984-1987	No	Yes	174 (116)
NPS- Neitlich	NPS- P. Neitlich	NOAT	Lichen dataset. Used location, site and dominant vascular species data.	2004-2005	No	Yes	88 (84)
NPS Swanson	NPS- D. Swanson	GAAR	Landscape ecosystems data for the Kobuk Boot.	1992-1993	No	Yes	249 (249)
UAF Plot Data	UAF- D. Bret-Harte	NOAT	Shrub expansion data in the upper Noatak River Basin.	2006	No	Yes	45 (45)
Talbot Selawik Data	USFWS- S. Talbot	Selawik NWR	Site and species data in the Refuge	2005	No	Yes	159 (159)
USFWS-Prehoda	USFWS	Selawik NWR	Moose herbivory dataset, only used veg class data.	2004-2005	No	Yes	664 (663)
USFWS-SVMP	USFWS	Selawik NWR	Vegetation dataset for land-cover mapping	1996 & 1998	No	Yes	98 (92)

contained vegetation and site environmental factors and were mostly comparable to ABR's. The majority of these additional data points were obtained from the NPS Fire Program (Firepro), including ground-truth (GT) and intensive mapping (IM) data (NPS 2005), and a paired-plot (PP) data set (Allen, unpublished data). Another large dataset consisted of ecosystem data from the Kobuk Boot of GAAR (Swanson 1995), and a smaller dataset focused on eastern NOAT (Bret-Harte et al. 2007). Additionally, we attained several other datasets with useful but more limited data (Table 1), primarily site data and photos. These data were primarily useful for mapping. Most data were in electronic format when acquired although some were entered from original field sheets. We entered floristic data from a study in the Arrigetch Peaks region of GAAR from a doctoral thesis (Cooper 1983).

The final major component of the comprehensive data consisted of three ecological datasets in the Selawik National Wildlife Refuge (SELA) adjacent to KOVA (Table 1). ABR, Inc. collected field data for an ELS and landcover map for SELA during 2007–2008 (Jorgenson et al. in prep) and these data were compiled with the ARCN data to create a seamless map for both management units. Two additional datasets in SELA were acquired from the U.S. Fish and Wildlife Service (USFWS) and were appended to the database.

Data Management

Data were processed through several screening steps. All datasets were imported into a comprehensive Microsoft Access database and variable codes were converted into ABR's coding system. Plot photos were linked to plot data, and the entire dataset was run through quality control routines. Records that lacked location data (excepting Cooper 1983), were excluded from the dataset; as were records without photos that had sparse or suspect data. In addition, plot locations were screened using a Geographic Information System (GIS). In some cases we moved plot locations to an area that was more accurate based on the plot data and photos (i.e. moving water plots into lakes from the margins). This was primarily applied to the FirePro IM plot data because location coordinates were mathematically derived from the centroids of map polygons (NPS 2005), resulting in coordinates that occurred outside of irregularly shaped polygons. We screened plots against fire history data and excluded plots where fire disturbance or post-fire succession effects have affected accuracy of the data. For example, data collected at plots that burned 25 years ago and were sampled 20 years ago would not accurately reflect current conditions. For some variables, such as water, organic matter, or thaw depth, the measured parameter occurred below the depth of observation. For water we assigned 2 m in the final observation field for analysis. For organic matter and thaw depth we assigned a rough estimate for analysis. Results of analysis for these parameters involving these estimates are noted with an asterisk in appropriate tables.

Ecological Classification

Ecosystems were classified at two levels. First, individual ecological components were classified and coded using standard classification systems developed for Alaska. Second, these ecological components were integrated to classify ecotypes (local-scale ecosystems) that best partitioned the range of variation for all the measured components.

Ecological Components

Geomorphic units were classified according to a system based on landform-soil characteristics for Alaska, originally developed by Kreig and Reger (1982) and the Alaska Division of Geological and Geophysical Survey (1983), and modified for this study. We relied on previous landscape analysis of northern Alaska (Jorgenson et al. 2002) as a guide to our identification of geomorphic and geologic units. We emphasized materials near the surface (<2 m) because they have the greatest influence on ecological processes. Within the geomorphic classification, we also classified waterbodies based on their depth, salinity, and genesis.

Surface forms (macrotopography) were classified according to a system modified from that of Schoeneberger et al. (1998). Microtopography was classified according to the periglacial system of Washburn (1973).

Vegetation generally was classified in the field to Level IV of the Alaska Vegetation Classification (AVC) developed by Viereck et al. (1992). Additionally, plant associations were classified and named according to standard methods (Vegetation Subcommittee 2008, Jennings et al. 2009). First, unknown specimens were identified and taxonomic nomenclature resolved for species with varying level of identification. Second, vegetation data (species cover by plot) were ordered into species groups using Program R (http://www. cran.r-project. org/). Third, sorted table analyses (Mueller-Dombois and Ellenberg 1974) were used to refine the groups and identify potential outlier plots. Finally, non-metric multidimensional scaling was used to chart the plots in species space to assess their dispersion and further identify outliers. After groups were finalized, each plant association was identified by dominant and characteristic species.

Ecotypes

Classification of ecotypes was accomplished in three general steps: (1) the ecological components were individually classified for each detailed ground description, (2) relationships along transects were examined to illustrate trends across the landscape, and (3) contingency tables were used to identify the common relationships and central tendencies among ecological components. In developing the ecotype classes, we emphasized ecological characteristics (primarily geomorphology and vegetation structure) that could be interpreted from aerial photographs. We also developed a nomenclature for ecotypes that describes ecological characteristics (climate, physiography, soil chemistry, moisture, vegetation structure, and dominant species) using a terminology that can be easily understood.

To reduce the number of ecotype classes, we aggregated the field data for individual ecological components (e.g., soil stratigraphy and vegetation composition), using a hierarchical approach. Geomorphic units were assigned to physiographic settings based on their erosional or depositional processes. Surface-forms were aggregated into a reduced set of slope elements (crest, upper slope, lower slope, toe, and flat). For vegetation, we used the structural levels of the AVC (Viereck et al. 1992), because they are readily identifiable on aerial photographs and a typical species common name (e.g., White Spruce Forest). Frequently, we grouped textural classes because the vegetation associated with them was similar, and some vegetation structures (e.g., open and closed shrub) were grouped because their species composition was similar. Full ecotype names were then based on the aggregated ecological components and include physiography, texture, soil moisture, chemistry, and vegetation (e.g., Riverine Gravelly Dry Circumalkaline Spruce–Poplar Forest).

Ecotypes are similar in concept to the Landtype Phase of the national ECOMAP classification (Cleland et al. 1997) and "ecotope" of Klijn et al. (1994), but we chose to use the term "ecotype" because it is a simple conjuntion of "ecosytem type" and because many tundra ecosystems have long persisting plant associations that do not have readily identifiable successional stages as indicated by the landtype phase (successional stage).

Common relationships among ecosystem components were identified by use of contingency tables. The contingency tables sorted plots by physiography, soil texture, geomorphic unit, slope position, drainage, soil chemistry (pH and salinity), vegetation structure, and plant association. From these tables, common associations were identified and unusual associations either were lumped with those having similar characteristics or excluded as atypical (outliers). Finally, ecotype names were abbreviated to emphasize primary characteristics of the class and facilitate discussion (e.g., Boreal Riverine Spruce–Poplar Forest). The resulting final ecotypes were used for mapping and to summarize the ground data.

Soils

Soils were classified to the soil subgroup level according to NRCS soil taxonomy, Ninth Edition (NRCS 2003). When data needed for the taxonomic keys were not available, a best guess was used when assigning classes. For example, it was difficult to determine if permafrost was present in rocky soils. Consequently, permafrost was assumed to be present in alpine environments assuming mean annual air temperatures were low. Similarly, differentiating eutrocryepts from dystrocryepts was based on a cutpoint of 5.5 for the pH reaction, although the actual diagnostic criteria is based on a cutpoint of 60% base saturation from laboratory analyses.

Soil landscapes were developed to characterize and map broader relationships among soil type, physiography, and vegetation. The soil landscapes were developed by cross-tabulating ecotypes and soil subgroups to identify associations of similar ecotypes that group with similar soil subgroups. The resulting associations were named based on physiography, soil texture, and dominant vegetation structure (e.g., dwarf shrub, woodland forest).

We did not use the standard NRCS term "soil association" because that term has a specific concept of widely differing soils being associated with each other across a repeating toposequence across the landscape. In addition, "soil associations" are used in mapping to be large map units with aggregated soil types. In our situation where the map is based on the 28-m pixel size, the term "soil landscape" is meant to be closely related soil types on a portion of the landscape at a large mapping scale.

Ecosystem Components Synthesis

Ecosystem components were analyzed to identify responses to evolving landscapes comprising a wide variety of geomorphic processes associated with physiographic regimes within ARCN. Identification of the patterns associated with geomorphic units and vegetation, along with analysis of changes in soil properties within physiographic settings, helps identify processes (e.g., acidification, sedimentation) that affect the changing patterns on the landscape. Understanding these ecological relationships provided parameters to recode the ecotype map into a derived map of other ecological characteristics, such as a soils map or a lichen map (see Section on Soils).

The contingency table analysis also was used to evaluate how well these general relationships conformed to the data set, and how reliably they could be used to extrapolate trends across the landscape. During development of the relationships, outliers were excluded from the table because of inconsistencies among physiography, texture, geomorphology, drainage, soil chemistry, and vegetation. We excluded these points because our primary goal was to identify the most distinct and consistent trends. These sites may be transitional ecotones, or sites where vegetation and soils have been affected by historical factors (e.g., changes in water levels, disturbances) in ways that are not readily explainable based on current environmental conditions.

Landcover and Ecosystem Mapping

Landsat Imagery Preprocessing

Acquistion

Enhanced Thematic Mapper Plus (ETM+) imagery was reviewed for the study area and a period in late July and early August 2002 was identified that provided nearly complete cloud-free cover of the study area. Additional ETM+ and Thematic Mapper (TM) scenes were acquired to fill in holes that were cloudy or hazy. Three different sources of Landsat data were used. First, we worked with the National Park Service to order several scenes which covered most of the study area. Second, circa 2000 GeoCover scenes were downloaded from the Goddard Land Cover Facility. Finally, additional scenes as well as new versions of the previously acquired scenes were ordered after the USGS opened the entire Landsat archive for free access starting in September 2008. These three data sources had some different processing parameters (Appendix 7). After the USGS free Landsat program went into effect, the capability to order scenes using user-specified processing parameters was removed. A flow chart demonstrating the imaging processing routine is in Figure 3.

Reprojection and Georeferencing

Following selection and import of the Landsat data from various sources, all of the imagery was reprojected and georeferenced to a consistent coordinate system and resolution. The project horizontal coordinate system is the Alaska Albers Conical Equal Area, NAD1983 horizontal datum. A pixel resolution of 28.5-m was selected as this is closest to the actual pixel resolution. The raster cell alignment followed the same convention as the GeoCover imagery. This results in a cell alignment where the center of one pixel would be located at (0,0) in the target coordinate system.

The GeoCover and most of the USGS imagery was precision terrain corrected. That is, it was geolocated with subpixel accuracy to match the circa 1990 GeoCover global Landsat mosaic. An informal assessment of the geolocation accuracy of the precision terrain corrected imagery was conducted. It was compared to a set of GPS tracks that followed water body edges and to the orthorectified IKONOS imagery. These comparisons indicated that the precision terrain corrected imagery was generally within ~15-m of these other independent data sources. Based on this finding, precision terrain corrected scenes were simply reprojected into the project coordinate system (all precision terrain corrected scenes were in a Universal Transverse Mercator (UTM) coordinate system). The non-precision terrain corrected scenes were georeferenced to a panchromatic (14.25 m) mosaic constructed from the precision terrain corrected scenes using first- or second-order polynomials.

When reprojecting or georeferencing Landsat scenes, the resampling algorithm is important. Nearest-neighbor (NN) resampling preserves the original pixel values, but introduces geolocation errors of up to a half pixel horizontally and vertically. Cubic convolution (CC) resampling alters pixel values but does a

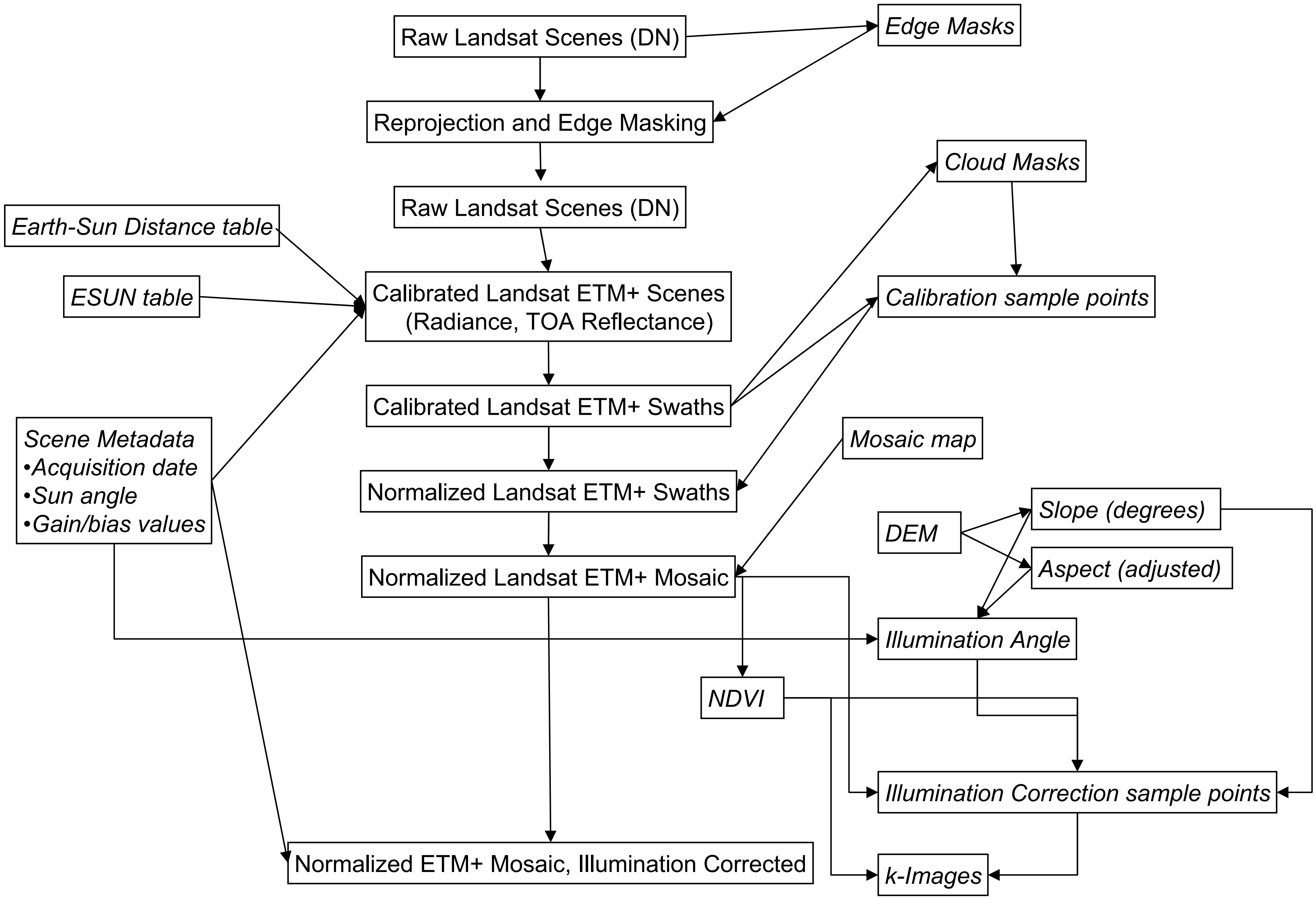


Figure 3. Flowchart illustrating image processing steps for creating the landcover map. DN = Digital Number. DEM = Digital Elevation Model. NDVI = Normalized Difference Vegetation Index

better job of preserving image smoothness and geolocation. Generally, the NN approach is preferred when performing a single image analysis such as classification. However, the CC approach produces better results when comparing one image to another, as in the radiometric normalization. The resampling history of the scenes used for the classification depended on the source. The NPS scenes were processed by the data provider with NN resampling and were then georeferenced using NN resampling a second time. The GeoCover scenes were processed by the data provider with the NN resampling and were then reprojected using NN resampling. Finally, the USGS free Landsat scenes were processed by the data provider with CC resampling and were then reprojected using NN resampling.

Edge Masking

Following reprojection all of the scenes were masked to remove both inconsistent edge data and large empty borders. The USGS scenes include all of the data for each band, including at the edges where the coverage of each band is different. Also, the cubic convolution resampling results in spurious values at the top and bottom of the scenes where the zero (background) values affect the resulting pixel values. An edge mask was manually digitized for each scene to remove these edge artifacts.

Radiometric Calibration

The scenes were then converted to top-of-atmosphere reflectance using the scene metadata and calibration coefficients from the Landsat 7 Science Data Users Handbook (http://landsathandbook.gsfc.nasa.gov/handbook.html). Landsat 5 data was calibrated using the coefficients from Chander et al. 2009. The scenes were stored in a 16-bit format to preserve precision. Adjacent scenes from the same acquisition date were then mosaicked into swaths.

Radiometric Normalization

The primary reference image for the mosaic was the Landsat ETM+ scenes acquired July 29, 2002 (path 78, rows 13–15). The objective of radiometric normalization is to correct the other scenes so that their pixel values are compatible with those of the reference images. Mainly this corrects for the effect of different atmospheric conditions on different acquisition dates. Scenes that did not overlap the primary swath were normalized using Landsat images that had already been normalized.

A set of stratified random points was generated for the mosaic area. Stratification ensured that the full range of scene brightness was represented, including rarer, bright pixels. Points within a preliminary cloud mask were excluded. Random points were used to sample the reference image and the target images. The resulting values were assessed interactively using scatterplots in ArcMap V. 9.3 (ESRI, Redlands, CA). The sample set was screened and, typically, snow, small clouds, and calibration points located near abrupt brightness changes were filtered out. A table containing the resulting set of filtered points was analyzed in a statistical package to determine linear regression coefficients. The normalization then applied these coefficients to the target image.

Mosaicking

A mosaic map layer (a non-overlapping vector polygon dataset) was maintained that identified which scene will be passed through to the final mosaic for each region of the study area. The construction of the final mosaic was an iterative process where a mosaic was created and then reviewed visually. Adjustments were made to the mosaic map layer, the mosaic was regenerated, and the process was repeated. When completed, the mosaic was maintained at 16-bit radiometric resolution (reflectance scaled by 10,000). In addition, an 8-bit version following the MRLC2001 convention (USGS 2006) was produced. The 8-bit version stored reflectance scaled by 400, and truncated at 0.6375. The mosaic map layer allows the scene specific information (such as solar elevation and azimuth) to be compiled for all portions of the mosaic.

Illumination Normalization

The radiometric calibration and normalization techniques described above do not address the problem of topographic effects on remote-sensing imagery. The Arctic Network parks contain extensive mountainous terrain, where these topographic effects are most pronounced. At high latitudes, sun angles are low, further increasing topographic effects. An illumination normalization procedure was performed to minimize these topographic effects. A backwards radiance correction transformation (Colby 1991) was performed. Rather than using a single Minnaert constant (*k)* for each band, a *k*-image was constructed for each band, similar to the procedure used by Lu et al. (2008). Lu et al. related the *k* value to slope, while we related the *k* value to the Normalized Difference Vegetation Index (NDVI). NDVI is fairly resistant to topographic effects and was used to distinguish a gradient of barren, partially vegetated and densely vegetated landcover types for the illumination normalization. An arc-second National Elevation Dataset Digital Elevation Model (NED DEM, about 30 by 60 m native resolution), reprojected to Alaska Albers NAD1983, with 28.5-m resolution and CC resampling was used. The geolocation of the DEM was assessed as part of the illumination normalization procedure and adjustment of the DEM was considered.

To perform the illumination correction, the DEM data were compiled and several derivatives were calculated. These include the slope, aspect, and illumination angle (which varies with sun-sensor geometry). The adjusted aspect (corrected for the map projection distortion; see below) was used for this analysis. Areas without direct sunlight were masked out using the ArcGIS hillshade function to model shadows. Stratified random points were generated, ensuring that a full range of illumination and brightness conditions are sampled. The points were used to sample the mosaic pixel values, DEM derivatives, and NDVI. The samples were reviewed and filtered interactively. An analysis of how the estimated *k*-value varied with band, slope, and NDVI was conducted, and models were produced to calculate *k*-images for each band as a function of NDVI. The *k*-images were applied in the backwards radiance correction transformation to produce a normalized mosaic in floating point formats. The mosaic was converted to 8-bit format using the MRLC conventions (reflectance scaled by 400, and truncated at 0.6375).

Spectral Classification Development

Preliminary Unsupervised Classifications

Several preliminary unsupervised classifications were generated from the illumination normalized mosaic. These were intended primarily to identify spectrally homogeneous patches to guide the supervised training set development. The mosaic was stratified using NDVI thresholds to segregate the image into vegetated and non-vegetated strata. Initially values greater than 0.3 were assigned to a vegetated strata and unsupervised classifications were performed in ERDAS Imagine 9.3.1 to generate preliminary spectral classes.

Three unsupervised vegetated strata classifications were produced, with 50, 75, and 100 classes (referred to as Veg50, Veg75 and Veg100). A 25-class non-vegetated strata classification (Nonveg25) was also produced based on pixels with NDVI less than or equal to 0.3. A 75-class non-vegetated strata classification (Nonveg75) was produced from pixels with NDVI less than or equal to 0.4.

Supervised Training Set Development

Plot locations were displayed in ArcGIS overlaid on the Landsat image mosaic, IKONOS imagery, and the preliminary unsupervised classifications. Training polygons were digitized so that they included a discrete vegetation patch consistent with interpretation of the plot data, Landsat imagery and IKONOS imagery. In addition the training polygons should be at least 10 Landsat pixels in area and should include a maximum of one or two spectral classes in at least one of the unsupervised strata (Veg50, Veg75, Veg100, or Nonveg75).

Some training polygons were digitized in areas without plot data. These non-plot training polygons were mainly generated for non-vegetated or partially vegetated types, primarily water and barrens. These types could be easily recognized on the IKONOS imagery and/or the Landsat mosaic. In addition, some non-plot training polygons were digitized over types for which plot data was rare, but which could be reliably distinguished on the IKONOS imagery.

The training polygons were compiled into a comprehensive vector GIS dataset. The training polygons were labeled with the plot GID based on an overlay with the plot points. The polygons were converted to a raster at the same resolution and cell alignment as the Landsat mosaic. The raster included all pixels whose center was contained within the polygon boundary. The training polygons were used to generate maximum likelihood signatures for each training polygon. The plot data, pixel data, and signature data for each training polygon was saved to a spectral database in Microsoft Access format. Several criteria were applied to remove problematic signatures—for example, those with a covariance matrix that was not invertible; those below the size threshold of ten pixels; and those with high spectral heterogeneity based on the diversity of classes from the preliminary unsupervised classifications.

Signature separability was evaluated based on the Bhattacharyya distance (which is also used to calculate the Jeffries-Matsushita distance commonly used). Lee and Choi (2000) estimated the probability of class confusion between two normally distributed maximum likelihood signatures. Pairs of signatures with high probabilities of confusion were reviewed and in this problematic training polygons and/or plot data were identified. Training polygons were revised or deleted to improve spectral separability. In addition a spectral cluster analysis was performed and overlap among similar signatures identified. Signature clusters were compared with ecotypes and poorly characterized signatures were eliminated. Signature fidelity (self-classification) was evaluated by assessing the classification of the pixels within training polygons. Training polygons that did not classify to the correct vegetation class (Viereck Level 4) with a frequency of at least 70% were reviewed carefully.

The classification area was stratified based on physiography, geology and treeline layers that were developed for this project. Each stratum was classified independently, with a set of signatures based on a lookup table for each stratum. Pixels that were not classified with high confidence were reclassified using the full signature set.

Coastal and riverine physiographic zones were derived from ecosubsection mapping (Jorgenson et al. 1992). Alpine and sub-alpine zones were derived from lower and upper elevation cutpoints defined for points on a 100-km grid. The remaining area was comprised of upland and lowland physiographies, which were often difficult to distinguish using subsections or topographic metrics. Some upland and lowland zones were defined using topographic metrics while much of the area was categorized to upland or lowland based on spectral signatures.

For the alpine and sub-alpine strata, the ecosubsection mapping was used to categorize the predominant geology and substrate chemistry into four classes: acidic/circumacidic, alkaline/circumalkaline, alkaline, and mafic. A treeline layer was developed to delineate regions where no trees were present (tundra), white spruce was present (boreal white spruce), and black spruce was also present (boreal black spruce). This was based primarily on the linework from the subsection mapping with some editing.

The completed classification was reviewed for consistency across the landscape and appropriate regional specificity. Some signatures were removed because they failed to classify well consistently and some signatures were restricted to particular regions using the ecosubsection mapping.

Results

Ecotypes and Plant Associations

Descriptions of 69 ecotypes are presented for ARCN (Tables 2–135). They were defined by general distribution, landscape features, plant associations, dominant plant species, dominant soil textures and chemistry, and hydrologic characteristics. A key to these ecotypes is provided in Table 136. Most ecotypes were only associated with a single plant association, however 10 ecotypes had multiple plant associations, and 11 plant associations were used to describe more than one ecotype. This overlap resulted from communities that were floristically comparable but had very different site factors (i.e. alpine communities on different bedrock types), or from communities that were immediately adjacent in a successional sequence (e.g., Riverine Poplar Forest and Riverine Spruce–Poplar Forest). There were a total of 64 plant associations. We did not describe or map an additional 7 ecotypes that were uncommon.

Ecotypes and Plant Associations

Alpine Acidic Barrens

Geomorphology:

This ecotype occurs throughout ARCN on non-carbonate bedrock, hillside colluvium, and talus. Bedrock types include granite, schist, sandstone and shale. It is typically found on upper slopes and crests at greater than 500 m elevation. Slope varies from gradual to steep, and it occurs at all aspects.

Plant Association:

Dryas octopetala–Hierochloe alpina

Fruticose lichen–*Racomitrium* sp.–*Cassiope tetragona*

Alpine Acidic Barrens is diverse in nonvascular plants, which can have up to 75% cover (Table 2). Lichens are more common than mosses due to dry soils. Individual species cover is usually less than 5%. Trees and shrubs taller than 20 cm are absent. Common species include *Cassiope tetragona*, *Selaginella sibirica*, *Hierochloe alpina*, *Flavocetraria nivalis*, and *Cladina stellaris*.

Alpine Acidic Barrens is most similar to Alpine Alkaline Barrens and Alpine Mafic Barrens, but has different parent material with lower pH and lower total species diversity, but higher lichen diversity. It is also similar to Alpine Acidic Dryas Dwarf Shrub and Alpine Acidic Ericaceous Dwarf Shrub, but with lower species cover.

Soils:

Soils are blocky or rubbly and surface organic horizons are very thin or completely lacking (Table 3). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m due to the cold temperatures at the high elevations. Frost boils are uncommon, and surface fragments are common and abundant. Loess caps are absent. Soil pH is acidic to circumneutral, and electrical conductivity (EC) is generally low. The soils are typically excessively to somewhat excessively drained. Depth to water table often could not be

Table 2. Vegetation cover and frequency for Alpine Acidic Barrens (n=43).

	Cover		Freq
	Mean	SD	%
Total Live Cover	115.1	46.6	100
Total Vascular Cover	31.1	22.8	94
Total Evergreen Tree Cover	0.0	0.0	3
Total Evergreen Shrub Cover	14.6	14.4	91
Cassiope tetragona	11.1	13.0	71
Diapensia lapponica	0.2	0.7	17
Dryas octopetala	0.4	1.3	11
Empetrum nigrum	0.1	0.3	14
Juniperus communis	<0.1	0.2	6
Ledum decumbens	0.6	2.1	26
Loiseleuria procumbens	0.6	2.0	23
Vaccinium vitis-idaea	1.7	2.9	49
Total Deciduous Tree Cover	0.0	0.0	3
Total Deciduous Shrub Cover	2.6	4.6	63
Arctostaphylos alpina	0.1	0.2	6
Rosa acicularis	<0.1	0.2	6
Salix phlebophylla	0.1	0.5	9
Salix planifolia ssp. *pulchra*	0.1	0.5	14
Salix polaris	0.2	0.9	9
Salix reticulata	0.3	1.7	6
Salix rotundifolia	0.8	3.3	14
Vaccinium uliginosum	0.8	3.0	26
Viburnum edule	0.1	0.3	6
Total Forb Cover	3.3	4.8	86
Anemone narcissiflora	0.9	1.4	46
Antennaria rosea	0.1	0.3	3
Arnica lessingii	<0.1	0.2	6
Artemisia alaskana	0.1	0.5	6
Artemisia arctica ssp. *arctica*	0.1	0.5	6
Campanula lasiocarpa	0.1	0.2	17
Cardamine bellidifolia	<0.1	0.2	17
Dryopteris fragrans	0.1	0.8	3
Epilobium angustifolium	0.5	1.8	11
Galium boreale	<0.1	0.2	6
Lycopodium selago	0.2	0.3	34
Minuartia macrocarpa	0.1	0.3	11
Pedicularis kanei	0.1	0.2	11
Polygonum bistorta	0.2	1.0	3
Saxifraga bronchialis	0.3	1.1	14
Saxifraga oppositifolia	0.1	0.3	3
Saxifraga reflexa	<0.1	0.2	6
Selaginella sibirica	0.1	0.3	17
Woodsia ilvensis	0.1	0.7	3
Total Grass Cover	4.0	4.5	80
Calamagrostis canadensis	0.2	1.0	3
Festuca altaica	0.1	0.2	6
Hierochloe alpina	3.6	4.5	77
Poa glauca	0.1	0.2	9
Total Sedge & Rush Cover	6.5	9.8	86
Carex microchaeta	5.7	9.9	60
Carex podocarpa	0.6	1.4	31
Luzula arcuata	0.2	0.9	11
Total Nonvascular Cover	84.0	32.3	100
Total Moss Cover	4.8	4.3	89
Anastrophyllum sp.	0.1	0.2	14
Chandonanthus sp.	0.2	0.5	31
Dicranum sp.	0.3	0.9	20
Pohlia sp.	<0.1	0.2	9

Table 2. Continued.

	Cover		Freq
	Mean	SD	%
Polytrichastrum alpinum	0.3	1.0	9
Polytrichum juniperinum	0.1	0.5	9
Polytrichum piliferum	0.2	0.7	6
Polytrichum sp.	0.2	0.6	23
Polytrichum strictum	0.2	0.5	26
Racomitrium lanuginosum	1.2	2.6	29
Racomitrium sp.	1.6	2.4	49
Unknown moss	0.1	0.6	9
Total Lichen Cover	79.2	31.4	100
Alectoria ochroleuca	0.2	0.8	9
Alectoria sp.	0.3	0.6	17
Arctoparmelia sp.	0.1	0.4	9
Asahinea chrysantha	0.2	0.7	14
Asahinea sp.	0.1	0.2	9
Cetraria cf. *islandica*	0.2	0.7	14
Cetraria nigricans	0.4	1.8	11
Cetraria sp.	1.3	2.0	49
Cladina arbuscula	10.5	11.3	63
Cladina mitis	0.3	0.9	11
Cladina rangiferina	6.2	6.7	60
Cladina stellaris	33.3	31.4	71
Cladina stygia	0.4	1.1	11
Cladonia amaurocraea	0.2	0.9	6
Cladonia sp.	2.4	2.6	80
Dactylina sp.	0.8	1.1	51
Flavocetraria cucullata	2.0	3.3	51
Flavocetraria nivalis	0.8	1.7	46
Lobaria linita	0.1	0.8	6
Masonhalea richardsonii	0.2	0.5	17
Nephroma arcticum	0.1	0.2	6
Parmelia omphalodes	0.8	3.5	9
Parmelia sp.	0.2	1.0	14
Rhizocarpon geographicum	0.7	2.3	14
Rhizocarpon sp.	0.6	3.4	3
Sphaerophorus fragilis	0.1	0.7	6
Sphaerophorus sp.	0.3	0.7	14
Stereocaulon sp.	0.1	0.2	9
Stereocaulon subcoralloides	1.0	5.9	6
Thamnolia sp.	0.6	0.9	43
Thamnolia vermicularis	0.2	0.5	29
Umbilicaria caroliniana	0.3	1.4	9
Umbilicaria proboscidea	0.8	2.4	26
Umbilicaria sp.	0.7	2.1	17
Unknown crustose lichen	6.8	16.1	23
Unknown foliose/fruticose lichen	2.3	9.4	6
Unknown lichen	2.3	7.9	14
Xanthoria sp.	<0.1	0.2	6
Total Bare Ground	20.9	27.6	43
Bare Soil	20.6	27.4	43
Litter alone	0.2	0.6	34

measured but it is assumed to be at substantial depths given the well drained soils.

Table 3. Soil characteristics for Alpine Acidic Barrens.

Property	Mean	SD	n
Elevation (m)	713.1	213.0	15
Slope (degrees)	22.2	14.9	13
Surface Organics Depth(cm)	2.0	1.4	2
Cumulative Org. in 40 cm (cm)	2.0	1.4	2
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	7.0	4.2	2
Surface Fragment Cover (%)	92.9	10.6	7
Frost Boil Cover (%)	4.8	6.8	4
Thaw Depth (cm)	36.0	22.6	2
Site pH at 10-cm depth	4.8	0.5	10
Site EC at 10-cm depth (µS/cm)	43.0	25.4	10
Water Depth (cm,+ above grnd)[a]	-187.7	42.7	12

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Gelorthents (poorly developed with permafrost below 1 m) and Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m). Less common subgroups include Lithic Cryorthents (poorly developed, <50 cm to bedrock, permafrost lacking), Lithic Haploturbels (<50 cm to bedrock, permafrost within 1 m, with cryoturbation), Typic Haploturbels (mineral soil over permafrost with cryoturbation), and Lithic Dystrogelepts (<50 cm to bedrock, acidic, partially developed, permafrost below 1 m). This ecotype and associated soils are part of the Alpine Rocky Acidic Barrens and Shrub soil landscape. Also included in this soil landscape are Alpine Acidic Dryas Dwarf Shrub and Alpine Ericaceous–Dryas Dwarf Shrub.

Alpine Acidic Dryas Dwarf Shrub

Geomorphology:

This is one of the most common alpine ecotypes in ARCN and provides quality habitat for Dall's sheep, marmots and ground squirrels. It occurs on weathered bedrock, hillside colluvium, older moraine and solifluction deposits. It mainly occurs on ridge crests, slopes and plateaus, generally between 450 and 900 m elevation. Slopes are typically gentle and this ecotype occurs on all aspects.

Plant Association:

Dryas octopetala–Hierochloe alpina

Alpine Acidic Dryas Dwarf Shrub has the 3rd highest average number of species per plot and the 3rd highest total species count overall (Table 4). We documented two rare species, *Arenaria chamissonis* (syn: *Stellaria dicranoides*) and *Oxytropis kokrinensis* in this ecotype. Trees and tall shrubs are absent. Dwarf shrubs and lichens are the most common life forms. Most species except *Dryas octopetala* have less than 3% cover. Common species include *Dryas octopetala*, *Vaccinium vitis-idaea*, *Saxifraga bronchialis*, *Hierochloe alpina*, *Flavocetraria nivalis* and *Flavocetraria cucullata*.

This ecotype is similar to Alpine Acidic Barrens, except it has higher species cover, and Alpine Ericaceous–Dryas Dwarf Shrub, but differs in the reduced presence of Ericaceous dwarf shrubs. It has different species assemblages relative to the alpine alkaline ecotypes.

Soils:

Soils are blocky or rubbly and are overlain by thin organic horizons (Table 5). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m due to the cold temperatures at the high elevations. Frost boils are uncommon, and surface fragments are

Table 4. Vegetation cover and frequency for Alpine Acidic Dryas Dwarf Shrub (n=21).

	Cover		Freq
	Mean	SD	%
Total Live Cover	86.1	29.7	100
Total Vascular Cover	51.7	25.4	100
Total Evergreen Shrub Cover	31.1	14.5	100
Cassiope tetragona	0.5	1.3	37
Diapensia lapponica	0.8	1.6	47
Dryas octopetala	23.3	18.0	84
Dryas octopetala ssp. *alaskensis*	3.7	11.0	11
Empetrum nigrum	0.4	0.8	32
Ledum decumbens	0.2	0.5	21
Loiseleuria procumbens	0.5	1.6	26
Vaccinium vitis-idaea	1.3	2.0	58
Total Deciduous Shrub Cover	9.5	6.6	95
Arctostaphylos alpina	0.8	2.3	32
Betula nana	0.5	1.0	32
Salix arctica	0.2	0.6	21
Salix glauca	0.1	0.2	16
Salix phlebophylla	3.2	3.7	68
Salix planifolia ssp. *pulchra*	0.1	0.2	16
Salix polaris	0.5	1.6	16
Salix reticulata	1.0	3.4	32
Salix rotundifolia	0.9	2.5	16
Vaccinium uliginosum	1.7	3.1	68
Total Forb Cover	7.3	6.7	100
Anemone narcissiflora	0.2	0.4	53
Antennaria friesiana	0.3	0.4	68
Arnica alpina ssp. *angustifolia*	0.1	0.2	16
Arnica lessingii	0.3	1.2	21
Artemisia arctica ssp. *arctica*	0.4	0.7	53
Campanula lasiocarpa	0.1	0.2	47
Castilleja hyperborea	0.1	0.2	16
Epilobium latifolium	0.1	0.2	11
Geum glaciale	0.1	0.5	16
Lupinus arcticus	0.4	1.2	16
Minuartia arctica	0.6	0.9	58
Oxytropis arctica	0.2	0.5	21
Oxytropis bryophila	0.1	0.3	21
Oxytropis nigrescens	0.2	0.6	11
Pedicularis capitata	0.1	0.2	37
Polygonum bistorta	0.1	0.5	21
Polygonum viviparum	0.2	0.6	21
Potentilla uniflora	0.3	0.5	53
Saxifraga bronchialis	0.3	0.6	68
Saxifraga eschscholtzii	0.1	0.2	16
Saxifraga flagellaris	0.1	0.2	21
Selaginella selaginoides	0.4	1.1	16
Selaginella sibirica	0.6	1.1	47
Senecio fuscatus	0.1	0.2	16
Total Grass Cover	2.1	1.8	100
Festuca altaica	0.3	1.2	21
Hierochloe alpina	1.1	1.3	89
Poa arctica	0.2	0.4	47
Poa glauca	0.1	0.5	32
Trisetum spicatum ssp. *spicatum*	0.1	0.3	53
Total Sedge & Rush Cover	1.7	2.8	89

Table 4. Continued.

	Cover Mean	Cover SD	Freq %
Carex microchaeta	0.4	0.8	47
Carex podocarpa	0.5	1.8	37
Carex scirpoidea	0.1	0.5	21
Luzula arctica	0.1	0.2	11
Total Nonvascular Cover	34.4	15.4	100
Total Moss Cover	8.2	9.1	100
Abietinella abietina	1.1	4.6	11
Dicranum sp.	0.5	1.0	21
Polytrichum piliferum	0.4	1.0	16
Polytrichum sp.	0.6	1.3	42
Racomitrium lanuginosum	1.2	2.0	53
Rhizomnium sp.	0.5	1.6	11
Rhytidium rugosum	1.7	2.7	47
Unknown moss	0.4	0.8	21
Total Lichen Cover	25.9	14.1	100
Alectoria ochroleuca	0.6	1.3	37
Alectoria sp.	0.2	0.5	11
Asahinea chrysantha	0.6	1.1	32
Asahinea sp.	0.1	0.2	16
Bryocaulon divergens	1.0	1.3	53
Bryoria nitidula	0.2	0.5	11
Bryoria sp.	0.3	1.2	11
Cetraria cf. *islandica*	0.5	0.8	42
Cetraria nigricans	0.8	2.0	32
Cladina arbuscula	0.3	0.8	16
Cladina rangiferina	0.5	1.2	16
Cladina sp.	0.4	1.2	11
Cladonia coccifera	0.2	0.5	11
Cladonia sp.	0.5	0.7	53
Cladonia subfurcata	0.1	0.5	16
Flavocetraria cucullata	1.2	1.4	79
Flavocetraria nivalis	1.9	1.5	95
Lopadium pezizoideum	0.3	0.8	11
Nephroma arcticum	0.2	0.5	11
Ochrolechia frigida	0.1	0.5	16
Parmelia omphalodes	2.7	6.7	26
Parmelia sp.	0.3	0.7	16
Pertusaria dactylina	0.4	0.8	26
Pertusaria subobducens	1.3	3.3	16
Rhizocarpon geographicum	0.6	2.8	11
Rhizocarpon sp.	0.9	2.5	16
Sphaerophorus globosus	1.1	1.5	42
Sphaerophorus sp.	0.3	0.7	21
Stereocaulon apocalypticum	0.7	2.4	11
Stereocaulon sp.	1.0	1.7	47
Thamnolia sp.	0.1	0.5	16
Thamnolia vermicularis	1.1	1.1	79
Umbilicaria caroliniana	0.3	0.8	11
Umbilicaria proboscidea	0.3	0.7	16
Umbilicaria sp.	1.1	3.5	21
Unknown crustose lichen	2.1	3.4	37
Total Bare Ground	36.0	21.5	100
Bare Soil	30.5	22.1	100
Litter alone	5.4	6.3	100

common and abundant. Loess caps are absent. Soil pH is acidic to circumneutral and EC is generally low. The soils are typically somewhat excessively to somewhat excessively drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 5. Soil characteristics for Alpine Acidic Dryas Dwarf Shrub.

Property	Mean	SD	n
Elevation (m)	685.3	201.1	19
Slope (degrees)	13.9	10.7	12
Surface Organics Depth(cm)	2.6	1.1	15
Cumulative Org. in 40 cm (cm)	2.6	1.1	15
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	6.3	8.6	10
Surface Fragment Cover (%)	42.5	35.5	11
Frost Boil Cover (%)	8.8	6.5	5
Thaw Depth (cm)	30.0		1
Site pH at 10-cm depth	5.2	0.4	19
Site EC at 10-cm depth (µS/cm)	43.3	47.5	18
Water Depth (cm,+ above grnd)[a]	-200.0	0.0	18

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m), Lithic Cryorthents (poorly developed, <50 cm to bedrock, permafrost absent), and Typic Haploturbels (mineral soil over permafrost with cryoturbation). A less common subgroup is Typic Cryorthents (poorly developed soils, lacking permafrost). This ecotype and associated soils are part of the Alpine Rocky Acidic Barrens and Shrub soil landscape. Also included in this soil landscape are Alpine Acidic Barrens and Alpine Ericaceous–Dryas Dwarf Shrub.

Alpine Alkaline Barrens

Geomorphology:

Alpine Alkaline Barrens occurs on carbonate sedimentary bedrock, metamorphic carbonate (marble) bedrock, weathered bedrock, hillside colluvium, and talus. Site chemistry is alkaline due to carbonate-rich parent material. It occurs at elevations above 400 m through ARCN. Macrotopography consists of upper slopes, shoulders, ridge crests, and plateaus. Slopes are typically steep and it occurs on all aspects.

Plant Association:

Dryas octopetala–Saxifraga oppositifolia
Salix arctica–Minuartia arctica

Vegetation cover is sparse in this ecotype, although species diversity is high, with the 9th highest total number of species documented. Plants are present in trace quantities (Table 6). Trees and shrubs taller than 20 cm are absent. Total non-vascular cover is low, and not always present at sites. Due to the limestone substrate, several rare species occur in this ecotype, including *Papaver gorodkovii*, *Papaver walpolei* and *Campanula aurita*. Common species include *Dryas octopetala*, *Saxifraga oppositifolia*, *Androsace chamaejasme*, and *Minuartia arctica*.

The most similar ecotype is Alpine Alkaline Dryas Dwarf Shrub, except that vegetative cover is greatly reduced. It is also similar to Alpine Acidic Barrens and Alpine Mafic Barrens except for differences in bedrock type, soil chemistry, and plant assemblages.

Table 6. Vegetation cover and frequency for Alpine Alkaline Barrens (n=52).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	34.3	25.9	100
Total Vascular Cover	27.2	20.8	98
Total Evergreen Tree Cover	0.0	0.0	2
Total Evergreen Shrub	4.0	5.0	56
Cassiope tetragona	0.1	0.7	7
Dryas integrifolia	0.7	2.1	14
Dryas octopetala	2.8	4.5	37
Dryas octopetala ssp.	0.4	1.7	7
Total Deciduous Shrub	9.5	12.0	84
Potentilla fruticosa	0.1	0.8	5
Salix arctica	0.1	0.4	21
Salix brachycarpa ssp.	0.1	0.9	2
Salix glauca	<0.1	0.2	7
Salix lanata ssp. *richardsonii*	0.1	0.5	5
Salix reticulata	<0.1	0.2	12
Salix rotundifolia	8.8	12.0	53
Salix rotundifolia ssp.	0.1	0.4	12
Total Forb Cover	12.1	12.4	98
Androsace chamaejasme	0.1	0.2	35
Anemone drummondii	<0.1	0.2	7
Anemone parviflora	<0.1	0.2	12
Artemisia furcata	<0.1	0.2	14
Boykinia richardsonii	0.1	0.5	7
Braya humilis ssp. *richardsonii*	<0.1	0.2	7
Castilleja elegans	0.1	0.5	23
Chrysosplenium tetrandrum	<0.1	0.2	5
Crepis nana	0.1	0.2	19
Draba nivalis	0.1	0.3	12
Epilobium latifolium	<0.1	0.2	5
Erigeron hyperboreus	0.3	0.7	28
Hedysarum mackenzii	0.1	0.3	12
Minuartia arctica	0.2	0.3	26
Minuartia obtusiloba	<0.1	0.2	7
Minuartia rubella	<0.1	0.2	7
Oxytropis arctica	<0.1	0.2	7
Oxytropis nigrescens	1.8	4.8	33
Parrya nudicaulis	0.1	0.2	23
Pedicularis kanei	<0.1	0.2	21
Phlox sibirica spp. *sibirica*	0.1	0.2	14
Potentilla biflora	<0.1	0.2	5
Potentilla hookeriana	<0.1	0.2	7
Potentilla uniflora	0.2	0.4	28
Saussurea angustifolia	<0.1	0.2	7
Saxifraga eschscholtzii	0.1	0.5	9
Saxifraga nivalis	<0.1	0.2	5
Saxifraga oppositifolia	7.0	8.9	95
Saxifraga punctata ssp.	0.1	0.4	7
Saxifraga rivularis	<0.1	0.2	5
Saxifraga tricuspidata	0.2	0.8	7
Selaginella sibirica	0.1	0.8	5
Senecio ogotorukensis	0.4	0.9	21
Tofieldia coccinea	<0.1	0.3	5
Total Grass Cover	0.8	2.7	37
Calamagrostis purpurascens	0.5	1.5	16
Poa glauca	0.2	0.9	19
Trisetum spicatum ssp.	0.1	0.3	14
Total Sedge & Rush Cover	0.8	1.8	53
Carex franklinii	<0.1	0.2	2
Carex lachenalii	<0.1	0.2	2
Carex nardina	0.5	1.8	23
Carex petricosa	<0.1	0.3	2
Carex rupestris	<0.1	0.2	12

Table 6. Continued.

	Cover		Freq
	Mean	SD	%
Carex scirpoidea	<0.1	0.2	16
Kobresia simpliciuscula	<0.1	0.2	2
Total Nonvascular Cover	7.1	7.7	88
Total Moss Cover	1.4	2.3	56
Abietinella abietina	<0.1	0.2	5
Ditrichum flexicaule	<0.1	0.2	5
Ditrichum sp.	0.6	1.4	19
Hypnum sp.	0.3	0.7	16
Racomitrium lanuginosum	0.1	0.5	7
Rhytidium rugosum	<0.1	0.2	7
Schistidium sp.	<0.1	0.2	5
Unknown moss	0.1	0.3	12
Total Lichen Cover	5.7	6.4	88
Acarospora sp.	0.1	0.4	7
Alectoria ochroleuca	0.1	0.2	12
Alectoria sp.	0.1	0.3	7
Asahinea chrysantha	<0.1	0.2	9
Cetraria sp.	1.1	2.1	42
Cetraria tilesii	0.1	0.4	21
Cladonia sp.	0.1	0.5	23
Cornicularia sp.	<0.1	0.2	7
Dactylina sp.	0.1	0.2	19
Diploschistes sp.	0.5	2.6	7
Evernia perfragilis	<0.1	0.2	7
Flavocetraria cucullata	0.3	0.7	35
Flavocetraria nivalis	0.7	1.8	33
Lecanora sp.	0.1	0.3	19
Nephroma arcticum	<0.1	0.2	5
Ochrolechia frigida	0.1	0.5	5
Ochrolechia sp.	0.1	0.5	5
Pannaria cf.	<0.1	0.2	5
Pertusaria sp.	0.1	0.3	9
Psora sp.	0.1	0.3	12
Rhizocarpon sp.	0.1	0.3	7
Sphaerophorus sp.	0.1	0.5	5
Stereocaulon sp.	<0.1	0.2	7
Thamnolia sp.	1.2	2.6	49
Thamnolia subuliformis	0.1	0.6	2
Thamnolia vermicularis	0.3	0.9	26
Toninia sp.	0.1	0.5	7
Unknown crustose lichen	0.2	1.0	7
Unknown lichen	0.3	0.9	9
Vulpicida tilesii	0.1	0.3	16
Total Bare Ground	43.9	45.8	49
Bare Soil	43.4	45.3	49
Litter alone	0.5	1.1	40

Soils:

Soils are blocky or rubbly and typically lack a surface organic horizon (Table 7). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m due to cold temperatures at the high elevations. Frost boils are rare, and loess caps are absent. Surface fragments are common and abundant. Soil pH is alkaline to circumneutral and EC is low. The soils are typically excessively to well drained. Depth to water table often

could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 7. Soil characteristics for Alpine Alkaline Barrens.

Property	Mean	SD	n
Elevation (m)	605.2	243.7	21
Slope (degrees)	22.9	10.8	19
Surface Organics Depth(cm)	4.0	1.4	2
Cumulative Org. in 40 cm (cm)	4.0	1.4	2
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	1.0		1
Surface Fragment Cover (%)	98.1	3.4	10
Frost Boil Cover (%)	2.2	1.9	4
Thaw Depth (cm)	30.0		1
Site pH at 10-cm depth	8.2	0.3	18
Site EC at 10-cm depth (µS/cm)	111.7	42.3	18
Water Depth (cm,+ above grnd)[a]	-176.5	57.5	20

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Gelorthents (poorly developed soils, permafrost below 1 m) and Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m). Less common subgroups include Typic Cryorthents (poorly developed soils, lacking permafrost) and Lithic Cryorthents (poorly developed, <50 cm to bedrock, permafrost lacking). This ecotype and associated soils are part of the Alpine Rocky Alkaline Barrens and Shrub soil landscape. Also included in this soil landscape are Alpine Mafic Barrens, Alpine Alkaline Dryas Dwarf Shrub, and Alpine Cassiope Dwarf Shrub.

Alpine Alkaline Dryas Dwarf Shrub

Geomorphology:

Alpine Alkaline Dryas Dwarf Shrub occurs on carbonate substrates on stable slopes and crests. Parent material consists of weathered bedrock, hillside colluvium, talus, young moraine, solifluction deposits and inactive alluvial fan deposits.

Plant Association:

Dryas octopetala– Saxifraga oppositifolia
Dryas integrifolia–Carex scirpoidea–Silene acaulis

Vegetation is dominated by dwarf shrubs, mainly *Dryas* species, and has a strong subcomponent of forbs and sedges (Table 8). Trees and shrubs taller than 20 cm are absent. Nonvascular species are always present in low quantities. This is a diverse ecotype with the highest total count of species, and has the 4th highest species richness per plot. Due to the limestone substrate, several rare species occur in this ecotype, including *Oxytropis huddelsonii*, *Papaver walpolei* and *Arenaria chamissonis* (syn: *Stellaria dicranoides*). Common species in addition to the floristic class components include *Minuartia arctica*, *Polygonum viviparum*, *Dactylina arctica*, and *Vulpicida tilesii*.

The most similar ecotype is Alpine Alkaline Barrens, except Alpine Alkaline Dryas Dwarf Shrub has much higher vegetative cover. It is also similar to Alpine Acidic Dryas Dwarf Shrub except for differences in bedrock type, higher soil pH, and much higher plant diversity.

Soils:

Soils are blocky or rubbly and are overlain by thin organic horizons (Table 9). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m due to the cold temperatures at the high elevations. Frost boils are uncommon, and surface fragments are common and abundant. Loess caps are rare, however when they occur they tend to be thick (>20 cm). Soil

Table 8. Vegetation cover and frequency for Alpine Alkaline Dryas Dwarf Shrub (n=160).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	98.1	36.6	100
Total Vascular Cover	78.5	29.0	100
Total Evergreen Shrub Cover	42.5	17.1	100
Andromeda polifolia	<0.1	0.2	4
Cassiope tetragona	2.4	7.4	31
Dryas integrifolia	3.3	12.0	9
Dryas octopetala	35.3	18.6	91
Dryas octopetala ssp. *alaskensis*	1.4	8.7	4
Rhododendron lapponicum	0.1	0.5	8
Total Deciduous Tree Cover	0.0	0.0	1
Total Deciduous Shrub Cover	6.1	10.7	72
Arctostaphylos rubra	2.4	9.1	18
Potentilla fruticosa	0.3	1.2	10
Salix arctica	0.3	1.1	13
Salix reticulata	2.3	4.3	51
Salix rotundifolia	0.3	1.8	11
Vaccinium uliginosum	0.4	1.8	15
Total Forb Cover	9.3	5.6	100
Androsace chamaejasme	0.3	0.5	61
Anemone parviflora	0.4	0.9	32
Artemisia furcata	<0.1	0.3	9
Astragalus aboriginum	0.1	0.3	7
Astragalus umbellatus	0.1	0.3	16
Boykinia richardsonii	0.1	0.5	5
Braya humilis ssp. *richardsonii*	<0.1	0.1	8
Castilleja elegans	0.1	0.3	10
Chrysanthemum integrifolium	0.2	0.4	37
Epilobium latifolium	0.3	1.2	15
Erigeron hyperboreus	<0.1	0.1	10
Gentiana propinqua	<0.1	0.1	20
Geum glaciale	<0.1	0.3	6
Hedysarum alpinum	1.1	2.3	29
Hedysarum mackenzii	0.1	0.3	5
Minuartia arctica	0.1	0.5	12
Minuartia obtusiloba	<0.1	0.1	5
Minuartia rossii	<0.1	0.1	5
Oxytropis borealis	0.4	1.4	9
Oxytropis campestris ssp. *jordalii*	0.1	0.4	4
Papaver macounii	<0.1	0.1	4
Parnassia palustris	<0.1	0.1	7
Pedicularis capitata	<0.1	0.1	12
Pedicularis kanei	0.3	0.5	40
Pedicularis sudetica	<0.1	0.1	7
Phlox sibirica sibirica	<0.1	0.2	7
Polygonum viviparum	0.1	0.2	23
Potentilla biflora	0.1	0.4	7
Saussurea angustifolia	<0.1	0.2	7
Saxifraga oppositifolia	3.3	4.3	71
Senecio lugens	<0.1	0.1	4
Senecio ogotorukensis	<0.1	0.2	11
Senecio resedifolius	0.1	0.2	22
Silene acaulis	0.8	1.4	47
Solidago multiradiata	0.1	0.4	5

Table 8. Continued.

	Cover		Freq
	Mean	SD	%
Thalictrum alpinum	0.1	0.4	26
Tofieldia coccinea	<0.1	0.2	9
Tofieldia pusilla	0.2	0.4	24
Zygadenus elegans	0.1	0.6	12
Total Grass Cover	3.0	8.1	36
Elymus innovatus	2.4	6.8	20
Festuca altaica	0.5	2.2	11
Total Sedge & Rush Cover	17.6	16.7	93
Carex franklinii	2.8	9.0	14
Carex glacialis	0.9	3.8	15
Carex misandra	0.3	1.3	15
Carex nardina	0.4	2.7	9
Carex rupestris	4.9	7.0	57
Carex scirpoidea	4.6	5.4	66
Kobresia simpliciuscula	3.3	12.2	10
Total Nonvascular Cover	19.6	18.2	99
Total Moss Cover	5.0	8.3	83
Abietinella sp.	0.1	0.3	7
Cynodontium sp.	0.2	0.8	4
Dicranum sp.	0.3	2.2	8
Distichium sp.	0.1	0.3	7
Ditrichum sp.	1.1	2.3	64
Hylocomium splendens	0.4	2.8	8
Hypnum sp.	0.8	2.5	26
Racomitrium lanuginosum	0.2	1.5	5
Racomitrium sp.	0.4	1.6	11
Rhytidium rugosum	0.6	2.0	23
Tomentypnum nitens	0.4	2.4	7
Tortella sp.	<0.1	0.1	5
Unknown moss	0.2	1.3	7
Total Lichen Cover	15.6	15.5	98
Alectoria sp.	0.1	0.3	11
Asahinea sp.	0.1	0.5	6
Cetraria cf. *islandica*	0.3	2.6	7
Cetraria sp.	4.6	5.1	78
Cetraria tilesii	<0.1	0.2	6
Cladina arbuscula	0.5	1.8	26
Cladina mitis	0.1	0.4	4
Cladonia sp.	0.8	1.9	35
Dactylina arctica	0.1	0.3	12
Dactylina sp.	0.5	1.0	46
Flavocetraria cucullata	2.9	4.8	67
Flavocetraria nivalis	1.4	3.1	52
Lecanora sp.	0.1	0.3	12
Masonhalea richardsonii	0.4	1.2	33
Ochrolechia frigida	0.2	1.6	4
Pertusaria sp.	0.2	1.3	7
Stereocaulon sp.	<0.1	0.1	5
Thamnolia sp.	1.2	2.0	51
Thamnolia vermicularis	0.4	1.7	13
Unknown crustose lichen	0.1	0.4	4
Vulpicida tilesii	<0.1	0.2	7
Total Bare Ground	7.5	17.3	20
Bare Soil	5.5	15.0	20
Litter alone	2.0	5.3	19

pH is alkaline to circumneutral and EC is low. The soils are typically excessively to well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 9. Soil characteristics for Alpine Alkaline Dryas Dwarf Shrub.

Property	Mean	SD	n
Elevation (m)	475.2	202.7	27
Slope (degrees)	17.8	10.3	25
Surface Organics Depth(cm)	3.4	2.1	20
Cumulative Org. in 40 cm (cm)	4.0	2.7	20
Loess Cap Thickness (cm)	18.0	17.0	2
Depth to Rocks (cm)	8.2	10.9	19
Surface Fragment Cover (%)	32.1	24.4	11
Frost Boil Cover (%)	9.8	14.7	10
Thaw Depth (cm)	40.5	19.6	4
Site pH at 10-cm depth	7.8	0.4	27
Site EC at 10-cm depth (µS/cm)	157.9	70.7	27
Water Depth (cm,+ above grnd)[a]	-162.5	58.5	22

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m). Less common subgroups include Typic Haplorthels (mineral soil over permafrost lacking cryoturbation), Typic Gelorthents (poorly developed soils, permafrost below 1 m), Typic Haploturbels (mineral soil over permafrost with cryoturbation), and Humic Eutrogelepts (non-acidic, well drained, a moderately thick organic-rich A horizon, permafrost below 1 m). This ecotype and associated soils are part of the Alpine Rocky Alkaline Barrens and Shrub soil landscape. Also included in this soil landscape are Alpine Mafic Barrens, Alpine Alkaline Barrens, and Alpine Cassiope Dwarf Shrub.

Alpine Cassiope Dwarf Shrub

Geomorphology:

Alpine Cassiope Dwarf Shrub is distributed in small patches throughout the mountainous regions of ARCN. It occurs at elevations above 450 m on upper and lower slopes on hillside colluvium. It generally occurs on north aspects and in late-lying snow beds, where soils are generally colder and moister than other alpine ecotypes. Slopes vary from gradual to steep.

Plant Association:

Cassiope tetragona–Dryas octopetala–Polygonum bistorta

This ecotype is dominated by dwarf shrubs, specifically *Cassiope tetragona*. Other common dwarf shrubs include *Dryas octopetala*, *Salix reticulata*, and *Vaccinium uliginosum* (Table 10). Within ARCN parklands, Alpine Cassiope Dwarf Shrub has the 11th highest average species diversity per plot and is moderately diverse. Across the study area, we documented two rare species, *Oxytropis kokrinensis* and *Papaver walpolei* in this ecotype.

Similar ecotypes include Alpine Ericaceous–Dryas Dwarf Shrub and Alpine Alkaline Dryas Dwarf Shrub. In these types the dominant species that defines the vegetation type is *Dryas* as opposed to *Cassiope*. Also, site chemistry is more acidic in Alpine Ericaceous–Dryas Dwarf Shrub and more alkaline in Alpine Alkaline Dryas Dwarf Shrub.

Soils:

Soils are blocky or rubbly and are overlain by thin organic horizons (Table 11). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m due to the cold temperatures at the high elevations. Frost boils are rare, however when present they tend to occur at high abundance. Surface fragments are common and moderately abundant, and loess caps are absent. Soil pH is circumneutral and EC is low. The

Table 10. Vegetation cover and frequency for Alpine Cassiope Dwarf Shrub (n=38).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	180.5	50.0	100
Total Vascular Cover	119.2	35.2	100
Total Evergreen Shrub Cover	69.7	21.5	100
Cassiope tetragona	29.3	18.1	100
Dryas octopetala	36.1	20.1	89
Dryas octopetala ssp. *alaskensis*	3.4	11.2	9
Ledum decumbens	<0.1	0.2	9
Vaccinium vitis-idaea	0.3	1.0	11
Total Deciduous Shrub Cover	21.1	19.6	96
Arctostaphylos rubra	0.3	1.1	11
Potentilla fruticosa	0.2	1.2	13
Salix arctica	0.9	2.8	26
Salix glauca	0.1	0.7	13
Salix lanata ssp. *richardsonii*	4.4	13.1	24
Salix reticulata	8.9	8.6	87
Salix rotundifolia	1.4	3.2	28
Vaccinium uliginosum	3.1	6.9	39
Total Forb Cover	21.6	13.0	100
Androsace chamaejasme	0.1	0.2	24
Anemone narcissiflora	0.1	0.2	15
Anemone parviflora	1.8	2.2	76
Astragalus umbellatus	0.6	1.2	48
Boykinia richardsonii	9.3	10.3	67
Chrysanthemum integrifolium	0.3	0.7	30
Dodecatheon frigidum	0.8	2.0	30
Epilobium latifolium	0.6	1.5	30
Equisetum scirpoides	0.4	1.6	11
Gentiana propinqua	0.1	0.2	26
Geum glaciale	0.6	1.6	20
Hedysarum alpinum	0.8	2.5	15
Lycopodium selago	<0.1	0.1	22
Minuartia arctica	0.1	0.4	15
Papaver macounii	<0.1	0.1	17
Parnassia palustris	0.1	0.4	26
Pedicularis capitata	0.2	0.5	37
Pedicularis kanei	0.1	0.2	24
Pedicularis sudetica	0.1	0.2	20
Polemonium acutiflorum	0.2	0.7	9
Polygonum bistorta	0.2	0.7	17
Polygonum viviparum	0.2	0.4	33
Pyrola grandiflora	0.2	0.6	15
Saussurea angustifolia	0.2	0.6	24
Saxifraga bronchialis	0.1	0.4	15
Saxifraga hieracifolia	0.1	0.5	15
Saxifraga oppositifolia	1.2	2.4	41
Saxifraga punctata ssp. *nelsoniana*	0.1	0.2	9
Senecio resedifolius	0.1	0.4	15
Silene acaulis	1.2	1.8	54
Solidago multiradiata	<0.1	0.1	11
Thalictrum alpinum	0.2	0.6	17
Tofieldia coccinea	<0.1	0.1	13
Tofieldia pusilla	<0.1	0.1	17
Total Grass Cover	3.1	4.2	63

Table 10. Continued.

	Cover		Freq
	Mean	SD	%
Arctagrostis latifolia	0.2	1.2	9
Festuca altaica	2.6	4.2	48
Hierochloe alpina	0.1	0.5	13
Poa arctica	0.1	0.2	11
Total Sedge & Rush Cover	3.7	5.6	59
Carex bigelowii	0.3	1.1	11
Carex microchaeta	0.4	2.2	11
Carex misandra	0.8	3.8	17
Carex podocarpa	0.8	1.7	22
Carex rupestris	0.6	1.7	13
Carex scirpoidea	0.5	1.6	20
Total Nonvascular Cover	61.3	32.1	98
Total Moss Cover	34.0	24.4	96
Abietinella sp.	0.2	0.7	11
Blepharostoma sp.	0.1	0.5	15
Brachythecium sp.	1.3	3.1	22
Bryum sp.	0.1	0.4	9
Campylium sp.	1.8	4.0	20
Cinclidium sp.	0.2	0.9	9
Dicranum sp.	3.2	4.6	57
Distichium sp.	0.1	0.4	11
Ditrichum sp.	0.8	1.2	43
Drepanocladus sp.	0.8	2.7	13
Hylocomium splendens	12.3	17.3	72
Hypnum sp.	2.7	5.1	43
Pleurozium schreberi	0.8	1.6	22
Racomitrium sp.	1.4	2.7	28
Rhytidium rugosum	0.9	2.8	22
Sanionia sp.	1.4	3.9	13
Timmia sp.	0.2	0.6	13
Tomentypnum nitens	3.2	6.2	39
Total Lichen Cover	28.0	21.7	98
Alectoria sp.	0.1	0.5	11
Cetraria cf. *islandica*	0.4	1.0	17
Cetraria sp.	6.5	7.5	63
Cladina arbuscula	3.8	6.8	57
Cladina rangiferina	0.6	1.8	22
Cladina stellaris	4.0	8.2	37
Cladonia sp.	1.1	2.0	65
Dactylina arctica	0.1	0.5	22
Dactylina sp.	1.0	1.5	54
Flavocetraria cucullata	4.0	5.0	78
Flavocetraria nivalis	0.5	1.1	35
Lobaria sp.	0.2	0.9	9
Masonhalea richardsonii	1.1	3.4	43
Peltigera aphthosa	0.3	0.7	26
Peltigera sp.	0.2	0.6	13
Pertusaria sp.	0.2	0.7	9
Stereocaulon sp.	0.3	0.8	22
Thamnolia sp.	0.3	0.9	37
Thamnolia vermicularis	0.3	0.8	15
Unknown crustose lichen	1.3	3.7	15
Total Bare Ground	4.8	9.9	26
Bare Soil	1.6	3.9	26
Litter alone	3.2	6.7	26

soils are typically somewhat excessively to well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 11. Soil characteristics for Alpine Cassiope Dwarf Shrub.

Property	Mean	SD	n
Elevation (m)	713.6	250.4	12
Slope (degrees)	20.3	10.2	12
Surface Organics Depth(cm)	5.4	3.6	10
Cumulative Org. in 40 cm (cm)	5.4	3.6	10
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	6.2	3.6	9
Surface Fragment Cover (%)	13.8	11.0	10
Frost Boil Cover (%)	10.5	13.4	2
Thaw Depth (cm)			0
Site pH at 10-cm depth	6.8	0.6	11
Site EC at 10-cm depth (µS/cm)	106.2	59.5	10
Water Depth (cm,+ above grnd)[a]	-200.0	0.0	12

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m) and Typic Gelorthents (poorly developed soils, permafrost below 1 m). A less common subgroup is Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m). This ecotype and associated soils are part of the Alpine Rocky Alkaline Barrens and Shrub soil landscape. Also included in this soil landscape are Alpine Mafic Barrens, Alpine Alkaline Barrens, and Alpine Alkaline Dryas Dwarf Shrub.

Alpine Ericaceous–Dryas Dwarf Shrub

Geomorphology:

Alpine Ericaceous–Dryas Dwarf Shrub occurs on hillside colluvium, older moraine, talus, weathered bedrock and abandoned alluvial fan deposits above 450 m elevation throughout ARCN. Macro-topography includes slopes, shoulders and crests. Slopes vary from gentle to steep and include all aspects.

Plant Association:

Betula nana–Loiseleuria procumbens
Betula nana–Vaccinium vitis-idaea–Dryas octopetala
Dryas octopetala–Vaccinium uliginosum–Festuca altaica

Dwarf shrubs characterize this ecotype (Table 12), while trees and shrubs taller than 20 cm are only present in trace amounts. Mosses and lichens are always present. Sedges, grasses and forbs are well represented but typically have low total cover. This ecotype has variable species assemblages, resulting in 3 co-dominant plant associations. Some sites contain predominantly dwarfed (<20 cm tall) *Betula nana* with ericaceous or *Dryas* dwarf shrubs, while others are dominated by a mix of *Dryas* and ericaceous dwarf shrubs. Additional common species include *Anemone narcissiflora*, *Carex podocarpa*, *Hylocomium splendens* and *Masonhalea richardsonii*.

This ecotype is most similar to Alpine Acidic Dryas Dwarf Shrub and Alpine Cassiope Dwarf Shrub, except for differences in site chemistry and plant associations.

Soils:

Soils are blocky or rubbly and are overlain by thin organic horizons (Table 13). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m due to the cold temperatures at the high elevations. Frost boils are uncommon, however when present they tend

Table 12. Vegetation cover and frequency for Alpine Ericaceous–Dryas Dwarf Shrub (n=61).

	Cover		Freq
	Mean	SD	%
Total Live Cover	149.5	65.2	100
Total Vascular Cover	88.5	33.3	100
Total Evergreen Tree Cover	0.1	0.4	11
Picea glauca	0.1	0.4	11
Total Evergreen Shrub Cover	36.2	16.5	100
Cassiope tetragona	7.2	8.2	76
Diapensia lapponica	0.2	0.8	19
Dryas octopetala	14.0	14.6	76
Empetrum nigrum	2.1	4.0	45
Ledum decumbens	3.1	5.9	55
Linnaea borealis	0.3	0.8	18
Loiseleuria procumbens	3.4	6.4	39
Vaccinium vitis-idaea	4.4	4.9	84
Total Deciduous Tree Cover	0.0	0.0	3
Total Deciduous Shrub Cover	36.8	23.1	100
Arctostaphylos alpina	1.3	3.5	19
Arctostaphylos rubra	0.6	2.1	15
Betula glandulosa	8.5	19.0	18
Betula nana	5.8	10.4	44
Potentilla fruticosa	0.7	2.5	13
Salix brachycarpa ssp. *niphoclada*	2.6	6.3	18
Salix glauca	0.5	1.6	18
Salix phlebophylla	1.0	2.4	23
Salix planifolia ssp. *pulchra*	1.4	4.3	35
Salix polaris	0.6	2.9	10
Salix reticulata	1.3	2.9	39
Spiraea beauverdiana	<0.1	0.1	15
Vaccinium uliginosum	11.9	13.0	92
Total Forb Cover	5.4	4.1	97
Anemone narcissiflora	0.7	1.2	56
Anemone parviflora	0.3	0.6	24
Antennaria friesiana	0.1	0.3	16
Arnica lessingii	0.2	0.5	16
Artemisia arctica ssp. *arctica*	0.5	1.5	29
Astragalus umbellatus	0.1	0.3	11
Boykinia richardsonii	0.1	0.4	11
Campanula lasiocarpa	0.1	0.2	27
Dodecatheon frigidum	0.2	0.6	16
Minuartia arctica	0.1	0.4	24
Pedicularis capitata	0.1	0.3	29
Pedicularis kanei	0.1	0.2	31
Pedicularis labradorica	<0.1	0.1	15
Polygonum bistorta	0.2	0.4	31
Polygonum viviparum	0.1	0.4	18
Saussurea angustifolia	<0.1	0.2	16
Saxifraga bronchialis	<0.1	0.2	15
Selaginella sibirica	0.2	0.5	16
Silene acaulis	0.3	1.1	24
Solidago multiradiata	0.2	0.7	18
Tofieldia coccinea	<0.1	0.1	11
Total Grass Cover	6.0	6.5	94
Arctagrostis latifolia	0.2	0.6	18

Table 12. Continued.

	Cover		Freq
	Mean	SD	%
Festuca altaica	4.5	6.7	60
Hierochloe alpina	1.0	1.8	56
Poa arctica	0.1	0.3	23
Trisetum spicatum ssp. *spicatum*	<0.1	0.2	13
Total Sedge & Rush Cover	4.2	4.9	92
Carex bigelowii	0.5	1.2	24
Carex microchaeta	0.8	2.0	37
Carex podocarpa	1.1	1.8	52
Carex scirpoidea	1.5	4.3	29
Luzula confusa	<0.1	0.3	18
Luzula multiflora	0.1	0.2	13
Total Nonvascular Cover	61.0	42.5	100
Total Moss Cover	17.0	18.9	97
Aulacomnium turgidum	0.3	1.3	18
Dicranum sp.	2.3	2.8	56
Hylocomium splendens	4.3	6.8	58
Hypnum sp.	0.1	0.7	13
Pleurozium schreberi	0.7	2.4	13
Polytrichum piliferum	1.3	6.5	16
Polytrichum sp.	1.0	2.6	32
Polytrichum strictum	0.3	0.8	16
Racomitrium lanuginosum	0.5	1.6	21
Racomitrium sp.	0.9	4.6	11
Rhytidium rugosum	0.9	1.9	27
Tomentypnum nitens	0.5	1.8	10
Total Lichen Cover	44.1	42.0	98
Asahinea chrysantha	0.2	0.8	16
Asahinea sp.	0.1	0.4	13
Bryoria sp.	0.5	2.3	13
Cetraria cf. *islandica*	0.4	1.0	23
Cetraria sp.	1.3	2.3	35
Cladina arbuscula	5.4	9.1	47
Cladina mitis	0.8	1.9	26
Cladina rangiferina	5.2	9.0	55
Cladina sp.	0.4	2.0	11
Cladina stellaris	13.0	23.3	35
Cladina stygia	0.7	2.2	18
Cladonia sp.	2.6	3.0	76
Dactylina arctica	0.1	0.3	24
Dactylina sp.	0.4	1.0	23
Flavocetraria cucullata	2.4	2.9	73
Flavocetraria nivalis	1.4	3.3	55
Lobaria sp.	0.1	0.4	21
Masonhalea richardsonii	1.2	1.8	65
Nephroma arcticum	0.1	0.5	16
Parmelia sp.	0.2	0.8	15
Peltigera aphthosa	0.3	0.9	29
Peltigera sp.	0.1	0.3	19
Sphaerophorus sp.	0.1	0.4	16
Stereocaulon sp.	1.2	2.8	52
Thamnolia sp.	0.5	1.2	24
Thamnolia vermicularis	0.3	0.6	27
Unknown crustose lichen	1.7	5.2	18
Total Bare Ground	10.8	11.7	61
Bare Soil	6.7	9.3	60
Litter alone	4.2	5.4	61

to occur at high abundance. Loess caps are generally absent, and surface fragments are common and abundant. Soil pH is acidic to circumneutral, and EC is low. The soils are typically somewhat excessively to well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 13. Soil characteristics for Alpine Ericaceous–Dryas Dwarf Shrub.

Property	Mean	SD	n
Elevation (m)	641.5	206.6	37
Slope (degrees)	14.0	7.9	33
Surface Organics Depth(cm)	3.4	2.7	38
Cumulative Org. in 40 cm (cm)	3.4	2.7	38
Loess Cap Thickness (cm)	2.0	NA	1
Depth to Rocks (cm)	4.7	3.5	29
Surface Fragment Cover (%)	18.0	16.5	29
Frost Boil Cover (%)	12.0	14.5	16
Thaw Depth (cm)	72.2	31.5	2
Site pH at 10-cm depth	5.4	0.7	37
Site EC at 10-cm depth (μS/cm)	43.8	30.9	37
Water Depth (cm,+ above grnd)[a]	-190.0	35.1	32

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m), Typic Haploturbels (mineral soil over permafrost with cryoturbation), and Typic Gelorthents (poorly developed soils, permafrost below 1 m). Less common subgroups include Typic Haplorthels (mineral soil over permafrost lacking cryoturbation) and Humic Dystrogelepts (acidic, well drained, a moderately thick organic-rich A horizon, permafrost below 1 m). This ecotype and associated soils are part of the Alpine Rocky Acidic Barrens and Shrub soil landscape. Also included in this soil landscape are Alpine Acidic Barrens and Alpine Acidic Dryas Dwarf Shrub.

Alpine Lake

Geomorphology:

Alpine Lake occurs in mountain cirques, and in depressions in bedrock or glacial moraine. This ecotype is found in mountainous regions throughout our study area and includes shallow (<1.5 m) to deep (≥1.5 m) lakes, usually above 400 m elevation.

Floristic classes were not developed for lake ecotypes since vegetation is lacking or sparse. Vegetation only occurs in shallow lakes or margins in this ecotype. The only vascular species we encountered was *Ranunculus hyperboreus* (Table 14), but additional species such as pondweeds (*Potamogeton* spp.) probably occur in Alpine Lake.

This ecotype is most similar to Lowland Lake but is less productive, has fewer plant species, and is much less prevalent across the landscape.

Table 14. Vegetation cover and frequency for Alpine Lake (n=2).

	Cover		Freq
	Mean	SD	%
Total Live Cover	1.1	1.5	50
Total Vascular Cover	0.1	0.1	50
Total Forb Cover	0.1	0.1	50
Ranunculus hyperboreus	0.1	0.1	50
Total Nonvascular Cover	1.0	1.4	50
Total Moss Cover	1.0	1.4	50
Warnstorfia exannulata	0.5	0.7	50
Warnstorfia sarmentosa	0.5	0.7	50
Total Bare Ground	100.0	0.1	100
Water	100.0	<0.1	100
Litter alone	0.1	0.1	50

Soils:

Flooded soils were not described. Water characteristics are listed in Table 15.

Table 15. Water characteristics for Alpine Lake.

Property	Mean	SD	n
Site pH at 10-cm depth	6.2		1
Site EC at 10-cm depth (µS/cm)	30.0		1
Water Depth (cm,+ above grnd)[a]	115.0	120.2	2

[a]Measurements >1 m indicate minimum depth, not true depth

Alpine Mafic Barrens

Geomorphology:

Alpine Mafic Barrens occurs on hillside colluvium or talus comprising intermediate, mafic and ultramafic plutonic rocks that have dark colored mineral assemblages with abundant iron and magnesium. Phosphorus is highly depleted, resulting in sparse vegetative cover. It occurs on upper slopes, shoulders and crests at elevations above 400 m, particularly in the north and western parts of NOAT.

Plant Association:

Salix arctica–Minuartia arctica
Dryas octopetala–Hierochloe alpina

Vegetation is sparse and most species are present in trace amounts (Table 16). Trees and shrubs taller than 20 cm are absent. This ecotype is moderately diverse. Rare species documented in this ecotype include *Thlaspi arcticum*, *Papaver gorodkovii*, and *Arenaria chamissonis* (syn: *Stellaria dicranoides*). Common species include *Carex podocarpa*, *Racomitrium lanuginosum*, and *Vulpicida tilesii*.

Similarly to Alpine Alkaline Barrens and Alpine Acidic Barrens, Alpine Mafic Barrens has low species cover and similar climate effects. The strong influence of different bedrock type results in different species assemblages.

Soils:

Soils are blocky or rubbly and lack surface organic horizons (Table 17). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m due to the cold temperatures at the high elevations. Frost boils are rare, however when present they tend to occur at high abundance. Loess caps are absent, and surface fragments are common and abundant. Soil pH is alkaline to circumneutral, and EC is low. The soils are typically excessively to somewhat excessively drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 16. Vegetation cover and frequency for Alpine Mafic Barrens (n=18).

	Cover		Freq
	Mean	SD	%
Total Live Cover	14.7	8.9	100
Total Vascular Cover	8.8	6.3	100
Total Evergreen Tree Cover	0.0	0.0	6
Total Evergreen Shrub Cover	2.0	3.0	72
Cassiope tetragona	0.1	0.3	28
Dryas integrifolia	1.3	3.1	22
Dryas octopetala	0.4	0.8	33
Dryas octopetala ssp. *alaskensis*	0.1	0.2	6
Empetrum nigrum	0.1	0.2	11
Total Deciduous Shrub Cover	1.2	1.2	89
Salix arctica	1.0	1.2	78
Salix phlebophylla	0.1	0.3	11
Salix rotundifolia	0.1	0.5	11
Total Forb Cover	4.3	3.5	100
Androsace chamaejasme	<0.1	<0.1	22
Anemone narcissiflora	<0.1	<0.1	22
Arabis sp.	0.1	0.2	11
Arenaria chamissonis	0.1	0.3	50
Armeria maritima	0.1	0.5	17
Artemisia arctica ssp. *arctica*	<0.1	<0.1	17
Artemisia globularia	0.2	0.5	11
Artemisia glomerata	<0.1	<0.1	17
Cardamine purpurea	<0.1	<0.1	22
Cerastium beeringianum	<0.1	<0.1	28
Cerastium beeringianum var. *beeringianum*	0.1	0.2	11
Cerastium beeringianum var. *grandiflorum*	0.1	0.2	11
Claytonia sarmentosa	<0.1	<0.1	17
Draba nivalis	<0.1	0.1	39
Draba sp.	<0.1	<0.1	22
Geum glaciale	0.1	0.2	17
Lagotis glauca ssp. *glauca*	0.1	0.2	6
Lupinus arcticus	0.1	0.5	6
Minuartia arctica	0.7	0.9	89
Minuartia elegans	0.1	0.5	6
Minuartia sp.	0.1	0.2	6
Papaver macounii	0.4	1.0	39
Pedicularis kanei	<0.1	<0.1	22
Pedicularis sp.	<0.1	<0.1	17
Phlox sibirica ssp. *sibirica*	<0.1	<0.1	17
Polygonum bistorta	0.1	0.2	6
Polygonum viviparum	<0.1	<0.1	28
Potentilla uniflora	0.2	0.5	33
Rumex acetosa ssp. *acetosa*	<0.1	<0.1	17
Sagina intermedia	<0.1	<0.1	22
Saxifraga bronchialis	0.4	0.6	83
Saxifraga eschscholtzii	0.1	0.3	17
Saxifraga flagellaris	<0.1	0.1	39
Saxifraga oppositifolia	<0.1	<0.1	28
Selaginella sibirica	<0.1	<0.1	22
Senecio resedifolius	0.1	0.2	33
Silene acaulis	0.2	0.5	50
Smelowskia borealis	0.1	0.2	6
Smelowskia calycina	0.2	0.5	28
Smelowskia calycina var. *porsildii*	0.1	0.2	6

Table 16. Continued.

	Cover		Freq
	Mean	SD	%
Woodsia glabella	0.1	0.2	17
Total Grass Cover	0.2	0.2	61
Deschampsia caespitosa	0.1	0.2	6
Poa arctica	<0.1	<0.1	22
Poa glauca	<0.1	<0.1	17
Total Sedge & Rush Cover	1.1	1.5	83
Carex glareosa	0.1	0.5	6
Carex microchaeta	0.2	0.5	33
Carex misandra	<0.1	0.1	11
Carex podocarpa	0.5	0.9	44
Carex scirpoidea	0.1	0.5	33
Carex sp.	0.1	0.2	11
Total Nonvascular Cover	6.0	6.8	94
Total Moss Cover	1.8	2.7	83
Andreaea rupestris	0.1	0.2	11
Aulacomnium turgidum	0.1	0.2	6
Bryum sp.	0.3	1.2	6
Distichium capillaceum	0.1	0.5	11
Oncophorus wahlenbergii	0.1	0.2	6
Racomitrium lanuginosum	0.9	1.5	61
Racomitrium sp.	<0.1	<0.1	17
Rhytidium rugosum	0.2	0.9	17
Total Lichen Cover	4.2	6.3	94
Alectoria nigricans	0.4	1.6	11
Alectoria ochroleuca	0.2	0.7	28
Alectoria sp.	0.1	0.2	22
Arctoparmelia sp.	0.1	0.5	11
Bryocaulon divergens	0.1	0.2	11
Cetraria cf. *islandica*	<0.1	<0.1	17
Cetrariella delisei	0.1	0.2	6
Cladonia sp.	0.1	0.3	22
Dactylina arctica	<0.1	<0.1	28
Dactylina ramulosa	0.1	0.2	11
Flavocetraria cucullata	0.1	0.3	17
Flavocetraria nivalis	<0.1	<0.1	33
Melanelia stygia	0.3	1.2	6
Parmelia omphalodes	0.1	0.2	6
Rhizocarpon sp.	0.8	2.6	17
Sphaerophorus sp.	0.1	0.2	17
Stereocaulon apocalypticum	0.1	0.2	17
Stereocaulon sp.	0.1	0.5	11
Thamnolia sp.	0.2	0.5	28
Thamnolia subuliformis	0.1	0.2	6
Thamnolia vermicularis	0.2	0.5	44
Umbilicaria proboscidea	0.1	0.2	11
Umbilicaria sp.	0.3	0.7	17
Unknown crustose lichen	0.3	1.2	22
Unknown foliose/fruticose lichen	0.1	0.2	6
Vulpicida sp.	0.1	0.2	6
Vulpicida tilesii	0.2	0.5	56
Total Bare Ground	89.7	7.1	100
Bare Soil	89.1	7.5	100
Water	0.1	0.5	6
Litter alone	0.5	0.7	67

Table 17. Soil characteristics for Alpine Mafic Barrens.

Property	Mean	SD	n
Elevation (m)	695.9	245.9	18
Slope (degrees)	20.7	12.3	18
Surface Organics Depth(cm)			0
Cumulative Org. in 40 cm (cm)			0
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)			0
Surface Fragment Cover (%)	94.9	8.5	18
Frost Boil Cover (%)	11.0	12.7	2
Thaw Depth (cm)			0
Site pH at 10-cm depth	6.9	0.5	18
Site EC at 10-cm depth (µS/cm)	101.1	74.2	18
Water Depth (cm,+ above grnd)[a]	-200.0	0.0	18

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Gelorthents (poorly developed soils, permafrost below 1 m). A less common subgroup is Lithic Eutrogelepts (non-acidic, <50 cm to bedrock, partially developed, permafrost below 1 m). This ecotype and associated soils are part of the Alpine Rocky Alkaline Barrens and Shrub soil landscape. Also included in this soil landscape are Alpine Alkaline Barrens, Alpine Alkaline Dryas Dwarf Shrub, and Alpine Cassiope Dwarf Shrub.

Alpine Wet Sedge Meadow

Geomorphology:

Alpine Wet Sedge Meadow generally occurs on gradual slopes of hillside colluvium at elevations between 500 and 900 m. It is found on concave surfaces and toe slopes where water tends to collect and is often associated with non-incised water tracks or seeps.

Plant Association:

Eriophorum angustifolium–Pedicularis sudetica

Sedges dominate this type, specifically *Eriophorum angustifolium, Carex bigelowii,* and *C. aquatilis* (Table 18). Forb and deciduous shrub cover is also high. Mosses are common but due to wet surfaces, lichens are not. Common species include a variety of dwarf willows, and the forbs *Pedicularis sudetica* and *Polygonum bistorta* (syn: *Bistorta plumosa*). Alpine Wet Sedge Meadow is relatively species-rich, but total diversity is not as high as other alpine ecotypes. We documented two rare species in this ecotype, *Aphragmus eschscholtzianus* and *Colpodium vahlianum*.

Lacustrine Wet Sedge Meadow and Riverine Wet Sedge Meadow are similar in soil moisture, site chemistry and vegetation structure except deciduous shrub cover is lower. Due to physiographic and geomorphic differences, Alpine Wet Sedge Meadow has rockier soils and a thinner organic horizon.

Table 18. Vegetation cover and frequency for Alpine Wet Sedge Meadow (n=8).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	162.5	86.9	100
Total Vascular Cover	97.2	35.6	100
Total Evergreen Shrub Cover	3.2	4.9	55
Cassiope tetragona	0.3	0.9	9
Dryas integrifolia	0.5	1.5	9
Dryas octopetala	1.3	2.3	36
Dryas octopetala ssp. *alaskensis*	0.7	2.4	9
Empetrum nigrum	0.1	0.3	9
Vaccinium vitis-idaea	0.4	1.2	9
Total Deciduous Shrub Cover	11.0	14.1	73
Salix arctica	2.5	3.3	45
Salix fuscescens	2.7	7.5	18
Salix lanata ssp. *richardsonii*	0.7	2.4	18
Salix planifolia ssp. *pulchra*	1.4	4.5	27
Salix reticulata	2.4	7.5	18
Salix rotundifolia	0.6	1.8	18
Vaccinium uliginosum	0.5	1.5	18
Total Forb Cover	19.6	14.8	100
Aconitum delphinifolium	0.4	0.9	27
Anemone parviflora	0.4	1.2	9
Arnica lessingii	0.2	0.6	27
Caltha palustris	0.5	1.0	27
Cerastium beeringianum	0.1	0.3	18
Claytonia acutifolia ssp. *graminifolia*	0.5	1.3	18
Claytonia sarmentosa	0.3	0.5	36
Claytonia scammaniana	0.3	0.9	9
Dodecatheon frigidum	0.1	0.3	9
Equisetum arvense	8.3	14.7	36
Gentiana propinqua	0.1	0.3	9
Lagotis glauca ssp. *glauca*	0.2	0.4	36
Melandrium apetalum	<0.1	0.1	36
Minuartia arctica	<0.1	0.1	36
Papaver macounii	0.1	0.3	27
Pedicularis kanei	0.2	0.6	9
Pedicularis parviflora ssp. *parviflora*	0.5	1.5	9
Pedicularis sudetica	0.9	1.2	55
Petasites frigidus	1.1	2.5	36
Polemonium acutiflorum	0.5	1.2	27
Polygonum bistorta	0.4	0.8	45
Polygonum viviparum	1.0	1.8	36
Ranunculus eschscholtzii	0.1	0.3	9
Rumex arcticus	0.3	0.6	55
Saxifraga cernua	0.1	0.3	27
Saxifraga hirculus	0.5	0.7	55
Saxifraga punctata ssp. *nelsoniana*	0.5	0.7	64
Stellaria laeta	0.3	0.6	27
Thalictrum alpinum	0.2	0.4	27
Valeriana capitata	1.1	2.4	45
Total Grass Cover	28.0	33.4	91
Alopecurus alpinus	1.4	4.5	9
Arctagrostis latifolia	2.7	3.7	64
Colpodium vahlianum	0.2	0.4	18
Festuca altaica	20.0	33.5	36
Hierochloe pauciflora	0.2	0.6	9

Table 18. Continued.

	Cover		Freq
	Mean	SD	%
Poa arctica	1.1	1.7	45
Trisetum spicatum ssp. *spicatum*	1.9	4.6	36
Total Sedge & Rush Cover	35.5	24.0	100
Carex aquatilis ssp. *aquatilis*	2.3	7.5	9
Carex atrofusca	0.8	1.7	27
Carex bigelowii	9.2	9.6	73
Carex canescens	0.5	1.5	9
Carex capillaris	0.5	0.9	36
Carex kelloggii	0.3	0.9	9
Carex membranacea	0.5	1.8	9
Carex misandra	1.1	2.2	27
Carex podocarpa	6.2	10.9	45
Carex saxatilis	0.5	1.0	18
Carex scirpoidea	0.7	1.7	36
Eriophorum angustifolium	10.9	17.5	73
Eriophorum callitrix	0.6	1.5	36
Juncus biglumis	0.5	0.8	45
Kobresia myosuroides	0.1	0.3	9
Kobresia simpliciuscula	0.5	1.5	9
Total Nonvascular Cover	65.2	56.7	100
Total Moss Cover	57.7	48.8	100
Anastrophyllum sp.	0.2	0.6	9
Aulacomnium palustre	9.5	12.5	55
Brachythecium sp.	0.4	0.9	18
Bryum cryophilum	1.1	2.6	18
Calliergon sp.	0.9	3.0	9
Campylium sp.	0.7	1.7	18
Cinclidium sp.	0.5	1.5	9
Dicranum sp.	1.1	1.8	45
Ditrichum sp.	0.3	0.9	9
Drepanocladus sp.	0.7	1.7	18
Hylocomium splendens	14.8	23.0	55
Hypnum sp.	0.7	2.4	9
Mnium sp.	0.3	0.6	18
Pleurozium schreberi	2.7	4.7	27
Pohlia sp.	0.2	0.6	9
Racomitrium sp.	0.4	0.8	18
Rhytidium rugosum	0.5	1.0	18
Sanionia sp.	3.2	5.6	27
Tomentypnum nitens	3.6	8.9	36
Unknown moss	15.6	26.8	45
Total Lichen Cover	7.8	16.4	73
Cetraria sp.	0.9	2.1	27
Cladina arbuscula	2.9	5.1	27
Cladina rangiferina	0.6	1.5	27
Cladonia sp.	1.5	4.5	18
Dactylina sp.	0.7	2.1	27
Lobaria sp.	0.5	1.5	18
Peltigera aphthosa	0.3	0.6	18
Peltigera sp.	0.3	0.6	18
Total Bare Ground	29.1	23.2	73
Bare Soil	5.2	5.2	73
Water	10.5	9.7	73
Litter alone	13.4	14.7	73

Soils:

Soils are gravelly, rubbly, blocky, or bouldery and are overlain by thin organic horizons (Table 19). Permafrost typically occurred within 2 m of the soil surface. Frost boils are rare, and surface fragments are common and abundant. Loess caps are absent. Soil pH is alkaline to circumneutral, and EC is generally low. The soils are typically poorly drained, and featured a shallow water table.

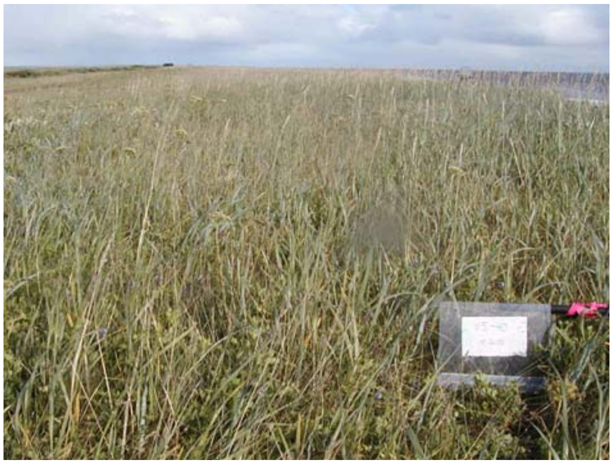
Table 19. Soil characteristics for Alpine Wet Sedge Meadow.

Property	Mean	SD	n
Elevation (m)	604.1	83.3	8
Slope (degrees)	6.8	6.0	8
Surface Organics Depth(cm)	6.9	4.9	8
Cumulative Org. in 40 cm (cm)	6.9	4.9	8
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	8.3	6.2	6
Surface Fragment Cover (%)	14.0	15.7	8
Frost Boil Cover (%)	15.0		1
Thaw Depth (cm)	78.0	38.0	4
Site pH at 10-cm depth	7.1	0.3	8
Site EC at 10-cm depth (μS/cm)	138.8	107.9	8
Water Depth (cm,+ above grnd)[a]	-9.0	5.6	8

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soils in this ecotype are Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation) and Typic Aquiturbels (wet, mineral soil over permafrost with cryoturbation). A less common subgroup is Typic Gelaquepts (wet, partially developed, permafrost below 1 m). This ecotype is the sole ecotype composing the Alpine Rocky Wet Meadow soil landscape.

Coastal Brackish Dunegrass Meadow



Geomorphology:

These dry meadows are located along the coastal sections of BELA and CAKR. This ecotype occurs on eolian active coastal sand deposits and active marine beaches. Surfaces are flat or are wave cut benches. Elevations are near sea level.

Plant Association:

Elymus arenarius ssp. *mollis–Lathyrus maritimus*

Vegetation is restricted to salt-tolerant species that can tolerate frequent root disturbance in unstable sands; as a result, plant diversity is low (Table 20). Dominant plants include *Elymus arenarius* spp. *mollis* (syn: *Leymus mollis*), *Lathyrus maritimus*, *Cnidium cnidiifolium* and *Honckenya peploides*. Trees, shrubs, sedges and lichens are absent. Total live cover is usually low.

This ecotype is most similar to Coastal Dry Barrens except vegetation cover is higher, and salinity values are lower.

Table 20. Vegetation cover and frequency for Coastal Brackish Dunegrass Meadow (n=6).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	55.5	28.7	100
Total Vascular Cover	55.2	28.7	100
Total Forb Cover	26.2	18.2	100
Artemisia tilesii	1.3	1.4	100
Astragalus eucosmus ssp. *sealei*	0.2	0.5	25
Bupleurum triradiatum ssp. *arcticum*	0.3	0.5	50
Chrysanthemum arcticum	<0.1	0.1	25
Chrysanthemum bipinnatum	<0.1	0.1	25
Cnidium cnidiifolium	1.5	1.3	75
Conioselinum chinense	0.8	1.5	25
Honckenya peploides	1.0	0.8	75
Lathyrus maritimus ssp. *maritimus*	17.5	15.0	75
Mertensia maritima	0.5	1.0	25
Papaver lapponicum	<0.1	0.1	25
Saussurea nuda	<0.1	0.1	25
Saxifraga bronchialis	<0.1	0.1	25
Senecio pseudoarnica	2.8	4.9	50
Stellaria sp.	0.2	0.5	25
Triglochin maritimum	<0.1	0.1	25
Total Grass Cover	29.0	11.8	100
Bromus sp.	0.8	1.5	25
Deschampsia caespitosa	<0.1	0.1	25
Elymus arenarius ssp. *mollis*	25.0	7.1	100
Festuca rubra	0.8	1.5	25
Festuca sp.	1.2	2.5	25
Poa arctica	1.2	2.5	25
Total Nonvascular Cover	0.3	0.5	50
Total Moss Cover	0.3	0.5	50
Bryum sp.	0.3	0.5	50
Total Bare Ground	45.8	33.1	100
Bare Soil	6.3	7.4	100
Litter alone	39.5	30.5	100

Soils:

Soils are sandy and often lack a surface organic horizon (Table 21). Permafrost occurs in the upper two meter of the soil profile. Frost boils, loess caps, and surface fragments are absent. Coarse fragments are occasionally present in the active layer. Soil pH is circumneutral to alkaline, and site chemistry is brackish. The soils are excessively drained, and the water table is moderately deep to deep.

Table 21. Soil characteristics for Coastal Brackish Dunegrass Meadow.

Property	Mean	SD	n
Elevation (m)	3.0	1.4	2
Slope (degrees)	3.0	0.0	2
Surface Organics Depth(cm)	3.0		1
Cumulative Org. in 40 cm (cm)	3.0		1
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	105.5	109.4	4
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	106.2	37.5	4
Site pH at 10-cm depth	7.5	0.7	4
Site EC at 10-cm depth (µS/cm)	95.0	66.1	4
Water Depth (cm,+ above grnd)[a]	-100.0	40.8	4

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Typic Cryopsamments (sandy, low coarse fragment content, well drained, lacking permafrost). A less common soil is Typic Psammorthels (sandy, permafrost within 1 m, lacking cryoturbation). This ecotype and associated soils are part of the Coastal Sandy Barrens, Meadow, and Shrub soil landscape. Also included in this soil landscape are Coastal Dry Barrens and Coastal Crowberry Dwarf Shrub.

Coastal Brackish Sedge–Grass Meadow

Geomorphology:

This ecotype occurs on flat areas on active and inactive tidal flats, particularly around deltas, in limited distribution along the coast. Elevations are at sea level or slightly raised. Soil electrical conductivity values are above 800µS.cm^{-1}.

Plant Association:

Carex ramenskii– Dupontia fischeri

Grasses and sedges characterize this ecotype, while forbs and low deciduous shrubs contribute a minor amount to the overall assemblage (Table 22). Trees, tall shrubs, mosses and lichens are absent. Vegetation on lower, wetter sites is dominated by *Carex ramenskii*, *Dupontia fischeri*, and *Calamagrostis deschampsioides*. *Salix ovalifolia* and *Deschampsia caespitosa* occur on micro-sites with better drainage.

This ecotype is most similar to Coastal Saline Wet Sedge–Grass Meadow, but contains *Dupontia fischeri* and *Salix ovalifolia* instead of *Puccinellia phryganodes*, is more sheltered from ocean water and as a result, has lower salinity values. The two ecotypes are spectrally similar and therefore were mapped together.

Table 22. Vegetation cover and frequency for Coastal Brackish Sedge–Grass Meadow (n=7).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	46.2	11.0	100
Total Vascular Cover	46.2	11.0	100
Total Deciduous Shrub Cover	2.6	4.2	60
Salix fuscescens	0.2	0.4	20
Salix ovalifolia	2.4	4.3	40
Total Forb Cover	8.6	6.0	100
Chenopodium sp.	0.2	0.4	40
Chrysanthemum bipinnatum	<0.1	<0.1	20
Cochlearia officinalis	1.8	2.2	60
Polygonum sp.	<0.1	<0.1	20
Potentilla egedii	2.2	4.4	60
Potentilla sp.	<0.1	<0.1	20
Rumex arcticus	0.3	0.4	80
Stellaria humifusa	4.0	3.7	100
Total Grass Cover	8.8	5.2	100
Calamagrostis deschampsioides	3.0	4.5	40
Calamagrostis holmii	2.4	4.3	40
Deschampsia caespitosa	1.0	2.2	20
Dupontia fischeri	2.0	1.9	80
Poa arctica	0.4	0.9	20
Total Sedge & Rush Cover	26.2	4.4	100
Carex aquatilis ssp. *aquatilis*	0.2	0.4	20
Carex ramenskii	26.0	4.2	100
Total Bare Ground	47.4	27.9	100
Bare Soil	11.2	21.7	100
Water	0.2	0.4	60
Litter alone	36.0	23.8	100

Soils:

Soils are loamy and typically feature a moderately thick surface organic horizon (Table 23). Permafrost occurs in the upper meter of the soil profile. Frost boils, loess caps, and surface fragments are absent. Coarse fragments are absent in the active layer. Organic horizons, buried by ocean sands and silts during tidal floods, are sometimes found in these soils. Soil pH is circumneutral, site chemistry is brackish, and EC is high. The soils are very poorly drained, and the water table is very shallow to above ground.

Table 23. Soil characteristics for Coastal Brackish Sedge–Grass Meadow.

Property	Mean	SD	n
Elevation (m)	3.0	1.0	3
Slope (degrees)			0
Surface Organics Depth(cm)	15.2	11.1	5
Cumulative Org. in 40 cm (cm)	16.4	9.9	5
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	5
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	76.6	30.9	5
Site pH at 10-cm depth	6.3	0.4	5
Site EC at 10-cm depth (µS/cm)	8750.0	5415.8	5
Water Depth (cm,+ above grnd)[a]	-8.0	6.5	4

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Historthels (wet, organic rich soil over permafrost and lacking cryoturbation) and Fluvaquentic Aquorthels (wet, saturated within 50 cm, mineral soil with thin buried horizons, permafrost within 1 m). A less common soil is Aquic Gelifluvents (wet, mineral soil with buried organic horizons, permafrost below 1 m). This ecotype and associated soils are part of the Coastal Loamy Barrens, Meadow, and Shrub soil landscape. Also included in this soil landscape are Coastal Wet Barrens, Coastal Brackish Willow Shrub, and Coastal Saline Sedge–Grass Meadow.

Coastal Brackish Water

Geomorphology:

Coastal Brackish Water comprises estuarine waters and lakes on the coast that are influenced by both fresh and nearshore water. In ARCN, this ecotype is restricted to coastal areas in BELA and CAKR. These waters are flooded periodically with saltwater during high tides or storm surges, subsequently resulting in fluctuations in salinity levels. Some lakes have distinct outlets or have been tapped and partially drained through erosional processes. Shallow lakes (<1.5m) freeze to the bottom during winter.

This ecotype is predominantly non-vegetated and we did not develop a plant association. Shallow coastal ponds are occasionally occupied by *Hippurus tetraphylla*.

Coastal Brackish Water is most similar to Nearshore Water and to Coastal Tidal River.

Soils:

Flooded soils were not described. Water characteristics are listed in Table 24.

Table 24. Water characteristics for Coastal Brackish Water.

Property	Mean	SD	n
Site pH at 10-cm depth	8.1	1.0	4
Site EC at 10-cm depth (µS/cm)	5010.0	5170.3	4
Water Depth (cm,+ above grnd)[a]	93.3	92.9	3

[a]Measurements >1 m indicate minimum depth, not true depth

Coastal Brackish Willow Shrub

Geomorphology:

Coastal Brackish Willow Shrub occurs uncommonly on stabilized sections of inactive tidal flats in BELA. Surfaces are flat, and elevations are close to sea level. Disturbance is primarily wind-borne salt water from storm surges, resulting in brackish soils. We could not map this ecotype because it occurs in fragmented patches that were too small to be differentiated by satellite.

Plant Association:

Salix ovalifolia–Deschampsia caespitosa

Salix ovalifolia, a halophytic, water-tolerant dwarf willow, is the dominant species in Coastal Brackish Willow Shrub (Table 25). This stable ecotype is the second most species-rich coastal ecotype. Trees, shrubs >20 cm tall, and lichens are absent. Sedges are common due to the wet soils. Common species include *Pedicularis sudetica*, *Rumex arcticus* and *Eriophorum angustifolium*.

This ecotype is most similar to Coastal Brackish Wet Sedge–Grass Meadow, except it has a higher shrub component and is more diverse.

Table 25. Vegetation cover and frequency for Coastal Brackish Willow Shrub (n=3).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	68.2	2.6	100
Total Vascular Cover	52.5	10.3	100
Total Evergreen Shrub Cover	0.4	0.6	67
Empetrum nigrum	0.4	0.6	67
Total Deciduous Shrub Cover	12.3	9.3	100
Salix ovalifolia	12.3	9.3	100
Total Forb Cover	6.1	4.5	100
Androsace chamaejasme	<0.1	0.1	33
Castilleja elegans	0.3	0.6	33
Chrysanthemum arcticum	0.7	0.6	67
Cochlearia officinalis ssp. *arctica*	0.7	0.6	67
Lathyrus maritimus ssp. *maritimus*	0.3	0.6	33
Melandrium apetalum	0.1	0.1	67
Pedicularis langsdorffii ssp. *arctica*	0.3	0.6	33
Pedicularis sudetica	1.7	0.6	100
Potentilla sp.	0.1	0.1	67
Primula borealis	<0.1	0.1	33
Rumex arcticus	0.1	<0.1	100
Saxifraga exilis	1.7	2.9	67
Sedum rosea ssp. *integrifolium*	0.1	0.1	67
Stellaria sp.	<0.1	0.1	33
Total Grass Cover	16.7	5.7	100
Arctagrostis latifolia	1.7	2.9	33
Calamagrostis deschampsioides	5.0	5.0	67
Deschampsia caespitosa	5.7	4.0	100
Dupontia fischeri	3.3	2.9	67
Elymus arenarius ssp. *mollis*	0.4	0.6	67
Puccinellia borealis	0.7	1.2	33
Total Sedge & Rush Cover	17.0	4.3	100
Carex amblyorhynca	1.7	2.9	33
Carex aquatilis ssp. *aquatilis*	0.7	1.2	33
Carex bigelowii	5.0	8.7	33
Carex canescens	1.3	1.2	67
Carex ramenskii	5.0	5.0	67
Eriophorum angustifolium	2.4	2.5	100
Juncus triglumis ssp. *albescens*	1.0	1.7	33
Total Nonvascular Cover	15.7	11.0	100
Total Moss Cover	15.7	11.0	100
Aulacomnium palustre	0.7	1.2	33
Bryum pallescens	1.7	2.9	33
Bryum sp.	2.5	2.5	67
Campylium polygamum	6.7	7.6	67
Campylium sp.	2.5	2.5	67
Leptobryum pyriforme	1.7	2.9	33
Total Bare Ground	6.7	5.9	67
Bare Soil	1.3	1.5	67
Water	2.0	2.6	67
Litter alone	3.3	2.9	67

Soils:

Soils are sandy and typically feature a thin to moderately thick surface organic horizon (Table 26). Permafrost occurs in the upper meter of the soil profile. Frost boils, loess caps, and surface fragments are absent. Coarse fragments are absent in the active layer. Organic horizons, buried by ocean sands and silts during tidal floods, are commonly found in these soils. Soil pH is circumneutral, site chemistry is brackish, and EC is moderately high to high. The soils are very poorly drained, and the water table is very shallow to above ground.

Table 26. Soil characteristics for Coastal Brackish Willow Shrub.

Property	Mean	SD	n
Elevation (m)	6.0		1
Slope (degrees)			0
Surface Organics Depth(cm)	6.7	9.8	3
Cumulative Org. in 40 cm (cm)	11.7	5.7	3
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	2
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	52.3	15.0	3
Site pH at 10-cm depth	6.5	0.1	3
Site EC at 10-cm depth (µS/cm)	2750.0	2941.4	3
Water Depth (cm,+ above grnd)[a]	-5.5	6.4	2

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Fluvaquentic Aquorthels (wet, saturated within 50 cm, mineral soil with thin buried horizons, permafrost within 1 m). This ecotype and associated soils are part of the Coastal Loamy Barrens, Meadow, and Shrub soil landscape. Also included in this soil landscape are Coastal Wet Barrens, Coastal Brackish Sedge–Grass Meadow, and Coastal Saline Sedge–Grass Meadow.

Coastal Crowberry Dwarf Shrub

Geomorphology:

This ecotype occurs on elevated sections of inactive eolian coastal sand deposits and inactive marine beaches in BELA and CAKR. It occurs on parabolic dunes, crests and on eolian patterned ground. Although geomorphology is marine derived, this ecotype is sheltered from active ocean effects, leading to low salinity values and higher species diversity.

Plant Association:

Empetrum nigrum–Elymus arenarius ssp. *mollis*

The dominant species in this ecotype is crowberry, *Empetrum nigrum* (Table 27). This is the most diverse coastal ecotype due to surface age and stability. Trees and tall shrubs are absent. Low shrubs and sedges occur in trace quantities. Mosses and lichens are common but grasses, forbs and dwarf shrubs are the most prevalent. Common species include *Betula nana*, *Armeria maritima*, *Rhytidium rugosum*, and *Flavocetraria cucullata*.

Soils:

Soils are sandy on inactive coastal dunes and gravelly on inactive marine beaches. The soils feature a thin, often discontinuous, surface organic horizon (Table 28). Permafrost occurs at or near a depth of 1 m below the soil surface. Frost boils and surface fragments are absent, and loess caps are rare. Coarse fragments are present in the active layer on active marine beaches. Soil pH is circumneutral, and EC is low. The soils are excessively to well drained, and the water table is moderately deep to deep.

Table 27. Vegetation cover and frequency for Coastal Crowberry Dwarf Shrub (n=6).

	Cover		Freq
	Mean	SD	%
Total Live Cover	100.8	29.1	100
Total Vascular Cover	61.4	18.3	100
Total Evergreen Shrub Cover	38.4	11.3	100
Cassiope tetragona	0.3	0.8	33
Empetrum nigrum	34.2	12.8	100
Ledum decumbens	1.2	1.5	50
Loiseleuria procumbens	0.2	0.4	17
Vaccinium vitis-idaea	2.5	3.8	67
Total Deciduous Shrub Cover	11.3	8.7	83
Arctostaphylos alpina	1.2	2.0	50
Arctostaphylos rubra	2.5	6.1	17
Betula nana	2.7	3.8	67
Salix alaxensis	0.3	0.8	17
Salix glauca	0.5	1.2	33
Salix lanata ssp. *richardsonii*	0.2	0.4	17
Salix ovalifolia	0.5	1.2	17
Salix phlebophylla	0.2	0.4	17
Salix planifolia ssp. *pulchra*	0.5	0.8	67
Salix reticulata	0.5	0.8	50
Salix rotundifolia	<0.1	<0.1	17
Vaccinium uliginosum	2.2	2.3	67
Total Forb Cover	7.5	5.6	100
Arenaria longipedunculata	<0.1	<0.1	17
Armeria maritima	0.2	0.4	83
Artemisia arctica ssp. *arctica*	0.5	0.8	33
Artemisia tilesii	0.2	0.4	17
Aster sibiricus	<0.1	<0.1	17
Astragalus eucosmus ssp. *sealei*	<0.1	<0.1	17
Astragalus umbellatus	<0.1	<0.1	17
Bupleurum triradiatum ssp. *arcticum*	0.2	0.4	33
Castilleja caudata	<0.1	<0.1	17
Castilleja elegans	0.2	0.4	17
Chrysanthemum bipinnatum	0.2	0.4	17
Epilobium latifolium	1.8	3.3	33
Geum rossii	<0.1	<0.1	17
Lathyrus maritimus ssp. *maritimus*	1.0	1.1	50
Lomatogonium rotatum	<0.1	0.1	33
Minuartia sp.	<0.1	<0.1	17
Oxytropis maydelliana	0.3	0.5	50
Potentilla sp.	<0.1	<0.1	17
Potentilla uniflora	0.8	2.0	17
Potentilla villosa	0.5	0.8	33
Saxifraga bronchialis	0.3	0.8	17
Saxifraga tricuspidata	0.8	2.0	17
Selaginella sibirica	0.2	0.4	33
Taraxacum sp.	<0.1	<0.1	17
Tofieldia coccinea	<0.1	<0.1	17
Total Grass Cover	3.7	2.3	100
Elymus arenarius ssp. *mollis*	1.7	1.5	83
Festuca rubra	0.5	1.2	33
Hierochloe alpina	0.5	1.2	50
Poa arctica	0.2	0.4	33
Poa glauca	0.2	0.4	17
Puccinellia sp.	0.2	0.4	17
Trisetum spicatum ssp. *spicatum*	0.4	0.5	67
Total Sedge & Rush Cover	0.6	0.8	83
Carex atrofusca	<0.1	<0.1	17
Juncus triglumis ssp. *albescens*	<0.1	<0.1	17
Luzula arctica	<0.1	<0.1	17

Table 27. Continued.

	Cover		Freq
	Mean	SD	%
Luzula confusa	<0.1	<0.1	17
Luzula multiflora	0.2	0.4	33
Luzula sp.	0.3	0.8	17
Total Nonvascular Cover	39.5	18.9	100
Total Moss Cover	10.1	7.3	100
Aulacomnium turgidum	0.5	1.2	17
Bryum sp.	1.5	2.0	50
Dicranum acutifolium	1.7	4.1	17
Dicranum sp.	2.5	4.2	33
Hylocomium splendens	0.3	0.8	17
Pleurozium schreberi	0.2	0.4	33
Polytrichum juniperinum	0.8	2.0	17
Polytrichum sp.	<0.1	0.1	33
Ptilidium ciliare	0.3	0.8	33
Rhytidium rugosum	2.0	2.4	67
Sanionia uncinata	0.2	0.4	17
Total Lichen Cover	29.4	14.0	100
Alectoria nigricans	1.3	2.2	33
Arctoparmelia sp.	<0.1	<0.1	17
Asahinea chrysantha	0.2	0.4	17
Bryocaulon divergens	2.7	4.1	50
Bryoria nitidula	0.9	2.0	33
Cetraria cf. *islandica*	0.5	0.8	33
Cetraria laevigata	0.7	1.2	33
Cladina arbuscula	2.5	3.9	50
Cladina rangiferina	1.8	4.0	33
Cladonia alaskana	<0.1	0.1	17
Cladonia furcata	<0.1	0.1	17
Cladonia pyxidata	0.2	0.4	17
Cladonia sp.	1.3	2.2	33
Dactylina arctica	<0.1	0.1	33
Flavocetraria cucullata	6.2	5.5	83
Flavocetraria nivalis	2.7	3.7	67
Hypogymnia physodes	<0.1	0.1	17
Lobaria linita	0.1	0.1	50
Nephroma arcticum	0.2	0.4	17
Ochrolechia frigida	0.3	0.8	33
Peltigera aphthosa	<0.1	0.1	33
Pertusaria sp.	2.5	6.1	17
Ramalina almquistii	<0.1	<0.1	17
Sphaerophorus fragilis	0.3	0.8	17
Sphaerophorus globosus	1.0	1.2	67
Stereocaulon alpinum	0.1	0.1	33
Stereocaulon sp.	1.7	4.1	33
Thamnolia vermicularis	1.3	1.9	67
Unknown crustose lichen	0.8	2.0	33
Total Bare Ground	16.2	12.8	100
Bare Soil	4.5	3.1	100
Litter alone	11.7	13.6	100

Table 28. Soil characteristics for Coastal Crowberry Dwarf Shrub.

Property	Mean	SD	n
Elevation (m)	3.5	1.3	4
Slope (degrees)	2.3	2.3	3
Surface Organics Depth(cm)	1.0	0.0	5
Cumulative Org. in 40 cm (cm)	1.5	0.8	6
Loess Cap Thickness (cm)	3.0		1
Depth to Rocks (cm)	134.7	101.2	6
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	83.8	5.3	5
Site pH at 10-cm depth	6.1	0.8	6
Site EC at 10-cm depth (µS/cm)	123.3	94.8	6
Water Depth (cm,+ above grnd)[a]	-74.0	24.1	6

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Typic Psammorthels (sandy, permafrost within 1 m, lacking cryoturbation). This ecotype and associated soils are part of the Coastal Sandy Barrens, Meadow, and Shrub soil landscape. Also included in this soil landscape are Coastal Brackish Dunegrass Meadow and Coastal Dry Barrens.

Coastal Dry Barrens

Geomorphology:

Coastal Dry Barrens comprises salt-affected active marine beaches and active eolian coastal sand deposits along ocean waters in CAKR and BELA. The surface is frequently scoured by wave action and storm surges.

Plant Association:

Elymus arenarius ssp. *mollis–Lathyrus maritimus*

High disturbance maintains the barren nature of this ecotype, and vegetation is sparse to non-existent (Table 29). Plant species occur in trace quantities. Trees, evergreen shrubs and lichens are absent. The species present in this ecotype are early colonizers tolerant of inundation by seawater and frequent scouring by wind and sand. Common species include *Honckenya peploides*, *Lathyrus maritimus* and *Elymus arenarius* ssp. *mollis*.

This ecotype is most similar to Coastal Brackish Dunegrass Meadow except it has lower species cover and a greater disturbance rate. It is also similar to Coastal Wet Barrens except surfaces are more elevated, are drier and have different associated species. Due to spectral similarities, we developed a single map class for Coastal Dry Barrens and Coastal Wet Barrens, which is Coastal Barrens.

Table 29. Vegetation cover and frequency for Coastal Dry Barrens (n=7).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	6.5	9.1	57
Total Vascular Cover	4.1	6.1	43
Total Deciduous Shrub Cover	0.0	0.1	14
Salix ovalifolia	<0.1	<0.1	14
Salix planifolia ssp. *pulchra*	<0.1	<0.1	14
Total Forb Cover	1.5	2.4	43
Artemisia tilesii	<0.1	<0.1	29
Aster sibiricus	<0.1	<0.1	14
Castilleja sp.	<0.1	<0.1	14
Cochlearia officinalis	<0.1	<0.1	14
Honckenya peploides	0.9	1.5	29
Lathyrus maritimus ssp. *maritimus*	0.2	0.4	29
Ligusticum scoticum	<0.1	<0.1	14
Mertensia maritima	0.3	0.8	14
Pedicularis sudetica	<0.1	<0.1	14
Potentilla egedii	<0.1	<0.1	14
Senecio pseudoarnica	<0.1	<0.1	14
Stellaria longipes	<0.1	<0.1	14
Stellaria sp.	<0.1	<0.1	14
Total Grass Cover	1.9	3.8	43
Elymus arenarius ssp. *mollis*	1.9	3.8	43
Festuca rubra	<0.1	<0.1	14
Poa eminens	<0.1	<0.1	14
Total Sedge & Rush Cover	0.7	1.9	14
Juncus arcticus	0.7	1.9	14
Total Nonvascular Cover	2.4	6.0	43
Total Moss Cover	2.4	6.0	43
Aulacomnium palustre	0.7	1.9	14
Bryum pseudotriquetrum	<0.1	0.1	14
Ceratodon purpureus	0.2	0.4	29
Dicranum spadiceum	<0.1	0.1	14
Leptobryum pyriforme	<0.1	0.1	14
Unknown moss	1.4	3.8	14
Total Bare Ground	97.6	4.6	100
Bare Soil	92.0	11.4	100
Water	1.4	3.8	14
Litter alone	4.1	6.0	57

Soils:

Soils are sandy and lack a surface organic horizon (Table 30). Permafrost occurs at or near a depth of 1 m below the soil surface. Frost boils, loess caps, and surface fragments are absent. Coarse fragments are absent in the active layer. Soil pH is circumneutral to alkaline, site chemistry is brackish or saline, and EC is high. The soils are excessively drained, and the water table is moderately deep to deep.

Table 30. Soil characteristics for Coastal Dry Barrens.

Property	Mean	SD	n
Elevation (m)	2.8	1.8	6
Slope (degrees)	4.4	3.4	5
Surface Organics Depth(cm)			0
Cumulative Org. in 40 cm (cm)			0
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	6
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	109.6	24.5	5
Site pH at 10-cm depth	7.2	0.9	6
Site EC at 10-cm depth (µS/cm)	2018.4	2497.0	5
Water Depth (cm,+ above grnd)[a]	-64.1	36.8	7

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Oxyaquic Cryopsamments (wet, saturated early in growing season, sandy, low coarse fragment content, lacking permafrost) and Typic Cryopsamments (sandy, low coarse fragment content, well drained, lacking permafrost). A less common soil is Aquic Cryopsamments (wet, saturated within 50 cm, sandy, low coarse fragment content, lacking permafrost). This ecotype and associated soils are part of the Coastal Sandy Barrens, Meadow, and Shrub soil landscape. Also included in this soil landscape are Coastal Brackish Dunegrass Meadow and Coastal Crowberry Dwarf Shrub.

Coastal Nearshore Water

Geomorphology:

Coastal Nearshore Water includes the ocean waters of Bering Strait, Kotzebue Sound and Chukchi Sea.

This ecotype is unvegetated and no plant association was developed. The most similar ecotype is Coastal Brackish Water, which comprises coastal lakes and estuarine waters.

Soils:

Flooded soils were not described. Water characteristics are listed in Table 31.

Table 31. Water characteristics for Coastal Nearshore Water.

Property	Mean	SD	n
Site pH at 10-cm depth	7.2	0.2	2
Site EC at 10-cm depth (µS/cm)	45850.0	777.8	2
Water Depth (cm,+ above grnd)[a]	50.0		1

[a]Measurements >1 m indicate minimum depth, not true depth

Coastal Saline Sedge–Grass Meadow

Geomorphology:

This ecotype occurs on low-lying, salt-affected areas on tidal flats and deltas that experience flooding by seawater. The vegetated surface is non-patterned, but small tidal ponds frequently are interspersed within the meadows.

Plant Association:

Carex ramenskii–Puccinellia phryganodes

Halophytic graminoids dominate this ecotype (Table 32), particularly the two species that make up the plant association. Additional common species include *Chrysanthemum arcticum* and *Carex subspathacea*. Trees, shrubs and non-vascular species are absent.

This ecotype is very similar to Coastal Brackish Sedge-Grass Meadow, except for differences in salinity and characteristic species. Spectrally, the two are indistinguishable, and were mapped as one type.

Table 32. Vegetation cover and frequency for Coastal Saline Sedge–Grass Meadow (n=6).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	55.6	9.3	100
Total Vascular Cover	55.6	9.3	100
Total Forb Cover	16.3	10.3	100
Chrysanthemum arcticum	7.3	6.6	100
Potentilla egedii	8.5	9.7	83
Saussurea nuda	0.3	0.8	33
Stellaria humifusa	0.1	<0.1	100
Total Grass Cover	14.2	7.8	83
Calamagrostis deschampsioides	2.5	4.2	33
Elymus arenarius ssp. *mollis*	4.0	4.3	83
Puccinellia phryganodes	7.7	6.1	83
Total Sedge & Rush Cover	25.2	15.6	100
Carex ramenskii	19.3	10.3	100
Carex subspathacea	5.8	10.2	33
Total Bare Ground	41.7	12.5	100
Bare Soil	4.2	5.6	83
Water	0.8	2.0	17
Litter alone	36.7	16.9	100

Soils:

Soils are loamy or sandy and typically feature a moderately thick surface organic horizon (Table 33). Permafrost occurs in the upper meter of the soil profile. Frost boils, loess caps, and surface fragments are absent. Coarse fragments are absent in the active layer. Organic horizons, buried by ocean sands and silts during tidal floods, are sometimes found in these soils. Soil pH is circumneutral, site chemistry is saline, and EC is very high. The soils are very poorly to somewhat poorly drained, and the water table is shallow.

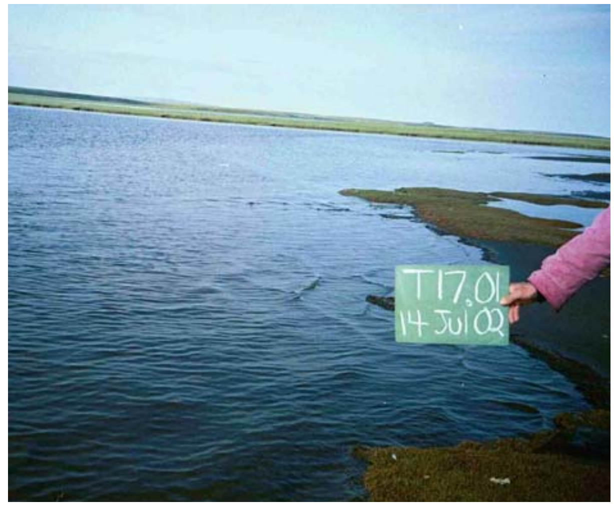
Table 33. Soil characteristics for Coastal Saline Sedge–Grass Meadow.

Property	Mean	SD	n
Elevation (m)	1.0	0.0	6
Slope (degrees)			0
Surface Organics Depth(cm)	20.8	13.1	5
Cumulative Org. in 40 cm (cm)	27.0	12.1	6
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	6
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	71.4	20.8	5
Site pH at 10-cm depth	6.7	0.3	6
Site EC at 10-cm depth (µS/cm)	22430.0	7537.3	6
Water Depth (cm,+ above grnd)[a]	-32.7	16.6	6

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Fluvaquentic Aquorthels (wet, saturated within 50 cm, mineral soil with thin buried horizons, permafrost within 1 m). Less common soils include Fluvaquentic Fibristels (wet, poorly decomposed organic horizon thicker than 40 cm interbedded with buried mineral horizons, permafrost within 1 m) and Fluvaquentic Historthels (wet, organic rich mineral soil with buried organic horizons over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Coastal Loamy Barrens, Meadow, and Shrub soil landscape. Also included in this soil landscape are Coastal Wet Barrens, Coastal Brackish Willow Shrub, and Coastal Brackish Sedge–Grass Meadow.

Coastal Tidal River



Geomorphology:

Coastal Tidal River occurs infrequently at the outlets of rivers to the ocean in BELA and CAKR. These rivers and tidal guts are a mixing zone between saline and fresh waters. Waters are brackish but the actual salinity fluctuates with the tide. Coastal Tidal River is unvegetated and we did not develop a plant association. This ecotype was mapped with Coastal Brackish Water.

Soils:

Flooded soils were not described. Water characteristics are listed in Table 34.

Table 34. Water characteristics for Coastal Tidal River.

Property	Mean	SD	n
Site pH at 10-cm depth	8.3	0.4	2
Site EC at 10-cm depth (µS/cm)	11150.0	495.0	2
Water Depth (cm,+ above grnd)[a]	200.0	0.0	2

[a]Measurements >1 m indicate minimum depth, not true depth

Coastal Wet Barrens

Geomorphology:

Coastal Wet Barrens occurs on active tidal flats in BELA and CAKR. These flats are actively scoured and vegetation is barely present. Loamy soils and proximity to sea level impede drainage, resulting in wet soils with poor drainage.

Plant Association:

Carex ramenskii–Puccinellia phryganodes

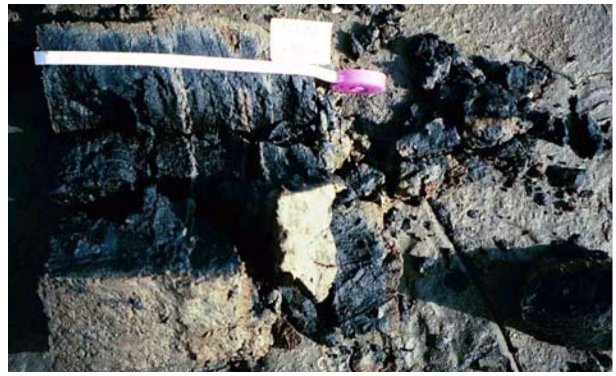
Vegetation is sparse and halophytic (Table 35). All life forms are absent except for graminoids, forbs and infrequent occurrences of mosses. We did not collect enough data to be able to fully describe variation in species assemblages that might exist, and our species list is incomplete.

Table 35. Vegetation cover and frequency for Coastal Wet Barrens (n=1).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	1.6	NA	100
Total Vascular Cover	1.4	NA	100
Total Forb Cover	0.3	NA	100
Chrysanthemum arcticum	0.1	NA	100
Potentilla egedii	0.1	NA	100
Stellaria humifusa	0.1	NA	100
Total Grass Cover	0.1	NA	100
Elymus arenarius ssp. *mollis*	0.1	NA	100
Total Sedge & Rush Cover	1.0	NA	100
Carex subspathacea	1.0	NA	100
Total Nonvascular Cover	0.2	NA	100
Total Moss Cover	0.2	NA	100
Sphagnum obtusum	0.2	NA	100
Total Bare Ground	99.1	NA	100
Bare Soil	98.0	NA	100
Water	1.0	NA	100
Litter alone	0.1	NA	100

This ecotype is spectrally distinct, but floristically is very similar to Coastal Loamy Wet Saline Sedge–Grass Meadow, with which is shares a floristic association. It is similar to Coastal Dry Barrens except for drainage and associated plant species. It and Coastal Dry Barrens were mapped as a single ecotype, Coastal Barrens.

Soils:



Soils are loamy and lack a surface organic horizon (Table 36). Permafrost typically occurs in the upper meter of the soil profile. Frost boils, loess caps, and surface fragments are absent. Coarse fragments are absent in the active layer. Organic horizons, buried by ocean sands and silts during tidal floods, are commonly found in these soils. Soil pH is circumneutral, site chemistry is saline, and EC is very high (>ca. 18000 μS/cm^{-1}). The soils are very poorly drained, and the water table is shallow to above ground.

Table 36. Soil characteristics for Coastal Wet Barrens.

Property	**Mean**	**SD**	**n**
Elevation (m)	1.0		1
Slope (degrees)			0
Surface Organics Depth(cm)			0
Cumulative Org. in 40 cm (cm)			0
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0		1
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	62.0		1
Site pH at 10-cm depth	7.2		1
Site EC at 10-cm depth (μS/cm)	18790.0		1
Water Depth (cm,+ above grnd)[a]	-10.0		1

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Fluvaquentic Aquorthels (wet, saturated within 50 cm, mineral soil with thin buried horizons, permafrost within 1 m). This ecotype and associated soils are part of the Coastal Loamy Barrens, Meadow, and Shrub soil landscape. Also included in this soil landscape are Coastal Brackish Willow Shrub, Coastal Brackish Sedge–Grass Meadow, and Coastal Saline Sedge–Grass Meadow.

Lacustrine Barrens

Geomorphology:

Lacustrine Barrens is a transitional ecotype that occurs either when a lake basin becomes tapped and drained, or when lakes lose water or completely dry up due to other effects. It occurs in both ice-rich and ice-poor thaw basin centers, along lake beaches, in draining organic fens, and on older moraine kettle lakes where thawing of subsurface permafrost affects the water table. Lacustrine Barrens generally occur at low elevations in lowland areas throughout ARCN, particularly west of GAAR. Lacustrine Barrens occurred in small, spectrally indistinct patches and was not mappable.

Plant Association:

Eriophorum angustifolium–Epilobium palustre

Early colonizing forbs and sedges are the characteristic life forms in Lacustrine Barrens (Table 37). Total live cover is variable depending on length of time post-lake drainage, but is typically <30%. Most species occur in trace amounts. A mix of aquatic and terrestrial species is common. Trees, shrubs and lichens occur infrequently, whereas mosses occur in trace amounts. Common species include the mastodon flower, *Senecio congestus* and the grass *Arctagrostis latifolia*.

This ecotype is most similar to Lacustrine Bluejoint Meadow, to which it sometimes transitions to in the successional sequence. The main difference is that Lacustrine Barrens has lower total cover, more ruderal species, and fewer species that are slower to establish.

Table 37. Vegetation cover and frequency for Lacustrine Barrens (n=6).

	Cover		Freq
	Mean	SD	%
Total Live Cover	48.9	49.1	100
Total Vascular Cover	40.0	46.7	100
Total Evergreen Shrub Cover	0.0	0.0	17
Dryas octopetala	<0.1	<0.1	17
Total Deciduous Shrub Cover	0.2	0.5	50
Betula nana	<0.1	<0.1	17
Salix alaxensis	0.2	0.4	17
Salix fuscescens	<0.1	<0.1	17
Salix planifolia ssp. *pulchra*	<0.1	0.1	33
Salix sp.	<0.1	<0.1	17
Total Forb Cover	23.6	33.9	83
Callitriche verna	<0.1	<0.1	17
Caltha palustris	<0.1	0.1	33
Cardamine sp.	<0.1	<0.1	17
Douglasia ochotensis	<0.1	<0.1	17
Draba juvenilis	<0.1	<0.1	17
Epilobium latifolium	0.3	0.8	33
Epilobium palustre	0.1	0.1	50
Equisetum arvense	0.2	0.4	17
Equisetum fluviatile	<0.1	<0.1	17
Equisetum palustre	0.2	0.4	17
Equisetum variegatum	0.5	1.2	17
Minuartia arctica	<0.1	<0.1	17
Polemonium acutiflorum	<0.1	<0.1	17
Potentilla hyparctica	<0.1	<0.1	17
Ranunculus gmelini	5.8	14.3	17
Ranunculus reptans	11.7	28.6	17
Rorippa islandica ssp. *fernaldiana*	2.5	6.1	17
Saxifraga bronchialis	0.3	0.8	17
Saxifraga cernua	<0.1	<0.1	17
Senecio congestus	1.8	4.0	33
Senecio fuscatus	<0.1	<0.1	17
Smelowskia calycina var. *porsildii*	<0.1	<0.1	17
Total Grass Cover	8.6	17.6	67
Alopecurus aequalis	0.7	1.6	17
Arctagrostis latifolia	1.4	2.1	50
Arctophila fulva	<0.1	<0.1	17
Calamagrostis lapponica	1.5	3.7	17
Hierochloe odorata	5.0	12.2	17
Poa glauca	<0.1	<0.1	17
Total Sedge & Rush Cover	7.6	14.7	67
Carex aquatilis ssp. *aquatilis*	<0.1	<0.1	17
Carex canescens	<0.1	<0.1	17
Carex livida	<0.1	<0.1	17
Carex saxatilis	0.3	0.8	33
Eleocharis palustris	0.8	1.6	33
Eriophorum angustifolium	4.2	10.2	33
Eriophorum scheuchzeri	1.7	4.1	17
Eriophorum sp.	0.2	0.4	17
Juncus filiformis	0.3	0.8	17
Luzula arctica	<0.1	<0.1	17
Total Nonvascular Cover	8.9	15.5	83
Total Moss Cover	8.6	15.6	83

Table 37. Continued.

	Cover		Freq
	Mean	SD	%
Aulacomnium palustre	<0.1	<0.1	17
Calliergon giganteum	0.2	0.4	17
Drepanocladus revolvens	0.7	1.6	17
Leptobryum pyriforme	3.3	8.2	17
Polytrichum formosum	<0.1	<0.1	17
Polytrichum juniperinum	<0.1	<0.1	17
Psilopilum laevigatum	3.3	8.2	17
Racomitrium lanuginosum	0.2	0.4	17
Rhytidium rugosum	0.3	0.8	17
Unknown moss	0.5	1.2	33
Total Lichen Cover	0.3	0.5	33
Asahinea chrysantha	<0.1	<0.1	17
Cetraria sp.	<0.1	<0.1	17
Cetraria tilesii	<0.1	<0.1	17
Cladonia sp.	<0.1	<0.1	17
Dactylina arctica	<0.1	<0.1	17
Flavocetraria cucullata	<0.1	<0.1	17
Parmelia sp.	<0.1	<0.1	17
Pseudephebe pubescens	<0.1	<0.1	17
Thamnolia sp.	<0.1	<0.1	17
Unknown crustose lichen	0.2	0.4	17
Unknown lichen	<0.1	<0.1	17
Total Bare Ground	55.7	48.5	100
Bare Soil	52.5	49.6	83
Water	<0.1	<0.1	17
Litter alone	3.2	3.5	83

Soils:

Soils are typically loamy and lack a surface organic horizon (Table 38). Permafrost seldom occurs within the upper meter of the soil profile. Frost boils and loess caps are absent. Surface fragments are common and abundant on rocky lake shores, and absent in drained-lake basins. Soil pH is circumneutral to alkaline, and EC is low. The soils are somewhat poorly to well drained, and the water table is moderately deep to deep.

Table 38. Soil characteristics for Lacustrine Barrens.

Property	Mean	SD	n
Elevation (m)	252.3	346.5	6
Slope (degrees)	3.0	2.8	2
Surface Organics Depth(cm)	3.0		1
Cumulative Org. in 40 cm (cm)	3.0		1
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	2
Surface Fragment Cover (%)	99.0	1.4	2
Frost Boil Cover (%)			0
Thaw Depth (cm)	105.0	63.6	2
Site pH at 10-cm depth	6.8	1.8	4
Site EC at 10-cm depth (µS/cm)	47.5	25.0	4
Water Depth (cm,+ above grnd)[a]	-90.8	66.0	5

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Oxyaquic Gelorthents (wet, saturated early in growing season, poorly developed with permafrost below 1 m) and Typic Gelorthents (poorly developed with permafrost below 1 m). A less common subgroup is Typic Umbrorthels (moist, organic rich mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Lacustrine Loamy Barrens Meadows and Shrublands. Also included in this soil landscape are Lacustrine Bluejoint Meadow and Lacustrine Willow Shrub.

Lacustrine Bluejoint Meadow

Geomorphology:

These lush meadows occur in drained basins, including both ice-rich and ice-poor thaw basin centers and margins. Surfaces are flat and non-patterned. These meadows occur at low elevations in lowland areas, particularly in NOAT, KOVA and CAKR, and to a lesser extent in GAAR. Lacustrine Bluejoint Meadow was not mappable because it occurs in small patches.

Plant Association:

Calamagrostis canadensis–Potentilla palustris

Bluejoint grass (*C. canadensis*) grows profusely in this ecotype (Table 39). Forbs and sedges create a quasi-understory in the tall grass. Mosses are typically present. Trees are absent, while shrubs and lichens occur infrequently, always with low total cover. Common species include *Polemonium acutiflorum*, *Eriophorum angustifolium* and *Aulacomnium palustre*.

This ecotype is similar to Lacustrine Barrens as described in the previous section. Riverine Bluejoint Meadow is very similar and shares a floristic association, but occurs on a different terrain type. Upland Bluejoint Meadow is only similar in the characteristic species, *C. canadensis*.

Table 39. Vegetation cover and frequency for Lacustrine Bluejoint Meadow (n=9).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	90.6	34.2	100
Total Vascular Cover	57.3	24.4	100
Total Deciduous Shrub Cover	2.5	6.3	50
Betula nana	<0.1	<0.1	25
Salix fuscescens	2.0	5.3	25
Salix lanata ssp. *richardsonii*	0.4	1.1	12
Salix planifolia ssp. *pulchra*	0.1	0.4	25
Spiraea beauverdiana	<0.1	<0.1	12
Total Forb Cover	13.6	9.4	100
Arnica alpina ssp. *angustifolia*	0.1	0.4	12
Artemisia tilesii	0.1	0.4	12
Barbarea orthoceras	0.1	0.4	25
Epilobium angustifolium	0.1	0.4	12
Epilobium palustre	<0.1	<0.1	25
Equisetum arvense	2.0	3.7	38
Equisetum fluviatile	2.6	7.0	38
Galium boreale	<0.1	<0.1	12
Galium trifidum ssp. *trifidum*	<0.1	<0.1	12
Ligusticum scoticum	<0.1	<0.1	12
Moehringia lateriflora	0.1	0.4	12
Petasites frigidus	2.9	5.5	38
Polemonium acutiflorum	2.0	2.7	75
Potentilla palustris	2.0	3.6	62
Ranunculus sp.	<0.1	<0.1	12
Rumex arcticus	0.3	0.5	38
Stellaria longipes	0.5	0.8	38
Stellaria sp.	<0.1	<0.1	12
Valeriana capitata	0.5	1.1	25
Viola sp.	<0.1	<0.1	12
Total Grass Cover	33.0	22.3	88
Agrostis sp.	0.2	0.5	25
Calamagrostis canadensis	31.2	22.3	88
Poa arctica	1.5	3.5	38
Total Sedge & Rush Cover	8.2	12.2	88
Carex aquatilis ssp. *aquatilis*	2.1	5.2	50
Carex arcta	<0.1	<0.1	12
Carex utriculata	0.1	0.4	12
Eriophorum angustifolium	5.9	9.3	50
Luzula multiflora	<0.1	<0.1	12
Total Nonvascular Cover	33.3	31.0	88
Total Moss Cover	33.2	30.8	88
Aulacomnium palustre	20.6	24.7	62
Aulacomnium turgidum	0.6	1.8	25
Brachythecium mildeanum	0.6	1.8	12
Brachythecium sp.	1.2	3.5	12
Calliergon giganteum	0.6	1.8	12
Calliergon stramineum	0.6	1.8	12
Drepanocladus sp.	2.2	3.7	38
Plagiomnium ellipticum	0.6	1.8	12
Pohlia nutans	0.1	0.4	12
Polytrichum jensenii	0.6	1.8	12

Table 39. Continued.

	Cover		Freq
	Mean	SD	%
Polytrichum juniperinum	0.1	0.4	12
Polytrichum sp.	0.5	1.1	38
Polytrichum strictum	1.2	3.5	12
Sanionia uncinata	0.6	1.8	12
Sphagnum squarrosum	0.4	1.1	12
Unknown liverwort	1.5	3.5	25
Unknown moss	0.1	0.4	25
Warnstorfia exannulata	0.6	1.8	12
Total Lichen Cover	0.1	0.4	25
Cladonia sp.	0.1	0.4	12
Nephroma sp.	<0.1	<0.1	12
Peltigera aphthosa	<0.1	<0.1	12
Total Bare Ground	37.6	28.1	100
Bare Soil	0.1	0.1	50
Water	7.5	21.2	38
Litter alone	30.0	18.5	100

Soils:

Soils are typically loamy with a moderately thick surface organic horizon (Table 40). Permafrost often occurs within the upper meter of the soil profile. Frost boils, surface fragments, and loess caps are absent. Soil pH is circumneutral to acidic, and EC is low. The soils are typically poorly to moderately well drained, and the water table occurs at shallow depths.

Table 40. Soil characteristics for Lacustrine Bluejoint Meadow.

Property	Mean	SD	n
Elevation (m)	39.2	32.0	8
Slope (degrees)	2.0		1
Surface Organics Depth(cm)	6.4	3.4	8
Cumulative Org. in 40 cm (cm)	7.1	4.4	8
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	5
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	39.8	12.3	6
Site pH at 10-cm depth	5.3	0.6	8
Site EC at 10-cm depth (µS/cm)	130.0	191.2	8
Water Depth (cm,+ above grnd)[a]	-25.0	26.8	6

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation) and Aquic Umbrorthels (wet, organic rich mineral soil over permafrost lacking cryoturbation). Less common subgroups include Oxyaquic Cryorthents (moist, saturated early in growing season, lacking permafrost) and Typic Umbrorthels (moist, organic rich mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Lacustrine Loamy Barrens Meadows and Shrublands. Also included in this soil landscape are Lacustrine Barrens and Lacustrine Willow Shrub.

Lacustrine Buckbean Fen

Geomorphology:

This productive ecotype occurs in fens (thick peat with groundwater input), margins of drained basins, shore fens, and in shallow thaw lakes. It is not abundant but is evenly distributed throughout lowland areas at low elevations in ARCN. Water actively moves through these hydrologically connected fen ecosystems. This ecotype could not be mapped separately due to the high reflectance of water.

Plant Association:

Menyanthes trifoliata–Potentilla palustris

Buckbean (*M. trifoliata*) is the dominant species in this ecotype (Table 41). It grows in dense mats, often floating over open water, which creates substrate for other species. Water-tolerant or aquatic species occur on these mats or in shallow water at the margins, while more terrestrial species occur along the shoreline. Flowing water supplies minerals and nutrients that promote productivity and species diversity. Trees and lichens are absent. Common species include *Potentilla palustris* (syn: *Comarum palustris*), *Carex limosa*, *Equisetum fluviatile*, and *Sphagnum obtusum*.

Similar ecotypes to Lacustrine Buckbean Fen include Lacustrine Horsetail Marsh and Lacustrine Marestail Marsh. The main differences are in characteristic species and Lacustrine Buckbean Fen occurs at shallower water depths.

Table 41. Vegetation cover and frequency for Lacustrine Buckbean Fen (n=7).

	Cover		Freq
	Mean	SD	%
Total Live Cover	102.7	35.7	100
Total Vascular Cover	56.0	25.4	100
Total Evergreen Shrub Cover	0.2	0.4	43
Andromeda polifolia	<0.1	<0.1	29
Chamaedaphne calyculata	<0.1	<0.1	14
Oxycoccus microcarpus	0.2	0.4	29
Total Deciduous Shrub Cover	0.3	0.8	29
Betula nana	<0.1	<0.1	14
Salix fuscescens	<0.1	<0.1	14
Salix lanata ssp. *richardsonii*	0.1	0.4	14
Salix planifolia ssp. *pulchra*	0.1	0.4	14
Total Forb Cover	39.7	29.5	100
Cicuta mackenzieana	0.4	1.1	29
Epilobium palustre	<0.1	<0.1	14
Equisetum fluviatile	1.7	3.7	43
Hippuris vulgaris	<0.1	<0.1	14
Menyanthes trifoliata	34.3	25.9	100
Myriophyllum spicatum	0.7	1.9	14
Potentilla palustris	2.1	2.0	86
Ranunculus pallasii	<0.1	<0.1	14
Triglochin maritimum	<0.1	<0.1	14
Utricularia minor	0.3	0.7	43
Total Grass Cover	0.0	0.0	14
Arctophila fulva	<0.1	<0.1	14
Total Sedge & Rush Cover	15.8	14.2	100
Carex aquatilis ssp. *aquatilis*	3.3	7.5	29
Carex chordorrhiza	1.1	2.0	29
Carex diandra	<0.1	<0.1	14
Carex leptalea	<0.1	<0.1	14
Carex limosa	3.2	4.7	57
Carex loliacea	0.1	0.4	14
Carex rostrata	1.3	2.2	29
Carex saxatilis	0.6	1.5	14
Carex sp.	<0.1	<0.1	14
Carex utriculata	5.0	13.2	14
Eriophorum angustifolium	<0.1	<0.1	14
Eriophorum russeolum	1.1	2.0	29
Total Nonvascular Cover	46.7	38.8	71
Total Moss Cover	46.7	38.8	71
Bryum pseudotriquetrum	1.4	3.8	14
Calliergon giganteum	2.9	7.6	14
Calliergon sp.	2.9	7.6	14
Calliergon stramineum	0.3	0.8	14
Campylium arcticum	1.4	3.8	14
Drepanocladus revolvens	3.1	4.2	43
Meesia triquetra	1.4	3.8	14
Sphagnum obtusum	25.7	44.0	29

Table 41. Continued.

	Cover		Freq
	Mean	SD	%
Sphagnum riparium	4.3	11.3	14
Warnstorfia exannulata	3.3	8.7	14
Total Bare Ground	42.2	36.0	100
Bare Soil	<0.1	0.1	43
Water	34.0	39.8	86
Litter alone	8.2	11.6	86

Soils:

Soils are poorly drained with thick accumulations of peat (Table 42). Permafrost is presumed to be absent because thaw depths are greater than 1.3 m. Coarse fragments are absent in the active layer. Frost boils, loess caps, and surface fragments are absent. Soil pH is circumneutral to acidic, and EC is low. The soils are typically very poorly drained to flooded, and the water table occurs at shallow depths or above ground.

Table 42. Soil characteristics for Lacustrine Buckbean Fen.

Property	Mean	SD	n
Elevation (m)	124.9	117.8	7
Slope (degrees)			0
Surface Organics Depth(cm)	50.3	19.8	6
Cumulative Org. in 40 cm (cm)	37.2	6.9	6
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	3
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	65.0		1
Site pH at 10-cm depth	5.4	1.2	6
Site EC at 10-cm depth (µS/cm)	120.0	141.8	6
Water Depth (cm,+ above grnd)[a]	14.5	24.3	4

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Typic Cryofibrists (wet, poorly decomposed peat, lacking permafrost). Less common subgroups include Hydric Cryofibrists (wet, poorly decomposed peat with a water layer below 60 cm, lacking permafrost) and Hydric Sphagnofibrists (wet, Sphagnum-rich, poorly decomposed peat with a water layer below 60 cm, lacking permafrost). This ecotype and associated soils are part of the Lacustrine Organic-rich Wet Meadows soil landscape. Also included in this soil landscape is Lacustrine Wet Sedge Meadow.

Lacustrine Horsetail Marsh

Geomorphology:

This ecotype occurs in water along the margins of shallow isolated thaw lakes and creates a highly visible swath of deep green color when viewed from a distance. It occurs in small dense patches throughout ARCN. This ecotype could not be mapped separately due to the high reflectance of water. Lacustrine Horsetail Marsh occurs at low elevations where water depths are less than 1 m.

Plant Association:

Equisetum fluviatile–Potentilla palustris

The horsetail *E. fluviatile* is the predominant species in this ecotype, often appearing to grow in a near monoculture. Only forbs, sedges, and the infrequent grass typically occur in Lacustrine Horsetail Marsh (Table 43). A common species is the aquatic bladderwort plant, *Utricularia vulgaris* ssp. *macrorhiza*.

This ecotype is similar to Lacustrine Marestail Marsh and Lacustrine Pendent Grass Marsh except for differences in plant associations.

Table 43. Vegetation cover and frequency for Lacustrine Horsetail Marsh (n=2).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	47.6	31.7	100
Total Vascular Cover	47.6	31.7	100
Total Forb Cover	42.5	38.8	100
Equisetum fluviatile	26.0	19.8	100
Potentilla palustris	0.5	0.7	50
Ranunculus sp.	0.1	0.1	50
Utricularia vulgaris ssp. *macrorhiza*	16.0	19.8	100
Total Grass Cover	0.1	0.1	50
Arctophila fulva	0.1	0.1	50
Total Sedge & Rush Cover	5.0	7.0	100
Carex aquatilis ssp. *aquatilis*	2.5	3.5	50
Carex chordorrhiza	1.0	1.4	50
Carex saxatilis	0.5	0.7	50
Carex sp.	0.1	0.1	50
Carex utriculata	0.5	0.7	50
Eriophorum angustifolium	0.5	0.7	50
Total Bare Ground	72.5	10.6	100
Water	72.5	10.6	100

Soils:

Flooded soils were not described. Water characteristics are listed in Table 44.

Table 44. Water characteristics for Lacustrine Horsetail Marsh.

Property	**Mean**	**SD**	**n**
Site pH at 10-cm depth	6.5	0.3	2
Site EC at 10-cm depth (µS/cm)	150.0	99.0	2
Water Depth (cm,+ above grnd)[a]	47.5	17.7	2

[a]Measurements >1 m indicate minimum depth, not true depth

Lacustrine Marestail Marsh

Geomorphology:

Lacustrine Marestail Marsh commonly occurs in small areas on the margins of deep and shallow isolated thaw lakes and in organic fens. It occurs at low elevations throughout ARCN. It occurs in water of < 1 m depth. This ecotype could not be mapped separately due to the high reflectance of water.

Plant Association:

Hippuris vulgaris–Utricularia vulgaris ssp. *macrorhiza*

The common marestail, *H. vulgaris*, is the most characteristic species of this ecotype, and grows partially submerged in the water (Table 45). Emergent species are common in this ecotype, including several species of pondweeds (*Potamogeton* spp.) and burreeds (*Sparganium* spp.). Additional common species include *Myriophyllum spicatum* and the aquatic moss, *Calliergon giganteum*.

Many of the species that occur in this ecotype also occur in Lacustrine Pendent Grass Marsh, Lacustrine Horestail Marsh and Lacustrine Buckbean Fen. Its primary distinguishing factor is in the dominant species.

Table 45. Vegetation cover and frequency for Lacustrine Marestail Marsh (n=9).

	Cover		Freq
	Mean	SD	%
Total Live Cover	23.5	19.5	100
Total Vascular Cover	21.7	18.1	100
Total Forb Cover	21.2	18.4	100
Caltha natans	<0.1	<0.1	11
Caltha palustris	0.1	0.3	11
Hippuris vulgaris	10.7	10.3	78
Menyanthes trifoliata	0.6	1.7	22
Myriophyllum spicatum	1.1	2.2	33
Potamogeton alpinus ssp. *tenuifolius*	0.2	0.7	11
Potamogeton berchtoldii	<0.1	<0.1	11
Potamogeton sp.	0.1	0.3	22
Potamogeton subsibiricus	1.7	5.0	11
Potentilla palustris	0.3	0.7	33
Ranunculus gmelini	<0.1	<0.1	22
Rumex arcticus	<0.1	<0.1	11
Sparganium hyperboreum	2.2	5.1	22
Sparganium sp.	2.2	5.1	22
Utricularia minor	<0.1	<0.1	11
Utricularia vulgaris ssp. *macrorhiza*	1.9	3.8	33
Total Grass Cover	0.1	0.3	44
Arctophila fulva	0.1	0.3	33
Calamagrostis nutkaensis	<0.1	<0.1	11
Total Sedge & Rush Cover	0.3	0.7	33
Carex aquatilis ssp. *aquatilis*	0.2	0.4	22
Eriophorum angustifolium	0.1	0.3	22
Total Nonvascular Cover	1.8	3.5	44
Total Moss Cover	1.8	3.5	44
Calliergon giganteum	0.7	1.7	22
Calliergon sp.	0.6	1.7	11
Unknown moss	<0.1	<0.1	11
Warnstorfia exannulata	0.6	1.7	11
Total Bare Ground	97.5	4.9	100
Water	97.4	5.0	100
Litter alone	<0.1	<0.1	22

Soils:

Flooded soils were not described. Water characteristics are listed in Table 46.

Table 46. Water characteristics for Lacustrine Marestail Marsh.

Property	Mean	SD	n
Site pH at 10-cm depth	6.6	0.6	9
Site EC at 10-cm depth (µS/cm)	106.7	88.9	9
Water Depth (cm,+ above grnd)[a]	54.2	22.7	9

[a]Measurements >1 m indicate minimum depth, not true depth

Lacustrine Pendent Grass Marsh

Geomorphology:

This ecotype is common in the shallow margins of small to large lakes throughout ARCN. It occurs at low elevations, primarily around lowland lakes. This includes shallow isolated thaw lakes, deep and shallow connected moraine or kettle lakes, ice-poor margins of drained-lake basins, and on glaciolacustrine deposits. Water depths are typically around 0.5 m but can be deeper. Water is always present in this ecotype, making it spectrally indistinct and therefore not mappable.

Plant Association:

Arctophila fulva–Hippuris vulgaris

Emergent species such as pendent grass (*A. fulva*) and common marestail (*H. vulgaris*) predominate (Table 47). Forbs and grasses are the dominant life forms. Trees, shrubs and lichens are absent. Sedges and hydrophilic mosses are sometimes present with low cover. Common species include *Ranunculus pallasii*, *Caltha palustris*, and *Scorpidium scorpioides*.

This ecotype is easy to distinguish from other lacustrine ecotypes by the presence of *A. fulva*.

Soils:

Flooded soils were not described. Water characteristics are listed in Table 48.

Table 47. Vegetation cover and frequency for Lacustrine Pendent Grass Marsh (n=8).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	50.4	34.4	100
Total Vascular Cover	38.0	20.2	100
Total Forb Cover	19.7	18.5	100
Caltha natans	1.9	5.3	12
Caltha palustris	2.9	7.0	25
Chrysosplenium tetrandrum	<0.1	<0.1	12
Epilobium palustre	0.6	1.8	12
Galium trifidum ssp. *trifidum*	0.2	0.7	12
Hippuris vulgaris	4.3	6.7	88
Menyanthes trifoliata	0.4	0.7	25
Myriophyllum sp.	0.1	0.4	12
Myriophyllum spicatum	0.4	1.1	25
Petasites frigidus	0.1	0.4	12
Potamogeton berchtoldii	0.2	0.7	12
Potamogeton sp.	0.2	0.5	25
Potamogeton zosterifolius	1.2	3.5	12
Potentilla palustris	2.9	7.0	25
Ranunculus gmelini	0.3	0.7	25
Ranunculus hyperboreus	0.4	1.1	25
Ranunculus pallasii	0.8	1.2	38
Sparganium hyperboreum	1.9	5.3	12
Stellaria sp.	0.4	1.1	12
Utricularia vulgaris ssp. *macrorhiza*	0.5	1.4	12
Total Grass Cover	17.1	10.9	100
Arctophila fulva	17.1	10.9	100
Total Sedge & Rush Cover	1.1	2.1	50
Carex aquatilis ssp. *aquatilis*	0.3	0.5	38
Eriophorum angustifolium	0.9	1.8	38
Total Nonvascular Cover	12.4	20.1	38
Total Moss Cover	12.4	20.1	38
Calliergon giganteum	3.8	10.6	12
Calliergon sp.	0.1	0.4	12
Drepanocladus aduncus	0.2	0.7	12
Drepanocladus sp.	2.5	7.1	12
Hamatocaulis vernicosus	0.4	1.1	12
Limprichtia revolvens	1.2	3.5	12
Scorpidium scorpioides	3.8	8.8	25
Sphagnum jensnii	0.1	0.4	12
Warnstorfia fluitans	0.2	0.7	12
Total Bare Ground	82.7	26.2	100
Bare Soil	2.1	5.2	50
Water	67.4	38.1	100
Litter alone	13.1	21.5	50

Table 48. Water characteristics for Lacustrine Pendent Grass Marsh.

Property	Mean	SD	n
Site pH at 10-cm depth	6.4	0.4	8
Site EC at 10-cm depth (µS/cm)	70.0	57.6	8
Water Depth (cm,+ above grnd)[a]	29.9	29.6	7

[a]Measurements >1 m indicate minimum depth, not true depth

Lacustrine Pondlily Lake

Geomorphology:

Lacustrine Pondlily Lake occurs in deep isolated kettle lakes and shallow isolated thaw lakes in lowland areas of ARCN. Water depths are typically 0.5 to 1.5 m. Plants typically grow along the shallow edges in deeper lakes, but in shallow lakes, vegetation may be evident across the entire surface. This ecotype could not be mapped separately due to the high reflectance of water.

Plant Association:

Nuphar polysepalum– Sparganium sp.

Lacustrine Pondlily Lake is dominated by aquatic forbs (Table 49). Sedges can occur in shallow water near the shoreline, but other major life forms are typically absent. Common species include *N. polysepalum*, *Sparganium* spp., *Potamogeton berchtoldii* (syn. *P. pusillus* ssp. *tenuissimus*), and *Utricularia vulgaris* ssp. *macrorhiza*.

This ecotype is most similar to Lowland Lake although it has a greater abundance of vegetation. It shares some common aquatic species with other lacustrine ecotypes but is distinguished by the predominance of pondlilies.

Soils:

Flooded soils were not described. Water characteristics are listed in Table 50.

Table 49. Vegetation cover and frequency for Lacustrine Pondlilly Lake (n=5).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	12.0	6.8	100
Total Vascular Cover	12.0	6.8	100
Total Forb Cover	12.0	6.7	100
Equisetum variegatum	<0.1	<0.1	20
Hippuris vulgaris	1.0	1.2	60
Menyanthes trifoliata	0.2	0.4	20
Nuphar polysepalum	5.4	3.2	100
Potamogeton alpinus ssp. *tenuifolius*	0.4	0.5	40
Potamogeton berchtoldii	0.2	0.4	40
Potamogeton epihydrus	1.0	2.2	20
Potamogeton gramineus	0.4	0.9	20
Sparganium sp.	0.8	0.8	80
Utricularia intermedia	<0.1	<0.1	20
Utricularia minor	0.2	0.4	60
Utricularia vulgaris ssp. *macrorhiza*	2.2	2.9	80
Total Sedge & Rush Cover	0.0	0.0	20
Carex rostrata	<0.1	<0.1	20
Total Bare Ground	96.8	3.9	100
Water	96.4	4.0	100
Litter alone	0.4	0.9	60

Table 50. Water characteristics for Lacustrine Pondlilly Lake.

Property	Mean	SD	n
Site pH at 10-cm depth	5.8	0.7	5
Site EC at 10-cm depth (µS/cm)	44.0	39.1	5
Water Depth (cm,+ above grnd)[a]	83.3	25.2	3

[a]Measurements >1 m indicate minimum depth, not true depth

Lacustrine Wet Sedge Meadow

Geomorphology:

This ecotype occurs in ice-poor centers and margins of drained-lake basins and in organic fens. It also occurs on lacustrine deposits on lake shore margins. Surfaces are flat, and water is commonly visible. It occurs at low elevations throughout ARCN. This ecotype occurred in small patches and was mapped as Lowland Sedge Fen.

Plant Association:

Carex aquatilis–Potentilla palustris

Lacustrine Wet Sedge Meadow is the most species rich of the lacustrine ecotypes. It is characterized by sedges and forbs, while shrubs, grasses and mosses are present in lower quantities (Table 51). Trees are absent, and lichens are only infrequently present. Common species include *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Eriophorum angustifolium*, *Carex chordorrhiza* and *Calliergon giganteum*. We documented a rare sedge, *Carex lapponica*, in this ecotype.

This ecotype is most similar to Lowland Sedge Fen except it is more strongly associated with lake processes and the characteristic species are more rapid colonizers.

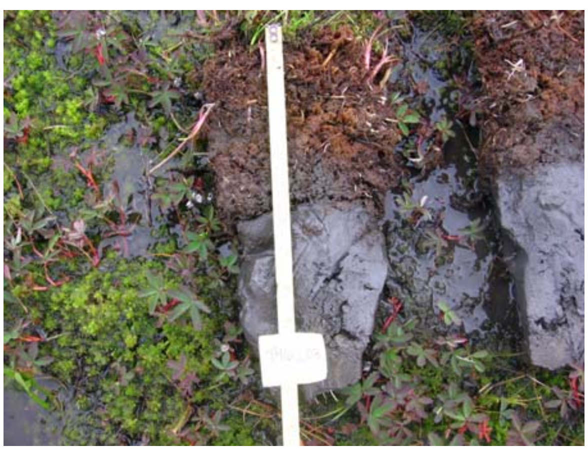
Table 51. Vegetation cover and frequency for Lacustrine Wet Sedge Meadow (n=12).

	Cover		Freq
	Mean	SD	%
Total Live Cover	87.4	45.0	100
Total Vascular Cover	60.1	29.9	100
Total Evergreen Shrub Cover	0.6	2.0	8
Andromeda polifolia	0.1	0.3	8
Chamaedaphne calyculata	0.4	1.4	8
Oxycoccus microcarpus	0.1	0.3	8
Total Deciduous Shrub Cover	6.2	12.5	50
Betula nana	0.4	1.4	8
Salix fuscescens	3.0	10.1	17
Salix planifolia ssp. *pulchra*	2.6	8.3	42
Vaccinium uliginosum	0.2	0.6	8
Total Forb Cover	21.9	25.1	100
Caltha palustris	0.5	1.4	25
Cerastium sp.	<0.1	<0.1	8
Chrysosplenium tetrandrum	<0.1	<0.1	8
Cicuta sp.	<0.1	<0.1	8
Epilobium palustre	<0.1	<0.1	25
Equisetum fluviatile	1.4	3.1	25
Equisetum variegatum	0.4	1.4	8
Galium trifidum ssp. *trifidum*	0.4	1.4	25
Hippuris tetraphylla	0.1	0.3	8
Hippuris vulgaris	0.1	0.3	8
Menyanthes trifoliata	0.3	0.6	25
Petasites frigidus	0.4	1.4	17
Polemonium acutiflorum	<0.1	<0.1	8
Potentilla palustris	17.0	21.4	92
Ranunculus pallasii	0.9	1.9	25
Stellaria sp.	0.1	0.3	17
Utricularia sp.	0.2	0.6	8
Utricularia vulgaris ssp. *macrorhiza*	0.1	0.3	8
Total Grass Cover	2.8	5.9	67
Arctagrostis latifolia	0.2	0.4	17
Arctophila fulva	0.2	0.6	8
Calamagrostis canadensis	0.8	1.4	33
Calamagrostis neglecta	<0.1	<0.1	17
Calamagrostis sp.	1.2	4.3	8
Poa sp.	0.4	1.4	8
Total Sedge & Rush Cover	28.6	16.0	100
Carex aquatilis ssp. *aquatilis*	14.3	15.3	83
Carex canescens	0.4	1.4	8
Carex chordorrhiza	1.8	3.0	42
Carex lapponica	0.1	0.3	8
Carex rostrata	0.4	1.4	8
Carex rotundata	<0.1	<0.1	8
Carex saxatilis	2.3	5.9	17
Carex tenuiflora	<0.1	<0.1	8
Carex utriculata	<0.1	<0.1	8
Eriophorum angustifolium	7.8	7.2	83
Eriophorum russeolum	0.6	1.5	33
Eriophorum scheuchzeri	0.4	1.4	8
Luzula sp.	0.4	1.4	8
Total Nonvascular Cover	27.3	27.9	100
Total Moss Cover	27.3	27.9	100
Aulacomnium palustre	1.2	3.1	17

Table 51. Continued.

	Cover		Freq
	Mean	SD	%
Aulacomnium turgidum	0.4	1.4	8
Calliergon giganteum	3.4	7.5	33
Calliergon sp.	1.5	3.1	33
Drepanocladus revolvens	0.8	2.9	8
Pohlia sp.	0.5	1.4	17
Polytrichum jensenii	0.2	0.6	8
Polytrichum sp.	0.2	0.6	8
Scorpidium scorpioides	0.4	1.4	8
Sphagnum lindbergii	5.4	18.8	8
Sphagnum riparium	1.2	4.3	8
Sphagnum sp.	6.8	20.1	33
Sphagnum squarrosum	2.4	5.7	25
Unknown fungus	<0.1	<0.1	8
Unknown liverwort	1.2	4.3	8
Unknown moss	0.2	0.6	17
Warnstorfia pseudostraminea	1.2	4.3	8
Total Lichen Cover	0.0	0.0	8
Peltigera sp.	<0.1	<0.1	8
Total Bare Ground	40.5	25.3	100
Bare Soil	0.2	0.4	42
Water	10.1	22.4	67
Litter alone	30.2	23.5	100

Soils:



Soils are organic-rich loams and silt-loams with a moderately thick to thick surface organic horizon (Table 52). Permafrost occurs within the upper meter of the soil profile. Frost boils, surface fragments, and loess caps are absent. Soil pH is circumneutral to acidic, and EC is low. The soils are typically very poorly to somewhat poorly drained, and the water table is typically slightly above or below the ground surface.

Table 52. Soil characteristics for Lacustrine Wet Sedge Meadow.

Property	Mean	SD	n
Elevation (m)	127.9	120.3	12
Slope (degrees)			0
Surface Organics Depth(cm)	31.4	34.4	12
Cumulative Org. in 40 cm (cm)	22.7	11.8	12
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	3
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	49.4	14.7	9
Site pH at 10-cm depth	5.6	1.0	11
Site EC at 10-cm depth (μS/cm)	113.6	88.0	11
Water Depth (cm,+ above grnd)[a]	-7.3	13.6	12

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation). A less common subgroup is Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Lacustrine Organic-rich Wet Meadows soil landscape. Also included in this soil landscape is Lacustrine Buckbean Fen.

Lacustrine Willow Shrub

Geomorphology:

This ecotype occurs on lacustrine deposits, older moraine near kettle basins, and on ice-poor centers of drained-lake basins. Common surface forms include depressions, wave cut benches, and concave lower slopes. It is common in small patches around lakes throughout ARCN. Due to small patch size, we could not map this ecotype. Larger patches were included with Lowland Willow Low Shrub.

Plant Association:

Salix planifolia ssp. *pulchra–Potentilla palustris*

Diamondleaf willow (*S. planifolia* ssp. *pulchra*; syn: *S. pulchra*) is the characteristic species. Low shrubs are the most common life form, followed by mosses and sedges (Table 53). Forbs are abundant in the understory, and trees and lichens are usually absent. Common species include *Betula nana*, *Arctagrostis latifolia*, *Carex aquatilis*, and *Aulacomnium palustre*.

This ecotype is most similar to Lowland Willow Low Shrub except for differences in geomorphology and reduced accumulation of organic soils. It is somewhat comparable to Riverine Willow Low Shrub but *S. planifolia* ssp. *pulchra* is the dominant species instead of *S. lanata* ssp. *richardsonii*.

Table 53. Vegetation cover and frequency for Lacustrine Willow Shrub (n=6).

	Cover		Freq
	Mean	SD	%
Total Live Cover	143.3	29.0	100
Total Vascular Cover	97.5	31.0	100
Total Evergreen Shrub Cover	6.0	12.0	50
Andromeda polifolia	<0.1	<0.1	17
Cassiope tetragona	0.3	0.8	17
Dryas integrifolia	0.5	1.2	33
Dryas octopetala	<0.1	<0.1	17
Empetrum nigrum	0.3	0.8	17
Ledum decumbens	1.5	3.2	33
Vaccinium vitis-idaea	3.3	8.2	17
Total Deciduous Shrub Cover	56.3	18.7	100
Arctostaphylos alpina	<0.1	<0.1	17
Arctostaphylos rubra	0.5	1.2	17
Betula nana	2.7	4.1	83
Salix alaxensis	1.7	4.1	50
Salix arbusculoides	<0.1	<0.1	17
Salix fuscescens	4.8	9.9	50
Salix glauca	0.5	0.8	33
Salix lanata ssp. *richardsonii*	10.8	22.0	33
Salix planifolia ssp. *pulchra*	31.8	25.3	83
Salix reticulata	0.8	2.0	33
Spiraea beauverdiana	0.3	0.8	17
Vaccinium uliginosum	2.2	4.0	50
Total Forb Cover	8.5	7.2	100
Astragalus umbellatus	<0.1	<0.1	17
Caltha palustris	0.5	1.2	17
Epilobium angustifolium	0.3	0.5	33
Epilobium latifolium	<0.1	<0.1	17
Epilobium palustre	<0.1	<0.1	17
Equisetum arvense	0.8	2.0	33
Equisetum palustre	0.7	1.6	17
Eutrema edwardsii	<0.1	<0.1	17
Parrya nudicaulis	<0.1	<0.1	17
Pedicularis labradorica	<0.1	0.1	33
Pedicularis sudetica	<0.1	<0.1	17
Petasites frigidus	0.8	2.0	17
Polemonium acutiflorum	1.4	2.8	50
Polygonum bistorta	0.2	0.4	17
Potentilla palustris	0.2	0.4	50
Pyrola asarifolia	<0.1	<0.1	17
Pyrola grandiflora	0.8	2.0	17
Pyrola secunda	<0.1	0.1	33
Ranunculus pallasii	<0.1	<0.1	17
Rubus chamaemorus	2.5	6.1	17
Saussurea angustifolia	<0.1	<0.1	17
Stellaria edwardsii	<0.1	<0.1	17
Tofieldia pusilla	<0.1	<0.1	17
Total Grass Cover	4.3	5.1	100
Arctagrostis latifolia	0.7	0.5	67
Calamagrostis canadensis	2.3	5.7	17
Calamagrostis lapponica	1.0	2.4	17
Poa arctica	0.3	0.5	50
Total Sedge & Rush Cover	22.4	17.7	100

Table 53. Continued.

	Cover		Freq
	Mean	SD	%
Carex aquatilis ssp. *aquatilis*	5.2	7.6	67
Carex bigelowii	9.5	17.8	50
Carex saxatilis	0.8	2.0	17
Carex vaginata	0.2	0.4	17
Eriophorum angustifolium	6.7	8.8	50
Juncus castaneus ssp. *castaneus*	<0.1	<0.1	17
Luzula multiflora	<0.1	<0.1	17
Total Nonvascular Cover	45.8	11.4	100
Total Moss Cover	44.9	11.6	100
Aulacomnium acuminatum	0.5	1.2	17
Aulacomnium palustre	12.0	12.6	67
Aulacomnium turgidum	1.7	4.1	17
Brachythecium sp.	2.5	6.1	17
Calliergon stramineum	0.2	0.4	17
Drepanocladus sp.	2.5	6.1	17
Hylocomium splendens	5.0	6.3	50
Paludella squarrosa	<0.1	<0.1	17
Pleurozium schreberi	4.2	5.8	50
Polytrichum sp.	3.3	5.2	33
Rhytidium rugosum	2.7	4.1	50
Sphagnum balticum	4.2	10.2	17
Sphagnum girgensohnii	3.3	8.2	17
Sphagnum squarrosum	0.8	2.0	17
Thuidium recognitum	0.8	2.0	17
Tomentypnum nitens	0.8	2.0	17
Warnstorfia exannulata	0.2	0.4	17
Warnstorfia sarmentosa	0.2	0.4	17
Total Lichen Cover	0.9	2.1	33
Cladina mitis	<0.1	<0.1	17
Cladonia sp.	<0.1	<0.1	17
Flavocetraria cucullata	0.2	0.4	17
Flavocetraria nivalis	<0.1	<0.1	17
Masonhalea richardsonii	0.5	1.2	17
Peltigera aphthosa	<0.1	0.1	33
Stereocaulon sp.	<0.1	<0.1	17
Thamnolia vermicularis	0.2	0.4	17
Total Bare Ground	13.5	7.3	100
Bare Soil	0.8	2.0	33
Water	0.7	1.6	33
Litter alone	12.0	7.3	100

Soils:

Soils are typically loamy with a thin to moderately thick surface organic horizon (Table 54). Permafrost occurs within the upper meter of the soil profile. Frost boils, surface fragments, and loess caps are absent. Soil pH is circumneutral to acidic, and EC is low. The soils are very poorly to somewhat poorly drained, and the water table is shallow.

Table 54. Soil characteristics for Lacustrine Willow Shrub.

Property	Mean	SD	n
Elevation (m)	378.0	328.9	6
Slope (degrees)	5.0	5.2	3
Surface Organics Depth(cm)	8.5	3.4	6
Cumulative Org. in 40 cm (cm)	8.8	3.5	6
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	24.0	7.6	4
Surface Fragment Cover (%)	0.1		1
Frost Boil Cover (%)			0
Thaw Depth (cm)	56.6	20.5	5
Site pH at 10-cm depth	6.0	0.8	5
Site EC at 10-cm depth (µS/cm)	72.0	47.1	5
Water Depth (cm,+ above grnd)[a]	-30.8	30.7	5

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation). A less common subgroup is Typic Umbrorthels (moist, organic rich mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Lacustrine Loamy Barrens Meadows and Shrublands. Also included in this soil landscape are Lacustrine Bluejoint Meadow and Lacustrine Barrens.

Lowland Alder Tall Shrub

Geomorphology:

Lowland Alder Tall Shrub occurs on hillside colluvium, abandoned meander overbank deposits, older moraine and organic fens throughout ARCN. Surfaces are flat or sloped. Site elevation is usually <300 m. This ecotype represents a community in transition from dwarf shrub or graminoid-dominated vegetation, and may be expanding in response to a warming climate.

Plant Association:

Alnus crispa–Salix planifolia ssp. *pulchra–Hylocomium splendens*

All life forms are represented in this stable ecotype, although it is not particularly species rich (Table 55). Alder, *A. crispa* (syn: *Alnus viridus* ssp. *fruticosa*) grows in mostly open patches. Additional common species include *Vaccinium uliginosum*, *Equisetum arvense*, *Calamagrostis canadensis*, and *Tomentypnum nitens*.

This ecotype is most similar to Lowland Willow Tall Shrub in environmental factors but has different characteristic species. It differs from Upland Alder–Willow Tall Shrub floristically, in physiography and dominant soil type.

Table 55. Vegetation cover and frequency for Lowland Alder Tall Shrub (n=6).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	176.3	69.6	100
Total Vascular Cover	134.7	44.1	100
Total Evergreen Tree Cover	2.5	4.0	50
Picea glauca	1.4	2.4	50
Picea mariana	1.2	2.9	17
Total Evergreen Shrub Cover	11.0	10.7	67
Andromeda polifolia	2.7	6.1	33
Cassiope tetragona	0.2	0.4	17
Chamaedaphne calyculata	1.7	4.1	33
Empetrum nigrum	1.9	4.0	50
Ledum decumbens	2.5	4.2	33
Ledum groenlandicum	0.7	1.6	17
Linnaea borealis	0.3	0.8	17
Vaccinium vitis-idaea	1.2	1.8	33
Total Deciduous Tree Cover	0.4	0.9	17
Betula hybrids	<0.1	<0.1	17
Betula papyrifera	0.3	0.8	17
Total Deciduous Shrub Cover	96.7	22.4	100
Alnus crispa	41.7	19.4	100
Arctostaphylos rubra	3.5	6.0	50
Betula glandulosa	10.8	22.0	33
Betula nana	4.7	10.0	33
Myrica gale	1.7	4.1	17
Potentilla fruticosa	0.3	0.8	33
Salix arbusculoides	0.3	0.8	17
Salix glauca	0.8	2.0	33
Salix lanata ssp. *richardsonii*	3.0	6.0	33
Salix planifolia ssp. *pulchra*	8.7	13.2	67
Salix reticulata	0.8	2.0	17
Salix sp.	0.2	0.4	17
Spiraea beauverdiana	0.2	0.4	17
Vaccinium uliginosum	20.0	16.4	67
Total Forb Cover	17.4	13.8	100
Aconitum delphinifolium	0.1	0.1	50
Anemone parviflora	0.2	0.4	17
Angelica lucida	0.2	0.4	17
Artemisia tilesii	0.8	2.0	17
Cypripedium passerinum	<0.1	<0.1	17
Equisetum arvense	4.7	6.4	67
Equisetum fluviatile	0.2	0.4	17
Equisetum pratense	1.3	3.3	17
Equisetum variegatum	<0.1	<0.1	17
Erigeron elatus	<0.1	<0.1	17
Galium boreale	<0.1	<0.1	17
Galium trifidum ssp. *trifidum*	<0.1	<0.1	17
Iris setosa	0.5	0.8	33
Lupinus arcticus	<0.1	<0.1	17
Lycopodium annotinum	<0.1	<0.1	17
Mertensia paniculata	<0.1	<0.1	17
Moneses uniflora	<0.1	<0.1	17
Parnassia palustris	<0.1	<0.1	17
Pedicularis capitata	<0.1	<0.1	17

Table 55. Continued.

	Cover		Freq
	Mean	SD	%
Pyrola secunda	<0.1	<0.1	17
Ranunculus lapponicus	<0.1	<0.1	17
Rubus arcticus	0.3	0.8	33
Rubus arcticus ssp. *arcticus*	1.0	2.0	33
Rubus arcticus ssp. *stellatus*	0.2	0.4	17
Rubus chamaemorus	6.2	14.1	33
Saussurea angustifolia	0.2	0.4	33
Saxifraga punctata	<0.1	<0.1	17
Senecio atropurpureus	<0.1	<0.1	17
Solidago multiradiata var. *multiradiata*	<0.1	<0.1	17
Trientalis europaea ssp. *arctica*	<0.1	<0.1	17
Valeriana capitata	0.8	1.6	33
Viola sp.	<0.1	<0.1	17
Total Grass Cover	2.2	1.6	100
Arctagrostis latifolia	0.7	1.2	33
Calamagrostis canadensis	1.5	1.9	67
Total Sedge & Rush Cover	4.4	9.2	67
Carex bigelowii	0.5	1.2	17
Carex capillaris	<0.1	<0.1	17
Carex sp.	<0.1	<0.1	17
Carex vaginata	0.5	1.2	33
Eriophorum vaginatum	3.3	8.2	17
Total Nonvascular Cover	41.6	34.2	100
Total Moss Cover	38.5	32.3	100
Abietinella abietina	1.2	2.9	17
Aulacomnium palustre	1.3	2.0	50
Brachythecium erythrorrhizon	0.2	0.4	17
Brachythecium sp.	0.8	2.0	17
Bryum sp.	<0.1	<0.1	17
Campylium polygamum	0.1	0.2	17
Dicranum sp.	0.2	0.4	17
Hylocomium splendens	20.8	28.2	67
Isopterygiopsis pulchella	0.1	0.2	17
Pleurozium schreberi	2.5	4.2	33
Pohlia cruda	0.2	0.4	17
Rhytidiadelphus triquetrus	<0.1	<0.1	17
Rhytidium rugosum	2.5	6.1	17
Sanionia uncinata	<0.1	<0.1	17
Sphagnum sp.	1.0	2.0	33
Tomentypnum nitens	7.2	9.5	67
Unknown moss	0.5	1.2	17
Total Lichen Cover	3.1	4.6	83
Cladina arbuscula	0.3	0.8	17
Cladina rangiferina	0.3	0.8	17
Cladina sp.	0.8	2.0	17
Cladina stygia	0.3	0.8	17
Cladonia sp.	<0.1	<0.1	17
Flavocetraria cucullata	1.2	2.0	33
Unknown lichen	<0.1	<0.1	17
Vulpicida sp.	<0.1	<0.1	17
Total Bare Ground	5.3	3.1	100
Bare Soil	2.5	4.2	50
Litter alone	2.8	1.8	100

Soils

The dominant soil subgroups in the ecotype are Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation) and Typic Histoturbels (wet, organic rich soil over permafrost with cryoturbation). A less common subgroup that occurs on sites with better drainage is Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m).

Table 56. Soil characteristics for Lowland Alder Tall Shrub.

Property	Mean	SD	n
Elevation (m)	151.8	106.9	6
Slope (degrees)	7.7	3.8	3
Surface Organics Depth(cm)	14.7	14.7	6
Cumulative Org. in 40 cm (cm)	18.2	13.7	6
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	71.5	86.1	4
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	62.8	25.7	4
Site pH at 10-cm depth	6.2	0.4	5
Site EC at 10-cm depth (µS/cm)	94.0	53.2	5
Water Depth (cm,+ above grnd)[a]	-36.8	24.7	4

[a]Measurements >1 m indicate minimum depth, not true depth

This ecotype and associated soils are part of the Lowland Organic-rich Shrub and Forests soil landscape. Also included in this soil landscape are Lowland Willow Low Shrub, Lowland Birch–Willow Low Shrub, Lowland Birch–Ericaceous Low Shrub, and Lowland Black Spruce Forest.Soils are typically loamy with a thin to moderately thick surface organic horizon (Table 56). Permafrost and evidence of cryoturbation often occurs within the upper meter of the soil profile. Frost boils and surface fragments are absent, and loess caps are rare. However, when loess occurs it tends to be thick. Soil pH is circumneutral, and EC is low. The soils are poorly to moderately well drained, and the water table is typically shallow.

Lowland Birch–Ericaceous Low Shrub

Geomorphology:

This ecotype is common throughout ARCN, usually at elevations less than 200 m. It occurs on thaw basin ice-rich centers and ice-rich margins, drained basin ice-rich centers, lowland loess, old alluvial terraces, solifluction deposits and abandoned meander overbank deposits. Surfaces are flat, terraced, or on planar slopes. Low- centered polygons, ice-cored mounds, or peat mounds create micro-topographic variability.

Plant Association:

Ledum decumbens–Vaccinium vitis-idaea–Foliose lichens

Low shrubs and mosses are the dominant life forms (Table 57). Sedges and lichens are always present in small quantities, while trees and grasses occur only infrequently. This ecotype is not particularly diverse with a below average total number of species documented. Common species include *Ledum decumbens*, *Betula nana*, *Hylocomium splendens*, *Flavocetraria cucullata*, and *Cladina arbuscula*.

This ecotype is most similar to Lowland Birch–Willow Low Shrub except for the prevalence of ericaceous shrubs instead of willow species. It is floristically similar to Upland Birch–Ericaceous Low Shrub although cover of dwarf birch is higher in the uplands, and site and soil factors are dissimilar.

Table 57. Vegetation cover and frequency for Lowland Birch–Ericaceous Low Shrub (n=12).

	Cover		Freq
	Mean	SD	%
Total Live Cover	170.2	52.7	100
Total Vascular Cover	88.5	35.1	100
Total Evergreen Tree Cover	0.9	2.9	17
Picea glauca	0.1	0.3	8
Picea mariana	0.8	2.9	8
Total Evergreen Shrub Cover	36.9	20.3	100
Chamaedaphne calyculata	<0.1	<0.1	8
Dryas integrifolia	<0.1	<0.1	8
Empetrum nigrum	7.7	6.2	100
Ledum decumbens	18.5	10.6	100
Loiseleuria procumbens	0.2	0.9	8
Oxycoccus microcarpus	0.2	0.4	25
Rhododendron lapponicum	0.1	0.3	8
Vaccinium vitis-idaea	10.2	10.0	92
Total Deciduous Tree Cover	0.0	0.0	8
Populus tremuloides	<0.1	<0.1	8
Total Deciduous Shrub Cover	38.1	25.8	100
Arctostaphylos alpina	0.1	0.3	8
Arctostaphylos rubra	0.1	0.3	8
Betula glandulosa	6.1	17.4	17
Betula nana	20.6	19.4	100
Potentilla fruticosa	0.1	0.3	8
Salix fuscescens	0.1	0.3	25
Salix glauca	0.2	0.9	8
Salix lanata ssp. *richardsonii*	0.1	0.3	8
Salix planifolia ssp. *pulchra*	1.3	2.9	42
Salix reticulata	0.2	0.6	8
Vaccinium uliginosum	9.3	8.4	92
Total Forb Cover	1.6	1.9	58
Equisetum arvense	0.1	0.3	8
Pedicularis labradorica	<0.1	<0.1	8
Pedicularis oederi	<0.1	<0.1	8
Petasites frigidus	0.2	0.6	17
Pinguicula villosa	<0.1	<0.1	17
Pyrola secunda	<0.1	<0.1	8
Rubus chamaemorus	1.2	1.8	42
Stellaria edwardsii	<0.1	<0.1	8
Total Grass Cover	0.2	0.6	17
Arctagrostis latifolia	0.2	0.6	17
Total Sedge & Rush Cover	10.8	14.3	100
Carex aquatilis ssp. *aquatilis*	6.0	14.2	50
Carex bigelowii	3.3	5.0	67
Carex rariflora	0.9	2.9	17
Carex scirpoidea	<0.1	<0.1	8
Carex vaginata	<0.1	<0.1	8
Eriophorum angustifolium	0.1	0.3	8
Eriophorum brachyantherum	0.1	0.3	17
Eriophorum russeolum	0.1	0.3	17
Eriophorum sp.	<0.1	<0.1	8
Eriophorum vaginatum	0.3	0.6	33
Total Nonvascular Cover	81.7	37.7	100
Total Moss Cover	71.9	40.3	100
Aulacomnium palustre	6.8	14.2	50

Table 57. Continued.

	Cover Mean	Cover SD	Freq %
Aulacomnium turgidum	2.7	4.9	50
Brachythecium sp.	<0.1	<0.1	8
Bryum sp.	0.8	2.9	8
Dicranum elongatum	0.4	1.0	17
Dicranum groenlandicum	0.2	0.9	8
Dicranum majus	0.2	0.6	8
Dicranum sp.	2.8	3.7	67
Ditrichum flexicaule	0.1	0.3	8
Hylocomium splendens	11.3	21.8	58
Pleurozium schreberi	3.3	9.5	33
Pohlia nutans	<0.1	0.1	8
Polytrichum juniperinum	1.3	3.1	33
Polytrichum sp.	0.6	1.4	25
Ptilidium ciliare	2.4	5.8	42
Ptilium crista-castrensis	<0.1	<0.1	8
Rhytidium rugosum	2.5	7.2	17
Sanionia uncinata	0.2	0.9	8
Sphagnum angustifolium	0.8	2.9	8
Sphagnum balticum	7.1	24.5	8
Sphagnum capillifolium	3.3	11.5	8
Sphagnum fuscum	8.8	17.9	33
Sphagnum rubellum	0.8	2.9	8
Sphagnum sp.	4.6	8.1	33
Sphagnum squarrosum	2.5	8.7	17
Sphagnum warnstorfii	0.2	0.9	8
Sphenolobus minutus	<0.1	<0.1	8
Thuidium recognitum	0.4	1.4	8
Tomentypnum nitens	0.1	0.3	8
Unknown moss	7.5	26.0	8
Total Lichen Cover	9.9	12.0	100
Cetraria cf. *islandica*	0.3	0.6	33
Cetraria laevigata	0.2	0.6	8
Cladina arbuscula	2.1	4.2	50
Cladina rangiferina	1.3	2.5	50
Cladina sp.	1.3	4.3	25
Cladina stellaris	0.1	0.3	8
Cladina stygia	1.2	2.9	25
Cladonia amaurocraea	0.5	1.4	17
Cladonia furcata	0.4	1.4	8
Cladonia macilenta	<0.1	0.1	8
Cladonia sp.	0.5	0.8	42
Flavocetraria cucullata	1.5	2.5	67
Flavocetraria nivalis	<0.1	<0.1	8
Hypogymnia sp.	<0.1	<0.1	8
Icmadophila ericetorum	<0.1	<0.1	8
Masonhalea richardsonii	<0.1	<0.1	8
Nephroma arcticum	<0.1	<0.1	17
Peltigera aphthosa	0.1	0.3	17
Peltigera sp.	<0.1	<0.1	17
Pertusaria dactylina	<0.1	<0.1	8
Thamnolia vermicularis	0.3	0.6	33
Total Bare Ground	6.5	7.2	83
Bare Soil	0.1	0.3	33
Litter alone	6.4	7.2	83

Soils:

Soils are typically loamy with moderately thick to thick surface organic horizons (Table 58). Depth to permafrost is typically less than 1 m. Frost boils and surface fragments are absent. Loess is rare, which the exception of one site where a thick (>120 cm) accumulation of loess occurred. Soil pH is circumneutral to acidic, and EC is low. The soils are typically very poorly to somewhat poorly drained. Water table is typically shallow to moderately deep.

Table 58. Soil characteristics for Lowland Birch–Ericaceous Low Shrub.

Property	Mean	SD	n
Elevation (m)	71.6	80.4	12
Slope (degrees)	8.5	9.2	2
Surface Organics Depth(cm)	17.0	8.1	12
Cumulative Org. in 40 cm (cm)	17.8	7.6	12
Loess Cap Thickness (cm)	122.0		1
Depth to Rocks (cm)	200.0	0.0	6
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	27.7	17.9	11
Site pH at 10-cm depth	4.7	0.6	11
Site EC at 10-cm depth (μS/cm)	89.1	103.7	11
Water Depth (cm,+ above grnd)[a]	-20.0	11.2	8

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups in this ecotype are Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation), Typic Hemistels (wet, moderately decomposed organic horizon ≥40 cm, permafrost present), and Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation). Less common subgroups include Typic Fibristels (wet, poorly decomposed thick peat, permafrost in upper meter), Typic Aquiturbels (wet, mineral soil over permafrost with cryoturbation), and Terric Hemistels (wet, thick, moderately decomposed organic horizon, with mineral soil within 1 m). This ecotype and associated soils are part of the Lowland Organic-rich Shrub and Forests soil landscape, which also includes Lowland Willow Low Shrub, Lowland Birch–Willow Low Shrub, and Lowland Black Spruce Forest ecotypes.

Lowland Birch–Willow Low Shrub

Geomorphology:

This common ecotype is found on hillside colluvium, lowland loess, lowland retransported deposits, solifluction deposits, abandoned braided overbank deposits, older moraine, ice-poor and ice-rich centers and ice-rich margins of thaw basins, and in bogs. Surfaces are flat or either concave or planar gradual slopes. Ice-cored, peat-cored or undifferentiated mounds are common micro-topographic features. This ecotype is stable and not prone to disturbance except for changes associated with thawing permafrost.

Plant Association:

Betula nana–Salix planifolia ssp. *pulchra– Eriophorum angustifolium*

Low deciduous shrubs characterize this ecotype (Table 59). Mosses and lichens are always present in small quantities. Forbs make up a minor component. This ecotype is the most diverse lowland ecotype, with the 14th highest overall species count. Common species include *Vaccinium uliginosum*, *Petasites frigidus*, *Carex bigelowii*, *Aulacomnium palustre*, and *Flavocetraria cucullata*.

This ecotype is most similar to Lowland Birch–Ericaceous Low Shrub as previously discussed, and to Lowland Willow Low Shrub, except for the prevalence of dwarf birch. It is comparable to Upland Birch–Willow Low Shrub, but site and soil factors are dissimilar and it is much less diverse floristically. It is similar to Riverine Birch–Willow Low Shrub except it has greater accumulation of organic soils.

Soils:

Soils are typically loamy with moderately thick to thick surface organic horizons (Table 60). Depth to permafrost is typically less than 1 m. Frost boils and surface fragments are rare. Loess is rare, however when loess did occur it was generally thick (>20 cm). Soil pH is circumneutral to acidic, and EC is low. The soils are typically very poorly to somewhat poorly drained. Water table was typically shallow to moderately deep.

Table 59. Vegetation cover and frequency for Lowland Birch–Willow Low Shrub (n=20).

	Cover		Freq
	Mean	SD	%
Total Live Cover	144.3	53.2	100
Total Vascular Cover	94.0	35.3	100
Total Evergreen Tree Cover	0.2	0.5	15
Picea glauca	0.2	0.5	15
Total Evergreen Shrub Cover	8.6	8.5	95
Andromeda polifolia	0.5	1.2	20
Cassiope tetragona	0.5	1.3	25
Chamaedaphne calyculata	0.1	0.2	5
Dryas integrifolia	0.8	3.3	10
Dryas octopetala	0.1	0.7	5
Empetrum nigrum	1.2	1.9	50
Ledum decumbens	3.0	3.8	75
Vaccinium vitis-idaea	2.5	3.9	55
Total Deciduous Shrub Cover	59.1	24.2	100
Alnus crispa	0.4	1.2	15
Arctostaphylos rubra	0.1	0.3	10
Betula nana	24.2	17.0	95
Potentilla fruticosa	0.3	1.2	10
Salix barclayi	0.2	1.1	5
Salix glauca	0.8	3.4	5
Salix lanata ssp. *richardsonii*	0.6	2.2	10
Salix planifolia ssp. *pulchra*	21.9	18.2	100
Salix reticulata	0.8	2.4	20
Spiraea beauverdiana	0.1	0.4	15
Vaccinium uliginosum	9.4	10.2	95
Total Forb Cover	10.8	18.8	85
Aconitum delphinifolium	0.1	0.2	5
Equisetum arvense	4.8	16.8	25
Pedicularis sudetica	0.1	0.3	15
Petasites frigidus	2.4	2.9	60
Polemonium acutiflorum	0.1	0.2	15
Polygonum bistorta	0.1	0.4	10
Polygonum viviparum	0.1	0.2	20
Potentilla palustris	0.1	0.7	5
Pyrola grandiflora	0.4	0.9	25
Rubus arcticus	0.3	1.2	10
Rubus arcticus ssp. *arcticus*	0.1	0.2	10
Rubus chamaemorus	1.5	4.5	35
Saussurea angustifolia	0.1	0.2	10
Saxifraga punctata	0.1	0.2	20
Valeriana capitata	0.1	0.2	20
Total Grass Cover	2.2	3.3	85
Arctagrostis latifolia	0.7	1.3	45
Calamagrostis canadensis	1.1	3.4	20
Poa arctica	0.1	0.3	50
Total Sedge & Rush Cover	13.2	15.6	95
Carex aquatilis ssp. *aquatilis*	2.9	8.9	35
Carex bigelowii	3.9	5.7	70
Carex chordorrhiza	0.1	0.4	5
Carex limosa	0.1	0.3	10
Carex membranacea	0.1	0.5	10
Carex saxatilis	0.2	1.1	5
Carex vaginata	0.1	0.2	10
Carex williamsii	0.1	0.7	5

Table 59. Continued.

	Cover		Freq
	Mean	SD	%
Eriophorum angustifolium	3.1	5.2	50
Eriophorum scheuchzeri	0.1	0.7	5
Eriophorum vaginatum	2.3	4.3	50
Luzula parviflora	0.1	0.2	10
Total Nonvascular Cover	50.2	25.8	100
Total Moss Cover	46.5	26.7	100
Aulacomnium palustre	9.3	12.1	75
Aulacomnium turgidum	2.0	3.4	35
Bryum sp.	0.2	1.1	5
Campylium stellatum	0.1	0.4	10
Dicranum groenlandicum	0.2	1.1	5
Dicranum sp.	1.9	3.7	30
Drepanocladus revolvens	0.3	1.1	15
Drepanocladus sp.	0.6	2.2	15
Hylocomium splendens	12.5	18.7	65
Mnium sp.	0.1	0.2	10
Paludella squarrosa	0.9	3.4	10
Pleurozium schreberi	0.6	1.5	35
Polytrichum juniperinum	0.9	2.4	20
Polytrichum sp.	0.4	0.7	30
Polytrichum strictum	0.6	2.3	10
Ptilidium ciliare	0.2	0.7	10
Rhytidium rugosum	0.4	0.9	25
Sanionia uncinata	0.3	0.8	15
Sphagnum capillifolium	1.1	4.9	5
Sphagnum fuscum	1.0	3.5	10
Sphagnum lenense	0.5	2.2	5
Sphagnum sp.	2.3	4.9	40
Sphagnum squarrosum	2.8	9.1	15
Sphagnum warnstorfii	1.2	5.6	5
Sphenolobus minutus	0.3	1.1	10
Tomentypnum nitens	4.8	8.1	50
Unknown moss	0.3	0.7	20
Total Lichen Cover	3.8	5.2	100
Cetraria cf. *islandica*	0.1	0.2	30
Cladina arbuscula	0.4	1.1	40
Cladina rangiferina	0.1	0.3	25
Cladina sp.	0.1	0.3	20
Cladina stygia	0.3	1.1	20
Cladonia sp.	0.2	0.5	45
Cladonia subfurcata	0.2	0.7	10
Dactylina arctica	0.2	0.5	30
Flavocetraria cucullata	0.5	0.9	40
Flavocetraria nivalis	0.1	0.2	10
Masonhalea richardsonii	0.1	0.3	15
Nephroma arcticum	0.3	1.1	10
Nephroma expallidum	0.2	0.9	5
Peltigera aphthosa	0.3	0.4	40
Thamnolia vermicularis	0.1	0.2	25
Unknown crustose lichen	0.2	0.8	10
Total Bare Ground	9.3	7.0	100
Bare Soil	1.2	2.4	50
Water	0.4	1.2	35
Litter alone	7.7	6.3	100

Table 60. Soil characteristics for Lowland Birch–Willow Low Shrub.

Property	Mean	SD	n
Elevation (m)	401.8	381.6	20
Slope (degrees)	4.0	2.5	10
Surface Organics Depth(cm)	16.3	8.5	20
Cumulative Org. in 40 cm (cm)	17.5	9.9	20
Loess Cap Thickness (cm)	32.2	55.2	4
Depth to Rocks (cm)	122.8	83.7	8
Surface Fragment Cover (%)	1.0	NA	1
Frost Boil Cover (%)	3.4	2.8	3
Thaw Depth (cm)	40.6	29.0	18
Site pH at 10-cm depth	5.8	0.6	20
Site EC at 10-cm depth (µS/cm)	67.3	42.5	20
Water Depth (cm,+ above grnd)[a]	-23.5	22.8	17

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation), Typic Hemistels (wet, moderately decomposed organic horizon thicker than 40 cm, permafrost present), and Typic Aquiturbels (wet, mineral soil over permafrost with cryoturbation). Less common subgroups include Typic Fibristels (wet, poorly decomposed thick peat, permafrost in upper meter) and Typic Histoturbels (wet, organic rich soil over permafrost with cryoturbation). This ecotype and associated soils are part of the Lowland Organic-rich Shrub and Forests soil landscape. Also included in this soil landscape are Lowland Willow Low Shrub, Lowland Birch– Ericaceous Low Shrub, and Lowland Black Spruce Forest.

Lowland Black Spruce Forest

Geomorphology:

This ecotype is common at elevations < 250 m throughout GAAR and KOVA but does not occur in NOAT, CAKR or BELA. These organic-rich black spruce forests occur on hillside colluvium, upland and lowland loess, older moraine, older till, retransported deposits and abandoned meander overbank deposits. Surfaces are gradually sloped or flat. Common micro-topographic features include ice-cored, mineral-cored, and undifferentiated hummocks.

Plant Association:

Picea mariana–Ledum decumbens

This fire-prone, late-successional ecotype is dominated by black spruce (Table 61). The forest canopy is open and the understory shrub canopy includes tall, low and dwarf shrubs growing out of a thick carpet of mosses and lichens. Forbs are always present in low quantities. Common species include *Vaccinium uliginosum*, *Carex bigelowii*, *Sphagnum* spp., *Cladina rangiferina*, and *Nephroma arcticum*.

This is the only ecotype characterized by black spruce trees, whose range doesn't extend as far westward through the Brooks Range as white spruce. Upland White Spruce–Ericaceous Forest has some similar species but soils are rockier with less organic accumulation and higher pH.

Table 61. Vegetation cover and frequency for Lowland Black Spruce Forest (n=14).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	183.4	36.3	100
Total Vascular Cover	126.9	18.9	100
Total Evergreen Tree Cover	29.2	11.5	100
Picea glauca	2.3	6.0	14
Picea mariana	26.9	11.7	100
Total Evergreen Shrub Cover	28.7	14.2	100
Andromeda polifolia	<0.1	<0.1	7
Chamaedaphne calyculata	0.7	1.8	14
Empetrum nigrum	6.6	5.4	93
Ledum decumbens	15.2	11.4	100
Ledum groenlandicum	0.4	1.3	7
Linnaea borealis	0.1	0.3	14
Oxycoccus microcarpus	0.2	0.4	29
Vaccinium vitis-idaea	5.6	4.7	86
Total Deciduous Shrub Cover	50.0	16.3	100
Alnus crispa	1.6	5.3	29
Arctostaphylos rubra	<0.1	<0.1	7
Betula glandulosa	2.9	7.0	21
Betula nana	16.2	11.9	79
Salix planifolia ssp. *pulchra*	1.4	2.2	50
Spiraea beauverdiana	3.6	6.2	64
Vaccinium uliginosum	24.3	11.2	100
Total Forb Cover	8.0	8.0	100
Epilobium angustifolium	0.2	0.8	7
Equisetum arvense	1.9	5.4	21
Equisetum scirpoides	<0.1	<0.1	7
Equisetum sylvaticum	0.1	0.5	7
Lycopodium alpinum	<0.1	<0.1	7
Lycopodium annotinum	0.1	0.5	7
Lycopodium clavatum	0.4	1.3	7
Pedicularis labradorica	<0.1	<0.1	7
Petasites frigidus	0.7	1.4	36
Rubus chamaemorus	4.6	5.2	79
Trientalis europaea ssp. *arctica*	<0.1	<0.1	7
Total Grass Cover	0.7	1.0	57
Arctagrostis latifolia	0.2	0.5	21
Calamagrostis canadensis	0.5	0.9	29
Calamagrostis lapponica	<0.1	<0.1	7
Total Sedge & Rush Cover	10.4	12.0	93
Carex bigelowii	8.8	10.6	93
Eriophorum angustifolium	0.2	0.6	14
Eriophorum brachyantherum	0.6	2.1	7
Eriophorum russeolum	0.2	0.8	7
Eriophorum vaginatum	0.6	1.4	21
Total Nonvascular Cover	56.5	21.3	100
Total Moss Cover	49.0	21.0	100
Aulacomnium palustre	1.2	4.0	21
Brachythecium sp.	0.1	0.3	7
Campylium stellatum	0.6	1.5	14
Dicranella subulata	0.1	0.3	7
Dicranum sp.	1.8	4.2	29
Drepanocladus sp.	0.4	1.3	7

Table 61. Continued.

	Cover		Freq
	Mean	SD	%
Hylocomium splendens	10.9	18.6	43
Hypnum sp.	0.1	0.3	21
Pleurozium schreberi	10.9	13.7	64
Polytrichum juniperinum	1.5	3.0	29
Polytrichum sp.	1.9	3.0	43
Polytrichum strictum	1.6	5.3	21
Ptilidium ciliare	0.1	0.4	14
Ptilium crista-castrensis	2.4	8.0	14
Sphagnum angustifolium	1.4	5.3	7
Sphagnum fuscum	4.3	16.0	7
Sphagnum girgensohnii	3.1	9.0	14
Sphagnum sp.	5.9	8.8	71
Tomentypnum nitens	0.5	1.9	7
Unknown moss	0.5	1.3	21
Total Lichen Cover	7.4	6.4	100
Cetraria cf. *islandica*	0.1	0.4	14
Cetraria islandica ssp. *islandica*	0.1	0.3	7
Cetraria sp.	<0.1	<0.1	7
Cladina arbuscula	0.4	0.9	14
Cladina rangiferina	2.2	2.9	64
Cladina sp.	1.4	2.1	43
Cladina stellaris	1.1	2.9	21
Cladina stygia	0.2	0.6	14
Cladonia sp.	0.5	0.5	79
Flavocetraria cucullata	0.1	0.3	14
Flavocetraria nivalis	<0.1	<0.1	7
Nephroma arcticum	0.6	1.1	71
Ochrolechia frigida	0.1	0.3	21
Peltigera aphthosa	0.2	0.4	50
Peltigera canina	0.1	0.3	7
Peltigera leucophlebia	0.1	0.5	7
Peltigera malacea	<0.1	<0.1	7
Peltigera scabrosa	<0.1	<0.1	7
Peltigera sp.	<0.1	<0.1	14
Stereocaulon sp.	<0.1	<0.1	7
Thamnolia vermicularis	0.1	0.4	14
Unknown lichen	0.1	0.3	7
Total Bare Ground	7.7	5.0	100
Bare Soil	0.8	1.4	71
Water	<0.1	<0.1	14
Litter alone	6.9	5.0	100

Soils:

Soils are typically loamy with moderately thick to thick surface organic horizons (Table 62). Depth to permafrost is typically less than 1 m at poorly drained sites. At sites with better drainage, permafrost is either absent or occurred in the upper 2 m along with evidence of cryoturbation in the upper meter. Frost boils and surface fragments are absent. Loess is uncommon. Soil pH is acidic, and EC is low. The soils are typically very poorly to somewhat poorly drained, or well to moderately well drained. Water table was typically moderately deep to deep.

Table 62. Soil characteristics for Lowland Black Spruce Forest.

Property	Mean	SD	n
Elevation (m)	125.4	95.6	14
Slope (degrees)	7.0	4.3	10
Surface Organics Depth(cm)	15.5	5.5	14
Cumulative Org. in 40 cm (cm)	15.8	5.5	14
Loess Cap Thickness (cm)	22.0	8.5	2
Depth to Rocks (cm)	119.5	113.8	2
Surface Fragment Cover (%)			0
Frost Boil Cover (%)	1.0		1
Thaw Depth (cm)	66.8	28.3	6
Site pH at 10-cm depth	4.3	0.5	13
Site EC at 10-cm depth (µS/cm)	70.0	42.6	13
Water Depth (cm,+ above grnd)[a]	-85.9	81.8	10

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation) and Typic Haploturbels (mineral soil over permafrost with cryoturbation). Less common subgroups include Typic Aquiturbels (wet, mineral soil over permafrost with cryoturbation) and Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m). This ecotype and associated soils are part of the Lowland Organic-rich Shrub and Forests soil landscape. Also included in this soil landscape are Lowland Willow Low Shrub, Lowland Birch–Willow Low Shrub, and Lowland Birch–Ericaceous Low Shrub.

Lowland Ericaceous Shrub Bog

Geomorphology:

This ecotype occurs in bogs, including collapse scar and undifferentiated bogs, and in the ice-rich centers of drained-lake basins, ice-poor thaw basin margins, and on abandoned meander overbank deposits. Flats, drained basins and thermokarst basins are the common types of macrotopography in this ecotype. Ground patterns where present include strang, low and high-centered polygons, peat, ice and mineral-cored mounds.

Plant Association:

Andromeda polifolia–Sphagnum sp.

These wet ombrotrophic bog communities are characterized by dwarfed and low shrubs, and mosses (Table 63). Sedges are always present. Lichens are infrequently present on raised micro-sites. Common species include *Betula nana*, *Carex aquatilis*, *C. rotundata*, and a mix of *Sphagnum* species, including *S. balticum* and *S. magellanicum*.

This ecotype is similar to Lowland Sedge–Willow Fen, which lacks *Sphagnum* mosses, has more abundant willow, and occurs in long, hydrologically conected landforms.

Soils:

Soils are poorly drained with moderately thick to thick accumulations of peat (Table 64). Permafrost is often present within 1 m depth. Coarse fragments are rarely encountered in the active layer. Frost boils and surface fragments are absent. Loess caps are uncommon, however when they occur they tend to be thick (>20 cm). Soil pH is acidic, and EC is low. The soils are typically very poorly to somewhat poorly drained, and the water table occurs at shallow depths or above ground.

Table 63. Vegetation cover and frequency for Lowland Ericaceous Shrub Bog (n=30).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	122.0	49.7	100
Total Vascular Cover	55.7	29.0	100
Total Evergreen Tree Cover	0.1	0.2	20
Picea glauca	<0.1	0.2	7
Total Evergreen Shrub Cover	12.4	12.1	97
Andromeda polifolia	6.4	7.8	97
Chamaedaphne calyculata	2.5	4.8	40
Empetrum nigrum	0.7	2.1	27
Ledum decumbens	1.6	2.6	57
Ledum groenlandicum	<0.1	0.2	3
Oxycoccus microcarpus	0.4	0.8	40
Vaccinium vitis-idaea	0.8	1.8	37
Total Deciduous Shrub Cover	10.3	15.9	87
Alnus crispa	<0.1	0.2	7
Betula nana	4.1	6.7	80
Myrica gale	0.2	1.3	3
Salix fuscescens	0.8	2.1	33
Salix planifolia ssp. *pulchra*	0.6	2.7	20
Vaccinium uliginosum	4.5	8.5	50
Total Forb Cover	1.6	3.2	67
Drosera rotundifolia	0.1	0.4	10
Equisetum fluviatile	0.2	0.9	3
Iris setosa	<0.1	0.2	3
Menyanthes trifoliata	0.5	2.7	7
Pedicularis parviflora ssp. *parviflora*	0.1	0.4	7
Pedicularis sudetica	<0.1	0.2	13
Potentilla palustris	<0.1	0.2	7
Rubus chamaemorus	0.5	1.5	17
Tofieldia coccinea	<0.1	0.2	3
Tofieldia pusilla	<0.1	0.2	10
Total Grass Cover	0.0	0.0	10
Total Sedge & Rush Cover	31.3	18.6	100
Carex aquatilis ssp. *aquatilis*	5.9	10.3	63
Carex bigelowii	0.3	1.5	7
Carex chordorrhiza	1.1	2.9	20
Carex limosa	2.4	5.8	23
Carex livida	0.1	0.5	3
Carex membranacea	0.3	1.8	3
Carex microglochin	0.1	0.4	3
Carex rariflora	0.4	1.3	20
Carex rotundata	9.3	14.5	63
Carex saxatilis	<0.1	0.2	3
Carex utriculata	0.1	0.4	3
Carex williamsii	0.3	1.8	3
Eriophorum angustifolium	1.7	4.0	37
Eriophorum callitrix	<0.1	0.2	3
Eriophorum russeolum	6.7	14.4	53
Eriophorum scheuchzeri	0.3	1.0	13
Eriophorum vaginatum	1.2	3.0	37
Trichophorum alpinum	0.1	0.4	3
Trichophorum caespitosum	0.8	4.6	7
Total Nonvascular Cover	66.3	32.4	100
Total Moss Cover	66.6	32.9	100

Table 63. Continued.

	Cover		Freq
	Mean	SD	%
Aulacomnium acuminatum	0.2	0.9	3
Aulacomnium palustre	1.9	5.1	20
Aulacomnium turgidum	2.5	5.1	40
Calliergon stramineum	0.4	1.4	7
Campylium stellatum	0.2	1.0	7
Dicranum laevidens	0.7	2.2	13
Dicranum sp.	0.1	0.5	3
Drepanocladus revolvens	0.7	2.2	10
Drepanocladus sp.	0.1	0.5	3
Hylocomium splendens	0.4	1.5	13
Limprichtia revolvens	0.1	0.4	10
Mnium sp.	<0.1	0.2	3
Mylia anomala	0.3	1.8	3
Pleurozium schreberi	0.3	1.8	3
Polytrichum jensenii	<0.1	0.2	3
Polytrichum juniperinum	0.1	0.4	3
Polytrichum sp.	0.3	1.0	13
Polytrichum strictum	0.1	0.4	10
Scorpidium scorpioides	0.2	0.9	3
Sphagnum angustifolium	0.7	3.7	3
Sphagnum balticum	11.6	21.1	43
Sphagnum compactum	2.1	6.7	10
Sphagnum fuscum	0.7	3.6	10
Sphagnum imbricatum	0.7	2.9	7
Sphagnum jensnii	4.3	13.8	10
Sphagnum lenense	4.7	17.0	10
Sphagnum lindbergii	3.2	10.3	13
Sphagnum magellanicum	1.5	5.6	17
Sphagnum obtusum	2.1	7.1	10
Sphagnum orientale	0.3	1.8	7
Sphagnum riparium	9.2	24.3	17
Sphagnum rubellum	0.5	1.9	7
Sphagnum russowii	1.2	5.5	7
Sphagnum sp.	7.2	16.8	40
Sphagnum squarrosum	1.7	9.1	3
Sphagnum steerei	1.5	8.2	3
Sphagnum subsecundum	0.5	2.7	3
Sphagnum warnstorfii	1.8	5.4	13
Tomentypnum nitens	0.5	2.7	7
Unknown moss	1.1	4.6	27
Warnstorfia exannulata	0.8	3.2	7
Warnstorfia sarmentosa	<0.1	0.2	7
Total Lichen Cover	1.3	3.8	37
Cetraria sp.	<0.1	0.2	3
Cladina rangiferina	<0.1	0.2	3
Cladina sp.	0.1	0.4	10
Cladonia sp.	0.5	1.5	23
Flavocetraria cucullata	0.3	1.0	23
Thamnolia vermicularis	0.1	0.5	3
Unknown crustose lichen	<0.1	0.2	3
Unknown lichen	0.1	0.5	3
Total Bare Ground	19.5	12.7	97
Bare Soil	0.5	1.3	33
Water	4.0	9.0	70
Litter alone	15.0	12.3	90

Table 64. Soil characteristics for Lowland Ericaceous Shrub Bog.

Property	Mean	SD	n
Elevation (m)	112.4	153.2	30
Slope (degrees)	1.5	0.7	2
Surface Organics Depth(cm)	50.8	31.6	30
Cumulative Org. in 40 cm (cm)	36.6	4.6	30
Loess Cap Thickness (cm)	20.0	21.8	3
Depth to Rocks (cm)	186.2	47.9	12
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	41.5	16.0	21
Site pH at 10-cm depth	4.8	0.5	30
Site EC at 10-cm depth (µS/cm)	50.0	28.0	30
Water Depth (cm,+ above grnd)[a]	-12.1	12.3	29

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Sphagnic Cryofibrists (wet, *Sphagnum*-rich, poorly decomposed peat, lacking permafrost), Sphagnic Fibristels (wet, *Sphagnum*-rich, poorly decomposed thick peat, permafrost in upper meter), Typic Fibristels (wet, poorly decomposed thick peat, permafrost in upper meter), and Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation). Less common soil subgroups include Terric Fibristels (wet, thick poorly decomposed organic horizon, with ≥ 30cm mineral horizon within 1 m), Typic Hemistels (wet, moderately decomposed organic horizon thicker than 40 cm, permafrost present), and Typic Histoturbels (wet, organic rich soil over permafrost with cryoturbation). This ecotype and associated soils are part of the Lowland Bogs and Fens soil landscape. Also included in this soil landscape are Lowland Sedge–Willow Fen and Lowland Sedge Fen.

Lowland Lake

Geomorphology:

Lowland Lake comprises the vast majority of lakes in ARCN. This ecotype includes shallow and deep isolated moraine or kettle lakes; deep connected moraine or kettle lakes; shallow and deep isolated thaw lakes; and shallow isolated dune lakes.

Plant Association:

Water–*Potamogeton* spp.

Submerged aquatic species characterize Lowland Lake (Table 65). Water usually covers at least 96% of the total lake surface. Sedges, grasses, and evergreen and deciduous shrubs can occur at the shoreline. Multiple pondweed species including *Potamogeton alpinus*, *Potamogeton berchtoldii* (syn: *Potamogeton pusillus* ssp. *tenuissimus*), and *Potamogeton gramineus* are common.

Lowland Lake is similar to Lacustrine Pondlily Lake except it has deeper water and few emergent aquatic species. It is also similar to Alpine Lake except it occurs at lower elevations, lake development is not driven by bedrock characteristics, and has higher biological productivity.

Soils:

Flooded soils were not described. Water characteristics are listed in Table 66.

Table 65. Vegetation cover and frequency for Lowland Lake (n=22).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	6.7	14.2	48
Total Vascular Cover	6.7	14.2	48
Total Evergreen Shrub Cover	0.0	0.0	5
Andromeda polifolia	<0.1	<0.1	5
Total Deciduous Shrub Cover	0.1	0.7	5
Salix planifolia ssp. *pulchra*	0.1	0.7	5
Total Forb Cover	4.0	7.7	43
Callitriche anceps	<0.1	<0.1	5
Equisetum fluviatile	0.1	0.2	10
Hippuris vulgaris	0.2	0.5	29
Lemna trisulca	0.2	0.9	5
Menyanthes trifoliata	0.5	2.2	14
Myriophyllum spicatum	<0.1	<0.1	5
Myriophyllum spicatum exalbescens	<0.1	0.2	5
Nuphar polysepalum	<0.1	<0.1	5
Potamogeton alpinus tenuifolius	0.2	0.7	14
Potamogeton berchtoldii	<0.1	<0.1	5
Potamogeton filiformis	0.1	0.7	5
Potamogeton friesii	<0.1	0.2	5
Potamogeton gramineus	0.1	0.3	10
Potamogeton perfoliatus richardsonii	0.7	3.3	5
Potamogeton sp.	0.7	3.3	14
Potentilla palustris	0.1	0.5	14
Ranunculus hyperboreus	<0.1	<0.1	5
Sparganium angustifolium	<0.1	<0.1	5
Sparganium sp.	0.6	1.8	10
Utricularia minor	0.1	0.2	10
Utricularia vulgaris ssp. *macrorhiza*	0.3	1.1	14
Total Grass Cover	0.3	1.1	19
Arctophila fulva	0.3	1.1	19
Total Sedge & Rush Cover	2.2	6.8	29
Carex aquatilis ssp. *aquatilis*	0.5	2.2	19
Carex canescens	<0.1	<0.1	5
Carex diandra	<0.1	<0.1	5
Carex utriculata	<0.1	<0.1	5
Eleocharis acicularis	1.4	6.5	5
Eriophorum angustifolium	0.2	1.1	10
Total Bare Ground	99.6	1.0	100
Water	99.5	1.2	100
Litter alone	0.2	0.4	29

Table 66. Water characteristics for Lowland Lake.

Property	Mean	SD	n
Site pH at 10-cm depth	7.2	0.8	21
Site EC at 10-cm depth (µS/cm)	112.4	89.6	21
Water Depth (cm,+ above grnd)[a]	145.8	84.9	19

[a]Measurements >1 m indicate minimum depth, not true depth

Lowland Sedge Fen

Geomorphology:

Lowland Sedge Fen occurs throughout ARCN on flat terrain. Geomorphology includes ice-rich centers of both thaw basins and drained-lake basins, ice-poor centers and margins of drained- lake basins, abandoned meander overbank deposits and organic fens. Surfaces are non-patterned on ice-poor soils, and include low-centered polygons, disjunct rims, and strang on ice-rich soils.

Plant Association:

Carex chordorrhiza–Carex aquatilis

Lowland Sedge Fen is characterized nearly exclusively by sedges; all other life forms have more variable presence and cover (Table 67). Trees and lichens are absent. This ecotype has median diversity relative to other ecotypes. Common species include *Carex chordorrhiza*, *Carex aquatilis*, *Eriophorum angustifolium*, *Potentilla palustris*, and *Scorpidium scorpioides*. We documented two rare plant species in this ecotype, *Eriophorum viridi-carinatum* and *Glyceria pulchella*.

This ecotype is very similar to Lowland Sedge–Willow Fen, except water levels are higher, and it has fewer shrubs. It is also comparable to Lacustrine Wet Sedge Meadow except for physiographic and species differences.

Soils:

Soils are poorly drained with moderately thick to thick accumulations of peat (Table 68). Permafrost is often present within 1 m depth. Coarse fragments are rarely encountered in the active layer. Frost boils, loess caps, and surface fragments are absent. Soil pH is circumneutral to acidic, and EC is low. The soils are typically very poorly to poorly drained, and the water table occurs at shallow depths or above ground.

Table 67. Vegetation cover and frequency for Lowland Sedge Fen (n=32).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	84.9	46.3	100
Total Vascular Cover	53.1	28.6	100
Total Evergreen Tree Cover	0.0	0.0	10
Total Evergreen Shrub Cover	0.7	1.3	41
Andromeda polifolia	0.5	0.9	38
Chamaedaphne calyculata	0.1	0.4	14
Dryas integrifolia	<0.1	0.2	3
Ledum decumbens	<0.1	0.2	7
Total Deciduous Shrub Cover	3.6	6.8	90
Betula nana	0.7	2.0	52
Myrica gale	0.2	0.9	10
Salix fuscescens	2.1	4.9	62
Salix phlebophylla	<0.1	0.2	3
Salix planifolia ssp. *pulchra*	0.4	1.3	24
Vaccinium uliginosum	<0.1	0.2	17
Total Forb Cover	5.1	10.4	93
Drosera rotundifolia	<0.1	0.2	7
Equisetum fluviatile	1.2	6.5	10
Equisetum variegatum	0.1	0.6	3
Menyanthes trifoliata	0.9	3.1	17
Pedicularis langsdorffii	0.1	0.4	3
Pedicularis langsdorffii ssp. *arctica*	0.1	0.4	7
Pedicularis parviflora ssp. *parviflora*	0.5	1.9	14
Pedicularis parviflora ssp. *pennellii*	<0.1	0.2	10
Pedicularis sudetica	0.2	0.5	41
Potentilla palustris	1.0	1.7	48
Ranunculus pallasii	<0.1	0.2	7
Saxifraga hirculus	<0.1	0.2	10
Utricularia intermedia	0.2	0.8	10
Utricularia minor	<0.1	0.2	10
Utricularia vulgaris ssp. *macrorhiza*	0.5	1.1	24
Total Grass Cover	0.2	0.5	21
Calamagrostis canadensis	<0.1	0.2	10
Calamagrostis sp.	<0.1	0.2	3
Dupontia fischeri	0.1	0.4	3
Hierochloe pauciflora	<0.1	0.2	3
Total Sedge & Rush Cover	43.5	25.4	100
Carex amblyorhynca	0.2	0.9	3
Carex aquatilis ssp. *aquatilis*	11.3	11.9	86
Carex capillaris	0.1	0.4	3
Carex chordorrhiza	15.9	15.8	100
Carex diandra	0.2	0.9	3
Carex garberi ssp. *bifaria*	<0.1	0.2	3
Carex limosa	0.8	2.1	28
Carex livida	1.0	3.5	10
Carex magellanica	0.1	0.6	3
Carex membranacea	0.8	1.4	31
Carex pluriflora	1.0	5.6	3
Carex rariflora	0.3	1.1	14
Carex rostrata	0.1	0.3	10
Carex rotundata	2.7	4.7	48
Carex saxatilis	0.8	2.9	14

Table 67. Continued.

	Cover		Freq
	Mean	SD	%
Carex sp.	0.1	0.4	3
Carex tenuiflora	0.9	4.6	7
Carex williamsii	0.1	0.4	3
Eriophorum angustifolium	4.8	6.9	76
Eriophorum russeolum	1.4	1.8	55
Eriophorum scheuchzeri	0.4	1.3	10
Eriophorum sp.	0.1	0.4	3
Eriophorum vaginatum	<0.1	0.2	7
Eriophorum viridi-carinatum	<0.1	0.2	3
Trichophorum caespitosum	0.4	1.3	14
Total Nonvascular Cover	31.8	28.9	97
Total Moss Cover	35.9	31.8	97
Aulacomnium acuminatum	<0.1	0.2	3
Aulacomnium palustre	0.2	0.9	7
Aulacomnium turgidum	0.7	1.5	24
Brachythecium sp.	0.1	0.4	3
Bryum pseudotriquetrum	0.2	1.0	7
Bryum subneodamense	0.1	0.6	3
Calliergon sp.	0.2	0.8	14
Campylium arcticum	0.1	0.4	3
Campylium stellatum	0.3	1.3	10
Cinclidium latifolium	0.2	0.9	3
Dicranum sp.	<0.1	0.2	3
Drepanocladus brevifolius	0.2	0.9	3
Drepanocladus revolvens	3.2	10.0	21
Drepanocladus sp.	0.2	0.9	10
Limprichtia revolvens	6.3	17.9	28
Meesia triquetra	0.1	0.6	3
Mnium sp.	0.1	0.5	10
Pohlia sp.	0.1	0.6	3
Polytrichum jensenii	0.1	0.4	3
Polytrichum sp.	0.2	0.5	10
Polytrichum strictum	0.1	0.4	7
Ptilidium ciliare	<0.1	0.2	3
Rhizomnium sp.	<0.1	0.2	3
Scorpidium scorpioides	9.3	22.0	34
Sphagnum aongstroemii	0.7	3.7	3
Sphagnum balticum	0.2	0.9	3
Sphagnum capillifolium	0.2	0.9	3
Sphagnum compactum	0.2	1.3	3
Sphagnum fimbriatum	0.2	1.3	3
Sphagnum fuscum	0.9	3.3	7
Sphagnum lenense	0.2	0.9	3
Sphagnum orientale	4.1	14.3	14
Sphagnum sp.	3.2	7.1	41
Sphagnum squarrosum	1.6	5.8	10
Sphagnum steerei	0.7	3.7	3
Thuidium sp.	<0.1	0.2	3
Tomentypnum nitens	0.1	0.4	3
Unknown liverwort	0.1	0.6	3
Unknown moss	1.1	4.8	7
Warnstorfia fluitans	0.2	1.3	3
Total Bare Ground	54.5	29.9	97
Bare Soil	3.7	8.7	45
Water	32.0	33.4	90
Litter alone	18.8	14.0	97

Table 68. Soil characteristics for Lowland Sedge Fen.

Property	Mean	SD	n
Elevation (m)	144.4	157.4	27
Slope (degrees)	1.0		1
Surface Organics Depth(cm)	39.2	18.7	28
Cumulative Org. in 40 cm (cm)	34.2	6.1	28
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	6
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	48.7	20.4	25
Site pH at 10-cm depth	5.8	0.7	29
Site EC at 10-cm depth (µS/cm)	85.2	67.5	29
Water Depth (cm,+ above grnd)[a]	1.1	7.7	27

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Fibristels (wet, poorly decomposed thick peat, permafrost in upper meter) and Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation). Less common subgroups include Terric Fibristels (wet, thick poorly decomposed organic horizon, with ≥ 30cm mineral horizon within 1 m) and Terric Hemistels (wet, thick moderately decomposed organic horizon, with ≥ 30cm mineral horizon within 1 m). This ecotype and associated soils are part of the Lowland Bogs and Fens soil landscape. Also included in this soil landscape are Lowland Ericaceous Shrub Bog and Lowland Sedge–Willow Fen.

Lowland Sedge–Willow Fen

Geomorphology:

Lowland Sedge–Willow Fen occurs on abandoned meander overbank deposits, abandoned braided fine channel deposits, abandoned alluvial fan deposits, older moraine, channel fens, organic fens and shore fens. Surfaces are flat and are frequently non-patterned, although micro- topographic features include strang, mineral-cored hummocks, peat mounds, and low-centered polygons.

Plant Association:

Carex aquatilis–Salix planifolia ssp. *pulchra*

This ecotype is sedge-dominated with a subcomponent of deciduous shrubs (Table 69). All life forms may be present, although trees are uncommon. Common species include *Betula nana*, *Potentilla palustris*, *Eriophorum angustifolium*, *Aulacomnium palustre*, and *Paludella squarrosa*.

This ecotype is most similar to Lowland Sedge Fen except it is drier and has higher shrub cover. It is also comparable to Lacustrine Wet Sedge Meadow except for physiographic and species differences. Lowland Sedge–Willow Fen was not spectrally distinct and was mapped as Lowland Sedge Fen.

Soils:

Soils are poorly drained with moderately thick to thick accumulations of peat (Table 70). Permafrost is often present within 1 m depth. Coarse fragments are rarely encountered in the active layer. Frost boils, loess caps, and surface fragments are absent. Soil pH is circumneutral to acidic, and EC is low. The soils are typically very poorly to poorly drained, and water table occurs at shallow depths or above ground.

Table 69. Vegetation cover and frequency for Lowland Sedge–Willow Fen (n=22).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	92.9	40.2	100
Total Vascular Cover	50.4	21.2	100
Total Evergreen Tree Cover	0.2	1.1	10
Picea glauca	0.2	1.1	5
Total Evergreen Shrub Cover	1.1	2.3	48
Andromeda polifolia	0.3	0.9	29
Empetrum nigrum	0.1	0.3	19
Ledum decumbens	0.5	1.2	33
Oxycoccus microcarpus	0.1	0.3	14
Vaccinium vitis-idaea	0.1	0.7	5
Total Deciduous Tree Cover	0.0	0.0	5
Total Deciduous Shrub Cover	11.3	13.2	90
Alnus crispa	<0.1	0.2	5
Betula glandulosa	0.2	1.1	5
Betula nana	2.1	2.9	52
Myrica gale	0.2	1.1	10
Salix fuscescens	1.3	3.3	48
Salix glauca	0.2	1.1	10
Salix planifolia ssp. *pulchra*	4.1	5.1	62
Salix reticulata	0.4	1.2	19
Salix scouleriana	1.0	4.4	10
Vaccinium uliginosum	1.7	3.5	43
Total Forb Cover	3.3	4.0	95
Caltha palustris	0.5	1.5	14
Chrysosplenium wrightii	<0.1	0.2	5
Epilobium palustre	<0.1	<0.1	14
Erigeron elatus	<0.1	<0.1	10
Menyanthes trifoliata	0.6	1.8	14
Parnassia palustris	<0.1	<0.1	10
Pedicularis sudetica	0.1	0.3	19
Petasites frigidus	0.2	0.7	19
Potentilla palustris	1.5	2.5	52
Ranunculus pallasii	<0.1	0.2	5
Rubus arcticus	0.1	0.7	5
Rumex arcticus	<0.1	0.2	5
Valeriana capitata	<0.1	<0.1	10
Total Grass Cover	0.9	1.8	48
Arctagrostis latifolia	0.1	0.4	10
Calamagrostis canadensis	0.7	1.6	24
Hierochloe pauciflora	0.1	0.5	10
Total Sedge & Rush Cover	33.4	17.7	100
Carex aquatilis ssp. *aquatilis*	18.8	17.6	100
Carex bigelowii	0.1	0.2	10
Carex canescens	<0.1	<0.1	14
Carex capillaris	<0.1	<0.1	10
Carex limosa	0.2	0.6	24
Carex membranacea	0.4	0.9	24
Carex rariflora	0.1	0.7	10
Carex rotundata	0.4	1.1	19
Carex saxatilis	1.0	3.0	14
Carex vaginata	<0.1	<0.1	10

Table 69. Continued.

	Cover		Freq
	Mean	SD	%
Eriophorum angustifolium	11.0	13.2	76
Eriophorum russeolum	0.9	1.4	38
Eriophorum scheuchzeri	0.2	1.1	5
Eriophorum sp.	<0.1	0.2	5
Eriophorum vaginatum	0.2	0.7	19
Luzula arcuata	<0.1	0.2	5
Luzula sp.	<0.1	0.2	5
Total Nonvascular Cover	42.5	31.7	86
Total Moss Cover	42.2	31.4	86
Aulacomnium acuminatum	<0.1	0.2	5
Aulacomnium palustre	4.6	5.6	62
Aulacomnium turgidum	0.6	1.3	33
Calliergon giganteum	1.0	4.4	5
Calliergon sp.	2.2	7.6	29
Calliergon stramineum	0.5	2.2	14
Campylium stellatum	0.6	1.3	24
Cinclidium subrotundum	<0.1	0.2	5
Dicranum sp.	0.1	0.5	10
Drepanocladus revolvens	0.9	1.9	19
Drepanocladus sp.	0.4	1.4	10
Hylocomium splendens	0.9	3.3	24
Limprichtia revolvens	0.1	0.4	5
Loeskypnum badium	<0.1	0.2	5
Meesia triquetra	<0.1	0.2	5
Mnium sp.	0.3	1.1	10
Paludella squarrosa	2.8	7.7	19
Plagiomnium sp.	0.1	0.4	5
Pohlia nutans	0.5	2.2	5
Pohlia sp.	0.2	1.1	5
Polytrichum jensenii	0.5	2.2	5
Polytrichum juniperinum	0.1	0.5	10
Rhizomnium sp.	0.2	1.1	5
Rhytidium rugosum	0.2	1.1	5
Sanionia uncinata	0.1	0.4	14
Scorpidium scorpioides	0.2	0.7	14
Sphagnum balticum	1.0	4.4	5
Sphagnum capillifolium	0.6	2.0	10
Sphagnum imbricatum	1.0	4.4	5
Sphagnum lenense	2.4	7.7	10
Sphagnum obtusum	1.2	3.8	10
Sphagnum sp.	3.7	11.7	29
Sphagnum squarrosum	4.6	11.5	24
Sphagnum subsecundum	0.1	0.7	5
Sphagnum teres	0.5	2.2	5
Sphagnum warnstorfii	2.6	6.8	19
Tomentypnum nitens	3.2	8.4	33
Unknown moss	1.4	3.1	24
Warnstorfia exannulata	1.1	3.6	10
Warnstorfia fluitans	1.2	4.4	10
Warnstorfia sarmentosa	0.4	1.7	5
Total Lichen Cover	0.3	1.1	24
Cladina arbuscula	0.2	0.9	14
Cladonia sp.	0.1	0.2	14
Total Bare Ground	47.0	28.0	100
Bare Soil	1.0	2.5	33
Water	21.0	26.5	95
Litter alone	25.0	23.1	95

Table 70. Soil characteristics for Lowland Sedge–Willow Fen.

Property	Mean	SD	n
Elevation (m)	393.6	350.2	21
Slope (degrees)	2.0	1.4	7
Surface Organics Depth(cm)	38.0	26.5	20
Cumulative Org. in 40 cm (cm)	31.1	11.0	20
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	173.1	71.1	7
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	41.7	18.0	16
Site pH at 10-cm depth	6.0	0.6	20
Site EC at 10-cm depth (µS/cm)	163.5	188.9	20
Water Depth (cm,+ above grnd)[a]	-0.6	7.8	19

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Fibristels (wet, poorly decomposed thick peat, permafrost in upper meter), Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation), and Typic Cryofibrists (wet, poorly decomposed peat, lacking permafrost). A less common soil subgroup is Typic Hemistels (wet, moderately decomposed organic horizon thicker than 40 cm, permafrost present). This ecotype and associated soils are part of the Lowland Bogs and Fens soil landscape. Also included in this soil landscape are the Lowland Ericaceous Shrub Bog and Lowland Sedge Fen ecotypes.

Lowland Willow Low Shrub

Geomorphology:

This willow-dominated lowland ecotype occurs on hillside colluvium, older moraine, upland loess, ice-rich thaw basins, and abandoned braided overbank deposits. The surface is usually flat or a gentle concave slope. It occurs throughout ARCN at <550 m elevation.

Plant Association:

Salix planifolia ssp. *pulchra–Valeriana capitata*

Deciduous shrubs and forbs characterize this ecotype (Table 71). Mosses often create a carpet in the understory. All life forms except deciduous trees may be present to some degree. Common species include *Vaccinium uliginosum*, *Equisetum arvense*, *Petasites frigidus*, *Calamagrostis canadensis*, and *Tomentypnum nitens*.

This ecotype is similar to Lowland Birch– Willow Low Shrub except for the absence of dwarf birch. It is different from Riverine Willow Low Shrub in physiographic characters and species composition.

Soils:

Soils are typically loamy with moderately thick surface organic horizons (Table 72). Depth to permafrost is typically less than 1 m. Frost boils and surface fragments are absent. Loess is rare, which the exception of one site where a thick (68 cm) accumulation of loess occurred over glacial till. Soil pH is circumneutral to acidic, and EC is low. The soils are typically very poorly to somewhat poorly drained. The water table is typically shallow.

Table 71. Vegetation cover and frequency for Lowland Willow Low Shrub (n=12).

	Cover		Freq
	Mean	SD	%
Total Live Cover	185.5	55.8	100
Total Vascular Cover	132.2	34.8	100
Total Evergreen Tree Cover	0.0	0.0	8
Total Evergreen Shrub Cover	1.2	3.2	33
Andromeda polifolia	0.2	0.6	8
Empetrum nigrum	0.4	1.4	17
Ledum decumbens	0.1	0.3	17
Ledum groenlandicum	0.1	0.3	8
Vaccinium vitis-idaea	0.4	1.4	17
Total Deciduous Shrub Cover	73.1	14.0	100
Alnus crispa	0.4	1.0	25
Arctostaphylos rubra	0.4	1.4	8
Betula nana	0.8	1.3	42
Myrica gale	1.7	5.8	8
Potentilla fruticosa	0.2	0.6	8
Salix alaxensis	0.8	2.3	17
Salix fuscescens	3.3	10.1	17
Salix glauca	0.6	1.5	17
Salix lanata ssp. *richardsonii*	1.7	3.3	33
Salix planifolia ssp. *pulchra*	55.9	22.7	100
Salix reticulata	2.7	4.9	33
Vaccinium uliginosum	4.1	5.5	58
Total Forb Cover	40.2	30.0	100
Aconitum delphinifolium	0.4	0.7	42
Anemone richardsonii	0.8	1.6	25
Artemisia arctica ssp. *arctica*	1.2	3.1	17
Cicuta mackenzieana	0.1	0.3	8
Dodecatheon frigidum	0.2	0.6	8
Epilobium angustifolium	0.1	0.3	17
Equisetum arvense	11.3	16.6	58
Equisetum fluviatile	2.1	7.2	8
Equisetum pratense	0.1	0.3	8
Equisetum scirpoides	0.1	0.3	8
Equisetum variegatum	0.1	0.3	8
Petasites frigidus	15.7	26.3	58
Petasites hyperboreus	2.1	7.2	8
Polemonium acutiflorum	0.4	0.6	50
Polygonum bistorta	0.2	0.4	17
Polygonum viviparum	0.1	0.3	8
Potentilla palustris	1.0	1.9	33
Pyrola minor	0.1	0.3	8
Rubus arcticus ssp. *arcticus*	0.2	0.4	25
Rubus chamaemorus	1.4	3.1	50
Saxifraga hirculus	0.1	0.3	8
Sedum rosea ssp. *integrifolium*	0.1	0.3	8
Stellaria longipes	0.2	0.4	25
Valeriana capitata	1.8	2.1	58
Total Grass Cover	9.1	7.0	100
Arctagrostis latifolia	1.4	1.9	50
Calamagrostis canadensis	5.1	7.8	58
Calamagrostis lapponica	1.2	4.3	8
Festuca altaica	0.6	1.4	33
Poa arctica	0.7	1.0	58

Table 71. Continued.

	Cover		Freq
	Mean	SD	%
Total Sedge & Rush Cover	8.6	8.9	92
Carex aquatilis ssp. *aquatilis*	3.3	4.6	67
Carex bigelowii	3.2	6.8	42
Carex canescens	0.4	1.4	8
Carex capitata	0.2	0.6	8
Carex loliacea	0.1	0.3	8
Carex membranacea	0.4	1.4	8
Carex podocarpa	0.1	0.3	8
Carex saxatilis	0.4	1.4	8
Eriophorum angustifolium	0.1	0.3	17
Eriophorum scheuchzeri	0.2	0.9	8
Eriophorum vaginatum	0.2	0.6	8
Total Nonvascular Cover	53.3	30.8	100
Total Moss Cover	52.2	30.6	100
Aulacomnium palustre	9.8	19.8	75
Aulacomnium turgidum	1.2	2.6	25
Brachythecium salebrosum	1.2	4.3	8
Brachythecium sp.	0.2	0.9	8
Bryum pseudotriquetrum	0.1	0.3	8
Calliergon sp.	2.1	7.2	8
Calliergon stramineum	3.8	11.4	25
Campylium stellatum	0.1	0.3	8
Cinclidium arcticum	0.1	0.3	8
Dicranum fuscescens	0.1	0.3	8
Dicranum laevidens	0.2	0.6	8
Dicranum majus	0.2	0.6	8
Dicranum sp.	1.9	3.9	25
Drepanocladus brevifolius	0.3	1.2	8
Drepanocladus sendtneri	0.3	1.2	8
Drepanocladus sp.	2.1	5.0	17
Hylocomium splendens	14.6	21.3	67
Meesia triquetra	0.2	0.6	8
Mnium sp.	1.8	5.8	17
Paludella squarrosa	2.2	7.8	8
Pleurozium schreberi	0.8	1.9	17
Pohlia sp.	0.4	1.4	8
Polytrichum commune	0.4	1.4	8
Polytrichum juniperinum	0.1	0.3	8
Polytrichum sp.	0.7	1.6	17
Polytrichum strictum	0.8	1.9	17
Sanionia uncinata	0.4	1.4	17
Sphagnum fuscum	0.1	0.3	8
Sphagnum girgensohnii	0.4	1.4	17
Sphagnum riparium	0.2	0.6	8
Sphagnum warnstorfii	1.5	3.5	17
Tomentypnum nitens	3.2	4.9	50
Unknown moss	0.2	0.4	17
Warnstorfia exannulata	0.2	0.6	8
Total Lichen Cover	1.0	1.3	75
Flavocetraria cucullata	0.2	0.4	17
Peltigera aphthosa	0.3	0.6	42
Unknown crustose lichen	0.2	0.6	8
Total Bare Ground	9.6	14.5	100
Water	5.3	14.4	50
Litter alone	4.3	5.5	92

Table 72. Soil characteristics for Lowland Willow Low Shrub.

Property	Mean	SD	n
Elevation (m)	266.2	261.2	12
Slope (degrees)	4.9	3.9	9
Surface Organics Depth(cm)	17.3	17.8	12
Cumulative Org. in 40 cm (cm)	16.3	14.5	12
Loess Cap Thickness (cm)	68.0		1
Depth to Rocks (cm)	86.9	87.1	9
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	56.6	23.3	7
Site pH at 10-cm depth	5.8	0.3	12
Site EC at 10-cm depth (µS/cm)	69.2	50.5	12
Water Depth (cm,+ above grnd)[a]	-21.9	22.9	10

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation) and Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation). Less common subgroups include Typic Haplorthels (mineral soil over permafrost lacking cryoturbation) and Typic Aquiturbels (wet, mineral soil over permafrost with cryoturbation). This ecotype and associated soils are part of the Lowland Organic-rich Shrub and Forests soil landscape. Other ecotypes in this soil landscape include Lowland Birch–Willow Low Shrub, Lowland Birch–Ericaceous Low Shrub, and Lowland Black Spruce Forest.

River

Geomorphology:

Rivers occur throughout ARCN and include both upper and lower perennial non-glacial rivers, mountain headwater streams, and lowland head-water streams. River channels are both braided and meandering. Elevations vary from sea level to >900 m in headwater streams. This ecotype and Riverine Lake were mapped together as Riverine Water.

Rivers are unvegetated in ARCN and we did not develop a plant association for this ecotype.

Soils:

Flooded soils were not described. Water characteristics are listed in Table 73.

Table 73. Water characteristics for River.

Property	Mean	SD	n
Site pH at 10-cm depth	7.4	0.6	28
Site EC at 10-cm depth (µS/cm)	273.5	172.6	26
Water Depth (cm,+ above grnd)[a]	58.7	39.8	29

[a]Measurements >1 m indicate minimum depth, not true depth

Riverine Alder Tall Shrub

Geomorphology:

This ecotype comprises closed alder stands on younger riverine surfaces. It occurs on braided and meander inactive overbank deposits, alluvial fan inactive channel deposits, and moderately steep headwater floodplains. Surface forms include interfluves, flat banks, point bars and drainage- ways.

Plant Association:

Alnus crispa–Rubus arcticus

Riverine Alder Tall Shrub consists of open to closed stands of *A. crispa* (syn: *A. viridis* ssp. *fruticosa*) with an understory of forbs and mosses (Table 74). Tall willows occasionally are co-dominant with alder. Trees are absent, and cover of lichens, sedges and grasses is variable. Common species include *Aconitum delphinifolium*, *Equisetum arvense*, *Calamagrostis canadensis*, and *Climacium dendroides*.

This ecotype is similar to Lowland Alder Tall Shrub and Upland Alder–Willow Tall Shrub, although it is strongly affected by riverine processes, and has different species assemblages.

Table 74. Vegetation cover and frequency for Riverine Alder Tall Shrub (n=8).

	Cover		Freq
	Mean	SD	%
Total Live Cover	145.7	33.3	100
Total Vascular Cover	137.6	26.2	100
Total Evergreen Tree Cover	0.0	0.0	17
Picea mariana	<0.1	<0.1	17
Total Evergreen Shrub Cover	0.9	2.1	17
Ledum decumbens	<0.1	<0.1	17
Linnaea borealis	0.8	2.0	17
Vaccinium vitis-idaea	<0.1	<0.1	17
Total Deciduous Tree Cover	0.0	0.0	17
Betula papyrifera	<0.1	<0.1	17
Total Deciduous Shrub Cover	92.3	18.4	100
Alnus crispa	67.5	24.4	100
Arctostaphylos rubra	0.5	1.2	17
Betula nana	0.2	0.4	17
Potentilla fruticosa	<0.1	<0.1	17
Ribes triste	0.8	2.0	17
Rosa acicularis	<0.1	0.1	33
Salix alaxensis	7.2	16.1	50
Salix arbusculoides	1.4	2.1	50
Salix arctica	2.0	4.9	17
Salix barclayi	0.3	0.8	17
Salix bebbiana	<0.1	<0.1	17
Salix brachycarpa ssp. *niphoclada*	0.8	2.0	17
Salix lanata ssp. *richardsonii*	3.8	8.0	33
Salix planifolia ssp. *pulchra*	0.3	0.8	17
Salix scouleriana	1.7	4.1	17
Spiraea beauverdiana	5.2	9.9	50
Vaccinium uliginosum	0.5	0.8	50
Viburnum edule	<0.1	0.1	33
Total Forb Cover	21.3	7.5	100
Aconitum delphinifolium	0.1	0.1	67
Anemone richardsonii	0.2	0.4	17
Artemisia tilesii	1.0	1.5	50
Aster sibiricus	<0.1	<0.1	17
Cardamine pratensis ssp. *angustifolia*	<0.1	<0.1	17
Dryopteris dilatata ssp. *americana*	<0.1	<0.1	17
Epilobium angustifolium	0.2	0.4	17
Equisetum arvense	3.9	5.8	83
Equisetum pratense	0.7	1.6	17
Galium boreale	<0.1	0.1	33
Galium trifidum ssp. *trifidum*	<0.1	<0.1	17
Lycopodium annotinum	1.7	4.1	17
Mertensia paniculata	1.0	2.0	33
Petasites frigidus	5.0	10.0	33
Polemonium acutiflorum	0.5	0.8	67
Potentilla palustris	<0.1	<0.1	17
Rubus arcticus	0.7	1.0	33
Rubus arcticus ssp. *arcticus*	2.2	2.3	67
Rubus chamaemorus	1.3	3.3	17
Saxifraga punctata	0.2	0.4	17
Stellaria longifolia	<0.1	<0.1	17
Stellaria sp.	<0.1	<0.1	17
Thalictrum sparsiflorum	1.0	2.0	33
Trientalis europaea	<0.1	<0.1	17
Trientalis europaea ssp. *arctica*	0.8	2.0	33
Valeriana capitata	0.8	2.0	17
Viola renifolia	<0.1	<0.1	17
Total Grass Cover	23.0	18.7	83
Arctagrostis latifolia	13.3	21.6	33
Calamagrostis canadensis	9.7	13.8	50
Total Sedge & Rush Cover	0.0	0.1	33
Carex sp.	<0.1	<0.1	17
Luzula sp.	<0.1	<0.1	17
Total Nonvascular Cover	8.1	12.1	100
Total Moss Cover	7.4	11.4	100
Brachythecium mildeanum	<0.1	<0.1	17
Brachythecium sp.	<0.1	0.1	33
Climacium dendroides	3.8	8.0	33
Dicranum sp.	0.3	0.8	17
Plagiomnium ellipticum	1.0	2.0	33
Polytrichum juniperinum	0.5	1.2	17
Polytrichum strictum	<0.1	<0.1	17
Sanionia uncinata	1.2	2.0	33
Scorpidium scorpioides	0.3	0.8	17
Unknown moss	0.2	0.4	17
Total Lichen Cover	0.7	1.1	33
Parmelia sp.	0.5	0.8	33
Unknown arborial lichen	0.2	0.4	33
Total Bare Ground	2.0	2.4	67
Litter alone	2.0	2.4	67

Soils:

Soils are loamy with a thin overlying organic horizon (Table 75). Permafrost is often found within the upper 1 m of soil, however permafrost was sometimes difficult to determine due to the rocky soils, and it was assumed in these cases to be present within 2 m. Frost boils, loess caps, and surface fragments are absent. Organic horizons, buried during flooding by riverine silts and sands, often occur in these soils. Soil pH is acidic to circumneutral, and EC is low. The soils are typically moderately well to somewhat poorly drained. Depth to water table often could not be measured, but it is assumed to fluctuate throughout the year within the upper 2 m of soil.

Table 75. Soil characteristics for Riverine Alder Tall Shrub.

Property	Mean	SD	n
Elevation (m)	153.1	227.2	7
Slope (degrees)	10.5	6.4	2
Surface Organics Depth(cm)	5.1	2.4	7
Cumulative Org. in 40 cm (cm)	7.4	4.4	7
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	31.3	18.0	3
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	40.7	26.3	3
Site pH at 10-cm depth	5.8	1.1	6
Site EC at 10-cm depth (μS/cm)	95.0	65.7	6
Water Depth (cm,+ above grnd)[a]			0

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups include Fluvaquentic Haplorthels (wet, minteral soil with buried organic horizons, permafrost within 1 m) and Fluventic Haplorthels (moist, mineral soil with buried organic horizons, permafrost within 1 m). Less common soils are Typic Gelorthents (poorly developed with permafrost below 1 m) and Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m). This ecotype and associated soils are part of the Riverine Loamy Meadows and Shrublands soil landscape. Other ecotypes found in this soil landscape winclude Riverine Birch–Willow Low Shrub, Riverine Wet Willow Tall Shrub, and Riverine Bluejoint Meadow.

Riverine Barrens

Geomorphology:

Riverine Barrens occurs on braided and meandering river bars that are frequently flooded and scoured. Geomorphology is depositional including both channel and overbank deposits. Surface forms include point bars, interfluves, flat bank channels, swales and guts on nearly flat surfaces under 550 m elevation throughout ARCN.

Plant Association:

Salix alaxensis–Epilobium latifolium

Vegetation is sparse, with primarily ruderal species and early colonizers present (Table 76). Mature trees and shrubs, mosses and lichens are mostly absent due to frequent disturbance. This ecotype is not particularly species rich, although it is the 2nd most diverse riverine ecotype, particularly in forbs and graminoid species. Common species include *Salix alaxensis*, *Epilobium latifolium*, *Hedysarum mackenzii*, and *Deschampsia caespitosa*. Two rare species occurred in this ecotype: *Aster yukonensis* (syn: *Symphyotrichum yukonense*) and *Limosella aquatica*.

This ecotype is similar to Riverine Dryas Dwarf Shrub and Riverine Moist Willow Tall Shrub except it occurs primarily on active deposits where there is greater disturbance.

Table 76. Vegetation cover and frequency for Riverine Barrens (n=33).

	Cover		Freq
	Mean	SD	%
Total Live Cover	17.9	25.1	91
Total Vascular Cover	17.0	24.4	91
Total Evergreen Tree Cover	0.0	0.0	9
Picea glauca	<0.1	<0.1	9
Total Evergreen Shrub Cover	0.2	0.5	18
Cassiope tetragona	<0.1	0.2	3
Dryas integrifolia	0.1	0.4	12
Empetrum nigrum	<0.1	<0.1	6
Total Deciduous Tree Cover	0.4	1.0	30
Populus balsamifera	0.4	1.0	30
Total Deciduous Shrub Cover	5.0	8.3	85
Alnus crispa	0.1	0.3	6
Arctostaphylos rubra	<0.1	0.2	6
Betula nana	<0.1	<0.1	12
Potentilla fruticosa	<0.1	0.2	18
Salix alaxensis	3.6	6.7	82
Salix arctica	0.1	0.3	3
Salix barclayi	0.3	1.7	9
Salix brachycarpa ssp. *niphoclada*	0.5	1.6	21
Salix glauca	0.1	0.4	6
Salix hastata	<0.1	0.2	12
Salix planifolia ssp. *pulchra*	0.1	0.4	12
Salix reticulata	<0.1	0.2	3
Shepherdia canadensis	0.1	0.2	9
Vaccinium uliginosum	<0.1	0.2	9
Total Forb Cover	6.7	10.4	88
Arnica alpina ssp. *angustifolia*	<0.1	<0.1	9
Artemisia arctica ssp. *arctica*	0.1	0.3	9
Artemisia borealis	0.3	1.4	12
Artemisia glomerata	<0.1	<0.1	9
Artemisia tilesii	0.2	0.5	33
Aster junciformis	0.1	0.7	3
Aster sibiricus	0.4	1.0	45
Astragalus alpinus	<0.1	<0.1	27
Astragalus polaris	<0.1	<0.1	9
Castilleja caudata	0.1	0.2	21
Cerastium beeringianum	<0.1	<0.1	9
Chrysanthemum integrifolium	<0.1	0.2	3
Crepis nana	<0.1	<0.1	18
Descurainia sophioides	<0.1	<0.1	6
Epilobium angustifolium	0.1	0.2	9
Epilobium latifolium	1.9	3.1	73
Equisetum arvense	0.6	3.1	18
Equisetum variegatum	<0.1	<0.1	9
Gentiana propinqua	<0.1	0.2	9
Hedysarum alpinum	0.2	0.6	27
Hedysarum mackenzii	0.6	1.5	24
Linum perenne	<0.1	0.2	3
Minuartia arctica	0.1	0.3	3
Minuartia rubella	<0.1	<0.1	6
Oxytropis borealis	0.2	0.9	3
Oxytropis campestris	0.1	0.2	12
Oxytropis viscida	0.2	0.9	9
Parnassia palustris	0.2	0.7	18

Table 76. Continued.

	Cover		Freq
	Mean	SD	%
Pedicularis sudetica	<0.1	<0.1	6
Pinguicula vulgaris	0.1	0.3	3
Polygonum viviparum	<0.1	0.2	9
Rorippa islandica ssp. *fernaldiana*	<0.1	<0.1	6
Saxifraga bronchialis	<0.1	0.2	3
Saxifraga oppositifolia	0.9	5.2	6
Senecio lugens	<0.1	<0.1	6
Silene acaulis	<0.1	0.2	6
Taraxacum sp.	<0.1	0.2	3
Tofieldia pusilla	<0.1	<0.1	6
Wilhelmsia physodes	<0.1	<0.1	27
Zygadenus elegans	<0.1	<0.1	6
Total Grass Cover	4.3	12.4	76
Agropyron boreale	<0.1	<0.1	15
Agropyron macrourum	0.1	0.3	12
Agropyron sp.	<0.1	0.2	15
Arctagrostis latifolia	<0.1	0.2	18
Bromus pumpellianus	0.1	0.4	15
Bromus pumpellianus var. *arcticus*	<0.1	0.2	6
Bromus pumpellianus var. *pumpellianus*	0.2	0.9	6
Calamagrostis canadensis	0.1	0.3	3
Calamagrostis lapponica	<0.1	0.2	3
Calamagrostis purpurascens	0.9	5.2	12
Calamagrostis sp.	<0.1	<0.1	9
Deschampsia caespitosa	<0.1	0.2	18
Elymus arenarius ssp. *mollis*	1.5	8.7	9
Elymus sp.	0.1	0.5	3
Elymus trachycaulus	0.1	0.2	12
Festuca brachyphylla	0.1	0.3	3
Festuca richardsonii	0.5	2.6	15
Festuca rubra	0.2	0.9	12
Poa alpigena	<0.1	0.2	9
Poa alpina	<0.1	0.2	21
Poa glauca	<0.1	<0.1	12
Trisetum spicatum ssp. *spicatum*	0.1	0.4	24
Total Sedge & Rush Cover	0.5	1.9	27
Carex atrofusca	<0.1	0.2	3
Carex capillaris	0.1	0.5	6
Carex krausei	0.1	0.3	3
Carex podocarpa	<0.1	0.2	3
Juncus arcticus	<0.1	<0.1	6
Juncus castaneus ssp. *castaneus*	<0.1	<0.1	6
Kobresia simpliciuscula	0.2	1.2	3
Total Nonvascular Cover	0.9	2.0	45
Total Moss Cover	0.8	2.0	45
Brachythecium sp.	<0.1	0.2	9
Ceratodon purpureus	0.6	1.8	18
Unknown moss	0.2	0.9	15
Total Lichen Cover	0.0	0.2	9
Cetraria cf. *islandica*	<0.1	0.2	3
Total Bare Ground	86.1	21.4	100
Bare Soil	83.6	24.0	100
Water	<0.1	0.2	18
Litter alone	2.4	3.6	79

Soils:

Soils are typically gravelly or sandy and lack a surface organic horizon (Table 77). Depth to permafrost is difficult to determine, however if permafrost does occur it is assumed to be greater than 1 m given the well drained soils and proximity to flowing water. Frost boils and loess caps are absent. Surface fragments are common and abundant. Soil pH is circumneutral to alkaline, and EC is low. The soils are excessively to moderately well drained. Depth to water table was difficult to determine in some cases, however in such cases it was assumed that the water table occurs within the upper meter of soil for at least the first few weeks of the growing season.

Table 77. Soil characteristics for Riverine Barrens.

Property	Mean	SD	n
Elevation (m)	155.9	162.0	33
Slope (degrees)	1.7	1.0	17
Surface Organics Depth(cm)	2.0		1
Cumulative Org. in 40 cm (cm)	2.0		1
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	111.1	95.2	8
Surface Fragment Cover (%)	86.2	22.6	18
Frost Boil Cover (%)			0
Thaw Depth (cm)	88.0	12.3	3
Site pH at 10-cm depth	7.8	0.6	33
Site EC at 10-cm depth (µS/cm)	147.6	211.1	29
Water Depth (cm,+ above grnd)[a]	-74.4	49.7	25

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Oxyaquic Cryorthents (moist, saturated early in growing season, lacking permafrost) and Oxyaquic Gelorthents (wet, saturated early in growing season, poorly developed with permafrost below 1 m). Less common soil types include Typic Cryopsamments (sandy, low coarse fragment content, well drained, lacking permafrost), Oxyaquic Cryopsamments (wet, saturated early in growing season, sandy, low coarse fragment content, lacking permafrost), and Typic Gelorthents (poorly developed with permafrost below 1 m). This ecotype and associated soils are part of the Riverine Gravelly Barrens and Shrublands soil landscape, which also included Riverine Moist Willow Tall Shrub, Riverine Dryas Dwarf Shrub, and Riverine Willow Low Shrub.

Riverine Birch–Willow Low Shrub

Geomorphology:

These low shrub communities grow in linear bands that segregate stands of spruce forest along meandering rivers throughout the boreal zone in ARCN. It occurs on meander inactive overbank deposits and meander fine inactive channel deposits. Surface forms include interfluves, bars and flat banks. It usually occurs at <60 m elevation.

Plant Association:

Betula nana–Salix planifolia ssp. *pulchra–Pyrola grandiflora*

The low, deciduous shrub canopy is typically closed (>75%) in this ecotype. Forbs and grasses characterize the understory, while the presence of trees, evergreen shrubs, sedges and nonvascular species is variable (Table 78). Common species include *Vaccinium uliginosum*, *Petasites frigidus*, *Valeriana capitata*, and *Hylocomium splendens*.

This ecotype is similar to Lowland Birch–Willow Low Shrub except soils are predominantly loamy and haven't had time to develop thick organic horizons.

Soils:

Soils are loamy with a thin organic horizon above the mineral soil surface (Table 79). Permafrost is often found in the upper meter of the soil profile. Frost boils, loess caps, and surface fragments are absent. Organic horizons, buried during flooding by riverine silts and sands, were commonly found in these soils. Soil pH is circumneutral to acidic, and EC is low. The soils are typically moderately well to somewhat poorly drained, and the water table is shallow to moderately deep.

Table 78. Vegetation cover and frequency for Riverine Birch–Willow Low Shrub (n=12).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	163.4	33.8	100
Total Vascular Cover	126.4	25.3	100
Total Evergreen Tree Cover	0.3	0.7	22
Picea glauca	0.3	0.7	22
Total Evergreen Shrub Cover	1.4	1.6	67
Ledum decumbens	0.7	0.9	56
Vaccinium vitis-idaea	0.7	1.7	33
Total Deciduous Shrub Cover	98.0	26.7	100
Alnus crispa	0.1	0.3	11
Arctostaphylos rubra	0.6	1.7	11
Betula glandulosa	1.1	3.3	11
Betula nana	23.3	25.9	89
Potentilla fruticosa	1.4	1.8	56
Rosa acicularis	0.1	0.3	11
Salix alaxensis	7.2	19.9	22
Salix arbusculoides	4.7	13.3	22
Salix barclayi	0.9	1.8	22
Salix brachycarpa ssp. *niphoclada*	1.1	3.3	11
Salix glauca	3.7	6.9	44
Salix hastata	0.3	0.7	22
Salix lanata ssp. *richardsonii*	8.9	23.2	22
Salix planifolia ssp. *pulchra*	28.6	27.5	100
Salix reticulata	0.1	0.3	11
Spiraea beauverdiana	1.1	3.3	11
Vaccinium uliginosum	14.8	19.0	100
Total Forb Cover	12.5	8.4	100
Aconitum delphinifolium	<0.1	<0.1	11
Anemone parviflora	<0.1	<0.1	11
Anemone sp.	<0.1	<0.1	11
Artemisia arctica ssp. *arctica*	<0.1	<0.1	11
Artemisia tilesii	0.2	0.7	11
Astragalus alpinus	<0.1	<0.1	11
Cardamine pratensis ssp. *angustifolia*	<0.1	<0.1	11
Castilleja caudata	<0.1	<0.1	11
Equisetum arvense	0.9	1.4	33
Galium boreale	0.2	0.7	22
Galium trifidum ssp. *trifidum*	<0.1	<0.1	11
Iris setosa	0.6	1.7	11
Lupinus arcticus	<0.1	<0.1	11
Moehringia lateriflora	<0.1	<0.1	11
Myosotis alpestris ssp. *asiatica*	<0.1	<0.1	11
Pedicularis capitata	<0.1	<0.1	22
Petasites frigidus	4.4	6.7	67
Polemonium acutiflorum	0.3	0.4	67
Polygonum bistorta	0.3	1.0	11
Potentilla palustris	1.1	3.3	11
Pyrola grandiflora	1.1	1.1	67
Rubus arcticus ssp. *arcticus*	0.7	1.7	22
Rubus chamaemorus	1.4	3.0	22
Saussurea angustifolia	0.3	0.7	22
Saxifraga punctata	<0.1	<0.1	11
Sedum rosea ssp. *integrifolium*	<0.1	<0.1	11

Table 78. Continued.

	Cover		Freq
	Mean	SD	%
Stellaria sp.	<0.1	0.1	33
Valeriana capitata	0.7	0.7	78
Wilhelmsia physodes	<0.1	<0.1	11
Total Grass Cover	10.0	5.6	100
Arctagrostis latifolia	1.8	3.3	44
Calamagrostis canadensis	6.1	7.4	56
Calamagrostis sp.	0.3	1.0	11
Festuca altaica	0.7	1.1	33
Festuca rubra	0.2	0.4	22
Poa arctica	0.9	1.6	44
Total Sedge & Rush Cover	4.2	8.2	56
Carex aquatilis ssp. *aquatilis*	0.1	0.3	11
Carex bigelowii	1.4	3.2	44
Carex canescens	0.2	0.7	11
Carex saxatilis	0.6	1.7	11
Eriophorum angustifolium	0.8	1.7	22
Eriophorum vaginatum	1.1	3.3	11
Luzula sp.	<0.1	<0.1	11
Total Nonvascular Cover	36.9	33.5	89
Total Moss Cover	35.5	32.0	89
Aulacomnium acuminatum	1.7	5.0	11
Aulacomnium palustre	2.8	6.5	56
Aulacomnium turgidum	0.8	1.3	44
Brachythecium sp.	0.4	1.0	22
Calliergon giganteum	0.2	0.7	11
Climacium dendroides	1.2	3.3	22
Dicranum groenlandicum	<0.1	0.1	11
Dicranum sp.	0.7	1.1	33
Hylocomium splendens	13.3	21.7	56
Hypnum sp.	0.1	0.3	11
Marchantia polymorpha	<0.1	<0.1	11
Mnium sp.	0.1	0.3	11
Pleurozium schreberi	2.2	6.7	11
Polytrichum juniperinum	0.4	1.0	22
Racomitrium lanuginosum	<0.1	<0.1	11
Rhytidium rugosum	0.1	0.3	11
Sanionia uncinata	1.3	3.3	44
Sphagnum balticum	<0.1	0.1	11
Sphagnum imbricatum	<0.1	0.1	11
Sphagnum sp.	2.8	8.3	11
Sphagnum squarrosum	0.1	0.3	11
Sphagnum subsecundum	<0.1	0.1	11
Sphagnum warnstorfii	<0.1	0.1	11
Tomentypnum nitens	7.0	16.3	44
Total Lichen Cover	1.4	1.8	56
Cetraria cf. *islandica*	0.1	0.3	11
Cladina rangiferina	0.1	0.3	22
Cladina stygia	0.1	0.3	11
Parmelia sp.	0.1	0.3	11
Peltigera aphthosa	0.8	1.7	22
Peltigera canina	<0.1	0.1	11
Peltigera didactyla var. *extenuata*	<0.1	0.1	11
Peltigera leucophlebia	<0.1	0.1	11
Total Bare Ground	3.7	3.2	89
Bare Soil	0.1	0.3	22
Litter alone	3.6	3.1	89

Table 79. Soil characteristics for Riverine Birch–Willow Low Shrub.

Property	Mean	SD	n
Elevation (m)	31.0	27.6	9
Slope (degrees)			0
Surface Organics Depth(cm)	4.1	1.4	9
Cumulative Org. in 40 cm (cm)	5.3	1.2	9
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	144.0	86.8	6
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	50.2	43.5	5
Site pH at 10-cm depth	5.8	0.3	9
Site EC at 10-cm depth (µS/cm)	55.6	25.5	9
Water Depth (cm,+ above grnd)[a]	-68.2	33.1	5

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Fluvaquentic Haplorthels (wet, saturated within 75 cm, mineral soil with buried organic horizons, permafrost within 1 m) and Fluvaquentic Aquorthels (wet, saturated within 50 cm, mineral soil with thin buried horizons, permafrost within 1 m). Less common soil types include Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m) and Typic Gelorthents (poorly developed with permafrost below 1 m). This ecotype and associated soils are part of the Riverine Loamy Meadows and Shrublands soil landscape. Other ecotypes found in this soil landscape are Riverine Alder Tall Shrub, Riverine Wet Willow Tall Shrub, and Riverine Bluejoint Meadow.

Riverine Bluejoint Meadow

Geomorphology:

This ecotype occurs at low elevations on meandering river inactive channel and overbank deposits. Surface forms include flood basins and point bars. The ground is usually non-patterned.

Plant Association:

Calamagrostis canadensis–Potentilla palustris

Riverine Bluejoint Meadow is dominated by grasses, sedges and forbs (Table 80). Trees and non-vascular species are absent. This ecotype is not species rich although we did document a rare grass, *Glyceria pulchella*, at two sites. Common species include *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Galium trifidum*, *Iris setosa*, and *Carex saxatilis*.

Riverine Bluejoint Meadow is most similar to Lacustrine Bluejoint Meadow. It shares a dominant species with Upland Bluejoint Meadow but soils are much wetter and floristic diversity is reduced in Riverine Bluejoint Meadow. Due to its low abundance, Riverine Bluejoint Meadow was not mapped.

Soils:

Soils are loamy with a thin surface organic horizon (Table 81). Thaw depths could not be determined as the depth to permafrost, if present, was always greater than the maximum depth sampled (1.3 m). Frost boils, loess caps, and surface fragments are absent. Coarse fragments are absent in the upper meter of the active layer. Organic horizons, buried during flooding by riverine silts and sands, were commonly found in these soils. Soil pH is acidic to circumneutral, and EC is low. The soils are moderately well drained, and the water table is deep to very deep.

Table 80. Vegetation cover and frequency for Riverine Bluejoint Meadow (n=3).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	109.1	19.2	100
Total Vascular Cover	109.1	19.2	100
Total Evergreen Shrub Cover	0.0	0.1	33
Andromeda polifolia	<0.1	0.1	33
Total Deciduous Shrub Cover	13.7	15.1	100
Betula glandulosa	2.3	2.5	67
Salix alaxensis	<0.1	0.1	33
Salix arbusculoides	0.4	0.6	67
Salix lanata ssp. *richardsonii*	1.7	2.9	33
Salix planifolia ssp. *pulchra*	9.0	10.1	67
Vaccinium uliginosum	0.3	0.6	33
Total Forb Cover	21.6	27.8	100
Cardamine pratensis ssp. *angustifolia*	<0.1	0.1	33
Epilobium palustre	<0.1	0.1	33
Equisetum arvense	1.7	2.9	67
Equisetum fluviatile	<0.1	0.1	33
Galium trifidum ssp. *trifidum*	0.7	1.1	67
Iris setosa	0.7	0.6	67
Potentilla norvegica	<0.1	0.1	33
Potentilla palustris	3.4	4.1	100
Rubus arcticus ssp. *arcticus*	15.0	26.0	33
Total Grass Cover	45.4	41.7	100
Calamagrostis canadensis	44.7	41.4	100
Glyceria pulchella	0.4	0.6	67
Poa pratensis	0.3	0.6	33
Total Sedge & Rush Cover	28.4	44.7	100
Carex aquatilis ssp. *aquatilis*	0.3	0.6	33
Carex arcta	1.7	2.9	33
Carex bigelowii	0.3	0.6	33
Carex membranacea	<0.1	0.1	33
Carex saxatilis	25.3	43.0	67
Carex utriculata	0.3	0.6	33
Eriophorum angustifolium	0.3	0.6	33
Total Bare Ground	10.3	4.5	100
Bare Soil	0.3	0.6	33
Litter alone	10.0	5.0	100

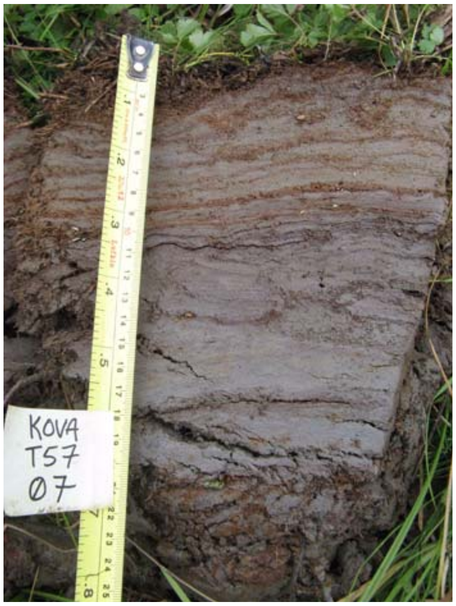


Table 81. Soil characteristics for Riverine Bluejoint Meadow.

Property	Mean	SD	n
Elevation (m)	23.7	5.5	3
Slope (degrees)	1.0		1
Surface Organics Depth(cm)	2.0	0.0	2
Cumulative Org. in 40 cm (cm)	3.3	1.2	3
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0		1
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	5.3	0.6	3
Site EC at 10-cm depth (μS/cm)	73.3	15.3	3
Water Depth (cm,+ above grnd)[a]			0

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Gelifluvents (poorly developed with buried organic horizons, permafrost below 1 m). A less common soil type is Oxyaquic Cryorthents (moist, saturated early in growing season, lacking permafrost). This ecotype and associated soils are part of the Riverine Loamy Meadows and Shrublands soil landscape. Other ecotypes found in this soil landscape are Riverine Alder Tall Shrub, Riverine Birch–Willow Low Shrub, and Riverine Wet Willow Tall Shrub.

Riverine Dryas Dwarf Shrub

Geomorphology:

Riverine Dryas Dwarf Shrub occurs on stabilized braided and meander abandoned and inactive deposits of both coarse and fine materials, and to a lesser extent on active braided overbank and channel deposits. Surfaces are primarily flat banks, terraces and interfluves at lower elevations along major rivers in ARCN.

Plant Associations:

Dryas integrifolia–Salix brachycarpa ssp. *niphoclada*

Dryas drummondii–Oxytropis campestris

Evergreen shrubs characterize this ecotype (Table 82) while deciduous low shrubs and forbs contribute to the secondary component. Trees species are present as seedlings in this early-successional ecotype, as are a few nonvascular species. Species richness per plot ranks 3rd across ecotypes, although total species count overall is average. Common species include *Salix alaxensis*, *Lupinus arcticus*, *Calamagrostis purpurascens*, and *Rhytidium rugosum*. Rare species include *Oxytropis tananensis* (nearest synonym in Hulten 1968: *Oxytropis campestris* ssp. *varians*) and *Aster yukonensis* (syn: *Symphyotrichum yukonense*).

This ecotype is similar to Riverine Barrens, although it is more stable and with much greater vegetative cover. It differs from Alpine Dryas Dwarf Shrub by its occurrence on floodplains.

Table 82. Vegetation cover and frequency for Riverine Dryas Dwarf Shrub (n=9).

	Cover		Freq
	Mean	SD	%
Total Live Cover	128.6	68.9	100
Total Vascular Cover	66.6	20.0	100
Total Evergreen Tree Cover	0.3	0.5	43
Picea glauca	0.3	0.5	43
Total Evergreen Shrub Cover	26.0	18.6	100
Dryas drummondii	7.1	15.0	29
Dryas integrifolia	16.9	20.3	71
Empetrum nigrum	0.4	1.1	29
Juniperus communis	1.4	3.8	14
Rhododendron lapponicum	0.1	0.4	14
Total Deciduous Tree Cover	0.7	1.9	29
Populus balsamifera	0.7	1.9	29
Total Deciduous Shrub Cover	17.9	14.4	100
Arctostaphylos alpina	0.6	1.5	14
Arctostaphylos rubra	1.2	2.0	43
Potentilla fruticosa	0.4	0.7	86
Salix alaxensis	1.9	2.0	71
Salix brachycarpa ssp. *niphoclada*	8.9	10.8	100
Salix glauca	2.4	5.6	43
Salix hastata	0.6	1.5	14
Shepherdia canadensis	1.0	1.9	57
Vaccinium uliginosum	1.0	1.7	29
Total Forb Cover	14.4	14.3	100
Androsace chamaejasme	<0.1	0.1	43
Artemisia borealis	0.3	0.5	29
Artemisia furcata	0.3	0.8	14
Aster sibiricus	0.6	1.1	71
Aster yukonensis	0.2	0.4	29
Astragalus aboriginum	0.2	0.4	43
Astragalus alpinus	0.3	0.5	29
Astragalus eucosmus ssp. *sealei*	0.3	0.8	29
Braya humilis	0.3	0.8	14
Castilleja caudata	0.1	0.4	14
Cnidium cnidiifolium	0.7	1.9	29
Epilobium latifolium	0.7	0.9	71
Galium boreale	0.1	0.4	14
Gentiana propinqua	0.7	1.9	29
Hedysarum alpinum	0.5	1.1	43
Hedysarum mackenzii	0.1	0.4	14
Lupinus arcticus	1.7	2.6	43
Minuartia arctica	0.2	0.4	29
Oxytropis borealis	0.3	0.8	14
Oxytropis campestris ssp. *jordalii*	0.7	1.5	29
Oxytropis campestris ssp. *varians*	2.1	5.7	14
Papaver lapponicum	0.1	0.4	14
Parnassia palustris	0.3	0.8	29
Potentilla hookeriana	0.1	0.4	14
Potentilla uniflora	0.3	0.8	29
Saxifraga flagellaris	0.2	0.4	29
Selaginella sibirica	0.9	2.3	14
Senecio lugens	0.4	0.8	43
Senecio ogotorukensis	0.3	0.5	29
Solidago multiradiata	0.3	0.8	29
Zygadenus elegans	0.2	0.4	57
Total Grass Cover	4.7	5.8	100
Bromus pumpellianus	0.2	0.4	43
Bromus pumpellianus var. *arcticus*	0.6	1.5	14
Bromus pumpellianus var. *pumpellianus*	0.4	0.8	29
Calamagrostis lapponica	0.1	0.4	14
Calamagrostis purpurascens	1.3	2.2	43
Elymus innovatus	0.3	0.5	29
Festuca altaica	0.9	1.9	43
Festuca rubra	0.1	0.4	14
Poa glauca	0.2	0.4	57
Total Sedge & Rush Cover	2.6	3.4	71
Carex concinna	0.7	1.9	29
Carex krausei	0.4	1.1	29
Carex scirpoidea	1.0	1.7	43
Kobresia myosuroides	0.3	0.7	43
Total Nonvascular Cover	62.0	52.7	100
Total Moss Cover	41.3	35.4	100
Abietinella abietina	10.4	24.2	29
Brachythecium salebrosum	0.3	0.8	14
Dicranum sp.	1.7	3.1	29
Distichium inclinatum	1.1	3.0	14
Ditrichum flexicaule	0.3	0.8	14
Hylocomium splendens	0.7	1.9	14
Polytrichum sp.	0.6	1.1	29
Racomitrium lanuginosum	7.0	14.7	43
Rhytidium rugosum	7.9	14.4	57
Sanionia uncinata	0.3	0.8	14
Tortella fragilis	1.0	2.6	14
Unknown moss	10.0	19.1	29
Total Lichen Cover	20.7	34.1	86
Alectoria ochroleuca	0.1	0.4	14
Asahinea chrysantha	0.4	1.1	29
Bryoria sp.	0.1	0.4	14
Cetraria cf. *islandica*	0.1	0.4	14
Cetrariella delisei	0.1	0.4	14
Cladonia pocillum	0.3	0.8	14
Cladonia pyxidata	0.1	0.4	14
Cladonia sp.	2.4	3.7	43
Cladonia symphycarpia	1.6	3.0	29
Flavocetraria cucullata	0.7	1.2	43
Flavocetraria nivalis	0.3	0.8	29
Hypogymnia sp.	0.4	1.1	14
Masonhalea richardsonii	0.3	0.5	29
Parmelia sp.	0.4	1.1	14
Peltigera sp.	0.2	0.4	43
Pertusaria sp.	0.7	1.9	29
Sphaerophorus sp.	0.4	1.1	14
Stereocaulon sp.	0.7	1.2	43
Thamnolia sp.	1.6	2.8	29
Thamnolia vermicularis	0.1	0.4	14
Unknown lichen	9.3	18.8	29
Total Bare Ground	36.5	29.4	100
Bare Soil	26.2	29.6	100
Litter alone	10.3	7.5	100

Soils:

Soils are typically gravelly or bouldery and often lack a surface organic horizon (Table 83). Depth to permafrost is difficult to determine in the rocky soils, however if permafrost does occur it is assumed to be greater than 1 m given the well drained soils. Frost boils and loess caps are absent. Surface soils. Frost boils and loess caps are absent. Surface fragments are present at low to moderate abundance. Soil pH is alkaline, and EC is low. The soils are typically excessively to well drained, and depth to water table is typically greater than 1 m.

Table 83. Soil characteristics for Riverine Dryas Dwarf Shrub.

Property	Mean	SD	n
Elevation (m)	206.3	137.3	7
Slope (degrees)	2.0	0.0	2
Surface Organics Depth(cm)	3.0	0.0	2
Cumulative Org. in 40 cm (cm)	2.2	1.4	3
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	2.3	1.2	3
Surface Fragment Cover (%)	11.8	13.4	6
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	7.9	0.3	7
Site EC at 10-cm depth (µS/cm)	80.0	82.2	6
Water Depth (cm,+ above grnd)[a]	-167.9	55.4	7

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups in this ecotype include Oxyaquic Cryorthents (moist, occasionally lacking permafrost) and Typic Gelorthents (poorly developed with permafrost below 1 m). Less common soil types include Oxyaquic Cryopsamments (wet, saturated early in growing season, sandy, lacking permafrost), Oxyaquic Gelorthents (wet, saturated early in growing season, poorly developed with permafrost below 1 m), and Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m). This ecotype and associated soils are part of the Riverine Gravelly Barrens and Shrublands soil landscape, which also includes Riverine Barrens, Riverine Moist Willow Tall Shrub, and Riverine Willow Low Shrub.

Riverine Forb Marsh

Geomorphology:

Riverine Forb Marsh occurs infrequently in channels, swales or flood basins on inactive channel deposits or on the margins of shallow riverine lakes. It is found infrequently at low elevations along the major rivers within the boreal zone in ARCN.

Plant Association:

Eleocharis acicularis–Equisetum fluviatile

Forbs dominate this ecotype, in particular horsetail (Table 84). Sedges and water-tolerant mosses are always present, while trees and lichens are absent. Common species include *Equisetum fluviatile*, *Caltha palustris*, *Carex saxatilis*, *Eleocharis acicularis*, and *Drepanocladus capillifolius*.

This ecotype is similar to Riverine Wet Sedge Meadow which occurs on similar terrain, but is drier, primarily arctic instead of boreal, and is dominated by sedges. Lacustrine Horsetail Marsh has some similar plant species but ecological processes, physical structure and community associations are unrelated. Riverine Forb Marsh was not mappable because it occurred in small, isolated patches.

Table 84. Vegetation cover and frequency for Riverine Forb Marsh (n=2).

	Cover		Freq
	Mean	SD	%
Total Live Cover	166.2	2.8	100
Total Vascular Cover	121.2	39.6	100
Total Deciduous Shrub Cover	0.2	0.1	100
Salix alaxensis	0.1	0.1	50
Salix arbusculoides	0.1	0.1	50
Salix lanata ssp. *richardsonii*	0.1	0.1	50
Total Forb Cover	75.9	32.8	100
Caltha palustris	1.1	1.3	100
Cardamine umbellata	0.1	0.1	50
Epilobium palustre	0.1	0.1	50
Equisetum arvense	0.5	0.7	50
Equisetum fluviatile	12.5	17.7	50
Equisetum scirpoides	0.1	0.1	50
Equisetum variegatum	0.1	0.1	50
Galium trifidum ssp. *trifidum*	0.1	0.1	50
Hippuris vulgaris	1.5	0.7	100
Potamogeton pectinatus	27.5	10.6	100
Potamogeton sp.	22.5	24.7	100
Potamogeton vaginatus	5.0	7.1	50
Ranunculus trichophyllus	5.0	7.1	50
Sparganium sp.	0.1	0.1	50
Wilhelmsia physodes	0.1	0.1	50
Total Grass Cover	1.1	1.6	50
Arctagrostis latifolia	0.1	0.1	50
Arctophila fulva	1.0	1.4	50
Deschampsia caespitosa	0.1	0.1	50
Total Sedge & Rush Cover	44.0	8.4	100
Carex aquatilis ssp. *aquatilis*	4.0	1.4	100
Carex saxatilis	12.5	3.5	100
Eleocharis acicularis	27.5	10.6	100
Juncus triglumis	0.1	0.1	50
Total Nonvascular Cover	45.0	42.4	100
Total Moss Cover	45.0	42.4	100
Calliergon sp.	30.0	42.4	50
Drepanocladus aduncus	2.0	2.8	50
Drepanocladus capillifolius	7.5	10.6	50
Limprichtia cossoni	2.0	2.8	50
Scorpidium scorpioides	3.5	4.9	50
Total Bare Ground	75.0	0.1	100
Bare Soil	30.0	28.3	100
Water	42.5	24.7	100
Litter alone	2.5	3.5	100

Soils:

Soils are typically loamy or sandy and lack a surface organic horizon (Table 85). Thaw depths could not be determined as the depth to permafrost, if present, was always greater than the maximum depth sampled (1.3 m). Frost boils, surface fragments, and loess caps are absent. Soil pH is circumneutral to alkaline, and EC is low to moderate. The soils are typically very poorly drained or flooded. The water table occurs at shallow depths or above ground.

Table 85. Soil characteristics for Riverine Forb Marsh.

Property	Mean	SD	n
Elevation (m)	67.0	1.4	2
Slope (degrees)			0
Surface Organics Depth(cm)			0
Cumulative Org. in 40 cm (cm)			0
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)			0
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	8.1	0.4	2
Site EC at 10-cm depth (µS/cm)	370.0	198.0	2
Water Depth (cm,+ above grnd)[a]	32.5	67.2	2

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups in this ecotype are Typic Gelaquents (wet, poorly developed with permafrost below 1 m) and Oxyaquic Gelorthents (wet, saturated early in growing season, poorly developed with permafrost below 1 m). This ecotype and associated soils are part of the Riverine Loamy Wet Meadows and Marshes soil landscape. Also included in this soil landscape is Riverine Wet Sedge Meadow.

Riverine Lake

Geomorphology:

This ecotype consists of shallow oxbow lakes that have been isolated from an actively flowing river through depositional processes. They are associated with lower elevations on floodplains.

Plant Association:

Potamogeton spp.–*Utricularia vulgaris* ssp. *macrorhiza*

Aquatic vegetation grows on shallow bottoms and near the margins of these lakes (Table 86). Multiple species of pondweeds, *Potamogeton* spp., are common. We documented one rare species in this ecotype, *Myriophyllum verticillatum*. Sedges and grasses sometimes occur on shallow water near the margins of Riverine Lake.

Riverine Lake is most similar to Lowland Lake except it is formed by different physical properties. It is not very similar to Alpine Lake, which has reduced vegetative cover and different physical characteristics. Riverine Lake and River were mapped together as Riverine Water.

Table 86. Vegetation cover and frequency for Riverine Lake (n=2).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	31.4	41.2	100
Total Vascular Cover	24.9	32.0	100
Total Deciduous Shrub Cover	0.1	0.0	100
Alnus tenuifolia	0.1	0.1	50
Salix lanata ssp. *richardsonii*	0.1	0.1	50
Total Forb Cover	24.6	32.2	100
Caltha palustris	0.1	0.1	50
Cardamine pratensis ssp. *angustifolia*	0.1	0.1	50
Equisetum fluviatile	0.6	0.6	100
Galium trifidum ssp. *trifidum*	0.1	0.1	50
Hippuris vulgaris	2.5	3.5	100
Menyanthes trifoliata	0.1	0.1	50
Myriophyllum verticillatum	5.0	7.1	50
Potamogeton alpinus ssp. *tenuifolius*	6.0	8.5	50
Potamogeton praelongus	0.1	0.1	50
Potamogeton zosterifolius	5.0	7.1	50
Potentilla palustris	0.1	<0.1	100
Ranunculus trichophyllus var. *hispidulus*	0.1	0.1	50
Sparganium minimum	1.5	2.1	50
Sparganium sp.	0.1	0.1	50
Utricularia intermedia	1.0	1.4	50
Utricularia minor	0.1	0.1	50
Utricularia vulgaris ssp. *macrorhiza*	2.5	3.5	100
Total Sedge & Rush Cover	0.1	0.1	50
Carex aquatilis ssp. *aquatilis*	0.1	0.1	50
Eriophorum angustifolium	0.1	0.1	50
Total Nonvascular Cover	6.5	9.2	50
Total Moss Cover	6.5	9.2	50
Scorpidium scorpioides	2.5	3.5	50
Unknown moss	4.0	5.7	50
Total Bare Ground	101.1	1.3	100
Bare Soil	0.1	0.1	50
Water	97.5	3.5	100
Litter alone	3.5	4.9	100

Soils:

Flooded soils were not described. Water characteristics are listed in Table 87.

Table 87. Water characteristics for Riverine Lake.

Property	Mean	SD	n
Site pH at 10-cm depth	7.7	0.6	2
Site EC at 10-cm depth (µS/cm)	120.0	28.3	2
Water Depth (cm,+ above grnd)[a]	100.0	0.0	2

[a]Measurements >1 m indicate minimum depth, not true depth

Riverine Moist Willow Tall Shrub

Geomorphology:

These tall willow communities occur on active floodplains, including braided active and inactive overbank deposits, meander active overbank deposits, braided and meander coarse active channel deposits, eolian active sand dunes, and moderately steep headwater channel deposits and floodplains. This ecotype is subject to frequent flooding.

Plant Association:

Salix alaxensis–Aster sibiricus

This early-successional community is characterized by tall felt-leaf willow (*S. alaxensis*). Forbs are the prevalent understory life form. The amount of understory cover is variable, and due to sedimentation from flood events, cover of bare ground can be high (Table 88). Common species include *Aster sibiricus* (syn: *Eurybia sibirica*), *Hedysarum alpinum*, *Artemisia tilesii*, and *Festuca altaica*.

This ecotype varies from two willow-dominated riverine ecotypes, Riverine Wet Tall Willow Shrub and Riverine Willow Low Shrub, in species assemblages. It has drier soils and a higher disturbance rate than Riverine Wet Willow Tall Shrub, and a boreal distribution versus an arctic or mountain headwater stream distribution like Riverine Willow Low Shrub.

Soils:

Soils are typically gravelly, sandy, or loamy and often lack a surface organic horizon (Table 89). Depth to permafrost is difficult to determine, however if permafrost does occur it is assumed to be greater than 1 m given the well drained soils and immediate adjacency of flowing water. Frost boils were absent and loess caps are rare. Surface fragments are uncommon, however when they occur they tend to be

Table 88. Vegetation cover and frequency for Riverine Moist Willow Tall Shrub (n=49).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	137.3	57.8	100
Total Vascular Cover	116.8	47.2	100
Total Evergreen Tree Cover	0.0	0.0	12
Total Evergreen Shrub Cover	16.2	22.0	54
Dryas integrifolia	1.9	12.3	6
Dryas octopetala	14.1	19.7	38
Empetrum nigrum	0.1	0.7	8
Total Deciduous Tree Cover	0.9	2.1	29
Populus balsamifera	0.8	2.0	25
Total Deciduous Shrub Cover	51.1	31.7	100
Alnus crispa	0.4	2.9	10
Arctostaphylos rubra	2.7	4.6	52
Betula glandulosa	0.3	1.5	8
Potentilla fruticosa	1.2	2.4	48
Salix alaxensis	28.5	21.3	100
Salix arbusculoides	0.6	3.0	15
Salix barclayi	1.4	5.6	10
Salix brachycarpa ssp. *niphoclada*	2.7	6.8	27
Salix glauca	0.8	3.0	17
Salix hastata	1.2	5.2	15
Salix lanata ssp. *richardsonii*	1.0	3.9	10
Salix monticola	0.5	2.2	10
Salix planifolia ssp. *pulchra*	0.6	3.0	12
Salix reticulata	5.8	8.1	50
Shepherdia canadensis	2.4	8.9	38
Vaccinium uliginosum	0.4	1.3	27
Total Forb Cover	25.6	23.7	100
Aconitum delphinifolium	0.1	0.3	15
Androsace chamaejasme	0.2	0.5	19
Anemone parviflora	0.7	0.9	52
Anemone richardsonii	0.2	0.9	10
Artemisia arctica ssp. *arctica*	0.2	0.8	17
Artemisia tilesii	0.8	1.6	52
Aster sibiricus	1.2	1.6	71
Astragalus alpinus	0.2	0.4	25
Astragalus umbellatus	0.1	0.3	19
Boykinia richardsonii	<0.1	0.3	8
Castilleja caudata	0.3	0.9	23
Chrysanthemum integrifolium	0.1	0.2	12
Cypripedium passerinum	0.1	0.6	8
Dodecatheon frigidum	0.3	1.0	15
Epilobium angustifolium	0.1	0.4	10
Epilobium latifolium	0.8	1.6	33
Equisetum arvense	5.6	17.5	44
Equisetum variegatum	1.4	5.6	21
Galium boreale	2.1	11.1	21
Gentiana propinqua	0.1	0.3	44
Hedysarum alpinum	3.1	3.3	71
Hedysarum mackenzii	0.8	2.4	12
Mertensia paniculata	0.3	1.5	10
Parnassia palustris	0.1	0.4	33
Pedicularis capitata	<0.1	0.1	10
Pedicularis sudetica	0.1	0.3	19

Table 88. Continued.

	Cover		Freq
	Mean	SD	%
Pedicularis verticillata	0.1	0.3	19
Polemonium acutiflorum	<0.1	0.2	10
Polygonum viviparum	0.1	0.3	23
Rubus arcticus	0.7	2.8	6
Rubus arcticus ssp. *arcticus*	0.1	0.5	8
Saxifraga oppositifolia	0.1	0.4	10
Senecio lugens	0.5	0.9	38
Silene acaulis	1.1	2.1	38
Solidago multiradiata	0.6	1.1	44
Thalictrum alpinum	0.1	0.4	17
Valeriana capitata	0.1	0.3	15
Wilhelmsia physodes	0.1	0.7	8
Zygadenus elegans	1.0	1.6	48
Total Grass Cover	13.0	11.0	100
Arctagrostis latifolia	0.7	2.9	25
Bromus pumpellianus	0.1	0.7	8
Calamagrostis canadensis	0.7	2.1	17
Calamagrostis purpurascens	0.3	1.6	10
Deschampsia caespitosa	<0.1	0.1	8
Elymus innovatus	5.2	8.9	40
Elymus trachycaulus	0.1	0.2	10
Festuca altaica	3.4	5.8	52
Festuca richardsonii	0.2	0.8	17
Festuca rubra	0.3	1.3	12
Poa alpigena	0.1	0.3	10
Poa alpina	0.1	0.4	23
Poa arctica	0.1	0.2	8
Trisetum spicatum ssp. *spicatum*	0.1	0.3	19
Total Sedge & Rush Cover	10.0	14.0	67
Carex capillaris	0.1	0.3	8
Carex rupestris	1.2	2.8	21
Carex scirpoidea	8.3	12.6	42
Total Nonvascular Cover	20.5	18.0	90
Total Moss Cover	13.8	16.3	88
Brachythecium sp.	1.5	5.8	33
Bryum sp.	0.2	0.8	12
Ceratodon purpureus	1.8	8.1	8
Dicranum sp.	0.3	1.1	12
Ditrichum sp.	0.5	0.9	29
Drepanocladus sp.	0.7	3.2	8
Hylocomium splendens	2.0	10.1	21
Hypnum sp.	0.4	1.2	15
Sanionia sp.	0.2	0.5	15
Sanionia uncinata	1.1	5.8	8
Unknown moss	1.6	5.9	15
Total Lichen Cover	7.1	12.6	54
Cetraria sp.	3.0	5.0	33
Cladina arbuscula	0.4	1.4	15
Cladonia sp.	1.5	2.6	38
Flavocetraria cucullata	0.4	1.0	27
Masonhalea richardsonii	0.3	1.0	25
Stereocaulon sp.	0.3	1.0	12
Total Bare Ground	22.0	31.1	54
Bare Soil	19.8	30.0	52
Litter alone	2.3	3.3	50

abundant. Soil pH is circumneutral to alkaline, and EC is low. The soils are typically somewhat excessively to well drained, and depth to water table was typically greater than 1 m.

Table 89. Soil characteristics for Riverine Moist Willow Tall Shrub.

Property	Mean	SD	n
Elevation (m)	155.9	148.8	30
Slope (degrees)	3.4	3.2	7
Surface Organics Depth(cm)	2.5	2.1	10
Cumulative Org. in 40 cm (cm)	2.3	1.8	15
Loess Cap Thickness (cm)	2.0		1
Depth to Rocks (cm)	75.3	79.2	23
Surface Fragment Cover (%)	34.4	36.3	11
Frost Boil Cover (%)			0
Thaw Depth (cm)	109.0	44.0	4
Site pH at 10-cm depth	7.4	0.8	29
Site EC at 10-cm depth (µS/cm)	93.3	75.3	27
Water Depth (cm,+ above grnd)[a]	-118.2	45.0	26

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups in this ecotype are Oxyaquic Cryorthents (moist, saturated early in growing season, lacking permafrost), Typic Gelorthents (poorly developed with permafrost below 1 m), and Oxyaquic Gelorthents (wet, saturated early in growing season, poorly developed with permafrost below 1 m). A less common soil type is Oxyaquic Cryopsamments (wet, saturated early in growing season, sandy, low coarse fragment content, lacking permafrost). This ecotype and associated soils are part of the Riverine Gravelly Barrens and Shrublands soil landscape. Other ecotypes found in this soil landscape include Riverine Barrens, Riverine Dryas Dwarf Shrub, and Riverine Willow Low Shrub.

Riverine Poplar Forest

Geomorphology:

These early to mid-successional poplar stands occur on braided active and inactive overbank deposits, meander active and inactive overbank deposits, and eolian inactive sand dunes. Surfaces consist of levees, interfluves, flat banks, point bars, and linear dunes.

Plant Association:

Populus balsamifera–Picea glauca–Salix alaxensis

The rapid rate of succession that this ecotype experiences is reflected in its plant association, which contains a dominant species from the three stages through 100 years of the floodplain successional sequence. *Populus balsamifera* is the dominant species while forbs characterize the understory (Table 90). *Picea glauca* occurs as seedlings in the understory. Additional common species include *Shepherdia canadensis*, *Aster sibiricus* (syn: *Eurybia sibirica*), *Equisetum variegatum*, and *Hedysarum alpinum*.

Riverine Poplar Forest is most similar to Riverine White Spruce–Poplar Forest because it transitions to this ecotype as spruce grows into mature trees.

Soils:

Soils are typically loamy or sandy, and occasionally bouldery, with a thin, often scattered, surface organic horizon (Table 91). Depth to permafrost is difficult to determine, however if permafrost does occur it is assumed to be greater than 1 m given the well drained soils and proximity of flowing water. Frost boils and loess caps are absent. Surface fragments are rare, however when they do occur they tend to be abundant. Organic horizons, buried during flooding by riverine silts and sands, sometimes occur in these soils. Soil pH is circumneutral to alkaline, and EC is low. The soils are typically somewhat excessively to moderately well drained. Depth to water table often could not be

Table 90. Vegetation cover and frequency for Riverine Poplar Forest (n=15).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	126.6	43.5	100
Total Vascular Cover	115.7	43.8	100
Total Evergreen Tree Cover	1.1	1.6	77
Picea glauca	1.1	1.6	77
Total Evergreen Shrub Cover	0.0	0.0	15
Juniperus communis	<0.1	<0.1	8
Linnaea borealis	<0.1	<0.1	8
Total Deciduous Tree Cover	46.9	16.7	100
Populus balsamifera	46.9	16.7	100
Total Deciduous Shrub Cover	37.4	23.0	100
Alnus crispa	5.3	13.1	38
Alnus tenuifolia	0.1	0.3	8
Arctostaphylos rubra	1.2	2.3	31
Betula nana	0.1	0.3	8
Potentilla fruticosa	0.2	0.6	23
Rosa acicularis	0.2	0.8	15
Salix alaxensis	13.9	15.4	85
Salix arbusculoides	0.1	0.3	23
Salix brachycarpa ssp. *niphoclada*	0.8	2.3	15
Salix glauca	1.6	5.5	23
Salix hastata	0.1	0.3	15
Salix monticola	0.8	1.9	15
Salix reticulata	0.2	0.6	8
Shepherdia canadensis	12.7	12.8	85
Vaccinium uliginosum	0.2	0.6	15
Total Forb Cover	24.9	17.9	100
Aconitum delphinifolium	0.2	0.6	8
Allium schoenoprasum	0.1	0.3	8
Anemone narcissiflora	<0.1	<0.1	15
Anemone parviflora	<0.1	<0.1	23
Anemone richardsonii	1.2	3.0	15
Arnica alpina ssp. *angustifolia*	0.1	0.3	8
Artemisia tilesii	1.3	2.7	69
Aster sibiricus	3.8	6.6	92
Astragalus alpinus	<0.1	<0.1	31
Boschniakia rossica	<0.1	<0.1	8
Castilleja caudata	0.1	0.3	8
Castilleja hyperborea	<0.1	<0.1	8
Chrysanthemum bipinnatum	0.3	0.8	15
Cypripedium passerinum	1.1	2.3	54
Epilobium angustifolium	0.2	0.6	8
Epilobium latifolium	0.3	0.7	23
Equisetum arvense	4.1	6.5	54
Equisetum pratense	0.1	0.3	8
Equisetum variegatum	0.1	0.3	46
Erigeron sp.	<0.1	<0.1	8
Galium boreale	0.5	1.4	31
Gentiana propinqua	<0.1	<0.1	23
Hedysarum alpinum	4.5	6.6	69
Hedysarum mackenzii	1.3	4.1	23
Lupinus arcticus	1.2	2.8	31
Mertensia paniculata	1.5	4.2	31
Moneses uniflora	0.1	0.3	23
Oxytropis campestris	0.3	0.9	23
Parnassia palustris	<0.1	0.1	38

Table 90. Continued.

	Cover		Freq
	Mean	SD	%
Pedicularis sudetica	0.1	0.3	23
Pedicularis verticillata	<0.1	<0.1	15
Platanthera obtusata	<0.1	0.1	38
Polygonum viviparum	<0.1	<0.1	15
Pyrola asarifolia	0.6	1.4	31
Pyrola secunda	<0.1	<0.1	23
Rubus arcticus	1.9	3.2	38
Trientalis europaea ssp. *arctica*	0.1	0.3	8
Zygadenus elegans	<0.1	<0.1	15
Total Grass Cover	4.8	6.4	100
Agropyron macrourum	0.1	0.3	8
Agropyron sp.	<0.1	<0.1	15
Arctagrostis latifolia	0.6	1.4	23
Bromus pumpellianus	0.2	0.6	15
Bromus sp.	1.1	2.0	46
Calamagrostis canadensis	0.2	0.6	23
Calamagrostis purpurascens	0.2	0.6	15
Elymus sp.	0.5	1.7	15
Elymus trachycaulus	0.2	0.4	15
Festuca altaica	0.2	0.4	23
Festuca richardsonii	0.9	2.8	23
Hierochloe odorata	0.3	1.1	8
Trisetum spicatum ssp. *spicatum*	0.3	1.1	38
Total Sedge & Rush Cover	0.6	1.5	23
Carex aurea	<0.1	<0.1	8
Carex concinna	<0.1	<0.1	8
Carex krausei	<0.1	<0.1	8
Carex lapponica	0.2	0.6	8
Carex podocarpa	0.4	1.4	8
Juncus arcticus	<0.1	<0.1	8
Total Nonvascular Cover	10.9	10.4	77
Total Moss Cover	10.2	9.1	77
Abietinella abietina	0.8	2.8	8
Brachythecium sp.	0.5	0.9	31
Campylium polygamum	0.2	0.6	8
Ceratodon purpureus	0.4	1.0	23
Ceratodon sp.	0.2	0.8	8
Didymodon sp.	0.5	1.7	8
Ditrichum flexicaule	0.5	1.7	8
Drepanocladus sendtneri	0.2	0.6	8
Hylocomium splendens	3.1	6.3	23
Hypnum lindbergii	0.2	0.6	8
Hypnum revolutum	0.8	1.9	15
Hypnum sp.	0.5	1.5	15
Pohlia sp.	0.1	0.3	8
Sanionia uncinata	2.5	6.4	23
Total Lichen Cover	0.7	1.5	54
Cladonia symphycarpia	0.2	0.8	8
Peltigera rufescens	0.1	0.3	8
Stereocaulon tomentosum	0.4	1.4	8
Total Bare Ground	24.7	28.2	92
Bare Soil	18.5	29.6	85
Litter alone	6.2	6.0	77

measured but it is assumed to fluctuate throughout the year within the upper 2 m of the soil profile given the immediate adjacency to river water.

Table 91. Soil characteristics for Riverine Poplar Forest.

Property	Mean	SD	n
Elevation (m)	152.3	134.3	13
Slope (degrees)	3.0		1
Surface Organics Depth(cm)	3.0	3.2	7
Cumulative Org. in 40 cm (cm)	4.2	2.7	10
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	76.3	69.7	11
Surface Fragment Cover (%)	60.0	14.1	2
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	7.6	0.9	10
Site EC at 10-cm depth (µS/cm)	98.0	60.3	10
Water Depth (cm,+ above grnd)[a]	-137.5	35.4	8

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Gelorthents (poorly developed with permafrost below 1 m) and Typic Cryorthents (poorly developed soils, lacking permafrost). Less common soil types include Oxyaquic Gelorthents (wet, saturated early in growing season, poorly developed with permafrost below 1 m) and Typic Gelifluvents (poorly developed with buried organic horizons, permafrost below 1 m). This ecotype and associated soils are part of the Riverine Gravelly-loamy Forests soil landscape. Other ecotypes found in this soil landscape include Riverine White Spruce–Poplar Forest, Riverine White Spruce–Willow Forest, and Riverine White Spruce–Alder Forest.

Riverine Wet Sedge Meadow

Geomorphology:

Riverine Wet Sedge Meadow occurs in inactive or abandoned channels that were initially shallow or have infilled. These include meander coarse abandoned channel deposits and meander inactive overbank deposits along rivers, particularly in the treeless regions of ARCN. Macrotopography includes channels, swales, flood basins, and interfluves.

Plant Association:

Carex aquatilis–Eriophorum angustifolium

Sedges are the dominant life form in Riverine Wet Sedge Meadow, with grasses and forbs always comprising a minor component (Table 92). Deciduous shrubs are always present although in low quantities. Common species include *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Polemonium acutiflorum*, *Saxifraga hirculus*, *Calamagrostis canadensis*, and *Carex saxatilis*.

This ecotype is similar to Riverine Forb Marsh, which has deeper water, is forb instead of sedge-dominated, and has a boreal distribution versus an arctic distribution. Riverine Wet Sedge Meadow occurred in patches too small to be mapped.

Table 92. Vegetation cover and frequency for Riverine Wet Sedge Meadow (n=3).

	Cover		Freq
	Mean	SD	%
Total Live Cover	88.5	23.0	100
Total Vascular Cover	78.4	24.9	100
Total Evergreen Shrub Cover	0.0	0.1	33
Andromeda polifolia	<0.1	0.1	33
Total Deciduous Shrub Cover	1.9	2.8	100
Arctostaphylos rubra	<0.1	0.1	33
Potentilla fruticosa	<0.1	0.1	33
Salix lanata ssp. *richardsonii*	<0.1	0.1	33
Salix ovalifolia	1.7	2.9	33
Salix planifolia ssp. *pulchra*	0.1	0.1	67
Salix reticulata	<0.1	0.1	33
Vaccinium uliginosum	<0.1	0.1	33
Total Forb Cover	10.2	8.4	100
Aconitum delphinifolium	0.3	0.6	33
Caltha palustris	<0.1	0.1	33
Cardamine sp.	<0.1	0.1	33
Chrysosplenium tetrandrum	0.3	0.6	33
Epilobium palustre	<0.1	0.1	33
Equisetum arvense	<0.1	0.1	33
Galium trifidum ssp. *trifidum*	2.7	4.6	33
Iris setosa	<0.1	0.1	33
Melandrium apetalum	<0.1	0.1	33
Parnassia kotzebuei	<0.1	0.1	33
Pedicularis sudetica ssp. *albolabiata*	<0.1	0.1	33
Petasites frigidus	1.7	2.9	33
Polemonium acutiflorum	0.4	0.6	67
Polygonum viviparum	<0.1	0.1	33
Potentilla palustris	1.3	2.3	33
Rorippa islandica ssp. *fernaldiana*	0.3	0.6	33
Rubus arcticus	<0.1	0.1	33
Rumex arcticus	0.7	1.2	33
Saxifraga cernua	0.7	1.2	33
Saxifraga hirculus	0.4	0.6	67
Sparganium hyperboreum	<0.1	0.1	33
Stellaria crassifolia	<0.1	0.1	33
Stellaria longipes	<0.1	0.1	33
Triglochin maritimum	<0.1	0.1	33
Valeriana capitata	1.0	1.7	33
Total Grass Cover	3.4	4.1	100
Calamagrostis canadensis	0.4	0.6	67
Dupontia fischeri	0.7	1.2	33
Glyceria pulchella	0.7	1.2	33
Poa alpigena	1.7	2.9	33
Poa arctica	<0.1	0.1	33
Total Sedge & Rush Cover	62.9	31.7	100
Carex aquatilis ssp. *aquatilis*	6.0	5.3	67
Carex arcta	10.0	17.3	33
Carex capitata	<0.1	0.1	33
Carex garberi ssp. *bifaria*	<0.1	0.1	33
Carex krausei	<0.1	0.1	33
Carex maritima	<0.1	0.1	33
Carex rostrata	16.7	28.9	33
Carex saxatilis	10.0	10.0	67
Carex vaginata	<0.1	0.1	33
Eriophorum angustifolium	20.0	20.0	67

Table 92. Continued.

	Cover		Freq
	Mean	SD	%
Kobresia simpliciuscula	<0.1	0.1	33
Trichophorum caespitosum	<0.1	0.1	33
Total Nonvascular Cover	10.0	13.3	67
Total Moss Cover	10.0	13.3	67
Brachythecium sp.	1.7	2.9	67
Scorpidium scorpioides	8.3	14.4	33
Total Bare Ground	53.4	20.2	100
Bare Soil	8.4	7.6	100
Water	8.4	14.4	67
Litter alone	36.7	12.6	100

Soils:

Soils are typically loamy with a thin to moderately thick surface organic horizon (Table 93). Thaw depths could not be determined as the depth to permafrost, if present, was always greater than the maximum depth sampled (1.3 m). Organic horizons, buried during flooding by riverine silts and sands, commonly occur in these soils. Frost boils, surface fragments, and loess caps are absent. Soil pH is circumneutral to acidic, and EC is generally low, except along coastal rivers where it may be moderately high. The soils are typically very poorly to moderately well drained, and the water table occurs at shallow depths or above ground.

Table 93. Soil characteristics for Riverine Wet Sedge Meadow.

Property	Mean	SD	n
Elevation (m)	90.7	135.8	3
Slope (degrees)			0
Surface Organics Depth(cm)	9.7	10.7	3
Cumulative Org. in 40 cm (cm)	14.0	8.0	3
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	145.7	94.1	3
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	30.0		1
Site pH at 10-cm depth	6.5	1.4	3
Site EC at 10-cm depth (μS/cm)	450.0	566.7	3
Water Depth (cm,+ above grnd)[a]	-7.0	8.5	2

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Gelaquents (wet, poorly developed with permafrost below 1 m) and Oxyaquic Cryofluvents (wet, saturated early in growing season, poorly developed with thin buried horizons, lacking permafrost). A less common soil type is Fluvaquentic Aquorthels (wet, mineral soil with thin buried horizons, permafrost within 1 m). This ecotype and associated soils are part of the Riverine Loamy Wet Meadows and Marshes soil landscape. Also included in this soil landscape is Riverine Forb Marsh.

Riverine Wet Willow Tall Shrub

Geomorphology:

This ecotype occurs along drainages and channels on meander fine inactive channel deposits, lowland headwater floodplains and overbank deposits, and moderately steep headwater floodplains. Surfaces are usually flat and it occurs at <300 m elevation, mainly in the boreal zone in GAAR and KOVA.

Plant Association:

Salix planifolia ssp. *pulchra–Potentilla palustris*

Tall (>1.5 m) deciduous shrubs, mainly *S. planifolia* spp. *pulchra* (syn: *S. pulchra*), dominate this ecotype with a strong component of low shrubs, forbs, grasses and mosses (Table 94). Sedge cover is variable. This ecotype contains a mix of species that grow in water-logged soils with those that grow on raised micro-sites. Common species include *Vaccinium uliginosum*, *Equisetum arvense*, *Carex aquatilis*, *Carex canescens*, and *Sanionia uncinata*.

This ecotype varies from two willow dominated riverine ecotypes, Riverine Moist Tall Willow Shrub and Riverine Willow Low Shrub, in species assemblages. It also has higher soil moisture and a lower disturbance rate than Riverine Moist Willow Tall Shrub, and a boreal distribution versus an arctic or mountain headwater stream distribution like Riverine Willow Low Shrub. Due to spectral similarities, this ecotype was mapped with Riverine Moist Willow Tall Shrub.

Table 94. Vegetation cover and frequency for Riverine Wet Willow Tall Shrub (n=6).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	181.2	35.6	100
Total Vascular Cover	122.7	22.0	100
Total Evergreen Tree Cover	0.1	0.1	67
Picea glauca	0.1	0.1	67
Total Evergreen Shrub Cover	0.0	0.1	17
Andromeda polifolia	<0.1	<0.1	17
Vaccinium vitis-idaea	<0.1	<0.1	17
Total Deciduous Shrub Cover	76.1	37.8	100
Alnus crispa	2.3	3.9	50
Betula glandulosa	<0.1	<0.1	17
Betula nana	1.2	2.9	17
Myrica gale	0.3	0.8	17
Potentilla fruticosa	0.7	1.6	17
Salix alaxensis	5.5	12.1	33
Salix arbusculoides	2.3	3.0	50
Salix bebbiana	<0.1	<0.1	17
Salix fuscescens	2.5	6.1	33
Salix glauca	<0.1	<0.1	17
Salix hastata	1.7	4.1	33
Salix lanata ssp. *richardsonii*	4.2	10.2	17
Salix planifolia ssp. *pulchra*	51.3	33.0	100
Spiraea beauverdiana	0.2	0.4	33
Vaccinium uliginosum	3.9	4.9	67
Total Forb Cover	27.1	15.4	100
Anemone richardsonii	1.3	3.3	17
Calla palustris	<0.1	<0.1	17
Cicuta mackenzieana	<0.1	<0.1	17
Epilobium angustifolium	<0.1	<0.1	17
Epilobium palustre	1.0	1.5	50
Equisetum arvense	2.8	2.8	67
Equisetum fluviatile	1.9	4.0	50
Equisetum palustre	1.7	4.1	17
Galium trifidum ssp. *trifidum*	<0.1	<0.1	17
Lycopodium annotinum	<0.1	<0.1	17
Parnassia palustris	<0.1	<0.1	17
Pedicularis sp.	<0.1	<0.1	17
Potentilla palustris	10.8	13.8	83
Pyrola asarifolia	<0.1	<0.1	17
Pyrola sp.	<0.1	<0.1	17
Ranunculus gmelini	<0.1	<0.1	17
Ranunculus lapponicus	<0.1	<0.1	17
Rubus arcticus	2.0	4.0	50
Rubus arcticus ssp. *arcticus*	1.0	2.4	17
Rubus chamaemorus	0.2	0.4	17
Rumex arcticus	2.5	6.1	17
Stellaria crassifolia	<0.1	<0.1	17
Stellaria longifolia	0.2	0.4	17
Viola epipsila ssp. *repens*	0.5	1.2	17
Viola sp.	1.0	1.5	33
Total Grass Cover	7.3	3.3	100
Arctagrostis latifolia	2.0	4.0	33
Calamagrostis canadensis	4.8	4.2	83

Table 94. Continued.

	Cover		Freq
	Mean	SD	%
Calamagrostis inexpansa	0.5	1.2	17
Poa alpigena	<0.1	<0.1	17
Total Sedge & Rush Cover	12.1	15.7	83
Carex aquatilis ssp. *aquatilis*	3.0	3.8	67
Carex canescens	1.0	2.0	67
Carex diandra	1.7	4.1	17
Carex media	0.5	1.2	17
Carex saxatilis	3.3	6.1	33
Carex sp.	<0.1	<0.1	17
Carex utriculata	1.7	4.1	17
Eriophorum angustifolium	<0.1	<0.1	17
Eriophorum brachyantherum	0.8	2.0	17
Total Nonvascular Cover	58.5	23.8	100
Total Moss Cover	58.4	23.8	100
Brachythecium nelsonii	6.7	16.3	17
Calliergon cordifolium	1.0	2.4	17
Calliergon sp.	10.8	17.4	33
Calliergon stramineum	3.3	8.2	17
Climacium dendroides	<0.1	<0.1	17
Drepanocladus sp.	1.3	3.3	17
Hypnum dieckei	10.8	26.5	17
Paludella squarrosa	4.2	10.2	17
Plagiomnium ellipticum	2.7	6.5	17
Pleurozium schreberi	0.8	2.0	17
Polytrichum sp.	<0.1	<0.1	17
Sanionia uncinata	6.3	8.0	50
Sphagnum sp.	1.2	2.8	33
Sphagnum warnstorfii	0.8	2.0	17
Unknown moss	8.3	7.6	83
Total Lichen Cover	0.1	0.1	50
Cladonia sp.	<0.1	<0.1	17
Peltigera aphthosa	<0.1	0.1	33
Peltigera sp.	<0.1	<0.1	17
Total Bare Ground	5.7	5.1	83
Bare Soil	0.7	1.2	67
Water	1.8	2.7	50
Litter alone	3.2	2.6	83

Soils:

Soils are loamy with a thin organic horizon above the mineral soil surface (Table 95). Permafrost is occasionally found in the upper meter of the soil profile, however permafrost is often difficult to determine due to the rocky soils, and it is assumed in these cases to be greater than 1 m given the well drained soils and immediate adjacency of flowing water. Frost boils, loess caps, and surface fragments are absent. Organic horizons, buried during flooding by riverine silts and sands, were commonly found in

these soils. Soil pH is acidic to circumneutral, and EC is low. The soils are typically moderately well to very poorly drained, and the water table is shallow to moderately deep.

Table 95. Soil characteristics for Riverine Wet Willow Tall Shrub.

Property	Mean	SD	n
Elevation (m)	204.5	68.9	6
Slope (degrees)	2.0	1.0	3
Surface Organics Depth(cm)	5.3	4.1	6
Cumulative Org. in 40 cm (cm)	8.5	3.6	6
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	97.2	76.3	4
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	62.0	4.2	2
Site pH at 10-cm depth	6.4	0.8	5
Site EC at 10-cm depth (µS/cm)	70.0	30.8	5
Water Depth (cm,+ above grnd)[a]	-24.2	25.0	5

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Fluvaquentic Aquorthels (wet, saturated within 50 cm, mineral soil with thin buried horizons, permafrost within 1 m). A less common soil subgroup is Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Riverine Loamy Meadows and Shrublands soil landscape. Other ecotypes found in this soil landscape include Riverine Alder Tall Shrub, Riverine Birch–Willow Low Shrub, and Riverine Bluejoint Meadow.

Riverine White Spruce–Alder Forest

Geomorphology:

This ecotype consists of mature white spruce stands with alder characterizing the understory, a legacy from an earlier successional stage. It occurs on inactive and abandoned meander overbank deposits, moderately steep headwater floodplains and alluvial fan coarse inactive channels. It is widespread in riverine corridors in the boreal zone of KOVA and GAAR.

Plant Association:

Picea glauca–Alnus crispa–Calamagrostis canadensis

All life forms are represented in Riverine White Spruce–Alder Forest, although it is not particularly diverse (Table 96). Evergreen trees and tall deciduous shrubs are co-dominant. Moss cover is typically high. Common species include *Linnaea borealis*, *Vaccinium vitis-idaea*, *Arctostaphylos rubra* (syn: *Arctous rubra*), *Rosa acicularis*, *Boschniakia rossica*, *Hylocomium splendens* and *Peltigera aphthosa*.

This ecotype is most similar to Riverine White Spruce–Willow Forest except spruce trees are co-dominant with *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*) instead of *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*). Due to spectral similarities, it was mapped as Riverine White Spruce–Willow Forest.

Soils:

Soils are typically gravelly, loamy, or sandy with a thin surface organic horizon (Table 97). Permafrost is often found in the upper meter of the soil profile, however permafrost was sometimes difficult to determine due to the rocky soils, and it was assumed in these cases to be present in the upper 2 m of the soil profile. Frost boils, surface fragments, and loess caps are absent. Organic horizons, buried during flooding by riverine silts and sands, often occur in these soils. Soil pH is acidic to circumneutral, and EC is low. The soils are well drained to moderately well drained.

Table 96. Vegetation cover and frequency for Riverine White Spruce–Alder Forest (n=8).

	Cover		Freq
	Mean	SD	%
Total Live Cover	223.5	61.9	100
Total Vascular Cover	153.2	51.6	100
Total Evergreen Tree Cover	26.6	8.7	100
Picea glauca	26.6	8.7	100
Total Evergreen Shrub Cover	14.0	14.0	100
Andromeda polifolia	0.4	1.1	12
Empetrum nigrum	1.9	3.7	25
Ledum decumbens	3.8	8.8	25
Linnaea borealis	4.6	7.1	62
Vaccinium vitis-idaea	3.4	4.4	75
Total Deciduous Tree Cover	1.1	1.9	38
Betula papyrifera	0.1	0.4	12
Populus balsamifera	1.0	1.9	25
Total Deciduous Shrub Cover	84.0	46.2	100
Alnus crispa	39.4	24.6	88
Alnus tenuifolia	0.2	0.7	12
Arctostaphylos rubra	3.8	5.8	62
Betula glandulosa	1.9	5.3	12
Betula occidentalis	0.1	0.4	12
Potentilla fruticosa	0.2	0.7	12
Ribes triste	1.0	2.4	38
Rosa acicularis	8.1	8.3	88
Salix alaxensis	0.5	0.9	38
Salix arbusculoides	<0.1	<0.1	12
Salix barclayi	4.4	12.4	12
Salix bebbiana	0.6	1.8	12
Salix glauca	0.6	1.8	25
Salix hastata	<0.1	<0.1	12
Salix planifolia ssp. *pulchra*	<0.1	<0.1	12
Salix reticulata	0.1	0.4	12
Salix scouleriana	1.2	3.5	12
Shepherdia canadensis	0.1	0.4	25
Spiraea beauverdiana	6.2	12.7	25
Vaccinium uliginosum	12.8	22.5	62
Viburnum edule	2.5	7.1	12
Total Forb Cover	24.1	21.0	100
Aconitum delphinifolium	<0.1	<0.1	25
Anemone richardsonii	1.4	3.5	50
Artemisia tilesii	0.2	0.3	50
Aster sibiricus	0.4	1.1	12
Astragalus alpinus	0.4	1.1	25
Boschniakia rossica	0.1	0.1	62
Cardamine sp.	<0.1	<0.1	12
Corallorrhiza trifida	<0.1	<0.1	12
Dryopteris dilatata ssp. *americana*	<0.1	<0.1	12
Epilobium angustifolium	<0.1	<0.1	12
Equisetum arvense	1.6	2.4	50
Equisetum pratense	7.1	19.4	38
Galium boreale	0.2	0.7	12
Geocaulon lividum	0.4	1.1	12
Hedysarum alpinum	0.1	0.4	25
Iris setosa	<0.1	<0.1	12
Listera borealis	<0.1	<0.1	25

Table 96. Continued.

	Cover		Freq
	Mean	SD	%
Lupinus arcticus	<0.1	0.1	38
Lycopodium annotinum	2.5	4.6	25
Mertensia paniculata	0.3	0.5	38
Moneses uniflora	0.3	0.5	38
Oxyria digyna	<0.1	<0.1	12
Petasites frigidus	<0.1	<0.1	12
Platanthera obtusata	0.1	0.3	38
Pyrola asarifolia	5.9	12.1	50
Pyrola grandiflora	0.1	0.4	12
Pyrola secunda	0.1	0.3	38
Ranunculus lapponicus	0.1	0.4	12
Rubus arcticus	0.4	0.7	25
Rubus arcticus ssp. *arcticus*	0.8	1.8	25
Rubus chamaemorus	1.2	3.5	12
Saxifraga punctata	<0.1	<0.1	12
Sedum rosea ssp. *integrifolium*	<0.1	<0.1	12
Solidago sp.	<0.1	<0.1	12
Stellaria sp.	<0.1	<0.1	12
Trientalis europaea ssp. *arctica*	0.1	0.4	12
Viola epipsila ssp. *repens*	<0.1	<0.1	12
Total Grass Cover	2.8	5.2	75
Calamagrostis canadensis	2.8	5.2	75
Trisetum spicatum ssp. *spicatum*	<0.1	<0.1	12
Total Sedge & Rush Cover	0.5	1.1	38
Carex concinna	0.2	0.5	25
Carex livida	0.2	0.7	12
Carex sp.	<0.1	<0.1	12
Total Nonvascular Cover	70.3	24.5	100
Total Moss Cover	69.6	24.1	100
Aulacomnium palustre	2.0	5.3	38
Brachythecium salebrosum	3.1	8.8	12
Dicranum sp.	1.6	2.1	62
Hylocomium splendens	51.9	25.9	100
Pleurozium schreberi	1.8	3.1	38
Polytrichum juniperinum	0.1	0.4	25
Polytrichum sp.	1.8	2.2	50
Polytrichum strictum	<0.1	<0.1	12
Ptilidium ciliare	<0.1	<0.1	12
Ptilium crista-castrensis	0.9	1.4	50
Rhytidiadelphus triquetrus	2.6	7.0	38
Sanionia uncinata	2.0	3.7	50
Sphagnum sp.	1.0	2.4	25
Thuidium sp.	0.1	0.4	12
Unknown moss	0.6	1.8	12
Total Lichen Cover	0.7	0.9	88
Cladina sp.	<0.1	<0.1	12
Cladonia sp.	0.2	0.3	75
Hypogymnia physodes	0.1	0.4	12
Peltigera aphthosa	0.2	0.3	75
Peltigera sp.	<0.1	<0.1	25
Rhizocarpon sp.	0.1	0.4	12
Usnea sp.	<0.1	<0.1	12
Total Bare Ground	128.2	351.9	100
Bare Soil	0.1	0.1	62
Litter alone	128.1	351.9	100

Depth to water table often could not be measured but it is assumed to fluctuate throughout the year within the upper 2 m of the soil profile given the immediate adjacency to river water.

Table 97. Soil characteristics for Riverine White Spruce–Alder Forest.

Property	Mean	SD	n
Elevation (m)	192.8	161.8	8
Slope (degrees)	1.7	1.2	3
Surface Organics Depth(cm)	6.4	4.9	8
Cumulative Org. in 40 cm (cm)	11.4	8.1	8
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	21.7	15.1	3
Surface Fragment Cover (%)	0.1		1
Frost Boil Cover (%)			0
Thaw Depth (cm)	57.2	8.4	4
Site pH at 10-cm depth	5.7	1.4	7
Site EC at 10-cm depth (µS/cm)	57.1	26.9	7
Water Depth (cm,+ above grnd)[a]	-48.5	20.7	4

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Gelifluvents (poorly developed with buried organic horizons, permafrost below 1 m) and Fluventic Historthels (wet, organic rich soil with buried organic horizons over permafrost, lacking cryoturbation). A less common soil type is Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Riverine Gravelly-loamy Forests soil landscape. Other ecotypes found in this soil landscape include Riverine Poplar Forest, Riverine White Spruce– Poplar Forest, and Riverine White Spruce–Willow Forest.

Riverine White Spruce–Poplar Forest

Geomorphology:

This is a mid-successional ecotype that occurs along rivers throughout GAAR, KOVA and NOAT. It occurs on braided and meander inactive overbank deposits, braided coarse inactive channel deposits, and eolian inactive sand dunes. It most commonly is found under 450 m elevation.

Plant Association:

Populus balsamifera–Picea glauca–Salix alaxensis

A mix of evergreen and deciduous trees characterizes this ecotype (Table 98). Deciduous shrubs, forbs and mosses are prevalent in the understory. Common species include *Shepherdia canadensis*, *Moneses uniflora*, *Pyrola secunda*, *Hylocomium splendens*, and *Sanionia uncinata*.

Riverine White Spruce–Poplar Forest is most similar to Riverine Poplar Forest although it is an older successional stage and spruce trees are co-dominant.

Soils:

Table 98. Vegetation cover and frequency for Riverine White Spruce–Poplar Forest (n=11).

	Cover		Freq
	Mean	SD	%
Total Live Cover	170.3	47.8	100
Total Vascular Cover	119.6	50.0	100
Total Evergreen Tree Cover	22.8	10.7	100
Picea glauca	22.8	10.7	100
Total Evergreen Shrub Cover	3.5	5.6	45
Dryas integrifolia	0.1	0.3	9
Dryas octopetala	<0.1	<0.1	18
Empetrum nigrum	1.2	2.4	27
Juniperus communis	1.6	4.5	18
Linnaea borealis	0.2	0.4	27
Vaccinium vitis-idaea	0.4	0.9	18
Total Deciduous Tree Cover	19.0	9.6	100
Populus balsamifera	19.0	9.6	100
Total Deciduous Shrub Cover	37.9	16.2	100
Alnus crispa	16.0	21.0	55
Arctostaphylos rubra	4.1	7.2	82
Potentilla fruticosa	0.2	0.6	36
Rosa acicularis	0.3	0.9	45
Salix alaxensis	5.8	2.8	100
Salix arbusculoides	1.1	2.5	36
Salix brachycarpa ssp. *niphoclada*	0.7	2.4	9
Salix glauca	3.3	9.0	27
Salix hastata	0.5	1.5	9
Salix lanata ssp. *richardsonii*	0.4	1.2	18
Salix monticola	0.9	2.0	18
Shepherdia canadensis	4.2	5.2	82
Vaccinium uliginosum	0.4	0.9	27
Total Forb Cover	34.3	37.5	100
Anemone parviflora	0.1	0.3	64
Anemone richardsonii	0.9	3.0	18
Arnica alpina ssp. *angustifolia*	0.3	0.9	18
Artemisia tilesii	<0.1	0.1	45
Aster sibiricus	0.4	0.9	55
Boschniakia rossica	<0.1	<0.1	27
Castilleja caudata	<0.1	<0.1	18
Cypripedium passerinum	0.6	1.5	27
Epilobium angustifolium	<0.1	<0.1	18
Equisetum arvense	10.9	24.3	45
Equisetum pratense	10.9	27.7	18
Equisetum scirpoides	<0.1	<0.1	27
Equisetum variegatum	0.5	1.5	36
Galium boreale	0.1	0.3	18
Gentiana propinqua	<0.1	0.1	36
Hedysarum alpinum	4.3	6.3	55
Hedysarum mackenzii	<0.1	<0.1	27
Listera borealis	<0.1	0.1	36
Lupinus arcticus	0.6	1.2	27
Mertensia paniculata	0.6	1.5	27
Moneses uniflora	0.4	0.7	64
Parnassia palustris	<0.1	0.1	36
Platanthera obtusata	0.1	0.1	64

Table 98. Continued.

	Cover		Freq
	Mean	SD	%
Polygonum viviparum	<0.1	<0.1	27
Pyrola asarifolia	0.6	0.9	73
Pyrola grandiflora	<0.1	<0.1	18
Pyrola secunda	0.6	1.2	82
Rubus arcticus	1.9	4.5	36
Senecio lugens	<0.1	<0.1	18
Solidago multiradiata	0.1	0.3	9
Valeriana capitata	<0.1	<0.1	18
Zygadenus elegans	<0.1	<0.1	27
Total Grass Cover	1.8	2.6	91
Arctagrostis latifolia	0.4	0.9	18
Bromus sp.	0.8	1.8	36
Calamagrostis canadensis	0.2	0.4	45
Calamagrostis purpurascens	<0.1	<0.1	27
Festuca altaica	0.1	0.3	27
Festuca richardsonii	0.1	0.3	18
Total Sedge & Rush Cover	0.2	0.4	55
Carex concinna	0.2	0.4	55
Total Nonvascular Cover	50.7	22.3	100
Total Moss Cover	44.7	21.4	100
Abietinella abietina	0.4	0.9	27
Brachythecium sp.	0.1	0.3	9
Ceratodon purpureus	0.5	1.5	18
Dicranum sp.	0.3	0.6	36
Hylocomium splendens	28.1	21.1	91
Hypnum lindbergii	0.3	0.9	9
Pleurozium schreberi	1.8	4.6	27
Polytrichum sp.	0.1	0.3	9
Polytrichum strictum	<0.1	<0.1	18
Rhytidiadelphus triquetrus	0.9	2.0	18
Rhytidium rugosum	2.1	6.9	9
Sanionia uncinata	9.0	10.7	82
Tomentypnum nitens	0.6	1.6	18
Unknown fungus	<0.1	<0.1	18
Unknown moss	0.5	1.5	9
Total Lichen Cover	6.0	14.5	91
Bryoria sp.	<0.1	<0.1	18
Cetraria pinastri	<0.1	<0.1	18
Cladina sp.	0.1	0.3	18
Cladonia sp.	0.2	0.6	55
Cladonia symphycarpia	0.5	1.5	9
Dactylina ramulosa	0.2	0.6	9
Flavocetraria nivalis	0.4	0.9	18
Hypogymnia physodes	<0.1	<0.1	18
Hypogymnia sp.	<0.1	<0.1	18
Leptogium sp.	<0.1	<0.1	18
Nephroma sp.	0.3	0.9	9
Parmelia sp.	<0.1	<0.1	18
Peltigera aphthosa	0.3	0.5	55
Peltigera canina	0.4	1.2	27
Peltigera leucophlebia	0.2	0.6	9
Peltigera rufescens	0.3	0.9	18
Stereocaulon alpinum	3.1	9.0	18
Vulpicida pinastri	<0.1	<0.1	18
Total Bare Ground	8.7	8.7	91
Bare Soil	1.2	3.0	45
Litter alone	7.5	7.8	91

Soils are typically loamy or sandy with a thin surface organic horizon (Table 99). Depth to permafrost is difficult to determine, however if permafrost does occur it is assumed to be greater than 1 m given the well drained soils and adjacency of flowing water. Frost boils and surface fragments are rare, and loess caps are absent. Organic horizons, buried during flooding by riverine silts and sands, sometimes occur in these soils. Soil pH is circumneutral to alkaline, and EC is low. The soils are typically somewhat excessively to moderately well drained. Depth to water table often could not be measured but it is assumed to fluctuate throughout the year within the upper 2 m of the soil profile given the proximity to river water.

Table 99. Soil characteristics for Riverine White Spruce–Poplar Forest.

Property	Mean	SD	n
Elevation (m)	232.6	178.2	11
Slope (degrees)	24.0		1
Surface Organics Depth(cm)	3.5	2.3	10
Cumulative Org. in 40 cm (cm)	6.4	2.8	10
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	97.6	87.2	8
Surface Fragment Cover (%)	8.0	9.9	2
Frost Boil Cover (%)	1.0		1
Thaw Depth (cm)	96.0		1
Site pH at 10-cm depth	7.5	0.6	10
Site EC at 10-cm depth (µS/cm)	87.0	39.2	10
Water Depth (cm,+ above grnd)[a]	-160.0	22.4	5

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Gelorthents (poorly developed with permafrost below 1 m) and Typic Cryorthents (poorly developed soils, lacking permafrost). Less common soil types include Typic Gelifluvents (poorly developed with buried organic horizons, permafrost below 1 m), Typic Cryopsamments (sandy, low coarse fragment content, well drained, lacking permafrost), and Typic Haplorthels (mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Riverine Gravelly-loamy Forests soil landscape. Other ecotypes found in this soil landscape include Riverine Poplar Forest, Riverine White Spruce–Willow Forest, and Riverine White Spruce–Alder Forest.

Riverine White Spruce–Willow Forest

Geomorphology:

Riverine White Spruce–Willow Forest occurs on braided and meander inactive overbank deposits, and meander fine inactive channel deposits. Surface forms include interfluves, flat banks or channels.

Plant Association:

Picea glauca–Salix lanata ssp. *richardsonii– Moneses uniflora*

Spruce trees in these mature forests have open canopies, and the understory consists of mixed low and tall shrubs and forbs growing out of a thick carpet of feather mosses (Table 100). All life forms can be present. Common species include *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Arctostaphylos rubra* (syn: *Arctous rubra*), *Salix reticulata*, *Equisetum arvense*, *Hylocomium splendens*, and *Tomentypnum nitens*.

This ecotype is most similar to Riverine White Spruce–Alder Shrub as previously discussed.

Soils:

Soils are typically loamy or sandy with a thin surface organic horizon (Table 101). Depth to permafrost is difficult to determine, however if permafrost does occur it is assumed to be greater than 1 m given the well drained soils and immediate adjacency of flowing water. Frost boils, surface fragments, and loess caps are absent. Organic horizons, buried during flooding by riverine silts and sands, often occur in these soils. Soil pH is circumneutral to alkaline, and EC is low. The soils are typically well- to moderately-well drained. Depth to water table often could not be measured but it is assumed to fluctuate throughout the year within the upper 2 m of the soil profile given its adjacency to river water.

Table 100. Vegetation cover and frequency for Riverine White Spruce–Willow Forest (n=8).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	191.8	70.2	100
Total Vascular Cover	127.4	56.0	100
Total Evergreen Tree Cover	24.5	9.8	100
Picea glauca	24.5	9.8	100
Total Evergreen Shrub Cover	6.4	11.3	62
Andromeda polifolia	0.2	0.7	12
Dryas integrifolia	1.2	3.5	12
Empetrum nigrum	3.9	6.9	62
Ledum decumbens	0.2	0.7	12
Vaccinium vitis-idaea	0.8	1.7	50
Total Deciduous Tree Cover	0.0	0.1	38
Populus balsamifera	<0.1	0.1	38
Total Deciduous Shrub Cover	74.2	39.1	100
Alnus crispa	12.8	15.2	50
Alnus tenuifolia	0.6	1.8	12
Arctostaphylos rubra	6.4	6.4	100
Betula glandulosa	3.1	7.0	25
Potentilla fruticosa	3.5	6.9	50
Rosa acicularis	1.9	5.3	25
Salix alaxensis	5.9	5.9	62
Salix arbusculoides	2.1	4.8	50
Salix barclayi	1.9	3.7	25
Salix bebbiana	1.9	3.7	25
Salix glauca	6.9	10.0	50
Salix hastata	0.1	0.4	25
Salix lanata ssp. *richardsonii*	7.8	8.6	75
Salix monticola	0.2	0.7	12
Salix planifolia ssp. *pulchra*	2.1	3.6	38
Salix reticulata	6.0	10.3	75
Shepherdia canadensis	1.9	3.7	25
Vaccinium uliginosum	9.0	18.8	75
Viburnum edule	0.1	0.4	12
Total Forb Cover	16.9	11.6	100
Anemone parviflora	0.3	0.7	25
Anemone richardsonii	0.4	1.1	12
Artemisia tilesii	0.3	0.7	38
Aster sibiricus	0.4	0.7	38
Chrysanthemum integrifolium	0.2	0.7	12
Cypripedium passerinum	0.1	0.4	25
Dodecatheon frigidum	0.1	0.4	12
Equisetum arvense	3.9	3.6	88
Equisetum scirpoides	0.2	0.3	50
Equisetum variegatum	0.1	0.4	12
Galium boreale	0.5	1.1	50
Gentiana propinqua	<0.1	0.1	38
Hedysarum alpinum	2.1	2.1	62
Lupinus arcticus	1.8	3.1	38
Mertensia paniculata	1.8	2.7	50
Moneses uniflora	0.1	0.1	50
Oxytropis deflexa var. *foliosa*	0.1	0.4	12
Pedicularis capitata	0.1	0.4	12
Petasites frigidus	0.1	0.4	25
Polygonum viviparum	0.2	0.3	50
Pyrola secunda	0.2	0.3	50

Table 100. Continued.

	Cover		Freq
	Mean	**SD**	**%**
Rubus arcticus	1.1	2.1	25
Sanguisorba officinalis	0.1	0.4	12
Saussurea angustifolia	0.6	1.2	25
Senecio lugens	0.1	0.3	38
Solidago multiradiata	0.2	0.7	12
Solidago multiradiata var. *multiradiata*	0.8	1.8	25
Thalictrum alpinum	0.2	0.7	12
Zygadenus elegans	0.1	0.4	25
Total Grass Cover	2.5	2.3	100
Arctagrostis latifolia	0.1	0.3	38
Calamagrostis canadensis	1.0	1.8	50
Elymus arenarius ssp. *mollis*	0.1	0.4	12
Festuca altaica	0.7	1.8	50
Total Sedge & Rush Cover	2.8	4.7	75
Carex capillaris	0.1	0.4	12
Carex concinna	0.1	0.4	12
Carex livida	0.1	0.4	12
Carex membranacea	0.5	1.1	25
Carex scirpoidea	1.2	3.5	12
Carex vaginata	0.4	1.1	12
Eriophorum angustifolium	0.1	0.4	12
Total Nonvascular Cover	64.4	23.3	100
Total Moss Cover	62.4	23.2	100
Aulacomnium acuminatum	1.6	3.1	25
Aulacomnium palustre	2.5	5.3	25
Aulacomnium turgidum	0.1	0.4	12
Bryum pseudotriquetrum	0.2	0.7	12
Campylium arcticum	0.5	1.4	12
Campylium polygamum	0.4	1.1	12
Ceratodon purpureus	3.5	7.2	25
Dicranum elongatum	0.5	1.4	12
Dicranum sp.	0.2	0.7	12
Ditrichum flexicaule	0.5	1.4	12
Drepanocladus revolvens	0.1	0.4	12
Hylocomium splendens	35.2	30.0	100
Polytrichum sp.	0.2	0.7	12
Rhytidiadelphus triquetrus	4.6	8.5	50
Sanionia uncinata	1.9	3.7	25
Tomentypnum nitens	10.1	11.4	75
Total Lichen Cover	1.9	2.6	88
Bryoria sp.	0.3	0.7	25
Cetraria cf. *islandica*	0.2	0.7	12
Cladina sp.	0.1	0.4	12
Cladonia sp.	0.1	0.4	12
Hypogymnia physodes	0.1	0.4	25
Peltigera sp.	0.1	0.4	25
Stereocaulon sp.	0.1	0.4	12
Thamnolia vermicularis	0.1	0.4	12
Unknown crustose lichen	0.6	1.2	25
Total Bare Ground	6.5	4.7	100
Bare Soil	0.6	1.1	50
Litter alone	5.9	4.0	100

Table 101. Soil characteristics for Riverine White Spruce–Willow Forest.

Property	Mean	SD	n
Elevation (m)	154.5	196.3	8
Slope (degrees)	1.0	0.0	2
Surface Organics Depth(cm)	6.2	3.1	6
Cumulative Org. in 40 cm (cm)	6.1	3.7	8
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	46.5	3.5	2
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)	102.0		1
Site pH at 10-cm depth	7.3	0.6	7
Site EC at 10-cm depth (µS/cm)	86.7	41.3	6
Water Depth (cm,+ above grnd)[a]	-166.7	28.9	3

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Gelorthents (poorly developed with permafrost below 1 m) and Typic Gelifluvents (poorly developed with buried organic horizons, permafrost below 1 m). A less common soil type is Typic Cryofluvents (poorly developed with buried organic horizons, lacking permafrost). This ecotype and associated soils are part of the Riverine Gravelly-loamy Forests soil landscape. Other ecotypes found in this soil landscape include Riverine Poplar Forest, Riverine White Spruce–Poplar Forest, and Riverine White Spruce–Alder Forest.

Riverine Willow Low Shrub

Geomorphology:

This ecotype is common along rivers throughout ARCN, particularly in the arctic regions of NOAT, GAAR and CAKR beyond circumpolar treeline. It occurs on braided active channel deposits, braided and meander active and inactive overbank deposits, meander inactive channel deposits, old alluvial fans and moderately steep headwater floodplains and channel deposits. Surface forms include interfluves, flat banks, terraces and drainage-ways.

Plant Association:

Salix lanata ssp. *richardsonii*–*Salix reticulata*

This ecotype is characterized by open canopied, low (<1.5 m) willow with a subcomponent of dwarf shrubs, forbs and mosses (Table 102). Presence of graminoids and evergreen trees is variable. Common species include *S. lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *S. reticulata*, *S. glauca*, *Anemone parviflora*, *Festuca altaica*, *Carex capillaris*, *Aulacomnium palustre*, *Hylocomium splendens* and *Flavocetraria cucullata*.

This ecotype differs from other riverine willow ecotypes in characteristic species, shrub heights are lower, and it has a more arctic distribution beyond circumpolar treeline.

Soils:

Soils are typically gravelly, loamy, or sandy with a thin surface organic horizon (Table 103). Depth to permafrost is difficult to determine in the rocky soils, however if permafrost does occur it is assumed to be greater than 1 m given the well drained soils. Frost boils and loess caps are absent, and surface fragments are rare. Soil pH is circumneutral to alkaline, and EC is low to moderate. The soils are typically excessively to well drained. Depth to water table often could not be

Table 102. Vegetation cover and frequency for Riverine Willow Low Shrub (n=16).

	Cover		Freq
	Mean	SD	%
Total Live Cover	194.4	53.0	100
Total Vascular Cover	127.7	38.6	100
Total Evergreen Tree Cover	0.4	1.3	14
Picea glauca	0.4	1.3	14
Total Evergreen Shrub Cover	13.7	15.9	64
Cassiope tetragona	0.1	0.3	14
Dryas integrifolia	12.3	14.6	57
Empetrum nigrum	0.7	2.7	14
Ledum decumbens	0.2	0.8	14
Rhododendron lapponicum	0.3	0.8	36
Total Deciduous Shrub Cover	82.5	39.8	100
Arctostaphylos rubra	8.0	15.8	71
Betula nana	0.6	1.3	36
Potentilla fruticosa	2.6	4.0	71
Salix alaxensis	10.4	18.3	64
Salix arbusculoides	0.9	1.8	29
Salix brachycarpa ssp. *niphoclada*	5.2	7.7	50
Salix glauca	5.9	9.1	64
Salix hastata	1.2	4.0	29
Salix lanata ssp. *richardsonii*	31.5	28.8	93
Salix planifolia ssp. *pulchra*	4.0	9.8	36
Salix reticulata	7.9	12.1	71
Shepherdia canadensis	0.1	0.5	14
Vaccinium uliginosum	4.1	7.0	64
Total Forb Cover	17.7	10.0	100
Anemone parviflora	1.2	1.6	79
Arnica lessingii	0.1	0.5	14
Aster sibiricus	0.2	0.6	50
Astragalus alpinus	0.1	0.4	21
Astragalus umbellatus	0.2	0.6	29
Bupleurum triradiatum ssp. *arcticum*	0.2	0.5	21
Dodecatheon frigidum	0.4	1.3	14
Epilobium latifolium	0.8	2.7	29
Equisetum arvense	2.7	4.7	50
Equisetum variegatum	3.1	5.3	57
Galium boreale	0.2	0.6	36
Gentiana propinqua	<0.1	0.1	43
Hedysarum alpinum	0.9	1.2	57
Lupinus arcticus	1.4	2.1	43
Oxytropis viscida	0.6	2.1	7
Parnassia kotzebuei	0.1	0.3	36
Parnassia palustris	0.2	0.8	29
Pedicularis verticillata	0.1	0.3	21
Polemonium acutiflorum	0.4	1.3	29
Polygonum viviparum	0.2	0.6	43
Pyrola grandiflora	0.1	0.4	14
Rubus arcticus	0.7	2.7	7
Rubus arcticus ssp. *arcticus*	0.4	1.3	7
Senecio lugens	0.4	0.7	50
Solidago multiradiata var. *multiradiata*	0.1	0.3	21
Tofieldia pusilla	0.2	0.4	36
Valeriana capitata	0.8	2.4	36
Zygadenus elegans	0.2	0.5	29
Total Grass Cover	4.4	4.4	86

Table 102. Continued.

	Cover		Freq
	Mean	SD	%
Arctagrostis latifolia	0.3	1.1	29
Bromus pumpellianus	0.5	1.4	14
Calamagrostis purpurascens	0.4	0.9	21
Festuca altaica	2.3	2.5	71
Festuca richardsonii	0.4	1.3	14
Festuca rubra	0.1	0.4	21
Total Sedge & Rush Cover	9.0	9.0	93
Carex aquatilis ssp. *aquatilis*	0.5	1.3	43
Carex bigelowii	1.4	3.3	21
Carex capillaris	0.6	1.5	57
Carex capitata	0.2	0.6	21
Carex krausei	0.1	0.3	14
Carex membranacea	3.3	5.9	50
Carex scirpoidea	1.1	2.7	29
Carex vaginata	0.1	0.5	14
Eriophorum angustifolium	0.3	0.8	14
Kobresia myosuroides	0.4	1.3	7
Kobresia simpliciuscula	0.7	2.7	7
Total Nonvascular Cover	66.7	61.2	93
Total Moss Cover	64.9	59.2	93
Abietinella abietina	0.9	2.7	21
Aulacomnium acuminatum	0.7	2.7	7
Aulacomnium palustre	3.3	5.3	57
Aulacomnium turgidum	0.2	0.8	7
Brachythecium sp.	1.1	4.0	7
Bryum sp.	0.4	1.3	7
Calliergon sp.	0.2	0.8	7
Campylium stellatum	0.5	1.6	14
Catoscopium nigritum	0.2	0.8	7
Ceratodon purpureus	0.7	2.7	7
Climacium dendroides	0.1	0.5	14
Distichium capillaceum	0.2	0.8	7
Ditrichum flexicaule	0.4	1.3	7
Drepanocladus sp.	1.8	5.4	14
Hamatocaulis vernicosus	0.2	0.8	7
Hylocomium splendens	5.9	8.4	43
Hypnum bambergeri	2.3	5.3	21
Hypnum lindbergii	0.4	1.3	7
Hypnum pratense	1.4	5.3	7
Rhytidium rugosum	2.9	7.5	21
Sanionia uncinata	2.7	6.9	21
Tomentypnum nitens	14.1	17.2	71
Tortella sp.	0.7	2.7	7
Unknown moss	23.1	35.7	50
Total Lichen Cover	1.8	3.5	57
Cladonia sp.	0.2	0.4	36
Flavocetraria cucullata	0.2	0.6	36
Masonhalea richardsonii	0.1	0.4	14
Stereocaulon sp.	0.2	0.4	29
Unknown lichen	0.7	1.7	21
Total Bare Ground	8.0	7.7	100
Bare Soil	2.0	3.5	71
Water	0.3	1.1	21
Litter alone	5.8	5.8	100

measured but it is assumed to fluctuate throughout the year within the upper 2 m of the soil profile given its adjacency to river water.

Table 103. Soil characteristics for Riverine Willow Low Shrub.

Property	Mean	SD	n
Elevation (m)	240.3	206.7	14
Slope (degrees)	3.3	1.5	3
Surface Organics Depth(cm)	3.1	1.5	13
Cumulative Org. in 40 cm (cm)	4.0	2.3	14
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	24.8	17.4	10
Surface Fragment Cover (%)	9.7	13.3	3
Frost Boil Cover (%)			0
Thaw Depth (cm)	51.5	4.9	2
Site pH at 10-cm depth	7.4	0.4	14
Site EC at 10-cm depth (μS/cm)	273.8	283.3	13
Water Depth (cm,+ above grnd)[a]	-80.5	67.3	10

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Gelorthents (poorly developed with permafrost below 1 m) and Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m). Less common soil types include Oxyaquic Cryorthents (moist, saturated early in growing season, lacking permafrost) and Oxyaquic Gelorthents (wet, saturated early in growing season, poorly developed with permafrost below 1 m). This ecotype and associated soils are part of the Riverine Gravelly Barrens and Shrublands soil landscape. Also included in this soil landscape are Riverine Barrens, Riverine Moist Willow Tall Shrub, and Riverine Dryas Dwarf Shrub.

Upland Alder–Willow Tall Shrub

Geomorphology:

This ecotype occurs on hillside colluvium, older moraine, solifluction deposits, talus and upland loess. It is found on upper and lower concave and convex slopes up to 600 m elevation throughout ARCN. At some sites, gelifluction lobes, tree mounds, and undifferentiated mounds create micro-topographic variation.

Plant Associations:

Alnus crispa–Calamagrostis canadensis
Alnus crispa–Salix lanata ssp. *richardsonii*

These tall shrub communities have open (>25%) to closed (>75%) canopies with an understory of low and dwarf shrubs, forbs, grasses and mosses (Table 104). Lichen, sedge and tree cover is more variable. There are two distinct community types for Upland Alder–Willow Tall Shrub. The first has bluejoint grass, *C. canadensis* as an understory dominant while the second has a stronger willow subcomponent, particularly *S. lanata* ssp. *richardsonii*. Common species are *S. pulchra*, *Vaccinium uliginosum*, *Boykinia richardsonii*, *Hylocomium splendens*, and *Peltigera aphthosa*.

Upland Alder–Willow Tall Shrub is most similar to Upland Birch Forest in site factors although species assemblages are distinctly different. It is similar to Riverine Alder Tall Shrub in the dominance of *A. crispa*., but physiographic characters are unrelated.

Soils:

Soils are typically loamy, blocky, or rubbly with a thin to moderately thick surface organic horizon (Table 105). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be absent or to occur below a depth of 1 m. Frost boils are absent, and surface fragments and loess caps are uncommon. Soil pH is acidic to circumneutral, and EC is low. The soils are typically well drained to moderately well drained. Depth to

Table 104. Vegetation cover and frequency for Upland Alder–Willow Tall Shrub (n=32).

	Cover		Freq
	Mean	SD	%
Total Live Cover	189.2	70.6	100
Total Vascular Cover	153.1	37.9	100
Total Evergreen Tree Cover	0.1	0.3	23
Picea glauca	0.1	0.3	23
Total Evergreen Shrub Cover	16.7	20.9	77
Andromeda polifolia	0.2	0.8	10
Cassiope tetragona	4.7	9.3	32
Dryas integrifolia	0.6	2.0	10
Dryas octopetala	3.1	7.2	23
Empetrum nigrum	1.4	3.1	42
Ledum decumbens	2.8	4.8	52
Ledum groenlandicum	0.2	0.9	6
Linnaea borealis	0.4	1.5	26
Vaccinium vitis-idaea	3.1	6.5	48
Total Deciduous Tree Cover	0.9	4.8	3
Total Deciduous Shrub Cover	101.6	27.2	100
Alnus crispa	53.7	21.3	100
Arctostaphylos rubra	2.0	4.2	39
Betula glandulosa	4.6	9.0	39
Betula nana	1.8	6.7	16
Potentilla fruticosa	1.5	3.2	35
Ribes triste	1.8	4.3	26
Salix alaxensis	1.5	3.9	16
Salix glauca	1.7	4.4	26
Salix lanata ssp. *richardsonii*	7.7	11.8	52
Salix planifolia ssp. *pulchra*	5.1	10.6	55
Salix reticulata	2.8	5.2	32
Spiraea beauverdiana	6.7	14.1	45
Vaccinium uliginosum	9.5	15.0	71
Viburnum edule	0.2	0.9	10
Total Forb Cover	15.4	9.8	100
Aconitum delphinifolium	0.2	0.6	35
Anemone narcissiflora	0.1	0.4	16
Artemisia arctica ssp. *arctica*	0.4	1.6	16
Artemisia tilesii	0.5	1.3	19
Boschniakia rossica	<0.1	0.2	13
Boykinia richardsonii	1.4	3.1	32
Dodecatheon frigidum	0.9	2.2	19
Dryopteris dilatata ssp. *americana*	0.7	2.1	16
Epilobium angustifolium	0.3	0.7	29
Equisetum arvense	2.0	5.1	29
Equisetum pratense	0.8	2.6	13
Galium boreale	0.2	0.7	13
Gymnocarpium dryopteris	0.9	3.1	13
Hedysarum alpinum	0.2	0.7	13
Lycopodium alpinum	0.3	1.8	6
Lycopodium annotinum	0.4	1.1	23
Mertensia paniculata	0.4	0.9	19
Moehringia lateriflora	0.3	1.3	10
Pedicularis capitata	0.1	0.2	29
Petasites frigidus	0.4	0.8	26
Polemonium acutiflorum	0.1	0.2	32
Pyrola grandiflora	0.1	0.7	10

Table 104. Continued.

	Cover		Freq
	Mean	SD	%
Rubus arcticus ssp. *arcticus*	0.6	2.0	13
Rubus chamaemorus	1.2	4.4	13
Saussurea angustifolia	0.2	0.6	16
Saxifraga oppositifolia	0.2	0.9	10
Saxifraga punctata	<0.1	0.2	10
Solidago multiradiata	0.2	0.7	13
Stellaria longipes	<0.1	0.2	10
Trientalis europaea ssp. *arctica*	0.3	1.0	10
Valeriana capitata	0.3	0.7	32
Total Grass Cover	11.6	13.5	90
Arctagrostis latifolia	0.3	0.6	16
Calamagrostis canadensis	8.3	14.2	48
Festuca altaica	2.9	5.9	35
Poa arctica	<0.1	0.2	10
Total Sedge & Rush Cover	6.9	12.3	68
Carex bigelowii	1.4	3.9	19
Carex podocarpa	0.9	3.7	13
Carex scirpoidea	4.6	12.1	32
Total Nonvascular Cover	36.1	38.8	90
Total Moss Cover	27.8	31.9	87
Aulacomnium palustre	1.4	5.5	16
Brachythecium sp.	1.1	2.2	29
Campylium sp.	0.5	1.9	13
Cyrtomnium sp.	0.2	0.5	10
Dicranum sp.	1.1	2.3	29
Ditrichum sp.	0.2	0.7	10
Drepanocladus sp.	1.4	3.3	23
Hylocomium splendens	9.7	13.0	52
Hypnum sp.	0.7	1.8	23
Pleurozium schreberi	1.5	3.8	16
Polytrichum sp.	0.7	1.8	19
Polytrichum strictum	0.1	0.4	13
Ptilium sp.	0.6	2.8	6
Racomitrium sp.	0.2	0.6	6
Rhytidium rugosum	1.2	3.4	13
Sanionia sp.	3.2	10.6	19
Sphagnum sp.	0.2	0.7	10
Tomentypnum nitens	1.2	5.0	6
Unknown moss	1.6	7.2	19
Total Lichen Cover	8.5	12.1	81
Cetraria cf. *islandica*	0.2	0.7	16
Cetraria sp.	0.5	1.5	16
Cladina arbuscula	1.3	2.9	29
Cladina mitis	0.2	0.6	19
Cladina rangiferina	0.9	2.1	32
Cladina sp.	0.4	1.8	10
Cladina stellaris	1.9	3.6	29
Cladonia sp.	0.7	0.9	58
Dactylina sp.	0.2	0.5	19
Flavocetraria cucullata	1.0	1.8	32
Peltigera aphthosa	0.5	1.2	32
Peltigera sp.	0.3	0.7	19
Total Bare Ground	4.5	5.5	61
Bare Soil	0.6	1.4	35
Litter alone	3.9	5.3	61

water table often could not be measured and it was assumed in such instances to be at substantial depths given the well drained soils.

Table 105. Soil characteristics for Upland Alder–Willow Tall Shrub.

Property	Mean	SD	n
Elevation (m)	389.4	189.9	22
Slope (degrees)	18.7	9.1	22
Surface Organics Depth(cm)	9.3	5.6	22
Cumulative Org. in 40 cm (cm)	10.0	6.1	22
Loess Cap Thickness (cm)	26.5	18.6	4
Depth to Rocks (cm)	24.3	22.7	18
Surface Fragment Cover (%)	0.7	0.5	3
Frost Boil Cover (%)	0.1	NA	1
Thaw Depth (cm)	55.2	22.7	4
Site pH at 10-cm depth	5.4	1.1	21
Site EC at 10-cm depth (µS/cm)	131.0	252.3	21
Water Depth (cm,+ above grnd)[a]	-133.1	74.2	8

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups in this ecotype include Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m), Typic Dystrocryepts (acidic, partially developed, lacking permafrost), and Typic Humicryepts (moist, acidic, organic-rich, partially developed, lacking permafrost). Less common subgroups include Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation) and Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m). This ecotype and associated soils are part of the Upland Rocky-loamy Circumacidic Tall Shrublands and Forests soil landscape, which includes Upland Birch Forest, Upland Spruce– Birch Forest, Upland Bluejoint Meadow, and Upland White Spruce–Ericaceous Forest.

Upland Birch Forest

Geomorphology:

The distribution of Upland Birch Forest is limited to localized, fragmented patches in GAAR and KOVA. It occurs on slopes of older moraine, hillside colluvium and eolian inactive sand dunes.

Plant Association:

Betula papyrifera–Picea glauca–Vaccinium vitis-idaea

Open to closed stands of birch (*Betula papyrifera*: syn: *B. neoalaskana*) dominate this ecotype, and all life forms except sedges are typically present (Table 106). Common species include *Ledum decumbens*, *Vaccinium uliginosum*, *Epilobium angustifolium*, *Polytrichum juniperinum*, and *Cladina rangiferina*.

Upland Birch Forest is comparable to Upland Spruce–Birch Forest, with which it shares a plant association. The primary difference is this ecotype is strictly birch-dominated, while the other is co-dominated by birch and white spruce.

Table 106. Vegetation cover and frequency for Upland Birch Forest (n=4).

	Cover		Freq
	Mean	SD	%
Total Live Cover	111.6	20.1	100
Total Vascular Cover	72.6	21.3	100
Total Evergreen Tree Cover	2.0	2.1	100
Picea glauca	1.3	0.9	100
Picea mariana	0.8	1.5	50
Total Evergreen Shrub Cover	8.6	11.7	100
Empetrum nigrum	0.8	1.5	50
Juniperus communis	<0.1	0.1	25
Ledum decumbens	2.0	2.4	75
Linnaea borealis	1.3	2.5	50
Vaccinium vitis-idaea	4.5	7.1	75
Total Deciduous Tree Cover	52.5	29.8	100
Betula papyrifera	52.5	29.9	100
Populus tremuloides	<0.1	0.1	25
Total Deciduous Shrub Cover	8.5	6.3	100
Alnus crispa	2.2	3.9	50
Betula glandulosa	0.8	1.5	25
Betula nana	1.0	2.0	25
Ribes triste	<0.1	0.1	25
Rosa acicularis	0.2	0.5	25
Salix bebbiana	0.8	0.9	75
Salix glauca	<0.1	0.1	25
Salix planifolia ssp. *pulchra*	<0.1	0.1	25
Salix scouleriana	<0.1	0.1	25
Spiraea beauverdiana	0.1	0.1	50
Vaccinium uliginosum	3.3	3.9	100
Total Forb Cover	0.6	0.5	100
Epilobium angustifolium	0.1	<0.1	100
Equisetum arvense	<0.1	0.1	25
Geocaulon lividum	0.1	0.1	75
Gymnocarpium dryopteris	<0.1	0.1	25
Lycopodium annotinum	<0.1	0.1	25
Lycopodium complanatum	0.3	0.5	50
Pedicularis labradorica	<0.1	0.1	25
Solidago multiradiata	<0.1	0.1	25
Total Grass Cover	0.3	0.4	100
Calamagrostis canadensis	0.3	0.5	50
Calamagrostis inexpansa	0.1	0.1	50
Festuca altaica	<0.1	0.1	25
Total Nonvascular Cover	39.0	18.9	100
Total Moss Cover	29.1	15.4	100
Ceratodon purpureus	1.2	2.5	25
Dicranum polysetum	1.2	2.5	25
Dicranum sp.	0.2	0.5	25
Dicranum undulatum	1.0	2.0	25
Hylocomium splendens	1.8	2.1	50
Hypnum sp.	<0.1	0.1	25
Pleurozium schreberi	1.0	1.4	50
Pohlia nutans	0.2	0.5	25
Polytrichum commune	1.2	2.5	25
Polytrichum juniperinum	19.2	20.0	100
Polytrichum piliferum	0.3	0.5	50
Racomitrium sp.	0.5	1.0	25
Rhytidium rugosum	1.0	2.0	25
Total Lichen Cover	8.7	4.3	100

Table 106. Continued.

	Cover		Freq
	Mean	SD	%
Cetraria laevigata	<0.1	0.1	25
Cladina arbuscula	0.8	1.5	25
Cladina rangiferina	1.0	1.4	50
Cladina sp.	<0.1	0.1	25
Cladina stellaris	<0.1	0.1	25
Cladonia cenotea	<0.1	0.1	25
Cladonia sp.	3.8	3.5	75
Flavocetraria cucullata	0.8	1.5	25
Nephroma arcticum	0.8	1.5	50
Peltigera aphthosa	0.2	0.5	25
Peltigera canina	<0.1	0.1	25
Peltigera sp.	0.5	1.0	50
Stereocaulon sp.	0.5	1.0	50
Trapeliopsis granulosa	1.2	2.5	25
Unknown crustose lichen	0.3	0.5	50
Total Bare Ground	17.0	7.6	100
Bare Soil	4.2	3.0	100
Litter alone	12.8	8.2	100

Soils:

Soils are typically rubbly, blocky, or bouldery and feature a thin surface organic horizon (Table 107). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be absent or to occur below a depth of 2 m. Frost boils and loess caps are rare. Surface fragments are common at low to moderate abundance. Soil pH is acidic, and EC is low. The soils are typically somewhat excessively to well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 107. Soil characteristics for Upland Birch Forest.

Property	Mean	SD	n
Elevation (m)	173.5	95.1	4
Slope (degrees)	23.2	11.1	4
Surface Organics Depth(cm)	3.8	1.3	4
Cumulative Org. in 40 cm (cm)	3.8	1.3	4
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	53.2	97.8	4
Surface Fragment Cover (%)	20.0	0.0	2
Frost Boil Cover (%)	2.0		1
Thaw Depth (cm)			0
Site pH at 10-cm depth	4.8	0.5	4
Site EC at 10-cm depth (µS/cm)	35.0	30.0	4
Water Depth (cm,+ above grnd)[a]	-200.0		1

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Typic Dystrocryepts (acidic, partially developed, lacking permafrost). A less common subgroup is Typic Haplocryods (moist, acidic, with a highly leached horizon). This ecotype and associated soils are part of the Upland Rocky-loamy Circumacidic Tall Shrublands and Forests soil landscape. Other ecotypes in this soil landscape include Upland Spruce–Birch Forest, Upland Alder–Willow Tall Shrub, Upland Bluejoint Meadow, and Upland White Spruce–Ericaceous Forest.

Upland Birch–Ericaceous Low Shrub

Geomorphology:

This low shrub-dominated ecotype is common throughout ARCN in upland areas up to the alpine boundary. It occurs on hillside colluvium, older moraine, solifluction deposits, upland loess, eolian inactive sand deposits, and abandoned alluvial fan deposits.

Plant Association:

Betula nana–Ledum decumbens

Both dwarf and low shrubs characterize this ecotype (Table 108). Mosses and lichens are well represented, and sedges, grasses, forbs and trees are present with low cover. Ericaceous shrubs and dwarf birch (*B. nana*) are abundant. Common species include *Vaccinium vitis-idaea*, *V. uliginosum*, *Pedicularis labradorica*, *Hylocomium splendens*, *Flavocetraria cucullata*, and *Cladina rangiferina*.

This ecotype is most similar to Upland Birch–Willow Low Shrub, where willows are co-dominant. Lowland Birch–Ericaceous Low Shrub has similar species but has wetter, loamy, and organic-rich soils.

Soils:

Soils are loamy, blocky, or rubbly and feature a thin to moderately thick surface organic horizon (Table 109). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present with in the upper 2 m of the soil profile. Cryoturbation is commonly evident. Frost boils are uncommon, and surface fragments and loess caps are rare. Soil pH is acidic, and EC is low. The soils are typically somewhat excessively to moderately well drained. Depth to water table ranges from shallow to moderately deep, however the rocky soils made it difficult to measure water depth.

Table 108. Vegetation cover and frequency for Upland Birch–Ericaceous Low Shrub (n=24).

	Cover		Freq
	Mean	SD	%
Total Live Cover	171.2	63.8	100
Total Vascular Cover	114.1	39.9	100
Total Evergreen Tree Cover	0.4	1.1	33
Picea glauca	0.4	1.1	33
Total Evergreen Shrub Cover	34.1	23.1	100
Cassiope tetragona	1.6	5.2	25
Dryas octopetala	0.8	2.1	17
Empetrum nigrum	5.7	7.4	75
Ledum decumbens	12.5	13.3	92
Linnaea borealis	0.1	0.3	17
Loiseleuria procumbens	1.1	3.4	21
Vaccinium vitis-idaea	12.4	11.6	96
Total Deciduous Tree Cover	0.3	1.2	8
Total Deciduous Shrub Cover	68.1	28.0	100
Alnus crispa	1.6	4.4	25
Arctostaphylos alpina	0.8	1.8	21
Arctostaphylos rubra	0.3	1.4	17
Betula glandulosa	10.4	23.4	21
Betula nana	28.4	25.7	79
Potentilla fruticosa	<0.1	0.2	8
Salix arctica	0.6	2.2	8
Salix brachycarpa ssp. *niphoclada*	2.7	5.7	21
Salix glauca	1.6	3.9	29
Salix lanata ssp. *richardsonii*	0.1	0.4	12
Salix phlebophylla	0.7	3.1	17
Salix planifolia ssp. *pulchra*	2.7	4.7	54
Salix reticulata	0.2	1.0	8
Spiraea beauverdiana	0.3	1.0	25
Vaccinium uliginosum	17.6	16.3	88
Total Forb Cover	3.6	5.6	88
Anemone narcissiflora	0.1	0.4	21
Antennaria friesiana	<0.1	0.2	8
Artemisia arctica ssp. *arctica*	0.1	0.3	38
Lupinus arcticus	0.1	0.4	8
Lycopodium alpinum	0.1	0.4	8
Lycopodium annotinum	0.1	0.2	12
Minuartia arctica	<0.1	0.2	8
Pedicularis capitata	<0.1	0.2	8
Pedicularis labradorica	0.1	0.2	21
Petasites frigidus	0.8	3.1	12
Polygonum bistorta	0.2	0.7	25
Pyrola asarifolia	0.2	1.0	8
Rubus chamaemorus	0.8	1.7	33
Saxifraga punctata	0.1	0.2	17
Selaginella sibirica	<0.1	0.2	8
Total Grass Cover	2.7	4.7	83
Arctagrostis latifolia	0.1	0.6	12
Calamagrostis canadensis	0.2	0.7	17
Festuca altaica	1.5	3.9	38
Hierochloe alpina	0.6	2.1	29
Poa arctica	0.2	0.5	25
Total Sedge & Rush Cover	4.9	7.6	75

Table 108. Continued.

	Cover Mean	Cover SD	Freq %
Carex aquatilis ssp. *aquatilis*	0.4	2.0	4
Carex bigelowii	2.3	3.4	50
Carex podocarpa	0.2	0.5	17
Eriophorum angustifolium	0.7	3.1	8
Eriophorum vaginatum	0.8	2.1	17
Luzula parviflora	0.1	0.4	8
Total Nonvascular Cover	57.1	38.0	96
Total Moss Cover	31.0	25.9	96
Abietinella abietina	0.4	2.0	4
Aulacomnium palustre	0.5	1.3	17
Aulacomnium sp.	0.6	2.5	12
Aulacomnium turgidum	1.2	3.8	25
Ceratodon purpureus	0.4	2.0	4
Dicranum sp.	1.2	2.0	42
Drepanocladus sp.	0.4	2.0	8
Hylocomium splendens	11.0	15.2	62
Pleurozium schreberi	0.8	1.7	21
Polytrichum commune	1.0	5.1	4
Polytrichum piliferum	1.8	6.4	17
Polytrichum sp.	0.8	1.6	29
Polytrichum strictum	0.9	1.6	33
Ptilidium ciliare	0.7	3.1	8
Ptilium crista-castrensis	1.0	4.9	4
Rhytidium rugosum	1.8	4.1	33
Sanionia uncinata	0.6	2.2	8
Sphagnum lenense	1.2	6.1	4
Sphagnum sp.	2.3	11.2	12
Tomentypnum nitens	0.5	1.5	12
Unknown moss	0.4	1.5	12
Total Lichen Cover	26.2	29.4	96
Cetraria cf. *islandica*	0.8	1.6	33
Cladina arbuscula	3.2	5.4	42
Cladina mitis	0.5	1.0	25
Cladina rangiferina	4.0	7.6	50
Cladina sp.	0.9	3.2	21
Cladina stellaris	6.2	16.8	25
Cladina stygia	0.8	2.4	12
Cladonia sp.	3.4	8.1	75
Dactylina arctica	0.1	0.3	12
Flavocetraria cucullata	2.4	3.4	62
Flavocetraria nivalis	0.3	0.5	33
Masonhalea richardsonii	0.3	0.6	33
Parmelia sp.	0.2	1.0	8
Peltigera aphthosa	0.4	0.9	38
Peltigera sp.	0.4	0.8	33
Pertusaria sp.	<0.1	0.2	8
Sphaerophorus globosus	0.1	0.3	8
Stereocaulon sp.	0.5	1.2	25
Thamnolia sp.	0.1	0.4	8
Thamnolia vermicularis	0.4	0.9	29
Unknown crustose lichen	0.5	2.1	8
Unknown lichen	0.1	0.3	8
Total Bare Ground	12.3	15.9	79
Bare Soil	5.0	10.7	58
Water	0.3	1.0	12
Litter alone	7.0	11.3	79

Table 109. Soil characteristics for Upland Birch–Ericaceous Low Shrub.

Property	Mean	SD	n
Elevation (m)	325.1	179.3	20
Slope (degrees)	11.0	9.6	17
Surface Organics Depth(cm)	9.0	7.8	20
Cumulative Org. in 40 cm (cm)	9.2	7.9	20
Loess Cap Thickness (cm)	13.0	NA	1
Depth to Rocks (cm)	73.7	88.7	16
Surface Fragment Cover (%)	4.8	8.5	5
Frost Boil Cover (%)	2.3	2.2	4
Thaw Depth (cm)	50.9	34.9	8
Site pH at 10-cm depth	4.9	0.7	19
Site EC at 10-cm depth (μS/cm)	66.8	54.4	19
Water Depth (cm,+ above grnd)[a]	-140.0	90.2	9

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups include Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m), Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation), and Typic Haploturbels (mineral soil over permafrost with cryoturbation). Less common subgroups include Typic Histoturbels (wet, organic rich soil over permafrost with cryoturbation) and Typic Haplorthels (mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Upland Rocky-loamy Acidic Low Shrublands soil landscape, which also includes Upland Birch– Willow Low Shrub and Upland Spiraea Low Shrub.

Upland Birch–Willow Low Shrub

Geomorphology:

Upland Birch–Willow Low Shrub is a widespread arctic ecotype that is abundant beyond treeline in GAAR, NOAT and northern KOVA. It occurs on older moraine, hillside colluvium, solifluction deposits, upland loess, upland retransported deposits, and abandoned alluvial fan deposits. Surfaces are typically sloped.

Plant Associations:

Betula nana–Vaccinium vitis-idaea–Dryas octopetala
Salix planifolia ssp. *pulchra–Betula nana– Polygonum bistorta*

This ecotype has two plant associations, both containing a mix of low birch and willow shrub communities (Table 110). The first is dominated by *B. nana* with a reduced willow component, and the second is dominated by S. *planifolia* ssp. *pulchra* with a reduced dwarf birch component. Upland Birch–Willow Low Shrub has variable cover of most life forms. Common species include *Salix glauca*, *Vaccinium uliginosum, Polygonum bistorta* (syn: *Bistora plumosa*), *Petasites frigidus*, *Carex bigelowii*, *Hylocomium splendens*, and *Flavocetraria cucullata*.

This ecotype is most similar to Upland Birch–Ericaceous Low Shrub as previously discussed. It is also comparable to Lowland Birch–Willow Low Shrub, although the vegetation community is different because soils are drier and rockier with less organic matter.

Soils:

Soils are loamy, blocky, or gravelly with a thin surface organic horizon (Table 111). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present within the upper 2 m of the soil profile. Cryoturbation is rare. Frost boils are uncommon, and surface fragments and loess caps are rare. Soil pH is acidic to circumneutral, and EC is low. The soils are typically well drained to moderately well drained, or somewhat poorly

Table 110. Vegetation cover and frequency for Upland Birch–Willow Low Shrub (n=27).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	169.8	61.6	100
Total Vascular Cover	115.1	46.4	100
Total Evergreen Tree Cover	0.2	1.0	20
Picea glauca	0.2	1.0	20
Total Evergreen Shrub Cover	17.6	12.9	92
Andromeda polifolia	0.4	1.3	20
Cassiope tetragona	1.8	3.0	60
Dryas integrifolia	0.3	1.1	8
Dryas octopetala	2.0	5.2	24
Dryas octopetala ssp. *alaskensis*	2.8	9.3	12
Empetrum nigrum	1.9	2.6	60
Ledum decumbens	3.0	5.5	60
Linnaea borealis	1.4	6.0	8
Loiseleuria procumbens	0.5	1.2	20
Vaccinium vitis-idaea	3.5	3.4	84
Total Deciduous Shrub Cover	68.0	25.9	96
Alnus crispa	0.6	2.1	12
Arctostaphylos alpina	0.2	1.0	12
Arctostaphylos rubra	0.8	4.0	8
Betula glandulosa	5.4	18.7	16
Betula nana	11.8	16.3	72
Salix arctica	0.8	2.4	12
Salix chamissonis	0.8	3.0	16
Salix glauca	5.9	9.3	52
Salix lanata ssp. *richardsonii*	1.2	3.5	16
Salix phlebophylla	0.2	0.7	16
Salix planifolia ssp. *pulchra*	26.1	24.7	88
Salix reticulata	3.4	5.2	52
Spiraea beauverdiana	0.8	2.2	36
Vaccinium uliginosum	9.6	10.1	88
Total Forb Cover	17.0	21.3	100
Aconitum delphinifolium	0.1	0.2	16
Anemone narcissiflora	0.6	1.3	40
Anemone parviflora	0.6	3.0	12
Arnica lessingii	0.6	1.5	24
Artemisia arctica ssp. *arctica*	1.6	3.1	36
Astragalus umbellatus	<0.1	0.2	12
Dodecatheon frigidum	0.6	1.2	24
Equisetum arvense	7.6	17.8	36
Lupinus arcticus	0.2	1.0	16
Lycopodium annotinum	0.2	0.7	8
Pedicularis capitata	0.2	0.3	44
Pedicularis labradorica	0.1	0.2	20
Petasites frigidus	1.4	2.3	60
Polemonium acutiflorum	0.5	1.2	36
Polygonum bistorta	0.4	0.7	64
Polygonum viviparum	0.1	0.2	28
Pyrola asarifolia	0.1	0.3	24
Pyrola grandiflora	0.1	0.3	20
Rubus chamaemorus	0.4	1.4	16
Saussurea angustifolia	0.2	0.5	48
Sedum rosea ssp. *integrifolium*	0.1	0.4	8
Valeriana capitata	0.4	0.9	24

Table 110. Continued.

	Cover		Freq
	Mean	SD	%
Total Grass Cover	4.9	5.1	92
Arctagrostis latifolia	2.4	2.5	72
Festuca altaica	1.8	3.8	32
Hierochloe alpina	0.1	0.4	16
Poa arctica	0.4	0.6	56
Total Sedge & Rush Cover	7.4	8.3	92
Carex bigelowii	4.3	5.0	72
Carex membranacea	0.4	1.3	8
Carex microchaeta	0.6	3.0	8
Carex podocarpa	1.4	3.3	24
Carex scirpoidea	0.1	0.4	8
Eriophorum angustifolium	0.2	1.0	8
Eriophorum vaginatum	0.2	1.0	8
Total Nonvascular Cover	54.7	27.0	96
Total Moss Cover	47.0	25.4	96
Aulacomnium acuminatum	0.7	2.2	12
Aulacomnium palustre	1.9	3.4	44
Aulacomnium turgidum	1.6	3.4	40
Brachythecium sp.	0.3	1.1	8
Dicranum elongatum	0.6	1.6	16
Dicranum sp.	0.4	1.2	24
Hylocomium splendens	14.2	16.3	60
Loeskypnum badium	0.4	1.5	8
Pleurozium schreberi	1.3	3.0	24
Polytrichum sp.	4.0	9.9	40
Polytrichum strictum	0.4	1.1	20
Rhytidium rugosum	1.0	2.2	20
Sanionia uncinata	1.2	5.1	12
Sphagnum sp.	3.4	10.6	28
Thuidium recognitum	2.4	7.1	12
Thuidium sp.	0.8	3.1	12
Tomentypnum nitens	3.7	7.2	36
Unknown moss	1.5	6.0	16
Total Lichen Cover	7.7	8.6	88
Cetraria cf. *islandica*	0.5	0.9	40
Cetraria islandica ssp. *islandica*	0.2	0.4	16
Cladina arbuscula	0.4	1.1	24
Cladina mitis	0.4	1.1	20
Cladina rangiferina	0.7	1.7	24
Cladina sp.	0.8	2.8	12
Cladonia sp.	0.5	0.8	52
Dactylina arctica	0.1	0.3	20
Flavocetraria cucullata	0.8	1.1	56
Flavocetraria nivalis	0.2	0.5	16
Lobaria sp.	0.1	0.2	20
Masonhalea richardsonii	0.2	0.5	36
Nephroma arcticum	0.4	0.8	28
Peltigera aphthosa	0.4	0.6	56
Sphaerophorus fragilis	0.1	0.4	12
Stereocaulon sp.	0.4	1.1	24
Thamnolia vermicularis	0.3	0.5	32
Unknown crustose lichen	0.4	1.2	16
Total Bare Ground	8.8	11.2	92
Bare Soil	3.7	11.0	68
Litter alone	5.1	4.2	88

drained. Depth to water table ranged from shallow to moderately deep, however the rocky soils made it difficult to measure water depth in all soil pits sampled.

Table 111. Soil characteristics for Upland Birch–Willow Low Shrub.

Property	Mean	SD	n
Elevation (m)	504.8	261.9	25
Slope (degrees)	8.2	6.0	25
Surface Organics Depth(cm)	8.2	5.5	24
Cumulative Org. in 40 cm (cm)	8.5	6.3	24
Loess Cap Thickness (cm)	21.5	30.4	4
Depth to Rocks (cm)	19.1	15.7	20
Surface Fragment Cover (%)	13.4	27.3	8
Frost Boil Cover (%)	6.5	13.6	10
Thaw Depth (cm)	58.0	13.1	7
Site pH at 10-cm depth	5.6	1.0	24
Site EC at 10-cm depth (μS/cm)	62.5	54.1	24
Water Depth (cm,+ above grnd)[a]	-84.9	70.5	10

[a]Measurements >1 m indicate minimum depth, not true depth

At well drained sites, the dominant soil subgroups are Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m) and Typic Haplorthels (mineral soil over permafrost lacking cryoturbation). At poorly drained sites, dominant soil subgroups include Typic Haploturbels (mineral soil over permafrost with cryoturbation) and Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation). This ecotype and associated soils are part of the Upland Rocky-loamy Acidic Low Shrublands soil landscape, which also includes Upland Birch–Ericaceous Low Shrub and Upland Spiraea Low Shrub ecotypes.

Upland Bluejoint Meadow

Geomorphology:

Upland Bluejoint Meadow primarily occurs after fire, and is uncommon in ARCN. It occurs on upper slopes on hillside colluvium. Due to its low abundance, this ecotype was not mapped.

Plant Association:

Calamagrostis canadensis–Polemonium acutiflorum

Upland Bluejoint Meadow is primarily grass-dominated although forbs can be co-dominant at some sites (Table 112). Trees and tall shrubs are absent, but all other life forms are represented. Total nonvascular cover is often low. Common species include *Aconitum delphinifolium*, *Petasites frigidus*, and *Carex podocarpa*.

Upland Bluejoint Meadow is similar to Riverine Bluejoint Meadow and Lacustrine Bluejoint Meadow in species composition, although physiographic factors are unrelated.

Soils:

Soils are typically loamy, blocky, or rubbly with a thin surface organic horizon and a thick, dense root mat (Table 113). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be absent or to occur below a depth of 1 m. Frost boils and loess caps are absent, and surface fragments are rare. Soil pH is acidic to circumneutral, and EC is low. The soils are typically well drained to moderately well drained. Depth to water table often could not be measured.

Table 112. Vegetation cover and frequency for Upland Bluejoint Meadow (n=4).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	137.1	34.8	100
Total Vascular Cover	119.8	38.0	100
Total Evergreen Shrub Cover	0.0	0.1	25
Vaccinium vitis-idaea	<0.1	0.1	25
Total Deciduous Shrub Cover	15.1	12.3	100
Rosa acicularis	1.2	2.5	25
Rubus idaeus	2.5	5.0	25
Salix chamissonis	2.5	5.0	25
Salix planifolia ssp. *pulchra*	2.5	2.9	75
Salix reticulata	1.2	2.5	25
Sorbus scopulina	<0.1	0.1	25
Spiraea beauverdiana	1.3	2.5	50
Viburnum edule	3.8	7.5	25
Total Forb Cover	45.5	27.3	100
Aconitum delphinifolium	3.5	3.7	75
Adoxa moschatellina	<0.1	0.1	25
Anemone narcissiflora	<0.1	0.1	25
Anemone parviflora	3.8	7.5	50
Anemone richardsonii	0.8	1.5	50
Arabis drummondii	<0.1	0.1	25
Arabis lyrata kamchatica	<0.1	0.1	25
Arnica lessingii	0.2	0.5	25
Artemisia arctica ssp. *arctica*	5.0	7.1	50
Artemisia tilesii	0.8	1.5	50
Astragalus alpinus	<0.1	0.1	25
Botrychium minganense	<0.1	0.1	25
Campanula lasiocarpa	<0.1	0.1	25
Cardamine pratensis ssp. *angustifolia*	0.2	0.5	25
Cardamine umbellata	<0.1	0.1	25
Castilleja elegans	<0.1	0.1	25
Cerastium beeringianum var. *grandiflorum*	0.2	0.5	25
Chrysosplenium tetrandrum	0.2	0.5	25
Claytonia sarmentosa	<0.1	0.1	25
Cryptogramma sitchensis	<0.1	0.1	25
Cystopteris fragilis	<0.1	0.1	25
Dodecatheon frigidum	1.5	2.4	50
Dryopteris fragrans	<0.1	0.1	25
Epilobium angustifolium	6.2	12.5	25
Epilobium latifolium	0.2	0.5	25
Equisetum arvense	5.0	7.1	50
Equisetum pratense	1.0	2.0	25
Galium boreale	0.8	1.5	25
Gentiana glauca	<0.1	0.1	25
Heracleum lanatum	<0.1	0.1	25
Mertensia paniculata	<0.1	0.1	25
Moehringia lateriflora	<0.1	0.1	25
Myosotis alpestris ssp. *asiatica*	<0.1	0.1	25
Parnassia kotzebuei	<0.1	0.1	25
Petasites frigidus	6.3	7.5	75
Polemonium acutiflorum	1.8	2.2	100
Ranunculus nivalis	<0.1	0.1	25
Rumex acetosa alpestris	0.8	1.5	25
Rumex arcticus	0.6	1.0	50
Saxifraga hieracifolia	<0.1	0.1	25

Table 112. Continued.

	Cover		Freq
	Mean	SD	%
Saxifraga punctata	1.2	2.5	25
Saxifraga punctata ssp. *nelsoniana*	0.1	0.1	50
Senecio lugens	0.2	0.5	25
Solidago multiradiata	0.5	1.0	50
Stellaria calycantha isophylla	<0.1	0.1	25
Stellaria edwardsii	<0.1	0.1	25
Valeriana capitata	3.0	4.8	50
Veratrum album oxysepalum	<0.1	0.1	25
Viola epipsila ssp. *repens*	0.8	1.0	50
Viola selkirkii	<0.1	0.1	25
Wilhelmsia physodes	<0.1	0.1	25
Woodsia ilvensis	<0.1	0.1	25
Woodsia sp.	<0.1	0.1	25
Zygadenus elegans	<0.1	0.1	25
Total Grass Cover	41.6	28.1	100
Agropyron pauciflorum pauciflorum	0.8	1.5	25
Arctagrostis latifolia	2.5	5.0	50
Calamagrostis canadensis	36.2	29.8	100
Festuca altaica	0.8	1.0	50
Poa alpigena	0.2	0.5	25
Poa alpina	<0.1	0.1	25
Poa arctica	0.1	0.1	50
Poa sp.	<0.1	0.1	25
Schizachne purpurascens	1.0	2.0	25
Total Sedge & Rush Cover	17.6	10.5	100
Carex aquatilis ssp. *aquatilis*	3.8	7.5	25
Carex bigelowii	0.2	0.5	25
Carex lachenalii	0.5	1.0	25
Carex podocarpa	11.3	13.1	75
Carex praticola	0.5	1.0	25
Carex stylosa	<0.1	0.1	25
Eriophorum angustifolium	1.2	2.5	25
Luzula multiflora	<0.1	0.1	25
Total Nonvascular Cover	17.4	29.5	75
Total Moss Cover	17.1	29.0	75
Brachythecium reflexum	<0.1	0.1	25
Bryum pseudotriquetrum	7.5	15.0	25
Campylium stellatum	2.5	5.0	25
Plagiomnium sp.	<0.1	0.1	25
Sanionia uncinata	2.5	5.0	25
Tomentypnum nitens	2.0	4.0	25
Unknown fungus	<0.1	0.1	25
Unknown liverwort	2.5	5.0	25
Total Lichen Cover	0.3	0.5	50
Peltigera aphthosa	<0.1	0.1	25
Peltigera canina	0.2	0.5	25
Total Bare Ground	10.8	11.5	100
Bare Soil	3.8	7.5	75
Water	0.3	0.5	50
Litter alone	6.8	5.3	100

Table 113. Soil characteristics for Upland Bluejoint Meadow.

Property	Mean	SD	n
Elevation (m)	367.0	223.1	4
Slope (degrees)	18.8	15.2	4
Surface Organics Depth(cm)	7.5	3.3	4
Cumulative Org. in 40 cm (cm)	7.5	3.3	4
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	56.8	95.5	4
Surface Fragment Cover (%)	2.0	1.4	2
Frost Boil Cover (%)			0
Thaw Depth (cm)	30.0		1
Site pH at 10-cm depth	5.4	0.9	4
Site EC at 10-cm depth (μS/cm)	137.5	79.7	4
Water Depth (cm,+ above grnd)[a]	-123.0	93.5	3

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups in this ecotype include Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m) and Typic Dystrogelepts (acidic, partially developed, permafrost below 1 m). A less common subgroup is Typic Haplocryolls (non-acidic, well drained, thick organic rich A horizon, lacking permafrost). This ecotype and associated soils are part of the Upland Rocky-loamy Circumacidic Tall Shrublands and Forests soil landscape, which also includes Upland Birch Forest, Upland Spruce–Birch Forest, Upland Alder–Willow Tall Shrub, and Upland White Spruce–Ericaceous Forest ecotypes.

Upland Dwarf Birch–Tussock Shrub

Geomorphology:

Upland Dwarf Birch–Tussock Shrub is the most abundant ecotype in ARCN. It is found on moderate to gentle slopes at elevations averaging 250 m. It occurs on lowland and upland loess, older moraine, hillside colluvium, ice-rich centers and margins of thaw basins, drained basins, and bogs.

Plant Association:

Betula nana–Eriophorum vaginatum

Vegetation in this type is dominated by the tussock forming sedge *Eriophorum vaginatum,* and the dwarf shrub *Betula nana* (Table 114). It is the primary ecotype used by caribou for winter lichen grazing, and lichen cover is higher in this ecotype than in other similar ones. Other common species include *Ledum decumbens, Vaccinium vitis-idaea, V. uliginosum, Rubus chamaemorus, Carex bigelowii,* and *Flavocetraria cucullata. Sphagnum* mosses are also abundant and diverse.

This ecotype is very similar to Upland Moist Birch–Ericaceous Shrub, Lowland Moist Birch–Ericaceous Shrub and Lowland Wet Dwarf Birch–Ericaceous Shrub but differs by the prevalence of tussocks formed by *Eriophorum vaginatum* and lower cover of ericaceous shrubs.

Soils:

Soils are typically organic-rich loams and silt-loams and feature a moderately thick to thick surface organic horizon (Table 115). Depth to permafrost is typically less than 1 m. Cryoturbation was common in the upper meter of the soil profile, and buried discontinuous organic layers sometimes occur as the result of cryoturbation of surface organics. Frost boils are uncommon with low abundance, while loess caps and surface fragments are rare. Soil pH is acidic, and EC is low. The soils are typically poorly to somewhat poorly drained, and water table was shallow to moderately deep.

Table 114. Vegetation cover and frequency for Upland Dwarf Birch–Tussock Shrub (n=80).

	Cover		Freq
	Mean	SD	%
Total Live Cover	136.6	40.5	100
Total Vascular Cover	81.9	31.4	100
Total Evergreen Tree Cover	0.0	0.0	8
Total Evergreen Shrub Cover	26.4	18.2	97
Andromeda polifolia	0.3	1.2	15
Cassiope tetragona	<0.1	0.2	8
Empetrum nigrum	2.6	3.5	59
Ledum decumbens	13.3	9.7	97
Oxycoccus microcarpus	0.1	0.2	15
Vaccinium vitis-idaea	10.1	9.1	95
Total Deciduous Shrub Cover	26.3	17.7	100
Alnus crispa	0.6	4.0	8
Arctostaphylos rubra	0.2	0.5	10
Betula nana	15.3	14.3	100
Salix fuscescens	0.3	1.6	5
Salix glauca	0.3	0.9	13
Salix planifolia ssp. *pulchra*	2.4	4.2	59
Salix reticulata	0.1	0.3	5
Vaccinium uliginosum	7.0	7.2	79
Total Forb Cover	5.7	6.5	95
Lupinus arcticus	<0.1	0.2	5
Pedicularis labradorica	<0.1	0.2	8
Petasites frigidus	0.7	1.9	23
Polygonum bistorta	0.1	0.2	10
Rubus chamaemorus	4.7	5.8	69
Rumex arcticus	<0.1	0.2	8
Total Grass Cover	0.4	1.1	33
Arctagrostis latifolia	0.3	1.0	23
Calamagrostis lapponica	<0.1	0.2	5
Hierochloe alpina	<0.1	0.2	5
Total Sedge & Rush Cover	23.1	16.8	100
Carex aquatilis ssp. *aquatilis*	0.6	1.7	28
Carex bigelowii	3.4	4.0	74
Carex rotundata	0.5	1.8	21
Carex stylosa	0.1	0.8	3
Eriophorum angustifolium	0.4	1.0	31
Eriophorum brachyantherum	3.3	11.8	8
Eriophorum scheuchzeri	0.1	0.3	3
Eriophorum vaginatum	14.5	9.7	97
Total Nonvascular Cover	54.8	25.7	100
Total Moss Cover	43.4	22.1	100
Abietinella abietina	0.1	0.8	3
Aulacomnium acuminatum	0.1	0.8	3
Aulacomnium palustre	2.3	3.3	46
Aulacomnium turgidum	3.2	3.7	67
Bryum sp.	0.1	0.3	3
Dicranum acutifolium	0.1	0.8	5
Dicranum elongatum	1.4	3.8	18
Dicranum groenlandicum	0.8	2.9	10
Dicranum laevidens	0.1	0.8	3
Dicranum majus	0.1	0.8	3
Dicranum sp.	1.0	1.8	36
Hylocomium splendens	6.2	11.3	36
Hypnum plicatulum	0.1	0.3	3

Table 114. Continued.

	Cover		Freq
	Mean	SD	%
Pleurozium schreberi	0.6	2.0	13
Polytrichum juniperinum	0.4	1.0	18
Polytrichum sp.	0.5	1.2	26
Polytrichum strictum	0.6	1.8	26
Ptilidium ciliare	<0.1	0.2	8
Rhytidium rugosum	0.7	2.6	15
Sanionia uncinata	0.1	0.2	8
Sphagnum angustifolium	0.1	0.8	3
Sphagnum balticum	5.1	10.6	26
Sphagnum capillifolium	1.2	4.7	8
Sphagnum fuscum	3.0	7.4	26
Sphagnum girgensohnii	0.1	0.8	5
Sphagnum lenense	0.8	3.5	8
Sphagnum magellanicum	0.3	1.6	3
Sphagnum sp.	12.8	19.9	64
Sphagnum warnstorfii	0.4	2.4	3
Sphenolobus minutus	0.1	0.4	10
Tomentypnum nitens	0.6	2.0	15
Unknown moss	<0.1	0.2	8
Warnstorfia sarmentosa	0.1	0.8	3
Total Lichen Cover	11.3	16.3	95
Alectoria nigricans	0.1	0.5	5
Cetraria cf. *islandica*	0.1	0.5	23
Cetraria islandica ssp. *crispiformis*	<0.1	0.2	5
Cetraria laevigata	0.1	0.4	8
Cetrariella delisei	0.2	0.9	8
Cladina arbuscula	0.9	2.6	33
Cladina mitis	1.0	3.0	18
Cladina rangiferina	1.8	3.1	54
Cladina sp.	0.5	1.6	28
Cladina stellaris	0.1	0.2	8
Cladina stygia	0.6	1.9	15
Cladonia bellidiflora	0.1	0.5	3
Cladonia pleurota	0.1	0.4	3
Cladonia sp.	0.4	0.9	59
Cladonia subfurcata	0.1	0.4	5
Cladonia uncialis	0.2	0.8	5
Flavocetraria cucullata	2.2	5.1	74
Flavocetraria nivalis	0.3	1.6	13
Lobaria sp.	<0.1	0.2	5
Nephroma arcticum	0.2	0.6	23
Ochrolechia frigida	0.2	0.9	5
Peltigera aphthosa	0.9	1.2	54
Peltigera canina	0.1	0.4	10
Peltigera sp.	0.1	0.2	15
Sphaerophorus globosus	0.1	0.2	8
Stereocaulon paschale	<0.1	0.2	5
Thamnolia vermicularis	0.5	1.0	38
Unknown crustose lichen	0.2	0.8	15
Total Bare Ground	12.1	9.1	95
Bare Soil	0.9	1.6	64
Water	0.1	0.4	26
Litter alone	11.1	8.3	95

Table 115. Soil characteristics for Upland Dwarf Birch–Tussock Shrub.

Property	Mean	SD	n
Elevation (m)	254.9	258.8	38
Slope (degrees)	3.4	2.7	18
Surface Organics Depth(cm)	22.0	13.0	39
Cumulative Org. in 40 cm (cm)	22.2	11.3	39
Loess Cap Thickness (cm)	12.1	11.5	8
Depth to Rocks (cm)	168.4	67.5	10
Surface Fragment Cover (%)	0.1	0.0	3
Frost Boil Cover (%)	3.6	3.9	13
Thaw Depth (cm)	33.2	9.7	38
Site pH at 10-cm depth	4.7	0.7	37
Site EC at 10-cm depth (μS/cm)	84.9	89.4	37
Water Depth (cm,+ above grnd)[a]	-25.8	13.2	32

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation) and Typic Aquiturbels (wet, mineral soil over permafrost with cryoturbation). Less common soil subgroups include Typic Fibristels (wet, poorly decomposed organic horizon thicker than 40 cm, permafrost present), Typic Hemistels (wet, moderately decomposed organic horizon thicker than 40 cm, permafrost present), and Typic Histoturbels (wet, organic rich soil over permafrost with cryoturbation). This is the sole ecotype comprising the Upland Loamy Wet Tussock Shrublands soil landscape.

Upland Mafic Barrens

Geomorphology:

The distribution of this unique ecotype is restricted to lava flows in BELA. These flows consist of younger volcanic mafic rocks, specifically basalts. Surface forms include slopes, crests and complex patterns.

Plant Association:

Cladina stellaris–Loiseleuria procumbens

Lichens characterize this ecotype, while other life forms grow in micro-sites in rock cracks and protected areas (Table 116). Trees are absent. Common species include *Loiseleuria procumbens*, *Ledum decumbens*, *Hierochloe alpina*, *Racomitrium lanuginosum*, *Alectoria ochroleuca*, *Bryocaulon divergens*, *Cladina stellaris*, *Flavocetraria cucullata* and *Thamnolia vermicularis*. Bare ground is always present.

Upland Mafic Barrens is unique. Some sites in Alpine Acidic Barrens have similar lichen communities and cover, but physiography, bedrock types, and plant associations are different.

Table 116. Vegetation cover and frequency for Upland Mafic Barrens (n=4).

	Cover		Freq
	Mean	SD	%
Total Live Cover	110.2	9.9	100
Total Vascular Cover	7.2	11.6	100
Total Evergreen Shrub Cover	2.7	3.7	100
Cassiope tetragona	<0.1	0.1	25
Empetrum nigrum	0.8	0.9	100
Ledum decumbens	0.3	0.5	75
Loiseleuria procumbens	1.6	2.3	100
Vaccinium vitis-idaea	<0.1	0.1	25
Total Deciduous Shrub Cover	4.0	7.4	100
Alnus crispa	0.5	1.0	50
Betula nana	2.5	5.0	25
Potentilla fruticosa	0.1	0.1	50
Salix brachycarpa ssp. *niphoclada*	<0.1	0.1	25
Salix glauca	<0.1	0.1	25
Salix phlebophylla	<0.1	0.1	25
Salix planifolia ssp. *pulchra*	0.2	0.5	25
Spiraea beauverdiana	<0.1	0.1	25
Vaccinium uliginosum	0.6	0.9	100
Total Forb Cover	0.1	0.1	75
Saxifraga bronchialis	<0.1	0.1	25
Saxifraga tricuspidata	<0.1	0.1	25
Senecio lugens	<0.1	0.1	25
Woodsia alpina	<0.1	0.1	25
Total Grass Cover	0.4	0.6	75
Festuca rubra	<0.1	0.1	25
Festuca sp.	<0.1	0.1	25
Hierochloe alpina	0.3	0.5	50
Poa arctica	<0.1	0.1	25
Trisetum spicatum ssp. *spicatum*	<0.1	0.1	25
Total Sedge & Rush Cover	0.1	0.1	75
Carex glareosa	<0.1	0.1	25
Carex sp.	0.1	0.1	50
Total Nonvascular Cover	103.0	11.1	100
Total Moss Cover	0.4	0.4	100
Dicranum sp.	<0.1	0.1	25
Polytrichum hyperboreum	<0.1	0.1	25
Racomitrium lanuginosum	0.3	0.5	100
Total Lichen Cover	102.6	11.2	100
Alectoria nigricans	1.3	2.5	50
Alectoria ochroleuca	3.8	4.8	75
Arctoparmelia sp.	0.5	1.0	25
Bryocaulon divergens	2.0	2.4	75
Bryoria nitidula	<0.1	0.1	25
Cetraria cf. *islandica*	0.8	1.0	50
Cetraria nigricans	0.1	0.1	50
Cetrariella delisei	0.2	0.5	25
Cladina arbuscula	0.8	1.5	50
Cladina mitis	0.2	0.5	25
Cladina sp.	0.5	1.0	25
Cladina stellaris	14.5	23.8	75
Cladina stygia	1.2	2.5	25
Cladonia coccifera	1.0	1.4	50
Cladonia nipponica	0.5	0.6	50
Cladonia squamosa	0.2	0.5	25

Table 116. Continued.

	Cover		Freq
	Mean	SD	%
Flavocetraria cucullata	0.8	0.9	75
Flavocetraria nivalis	1.5	1.7	50
Nephroma arcticum	0.1	0.1	50
Ochrolechia frigida	17.5	35.0	25
Ophioparma lapponica	3.8	7.5	25
Pertusaria sp.	0.2	0.5	25
Pseudephebe pubescens	1.2	2.5	25
Rhizocarpon geographicum	2.5	2.9	50
Sphaerophorus globosus	<0.1	0.1	25
Thamnolia vermicularis	1.0	0.8	100
Umbilicaria hyperborea	16.2	26.3	50
Unknown crustose lichen	16.2	29.3	50
Unknown foliose/fruticose lichen	6.2	9.5	50
Xanthoria sp.	7.5	9.6	50
Total Bare Ground	13.5	9.6	100
Bare Soil	12.5	9.6	100
Water	<0.1	0.1	25
Litter alone	1.0	0.8	75

Soils:

The soils in this ecotype were rarely sampled due to the typical very high cover of exposed bedrock and surface fragments. The soils that do occur in this ecotype are typically patchy, minimally developed, and occur as a thin veneer over basalt bedrock (Table 117).

Table 117. Soil characteristics for Upland Mafic Barrens.

Property	Mean	SD	n
Elevation (m)	221.2	27.2	4
Slope (degrees)			0
Surface Organics Depth(cm)	3.5		1
Cumulative Org. in 40 cm (cm)	3.5		1
Loess Cap Thickness (cm)	17.0		1
Depth to Rocks (cm)	20.0		1
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	6.7		1
Site EC at 10-cm depth (µS/cm)	20.0		1
Water Depth (cm,+ above grnd)[a]	-140.0	103.9	3

[a]Measurements >1 m indicate minimum depth, not true depth

The one soil that was sampled was classified to Lithic Dystrogelepts. The soil was shallow to bedrock, with a thin surface organic horizon and a high volume of course fragments. Upland Mafic Barrens is the sole ecotype in the Upland Rocky Circumalkaline Barrens soil landscape.

Upland Sandy Barrens

Geomorphology:

Upland Sandy Barrens encompasses the active portions of the Great Kobuk Sand Dunes, Little Kobuk Sand Dunes and isolated smaller exposed dunes in ARCN. These eolian active sand dunes are found at < 100 m elevation.

Plant Association:

Calamagrostis purpurascens–Oxytropis kobukensis

The unique flora of the Kobuk Sand Dunes has been well documented (Parker 1996). All life forms can be present in trace quantities (Table 118). Forbs and grasses are the most represented. We documented two rare species in this ecotype, *Oxytropis kobukensis* and *Lupinus kuschei*. Common species include *Eritrichium splendens*, *Minuartia elegans*, *Senecio ogotorukensis*, *Bromus pumpellianus* var. *arcticus*, and *Calamagrostis purpurascens*.

This ecotype is unique. Its closest analog is Upland White Spruce–Lichen Woodland, which occurs adjacent to it on stabilized dunes.

Table 118. Vegetation cover and frequency for Upland Sandy Barrens (n=13).

	Cover		Freq
	Mean	SD	%
Total Live Cover	16.4	17.1	92
Total Vascular Cover	13.5	11.7	92
Total Evergreen Tree Cover	0.0	0.0	8
Picea glauca	<0.1	<0.1	8
Total Deciduous Tree Cover	3.1	11.1	8
Populus balsamifera	3.1	11.1	8
Total Deciduous Shrub Cover	0.0	0.1	15
Salix alaxensis	<0.1	<0.1	15
Salix glauca	<0.1	<0.1	8
Total Forb Cover	5.5	5.1	92
Androsace chamaejasme	<0.1	<0.1	15
Anemone drummondii	<0.1	<0.1	23
Arabis lyrata ssp. *kamchatica*	0.1	0.3	15
Artemisia borealis	0.7	1.0	46
Artemisia furcata	0.4	0.6	46
Aster sibiricus	0.4	0.9	38
Astragalus aboriginum	0.1	0.3	46
Astragalus alpinus	0.2	0.6	15
Braya humilis	<0.1	<0.1	15
Bupleurum triradiatum ssp. *arcticum*	0.3	0.8	46
Chrysanthemum bipinnatum	0.2	0.6	15
Cnidium cnidiifolium	0.4	1.1	62
Dianthus repens	<0.1	0.1	38
Draba cinerea	<0.1	<0.1	8
Epilobium latifolium	<0.1	<0.1	8
Erigeron elatus	0.1	0.3	8
Eritrichium splendens	0.1	0.3	54
Lesquerella arctica	<0.1	<0.1	31
Lupinus kuschei	0.2	0.5	38
Minuartia arctica	0.2	0.4	23
Minuartia elegans	0.2	0.4	54
Oxytropis borealis	<0.1	<0.1	15
Oxytropis campestris ssp. *jordalii*	0.1	0.3	8
Oxytropis kobukensis	0.4	0.5	69
Parrya nudicaulis	<0.1	<0.1	23
Parrya nudicaulis ssp. *interior*	<0.1	<0.1	8
Plantago canescens	0.3	0.7	31
Pulsatilla patens ssp. *multifida*	0.1	0.3	8
Senecio ogotorukensis	0.3	0.6	69
Silene acaulis	<0.1	<0.1	15
Zygadenus elegans	0.5	1.0	38
Total Grass Cover	4.3	4.0	92
Bromus pumpellianus	0.2	0.8	8
Bromus pumpellianus var. *arcticus*	0.8	1.5	62
Calamagrostis purpurascens	2.8	4.2	69
Elymus arenarius ssp. *mollis*	0.4	1.0	23
Festuca richardsonii	<0.1	0.1	38
Festuca rubra	0.1	0.3	8
Total Sedge & Rush Cover	0.6	1.2	31
Carex filifolia	0.5	1.1	23
Carex supina ssp. *spaniocarpa*	0.2	0.6	8
Total Nonvascular Cover	2.8	10.0	38
Total Moss Cover	1.4	5.0	31

Table 118. Continued.

	Cover		Freq
	Mean	SD	%
Tortella inclinata	<0.1	<0.1	15
Unknown moss	0.1	0.3	15
Total Lichen Cover	1.4	5.0	31
Cetraria aculeata	0.1	0.3	23
Evernia perfragilis	<0.1	<0.1	15
Flavocetraria nivalis	0.1	0.3	8
Stereocaulon paschale	1.2	4.2	8
Stereocaulon sp.	<0.1	<0.1	15
Thamnolia sp.	<0.1	<0.1	8
Thamnolia vermicularis	0.1	0.3	8
Total Bare Ground	89.6	16.9	100
Bare Soil	87.1	20.1	100
Litter alone	2.6	4.1	85

Table 119. Soil characteristics for Upland Sandy Barrens.

Property	Mean	SD	n
Elevation (m)	81.2	13.0	13
Slope (degrees)	4.8	3.2	9
Surface Organics Depth(cm)			0
Cumulative Org. in 40 cm (cm)	1.0		1
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	12
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	8.4	0.7	12
Site EC at 10-cm depth (µS/cm)	32.5	12.9	12
Water Depth (cm,+ above grnd)[a]	-200.0	0.0	12

[a]Measurements >1 m indicate minimum depth, not true depth

Soils:

Soils are sandy and lack a surface organic horizon (Table 119). Thaw depths could not be determined as the depth to permafrost, if present, was always greater than the maximum depth sampled (1.3 m). Frost boils, surface fragments, and loess caps are absent. Thin organic horizons, buried by wind blown sands, occurred occasionally. Soil pH is alkaline to circumneutral, and EC is low. The soils are excessively drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the excessively drained soils.

This ecotype included one soil subgroup, Typic Cryopsamments (sandy, low coarse fragment content, well drained, lacking permafrost). This is the sole ecotype comprising the Upland Sandy Barrens soil landscape.

Upland Sedge–Dryas Meadow

Geomorphology:

These upland meadows are strongly associated with carbonate-rich bedrock types. Surface geomorphology consists of hillside colluvium, older moraine, and upland retransported deposits. Surfaces are sloped and feature mineral-cored hummocks, stripes, and gelifluction lobes. It occurs at elevations up to 800 m throughout ARCN, particularly in CAKR and NOAT.

Plant Association:

Dryas integrifolia–Carex bigelowii–Equisetum arvense
Dryas integrifolia–Carex scirpoidea– Rhododendron lapponicum

Dwarf shrubs, sedges, forbs and mosses are prevalent in Upland Sedge–Dryas Meadow (Table 120). This ecotype is diverse with the highest average species count per plot across ecotypes, and the 6th highest species count overall. We identified two distinct plant associations in this ecotype. Common species include *Salix reticulata*, *Chrysanthemum integrifolium* (syn: *Hulteniella integrifolia*), *Polygonum viviparum* (syn: *Bistorta vivipara*), *Thalictrum alpinum*.

This ecotype is similar to Alpine Alkaline Dryas Dwarf Shrub except soils are moist to wet instead of dry, and sites occur at slightly lower elevations and have higher cover of sedges.

Lowland Sedge–Dryas Meadow is a regionally rare but locally abundant ecotype originally mapped on the coastal plains of BELA and CAKR (Jorgenson et al. 2004) that was included in Upland Sedge–Dryas Meadow to simplify the classification (see the following section, Rare Ecotypes). The lowland class was retained in the ARCN-wide mapping because of its importance in BELA.

Table 120. Vegetation cover and frequency for Upland Sedge–Dryas Meadow (n=38).

	Cover		Freq
	Mean	SD	%
Total Live Cover	141.1	49.8	100
Total Vascular Cover	92.8	22.2	100
Total Evergreen Shrub Cover	29.4	22.4	100
Andromeda polifolia	0.5	1.2	32
Cassiope tetragona	0.7	1.3	41
Dryas integrifolia	23.6	22.0	68
Dryas octopetala	2.9	7.6	27
Rhododendron lapponicum	1.5	2.7	45
Total Deciduous Shrub Cover	17.2	7.1	100
Arctostaphylos rubra	2.2	2.8	68
Potentilla fruticosa	0.7	1.5	36
Salix alaxensis	0.1	0.2	14
Salix arctica	3.5	3.6	73
Salix glauca	0.4	1.3	9
Salix lanata ssp. *richardsonii*	0.9	1.6	59
Salix reticulata	6.8	6.6	77
Salix rotundifolia	1.2	3.0	18
Shepherdia canadensis	0.1	0.5	18
Vaccinium uliginosum	1.3	1.5	50
Total Forb Cover	18.5	13.6	100
Androsace chamaejasme	0.4	1.1	50
Anemone parviflora	0.3	0.9	36
Astragalus umbellatus	0.2	0.3	41
Castilleja elegans	0.2	0.5	23
Chrysanthemum integrifolium	0.6	1.1	64
Epilobium latifolium	0.3	0.6	23
Equisetum arvense	7.0	13.1	41
Equisetum palustre	1.1	3.8	9
Equisetum scirpoides	0.1	0.2	14
Equisetum variegatum	0.2	0.5	18
Gentiana propinqua	0.1	0.2	14
Hedysarum alpinum	0.5	1.2	32
Lagotis glauca ssp. *glauca*	0.1	0.2	45
Minuartia arctica	0.1	0.2	32
Minuartia rossii	0.1	0.3	14
Oxytropis borealis	0.7	1.9	23
Papaver macounii	0.1	0.5	14
Parnassia palustris	0.1	0.2	32
Pedicularis capitata	0.1	0.3	32
Pinguicula vulgaris	0.1	0.2	36
Polygonum bistorta	0.1	0.2	14
Polygonum viviparum	0.5	0.6	82
Potentilla biflora	0.2	0.4	32
Saussurea angustifolia	0.2	0.3	32
Saxifraga hirculus	0.3	0.4	50
Saxifraga oppositifolia	1.9	4.4	41
Senecio atropurpureus	0.1	0.2	32
Silene acaulis	0.6	1.0	45
Thalictrum alpinum	0.1	0.1	55
Tofieldia pusilla	0.1	0.3	50
Total Grass Cover	0.9	1.3	68
Arctagrostis latifolia	0.5	0.8	41
Festuca altaica	0.2	0.7	18

Table 120. Continued.

	Cover		Freq
	Mean	SD	%
Poa arctica	0.1	0.2	14
Total Sedge & Rush Cover	26.8	19.0	100
Carex atrofusca	8.1	13.8	64
Carex bigelowii	3.5	5.5	45
Carex capillaris	0.2	0.5	27
Carex krausei	1.0	1.9	27
Carex membranacea	3.0	6.6	41
Carex misandra	3.6	8.8	55
Carex rotundata	0.4	1.2	18
Carex scirpoidea	2.4	2.2	77
Eriophorum angustifolium	1.4	2.9	27
Eriophorum callitrix	0.4	1.5	14
Eriophorum vaginatum	0.1	0.2	14
Juncus biglumis	0.2	0.4	32
Juncus castaneus ssp. *castaneus*	0.1	0.4	27
Juncus triglumis	0.2	0.9	18
Total Nonvascular Cover	48.3	36.1	100
Total Moss Cover	42.0	35.4	100
Andreaeobryum sp.	0.9	2.9	9
Aulacomnium acuminatum	1.6	4.7	14
Aulacomnium palustre	0.2	0.7	18
Campylium sp.	0.9	2.5	14
Campylium stellatum	0.5	1.5	14
Catoscopium sp.	1.3	2.9	18
Cinclidium sp.	0.7	1.8	14
Dicranum sp.	1.2	2.1	27
Distichium capillaceum	0.1	0.3	14
Ditrichum flexicaule	0.1	0.3	14
Drepanocladus sp.	0.7	1.7	18
Hylocomium splendens	4.5	7.9	36
Hypnum bambergeri	0.9	2.5	14
Hypnum sp.	1.0	2.4	18
Pohlia sp.	2.0	3.6	32
Ptilidium ciliare	0.6	1.5	18
Rhytidium rugosum	3.6	5.4	50
Sanionia sp.	0.6	2.0	9
Tomentypnum nitens	12.9	17.9	55
Unknown moss	4.1	16.0	23
Total Lichen Cover	6.5	8.1	82
Asahinea chrysantha	0.4	1.1	27
Cetraria cf. *islandica*	0.2	0.5	23
Cetraria tilesii	0.1	0.3	14
Cladonia sp.	0.2	0.5	27
Dactylina arctica	0.1	0.2	14
Flavocetraria cucullata	1.8	2.5	68
Flavocetraria nivalis	0.5	0.7	32
Masonhalea richardsonii	0.1	0.5	18
Pertusaria sp.	0.8	1.7	27
Thamnolia vermicularis	1.1	1.8	36
Unknown lichen	0.5	2.2	9
Vulpicida tilesii	0.1	0.2	14
Total Bare Ground	11.0	9.3	73
Bare Soil	2.6	3.6	73
Water	0.6	1.0	45
Litter alone	7.9	6.8	73

Soils:

Soils are loamy to rubbly, with a thin to moderately thick surface organic horizon (Table 121). Permafrost often occurs in the upper meter of the soil profile. Frost boils and sorted ground are common. Surface fragments and loess caps are rare. Buried discontinuous organic layers sometimes occur as the result of cryoturbation. Soil pH is alkaline to circumneutral, and EC is low. The soils are somewhat poorly drained, and occasionally well drained. The water table is shallow to moderately deep.

Table 121. Soil characteristics for Upland Sedge–Dryas Meadow.

Property	Mean	SD	n
Elevation (m)	296.9	182.8	16
Slope (degrees)	7.5	5.6	16
Surface Organics Depth(cm)	6.9	4.8	16
Cumulative Org. in 40 cm (cm)	7.0	4.9	16
Loess Cap Thickness (cm)	10.0	NA	1
Depth to Rocks (cm)	34.8	64.7	16
Surface Fragment Cover (%)	4.7	4.7	3
Frost Boil Cover (%)	4.5	4.3	11
Thaw Depth (cm)	70.8	20.6	9
Site pH at 10-cm depth	7.6	0.3	16
Site EC at 10-cm depth (µS/cm)	313.1	133.5	16
Water Depth (cm,+ above grnd)[a]	-35.5	34.2	15

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups include Typic Aquiturbels (wet, mineral soil over permafrost with cryoturbation), Ruptic-histic Aquiturbels (wet, highly cryoturbated surface organics and mineral soil above permafrost), and Typic Gelaquepts (wet, partially developed, permafrost below 1 m). A less common subgroup that occurs on sites with better drainage is Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m). This ecotype and associated soils are part of the Upland Rocky-loamy Circumalkaline Low Shrublands and Forests soil landscape, which also includes Upland Willow Low Shrub and Upland White Spruce–Willow Forest ecotypes.

Upland Spiraea Low Shrub

Geomorphology:

Upland Spiraea Low Shrub occurs on moderate to steep slopes of hillside colluvium. This type is found at mid-elevations, averaging 500 m.

Plant Association:

Spiraea beauverdiana–Festuca altaica

Vegetation in this ecotype is dominated by deciduous shrubs, specifically *Spiraea beauverdiana* (syn: *S. stevenii*). All life forms can be present although low shrubs and forbs typically contribute the most to total cover (Table 122). Other common species include *Vaccinium uliginosum*, *V. vitis-idaea, Anemone narcissiflora, Festuca altaica, Calamagrostis canadensis* and *Carex podocarpa*. We found two rare species in this ecotype, *Carex deflexa* and *Schizachne purpurascens*.

This ecotype is similar to Upland Birch–Ericaceous Low Shrub and Upland Birch–Willow Low Shrub, except it has fewer forbs, and birch shrubs and willows are not dominant. It is spectrally indistinguishable from Upland Birch–Willow Low Shrub, with which it was mapped.

Soils:

Soils are typically rubbly or blocky and feature a thin surface organic horizon (Table 123). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be absent or present below 2 m due to the steep slope gradients, south- and west-slope aspects, and rocky, well drained soils associated with these sites. Frost boils and loess caps are rare, and surface fragments are common at low abundance. Soil pH is acidic, and EC is low. The soils are typically somewhat excessively to moderately well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 122. Vegetation cover and frequency for Upland Spiraea Low Shrub (n=10).

	Cover		Freq
	Mean	SD	%
Total Live Cover	147.1	33.4	100
Total Vascular Cover	123.7	36.0	100
Total Evergreen Tree Cover	1.2	3.8	60
Picea glauca	1.2	3.8	60
Total Evergreen Shrub Cover	18.6	20.3	100
Andromeda polifolia	<0.1	<0.1	10
Cassiope tetragona	0.1	0.3	20
Empetrum nigrum	3.1	5.2	50
Juniperus communis	2.2	6.3	30
Ledum decumbens	2.0	2.6	50
Linnaea borealis	3.3	5.0	60
Loiseleuria procumbens	0.2	0.6	10
Vaccinium vitis-idaea	7.6	20.2	70
Total Deciduous Tree Cover	0.5	1.6	10
Betula hybrids	0.5	1.6	10
Total Deciduous Shrub Cover	58.3	35.9	100
Alnus crispa	6.0	11.5	40
Betula nana	1.5	4.7	10
Rosa acicularis	1.0	3.2	10
Salix arctica	0.1	0.3	10
Salix planifolia ssp. *pulchra*	9.1	26.7	40
Spiraea beauverdiana	24.5	16.2	100
Vaccinium uliginosum	15.1	16.0	90
Viburnum edule	1.0	3.2	10
Total Forb Cover	19.6	20.3	100
Aconitum delphinifolium	0.1	0.3	30
Anemone narcissiflora	0.8	1.9	70
Angelica lucida	<0.1	<0.1	10
Antennaria sp.	0.2	0.6	10
Arabis lyrata ssp. *kamchatica*	<0.1	<0.1	10
Artemisia arctica	0.8	1.4	30
Artemisia arctica ssp. *arctica*	6.1	9.2	60
Campanula lasiocarpa	<0.1	<0.1	20
Castilleja elegans	<0.1	<0.1	10
Claytonia sarmentosa	0.3	0.7	20
Dryopteris dilatata ssp. *americana*	<0.1	<0.1	30
Epilobium angustifolium	0.6	0.7	50
Galium boreale	0.3	0.9	10
Gentiana glauca	<0.1	<0.1	30
Gymnocarpium dryopteris	1.0	3.2	30
Lupinus arcticus	2.1	3.3	40
Lycopodium alpinum	0.1	0.3	40
Lycopodium annotinum	0.6	1.1	40
Polemonium acutiflorum	0.3	0.7	40
Polygonum bistorta	0.2	0.6	20
Pulsatilla patens ssp. *multifida*	<0.1	<0.1	10
Pyrola minor	<0.1	<0.1	10
Rubus arcticus	2.6	6.9	20
Rubus arcticus ssp. *arcticus*	0.4	0.8	20
Rubus arcticus ssp. *stellatus*	0.2	0.6	10
Rubus chamaemorus	0.2	0.6	20
Saxifraga bronchialis	<0.1	<0.1	10

Table 122. Continued.

	Cover		Freq
	Mean	SD	%
Saxifraga tricuspidata	<0.1	<0.1	10
Sedum rosea ssp. *integrifolium*	0.1	0.3	10
Selaginella sibirica	0.6	1.3	20
Silene repens	<0.1	<0.1	10
Solidago multiradiata	0.3	0.7	30
Thelypteris phegopteris	0.4	1.3	20
Trientalis europaea ssp. *arctica*	0.7	1.2	30
Valeriana capitata	0.1	0.3	20
Viola sp.	0.1	0.3	10
Woodsia ilvensis	<0.1	<0.1	10
Total Grass Cover	21.7	20.7	100
Calamagrostis canadensis	13.3	22.1	100
Festuca altaica	8.1	11.7	70
Hierochloe alpina	0.1	0.3	10
Poa arctica	0.1	0.3	10
Schizachne purpurascens	0.1	0.3	10
Total Sedge & Rush Cover	3.7	3.4	90
Carex bigelowii	1.5	2.8	50
Carex brunnescens	0.1	0.3	10
Carex deflexa	0.1	0.3	10
Carex podocarpa	1.9	2.8	70
Luzula multiflora	<0.1	<0.1	20
Luzula parviflora	<0.1	<0.1	20
Luzula wahlenbergii ssp. *wahlenbergii*	<0.1	<0.1	10
Total Nonvascular Cover	23.5	26.7	100
Total Moss Cover	18.4	20.8	100
Brachythecium sp.	0.3	0.9	10
Dicranum sp.	1.0	1.2	50
Drepanocladus sp.	0.5	0.8	30
Hylocomium splendens	2.6	5.4	30
Pleurozium schreberi	5.2	10.7	30
Polytrichum juniperinum	4.7	11.1	30
Polytrichum piliferum	0.1	0.3	10
Polytrichum sp.	1.8	2.8	40
Racomitrium sp.	0.2	0.6	10
Rhytidium rugosum	0.2	0.6	10
Rhytidium sp.	0.1	0.3	10
Sphagnum sp.	0.5	1.6	20
Thuidium recognitum	0.5	1.6	10
Unknown moss	0.6	1.0	30
Total Lichen Cover	5.1	6.8	90
Cetraria cf. *islandica*	0.5	1.3	60
Cladina arbuscula	1.3	3.2	20
Cladina rangiferina	0.3	0.7	20
Cladina sp.	0.1	0.3	10
Cladina stellaris	0.6	1.3	20
Cladina stygia	0.3	0.9	10
Cladonia sp.	1.4	2.5	80
Masonhalea richardsonii	<0.1	<0.1	20
Peltigera aphthosa	<0.1	<0.1	20
Peltigera sp.	<0.1	<0.1	20
Stereocaulon sp.	<0.1	<0.1	20
Unknown crustose lichen	0.4	1.0	20
Total Bare Ground	15.3	15.5	100
Bare Soil	4.4	11.0	90
Litter alone	10.9	8.7	100

Table 123. Soil characteristics for Upland Spiraea Low Shrub.

Property	Mean	SD	n
Elevation (m)	488.4	135.6	10
Slope (degrees)	21.2	9.4	10
Surface Organics Depth(cm)	5.4	2.3	10
Cumulative Org. in 40 cm (cm)	6.3	3.9	10
Loess Cap Thickness (cm)	8.5	4.9	2
Depth to Rocks (cm)	17.1	20.0	10
Surface Fragment Cover (%)	8.3	2.9	3
Frost Boil Cover (%)	5.0		1
Thaw Depth (cm)			0
Site pH at 10-cm depth	4.3	0.3	10
Site EC at 10-cm depth (μS/cm)	28.9	11.7	9
Water Depth (cm,+ above grnd)[a]	-185.0	47.4	10

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Dystrocryepts (acidic, partially developed, lacking permafrost) and Typic Dystrogelepts (acidic, well drained, moderately thin organic horizon, permafrost below 1 m). Less common soil subgroups include Typic Cryorthents (poorly developed soil lacking permafrost) and Typic Humicryepts (moist, acidic, organic-rich, partially developed, lacking permafrost). This ecotype and associated soils are part of the Upland Rocky-loamy Acidic Low Shrublands soil landscape. Other ecotypes found in this soil landscape include Upland Birch–Ericaceous Low Shrub and Upland Birch–Willow Low Shrub.

Upland Spruce–Birch Forest

Geomorphology:

These mixed forests are uncommon and occur on hillside colluvium, eolian inactive sand deposits, older moraine and older till within the boreal forest zone in KOVA and GAAR. Surfaces are always sloped, and rock outcrops are frequently present.

Plant Association:

Betula papyrifera–Picea glauca–Vaccinium vitis-idaea

White spruce and birch trees are co-dominant in open to closed stands in this ecotype, and all life forms except sedges are typically present (Table 124). Common species include *Ledum decumbens*, *Vaccinium uliginosum*, *Geocaulon lividum*, *Pleurozium schreberi*, *Cladina rangiferina*, and *Peltigera aphthosa*.

Upland Spruce–Birch Forest is comparable to Upland Birch Forest, as previously discussed. It is somewhat similar to Upland White Spruce–Ericaceous Forest and Upland White Spruce–Willow Forest in that white spruce is a dominant species, but varies in actual species composition and site factors.

Soils:

Table 124. Vegetation cover and frequency for Upland Spruce–Birch Forest (n=10).

	Cover		Freq
	Mean	**SD**	**%**
Total Live Cover	132.2	21.7	100
Total Vascular Cover	94.8	31.6	100
Total Evergreen Tree Cover	21.5	8.4	100
Picea glauca	19.7	9.5	100
Picea mariana	1.8	3.3	40
Total Evergreen Shrub Cover	16.0	13.1	100
Arctostaphylos uva-ursi	<0.1	<0.1	10
Cassiope tetragona	<0.1	<0.1	10
Dryas integrifolia	0.1	0.3	20
Empetrum nigrum	2.9	5.3	50
Juniperus communis	0.1	0.3	40
Ledum decumbens	4.0	5.0	70
Ledum groenlandicum	2.3	4.2	30
Linnaea borealis	0.5	1.1	50
Loiseleuria procumbens	<0.1	<0.1	20
Vaccinium vitis-idaea	5.9	9.0	100
Total Deciduous Tree Cover	21.2	10.6	100
Betula hybrids	<0.1	<0.1	10
Betula papyrifera	20.5	11.3	100
Populus balsamifera	0.4	1.3	20
Populus tremuloides	0.3	0.9	10
Total Deciduous Shrub Cover	27.9	14.4	100
Alnus crispa	7.2	8.7	50
Arctostaphylos alpina	0.3	0.9	10
Arctostaphylos rubra	0.1	0.3	20
Betula glandulosa	0.4	0.8	20
Potentilla fruticosa	0.5	1.1	30
Ribes triste	0.8	2.2	30
Rosa acicularis	2.0	2.7	50
Rubus idaeus	0.3	0.9	10
Salix arbusculoides	0.5	1.6	10
Salix bebbiana	3.2	4.6	50
Salix glauca	2.5	4.1	40
Salix planifolia ssp. *pulchra*	<0.1	<0.1	20
Salix scouleriana	0.1	0.3	10
Spiraea beauverdiana	1.1	1.9	50
Vaccinium uliginosum	8.8	7.7	80
Total Forb Cover	6.8	8.9	100
Cystopteris fragilis	<0.1	<0.1	30
Epilobium angustifolium	<0.1	0.1	40
Equisetum arvense	<0.1	<0.1	10
Equisetum pratense	0.2	0.6	10
Equisetum scirpoides	<0.1	<0.1	20
Equisetum sylvaticum	3.0	9.5	20
Gentiana propinqua	<0.1	<0.1	20
Geocaulon lividum	2.1	3.2	60
Gymnocarpium dryopteris	0.2	0.6	20
Hedysarum alpinum	0.1	0.3	10
Lycopodium annotinum	<0.1	<0.1	20
Lycopodium clavatum	0.5	1.1	20
Lycopodium complanatum	<0.1	<0.1	30
Mertensia paniculata	0.1	0.3	20
Petasites frigidus	0.1	0.3	10
Polygonum alaskanum	<0.1	<0.1	10

Table 124. Continued.

	Cover		Freq
	Mean	SD	%
Pyrola asarifolia	<0.1	<0.1	20
Pyrola grandiflora	<0.1	<0.1	20
Pyrola secunda	<0.1	<0.1	20
Solidago multiradiata var. *multiradiata*	0.1	0.3	10
Stellaria sp.	<0.1	<0.1	10
Total Grass Cover	1.2	1.4	80
Calamagrostis canadensis	0.9	1.4	30
Calamagrostis purpurascens	<0.1	<0.1	20
Festuca altaica	0.2	0.6	30
Total Sedge & Rush Cover	0.2	0.3	50
Carex bigelowii	<0.1	<0.1	10
Carex concinna	<0.1	<0.1	20
Carex scirpoidea	0.1	0.3	10
Carex sp.	<0.1	<0.1	20
Carex vaginata	<0.1	<0.1	20
Total Nonvascular Cover	37.5	25.2	100
Total Moss Cover	19.6	15.0	100
Dicranum polysetum	0.1	0.3	10
Dicranum sp.	0.9	1.7	30
Ditrichum flexicaule	0.2	0.6	10
Hylocomium splendens	7.6	8.4	70
Hypnum sp.	4.2	13.3	10
Pleurozium schreberi	3.1	3.3	60
Polytrichum juniperinum	0.3	0.9	10
Polytrichum piliferum	0.8	2.5	10
Polytrichum sp.	0.4	0.8	50
Racomitrium sp.	1.4	4.4	10
Rhytidium rugosum	0.2	0.6	10
Tomentypnum nitens	0.1	0.3	10
Tortella fragilis	0.1	0.3	10
Unknown moss	0.1	0.3	10
Total Lichen Cover	17.9	24.1	100
Cetraria cf. *islandica*	0.7	1.5	20
Cetrariella delisei	0.3	0.9	10
Cladina arbuscula	1.2	3.2	20
Cladina mitis	0.9	1.9	20
Cladina rangiferina	2.9	4.6	80
Cladina sp.	1.0	3.2	10
Cladina stellaris	1.4	2.7	30
Cladina stygia	0.1	0.3	10
Cladonia amaurocraea	0.1	0.3	10
Cladonia cenotea	0.3	0.9	10
Cladonia sp.	2.8	6.1	80
Flavocetraria cucullata	1.0	3.2	10
Nephroma arcticum	0.3	0.7	20
Peltigera aphthosa	0.8	2.2	70
Peltigera canina	0.2	0.4	30
Peltigera sp.	0.2	0.6	40
Stereocaulon sp.	1.9	4.7	30
Umbilicaria sp.	0.1	0.3	10
Unknown crustose lichen	1.5	4.7	40
Total Bare Ground	12.1	7.4	100
Bare Soil	0.5	0.7	90
Litter alone	11.6	7.5	100

Soils are typically loamy, sandy, or rubbly and feature a thin to moderately thick surface organic horizon (Table 125). Thaw depths could not be determined in the rocky soils, but in most cases permafrost is presumed to be absent or to occur below a depth of 2 m. Frost boils and loess caps are absent. Evidence of cryoturbation sometimes occurs in the upper meter of the soil profile. Surface fragments are common and occur at low abundance. Soil pH is acidic to circumneutral, and EC is low. The soils are typically somewhat excessively to well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 125. Soil characteristics for Upland Spruce–Birch Forest.

Property	Mean	SD	n
Elevation (m)	206.4	115.6	10
Slope (degrees)	23.9	11.3	9
Surface Organics Depth(cm)	13.1	8.5	10
Cumulative Org. in 40 cm (cm)	13.3	9.0	10
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	63.0	85.0	8
Surface Fragment Cover (%)	5.4	8.4	5
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	5.8	1.4	10
Site EC at 10-cm depth (µS/cm)	65.0	46.5	10
Water Depth (cm,+ above grnd)[a]	-200.0	0.0	4

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups in this ecotype are Typic Dystrocryepts (acidic, partially developed, lacking permafrost), and Typic Haplocryepts (non-acidic, partially developed, lacking permafrost). Less common subgroups include Spodic Dystrocryepts (moist, acidic, partially developed and somewhat leached), and Typic Histoturbels (wet, organic rich soil over permafrost with cryoturbation). This ecotype and associated soils are part of the Upland Rocky-loamy Circumacidic Tall Shrublands and Forests soil landscape. Other ecotypes found in this soil landscape include Upland Birch Forest, Upland Alder–Willow Tall Shrub, Upland Bluejoint Meadow, and Upland White Spruce– Ericaceous Forest.

Upland White Spruce–Dryas Woodland

Geomorphology:

This woodland ecotype is strongly associated with sand dunes in KOVA and occurs on both eolian active and inactive sands. Average elevation is 60 m and surface forms include flats, crests and eolian patterns.

Plant Association:

Picea glauca–Dryas integrifolia

White spruce trees have 10–24% cover in Upland White Spruce–Dryas Woodland, while dwarf and low shrubs, forbs, mosses and lichens characterize the understory (Table 126). All species are adapted to dry, sandy soil. Common species include *Picea glauca*, *Arctostaphylos uva-ursi*, *Dryas integrifolia*, *Shepherdia canadensis*, *Solidago multiradiata*, *Calamagrostis purpurascens*, *Carex glacialis*, *Abietinella abietina*, and *Stereocaulon* spp.

This ecotype is most similar to Upland White Spruce–Lichen Woodland, except *Dryas integrifolia* is dominant and lichen cover is lower. It occurred in patch sizes too small to be mappable and was, therefore, included within Upland White Spruce–Lichen Woodland.

Soils:

Soils are sandy and lack a surface organic horizon (Table 127). Thaw depths could not be determined as the depth to permafrost, if present, was always greater than the maximum depth sampled (1.3 m). Frost boils, surface fragments, and loess caps are absent. Soil pH is alkaline to circumneutral, and EC is low. The soils are somewhat excessively drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 126. Vegetation cover and frequency for Upland White Spruce–Dryas Woodland (n=6).

	Cover		Freq
	Mean	SD	%
Total Live Cover	120.2	74.1	100
Total Vascular Cover	81.7	45.7	100
Total Evergreen Tree Cover	10.3	11.5	100
Picea glauca	10.3	11.5	100
Total Evergreen Shrub Cover	36.4	13.2	100
Arctostaphylos uva-ursi	10.0	8.3	83
Dryas integrifolia	25.0	16.7	100
Empetrum nigrum	0.8	2.0	17
Juniperus communis	0.5	0.5	50
Total Deciduous Tree Cover	0.0	0.0	17
Populus balsamifera	<0.1	<0.1	17
Total Deciduous Shrub Cover	26.6	37.1	100
Arctostaphylos rubra	9.0	14.0	83
Betula glandulosa	0.8	2.0	17
Salix alaxensis	0.2	0.4	17
Salix brachycarpa ssp. *niphoclada*	<0.1	<0.1	17
Salix glauca	11.5	15.0	67
Salix hastata	<0.1	<0.1	17
Salix reticulata	1.7	4.1	17
Shepherdia canadensis	1.7	1.8	83
Vaccinium uliginosum	1.7	4.1	17
Total Forb Cover	5.2	2.8	100
Androsace chamaejasme	0.1	0.1	50
Anemone drummondii	<0.1	0.1	33
Anemone narcissiflora	<0.1	0.1	33
Artemisia borealis	0.8	2.0	17
Artemisia furcata	<0.1	0.1	33
Aster sibiricus	0.2	0.4	50
Aster yukonensis	<0.1	<0.1	17
Astragalus aboriginum	0.2	0.4	50
Braya humilis	<0.1	<0.1	17
Bupleurum triradiatum ssp. *arcticum*	<0.1	0.1	33
Castilleja hyperborea	<0.1	<0.1	17
Cnidium cnidiifolium	<0.1	0.1	33
Dianthus repens	0.1	0.1	50
Draba cinerea	<0.1	<0.1	17
Equisetum variegatum	<0.1	<0.1	17
Erigeron elatus	<0.1	<0.1	17
Listera borealis	<0.1	<0.1	17
Lupinus arcticus	0.2	0.4	33
Lupinus kuschei	<0.1	<0.1	17
Minuartia arctica	0.2	0.4	33
Minuartia elegans	0.1	0.1	50
Oxytropis borealis	0.3	0.8	33
Oxytropis kobukensis	0.1	0.1	50
Pedicularis kanei	<0.1	0.1	33
Pedicularis labradorica	0.2	0.4	17
Pedicularis langsdorffii ssp. *arctica*	0.2	0.4	33
Polygonum viviparum	<0.1	<0.1	17
Pyrola asarifolia	0.2	0.4	17
Pyrola grandiflora	<0.1	<0.1	17
Pyrola secunda	0.2	0.4	33
Saxifraga oppositifolia	<0.1	<0.1	17

Table 126. Continued.

	Cover Mean	Cover SD	Freq %
Senecio ogotorukensis	<0.1	0.1	33
Silene acaulis	0.5	0.8	33
Solidago multiradiata var. *multiradiata*	1.0	0.9	100
Tofieldia pusilla	0.3	0.8	33
Zygadenus elegans	0.1	0.1	50
Total Grass Cover	1.2	1.6	83
Bromus pumpellianus var. *arcticus*	<0.1	0.1	33
Calamagrostis purpurascens	1.0	1.5	83
Festuca altaica	<0.1	<0.1	17
Festuca richardsonii	<0.1	0.1	33
Festuca rubra	<0.1	0.1	33
Total Sedge & Rush Cover	2.0	2.3	100
Carex filifolia	0.7	1.6	33
Carex glacialis	0.7	0.8	67
Carex petricosa	0.2	0.4	17
Carex williamsii	0.2	0.4	17
Kobresia sibirica	0.3	0.8	33
Total Nonvascular Cover	38.5	41.3	100
Total Moss Cover	14.3	25.0	83
Abietinella abietina	10.7	24.2	50
Bryum sp.	0.2	0.4	17
Ceratodon purpureus	0.2	0.4	17
Ditrichum flexicaule	0.7	1.6	17
Hylocomium splendens	0.8	2.0	17
Pohlia sp.	0.2	0.4	17
Racomitrium canescens	0.8	2.0	17
Rhytidium rugosum	0.2	0.4	17
Syntrichia ruralis	0.7	1.6	17
Total Lichen Cover	23.1	27.8	100
Cetraria aculeata	5.0	10.0	50
Cetraria islandica ssp. *islandica*	0.5	1.2	50
Cetraria tilesii	<0.1	<0.1	17
Cladina rangiferina	1.7	4.1	17
Cladina sp.	0.2	0.4	17
Cladonia sp.	1.7	4.1	17
Dactylina arctica	<0.1	0.1	33
Dactylina madreporiformis	0.2	0.4	17
Flavocetraria cucullata	0.8	2.0	17
Flavocetraria nivalis	1.0	1.3	50
Peltigera rufescens	0.2	0.4	33
Peltigera sp.	<0.1	<0.1	17
Squamarina lentigera	0.8	1.3	33
Stereocaulon glareosum	2.8	6.0	33
Stereocaulon sp.	5.7	9.7	67
Thamnolia sp.	1.3	3.3	17
Thamnolia vermicularis	0.5	0.8	33
Unknown crustose lichen	1.7	4.1	33
Total Bare Ground	39.0	29.7	100
Bare Soil	27.7	25.6	83
Litter alone	11.3	11.2	100

Table 127. Soil characteristics for Upland White Spruce–Dryas Woodland.

Property	Mean	SD	n
Elevation (m)	60.5	14.4	6
Slope (degrees)	4.0	4.2	2
Surface Organics Depth(cm)			0
Cumulative Org. in 40 cm (cm)			0
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0	0.0	2
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	7.2	1.1	6
Site EC at 10-cm depth (µS/cm)	36.7	5.2	6
Water Depth (cm,+ above grnd)[a]	-200.0	0.0	2

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Typic Cryopsamments (sandy, low coarse fragment content, well drained, lacking permafrost). A less common subgroup is Typic Haplocryepts (non-acidic, partially developed, lacking permafrost). This ecotype and associated soils are part of the Upland Sandy Forest soil landscape. Also included in this soil landscape is Upland White Spruce–Lichen Woodland.

Upland White Spruce–Ericaceous Forest

Geomorphology:

Upland White Spruce–Ericaceous Forest is common throughout GAAR, KOVA, NOAT and CAKR, commonly forming the circumpolar treeline. Surfaces are sloped. It is found on hillside colluvium, upland loess, older moraine, retransported deposits and eolian inactive sand dunes upwards to 700 m elevation.

Plant Association:

Picea glauca–Ledum decumbens

White spruce, *P. glauca*, predominates and occurs in open stands (Table 128). The understory is dominated by evergreen shrubs but also contains a mixture of deciduous low and tall shrubs, forbs, and nonvascular species, with more variable cover of graminoids. Common species include *Empetrum nigrum*, *Ledum decumbens*, *Vaccinium uliginosum*, *Lycopodium annotinum*, *Hylocomium splendens*, *Pleurozium schreberi*, and *Cladina rangiferina*.

This ecotype is similar to Upland White Spruce–Willow Forest except that low and dwarf ericaceous shrubs are more prevalent than are willow species, it is more acidic, and has lower species diversity.

Soils:

Soils are typically loamy, blocky, or rubbly with a thin to moderately thick surface organic horizon (Table 129). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be absent or to occur below a depth of 1 m. Frost boils are absent, and surface fragments are rare. Loess caps are uncommon and moderately thick to thick. Soil pH is acidic to circumneutral, and EC is low. The soils are well to moderately well drained. Depth to water table often could not be measured and it is assumed to be at substantial depth.

Table 128. Vegetation cover and frequency for Upland White Spruce–Ericaceous Forest (n=20).

	Cover		Freq
	Mean	SD	%
Total Live Cover	198.2	52.5	100
Total Vascular Cover	133.9	36.2	100
Total Evergreen Tree Cover	21.5	8.7	100
Picea glauca	21.5	8.7	100
Total Evergreen Shrub Cover	23.2	13.5	100
Andromeda polifolia	0.1	0.5	6
Dryas octopetala ssp. *alaskensis*	0.4	1.7	12
Empetrum nigrum	9.5	9.7	82
Juniperus communis	0.1	0.2	12
Ledum decumbens	4.6	5.5	82
Ledum groenlandicum	0.3	0.8	12
Linnaea borealis	2.4	3.2	53
Loiseleuria procumbens	0.1	0.2	6
Vaccinium vitis-idaea	5.8	6.1	94
Total Deciduous Tree Cover	0.0	0.0	12
Total Deciduous Shrub Cover	67.7	33.2	100
Alnus crispa	9.2	11.4	59
Arctostaphylos alpina	0.1	0.3	12
Arctostaphylos rubra	0.5	1.1	24
Betula glandulosa	12.7	19.2	53
Betula nana	6.2	12.0	47
Rosa acicularis	0.1	0.2	12
Salix chamissonis	1.5	4.9	12
Salix fuscescens	1.0	3.6	12
Salix glauca	1.5	3.4	24
Salix lanata ssp. *richardsonii*	0.9	1.9	29
Salix planifolia ssp. *pulchra*	3.9	7.5	65
Shepherdia canadensis	0.2	0.5	12
Spiraea beauverdiana	7.7	13.0	65
Vaccinium uliginosum	22.1	17.1	94
Total Forb Cover	12.8	19.0	100
Anemone parviflora	0.4	1.5	6
Anemone richardsonii	0.1	0.2	6
Artemisia arctica ssp. *arctica*	0.2	0.7	12
Boykinia richardsonii	0.1	0.5	6
Dodecatheon frigidum	0.4	1.1	12
Dryopteris dilatata ssp. *americana*	0.3	1.2	6
Equisetum arvense	1.2	3.7	24
Equisetum pratense	4.1	15.7	12
Equisetum sylvaticum	0.2	0.7	12
Gymnocarpium dryopteris	0.3	1.2	6
Lupinus arcticus	0.2	0.7	12
Lycopodium alpinum	0.4	1.7	6
Lycopodium annotinum	0.5	1.0	47
Lycopodium clavatum	0.1	0.2	12
Lycopodium complanatum	0.1	0.2	6
Mertensia paniculata	0.1	0.2	6
Pedicularis labradorica	0.1	0.2	29
Petasites frigidus	0.8	2.9	12
Pyrola secunda	0.2	0.5	29
Rubus arcticus	0.2	1.0	12
Rubus arcticus ssp. *arcticus*	0.2	0.5	12
Rubus arcticus ssp. *stellatus*	0.1	0.2	6

Table 128. Continued.

	Cover		Freq
	Mean	SD	%
Rubus chamaemorus	2.0	5.1	29
Saussurea angustifolia	0.1	0.3	29
Trientalis europaea ssp. *arctica*	0.2	0.6	24
Valeriana capitata	0.1	0.2	18
Total Grass Cover	5.0	6.8	94
Arctagrostis latifolia	0.5	0.9	35
Calamagrostis canadensis	3.7	6.9	59
Festuca altaica	0.7	1.8	24
Total Sedge & Rush Cover	3.8	6.7	71
Carex aquatilis ssp. *aquatilis*	0.1	0.2	6
Carex bigelowii	1.1	1.7	53
Carex membranacea	0.1	0.5	6
Carex podocarpa	0.5	1.2	18
Carex scirpoidea	0.7	2.9	18
Carex vaginata	0.1	0.2	6
Eriophorum angustifolium	1.2	4.9	6
Eriophorum vaginatum	0.1	0.2	6
Total Nonvascular Cover	64.2	27.7	100
Total Moss Cover	49.8	28.1	100
Aulacomnium acuminatum	0.3	1.2	6
Aulacomnium palustre	0.8	1.6	35
Aulacomnium sp.	0.2	1.0	6
Aulacomnium turgidum	0.2	0.8	18
Dicranum elongatum	0.2	1.0	6
Dicranum sp.	1.6	1.9	59
Hylocomium splendens	27.3	22.3	82
Pleurozium schreberi	9.1	8.5	76
Polytrichum commune	1.2	4.9	6
Polytrichum juniperinum	0.3	0.8	12
Polytrichum sp.	0.7	1.4	35
Ptilidium ciliare	0.9	3.6	18
Rhytidiadelphus triquetrus	0.2	0.7	6
Rhytidium rugosum	0.4	1.3	12
Sphagnum sp.	3.6	12.0	41
Thuidium sp.	0.6	2.4	6
Tomentypnum nitens	1.2	3.8	18
Unknown moss	0.6	2.4	12
Total Lichen Cover	14.4	18.3	94
Cetraria cf. *islandica*	1.4	2.5	53
Cetraria islandica ssp. *islandica*	0.4	1.7	6
Cladina arbuscula	1.2	2.9	18
Cladina mitis	0.3	0.8	18
Cladina rangiferina	2.4	4.2	59
Cladina sp.	0.5	1.3	18
Cladina stellaris	3.5	9.1	41
Cladina stygia	1.0	2.2	18
Cladonia sp.	2.1	3.9	59
Flavocetraria cucullata	0.5	1.3	24
Nephroma arcticum	0.4	1.0	29
Peltigera aphthosa	0.2	0.4	47
Peltigera sp.	0.1	0.3	24
Stereocaulon sp.	0.2	0.8	12
Total Bare Ground	4.9	3.1	100
Bare Soil	0.4	1.2	53
Litter alone	4.4	2.6	100

Table 129. Soil characteristics for Upland White Spruce–Ericaceous Forest.

Property	Mean	SD	n
Elevation (m)	289.9	178.4	16
Slope (degrees)	11.8	5.3	16
Surface Organics Depth(cm)	9.8	6.9	17
Cumulative Org. in 40 cm (cm)	10.2	7.1	17
Loess Cap Thickness (cm)	24.6	31.2	5
Depth to Rocks (cm)	51.1	69.2	14
Surface Fragment Cover (%)	1.4	1.5	3
Frost Boil Cover (%)			0
Thaw Depth (cm)	49.0	33.9	2
Site pH at 10-cm depth	5.0	1.0	17
Site EC at 10-cm depth (µS/cm)	55.9	33.9	17
Water Depth (cm,+ above grnd)[a]	-169.8	70.5	12

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups include Typic Dystrocryepts (acidic, partially developed, lacking permafrost), Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m), and Typic Haplorthels (mineral soil over permafrost lacking cryoturbation). Uncommon subgroups include Humic Dystrogelepts (acidic, well drained, a moderately thick organic-rich A horizon, permafrost below 1 m) and Typic Haplocryods (moist, acidic, highly leached). This ecotype and associated soils are part of the Upland Rocky-loamy Circumacidic Tall Shrublands and Forests soil landscape, which also includes Upland Birch Forest, Upland Spruce–Birch Forest, Upland Alder–Willow Tall Shrub, and Upland Bluejoint Meadow.

Upland White Spruce–Lichen Woodland

Geomorphology:

This ecotype occurs on eolian inactive sand dunes in KOVA. These dunes are stable enough for a thick cover of lichens to develop. Surface forms include slopes, shoulders and crests.

Plant Association:

Picea glauca–Cladina stellaris

Lichens and white spruce are co-dominant in this ecotype (Table 130). Spruce trees have 10–24% cover. Deciduous and evergreen shrubs, grasses and forbs are always present in low quantities. Sedges are absent. Common species include *Empetrum nigrum*, *Vaccinium uliginosum*, *Solidago multiradiata*, *Cladina rangiferina*, *C. stellaris*, *Flavocetraria nivalis* and *Stereocaulon* sp.

This ecotype is most similar to Upland White Spruce–Dryas Woodland except the substrate is more stabilized and lichens are more prevalent.

Table 130. Vegetation cover and frequency for Upland White Spruce–Lichen Woodland (n=4).

	Cover		Freq
	Mean	SD	%
Total Live Cover	122.6	6.0	100
Total Vascular Cover	45.7	27.4	100
Total Evergreen Tree Cover	20.0	10.0	100
Picea glauca	20.0	10.0	100
Total Evergreen Shrub Cover	8.0	8.7	100
Arctostaphylos uva-ursi	1.3	0.6	100
Empetrum nigrum	6.0	7.8	100
Vaccinium vitis-idaea	0.7	1.1	67
Total Deciduous Tree Cover	0.1	0.1	67
Populus balsamifera	<0.1	0.1	33
Populus tremuloides	<0.1	0.1	33
Total Deciduous Shrub Cover	14.2	16.3	100
Betula nana	5.0	8.6	67
Betula occidentalis	0.7	1.2	33
Salix bebbiana	<0.1	0.1	33
Salix monticola	<0.1	0.1	33
Salix sp.	<0.1	0.1	33
Vaccinium uliginosum	8.4	7.6	100
Total Forb Cover	2.7	2.3	100
Armeria maritima	<0.1	0.1	33
Arnica frigida	<0.1	0.1	33
Artemisia arctica ssp. *arctica*	0.7	1.2	33
Artemisia furcata	<0.1	0.1	33
Astragalus aboriginum	<0.1	0.1	33
Bupleurum triradiatum ssp. *arcticum*	<0.1	0.1	33
Cnidium cnidiifolium	<0.1	0.1	33
Dianthus repens	<0.1	0.1	33
Epilobium angustifolium	<0.1	0.1	33
Erigeron elatus	<0.1	0.1	33
Geocaulon lividum	1.3	1.5	67
Lupinus arcticus	<0.1	0.1	33
Lupinus kuschei	<0.1	0.1	33
Minuartia sp.	<0.1	0.1	33
Pedicularis labradorica	0.1	0.1	67
Pulsatilla patens multifida	<0.1	0.1	33
Rumex acetosa ssp. *acetosa*	<0.1	0.1	33
Selaginella sibirica	<0.1	0.1	33
Senecio ogotorukensis	<0.1	0.1	33
Solidago multiradiata var. *multiradiata*	0.1	<0.1	100
Total Grass Cover	0.8	0.4	100
Bromus pumpellianus var. *arcticus*	<0.1	0.1	33
Calamagrostis purpurascens	<0.1	0.1	33
Festuca altaica	0.7	0.6	67
Festuca saximontana	<0.1	0.1	33
Total Nonvascular Cover	76.8	21.5	100
Total Moss Cover	9.1	9.9	100
Abietinella abietina	<0.1	0.1	33
Dicranum sp.	0.3	0.6	33
Pleurozium schreberi	1.7	2.9	67
Polytrichum juniperinum	0.3	0.6	33
Polytrichum piliferum	1.7	2.9	33
Racomitrium lanuginosum	5.0	8.7	33
Rhytidium rugosum	<0.1	0.1	33

Table 130. Continued.

	Cover		Freq
	Mean	SD	%
Total Lichen Cover	67.7	14.3	100
Cetraria cf. *islandica*	0.3	0.6	33
Cladina arbuscula	3.3	5.8	33
Cladina mitis	3.3	5.8	33
Cladina rangiferina	5.0	5.0	67
Cladina sp.	0.7	1.2	33
Cladina stellaris	28.3	20.2	100
Cladonia amaurocraea	3.3	5.8	33
Cladonia sp.	3.0	1.7	100
Flavocetraria nivalis	2.3	1.5	100
Peltigera aphthosa	1.0	1.0	67
Peltigera canina	0.4	0.6	67
Peltigera sp.	<0.1	0.1	33
Stereocaulon paschale	15.0	26.0	33
Stereocaulon sp.	1.3	1.2	67
Thamnolia sp.	0.3	0.6	33
Total Bare Ground	1.7	0.6	100
Bare Soil	<0.1	0.1	33
Litter alone	1.7	0.6	100

Soils

Soils are sandy and typically feature a thin discontinuous surface organic horizon (Table 131). Thaw depths could not be determined as the depth to permafrost, if present, was always greater than the maximum depth sampled (1.3 m). Frost boils, surface fragments, and loess caps are absent. Soil pH is acidic, and EC is low. The soils are typically excessively to somewhat excessively well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 131. Soil characteristics for Upland White Spruce–Lichen Woodland.

Property	**Mean**	**SD**	**n**
Elevation (m)	77.0	4.9	4
Slope (degrees)	8.0	2.8	2
Surface Organics Depth(cm)	1.7	1.2	3
Cumulative Org. in 40 cm (cm)	1.7	1.2	3
Loess Cap Thickness (cm)			0
Depth to Rocks (cm)	200.0		1
Surface Fragment Cover (%)			0
Frost Boil Cover (%)			0
Thaw Depth (cm)			0
Site pH at 10-cm depth	5.4	0.1	4
Site EC at 10-cm depth (µS/cm)	20.0	17.3	3
Water Depth (cm,+ above grnd)[a]	-200.0		1

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroup in this ecotype is Typic Cryopsamments (sandy, low coarse fragment content, well drained, lacking permafrost). A less common subgroup is Typic Dystrocryepts (acidic, partially developed, lacking permafrost). This ecotype and associated soils are part of the Upland Sandy Forest soil landscape. Also included in this soil landscape is Upland White Spruce–Dryas Woodland.

Upland White Spruce–Willow Forest

Geomorphology:

This ecotype is widespread in uplands in the boreal regions of ARCN, sometimes comprising circumpolar treeline. Surfaces are sloped and it occurs at elevations up to 550 m. It is found on hillside colluvium, older moraine, retransported deposits and abandoned alluvial fan deposits. Parent material is usually alkaline.

Plant Association:

Picea glauca–Salix reticulata–Carex scirpoidea

Vegetation is dominated by white spruce and deciduous shrubs. White spruce stands vary from woodlands to open canopies (10–74% cover). Cover of evergreen shrubs, forbs and mosses can be high (Table 132). Sedges are usually present in low amounts. This ecotype has high species diversity and ranks 3rd highest in species count per plot and 7th highest in the overall species count. Common species include *Arctostaphylos rubra*, *Potentilla fruticosa* (syn: *Dasiphora fruticosa*), *Salix reticulata*, *S. lanata* ssp. *richardsonii* (syn. *S. richardsonii*), *Vaccinium uliginosum*, *Anemone parviflora*, *Carex scirpoidea*, *Hylocomium splendens*, and *Peltigera aphthosa*.

This ecotype is similar to Upland White Spruce–Ericaceous Forest except willow is the dominant understory species instead of ericaceous shrubs. Site chemistry is also more alkaline, and it has higher species diversity.

Soils:

Soils are typically rubbly, blocky, or loamy and feature a thin to moderately thick surface organic horizon (Table 133). Thaw depths often could not be determined in the rocky soils, but permafrost is presumed to be present below 1 m. Frost boils, loess caps, and surface fragments are rare. Soil pH is alkaline to circumneutral, and EC is low. The soils are typically moderately well to well drained. Depth to water table often could not be measured but it is assumed to be at substantial depths given the well drained soils.

Table 132. Vegetation cover and frequency for Upland White Spruce–Willow Forest (n=19).

	Cover		Freq
	Mean	SD	%
Total Live Cover	176.9	59.7	100
Total Vascular Cover	132.2	41.1	100
Total Evergreen Tree Cover	26.2	15.5	100
Picea glauca	24.1	11.9	100
Picea mariana	2.1	8.5	12
Total Evergreen Shrub Cover	17.2	12.3	100
Andromeda polifolia	1.1	2.6	59
Cassiope tetragona	1.0	1.8	41
Dryas integrifolia	2.5	6.4	41
Dryas octopetala	5.4	9.1	41
Empetrum nigrum	3.2	4.9	65
Juniperus communis	0.6	1.1	35
Ledum decumbens	0.3	0.7	18
Ledum groenlandicum	0.5	1.4	12
Linnaea borealis	0.7	1.6	24
Vaccinium vitis-idaea	1.0	2.6	29
Total Deciduous Tree Cover	0.0	0.0	6
Total Deciduous Shrub Cover	53.5	28.0	100
Alnus crispa	8.4	11.2	59
Arctostaphylos rubra	4.4	6.2	88
Betula glandulosa	0.4	1.2	18
Betula nana	4.3	11.9	47
Potentilla fruticosa	4.9	4.9	82
Salix alaxensis	1.4	3.9	29
Salix arctica	1.4	2.8	24
Salix glauca	4.2	5.4	59
Salix lanata ssp. *richardsonii*	5.6	5.1	76
Salix planifolia ssp. *pulchra*	0.7	2.4	24
Salix reticulata	8.6	9.4	76
Vaccinium uliginosum	8.1	9.6	76
Total Forb Cover	26.3	14.9	100
Anemone parviflora	1.4	2.0	71
Aster sibiricus	1.3	2.5	41
Boykinia richardsonii	1.6	6.1	12
Chrysanthemum integrifolium	0.4	0.9	29
Cypripedium passerinum	0.2	0.5	24
Cystopteris montana	0.2	0.7	12
Dodecatheon frigidum	0.4	0.6	35
Dodecatheon pulchellum	0.5	1.3	18
Equisetum arvense	7.6	12.7	59
Equisetum scirpoides	0.3	0.6	41
Equisetum variegatum	0.1	0.2	18
Gentiana propinqua	0.2	0.4	29
Hedysarum alpinum	1.4	2.0	47
Lagotis glauca ssp. *glauca*	0.4	0.7	47
Lycopodium annotinum	0.3	0.8	12
Mertensia paniculata	0.8	1.4	35
Minuartia arctica	0.2	0.6	18
Moneses uniflora	0.1	0.5	35
Parnassia palustris	0.1	0.3	24
Parrya nudicaulis	0.1	0.2	18
Pedicularis capitata	0.2	0.6	24
Pedicularis labradorica	0.2	0.5	24
Pedicularis langsdorffii	0.1	0.3	24
Pinguicula vulgaris	0.1	0.2	18

Table 132. Continued.

	Cover Mean	Cover SD	Freq %
Polygonum bistorta	0.1	0.2	18
Polygonum viviparum	0.3	0.5	47
Rubus arcticus	0.4	1.2	18
Saussurea angustifolia	1.2	1.7	65
Saxifraga bronchialis	0.1	0.2	18
Senecio atropurpureus	0.1	0.3	18
Silene acaulis	0.4	0.6	47
Solidago multiradiata	0.4	1.0	29
Solidago multiradiata var. *multiradiata*	0.2	0.5	18
Thalictrum alpinum	0.3	0.8	47
Tofieldia coccinea	0.2	0.4	29
Tofieldia pusilla	0.1	0.2	24
Zygadenus elegans	0.6	0.9	41
Total Grass Cover	3.0	2.6	94
Arctagrostis latifolia	0.2	0.4	35
Calamagrostis canadensis	0.1	0.3	24
Festuca altaica	2.4	2.5	65
Total Sedge & Rush Cover	5.9	4.7	100
Carex bigelowii	0.4	1.3	18
Carex capillaris	0.1	0.3	24
Carex membranacea	0.5	1.1	35
Carex scirpoidea	4.0	4.4	71
Kobresia myosuroides	0.2	0.5	12
Total Nonvascular Cover	44.7	29.3	100
Total Moss Cover	39.9	29.9	100
Aulacomnium palustre	1.3	3.8	18
Brachythecium salebrosum	0.7	2.1	12
Dicranum sp.	0.9	1.8	29
Drepanocladus sp.	0.8	1.7	24
Hylocomiastrum pyrenaicum	0.3	1.0	12
Hylocomium splendens	23.2	25.4	71
Pleurozium schreberi	0.4	1.2	12
Ptilidium ciliare	0.1	0.3	18
Rhytidium rugosum	3.5	7.7	24
Sanionia uncinata	1.9	3.0	47
Tomentypnum nitens	3.8	6.5	41
Unknown moss	0.4	0.9	18
Total Lichen Cover	4.8	5.4	100
Cetraria cf. *islandica*	0.3	0.7	18
Cladina arbuscula	0.3	0.8	18
Cladina mitis	0.4	1.3	24
Cladina rangiferina	0.2	0.7	12
Cladina stygia	0.2	0.8	12
Cladonia sp.	0.5	1.0	65
Flavocetraria cucullata	0.2	0.7	18
Flavocetraria nivalis	0.4	1.0	12
Peltigera aphthosa	0.2	0.4	47
Peltigera sp.	0.1	0.3	24
Unknown crustose lichen	1.0	2.6	18
Vulpicida sp.	0.4	0.9	18
Total Bare Ground	9.3	12.0	94
Bare Soil	1.9	4.3	53
Litter alone	7.4	8.2	94

Table 133. Soil characteristics for Upland White Spruce–Willow Forest.

Property	Mean	SD	n
Elevation (m)	237.5	121.4	17
Slope (degrees)	10.3	7.7	17
Surface Organics Depth(cm)	9.2	6.7	17
Cumulative Org. in 40 cm (cm)	9.5	6.8	17
Loess Cap Thickness (cm)	13.0	NA	1
Depth to Rocks (cm)	16.1	11.5	15
Surface Fragment Cover (%)	13.3	10.4	3
Frost Boil Cover (%)	6.5	5.7	4
Thaw Depth (cm)	107.0	60.8	2
Site pH at 10-cm depth	7.0	0.8	16
Site EC at 10-cm depth (µS/cm)	118.8	39.8	16
Water Depth (cm,+ above grnd)[a]	-152.3	45.4	11

[a]Measurements >1 m indicate minimum depth, not true depth

The dominant soil subgroups in this ecotype are Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m), Humic Eutrogelepts (non-acidic, well drained, a moderately thick organic-rich A horizon, permafrost below 1 m), and Typic Haplorthels (mineral soil over permafrost lacking cryoturbation). Less common subgroups include Typic Haplocryepts (non-acidic, partially developed, lacking permafrost) and Typic Haplogelolls (non-acidic, well-drained, thick organic-rich A horizon, permafrost below 1 m and lacking cryoturbation). This ecotype and associated soils are part of the Upland Rocky-loamy Circumalkaline Low Shrublands and Forests soil landscape. Other ecotypes found in this soil landscape include Upland Sedge–Dryas Meadow and Upland Willow Low Shrub.

Upland Willow Low Shrub

Geomorphology:

Upland gentle to moderate slopes on colluvium and alluvial fan deposits. This type is found throughout ARCN at elevations between 150 and 600 m and is associated with alkaline soil parent material.

Plant Association:

Salix lanata ssp. *richardsonii–Equisetum arvense*

Vegetation is dominated by low willows (0.2–1.5 m tall), with an open to closed canopy (Table 134). The canopy is dominated by *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), but often includes *S. glauca* and *S. planifolia* ssp. *pulchra* (syn: *S. pulchra*). Forbs are prevalent, specifically *Equisetum arvense and Valeriana capitata*. Other common species include *Dryas* spp., *Vaccinium uliginosum, S. reticulata,* and *Festuca altaica*. The mosses *Tomentypnum nitens* and *Hylocomium splendens* are also common. This ecotype has high species diversity.

Upland Birch–Willow Low Shrub is similar to this ecotype except dwarf birch is co-dominant and *S. planifolia* ssp. *pulchra* is usually the dominant willow.

Soils:

Soils are loamy with a moderately thick surface organic horizon (Table 135). Permafrost often occurs in the upper meter of the soil profile. Frost boils, surface fragments, and loess caps are rare. Buried discontinuous organic layers sometimes occur as the result of cryoturbation of the surface organics. Soil pH is alkaline to circumneutral, and EC is low. The soils are somewhat poorly to well drained. The water table is shallow to moderately deep.

Table 134. Vegetation cover and frequency for Upland Willow Low Shrub (n=13).

	Cover		Freq
	Mean	SD	%
Total Live Cover	217.3	74.8	100
Total Vascular Cover	152.1	45.8	100
Total Evergreen Shrub Cover	13.2	12.3	77
Andromeda polifolia	0.9	1.9	31
Cassiope tetragona	0.3	0.4	54
Dryas integrifolia	5.2	7.9	46
Dryas octopetala	0.4	1.4	8
Dryas octopetala ssp. *alaskensis*	5.4	11.1	23
Empetrum nigrum	0.3	0.8	31
Ledum decumbens	0.4	1.0	31
Rhododendron lapponicum	0.2	0.6	31
Vaccinium vitis-idaea	0.1	0.3	23
Total Deciduous Shrub Cover	76.6	22.6	100
Arctostaphylos alpina	0.7	1.7	15
Arctostaphylos rubra	2.5	5.6	46
Betula glandulosa	2.1	6.9	23
Betula nana	0.9	1.5	46
Potentilla fruticosa	1.4	2.3	38
Salix alaxensis	1.4	4.2	23
Salix glauca	4.4	8.6	46
Salix hastata	5.8	20.8	15
Salix lanata ssp. *richardsonii*	29.5	18.7	92
Salix planifolia ssp. *pulchra*	2.7	5.9	38
Salix reticulata	21.2	16.6	92
Shepherdia canadensis	0.3	0.9	15
Vaccinium uliginosum	3.8	4.8	85
Total Forb Cover	49.1	31.5	100
Aconitum delphinifolium	0.2	0.6	15
Anemone parviflora	3.0	5.1	62
Anemone richardsonii	0.8	2.2	31
Arnica lessingii	0.1	0.3	15
Artemisia arctica ssp. *arctica*	0.3	0.9	15
Aster sibiricus	0.8	1.6	38
Boykinia richardsonii	0.5	1.4	15
Dodecatheon frigidum	1.1	2.0	54
Epilobium angustifolium	0.2	0.8	8
Equisetum arvense	30.8	31.1	92
Equisetum scirpoides	0.1	0.3	23
Equisetum variegatum	0.1	0.3	31
Hedysarum alpinum	1.8	3.3	38
Mertensia paniculata	0.5	1.9	8
Myosotis alpestris ssp. *asiatica*	0.5	1.1	15
Pedicularis capitata	<0.1	0.1	46
Petasites frigidus	1.2	2.8	31
Petasites hyperboreus	0.4	1.0	15
Polemonium acutiflorum	2.6	8.2	62
Polygonum bistorta	0.1	0.3	23
Polygonum viviparum	0.1	0.3	38
Rubus chamaemorus	0.2	0.8	8
Saussurea angustifolia	0.1	0.3	31
Saxifraga punctata	0.2	0.4	15
Senecio lugens	0.2	0.5	38
Solidago multiradiata var. *multiradiata*	0.1	0.3	23

Table 134. Continued.

	Cover		Freq
	Mean	SD	%
Thalictrum alpinum	0.2	0.6	31
Valeriana capitata	1.6	2.7	92
Zygadenus elegans	0.3	0.8	38
Total Grass Cover	6.3	9.7	100
Arctagrostis latifolia	0.6	1.1	38
Festuca altaica	5.0	9.3	77
Poa alpina	0.1	0.3	31
Poa arctica	0.1	0.3	31
Trisetum spicatum ssp. *spicatum*	0.1	0.3	54
Total Sedge & Rush Cover	7.0	7.5	85
Carex aquatilis ssp. *aquatilis*	0.8	2.8	8
Carex atrofusca	0.1	0.3	15
Carex bigelowii	3.6	5.8	62
Carex membranacea	0.4	0.8	23
Carex podocarpa	0.7	1.7	15
Carex scirpoidea	0.6	1.0	46
Eriophorum angustifolium	0.3	0.9	15
Eriophorum brachyantherum	0.3	1.1	8
Total Nonvascular Cover	65.2	48.4	100
Total Moss Cover	63.1	48.2	100
Abietinella abietina	0.2	0.6	8
Aulacomnium palustre	3.7	7.4	31
Brachythecium coruscum	0.8	2.8	8
Bryum pseudotriquetrum	0.8	2.8	8
Bryum sp.	0.1	0.3	15
Dicranum sp.	0.9	1.3	38
Distichium capillaceum	0.2	0.8	8
Drepanocladus sp.	2.3	5.6	15
Hylocomium splendens	14.4	21.0	69
Hypnum sp.	0.4	1.4	8
Mnium sp.	0.8	1.9	15
Pleurozium schreberi	0.7	1.7	15
Polytrichum juniperinum	0.2	0.8	15
Ptilidium ciliare	0.8	1.9	15
Racomitrium lanuginosum	0.2	0.6	8
Rhytidium rugosum	0.5	1.7	8
Sanionia uncinata	1.2	2.2	23
Syntrichia norvegica	0.2	0.6	8
Thuidium recognitum	0.6	2.2	8
Tomentypnum nitens	12.8	13.6	92
Tortula norvegica	0.2	0.8	15
Unknown moss	21.2	30.1	46
Total Lichen Cover	2.1	3.3	77
Cetraria cf. *islandica*	0.2	0.6	15
Cladina arbuscula	0.1	0.3	15
Cladonia sp.	0.3	0.6	46
Flavocetraria cucullata	0.2	0.5	31
Peltigera aphthosa	0.3	0.6	38
Peltigera sp.	0.1	0.3	23
Stereocaulon sp.	0.2	0.8	8
Unknown lichen	0.2	0.6	15
Total Bare Ground	6.3	5.4	100
Bare Soil	1.0	1.9	69
Water	0.2	0.6	15
Litter alone	5.2	4.8	100

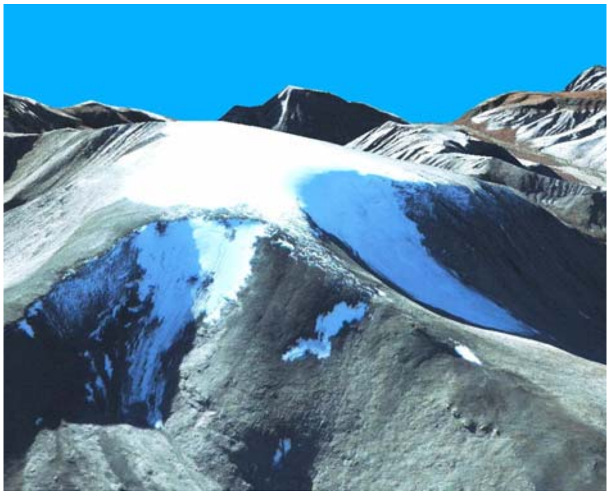
Table 135. Soil characteristics for Upland Willow Low Shrub.

Property	Mean	SD	n
Elevation (m)	363.7	174.1	13
Slope (degrees)	10.2	7.3	13
Surface Organics Depth(cm)	9.5	6.3	13
Cumulative Org. in 40 cm (cm)	12.2	6.9	13
Loess Cap Thickness (cm)	13.0	NA	1
Depth to Rocks (cm)	85.2	81.2	10
Surface Fragment Cover (%)	1.0	NA	1
Frost Boil Cover (%)	1.0	0.0	2
Thaw Depth (cm)	67.0	33.7	7
Site pH at 10-cm depth	7.0	0.6	13
Site EC at 10-cm depth (µS/cm)	214.6	168.0	13
Water Depth (cm,+ above grnd)[a]	-63.2	53.0	12

[a]Measurements >1 m indicate minimum depth, not true depth

Dominant soil subgroups include Typic Aquorthels (wet, mineral soil over permafrost lacking cryoturbation) and Typic Eutrogelepts (non-acidic, partially developed with permafrost below 1 m). Uncommon subgroups include Aquic Eutrogelepts (wet, non-acidic, mineral soil, permafrost below 1 m), Typic Historthels (wet, organic rich soil over permafrost lacking cryoturbation), and Typic Haploturbels (mineral soil over permafrost with cryoturbation). This ecotype and associated soils are part of the Upland Rocky-loamy Circumalkaline Low Shrublands and Forests soil landscape, which also includes Upland Sedge–Dryas Meadow and Upland White Spruce–Willow Forest ecotypes.

Snow/Glaciers



Geomorphology:

Permanent snowfields and glaciers occur infrequently on high-elevation mountaintops and cirques within GAAR and NOAT. Snow/Glaciers occur near the crest of the Brooks Range.

Plant Association:

No vegetation is present on the snow and ice surfaces.

Soil:

No soils are associated with the snow and ice, although rocks and fine-grained debris can accumulate on the glacial surface at lower elevations.

Rare Ecotypes

We identified 8 ecotypes that were rare in ARCN. These include Alpine Rocky-loamy Moist Circumneutral Willow Dwarf Shrub, Coastal Aquatic Brackish Marestail Marsh, Lowland Circumneutral Sweetgale Low Shrub Fen, Lowland Organic-rich Moist Circumalkaline White Spruce Forest, Riverine Loamy Moist Circumacidic Birch Forest, Upland Loamy Moist Circumacidic Willow Tall Shrub, and Upland Sandy Dry Circumneutral Aspen Forest.

Alpine Rocky-loamy Moist Circumneutral Willow Dwarf Shrub occurs in small patches in late-thawing snow beds in the mountains throughout ARCN. It is species-rich with a plant association of *Salix polaris–Boykinia richardsonii*. Common species include *Salix reticulata*, *Salix rotundifolia*, *Equisetum arvense* and *Racomitrium* spp. Surface horizons vary from thin to thick and the dominant texture varies from blocky to organic.

Coastal Aquatic Brackish Marestail Marsh occurs in shallow waters near the coast in BELA and CAKR. It is characterized by *Hippurus tetraphylla*. Water is brackish and soils are permanently flooded.

Lowland Circumneutral Sweetgale Low Shrub Fen occurs in small patches in organic fen ecosystems and usually grows inter-mixed with Lowland Birch–Willow Low Shrub. Dominant plant species include *Equisetum fluviatile*, *Myrica gale*, *Menyanthes trifoliata*, *Sphagnum russowii* and *Sphagnum fuscum*. Surface horizons are typically thick and depth to the water table is shallow.

Lowland Organic-rich Moist Circumalkaline White Spruce Forest is occurs uncommonly throughout the boreal regions of KOVA and GAAR. Dominant plant species include *Picea glauca*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Hylocomium splendens*, and *Sphagnum warnstorfii*. Soils are loamy to organic and surface organic layers are moderate to thick. Surface geomorphology includes braided abandoned overbank deposits and retransported deposits.

Riverine Loamy Moist Circumacidic Birch Forest occurs infrequently on meander inactive overbank deposits in GAAR. Dominant plant species include *Betula papyrifera* (syn: *B. neoalaskana*), *Calamagrostis canadensis*, *Linnaea borealis*, *Equisetum pratense* and *Hylocomium splendens*. Soils are loamy with a thin surface organic horizon.

Upland Loamy Moist Circumacidic Willow Tall Shrub was documented in CAKR. Dominant plant species include *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *Equisetum arvense*, *Petasites frigidus*, and *Valeriana capitata*. We did not collect any soils data on this ecotype.

Upland Sandy Dry Circumneutral Aspen Forest occurs in small, isolated stands on stabilizedeolian inactive sand dunes in KOVA. Dominant plant species include *Populus tremuloides*, *Cladina* spp., *Salix glauca*, *Rosa acicularis*, *Polytrichum piliferum*, and *Flavocetraria cucullata*. Soils are sandy with a thin surface organic horizon. The water table is typically at >2 m depth.

Lowland Sedge–Dryas Meadow occurs on the coastal plains of BELA and CAKR. The main difference between this ecotype and Upland Sedge–Dryas Meadow, with which it was aggregated for mapping in NOAT and KOVA, is that it occurs at lower elevations on coastal plains and drainages versus upland or mountainous areas.

Table 136. Key to ecotypes for the Arctic Network.[1,2]

1a. Permanent **waterbody** (water typically >10 cm deep)…… 2
2a. Waterbody with < 10% cover of emergent vegetation…… 3
3a. Waterbody occurs near the coast and is affected by the ocean…… 4
4a. Waterbody is an ocean…… Coastal Nearshore Water
4b. Waterbody is a river near its confluence with the ocean that experiences tidal fluctuations…… Coastal Tidal River
4c. Waterbody is an estuarine lake or pond…… Coastal Brackish Water
3b. Waterbody occurs inland and is not affected by the ocean…… 5
5a. Waterbody is a perennial river (flowing water)…… River
5b. Waterbody is a lake or pond…… 6
6a. Lake developed in an abandoned river channel on a floodplain…… Riverine Lake
6b. Lake did not develop in an abandoned river channel on a floodpain……7
7a. Lake is at low elevations in valley bottoms and flatlands……Lowland Lake
7b. Lake is at high elevations in the mountains……Alpine Lake
2b. Waterbody with ≥ 10% cover of emergent vegetation…… 8
8a. Waterbody occurs in a shallow river channel and *Equisetum fluviatile* is the dominant species……Riverine Forb Marsh
8b. Waterbody occurs in a lake basin……9
9a. Vegetation has higher cover of graminoids than forbs ……Lacustrine Pendent Grass Marsh
9b. Vegetation is predominately forbs……10
10a. Vegetation occurs on floating mats and the dominant forb is *Menyanthes trifoliata*……Lacustrine Buckbean Fen
10b. Vegetation does not occur on floating mats and *Menyanthes trifoliata* is not the dominant forb…… 11
11a. Pondlily, *Nuphar polysepalum* is the dominant forb and grows in deep water……Lacustrine Pondlily Lake
11b. Pondlilies are absent or present in trace amounts……12
12a. The dominant species is marestail, *Hippurus vulgaris*…… Lacustrine Marestail Marsh
12b. The dominant species is horsetail, *Equisetum fluviatile*…… Lacustrine Horsetail Marsh
1b. Not a permanent waterbody……13
13a. Site is proximal to the **ocean**, electrical conductivity (EC) is > 800 µs/cm, and is affected by ocean processes including tidal fluctuations, storm surges, and wind-borne salt water…… 14
14a. Vegetation cover <30% …… 15
15a. Site occurs on active marine beaches and soil is dry……Coastal Dry Barrens
15b. Site occurs on active tidal flats and soil is wet……Coastal Wet Barrens
14b. Vegetation cover ≥30%…… 16
16a.Shrub cover ≥ 25%…… 17
17a. Soils are moist to dry and dominant species is crowberry, *Empetrum nigrum*……Coastal Crowberry Dwarf Shrub
17b. Soils are wet and dominant species is the willow, *Salix ovalifolia*……Brackish Willow Shrub
16b. Shrub cover < 25%…… 18
18a. Soils are moist to dry and dominant species is lyme grass (*Elymus arenarius* ssp. *mollis* or syn: *Leymus mollis*)…… Coastal Brackish Dunegrass Meadow
18b. Sites are wet and dominant species is *Carex ramenskii*……19
19a. Water chemistry is brackish (800-15,999 µs/cm) and *Dupontia fischeri* is abundant…… Coastal Brackish Sedge–Grass Meadow
19b. Water chemistry is saline (>16,000 µs/cm) and *Puccinellia phryganodes* is abundant……Coastal Saline Sedge–Grass Meadow
13b. Site occurs **inland**, electrical conductivity is < 800 µs/cm, and is not affected by the ocean…… 20
20a. **Barren** or partially vegetated where total <u>vascular</u> plant cover <30%…… 21
21a. Site is on an active floodplain…… Riverine Barrens
21b. Site is on other terrain……22
22a. Site located in drained lake basin or margin of a waterbody……Lacustrine Barrens
22b. Site not adjacent to a waterbody or lake basin……23
23a. Site occurs on old lava flows in BELA……Upland Mafic Barrens
23b. Site occurs elsewhere…… 24
24a. Site is an active sand dune……Upland Sandy Barrens
24b. Site is in mountains at higher elevations than the vegetated zone…… 25
25a. Site chemistry is acidic…… Alpine Acidic Barrens
25b. Site chemistry is alkaline…… 26
26a. Bedrock consists of mafic or ultramafic, iron-rich rocks……Alpine Mafic Barrens
26b. Bedrock consists of other types of alkaline rocks…… Alpine Alkaline Barrens
20b. Vegetation cover (vascular species only) ≥ 30% …… 27

Table 136. Continued.

27a. **Tree canopy is < 10% cover** …… 28

28a. **Shrub cover is < 25%** and vegetation is primarily graminoid-dominated …… 29

29a. Cover of grasses, particularly bluejoint, *Calamagrostis* spp., is > cover of sedges …… 30

30a. Soils are wet and site occurs in a lake basin …… Lacustrine Bluejoint Meadow

30b. Soils are wet to moist and site occurs on an inactive floodplain …… Riverine Bluejoint Meadow

30c. Soils are moist and site occurs on a hillside …… Upland Bluejoint Meadow

29b Cover of sedges is greater than cover of grasses …… 31

31a. Tussock cover is >25% …… Upland Dwarf Birch–Tussock Shrub

31b. Tussock cover is < 25% …… 32

32a. Soils are moist and *Dryas* spp. have 1–24% cover …… Upland Sedge–Dryas Meadow

32b. Soils are wet and *Dryas* spp. mostly absent …… 33

33a. Site is located on a floodplain and soils are predominantly loamy …… Riverine Wet Sedge Meadow

33b. Site is not located on a floodplain …… 34

34a Site is located in a lake basin, soils are loamy to organic, *Potentilla palustris* (syn: *Comarum palustris*) typically present …… Lacustrine Wet Sedge Meadow

34b Site is not located in a lake basin …… 35

35a. Soils are rocky and/or elevation >500 m …… Alpine Wet Sedge Meadow

35b. Soils are peaty to organic-rich, elevation lower …… 36

36a. Diamond-leaved willow, *S. planifolia* ssp. *pulchra* (syn: *S. pulchra*) is present …… Lowland Sedge–Willow Fen

36b. *S. pulchra* usually absent or in trace quantities, total shrub cover is <5% …… Lowland Sedge Fen

28b. **Shrub cover is >25%** …… 37

37a. **Shrub height < 0.20 m** …… 38

38a. *Dryas* spp. are dominant and have higher cover than other shrub species …… 39

39a. Site occurs on river floodplains …… Riverine Dryas Dwarf Shrub

39b. Site occurs at higher elevations, not on floodplains …… 40

40a. Sedges are co-dominant and *Dryas* cover is near 25% …… Upland Sedge–Dryas Meadow

40b. Sedges are not co-dominant and *Dryas* cover is typically higher …… 41

41a. Soils are acidic, *Hierochloe alpina* usually present …… Alpine Acidic Dryas Dwarf Shrub

41b. Soils are alkaline, *Hierochloe alpina* usually absent …… Alpine Alkaline Dryas Dwarf Shrub

38b. Ericaceous species are dominant and have higher cover than *Dryas* spp. …… 42

42a. Bell Heather, *Cassiope tetragona* is the most common ericaceous shrub …… Alpine Cassiope Dwarf Shrub

42b. *C. tetragona* is not the most common ericaceous shrub …… Alpine Ericaceous–Dryas Dwarf Shrub

37b. Shrub height > 0.20m …… 43

43a. **Shrub height < 1.5 m** …… 44

44a. Tussocks (formed by *Eriophorum vaginatum*) have >25% cover …… Upland Dwarf Birch–Tussock Shrub

44b. Tussocks have <25% cover …… 45

45a. Site is on a riverine floodplain …… 46

46a. Dwarf birch, *Betula nana* is co-dominant with *Salix pulchra* …… Riverine Birch–Willow Low Shrub

46b. *B. nana* is absent or has low cover, and the dominant species is *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*) …… Riverine Willow Low Shrub

45b. Sites are in lowland, lacustrine or upland areas …… 47

47a. Site is in a basin at the edge of a lake or pond …… Lacustrine Willow Shrub

47b. Site is not in a lake basin …… 48

48a. Site occurs on hillsides in upland areas; soils are rocky or loamy, infrequently organic rich …… 49

50a. *Spiraea beauverdiana* (syn: *S. stevenii*) has the highest shrub cover …… Upland Spiraea Low Shrub

50b. Dwarf birch and willows are co-dominant, and willow cover is > ericaceous shrub cover …… Upland Birch–Willow Low Shrub

50c. Dwarf birch and ericaceous species are co-dominant, and willow cover is < ericaceous shrub cover …… Upland Birch–Ericaceous Low Shrub

48b. Site is on flats or in lowland areas, soils are organic to peaty …… 51

51a. Willow comprises ≥75% of total shrub cover …… Lowland Willow Low Shrub

51b. Willow comprises <25% of total shrub cover …… 52

52a. Dwarf birch and willows are co-dominant, and willow cover is > ericaceous shrub cover …… Lowland Birch–Willow Low Shrub

52b. Ericaceous species cover is > willow cover …… 53

53a. Dwarf birch cover is typically < 15%, site is wet …… Lowland Ericaceous Shrub Bog

53b. Dwarf birch cover is typically ≥ 15%, site is moist to wet …… Lowland Birch–Ericaceous Low Shrub

Table 136. Continued.

43b. **Shrub height > 1.5 m** ... 54
54a. Site is on hillslopes in upland areas ... Upland Alder–Willow Tall Shrub
54b. Site is located on low, gentle slopes and flats in lowland areas ... Lowland Alder Tall Shrub
54c. Site is located on riverine floodplains ... 55
55a. Vegetation is predominantly alder ... Riverine Alder Tall Shrub
55b. Vegetation is predominantly willow ... 56
56a. Felt Leaf willow, *Salix alaxensis* is the dominant species ... Riverine Moist Willow Tall Shrub
56b. Diamond leaf willow, *S. pulchra* is the dominant species ... Riverine Wet Willow Tall Shrub
28b. **Tree canopy is >10%** cover ... 57
57a. **Needleleaf** trees comprise >75% of total tree cover ... 58
58a. Site occurs in lowland areas and black spruce, *Picea mariana* is the dominant tree species ... Lowland Black Spruce Forest
58b. Site occurs in other areas and white spruce, *P. glauca* is the dominant tree ... 59
59a. Site occurs on a floodplain ... 60
60a. The dominant understory species is *Alnus crispa* and site chemistry is circumacidic ... Riverine White Spruce–Alder Forest
60b. The dominant understory species is *Salix richardsonii* and site chemistry is circumalkaline ... Riverine White Spruce–Willow Forest
59b. Site occurs on upland slopes in KOVA and GAAR ... 61
61a. Site occurs on hill slopes and mountainsides, usually on rocky or loamy soils ... 62
62a. Ericaceous species are dominant in the understory and site chemistry is circumacidic ... Upland White Spruce–Ericaceous Forest
62b. Willow species are dominant in the understory and site chemistry is circumalkaline ... Upland White Spruce–Willow Forest
61b. Site occurs on stabilized sand dunes ... 63
63a. Soils are circumalkaline and *Dryas* species are dominant in the understory ... Upland White Spruce–Dryas Woodland
63b. Soils are acidic and reindeer lichen, *Cladina* spp., are dominant in the understory ... Upland White Spruce–Lichen Woodland
57b. Needleleaf trees comprise <75% of total tree cover ... 64
64a. **Deciduous tree** species comprise >75% of total tree cover ... 65
65a. Site occurs on a floodplain and the dominant tree species is *Populus balsamifera* ... Riverine Poplar Forest
65b. Site occurs on hill slopes and the dominant tree species is *Betula papyrifera* (syn: *B. neoalaskana*) ... Upland Birch Forest
64b. Deciduous tree species comprise < 75% total tree cover ... 66
66a. Site occurs on a floodplain and *Picea glauca* and *Populus balsamifera* are co-dominant ... Riverine White Spruce–Poplar Forest
66b. Site occurs on hill slopes and *Picea glauca* and *Betula papyrifera* (syn: *B. neoalaskana*) are co-dominant ... Upland Spruce–Birch Forest

1. Shrub cover cutpoints represent general guidelines and classification should also rely on dominant indicator species and landscape position.
2. Rare ecotypes were not included in mapping, analysis or this key. These include Alpine Rocky-loamy Moist Circumneutral Willow Dwarf Shrub, Coastal Aquatic Brackish Marestail Marsh, Lowland Circumneutral Sweetgale Low Shrub Fen, Lowland Organic-rich Moist Circumalkaline White Spruce Forest, Riverine Loamy Moist Circumacidic Birch Forest, Upland Loamy Moist Circumacidic Willow Tall Shrub, and Upland Sandy Dry Circumneutral Aspen Forest.

Relationships Among Ecological Components

Landscape Relationships

Toposequences

The classification of ecotypes (local-scale ecosystems) was based on the survey of ecological components (topography, geomorphology, soil, hydrology, permafrost, and vegetation) along toposequences. The toposequences display two-dimensional views of the lithofacies that were used as the basis for classifying and mapping geomorphic units (Figures 4–8). Vegetation classes follow the AVC. Five ecosubsections within the study area are described below and they summarize some of the main ecological relationships within alkaline alpine-upland, nonalkaline alpine-upland, lowland (coastal plain), riverine, and coastal physiographic environments.

On an alpine and upland toposequence representative of the Nukatpiat Mountains, which were formed from noncarbonated sedimentary rock, the geomorphology was dominated by weathered bedrock, residual soils, hillslope colluvium, and narrow headwater floodplains (Figure 4). Soils on the rounded mountains vary from extremely rocky, excessively drained, strongly acidic soils near the summits, to moderately well-drained soils with moderately thick organic horizons mid-slope, to saturated organic soils on the toe slopes. Vegetation ranges from partially vegetated areas at the crests, to Dryas Dwarf Shrub Tundra on the upper slopes, to moist Open Low Shrub Birch–Ericaceous Shrub on mid- to lower slopes. The headwater floodplains support Open Tall Alder Shrub.

On an alkaline alpine and upland toposequence representative of the Squirrel Mountains, which were formed from carbonate sedimentary rock, the geomorphology was dominated by weathered bedrock, hillslope colluvium, and narrow headwater floodplains (Figure 5). Soils on the rounded mountains range from extremely rocky, excessively drained, strongly alkaline soils near the peaks, to moderately well-drained soils with moderately thick organic horizons mid-slope, to saturated organic soils on the toe slope. Vegetation ranges from partially vegetated areas at the crests, to Dryas Dwarf Shrub Tundra on the upper slopes, to Sedge–Dryas Tundra on mid- to lower slopes. The headwater floodplains support Open Tall Alder–Willow Shrub. Snowbeds, which are uncommon, support Cassiope Dwarf Shrub Tundra.

On a lowland and upland toposequence on glaciated terrain representative of the Nigu Glaciated Upland, the topography is gently undulating with prominent kettle lakes and drained basins (Figure 6). Geomorphic units include glacial till and colluvium draping old gentle slopes. Soils range from poorly drained silt loam soils to very poorly drained organic soils in drained basins, to moderately well-drained deposits on gentle upland slopes. In lake basins, vegetation shifts from Marestail and Fresh Grass Marshes in shallow water, to Bluejoint Meadows and Open Low Willow Shrub in recently drained basins, to Sedge Fen Meadows, Sedge–Moss Fen Meadows and Open Low Shrub Birch–Willow Shrub in wet, older portions of the basins. The gently sloping upland areas are dominated by Open Low Mixed Shrub Birch–Tussock Tundra and Mesic Shrub–Tussock Tundra, while windswept gravelly ridges support Dryas Tundra.

On a riverine toposequence representative of the Lower Noatak Floodplain, the geomorphology ranges from active, high-energy fluvial regimes associated with the meander active channel deposits to lower energy regimes associated with meander inactive overbank deposits and abandoned channels (Figure 7). Across this

Nukatpiat Mountains

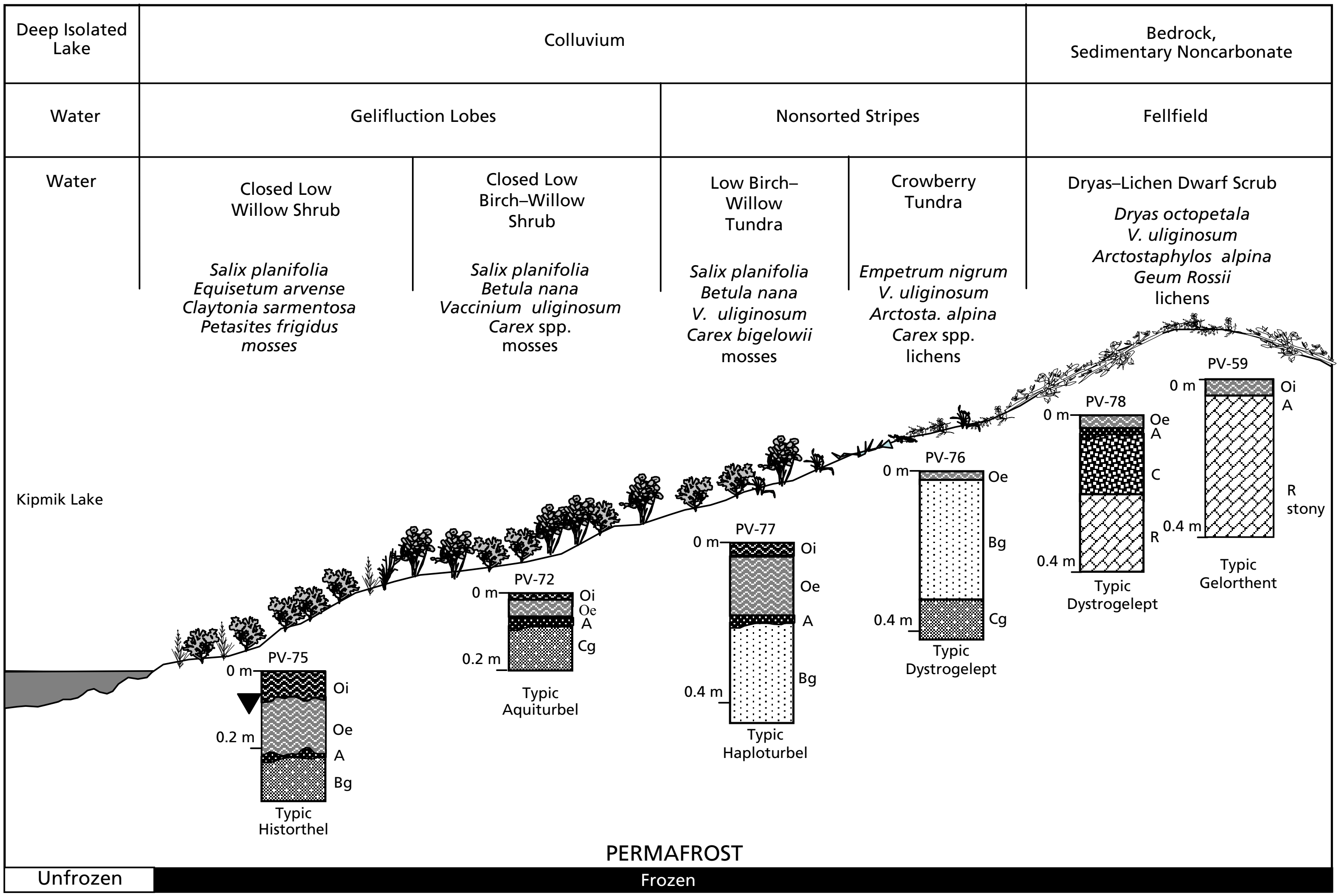


Figure 4. A generalized toposequence illustrating relationships among topography, geology, geomorphology, permafrost, soils, and vegetation within the Nukatpiat Mountains subsection.

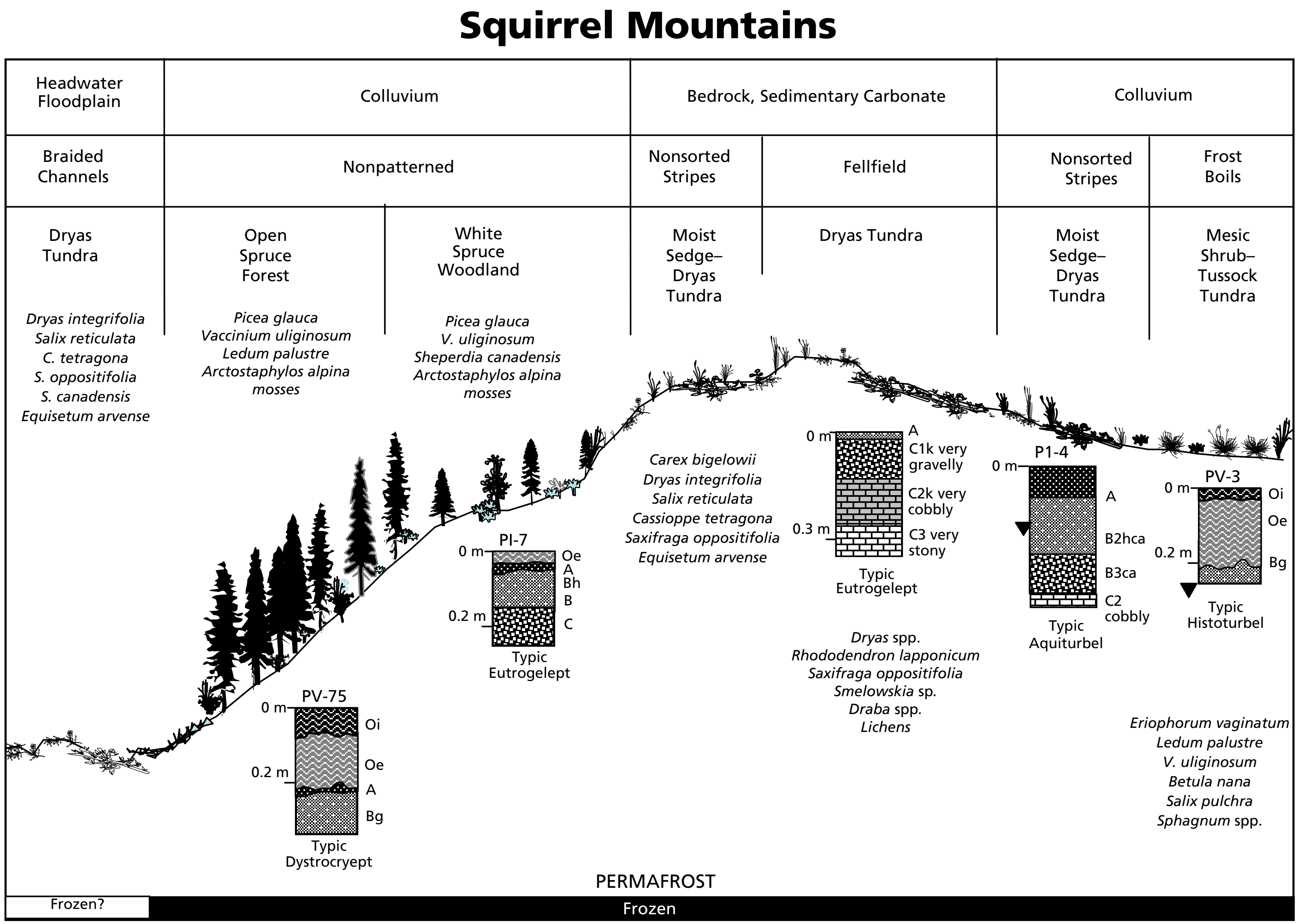


Figure 5. A generalized toposequence illustrating relationships among topography, geology, geomorphology, permafrost, soils, and vegetation within the Squirrel Mountains subsection.

Nigu Glaciated Upland

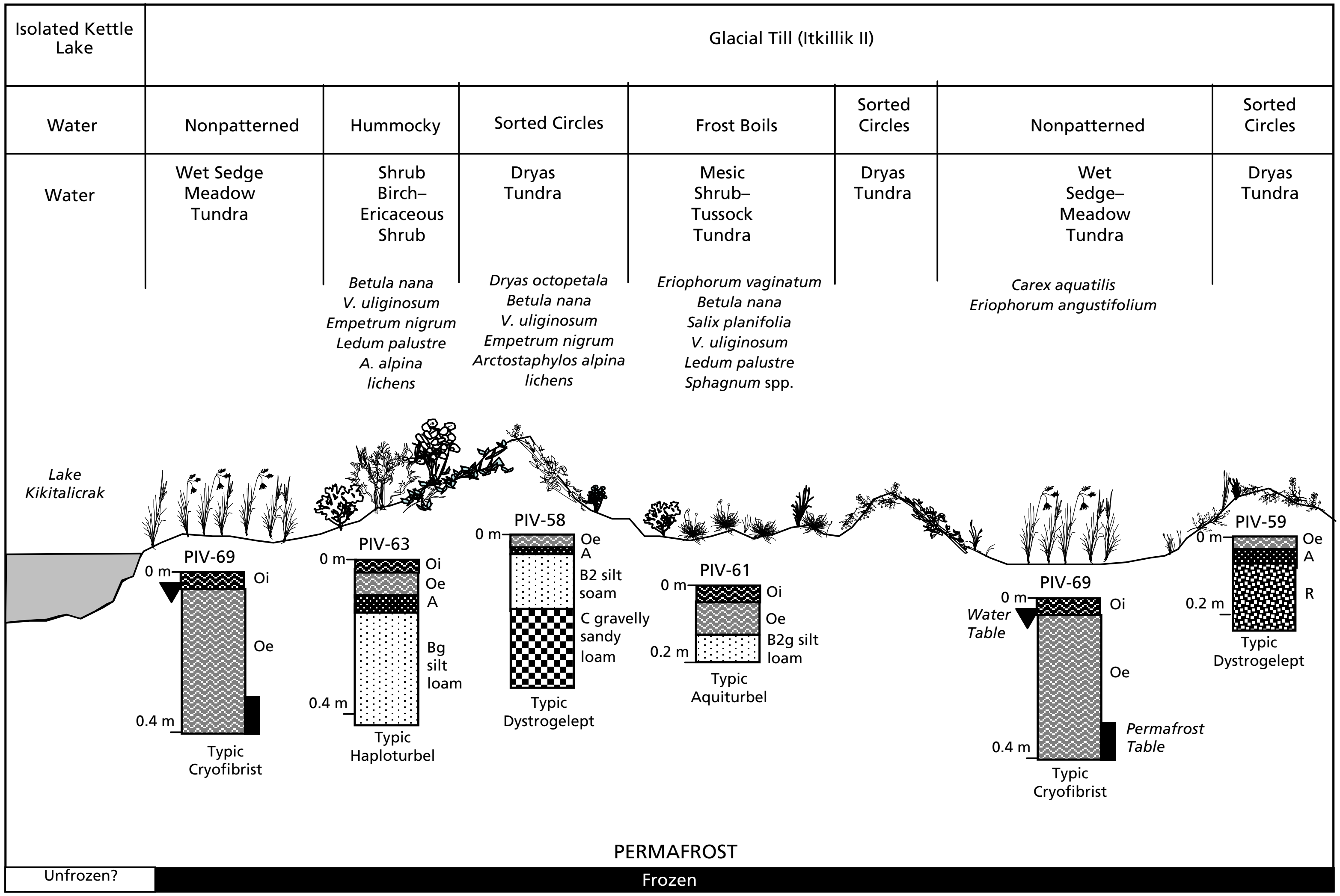


Figure 6. A generalized toposequence illustrating relationships among topography, geomorphology, permafrost, soils, and vegetation within the Nigu Glaciated Upland.

Lower Noatak Floodplain

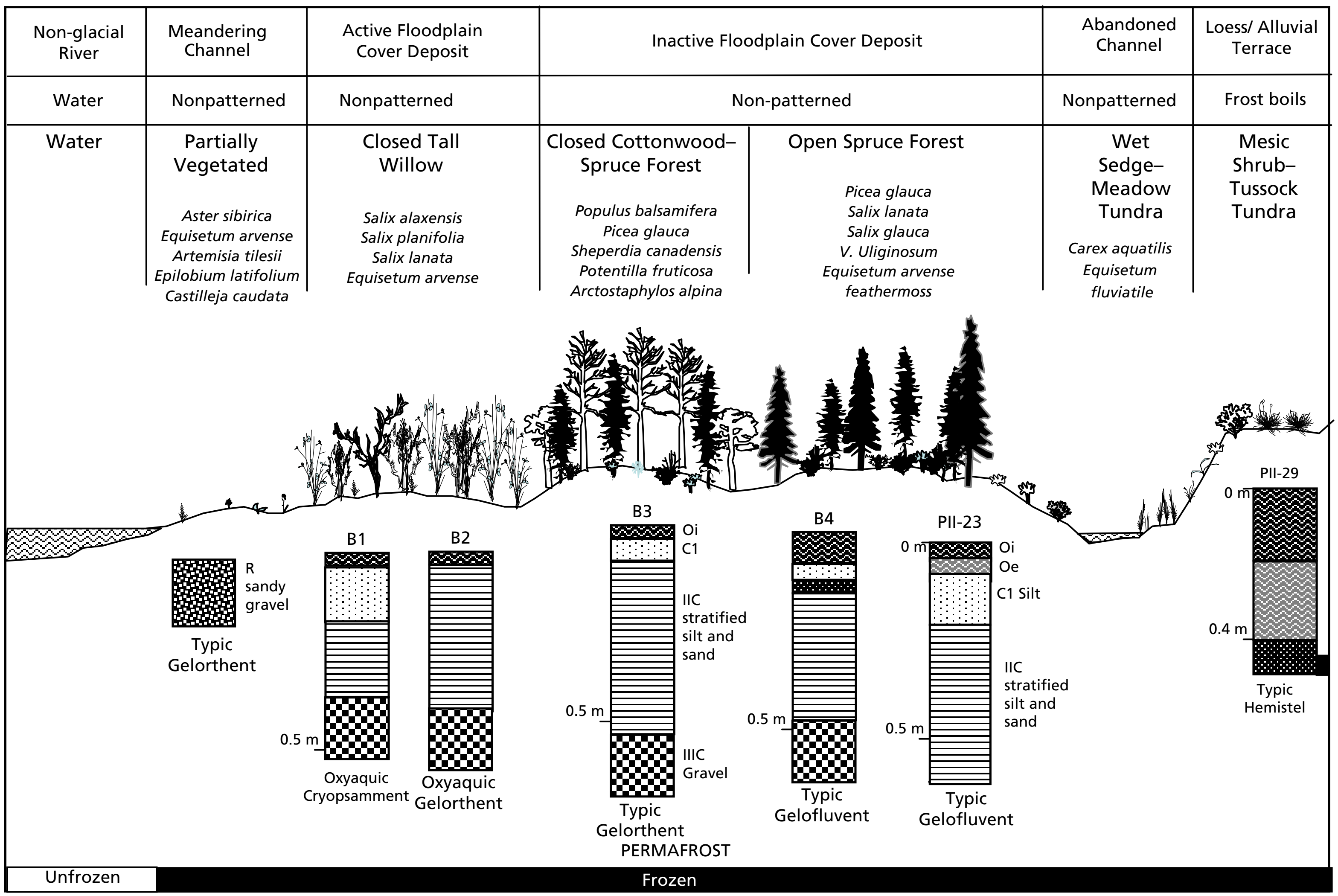


Figure 7. A generalized toposequence illustrating relationships among topography, geomorphology, permafrost, soils, and vegetation within the Lower Noatak Floodplain subsection.

Cape Espenberg Coast

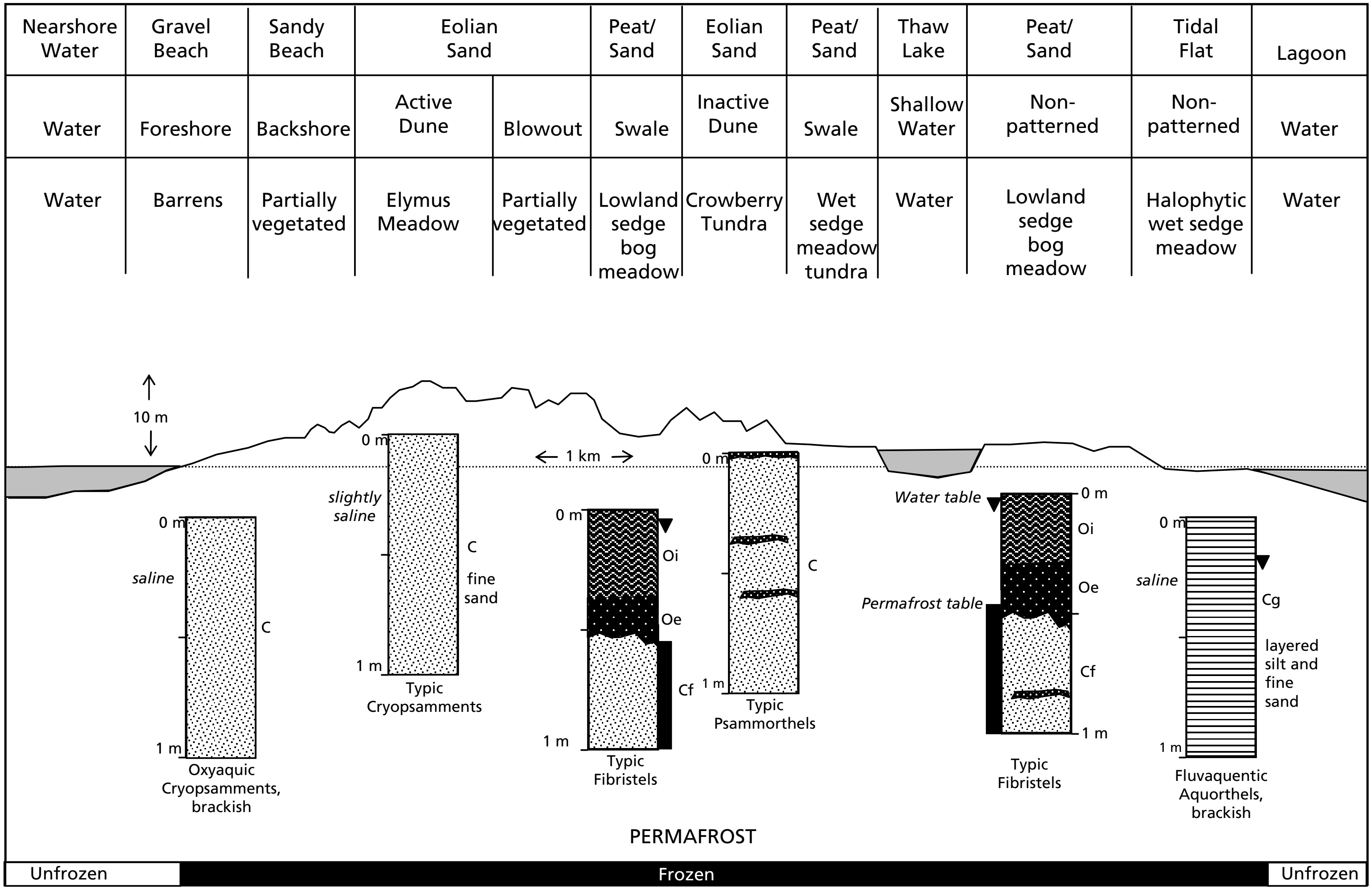


Figure 8. A generalized toposequence illustrating relationships among topography, geomorphology, permafrost, soils, and vegetation within the Cape Espenberg Coast subsection.

toposequence, the rate of sedimentation decreases while accumulation rates for organic matter and ice increase. On the newly-formed surfaces associated with the active floodplain, soils along the channels are well drained and sandy, whereas the soils on the older portions of the floodplain are poorly drained and have thick organic accumulations. Soil nutrients become less available, due to decreasing cation concentrations (indicated by lower electrical conductivity) and pH. Over the successional sequences, ice aggrades both as segregated ice and as wedge ice, transforming the surface patterns from non-patterned to low-centered polygons. The oldest ice-rich portions of the floodplain accumulate sufficient ground ice that they become unstable and susceptible to thermokarst and formation of thaw lakes. Vegetation responds to these changing environmental conditions with changes in both structure and species composition. Open Tall Willow Shrub, dominated by *Salix alaxensis*, occurs on the well-drained, sandy soils. Behind this zone, Open Low Willow Shrub, dominated by *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *S. planifolia* ssp. *pulchra* (syn: *S. pulchra*), and *S. brachycarpa* ssp. *niphoclada* (syn: *S. niphoclada*) is found on moderately well-drained soils with thin, interbedded organic layers. Farther back from the channel, moist Open Low Shrub Birch–Willow Shrub, dominated by *Betula nana* and *S. pulchra*, occurs on somewhat poorly drained soils, while Lowland Sedge–Moss Fen Meadows, dominated by *Carex aquatilis* and *Sphagnum* spp., is found on very poorly drained organic soils.

On a coastal toposequence representative of the Cape Espenberg Coast, which is dominated by marine and estuarine processes, the geomorphology is dominated by sandy beaches, eolian coastal sand, active and inactive tidal flats, and nearshore water (Figure 8). The topography is generally flat except for prominent ridges of dunes, beach ridges, and swales that form parallel features along the coast. The soils on active tidal flats are loamy, poorly drained, and lack organic matter accumulation, while soils on inactive tidal flats have moderately thick organic accumulations. Coastal dunes have well drained sandy soils, while beach ridges formed during storm surges have excessively drained soils. Vegetation on these deposits ranged from saline Halophytic Sedge–Grass Wet Meadow (dominated by *Puccinellia phryganodes*), brackish Halophytic Sedge–Grass Wet Meadow (dominated by *Carex ramenskii*), Marestail Marsh (mostly *Hippuris tetraphylla*), and Elymus Meadow. On inactive dunes away from the coast, Crowberry Tundra (dominated by *Empetrum nigrum*) is prevalent.

Hierarchical Organization of Ecological Components

We developed hierarchical relationships among ecological components by successively grouping data from the 986 intensive plots by physiography, soil texture, geomorphology, slope position, surface form, drainage, soil chemistry, vegetation structure, and floristic class. Frequently, geomorphic units with similar textures or genesis were grouped (e.g., loamy and organic were grouped for some lowlands) to reduce the number of classes. Ecotypes then were derived from these tabular associations to differentiate sets of associated characteristics.

Analyzing the toposequences and cross-tabulation of the plot data revealed consistent associations among soil texture, geomorphic units that denote depositional environments, slope position, surface forms related to ice aggradation and active-layer processes, hydrology, and vegetation structure (Table 137). The hierarchical organization of the ecological components reveals how tightly or

Table 137. Landscape relationships for ecotypes in the Arctic Network, 2002–2008.

Physiography	Geomorphic Units	Soil–Water Chemistry	Soil Texture	Drainage	Vegetation Types (Level IV)	Plant Association	Ecotype
Alpine	Weathered Bedrock, Talus, Hillside Colluvium, Solifluction Deposit, Younger Moraine, Carbonate Sedimentary	Alkaline	Blocky–Rubbly	Excessive to Somewhat Excessive	Barrens (<5% veg.), Partially Vegetated (5–30% Vegetated)	*Salix arctica–Minuartia arctica*	Alpine Alkaline Barrens
						Dryas octopetala–Saxifraga oppositifolia	Alpine Alkaline Barrens
				Excessive to Well	Dryas–Lichen Dwarf Shrub Tundra, Dryas Dwarf Shrub Tundra, Dryas–Sedge Dwarf Shrub Tundra	*Dryas integrifolia–Carex scirpoidea–Silene acaulis*	Alpine Alkaline Dryas Dwarf Shrub
						Dryas octopetala–Saxifraga oppositifolia	Alpine Alkaline Dryas Dwarf Shrub
	Talus, Hillside Colluvium, Solifluction Deposit, Alluvial Fan Inactive Deposit, Mafic Intrusive, Ultramafic Intrusive	Circumalkaline	Blocky–Rubbly	Excessive to Well	Barrens (<5% veg.), Partially Vegetated (5–30% Vegetated)	*Salix arctica–Minuartia arctica*	Alpine Mafic Barrens
	Weathered Bedrock, Talus, Hillside Colluvium, Solifluction Deposit, Older Moraine, Noncarbonate Metamorphic, Noncarbonate Sedimentary, Felsic Intrusive, Mafic Intrusive	Acidic	Blocky–Rubbly	Excessive to Somewhat Excessive	Barrens (<5% veg.),–Partially Vegetated (5–30% Vegetated)	Lichen–*Hierochloe alpina*	Alpine Acidic Barrens
					Dryas–Lichen Dwarf Shrub Tundra, Dryas Dwarf Shrub Tundra, Dryas–Sedge Dwarf Shrub Tundra	*Dryas octopetala–Hierochloe alpina*	Alpine Acidic Dryas Dwarf Shrub
		Circumacidic	Blocky–Rubbly	Somewhat Excessive to Well	Dryas Dwarf Shrub Tundra, Ericaceous Dwarf Shrub Tundra, Crowberry Dwarf Shrub Tundra, Cassiope Dwarf Shrub Tundra, Open Shrub Birch–Ericaceous Shrub	*Dryas octopetala–Vaccinium uliginosum–Festuca altaica*	Alpine Ericaceous–Dryas Dwarf Shrub
						Betula nana–Vaccinium vitis-idaea–Dryas octopetala	Alpine Ericaceous–Dryas Dwarf Shrub
						Betula nana–Loiseleuria procumbens	Alpine Ericaceous–Dryas Dwarf Shrub
	Weathered Bedrock, Talus, Hillside Colluvium, Solifluction Deposit, Carbonate Sedimentary, Noncarbonate Sedimentary, Noncarbonate Metamorphic	Circumneutral	Blocky–Rubbly	Somewhat Excessive to Well	Cassiope Dwarf Shrub Tundra, Dryas Dwarf Shrub Tundra	*Cassiope tetragona–Dryas octopetala–Boykinia richardsonii*	Alpine Cassiope Dwarf Shrub

Table 137. Continued.

Physio–graphy	Geomorphic Units	Soil–Water Chemistry	Soil Texture	Drainage	Vegetation Types (Level IV)	Plant Association	Ecotype
	Hillside Colluvium, Solifluction Deposit, Noncarbonate Metamorphic, Noncarbonate Sedimentary, Felsic Intrusive, Mafic Intrusive, Ultramafic Intrusive	Circumneutral	Blocky–Rubbly–Loamy–Organic	Somewhat Poor to Poor	Wet Sedge Tundra, Mixed Herbs	*Eriophorum angustifolium–Pedicularis sudetica*	Alpine Wet Sedge Meadow
	Deep Isolated Lake	Circumalkaline	Water	Flooded	Water	Water	Alpine Lake
Upland	Volcanic–mafic–younger (basalt) & Volcanic–mafic–younger	Circumneutral	Blocky	Excessive to Somewhat Excessive	Dry Bryophyte	*Cladina stellaris–Loiseleuria procumbens*	Upland Mafic Barrens
	Eolian Active Sand Dune	Alkaline	Sandy	Excessive to Somewhat Excessive	Barrens (<5% veg.), Partially Vegetated (5–30% Vegetated)	*Calamagrostis purpurascens–Oxytropis kobukensis*	Upland Sandy Barrens
	Eolian Active Sand Dune, Eolian Inactive Sand Dune	Acidic	Sandy	Excessive to Somewhat Excessive	Open White Spruce Forest, White Spruce Woodland	*Picea glauca–Cladina stellaris*	Upland White Spruce–Lichen Woodland
		Circumalkaline	Sandy	Excessive to Somewhat Excessive	Woodland White Spruce Forest, Dryas Dwarf Shrub Tundra	*Picea glauca–Arctostaphylos uva-ursi*	Upland White Spruce–Dryas Woodland
	Hillside Colluvium, Solifluction Deposit, Retransported Deposit, Carbonate Sedimentary, Older Moraine, Alluvial Fan Abandoned Deposit	Alkaline	Blocky–Rubbly–Loamy	Moderately Well to Somewhat Poor	Moist Sedge–Dryas Meadow, Dryas–Sedge Dwarf Shrub	*Dryas integrifolia–Carex bigelowii–Equisetum arvense*	Upland Sedge–Dryas Meadow
						Dryas integrifolia–Carex scirpoidea–Rhododendron lapponicum	Upland Sedge–Dryas Meadow
		Circumalkaline	Blocky–Rubbly–Loamy	Well to Moderately Well	Open White Spruce Forest, Woodland White Spruce Forest	*Picea glauca–Salix reticulata*	Upland White Spruce–Willow Forest
				Well to Somewhat Poor	Open Tall Willow Shrub, Open Low Willow Shrub, Closed Tall Willow Shrub, Closed Low Willow Shrub	*Salix lanata* ssp. *richardsonii–Equisetum arvense*	Upland Willow Low Shrub
	Bogs, Hillside Colluvium, Lowland Loess, Ice–Rich Thaw Basin, Meander Abandoned Overbank Deposit , Old Alluvial Terrace, Older Moraine	Acidic	Loamy–Organic–Peat	Moderately Well to Poor	Open Mixed–Shrub Tussock Tundra, Tussock Tundra, Open Mixed–Shrub Tussock Tundra Bog	*Betula nana–Eriophorum vaginatum*	Upland Dwarf Birch–Tussock Shrub
						E. vaginatum–Drosera rotundifolia	Upland Dwarf Birch–Tussock Shrub

Table 137. Continued.

Physio–graphy	Geomorphic Units	Soil–Water Chemistry	Soil Texture	Drainage	Vegetation Types (Level IV)	Plant Association	Ecotype
	Hillside Colluvium, Upland Loess, Eolian Inactive Sand Dune, Alluvial Fan Abandoned Deposit–Older Moraine, Noncarbonate Sedimentary, Schist, Mafic Intrusive	Acidic	Blocky–Rubbly	Well	Open Low Ericaceous Shrub, Vaccinium Dwarf Shrub Tundra, Open Tall Alder Shrub	*Spiraea beauverdiana–Festuca altaica*	Upland Spiraea Low Shrub
			Blocky–Rubbly	Well to Somewhat Poor	Closed Low Birch Shrub, Closed Low Birch Ericaceous Shrub, Open Shrub Birch–Ericaceous Shrub	*Betula nana–Ledum decumbens*	Upland Birch–Ericaceous Low Shrub
		Circumacidic	Blocky–Rubbly–Sandy–Loamy	Somewhat Excessive to Moderately Well	Closed Birch Forest, Open Birch Forest	*Betula papyrifera–Picea glauca–Vaccinium vitis-idaea*	Upland Birch Forest
					Open Spruce–Birch Forest, Spruce–Birch Woodland	*Betula papyrifera–Picea glauca–Vaccinium vitis-idaea*	Upland Spruce–Birch Forest
					Open White Spruce Forest, Woodland White Spruce Forest	*Picea glauca–Ledum decumbens*	Upland White Spruce–Ericaceous Forest
					Bluejoint Meadow, Bluejoint–Shrub Meadow	*Calamagrostis canadensis–Polemonium acutiflorum*	Upland Bluejoint Meadow
					Closed Tall Alder Shrub, Open Tall Alder Shrub, Open Tall Alder–Willow Shrub, Low Open Alder–Willow Shrub	*Alnus crispa–Calamagrostis canadensis*	Upland Alder–Willow Tall Shrub
				Well to Somewhat Poor	Closed Low Birch Shrub, Closed Low Birch–Willow Shrub, Low Open Birch–Willow Shrub, Open Shrub Birch–Ericaceous Shrub, Open Low Willow	*Salix planifolia* ssp. *pulchra–Betula nana–Polygonum bistorta*	Upland Birch–Willow Low Shrub
Lowland	Solifluction Deposit, Hillside Colluvium, Lowland Loess, Ice–Rich Thaw Basin, Older Moraine, Meander Abandoned Overbank Deposit, Braided Abandoned Overbank Deposit	Acidic	Loamy–Organic	Moderately Well to Somewhat Poor	Closed Low Birch Ericaceous Shrub, Open Shrub Birch–Ericaceous Shrub	*Andromeda polifolia–Sphagnum* sp.	Lowland Birch–Ericaceous Low Shrub
						*Ledum decumbens–Vaccinium vitis-idaea–*Foliose/fruticose lichen	Lowland Birch–Ericaceous Low Shrub

Table 137. Continued.

Physio–graphy	Geomorphic Units	Soil–Water Chemistry	Soil Texture	Drainage	Vegetation Types (Level IV)	Plant Association	Ecotype
		Acidic			Open Black Spruce Forest, Black Spruce Woodland, Dwarf Open Black Spruce Scrub Forest	*Picea mariana–Ledum decumbens*	Lowland Black Spruce Forest
		Circumacidic	Loamy–Organic	Moderately Well to Poor	Open Tall Willow, Open Low Willow, Closed Tall Willow, Closed Low Willow	*Salix planifolia* ssp. *pulchra–Valeriana capitata*	Lowland Willow Low Shrub
					Closed Low Birch Shrub, Closed Low Birch–Willow Shrub, Low Open Birch–Willow Shrub, Open Shrub Birch–Ericaceous Shrub	*Betula nana–Salix planifolia* ssp. *pulchra–Eriophorum angustifolium*	Lowland Birch–Willow Low Shrub
	Bogs, Meander Abandoned Overbank Deposit, Ice-rich and Ice-poor Drained Basin, Older Moraine	Acidic	Peat–Organic	Poor to Very Poor	Open Low Ericaceous Shrub Bog, Low Open Birch Shrub Bog, Wet Sedge–Moss Bog	*Andromeda polifolia–Sphagnum* sp.	Lowland Ericaceous Shrub Bog
	Organic Fen, Meander Abandoned Overbank Deposit , Ice–rich Drained Basin, Ice–Poor Drained Basin, Older Moraine	Circumacidic	Peat–Organic	Very Poor	Wet Sedge–Moss Bog, Subarctic Lowland Sedge Wet Meadow, Wet Sedge Tundra	*Carex chordorrhiza–Carex aquatilis*	Lowland Sedge Fen
					Wet Sedge Tundra, Subarctic Lowland Sedge Wet Meadow, Wet Sedge–Moss Bog	*Carex aquatilis–Salix planifolia* ssp. *pulchra*	Lowland Sedge–Willow Fen
Lacustrine	Ice–Poor Drained Basin, Glaciolacustrine Deposit, Older Moraine	Circumalkaline	Blocky–Gravelly–Sandy–Loamy–Peat	Well to Somewhat Poor	Barrens (<5% veg.), Partially Vegetated (5–30% Vegetated)	*Eriophorum angustifolium–Epilobium palustre*	Lacustrine Barrens
		Circumacidic	Loamy	Moderately Well to Somewhat Poor	Bluejoint Meadow, Bluejoint–Herb Meadow	*Calamagrostis canadensis–Potentilla palustris*	Lacustrine Bluejoint Meadow
		Circumneutral	Blocky–Gravelly–Sandy–Loamy–Peat	Somewhat Poor to Poor	Open Low Willow, Closed Low Willow, Low Open Birch–Willow Shrub	*Salix planifolia* ssp. *pulchra–Potentilla palustris*	Lacustrine Willow Shrub

Table 137. Continued.

Physio–graphy	Geomorphic Units	Soil–Water Chemistry	Soil Texture	Drainage	Vegetation Types (Level IV)	Plant Association	Ecotype
	Organic Fen, Ice–Poor Thaw Basin, Ice–Rich Thaw Basin, Older Moraine	Circumacidic	Loamy–Organic	Very Poor	Wet Sedge Tundra, Subarctic Lowland Sedge Wet Meadow, Subarctic Lowland Sedge Bog Meadow	*Carex aquatilis–Potentilla palustris*	Lacustrine Wet Sedge Meadow
			Peat–Organic	Flooded to Very Poor	Subarctic Lowland Herb Bog Meadow, Subarctic Lowland Sedge Wet Meadow	*Menyanthes trifoliata–Potentilla palustris*	Lacustrine Buckbean Fen
	Shallow Isolated Thaw Lake, Shallow Isolated Moraine or Kettle Lake, Ice–poor Drained Basin, Older Moraine	Circumneutral	Sandy–Loamy	Flooded to Very Poor	Fresh Grass Marsh, Common Marestail	*Arctophila fulva–Hippuris vulgaris*	Lacustrine Pendent Grass Marsh
	Shallow Isolated Thaw Lake, Shallow Isolated Moraine or Kettle Lake	Circumneutral	Water	Flooded	Common Marestail, Pondlily, Fresh Pondweed, Burreed	*Equisetum fluviatile–Potentilla palustris*	Lacustrine Horsetail Marsh
						Hippuris vulgaris–Utricularia vulgaris ssp. *macrorhiza*	Lacustrine Marestail Marsh
	Deep Isolated Moraine or Kettle Lake, Shallow Isolated Moraine or Kettle Lake, Shallow Isolated Thaw Lake	Circumacidic	Water	Flooded	Pondlily, Fresh Pondweed	*Nuphar polysepalum–Sparganium* sp.	Lacustrine Pondlily Lake
	Deep or Shallow Isolated Thaw Lake, Deep or Shallow Isolated Moraine or Kettle Lake, Deep Connected Moraine or Kettle Lake, Shallow Isolated Dune L.	Circumalkaline	Water	Flooded	Water, Aquatic Buttercup, Fresh Pondweed	Water–*Potamogeton* sp.	Lowland Lake
Riverine	Braided or Meander Active Channel Deposit, Braided or Meaner Active Overbank Deposit, Moderately Steep Headwater Floodplain	Alkaline	Blocky–Gravelly–Sandy	Excessive to Somewhat Excessive	Dryas Dwarf Shrub, Dryas–Lichen Dwarf Shrub, Open Low Willow Shrub	*Dryas drummondii–Oxytropis campestris*	Riverine Dryas Dwarf Shrub
						Dryas integrifolia–Salix brachycarpa ssp. *niphoclada*	Riverine Dryas Dwarf Shrub
		Circumalkaline	Blocky–Gravelly–Sandy	Excessive to Well	Barrens (<5% veg.), Partially Vegetated (5–30% Vegetated), Elymus, Seral Herbs	*Salix alaxensis–Epilobium latifolium*	Riverine Barrens
			Blocky–Gravelly–Sandy–Loamy	Somewhat Excessive to Well	Closed Tall Willow Shrub, Open Tall Willow Shrub	*Salix alaxensis–Aster sibiricus*	Riverine Moist Willow Tall Shrub

Table 137. Continued.

Physio–graphy	Geomorphic Units	Soil–Water Chemistry	Soil Texture	Drainage	Vegetation Types (Level IV)	Plant Association	Ecotype
	Braided Active Overbank Deposit, Meander Active Overbank Deposit, Braided Inactive Overbank Deposit, Meander Inactive Overbank Deposit	Circumalkaline	Blocky–Gravelly–Sandy–Loamy	Somewhat Excessive to Moderately Well	Closed Poplar Forest, Open Poplar Forest	*Populus balsamifera–Picea glauca–Salix alaxensis*	Riverine Poplar Forest
					Open Mixed Spruce–Poplar Forest, Mixed Spruce–Poplar Woodland	*Populus balsamifera–Picea glauca–Salix alaxensis*	Riverine White Spruce–Poplar Forest
				Well to Somewhat Poor	Open Tall Willow Shrub, Open Low Willow Shrub, Moist Sedge–Dryas Meadow	*Salix lanata* ssp. *richardsonii–Salix reticulata*	Riverine Willow Low Shrub
	Meander Inactive Overbank Deposit, Braided Inactive Overbank Deposit, Meander Inactive Channel Deposit, Moderately Steep Headwater Floodplain, Lowland Headwater Floodplain	Circumalkaline	Blocky–Gravelly–Sandy–Loamy	Well to Moderately Well	Open White Spruce Forest, White Spruce Woodland	*Picea glauca–Salix lanata* ssp. *richardsonii–Salix arbusculoides*	Riverine White Spruce–Willow Forest
		Circumacidic	Blocky–Gravelly–Sandy–Loamy	Well to Moderately Well	Open White Spruce Forest, White Spruce Woodland	*Picea glauca–Alnus crispa–Artemisia tilesii*	Riverine White Spruce–Alder Forest
			Loamy	Moderately Well to Somewhat Poor	Closed Low Birch–Willow Shrub, Closed Low Birch Shrub, Closed Low Birch–Ericaceous Shrub	*Betula nana–Salix planifolia* ssp. *pulchra–Pyrola grandiflora*	Riverine Birch–Willow Low Shrub
					Closed Tall Alder Shrub, Open Tall Alder Shrub, Closed Tall Alder–Willow Shrub	*Alnus crispa–Rubus arcticus*	Riverine Alder Tall Shrub
				Moderately Well to Poor	Bluejoint Meadow, Bluejoint–Herb Meadow	*Calamagrostis canadensis–Potentilla palustris*	Riverine Bluejoint Meadow
					Closed Tall Willow Shrub, Open Tall Willow Shrub, Tall Closed Birch–Willow Shrub	*Salix planifolia* ssp. *pulchra–Potentilla palustris*	Riverine Wet Willow Tall Shrub
					Wet Sedge Tundra, Subarctic Lowland Sedge Wet Meadow	*Carex aquatilis–Eriophorum angustifolium*	Riverine Wet Sedge Meadow

Table 137. Continued.

Physiography	Geomorphic Units	Soil–Water Chemistry	Soil Texture	Drainage	Vegetation Types (Level IV)	Plant Association	Ecotype
	Shallow Isolated Riverine Lake, Braided Inactive Channel Deposit, Meander Inactive Channel Deposit	Circumalkaline	Water	Flooded	Fresh Pondweed	*Potamogeton* sp.–*Utricularia vulgaris ssp. macrorhiza*	Riverine Lake
		Circumneutral	Loamy	Flooded to Somewhat Poor	Fresh Pondweed, Subarctic Lowland Sedge Wet Meadow	*Equisetum fluviatile–Hippurus vulgaris*	Riverine Forb Marsh
	Non–glacial Lower Perennial and Upper Perennial River, Mountain Headwater Stream	Circumalkaline	Water	Flooded	Water	Water	River
Coastal	Active Marine Beach, Eolian Active Coastal Sand Deposit	Saline–Brackish	Sandy	Excessive to Poor	Barrens (<5% veg.), Partially Vegetated (5–30% Vegetated)	*Elymus arenarius* ssp. *mollis–Lathyrus maritimus*	Coastal Dry Barrens
		Brackish	Gravelly–Sandy	Excessive to Somewhat Excessive	Elymus	*Elymus arenarius* ssp. *mollis–Lathyrus maritimus*	Coastal Brackish Dunegrass Meadow
	Inactive Marine Beach, Eolian Inactive Coastal Sand Deposit	Circumacidic	Gravelly–Sandy	Somewhat Excessive to Well	Crowberry Dwarf Shrub Tundra	*Empetrum nigrum–Elymus arenarius* ssp. *mollis*	Coastal Crowberry Dwarf Shrub
	Active Tidal Flat	Saline–Brackish	Sandy	Excessive to Poor	Barrens (<5% veg.), Partially Vegetated (5–30% Vegetated)	*Carex ramenskii–Puccinellia phryganodes*	Coastal Wet Barrens
	Inactive Tidal Flat	Saline	Sandy–Loamy–Organic	Moderately Well to Poor	Halophytic Sedge–Grass Wet Meadow, saline	*Carex ramenskii–Puccinellia phryganodes*	Coastal Saline Sedge–Grass Meadow
		Brackish	Sandy–Loamy–Organic	Moderately Well to Poor	Halophytic Sedge–Grass Wet Meadow, brackish	*Carex ramenskii–Dupontia fischeri*	Coastal Brackish Sedge–Grass Meadow
			Sandy	Very Poor	Halophytic Willow–Graminoid Dwarf Shrub Tundra	*Salix ovalifolia–Deschampsia caespitosa*	Coastal Brackish Willow Shrub
	Tidal River, Tidal Gut	Brackish	Water	Flooded	Marine Water	Water	Coastal Tidal River
	Isolated or Connected Brackish Shallow Lake, Tidal Lake	Brackish	Water	Flooded	Marine Water	Water	Coastal Brackish Water
	Nearshore Water	Saline	Water	Flooded	Marine Water	Water	Coastal Nearshore Water

loosely the components are linked. For example, some physiographic settings included several geomorphic units with similar soil textures. Similarly, a given vegetation type could occur on several geomorphic units, depending on surface form characteristics and hydrology. In contrast, some geomorphic units (e.g. tidal flats) were associated only with a few distinct vegetation types.

Results from this analysis were used in several ways. First, they were used to evaluate how ecosystems respond to the evolving landscape comprising a wide variety of geomorphic processes associated with alpine, upland, lowland, lacustrine, riverine, and coastal areas (see section on Factors Affecting Landscape Evolution). Identifying the changing patterns in geomorphic units and vegetation, along with analysis of changes in soil properties, helps identify processes (e.g., acidification, sedimentation) that affect the changing patterns. Second, the hierarchical relationships developed "from the ground up" were used to determine the rules for modeling and restricting the distribution of map classes differentiated by spectral characteristics "from the top down" (see Methods, Spectral Classification Development). Third, knowing the ecological relationships, we can recode the ecotype map and derive maps of other ecological characteristics, such as a soils map or a lichen map (see Results, Classification and Description of Soil Landscapes).

The contingency table analysis also can be used to evaluate how well these general relationships conform to the data set, and how reliably they can be used to extrapolate trends across the landscape. During development of the relationships, 11% of the observations were excluded from the table because of inconsistencies among physiography, texture, geomorphology, drainage, soil chemistry, and vegetation. We excluded these points because our primary goal was to identify the most distinct and consistent trends, not necessarily to include every plot. We believe that there is an upper limit to our ability to describe landscape patterns; there will always be a proportion (in this case 11%) of sites that do not conform to the overall relationships among factors. These sites may be: (1) transitional (ecotones); (2) sites where vegetation and soils have been affected by historical factors (e.g., changes in water levels, disturbances) in ways that are not readily explainable based on current environmental conditions, or (3) rare and thus not mappable.

Environmental Characteristics

Single-factor Comparisons by Ecotype

Six environmental parameters (surface organic-horizon thickness, rock depth, thaw depth, depth to groundwater, pH, and electrical conductivity) were charted for comparison among ecotypes. We excluded ecotypes with insufficient data.

The thickness of the surface organic horizon showed large differences among sites (Figure 9). Ecotypes where surface organic accumulations were absent ranged from areas with severe climate and soil conditions, such as Alpine Alkaline Barrens, to areas with frequent sediment deposition, such as Riverine Barrens and Riverine Moist Tall Willow Shrub. The thickest surface organic accumulations were found in Lowland Buckbean Fen and Lowland Ericaceous Shrub Bog, indicating long-term paludification and reduced frequency or absence of sedimentation events.

Depth to rocks (soils with >15% rocks) was shallowest on alpine ridges and crests (e.g., Alpine Alkaline Dryas Shrub) and rocky hillsides (Upland Alder–Willow Tall Shrub) and deepest in lowland and coastal areas with fine-grained deposits (e.g. Coastal Barrens, Lowland Buckbean Fen) (Figure 9). Ecotypes with rock depths ≥ 2 m represent an estimated minimum depth. Thaw depths varied four-fold among ecotypes (Figure 9). While permafrost

Figure 9. Mean (± SD) thickness of the surface organic layer, depth to rock (>15% coarse fragments) and depth of thaw for ecotypes in the Arctic Network. Outliers have been excluded.

was found at all sites with fine-grained soils, the permafrost status of rocky sites, particularly on south-facing slopes, is unknown. Values generally were shallowest for lowland and lacustrine ecotypes and for gently sloping upland areas with Upland Dwarf Birch–Tussock Shrub. Deepest thaw depths were found in coastal and riverine areas with well-drained sandy soils and early successional vegetation (e.g. Coastal Dunegrass Meadow, Riverine Moist Tall Willow Shrub).

Depth to water above (+) or below (–) the surface also varied widely among ecotypes, but relatively little within ecotypes (Figure 10). Mean water depths were above the soil surface for 12 ecotypes, and were highest for Coastal Tidal River and Lowland Lake. Ecotypes with the deepest water tables were found in alpine areas with rocky soils (e.g., Alpine Alkaline Dryas Dwarf Shrub) and upland areas with sandy soils (e.g., Upland Sandy Barrens). Values ≥ 1 m represent minimum, estimated depths.

Site pH values ranged from 3.3–8.3 among ecotypes (Figure 10). Ecotypes with the lowest (most acidic) pH values occurred in alpine acidic ecotypes (e.g., Alpine Acidic Dryas Dwarf Shrub), late-successional upland ecotypes (Upland Dwarf Birch–Tussock Shrub, Upland Spiraea Low Shrub), and in lowland ecotypes (e.g., Lowland Ericaceous Shrub Bog, Lowland Black Spruce Forest). These ecotypes are late successional, where carbonates have been leached from soils over long periods. Ecotypes with the highest pH values tended to occur in alkaline alpine and upland areas (Alpine Alkaline Dryas Dwarf Shrub, Upland Moist Sedge–Dryas Dwarf Shrub) and in riverine and coastal early successional environments with frequent mineral sedimentation (e.g., Riverine Barrens, Coastal Barrens). The Upland Sandy Barrens ecotype at the Kobuk dunes had unusually high pH values, presumably due to high sodium concentrations. Electrical conductivity (EC) measurements indicated that most ecotypes were non-saline (Figure 10). High mean EC values (>800 $\mu S/cm^{-1}$), indicating brackish or slightly brackish to saline conditions, were limited to coastal areas (e.g., Coastal Saline Wet Sedge–Grass Meadow, Coastal Barrens). EC values were low (<200 $\mu S/cm^{-1}$) in nearly all other ecotypes. Variability was low within non-saline ecotypes and high within saline ecotypes.

Single-factor Comparisons by Plant Species

To determine how the environmental parameters measured influence the distribution of individual plant and cryptogam species, we calculated the mean value of each parameter for 99 common species that occur in lowland, lacustrine, and riverine ecotypes (Figures 11–14) and for 98 common species that occur in upland and alpine ecotypes. Only sites where a species had >1% cover were included, to exclude locations with atypical conditions for that species.

Thickness of the surface organic horizon (an indication of frequency of sedimentation) was highly variable both among and within species in field plots (Figures 11 and 13). Species typically found on sites with thin organic horizons at the surface (indicating frequent sedimentation), included *Lathyrus maritimus, Epilobium latifolium, Deschampsia caespitosa,* and *Salix alaxensis*. These species typically occur mainly in early successional ecotypes subject to frequent fluvial or eolian deposition. Species characteristic of sites with thick surface organic accumulations included *Carex chordorrhiza, Calla palustris, Salix fuscescens, Carex aquatilis,* and *Sphagnum fuscum*. These species typically occurred on wet soils subjected to little or no disturbance.

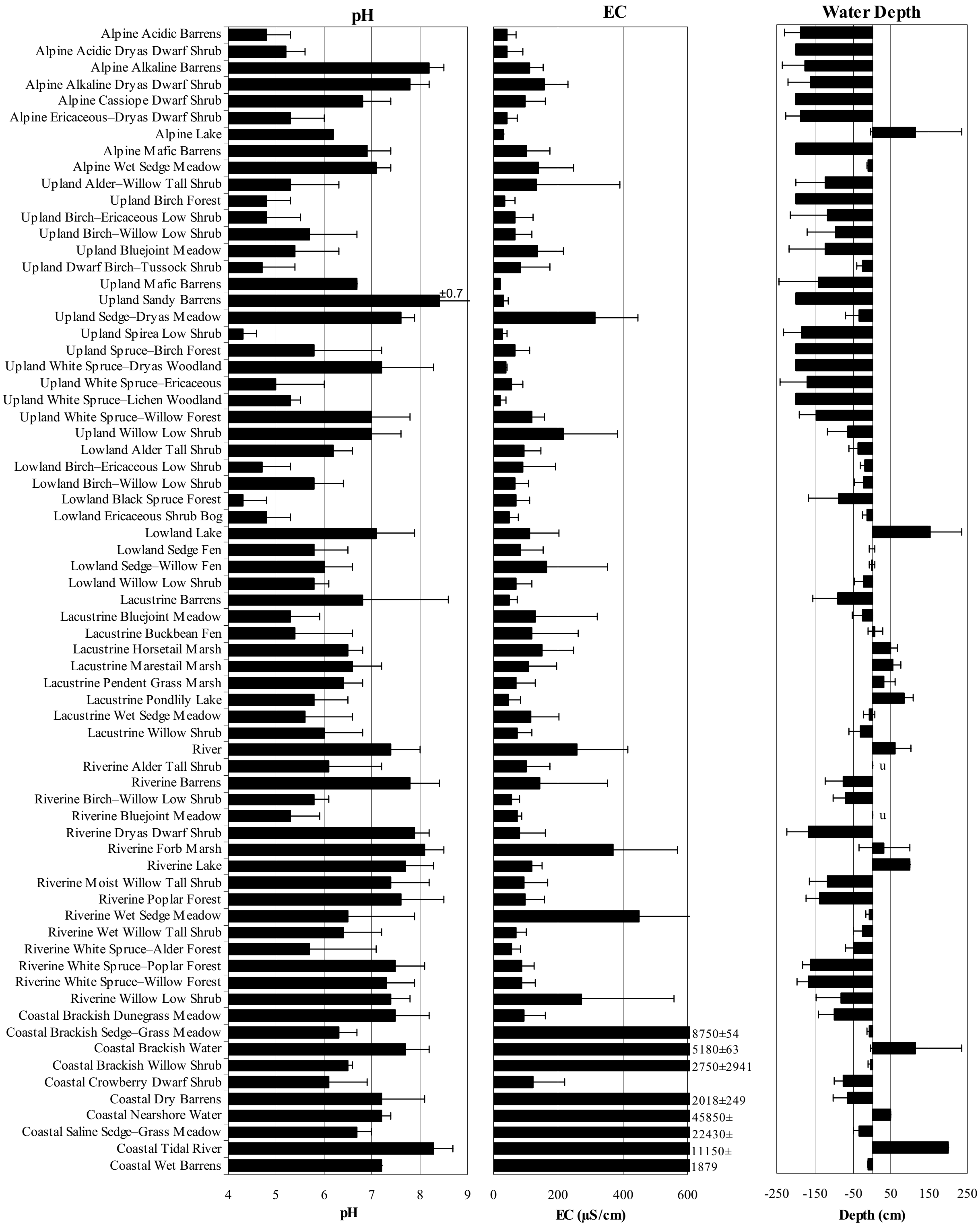


Figure 10. Mean (± SD) pH, electrical conductivity (EC), and water depth for ecotypes in the Arctic Network. Outliers have been excluded.

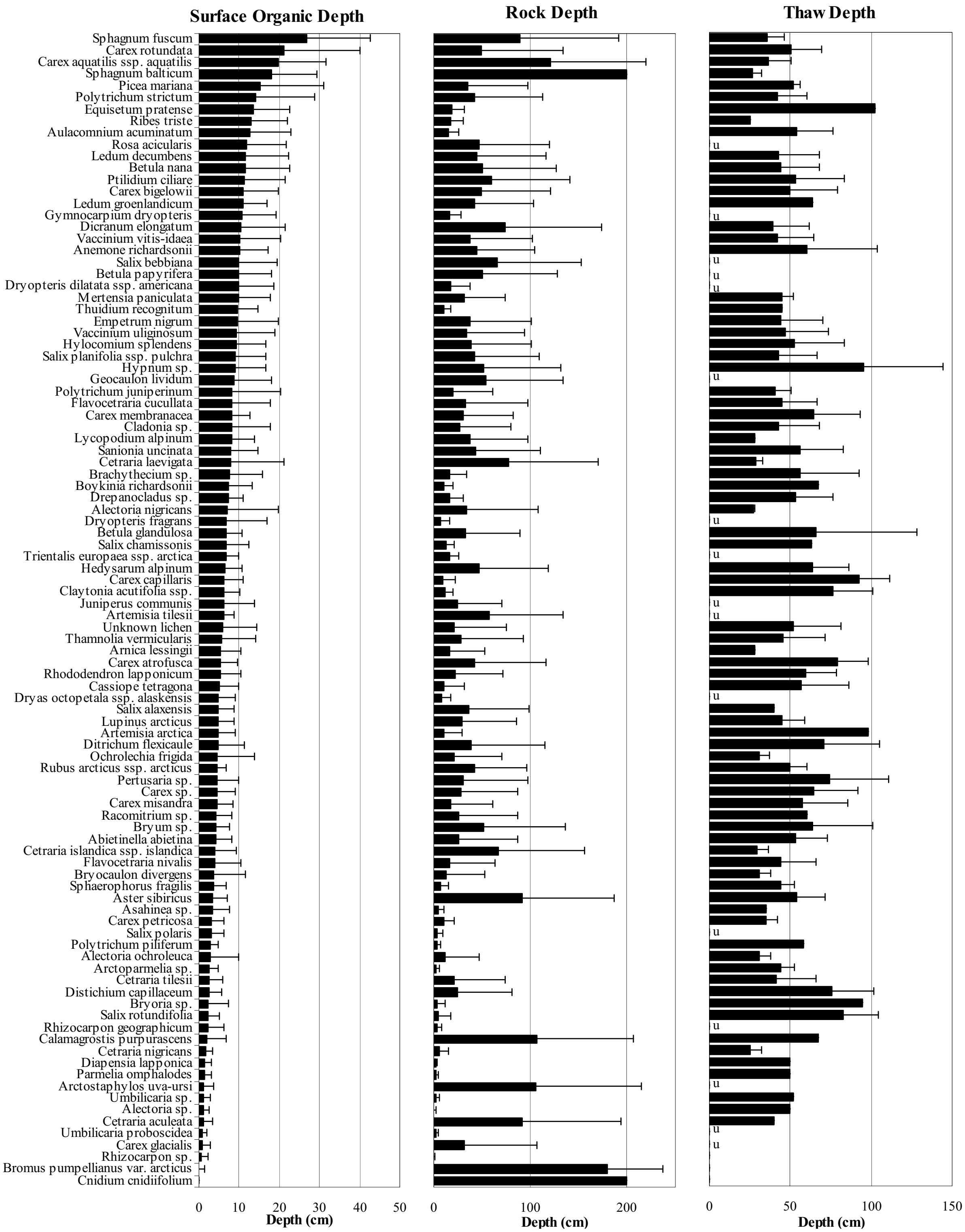


Figure 11. Mean (± SD) thickness of the surface organic layer, depth to rock (>15% coarse fragments) and depth of thaw for plant and cryptogam species in upland and alpine ecotypes in the Arctic Network. Outliers have been excluded.

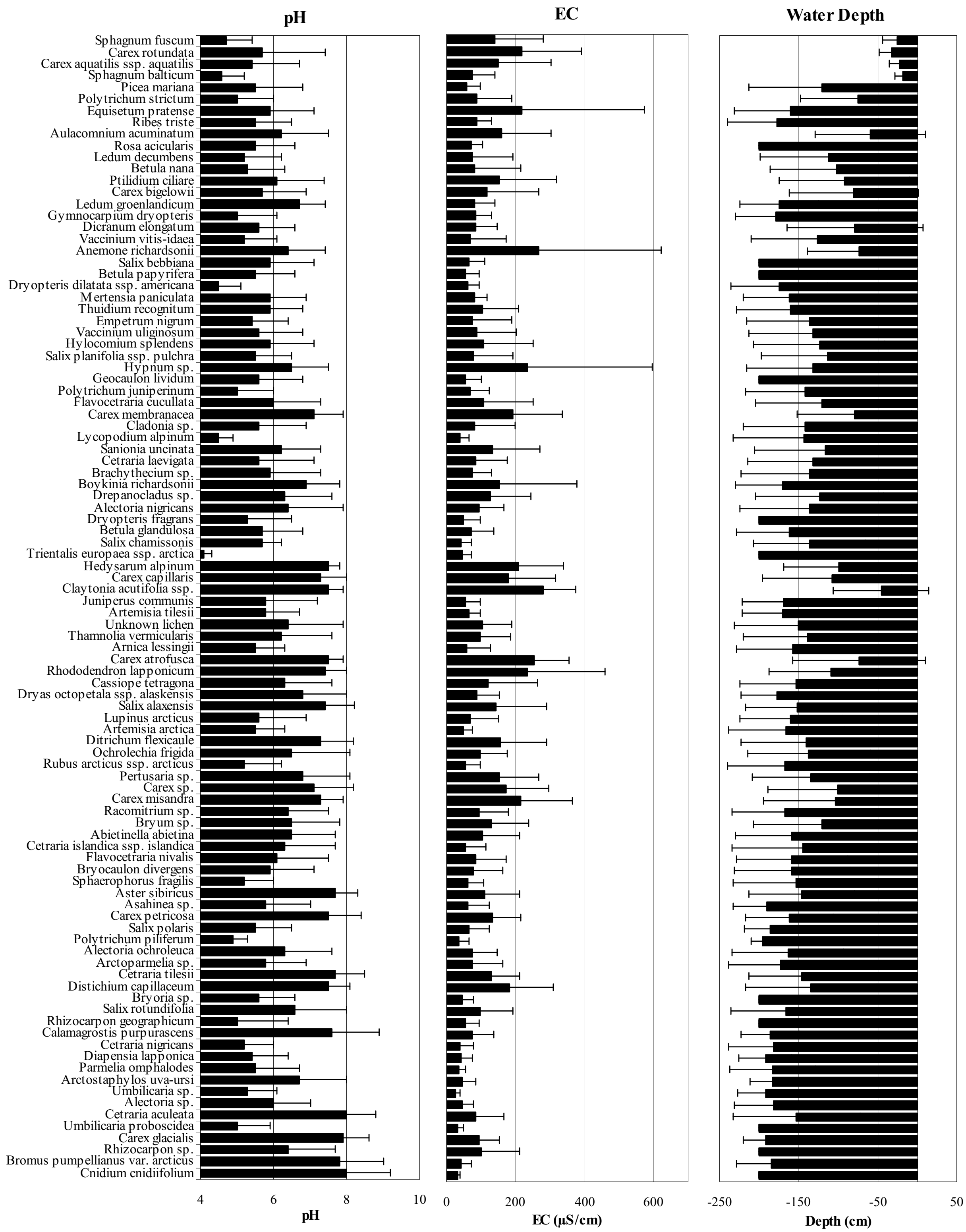


Figure 12. Mean (± SD) pH, electrical conductivity (EC), and water depth for plant and cryptogam species in upland and alpine ecotypes in the Arctic Network. Outliers have been excluded.

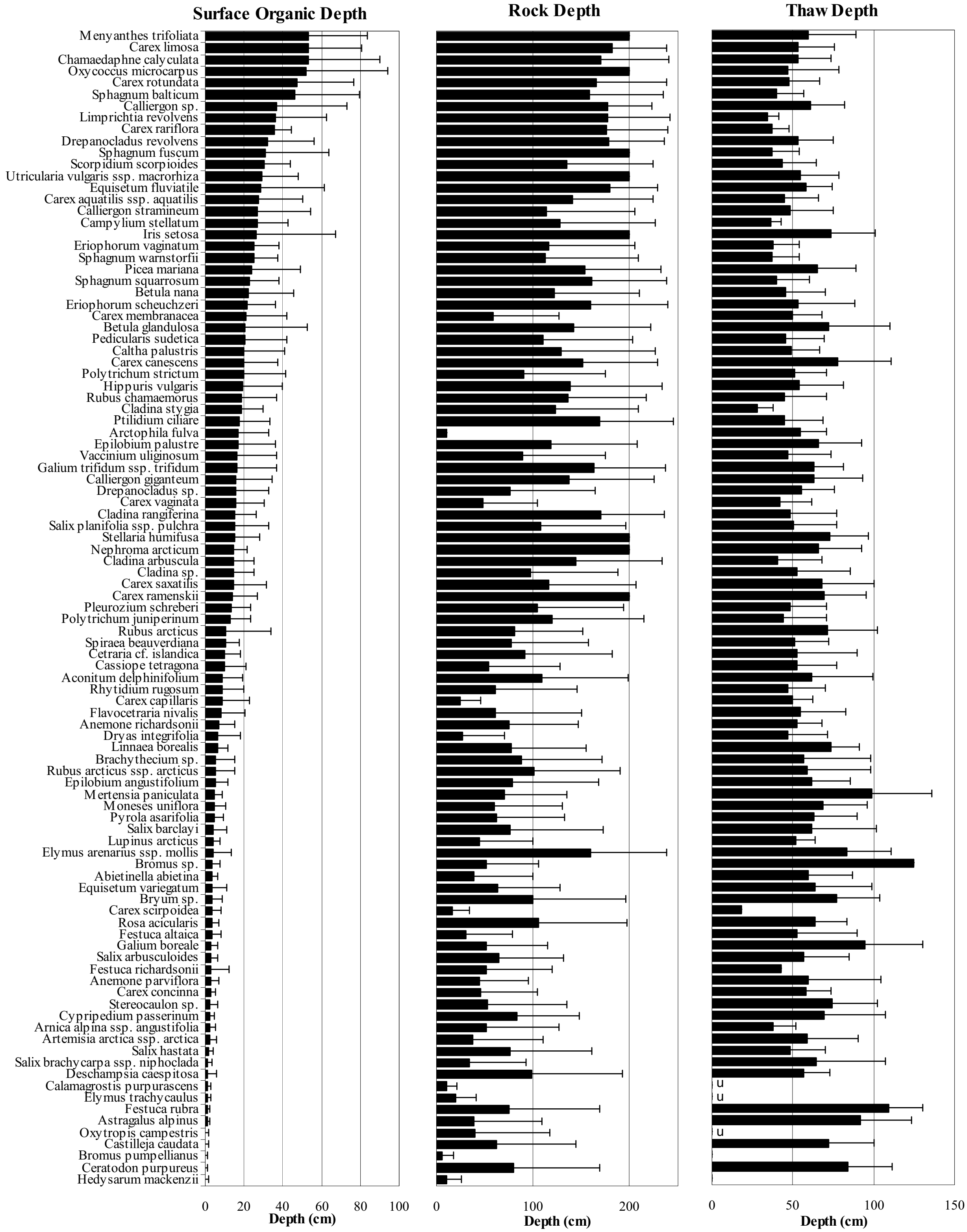


Figure 13. Mean (± SD) thickness of the surface organic layer, depth to rock (>15% coarse fragments) and depth of thaw for plant and cryptogam species in lowland, lacustrine, riverine and coastal ecotypes in the Arctic Network. Outliers have been excluded.

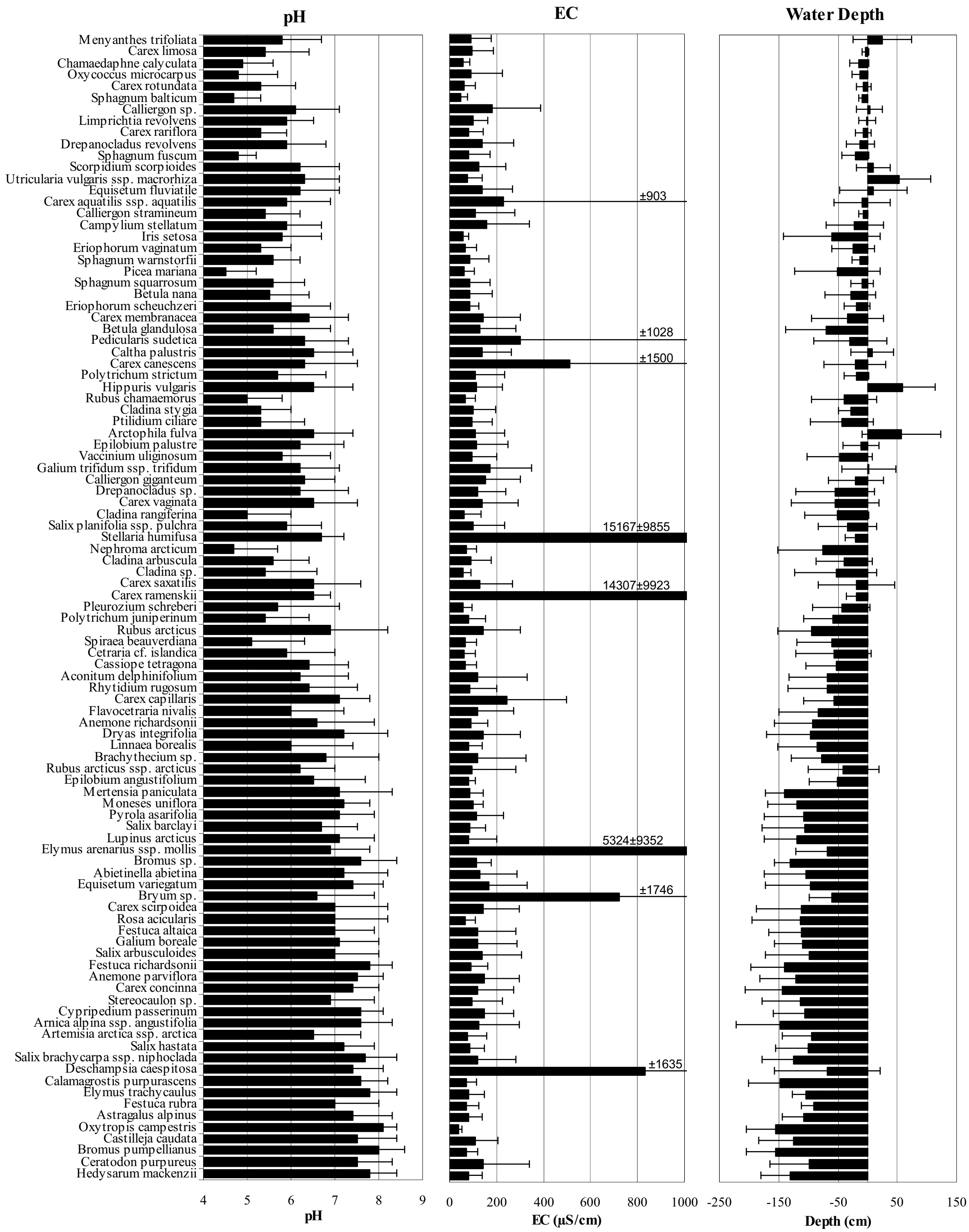


Figure 14. Mean (± SD) pH, electrical conductivity (EC), and water depth for plant and cryptogam species in lowland, lacustrine, riverine and coastal ecotypes in the Arctic Network. Outliers have been excluded.

Depth to rocks also was highly variable among species and within many species (Figures 11 and 13). Species commonly associated with rocks near the surface include *Minuartia arctica, Potentilla uniflora* (syn: *Dasiphora fruticosa*), *Salix phlebophylla, Cladina stellaris*, and *Alectoria ochroleuca*. Species commonly found on thick silt or organic deposits include *Hippuris vulgaris, Potentilla egedii, Rumex arcticus, Rubus chamaemorus*, and *Sphagnum fuscum*.

Thaw depths varied up to four-fold among species (Figures 11 and 13). Species associated with the greatest thaw depths included *Lathyrus maritimus, Epilobium latifolium, Aster sibiricus, Elymus arenarius* ssp. *mollis* (syn: *Leymus mollis*), and *Carex subspathacea*. These species typically occur on sandy to loamy soils in early successional ecotypes. Species generally found on sites with shallow thaw depths included *Sphagnum fuscum, Rubus chamaemorus, Eriophorum vaginatum, Ledum decumbens*, *Pyrola grandiflora*, and *Cladina stygia*. These species are characteristic of late successional sites where soils are acidic, ice-rich, and highly organic.

Depth to water above (+) or below (–) the surface varied widely both among and within species (Figures 12 and 14). Species associated with the deepest surface water were *Hippuris vulgaris, Caltha palustris*, and *Carex chordorrhiza*, which was not surprising, given that these species typically grow in standing water. Species that occurred mostly on sites where water was near the surface included *Carex aquatilis, Carex saxatilis, Pedicularis sudetica*, *Eriophorum angustifolium, Dupontia fischeri, Salix fuscescens*, and *Aulacomnium palustre*. Species associated with the greatest depths to groundwater included *Salix alaxensis*, *Salix barclayi, Minuartia arctica, Dryas octopetala*, and *Epilobium latifolium*. Many species occurred on sites with a wide range of water depths, indicating that most tundra plants can tolerate a wide range of moisture conditions. Depth to groundwater was highly variable both spatially and temporally, contributing to high standard deviations both within and among species.

The pH of groundwater or soil (when groundwater was not present) was circumneutral (5.6–7.3) for most species and highly variable within species (Figures 12 and 14). Species associated with strongly acidic sites included *Ledum decumbens*, *Vaccinium vitis-idaea, Eriophorum vaginatum, Rubus chamaemorus,* and *Sphagnum fuscum*. Species associated with alkaline (>7.3) soils included *Saxifraga oppositifolia, Minuartia arctica, Rhododendron lapponicum*, and *Dryas integrifolia*. The latter group typically was associated with soils on carbonate bedrock. However, most species occurred on sites with a wide range of pH values, indicating broad ecological tolerances to pH conditions.

EC values were low for most species, indicating non-saline conditions (Figures 12 and 14). Species associated with saline conditions (mean EC >16,000 µS/cm) included *Carex subspathacea*, *Puccinellia phryganodes, Chrysanthemum arcticum,* and *Potentilla egedii*. Species associated with brackish conditions (EC 800–16,000 µS/cm) included *Carex ramenskii*, *Deschampsia caespitosa, Salix ovalifolia, Dupontia fischeri, Elymus arenarius* ssp. *mollis*, *Rumex arcticus,* and *Hippuris tetraphylla*. Their high standard deviations indicate they tolerated a broad range of salinity conditions.

Vegetation Composition

Species Summary

There were 69 ecotypes, consisting of 106 AVC vegetation classes at the plot level and 70 plant associations (Table 138). Species diversity varied among ecotypes by a factor of 237, and by plot, it varied by a factor of 31 (Table 139). The

Table 138. Crosswalk of abbreviated ecotypes with original ecotypes, floristic classes and Viereck level IV vegetation classes in the Arctic Network.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
Alpine Acidic Barrens	Alpine Rocky Dry Acidic Barrens	Lichen–*Hierochloe alpina*	Barren
			Dry Bryophyte
			Lichen
			Partially Vegetated
Alpine Acidic Dryas Dwarf Shrub	Alpine Rocky Dry Acidic Dryas Dwarf Shrub	*Dryas octopetala–Hierochloe alpina*	Dryas Dwarf Shrub Tundra
			Dryas–Lichen Dwarf Shrub Tundra
			Dryas–Sedge Dwarf ShrubTundra
Alpine Alkaline Barrens	Alpine Rocky Dry Alkaline Barrens	*Dryas octopetala–Saxifraga oppositifolia*	Barren
			Partially Vegetated
		Salix arctica–Minuartia arctica	Barren
			Partially Vegetated
Alpine Alkaline Dryas Dwarf Shrub	Alpine Rocky Dry Alkaline Dryas Dwarf Shrub	*Dryas integrifolia–Carex scirpoidea–Silene acaulis*	Dryas Dwarf Shrub Tundra
			Dryas–Lichen Dwarf Shrub Tundra
			Dryas–Sedge Dwarf ShrubTundra
		Dryas octopetala–Saxifraga oppositifolia	Dryas Dwarf Shrub Tundra
			Dryas–Lichen Dwarf Shrub Tundra
			Dryas–Sedge Dwarf Shrub Tundra
Alpine Cassiope Dwarf Shrub	Alpine Rocky Moist Circumneutral Cassiope Dwarf Shrub	*Cassiope tetragona–Dryas octopetala–Polygonum bistorta*	Cassiope Dwarf Shrub Tundra
			Dryas–Forb Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub Tundra
			Open Low Willow
			Willow Dwarf Shrub Tundra
Alpine Ericaceous–Dryas Dwarf Shrub	Alpine Rocky Moist Circumacidic Ericaceous–Dryas Dwarf Shrub	*Betula nana–Loiseleuria procumbens*	Crowberry Dwarf Shrub Tundra
			Dryas–Lichen Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub–Lichen Tundra

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
			Open Low Mesic Shrub Birch–Ericaceous Shrub
		Betula nana–Vaccinium vitis-idaea–Dryas octopetala	Closed Low Shrub Birch–Ericaceous Shrub
			Dryas Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub–Lichen Tundra
			Open Low Mesic Shrub Birch–Ericaceous Shrub
			Open Low Shrub Birch–Willow
			Vaccinium Dwarf Shrub Tundra
		Dryas octopetala–Vaccinium uliginosum–Festuca altaica	Cassiope Dwarf Shrub Tundra
			Dryas Dwarf Shrub Tundra
			Dryas–Lichen Dwarf Shrub Tundra
			Dryas–Sedge Dwarf ShrubTundra
			Ericaceous Dwarf Shrub Tundra
			Moist Sedge–Shrub Tundra
			Open Low Mesic Shrub Birch–Ericaceous Shrub
			Open Low Willow
Alpine Lake	Alpine Lake	*Water*	Fresh Water
Alpine Mafic Barrens	Alpine Rocky Dry Mafic Barrens	*Dryas octopetala–Hierochloe alpina*	Partially Vegetated
		Salix arctica–Minuartia arctica	Barren
			Partially Vegetated
Alpine Wet Sedge Meadow	Alpine Rocky Circumneutral Wet Sedge Meadow	*Eriophorum angustifolium–Pedicularis sudetica*	Mixed Herbs
			Wet Sedge Meadow Tundra
			Wet Sedge–Willow Tundra
Upland Alder–Willow Tall Shrub	Upland Rocky–loamy Moist Circumacidic Alder–Willow Tall Shrub	*Alnus crispa–Calamagrostis canadensis*	Closed Tall Alder
			Closed Tall Alder–Willow
			Open Low Alder
			Open Paper Birch
			Open Tall Alder
			Open Tall Alder–Willow
		Alnus crispa–Salix lanata ssp. *richardsonii*	Open Low Alder–Willow

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
Upland Birch Forest	Upland Rocky–loamy Moist Circumacidic Birch Forest	*Betula papyrifera–Picea glauca–Vaccinium vitis-idaea*	Closed Paper Birch
			Open Paper Birch
			Paper Birch Woodland
Upland Birch–Ericaceous Low Shrub	Upland Rocky–loamy Moist Acidic Birch–Ericaceous Low Shrub	*Betula nana–Ledum decumbens*	Closed Low Shrub Birch
			Closed Low Shrub Birch–Ericaceous Shrub
			Open Low Alder–Willow
			Open Low Mesic Shrub Birch–Ericaceous Shrub
			Open Low Shrub Birch–Willow
			Open Tall Scrub, post burn or disturbance
			Vaccinium Dwarf Shrub Tundra
Upland Birch–Willow Low Shrub	Upland Rocky–loamy Moist Circumacidic Birch–Willow Low Shrub	*Betula nana–Vaccinium vitis-idaea–Dryas octopetala*	Open Low Shrub Birch–Willow
		Salix planifolia ssp. *pulchra–Betula nana–Polygonum bistorta*	Closed Low Ericaceous Shrub
			Closed Low Shrub Birch–Ericaceous Shrub
			Closed Low Willow
			Closed Tall Shrub Birch
			Closed Tall Shrub Birch–Willow
			Closed Tall Willow
			Open Low Mesic Shrub Birch–Ericaceous Shrub
			Open Low Shrub Birch–Willow
			Open Low Willow
			Open Tall Shrub Birch–Willow
Upland Bluejoint Meadow	Upland Rocky–loamy Moist Circumacidic Bluejoint Meadow	*Calamagrostis canadensis–Polemonium acutiflorum*	Bluejoint Meadow
			Bluejoint–Herb
			Bluejoint–Shrub
Upland Dwarf Birch–Tussock Shrub	Upland Organic–rich Moist Acidic Dwarf Birch–Tussock Shrub	*Betula nana–Eriophorum vaginatum*	Closed Low Shrub Birch
			Open Low Alder–Willow
			Open Low Mesic Shrub Birch–Ericaceous Shrub
			Open Low Shrub Birch–Ericaceous Shrub Bog

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
			Open Mixed Low Shrub–Sedge Tussock Bog Meadow
			Open Mixed Low Shrub–Sedge Tussock Tundra
			Tussock Tundra
Upland Mafic Barrens	Upland Rocky Dry Mafic Barrens	*Cladina stellaris–Loiseleuria procumbens*	Lichen
Upland Sandy Barrens	Upland Sandy Dry Alkaline Barrens	*Calamagrostis purpurascens–Oxytropis kobukensis*	Barren
			Bluejoint–Herb
			Open Dwarf Balsam Poplar
			Partially Vegetated
Upland Sedge–Dryas Meadow	Upland Rocky–loamy Moist Alkaline Sedge–Dryas Meadow	*Dryas integrifolia–Carex bigelowii–Equisetum arvense*	Moist Sedge–Dryas Tundra
			Moist Sedge–Shrub Tundra
		Dryas integrifolia–Carex scirpoidea–Rhododendron lapponicum	Dryas Dwarf Shrub Tundra
			Dryas–Forb Dwarf Shrub Tundra
			Dryas–Sedge Dwarf ShrubTundra
			Moist Sedge–Dryas Tundra
			Moist Sedge–Shrub Tundra
Upland Spiraea Low Shrub	Upland Rocky Moist Acidic Spiraea Low Shrub	*Spiraea beauverdiana–Festuca altaica*	Bluejoint–Shrub
			Closed Low Willow
			Open Low Ericaceous Shrub
			Open Low Shrub
			Open Tall Alder
			Vaccinium Dwarf Shrub Tundra
			White Spruce Woodland
Upland Spruce–Birch Forest	Upland Rocky–loamy Moist Circumacidic Spruce–Birch Forest	*Betula papyrifera–Picea glauca–Vaccinium vitis-idaea*	Open Spruce–Paper Birch
			Spruce–Paper Birch Woodland
Upland White Spruce–Dryas Woodland	Upland Sandy Dry Circumalkaline White Spruce–Dryas Woodland	*Picea glauca–Dryas integrifolia*	Dryas Dwarf Shrub Tundra
			Dryas–Lichen Dwarf Shrub Tundra
			Open Low Willow
			Open White Spruce Forest
			White Spruce Woodland
Upland White Spruce–Ericaceous Forest	Upland Rocky–loamy Moist Circumacidic White Spruce–Ericaceous Forest	*Picea glauca–Ledum decumbens*	Open Dwarf White Spruce

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
			Open White Spruce Forest White Spruce Woodland
Upland White Spruce–Lichen Woodland	Upland Sandy Dry Acidic White Spruce–Lichen Woodland	*Picea glauca–Cladina stellaris*	Open White Spruce Forest White Spruce Woodland
Upland White Spruce–Willow Forest	Upland Rocky–loamy Moist Circumalkaline White Spruce–Willow Forest	*Picea glauca–Salix reticulata–Carex scirpoidea*	Dwarf White Spruce Woodland Open White Spruce Forest White Spruce Woodland
Upland Willow Low Shrub	Upland Loamy Moist Circumalkaline Willow Low Shrub	*Salix lanata* ssp. *richardsonii–Equisetum arvense*	Closed Low Willow Open Low Shrub Birch–Willow Open Low Willow Open Tall Willow
Lacustrine Barrens	Lacustrine Wet Circumalkaline Barrens	*Eriophorum angustifolium–Epilobium palustre*	Barren Bluejoint–Herb Mixed Herbs Moist Forb Meadow Partially Vegetated
Lacustrine Bluejoint Meadow	Lacustrine Loamy Wet Circumacidic Bluejoint Meadow	*Calamagrostis canadensis–Potentilla palustris*	Bluejoint Meadow Bluejoint–Herb Fresh Sedge Marsh
Lacustrine Buckbean Fen	Lacustrine Circumacidic Buckbean Fen	*Menyanthes trifoliata–Potentilla palustris*	Subarctic Lowland Herb Bog Meadow Subartic Lowland Sedge Wet Meadow
Lacustrine Horsetail Marsh	Lacustrine Circumneutral Horsetail Marsh	*Equisetum fluviatile–Potentilla palustris*	Emergent Horsetail
Lacustrine Marestail Marsh	Lacustrine Circumneutral Marestail Marsh	*Hippuris vulgaris–Utricularia vulgaris* ssp. *macrorhiza*	Common Marestail Fresh Pondweed Fresh Water
Lacustrine Pendent Grass Marsh	Lacustrine Circumneutral Pendent Grass Marsh	*Arctophila fulva–Hippuris vulgaris*	Common Marestail Fresh Grass Marsh Fresh Water
Lacustrine Pondlily Lake	Lacustrine Circumacidic Pondlily Lake	*Nuphar polysepalum–Sparganium* sp.	Fresh Water Pondlily
Lacustrine Wet Sedge Meadow	Lacustrine Organic–rich Wet Circumacidic Sedge Meadow	*Carex aquatilis–Potentilla palustris*	Aquatic Fresh Herb Fresh Sedge Marsh Mixed Herbs

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
			Moist Sedge–Grass Meadow Tundra
			Open Low Willow
			Subartic Lowland Sedge Bog Meadow
			Subartic Lowland Sedge–Moss Bog Meadow
			Wet Sedge Meadow Tundra
			Wet Sedge–Herb Meadow Tundra
Lacustrine Willow Shrub	Lacustrine Loamy Wet Circumneutral Willow Shrub	*Salix planifolia* ssp. *pulchra–Potentilla palustris*	Closed Low Willow
			Open Low Shrub Birch–Willow
			Open Low Willow
Lowland Alder Tall Shrub	Lowland Organic–rich Wet Circumacidic Alder Tall Shrub	*Alnus crispa–Salix planifolia* ssp. *pulchra–Hylocomium splendens*	Closed Tall Alder
			Open Low Alder
			Open Low Alder–Willow
			Open Tall Alder
Lowland Birch–Ericaceous Low Shrub	Lowland Organic–rich Wet Acidic Birch–Ericaceous Low Shrub	*Andromeda polifolia–Sphagnum* sp.	Subartic Lowland Sedge–Moss Bog Meadow
		*Ledum decumbens–Vaccinium vitis-idaea–*Foliose/fruticose lichen	Closed Low Shrub Birch–Ericaceous Shrub
			Open Low Mesic Shrub Birch–Ericaceous Shrub
			Open Low Shrub Birch–Willow
			Subartic Lowland Sedge–Moss Bog Meadow
			Wet Sedge–Birch Tundra
Lowland Birch–Willow Low Shrub	Lowland Organic–rich Wet Circumacidic Birch–Willow Low Shrub	*Betula nana–Salix planifolia* ssp. *pulchra–Eriophorum angustifolium*	Closed Low Shrub Birch–Willow
			Closed Low Willow
			Open Low Mesic Shrub Birch–Ericaceous Shrub
			Open Low Shrub Birch–Willow
			Open Low Willow
Lowland Black Spruce Forest	Lowland Organic–rich Wet Acidic Black Spruce Forest	*Picea mariana–Ledum decumbens*	Black Spruce Woodland
			Black Spruce–White Spruce Woodland
			Open Black Spruce Forest
			Open Dwarf Black Spruce

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
Lowland Ericaceous Shrub Bog	Lowland Acidic Ericaceous Shrub Bog	*Andromeda polifolia–Sphagnum* sp.	Open Low Ericaceous Shrub Bog Open Low Mesic Shrub Birch–Ericaceous Shrub Open Low Shrub Birch–Ericaceous Shrub Bog Subartic Lowland Sedge Bog Meadow Subartic Lowland Sedge–Moss Bog Meadow Wet Sedge Meadow Tundra
Lowland Lake	Lowland Lake	*Water–Potamogeton* sp.	Burreed Fresh Water
Lowland Sedge Fen	Lowland Circumacidic Sedge Fen	*Carex chordorrhiza–Carex aquatilis*	Subarctic Lowland Herb Wet Meadow Subartic Lowland Sedge Bog Meadow Subartic Lowland Sedge Wet Meadow Subartic Lowland Sedge–Moss Bog Meadow Wet Sedge Meadow Tundra
Lowland Sedge–Willow Fen	Lowland Circumacidic Sedge–Willow Fen	*Carex aquatilis–Salix planifolia* ssp. *pulchra*	Fresh Sedge Marsh Open Low Willow Subartic Lowland Sedge Bog Meadow Subartic Lowland Sedge Wet Meadow Subartic Lowland Sedge–Moss Bog Meadow Wet Sedge Meadow Tundra Wet Sedge–Willow Tundra
Lowland Willow Low Shrub	Lowland Organic–rich Wet Circumacidic Willow Low Shrub	*Salix planifolia* ssp. *pulchra–Valeriana capitata*	Closed Low Willow Open Low Willow Open Tall Willow
River	River	*Water*	Fresh Water Water
Riverine Alder Tall Shrub	Riverine Loamy Moist Circumacidic Alder Tall Shrub	*Alnus crispa–Rubus arcticus*	Closed Tall Alder Closed Tall Alder–Willow Open Tall Alder
Riverine Barrens	Riverine Gravelly Moist Circumalkaline Barrens	*Salix alaxensis–Epilobium latifolium*	Barren Elymus

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
			Mixed Herbs Open Low Willow Partially Vegetated Seral Herbs
Riverine Birch–Willow Low Shrub	Riverine Loamy Moist Circumacidic Birch–Willow Low Shrub	*Betula nana–Salix planifolia* ssp. *pulchra–Pyrola grandiflora*	Closed Low Shrub Birch
			Closed Low Shrub Birch–Ericaceous Shrub Closed Low Shrub Birch–Willow Closed Low Willow Closed Tall Willow Open Low Shrub Birch–Willow
Riverine Bluejoint Meadow	Riverine Loamy Wet Circumacidic Bluejoint Meadow	*Calamagrostis canadensis–Potentilla palustris*	Bluejoint Meadow
			Bluejoint–Herb Open Low Willow–Sedge Shrub Tundra
Riverine Dryas Dwarf Shrub	Riverine Gravelly Dry Alkaline Dryas Dwarf Shrub	*Dryas drummondii–Oxytropis campestris*	Dryas Dwarf Shrub Tundra
		Dryas integrifolia–Salix brachycarpa ssp. *niphoclada*	Dryas Dwarf Shrub Tundra
			Dryas–Lichen Dwarf Shrub Tundra Moist Sedge–Willow Tundra Open Low Willow
Riverine Forb Marsh	Riverine Circumneutral Aquatic Forb Marsh	*Eleocharis acicularis–Equisetum fluviatile*	Emergent Horsetail
			Fresh Pondweed
Riverine Lake	Riverine Circumalkaline Lake	*Potamogeton* sp.–*Utricularia vulgaris* ssp. *macrorhiza*	Fresh Pondweed
			Fresh Water
Riverine Moist Willow Tall Shrub	Riverine Gravelly–loamy Moist Circumalkaline Willow Tall Shrub	*Salix alaxensis–Aster sibiricus*	Closed Tall Alder–Willow
			Closed Tall Willow Open Low Willow Open Tall Willow
Riverine Poplar Forest	Riverine Gravelly–loamy Moist Circumalkaline Poplar Forest	*Populus balsamifera–Picea glauca–Salix alaxensis*	Closed Balsam Poplar
			Open Balsam Poplar Forest
Riverine Wet Sedge Meadow	Riverine Loamy Wet Circumacidic Wet Sedge Meadow	*Carex aquatilis–Eriophorum angustifolium*	Subartic Lowland Sedge Wet Meadow

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
			Wet Sedge Meadow Tundra
Riverine Wet Willow Tall Shrub	Riverine Loamy Wet Circumacidic Willow Tall Shrub	*Salix planifolia* ssp. *pulchra–Potentilla palustris*	Closed Tall Willow
			Open Tall Alder–Willow
			Open Tall Willow
Riverine White Spruce–Alder Forest	Riverine Gravelly–loamy Moist Circumacidic White Spruce–Alder Forest	*Picea glauca–Alnus crispa–Calamagrostis canadensis*	Open White Spruce Forest
			White Spruce Woodland
Riverine White Spruce–Poplar Forest	Riverine Gravelly–loamy Moist Circumalkaline White Spruce–Poplar Forest	*Populus balsamifera–Picea glauca–Salix alaxensis*	Open Spruce–Balsam Poplar Forest
			Open White Spruce Forest
			Spruce–Balsam Poplar Woodland
Riverine White Spruce–Willow Forest	Riverine Gravelly–loamy Moist Circumalkaline White Spruce–Willow Forest	*Picea glauca–Salix lanata* ssp. *richardsonii–Moneses uniflora*	Open Tall Alder–Willow
			Open White Spruce Forest
			White Spruce Woodland
Riverine Willow Low Shrub	Riverine Gravelly–loamy Moist Circumalkaline Willow Low Shrub	*Salix lanata* ssp. *richardsonii–Salix reticulata*	Closed Low Willow
			Closed Tall Willow
			Dryas–Forb Dwarf Shrub Tundra
			Moist Sedge–Dryas Tundra
			Open Low Willow
			Open Tall Willow
Coastal Brackish Dunegrass Meadow	Coastal Sandy Dry Brackish Dunegrass Meadow	*Elymus arenarius* ssp. *mollis–Lathyrus maritimus*	Elymus
			Partially Vegetated
Coastal Brackish Sedge–Grass Meadow	Coastal Loamy Wet Brackish Sedge–Grass Meadow	*Carex ramenskii–Dupontia fischeri*	Halophytic Sedge Wet Meadow, brackish
			Halophytic Sedge–Grass Wet Meadow, brackish
Coastal Brackish Water	Coastal Brackish Water	*Water*	Marine Water
Coastal Brackish Willow Shrub	Coastal Sandy Wet Brackish Willow Shrub	*Salix ovalifolia–Deschampsia caespitosa*	Halophytic Grass Wet Meadow, brackish
			Halophytic Sedge–Grass Wet Meadow, brackish
			Wet Sedge–Willow Tundra
Coastal Crowberry Dwarf Shrub	Coastal Sandy Moist Circumacidic Crowberry Dwarf Shrub	*Empetrum nigrum–Elymus arenarius* ssp. *mollis*	Crowberry Dwarf Shrub Tundra
Coastal Dry Barrens	Coastal Sandy Dry Barrens	*Elymus arenarius* ssp. *mollis–Lathyrus maritimus*	Barren
			Partially Vegetated
Coastal Nearshore Water	Coastal Nearshore Water	*Water*	Marine Water

Table 138. Continued.

Ecotype (short name)	Ecotype (long name)	Plant Association	Vegetation Class
Coastal Saline Sedge–Grass Meadow	Coastal Loamy Wet Saline Sedge–Grass Meadow	*Carex ramenskii–Puccinellia phryganodes*	Halophytic Sedge Wet Meadow, saline Halophytic Sedge–Grass Wet Meadow, brackish Halophytic Sedge–Grass Wet Meadow, saline
Coastal Tidal River	Coastal Tidal River	*Water*	Marine Water
Coastal Wet Barrens	Coastal Loamy Wet Barrens	*Carex ramenskii–Puccinellia phryganodes*	Barren

Table 139. Mean count of species per individual plot and total species occurrences per ecotype, Arctic Network, 2002–2008.

Ecotype	Plot Mean	SD	Total*	n
Alpine Acidic Barrens	26	12	163	15
Alpine Acidic Dryas Dwarf Shrub	40	6	235	19
Alpine Alkaline Barrens	26	9	201	21
Alpine Alkaline Dryas Dwarf Shrub	38	12	281	27
Alpine Cassiope Dwarf Shrub	42	10	195	12
Alpine Ericaceous-Dryas Dwarf Shrub	40	12	258	36
Alpine Lake	3	ND	3	1
Alpine Mafic Barrens	27	13	204	18
Alpine Wet Sedge Meadow	35	14	138	8
Coastal Brackish Dunegrass Meadow	10	3	23	4
Coastal Brackish Sedge–Grass Meadow	8	2	17	5
Coastal Brackish Willow Shrub	20	6	35	3
Coastal Crowberry Dwarf Shrub	32	13	98	6
Coastal Dry Barrens	8	6	25	4
Coastal Saline Sedge–Grass Meadow	7	1	9	6
Coastal Wet Barrens	6	ND	6	1
Lacustrine Barrens	13	7	65	6
Lacustrine Bluejoint Meadow	13	7	54	8
Lacustrine Buckbean Fen	10	4	40	7
Lacustrine Horsetail Marsh	7	5	11	2
Lacustrine Marestail Marsh	5	4	24	9
Lacustrine Pendent Grass Marsh	7	4	32	8
Lacustrine Pondlily Lake	6	2	13	5
Lacustrine Wet Sedge Meadow	11	3	62	12
Lacustrine Willow Shrub	22	10	79	6
Lowland Alder Tall Shrub	26	10	97	6
Lowland Birch-Ericaceous Low Shrub	22	5	100	12
Lowland Birch-Willow Low Shrub	27	8	175	20
Lowland Black Spruce Forest	22	3	78	14
Lowland Ericaceous Shrub Bog	17	6	132	30
Lowland Lake	6	3	30	10
Lowland Sedge Fen	16	7	136	29
Lowland Sedge-Willow Fen	18	9	133	21
Lowland Willow Low Shrub	26	11	159	12
River	1	0	3	3
Riverine Alder Tall Shrub	19	4	66	6
Riverine Barrens	16	11	197	30
Riverine Birch-Willow Low Shrub	24	6	101	9
Riverine Bluejoint Meadow	13	2	26	3
Riverine Dryas Dwarf Shrub	40	18	158	7
Riverine Forb Marsh	19	9	30	2
Riverine Lake	14	1	23	2
Riverine Moist Willow Tall Shrub	27	11	223	30
Riverine Poplar Forest	23	8	116	13
Riverine Wet Sedge Meadow	20	5	52	3

Table 139. Continued.

Ecotype	Plot Mean	SD	Total*	n
Riverine Wet Willow Tall Shrub	21	4	74	6
Riverine White Spruce-Alder Forest	27	7	93	8
Riverine White Spruce-Poplar Forest	34	12	135	11
Riverine White Spruce-Willow Forest	34	7	129	8
Riverine Willow Low Shrub	37	14	190	14
Upland Alder-Willow Tall Shrub	24	9	172	22
Upland Birch Forest	25	11	59	4
Upland Birch-Ericaceous Low Shrub	27	9	163	20
Upland Birch-Willow Low Shrub	35	13	227	26
Upland Bluejoint Meadow	30	7	90	4
Upland Dwarf Birch-Tussock Shrub	23	6	160	39
Upland Mafic Barrens	25	8	58	4
Upland Sandy Barrens	15	6	54	12
Upland Sedge-Dryas Meadow	46	8	211	16
Upland Spirea Low Shrub	28	6	117	10
Upland Spruce-Birch Forest	29	7	117	10
Upland White Spruce-Dryas Woodland	30	6	88	6
Upland White Spruce-Ericaceous Forest	29	8	156	17
Upland White Spruce-Lichen Woodland	28	9	58	3
Upland White Spruce-Willow Forest	40	10	207	17
Upland Willow Low Shrub	38	11	181	13

*Total number of species documented per ecotype ecotypes with the highest species richness occurred in alpine or upland physiographies. Alpine Ericaceous–Dryas Dwarf Shrub and Alpine Alkaline Dryas Dwarf Shrub were the ecotypes with the highest species richness. The total species count was, however, slightly influenced by the number of plots sampled per ecotype, and we did not control for this. The least species rich ecotypes were those where the AVC vegetation class was aquatic or where the physiography was coastal. In general, ecotypes where the landscape was young and disturbance events occurred more frequently (such as riverine or coastal ecotypes), were less species rich, and ecotypes with old landscapes that were less frequently disturbed (alpine or upland) were more species rich. Species counts should be considered a point for comparison among ecotypes rather than an absolute number, due to our sampling methods and the fact that we probably overlooked species. This is especially true for aquatic ecotypes since we were not equipped to sample lakes thoroughly. We recorded 572 vascular species (excluding subspecies) compared to 706 species documented during a floristic inventory conducted for the NPS Inventory & Monitoring Program (Parker 2006), but a comprehensive floristic survey was beyond the scope of this project.

Ordination of Vegetation

In addition to the single-factor comparisons, nonmetric multidimensional scaling (NMDS) (Shepard 1962a,b; Kruskal 1964a,b) was used to separate plots by species composition. Because of the large number of species, ecotypes, and differing environmental gradients, the ordinations were calculated separately for each physiographic grouping (Figures 15–17). Within each of the physiographic groupings, species occurring in only one plot at less than 5 percent cover were removed, prior to analysis, and the remaining cover values square root transformed. Each physiographic ordination was computed using a Bray/Curtis dissimilarities matrix calculated for each physiographic group from the transformed abundance data (Bray and Curtis 1957). The combined effects of physiography and various environmental variables were assessed by superimposing the ecotype class for each plot on the ordination. On the ordinations, the central cluster of each ecotype was circled and outliers were occasionally excluded to better differentiate highly central tendencies. The ordinations reveal which ecotypes have very similar species composition and which ones have distinct species assemblages.

Alpine ecotypes had numerous ecotypes with good separation in species assemblages. There was little overlap in species composition, or “species space”, among alkaline, mafic, and acidic barren ecotypes (Figure 15a). In contrast, there was substantial overlap in species assemblages among Alpine Acidic Dryas Dwarf Shrub, Alpine Ericaceous–Dryas Dwarf Shrub, and Alpine Cassiope Dwarf Shrub.

Upland ecotypes had few very distinct classes and many classes had substantial overlap among ecotypes (Figure 15b). Distinct ecotypes included Upland Mafic Barrens on lava flows, Upland Sandy Barrens on the Kobuk Dunes, and Upland Sedge–Dryas Meadow on alkaline bedrock. In contrast, upland forest types had a high degree of overlap in species composition.

Lowland ecotypes showed numerous ecotypes with distinct species composition (Figure 16a). Lowland Ericaceous Shrub Bog had little similarity to Lowland Sedge–Willow Fen and Lowland Birch–Ericaceous Low Shrub. The greatest similarity occurred between Lowland Black Spruce Forest and Lowland Birch–Ericaceous Low Shrub.

Lacustrine ecotypes also were fairly distinct (Figure 16b). The highest similarity occurred between Lacustrine

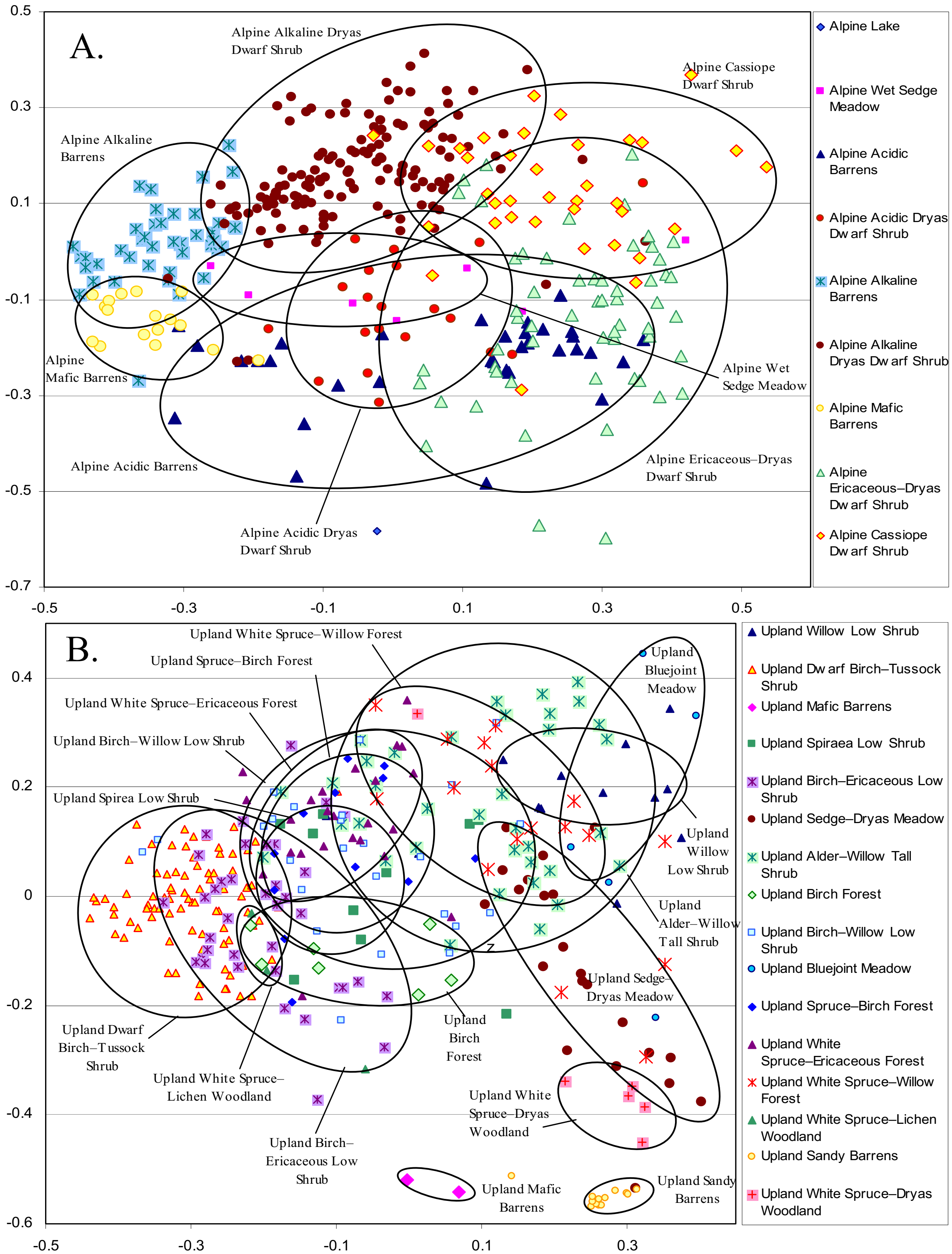


Figure 15. Non-metric multidimensional scaling species composition for alpine (A) and upland (B) ecotypes in the Arctic Network. Outliers have been excluded.

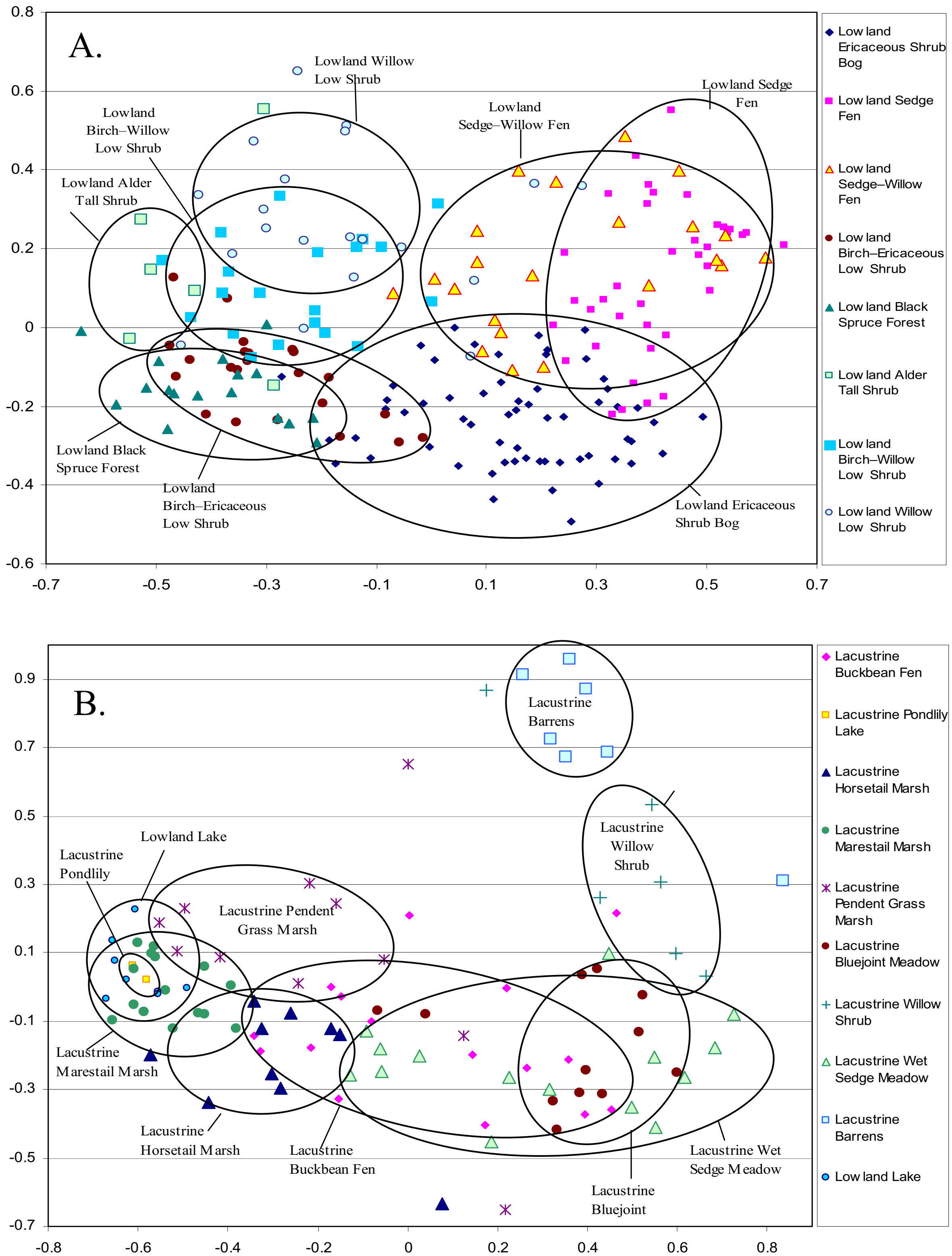


Figure 16. Non-metric multidimensional scaling species composition for lowland (A) and lacustrine (B) ecotypes in the Arctic Network. Outliers have been excluded.

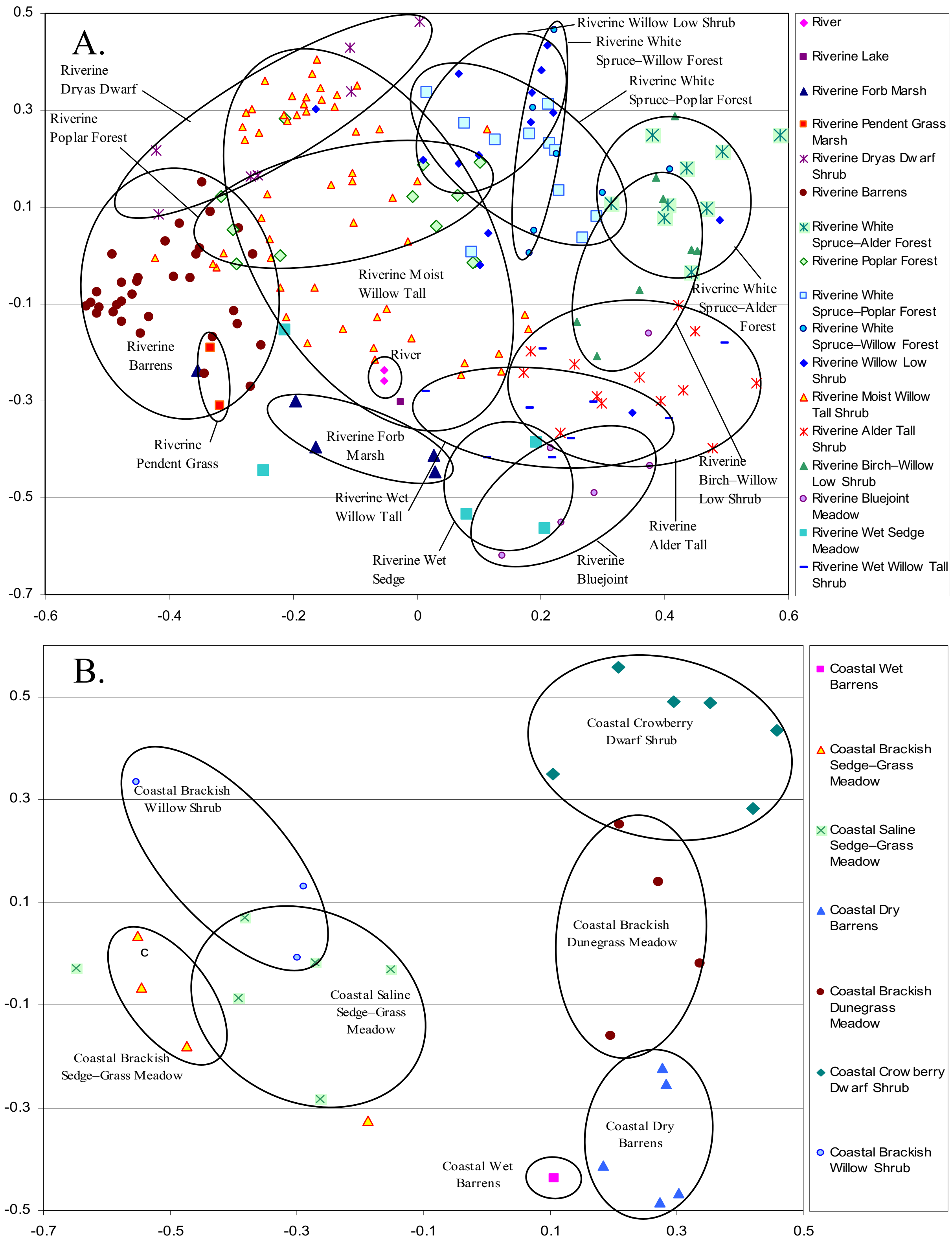


Figure 17. Non-metric multidimensional scaling species composition for riverine (A) and coastal (B) ecotypes in the Arctic Network. Outliers have been excluded.

Table 140. Mean plant cover by alpine ecotypes within the Arctic Network. Numbers with an underline are dominent and differential species; bold indicates species frequency >60%; and zeros have trace values <0.5%.

Taxon	Alpine Mafic Barrens	Alpine Alkaline Barrens	Alpine Alkaline Dryas Dwarf Shrub	Alpine Cassiope Dwarf Shrub	Alpine Wet Sedge Meadow	Alpine Ericaceous-Dryas Dwarf Shrub	Alpine Acidic Dryas Dwarf Shrub	Alpine Acidic Barrens
Claytonia sarmentosa	0			0	0			
Smelowskia calycina	0	0					0	
Dryas integrifolia	1	1	3		1	0	1	
Saxifraga oppositifolia	0	**7**	**3**	1		0	0	0
Artemisia furcata	0	0	0					
Potentilla biflora		0	0	0	0		0	
Oxytropis campestris ssp. *jordalii*		0	0				0	
Rhododendron lapponicum	0	0	0	0		0		
Sanionia uncinata		0	0	2		0	0	
Hedysarum hedysaroides		0	0	0				
Thamnolia subuliformis	0	1	1	0		0		0
Hedysarum alpinum		0	1	1		0		
Oxyria digyna	0		0	0				
Anemone drummondii	0	0	0			0	0	
Alectoria nigricans	0	0	0			0	0	0
Anemone parviflora	0	0	0	**2**	0	0	0	0
Carex misandra	0	0	0	0	2	0		
Bupleurum triradiatum ssp.	0	0	0	0	0	0	0	0
Carex atrofusca		0	0		1			
Ochrolechia frigida		0	0	0		0	0	0
Pertusaria sp.		0	0	0		0	0	0
Oxytropis nigrescens		2	0	0		0	0	
Boykinia richardsonii		0	0	**12**		0		
Arctostaphylos rubra		0	2	0		1	0	
Cetraria islandica ssp. *islandica*		0	**4**	3		1	0	1
Dryas octopetala ssp. *alaskensis*	0	0	1	4	1	1	4	0
Poa glauca	0	0	0	0		0	0	0
Salix rotundifolia	0	0	0	2	1	0	1	1
Potentilla uniflora	0	0	0				0	0
Saxifraga bronchialis	**0**	0	0	0	0	0	**0**	0
Thalictrum alpinum	0	0	0	0	0	0		
Tomentypnum nitens	0	0	0	4	5	1	1	
Papaver macounii	0	0	0	0	0	0	0	
Silene acaulis	0	0	1	1		0	0	
Salix arctica	**1**	0	0	1	**4**	0	0	
Minuartia arctica	**1**	0	0	0	0	0	1	0
Dryas octopetala	0	3	**35**	**35**	2	**14**	**23**	0
Thamnolia vermicularis	0	0	0	0	0	0	**1**	0
Carex scirpoidea	0	0	**5**	1	1	2	0	
Carex rupestris		0	5	0		0		
Cassiope tetragona	0	0	2	**30**	0	**7**	1	**11**
Polygonum bistorta	0		0	0	**1**	0	0	0
Rhytidium rugosum	0	0	1	1	1	1	2	0
Salix reticulata	0	0	2	**9**	3	1	1	0
Polygonum viviparum	0	0	0	0	1	0	0	
Flavocetraria nivalis	0	1	1	0		1	**2**	1
Flavocetraria cucullata	0	0	**3**	**3**		**2**	**1**	2
Vaccinium uliginosum	0		0	4	1	**12**	**2**	1
Cladonia sp.	0	0	0	0		1	0	1
Carex podocarpa	1		0	1	1	1	0	1
Stereocaulon sp.	0	0	0	0		1	1	0
Anemone narcissiflora	0	0	0	0	0	1	0	1
Hylocomium splendens		0	0	**14**	2	4	0	0
Masonhalea richardsonii			0	1		**1**	0	0
Racomitrium lanuginosum	**1**	0	1	1		1	1	**3**
Artemisia arctica ssp. *arctica*	0		0			1	0	0
Poa arctica	0	0	0	0	**2**	0	0	
Alectoria ochroleuca	0	0	0	0		0	1	0
Salix phlebophylla	0	0	0	0		1	**3**	0
Nephroma arcticum		0	0	0		0	0	0
Cladina rangiferina			0	0		5	0	6
Arctostaphylos alpina			0	0	0	1	1	0

Table 140. Continued.

Taxon	Alpine Mafic Barrens	Alpine Alkaline Barrens	Alpine Alkaline Dryas Dwarf Shrub	Alpine Cassiope Dwarf Shrub	Alpine Wet Sedge Meadow	Alpine Ericaceous-Dryas Dwarf Shrub	Alpine Acidic Dryas Dwarf Shrub	Alpine Acidic Barrens
Dicranum sp.			0	1	0	1	0	0
Lupinus arcticus	0		0	0		0	0	
Cetraria laevigata			0	1		0	0	0
Carex membranacea			0	0	1	0		
Equisetum arvense			0	0	11	0		
Salix lanata ssp. *richardsonii*		0	0	5	1	0		
Pleurozium schreberi			0	1		1	0	
Geum glaciale	0		0	1		0	0	
Pedicularis sudetica			0	0	**1**	0		
Eriophorum angustifolium	0		0	0	**15**	0		
Arctagrostis latifolia			0	0	**4**	0	0	
Carex bigelowii			0	0	**13**	0	0	
Thuidium recognitum				1		1	0	
Carex aquatilis					3			
Aulacomnium palustre		0		0	11	0	0	
Rhizocarpon sp.	1	0	0				1	1
Stereocaulon apocalypticum	0					0	1	0
Festuca altaica	0		1	2	1	**5**	0	0
Ledum decumbens	0			0	0	3	0	1
Umbilicaria sp.	0					0	1	1
Selaginella sibirica	0	0	0			0	1	0
Carex microchaeta	0			1		1	0	6
Sphaerophorus sp.	0		0	0		0	0	0
Luzula confusa	0			0		0	0	0
Polytrichum sp.	0		0	0	0	1	1	0
Hierochloe alpina	0			0	0	1	**1**	**4**
Vaccinium vitis-idaea	0		0	0	0	**4**	1	2
Empetrum nigrum	0	0	0	0	0	2	0	0
Betula nana					0	5	0	0
Salix planifolia ssp. *pulchra*	0	0		0	2	1	0	0
Loiseleuria procumbens	0			0		4	0	1
Cladina mitis	0		0	0		1	0	0
Polytrichum piliferum				0		1	0	0
Diapensia lapponica	0		0	0		0	1	0
Cladina arbuscula		0	0	3		6	0	**10**
Cladina stygia						1	0	0
Arnica lessingii				0	0	0	0	0
Salix polaris						1	1	0
Polytrichum juniperinum	0					0	0	0
Antennaria friesiana	0		0			0	**0**	0
Bryocaulon divergens	0	0	0			0	1	0
Sphaerophorus globosus	0	0	0	0		0	1	0
Umbilicaria proboscidea	0					0	0	1
Cladina stellaris		0	0	3		13	0	**33**
Luzula arcuata				0		0	0	0
Parmelia omphalodes	0					0	3	1
Cetraria nigricans						0	1	1
Rhizocarpon geographicum			0			0	1	1
Racomitrium canescens		0		0		0		
Salix chamissonis						0		
Bryoria nitidula			0			0	0	
Arnica alpina ssp. *angustifolia*			0			0	0	0
Pertusaria subobducens			0				1	
Umbilicaria caroliniana							0	0
Cladonia uncialis				0		0	0	0
Bare Soil	**89**	**75**	**36**	**15**	**7**	**13**	**30**	**28**
Sample Size	18	43	137	37	8	60	19	35

Table 141. Mean plant cover by upland ecotypes within the Arctic Network. Numbers with an underline are dominent and differential species; bold indicates species frequency >60%; and zeros have trace values <0.5%.

Taxon	Upland Mafic Barrens	Upland Sandy Barrens	Upland White Spruce-Dryas Woodland	Upland White Spruce-Lichen Woodland	Upland Sedge-Dryas Meadow	Upland Willow Tall Shrub	Upland Willow Low Shrub	Upland White Spruce-Willow Forest	Upland Bluejoint Meadow	Upland Spirea Low Shrub	Upland Alder-Willow Tall Shrub	Upland Birch Forest	Upland Spruce-Birch Forest	Upland White Spruce-Ericaceous Forest	Upland Birch-Ericaceous Low Shrub	Upland Birch-Willow Low Shrub	Upland Dwarf Birch-Tussock Shrub
Zygadenus elegans		0	0		0	0	0	1	0				0				
Bromus pumpellianus		**1**	0	0				0									
Artemisia furcata		0	0	0	0												
Oxytropis kobukensis		**<u>0</u>**	0														
Calamagrostis purpurascens		**<u>3</u>**	**1**	0	0			0					0		0	0	
Arctostaphylos uva-ursi			**10**	**1**				0					0				
Solidago multiradiata			**1**	**0**	0	0	0	0			0		0	0			
Abietinella abietina			11	0	1		0				0				0	0	0
Lupinus arcticus			0	0	0					2				0	0	0	0
Shepherdia canadensis			**2**		0	1	0	0			0		0	0			
Dryas integrifolia			**<u>25</u>**		**<u>24</u>**	0	5	3			1		0	0		0	
Rhododendron lapponicum					<u>2</u>		0	0			0					0	
Salix arctica					**4**	0	0	1		0					1	1	
Carex membranacea					3	5	0	1			0			0		0	0
Carex scirpoidea					**<u>2</u>**	6	1	**<u>4</u>**			<u>5</u>		0	1	0	0	
Carex atrofusca					**<u>8</u>**		0										
Rhytidium rugosum			0	0	4	0	0	4		0	1	1	0	0	2	1	1
Tomentypnum nitens					13	0	**13**	4	2		1		0	1	1	4	1
Salix reticulata			2		**7**	**<u>18</u>**	**21**	**<u>9</u>**	1		3				0	3	0
Anemone parviflora					0	1	**3**	**1**	4					0	0	1	
Arctostaphylos rubra			**9**		**2**	3	2	**4**			2		0	1	0	1	0
Cassiope tetragona	0				1	1	0	1		0	5		0	0	2	**2**	0
Hylocomium splendens			1		4	9	**14**	**22**		3	10	2	**8**	**27**	**11**	**14**	6
Festuca altaica			0	**1**	0	7	**5**	**2**	1	**<u>8</u>**	3	0	0	1	2	2	
Potentilla fruticosa	0				1	1	1	**5**			1		1	0	0	0	0
Thamnolia vermicularis	**1**	0	0		1		0	0							0	0	1
Hedysarum alpinum					1	2	2	1			0		0				
Saussurea angustifolia					0	0	0	**1**			0			0	0	0	0
Dryas octopetala					<u>3</u>	**<u>14</u>**	0	6			3				1	<u>2</u>	
Andromeda polifolia					1	0	1	**1**		0	0			0	0	0	0
Senecio lugens	0				0	<u>1</u>	0	0	0		0					0	
Dodecatheon frigidum					0	4	1	0	2		1		0	0		1	
Salix alaxensis		0	0		0	**<u>22</u>**	1	1			2		0				
Sanionia uncinata					1	5	1	1	2	0	3			0	1	1	0
Rubus arcticus								0		3	0			0			
Artemisia arctica ssp. *arctica*				1		0	0	0	5	6	0			0	0	2	
Arctagrostis latifolia					1	2	1	0	3		0		0	1	0	**2**	0
Aconitum delphinifolium					0	0	0	0	**4**	0	0			0		0	
Valeriana capitata						1	**2**	0	3	0	0			0		0	0
Carex bigelowii					<u>3</u>	1	**4**	0	0	2	1		0	1	2	**4**	**3**
Polemonium acutiflorum					0	0	**3**	0	**<u>2</u>**	0	0		0	0		0	0
Calamagrostis canadensis							0	0	**<u>36</u>**	**13**	<u>8</u>	0	1	4	0	0	0
Carex podocarpa					0	0	1	0	**11**	**2**	1			0	0	1	
Salix glauca	0	0	**12**		0		4	4			1	0	2	2	2	6	0
Equisetum arvense					<u>7</u>	**<u>24</u>**	**<u>31</u>**	6	5		2	0	0	1		8	
Salix lanata ssp. *richardsonii*					1	**<u>39</u>**	**<u>29</u>**	**5**			<u>8</u>			1	0	1	0
Picea glauca		0	**<u>10</u>**	**<u>20</u>**		0		**<u>23</u>**		1	0	**<u>1</u>**	**<u>20</u>**	**<u>21</u>**	0	0	0
Alnus crispa	1						0	9		6	**<u>54</u>**	2	7	9	2	1	1
Salix planifolia ssp. *pulchra*	0				0	1	3	1	**3**	9	5	0	0	**4**	3	**<u>27</u>**	2
Vaccinium uliginosum	**1**		2	**8**	1	1	**4**	**9**		**15**	**10**	**3**	**9**	**22**	**18**	**10**	**7**
Vaccinium vitis-idaea	0			**1**		0	0	1	0	**8**	3	**<u>5</u>**	**<u>6</u>**	**6**	**12**	**<u>4</u>**	**10**
Ledum decumbens	**0**					0	0	0		2	3	**2**	**4**	**<u>5</u>**	**<u>13</u>**	**3**	**13**
Empetrum nigrum	**1**		1	**6**	0	0	0	**3**		3	1	1	3	**9**	**6**	2	3
Cladonia sp.			2	**3**	0		0	**1**		**1**	0	**4**	**3**	2	3	0	0
Betula nana	2			**5**		0	1	5		2	2	1		6	**<u>29</u>**	**<u>13</u>**	**<u>15</u>**
Flavocetraria cucullata	**1**		1		**2**	1	0	0		0	1	1	1	1	**3**	1	**2**
Cetraria cf. *islandica*	1			0	0		0	0		1	0		1	1	1	0	0
Cladina stellaris	**<u>1</u>**			**<u>28</u>**		0	0	0		1	2	0	1	4	6	0	0
Flavocetraria nivalis	2	0	1	**2**	0	0		0		0					0	0	0
Cladina rangiferina			2	**5**	0	0	0	0		0	1	1	**3**	2	4	1	2
Pleurozium schreberi				**2**		1	1	0		5	2	1	3	**9**	1	1	1

Table 141. Continued.

Taxon	Upland Mafic Barrens	Upland Sandy Barrens	Upland White Spruce-Dryas Woodland	Upland White Spruce-Lichen Woodland	Upland Sedge-Dryas Meadow	Upland Willow Tall Shrub	Upland Willow Low Shrub	Upland White Spruce-Willow Forest	Upland Bluejoint Meadow	Upland Spirea Low Shrub	Upland Alder-Willow Tall Shrub	Upland Birch Forest	Upland Spruce-Birch Forest	Upland White Spruce-Ericaceous Forest	Upland Birch-Ericaceous Low Shrub	Upland Birch-Willow Low Shrub	Upland Dwarf Birch-Tussock Shrub
Spiraea beauverdiana	0								1	<u>**24**</u>	7	0	1	**8**	0	1	0
Peltigera aphthosa				**1**	0	0	0	0	0	0	1	0	**1**	0	0	0	1
Petasites frigidus					0	3	1		**6**	0	0		0	1	1	1	1
Polygonum bistorta					0	0	0	0		0	0				0	<u>**0**</u>	0
Poa arctica	0				0		0	0	0	0	0			0	0	0	0
Aulacomnium palustre					0	2	4	1			1			1	1	2	2
Betula glandulosa			1			1	2	0			5	1	0	13	11	5	
Stereocaulon sp.		0	**6**	**1**			0			0	0	1	2	0	1	0	0
Unknown crustose lichen	1		2		3	0		1		0	0	0	2		1	0	0
Peltigera canina				**0**		0		0	0		0	0	0	0		0	0
Cetraria islandica			1		0	3	0				0			0	0	0	0
Mertensia paniculata							1	1	0		0		0	0		0	
Artemisia tilesii								0	1		0		0	0			
Equisetum pratense					1				1		1		0	4			
Viburnum edule									4	1	0			0			
Rubus arcticus ssp. *arcticus*							0	0		0	1			0		0	
Gymnocarpium dryopteris								0		1	1	0	0	0			
Polytrichum juniperinum				0			0	0		5	0	**19**	0	0		0	0
Lycopodium annotinum								0		1	0	0	0	0	0	0	0
Linnaea borealis								1		3	0	1	1	2	0	1	
Epilobium angustifolium				0	0	2	0	0	6	1	0	**0**	0	0	0	0	
Ribes triste								0			1	0	1	0			
Betula papyrifera												<u>**52**</u>	<u>**20**</u>	0	0		
Salix bebbiana				0				0				**1**	3	0			
Geocaulon lividum				**1**				2				**0**	2	0	0		
Rosa acicularis									1	1		0	2	0		0	
Ledum groenlandicum								0			0		2	0			
Polytrichum commune												1		1	1		
Populus tremuloides				0								0	0		0		
Equisetum sylvaticum											0		3	0	0		
Loiseleuria procumbens	<u>**2**</u>									0			0	0	1	0	
Polytrichum piliferum				2						0		0	1	0	2		0
Cladina mitis	0			3		0	0	0		0	0		1	0	0	0	1
Arctostaphylos alpina							1	1			0		0	0	1	0	0
Pedicularis labradorica			0	**0**			0	0			0	0		0	0	0	0
Nephroma arcticum	0									0	0	1	0	0	0	0	0
Cladina stygia	1						0	0		0	0		0	1	1	0	1
Picea mariana								2				1	2		0		0
Cladina arbuscula	1			3		1	0	0		1	1	1	1	1	3	0	1
Sphagnum sp.								0		1	0		0	4	2	3	**13**
Rubus chamaemorus							0			0	1			2	1	0	**5**
Aulacomnium turgidum					0			0			0			0	2	2	**3**
Eriophorum vaginatum					0		0				0			0	1	0	<u>**15**</u>
Eriophorum angustifolium					1	0	0		1					1	1	0	0
Salix phlebophylla	0				0										1	0	0
Carex rotundata					0												1
Polytrichum strictum											0				1	0	1
Sphagnum fuscum																1	3
Dicranum elongatum														0	0	1	1
Carex aquatilis					0		1		4					0	0	0	1
Cetraria laevigata					0	1					0	0					0
Sphagnum angustifolium																2	0
Sphagnum girgensohnii															0		0
Icmadophila ericetorum													0		0	0	0
Oxycoccus microcarpus																	0
Chamaedaphne calyculata																	0
Sphagnum lenense															1		1
Eriophorum brachyantherum							0										3
Sphagnum balticum																	5
Bare Soil	**12**	**87**	**28**	0	**18**	**18**	**1**	2	**4**	**4**	3	**4**	**0**	0	**7**	**4**	**1**
Sample Size	4	13	6	3	22	38	13	16	4	10	30	4	10	17	23	25	39

Table 142. Mean plant cover by lowland ecotypes within the Arctic Network. Numbers with an underline are dominent and differential species; bold indicates species frequency >60%; and zeros have trace values <0.5%.

Taxon	Lowland Sedge Fen	Lowland Sedge-Willow Fen	Lowland Ericaceous Shrub Bog	Birch-Ericaceous Low Shrub	Lowland Black Spruce Forest	Lowland Birch-Willow Low Shrub	Lowland Alder Tall Shrub	Lowland Willow Low Shrub
Water	**32**	**21**	**4**	0	0	0		5
Utricularia vulgaris ssp. *macrorhiza*	1							
Carex chordorrhiza	**16**		1			0		0
Sphagnum orientale	4		0					
Equisetum fluviatile	1		0				0	2
Limprichtia revolvens	6	0	0					0
Carex livida	1		0					
Pedicularis parviflora ssp. *parviflora*	0		0					
Utricularia intermedia	0	0						
Trichophorum caespitosum	0		1					
Calliergon sp.	0	2						2
Caltha palustris	0	1						
Saxifraga hirculus	0	0				0		0
Myrica gale	0	0	0				2	2
Drosera rotundifolia	0		0					
Campylium stellatum	0	1	0		1	0		0
Tofieldia pusilla	0		0					
Carex capillaris	0	0					0	
Carex saxatilis	1	1	0			0		0
Menyanthes trifoliata	1	1	1					
Carex rariflora	0	0	0	1				
Carex canescens	0	0	0					0
Sphagnum steerei	1		2					
Carex limosa	1	0	2			0		
Utricularia minor	0	0						
Pedicularis sudetica	0	0	0			0		
Potentilla palustris	1	2	0			0	0	1
Eriophorum russeolum	1	1	7	0	0			
Carex rotundata	3	0	**9**			0		
Scorpidium scorpioides	9	0	0					
Polygonum viviparum	0	0				0		0
Pedicularis parviflora ssp. *pennellii*	0	0						
Epilobium palustre	0	0				0		0
Sphagnum capillifolium	0	1		3		1		
Mnium sp.	0	0	0			0		2
Carex membranacea	1	0	0			0		0
Sphagnum squarrosum	2	5	2	3		3		0
Drepanocladus revolvens	3	1	1			0		
Eriophorum scheuchzeri	0	0	0			0		0
Paludella squarrosa		3	0			1		2
Sphagnum lenense	0	2	5			0		
Aulacomnium acuminatum	0	0	0			0		
Calliergon stramineum		0	0					4
Warnstorfia exannulata		1	1					0
Sphagnum warnstorfii		3	2	0		1		2
Sphagnum imbricatum		1	1					
Sphagnum balticum	0	1	12	7				
Chamaedaphne calyculata	0		3	0	1	0	2	0
Sphagnum compactum	0		2					
Sphagnum lindbergii			3			0		
Sphagnum jensnii			4					
Icmadophila ericetorum			0	0		0		
Iris setosa	0		0			0	0	
Sphagnum riparium			9					0
Sphagnum magellanicum			2					
Pedicularis langsdorffii ssp. *arctica*	0	0	0			0		
Pedicularis labradorica			0	0	0	0		0
Sphagnum rubellum			0	1				
Potentilla fruticosa	0			0		0	0	0
Cassiope tetragona		0				0	0	
Carex vaginata		0		0		0	1	

Table 142. Continued.

Taxon	Lowland Sedge Fen	Lowland Sedge-Willow Fen	Lowland Ericaceous Shrub Bog	Birch-Ericaceous Low Shrub	Lowland Black Spruce Forest	Lowland Birch-Willow Low Shrub	Lowland Alder Tall Shrub	Lowland Willow Low Shrub
Salix lanata ssp. *richardsonii*	0	0		0		1	3	2
Rhytidium rugosum		0	0	2		0	2	
Eriophorum brachyantherum	0		0	0	1			
Sphagnum fuscum	1		1	9	4	1		0
Oxycoccus microcarpus		0	0	0	0	0		
Aulacomnium turgidum	1	1	2	3		2		1
Salix fuscescens	**2**	1	1	0		0		3
Eriophorum angustifolium	**5**	**11**	2	0	0	3		0
Carex aquatilis	**11**	**19**	**6**	6		3		**3**
Andromeda polifolia	1	0	**6**		0	0	3	0
Sphagnum sp.	3	4	7	5	**6**	2	1	
Betula nana	1	2	**4**	**21**	**16**	**24**	5	1
Aulacomnium palustre	0	**5**	2	7	1	**9**	1	**10**
Salix planifolia ssp. *pulchra*	0	**4**	1	1	1	**22**	**9**	**56**
Calamagrostis canadensis	0	1	0		0	1	**2**	5
Eriophorum vaginatum	0	0	1	0	1	2	3	0
Vaccinium uliginosum	0	2	5	**9**	**24**	**9**	**20**	4
Ledum decumbens	0	0	2	**18**	**15**	**3**	2	0
Vaccinium vitis-idaea	0	0	1	**10**	**6**	2	1	0
Empetrum nigrum		0	1	**8**	**7**	1	2	0
Carex bigelowii	0	0	0	**3**	**9**	**4**	0	3
Hylocomium splendens		1	0	11	11	**12**	**21**	**15**
Flavocetraria cucullata		0	0	**2**	0	0	1	0
Dicranum sp.	0	0	0	**3**	2	2	0	2
Polytrichum sp.	0		0	1	2	0		1
Polytrichum juniperinum		0	0	1	2	1		0
Drepanocladus sp.	0	0	0		0	1		2
Thamnolia vermicularis		0	0	0	0	0		
Cladina stygia			0	1	0	0	0	0
Cladina sp.			0	1	1	0	1	0
Salix reticulata	0	0		0		1	1	3
Polytrichum strictum	0	0	0		2	1		1
Picea glauca	0	0	0	0	2	0	1	
Alnus crispa	0	0	0		2	0	**42**	0
Ptilidium ciliare	0	0	0	2	0	0		
Cladina arbuscula		0		2	0	0	0	
Sphagnum angustifolium			1	1	1			
Cladina stellaris				0	1			
Nephroma arcticum				0	**1**	0		
Cladina rangiferina			0	1	**2**	0	0	
Cladonia sp.		0	1	1	**0**	0	0	
Picea mariana		0	0	1	**27**		1	0
Spiraea beauverdiana				0	**4**	0	0	0
Pleurozium schreberi			0	3	**11**	1	2	1
Rubus chamaemorus			0	1	**5**	2	6	1
Polemonium acutiflorum	0	0				0	0	0
Salix glauca		0		0		1	1	1
Arctagrostis latifolia		0		0	0	1	1	1
Tomentypnum nitens	0	3	1	0	0	5	**7**	3
Petasites frigidus		0		0	1	2	0	16
Poa arctica		0		0		0		1
Valeriana capitata	0	0				0	1	2
Equisetum arvense		0		0	2	5	**5**	11
Arctostaphylos rubra	0			0	0	0	4	0
Dactylina arctica						0		
Sphagnum girgensohnii					3			0
Aconitum delphinifolium						0	0	0
Betula glandulosa		0		6	3		11	0
Bare Soil	4	1	1	0	**1**	1	3	0
Sample Size	29	21	30	12	14	20	6	12

Table 143. Mean plant cover by lacustrine ecotypes within the Arctic Network. Numbers with an underline are dominent and differential species; bold indicates species frequency >60%; and zeros have trace values <0.5%.

Taxon	Lowland Lake	Lacustrine Pondlily Lake	Riverine Lake	Riverine Forb Marsh	Lacustrine Marestail Marsh	Lacustrine Horsetail Marsh	Lacustrine Pendent Grass Marsh	Lacustrine Buckbean Fen	Lacustrine Willow Shrub	Lacustrine Wet Sedge Meadow	Riverine Wet Sedge Meadow	Lacustrine Bluejoint Meadow	Lacustrine Barrens
Water	**99**	**96**	**98**	**42**	**97**	**72**	**67**	**34**	1	**10**	**8**	8	0
Potamogeton zosterifolius			5				1						
Potamogeton perfoliatus ssp. *richardsonii*	1												
Myriophyllum spicatum ssp. *exalbescens*	0												
Potamogeton friesii	0												
Lemna trisulca	0												
Utricularia intermedia		0	1										
Potamogeton berchtoldii	0	0			0		0						
Utricularia minor	0	0	0		0			0					
Potamogeton alpinus ssp. *tenuifolius*	0	0	6		0								
Nuphar polysepalum	0	**5**											
Sparganium sp.	1	**1**	0	0	2								
Utricularia vulgaris ssp. *macrorhiza*	0	**2**	**3**		2	**16**	0			0			
Potamogeton sp.	1			**22**	0		0						
Myriophyllum spicatum	0				1		0	1					
Sparganium hyperboreum					2		2				0		
Caltha natans					0		2						
Eleocharis acicularis	1			**28**									
Rorippa islandica ssp. *fernaldiana*											0		2
Scorpidium scorpioides			2	4			4			0	8		
Ranunculus gmelini					0		0						6
Limprichtia revolvens							1						
Sphagnum riparium								4		1			
Sphagnum obtusum								26					
Carex rostrata		0						1		0	17		
Warnstorfia exannulata					1			3	0			1	
Carex utriculata	0					0		5		0		0	
Galium trifidum ssp. *trifidum*			0	0			0			0	3	0	
Eriophorum scheuchzeri										0			2
Hippuris vulgaris	0	1	**3**	**2**	**11**		**4**	0		0			
Equisetum fluviatile	0		**1**	12		**26**		2		1		3	0
Arctophila fulva	0			1	0	0	**17**	0		0			0
Menyanthes trifoliata	1	0	0		1		0	**34**		0			
Potentilla palustris	0		**0**		0	0	3	**2**	0	**17**	1	**2**	
Eriophorum angustifolium	0		0		0	0	1	0	7	**8**	**20**	6	4
Carex aquatilis	1		0	**4**	0	2	0	3	**5**	**14**	**6**	2	0
Caltha palustris			0	**1**	0		3		0	1	0		0
Calliergon giganteum					1		4	3		3		1	0
Calliergon sp.				30	1		0	3		2			
Carex chordorrhiza						1		1		2			
Epilobium palustre				0			1	0	0	0	0	0	0
Carex saxatilis				**12**		0		1	1	2	**10**		0
Ranunculus pallasii							1	0	0	1			
Eriophorum russeolum								1		1			
Andromeda polifolia	0							0	0	0	0		
Drepanocladus revolvens								3		1			1
Sphagnum sp.										7			
Calamagrostis canadensis									2	1	**0**	**31**	
Polemonium acutiflorum									1	0	**0**	**2**	0
Betula nana								0	**3**	0		0	0
Salix planifolia ssp. *pulchra*	0							0	**32**	3	**0**	0	0
Sphagnum squarrosum									1	2		0	
Petasites frigidus							0		1	0	2	3	
Drepanocladus sp.							2		2			2	
Equisetum arvense				0					1		0	2	0
Vaccinium uliginosum									2	0	0		
Salix lanata ssp. *richardsonii*			0	0				0	11		0	0	
Calliergon stramineum								0	0			1	
Senecio congestus													2
Arctagrostis latifolia				0					**1**	0			1
Epilobium latifolium									0				0
Sample Size	21	5	2	2	9	2	8	7	6	12	3	8	6

Table 144. Mean plant cover by riverine ecotypes within the Arctic Network. Numbers with an underline are dominent and differential species; bold indicates species frequency >60%; and zeros have trace values <0.5%.

Taxon	Riverine Barrens	Riverine Dryas Dwarf Shrub	Riverine Moist Willow Tall Shrub	Riverine Willow Low Shrub	Riverine Poplar Forest	Riverine White Spruce-Poplar Forest	Riverine White Spruce-Willow Forest	Riverine White Spruce-Alder Forest	Riverine Alder Tall Shrub	Riverine Birch-Willow Low Shrub	Riverine Wet Willow Tall Shrub	Riverine Bluejoint Meadow	River
Eleocharis acicularis	0												
Oxytropis borealis	0	0		0									
Poa glauca	0	0		0									
Castilleja elegans		0	0										
Cnidium cnidiifolium	0	1	0			0							
Saxifraga bronchialis	0	0	0										
Aster yukonensis	0	0											
Dryas drummondii	0	<u>7</u>											
Elymus arenarius ssp. *mollis*	2		0				0						
Elymus innovatus		0	5										
Wilhelmsia physodes	0		0	0			0			0			
Astragalus eucosmus ssp. *sealei*		0	0	0									
Bupleurum triradiatum ssp. *arcticum*	0	0		0									
Allium schoenoprasum	0	0	0	0	0								
Stellaria longipes	0	0	0	0									
Festuca rubra	0	0	0	0						0			
Juncus arcticus	0		0	0	0		0						
Oxytropis campestris ssp. *jordalii*	0	1	0	0									
Racomitrium lanuginosum	0	7	0							0			
Rhododendron lapponicum		0		0									
Eriophorum angustifolium				0			0			1	0	0	
Moehringia lateriflora			0		0		0			0			
Saussurea angustifolia		0	0				1			0			
Elymus alaskanus	0		0		0								
Deschampsia caespitosa	0	0	0										
Artemisia borealis	0	0	0	0									
Artemisia glomerata	0		0										
Carex scirpoidea	0	1	8	1			1						
Tofieldia pusilla	0	0	0	0			0						
Artemisia arctica ssp. *arctica*	0		0	0						0			
Calamagrostis lapponica	0	0	0										
Rhytidium rugosum	0	8	0	3		2				0			
Stereocaulon sp.	0	1	0	0			0			0			
Erigeron purpuratus	0	0	0	0									
Parnassia kotzebuei			0	0									
Arnica lessingii			0	0									
Climacium dendroides			0	0					4	1	0		
Dodecatheon frigidum			0	0			0						
Cardamine pratensis ssp. *angustifolia*			0	0					0	0		0	
Thalictrum alpinum			0	0			0						
Astragalus umbellatus			0	0		0							
Carex membranacea			0	3			0					0	
Aulacomnium palustre			0	3		0	2	2		3			
Solidago multiradiata var. *multiradiata*			1	0		0	1						
Carex capillaris	0	0	0	1			0						
Gentiana propinqua	0	1	0	0	0	0	0						
Bromus pumpellianus	0	1	0	0	0	0							
Lupinus arcticus	0	2	0	1	1	1	2	0		0			
Abietinella abietina		10	0	1	1	0							
Solidago multiradiata	0	0	0	0	0	0	0						
Festuca richardsonii	0	0	0	0	1	0							
Poa alpigena	0		0		0	0					0		
Hypnum lindbergii			0	0	0	0							
Juniperus communis		1	0		0	2							
Equisetum scirpoides			0			0	0						
Equisetum pratense			0		0	11		7	1				
Salix monticola			0		1	1	0						
Stereocaulon alpinum			0			3							

Table 144. Continued.

Taxon	Riverine Barrens	Riverine Dryas Dwarf Shrub	Riverine Moist Willow Tall Shrub	Riverine Willow Low Shrub	Riverine Poplar Forest	Riverine White Spruce-Poplar Forest	Riverine White Spruce-Willow Forest	Riverine White Spruce-Alder Forest	Riverine Alder Tall Shrub	Riverine Birch-Willow Low Shrub	Riverine Wet Willow Tall Shrub	Riverine Bluejoint Meadow	River
Chrysanthemum bipinnatum	0		0		0	0							
Pedicularis sudetica	0	0	0	0	0	0							
Elymus trachycaulus	0		0		0	0							
Carex krausei	0	0	0	0	0								
Calamagrostis inexpansa	0	0	0	0	0						0		
Silene acaulis	0	0	1	0									
Castilleja caudata	0	0	0	0	0	0				0			
Flavocetraria cucullata	0	1	0	0		0				0			
Platanthera obtusata		0	0	0	0	**0**	0	0					
Agropyron macrourum	0	0	0		0	0							
Calamagrostis purpurascens	1	1	0	0	0	0							
Oxytropis campestris	0	0	0	0	0	0							
Hedysarum mackenzii	1	0	1		1	0	0						
Eriophorum angustifolium ssp. *triste*													
Cypripedium passerinum			0	0	1	1	0						
Oxytropis viscida	0	0	0	1		0	0						
Epilobium latifolium	**2**	**1**	1	1	0								
Astragalus alpinus	0	0	0	0	0	0		0		0			
Salix brachycarpa ssp. *niphoclada*	1	**9**	3	5	1	1			1	1			
Dryas integrifolia	0	**17**	2	12		0	1						
Arnica alpina ssp. *angustifolia*	0	0	0	0	0	0							
Tomentypnum nitens	0		0	**14**		1	**10**			7			
Pedicularis verticillata	0	0	0	0	0	0							
Zygadenus elegans	0	0	1	0	0	0	0						
Poa alpina	0	0	0		0		0						
Senecio lugens	0	0	0	0	0	0	0						
Empetrum nigrum	0	0	0	1		1	**4**	2					
Polygonum viviparum	0	0	0	0	0	0	0						
Peltigera aphthosa			0	0	0	0	0	**0**		1	0		
Carex concinna		1		0	0	0	0	0					
Bromus sp.			0		1	1	0						
Pyrola secunda		0	0	0	0	**1**	0	0					
Anemone richardsonii		0	0	0	1	1	0	1	0		1		
Campylium polygamum	0		1	0	0		0						
Ceratodon purpureus	1		2	1	0	0	4						
Trisetum spicatum ssp. *spicatum*	0	0	0		0	0	0	0					
Brachythecium sp.	0		1	1	0	0			0	0			
Salix hastata	0	1	1	1	0	0	0	0		0	2		
Arctagrostis latifolia	0	0	1	0	1	0	0		13	2	2		
Galium boreale	0	0	2	0	0	0	1	0	0	0			
Parnassia palustris	0	0	0	0	0	0	0				0		
Artemisia tilesii	0	0	1	0	**1**	0	0	0	1	0			0
Equisetum arvense	1		6	3	4	11	**4**	2	**4**	1	**3**	**2**	
Salix alaxensis	**4**	**2**	**29**	**10**	**14**	**6**	**6**	1	7	7	6	0	0
Aster sibiricus	0	**1**	**1**	0	**4**	0	0	0	0				
Equisetum variegatum	0	0	1	3	0	0	0						
Festuca altaica	0	1	3	**2**	0	0	1			1			
Anemone parviflora	0	0	1	**1**	0	**0**	0			0			
Potentilla fruticosa	0	**0**	1	**3**	0	0	4	0	0	1	1		
Salix glauca	0	2	1	**6**	2	3	7	1		4	0		
Salix lanata ssp. *richardsonii*			1	**32**		0	**8**		4	9	4	2	
Salix reticulata	0	0	6	**8**	0	0	**6**	0		0			
Arctostaphylos rubra	0	1	3	**8**	1	**4**	**6**	**4**	0	1			
Hedysarum alpinum	0	0	**3**	1	**4**	4	**2**	0					
Populus balsamifera	0	1	1		**47**	**19**	0	1					
Shepherdia canadensis	0	1	2	0	**13**	**4**	2	0					
Pyrola asarifolia	0	0	0	0	1	**1**	0	6			0		
Salix arbusculoides	0	0	1	1	0	1	2	0	1	5	2	**0**	
Sanionia uncinata	0	0	1	3	2	**9**	2	2	1	1	6		
Hylocomium splendens	0	1	2	6	3	**28**	**35**	**52**		13			

Table 144. Continued.

Taxon	Riverine Barrens	Riverine Dryas Dwarf Shrub	Riverine Moist Willow Tall Shrub	Riverine Willow Low Shrub	Riverine Poplar Forest	Riverine White Spruce-Poplar Forest	Riverine White Spruce-Willow Forest	Riverine White Spruce-Alder Forest	Riverine Alder Tall Shrub	Riverine Birch-Willow Low Shrub	Riverine Wet Willow Tall Shrub	Riverine Bluejoint Meadow	River
Picea glauca	0	0	0	0	**1**	**23**	**24**	**27**		0	**0**		
Alnus crispa	0		0	0	5	16	13	**39**	**68**	0	2		
Calamagrostis canadensis	0	0	1	0	0	0	1	**3**	10	6	**5**	**45**	
Vaccinium vitis-idaea			0	0		0	1	**3**	0	1	0		
Salix barclayi	0		1				2	4	0	1			
Rosa acicularis	0		0		0	0	2	**8**	0	0			
Cladonia sp.		2	0	0	0	0	0	**0**		0	0		
Alnus tenuifolia			0		0	0	1	0					
Moneses uniflora					0	**0**	0	0					
Rhytidiadelphus triquetrus						1	5	3					
Hypogymnia physodes						0	0	0					
Linnaea borealis					0	0		**5**	1				
Boschniakia rossica					0	0	0	**0**					
Pleurozium schreberi	0		0			2		2		2	1		
Ribes triste								1	1				
Viburnum edule						0	0	2	0				
Trientalis europaea ssp. *arctica*					0			0	1				
Rubus arcticus			1	1	2	2	1	0	1		2		
Mertensia paniculata	0		0		1	1	2	0	1				
Epilobium angustifolium	0		0		0	0	0	0	0		0		
Aconitum delphinifolium			0	0	0		0	0	**0**	0			
Poa arctica	0		0	0			0			1			
Rubus arcticus ssp. *arcticus*	0		0	0				1	**2**	1	1	15	
Valeriana capitata			0	1		0	0		1	**1**			
Vaccinium uliginosum	0	1	0	**4**	0	0	**9**	**13**	1	**15**	**4**	0	
Salix planifolia ssp. *pulchra*	0		1	4			2	0	0	**29**	**51**	**9**	
Betula nana	0		0	1	0				0	**23**	1		
Petasites frigidus	0		0	0			0	0	5	**4**			
Pyrola grandiflora		0		0	0	0	0	0		**1**			
Polemonium acutiflorum	0		0	0	0	0	0		**1**	**0**			
Ledum decumbens		0	0	0		0	0	4	0	1			
Aulacomnium turgidum				0			0			1			
Carex bigelowii	0			1			0			1		0	
Spiraea beauverdiana	0		0					6	5	1	0		
Salix bebbiana							2	1	0		0		
Betula glandulosa			0				3	2		1	0	**2**	
Sphagnum sp.								1		3	1		
Rubus chamaemorus								1	1	1	0		
Iris setosa			0				0	0		1		**1**	
Potentilla palustris	0								0	1	**11**	**3**	
Carex canescens										0	**1**		
Carex aquatilis ssp. *aquatilis*	0	0	0	1						0	**3**	0	
Calliergon sp.				0							11		
Epilobium palustre	0										1	0	
Equisetum fluviatile											2	0	
Galium trifidum ssp. *trifidum*			0						0	0	0	**1**	
Carex saxatilis		0	0	0						1	3	**25**	
Scorpidium scorpioides									0				
Hippuris vulgaris	0												
Water	0		0	0							2		**99**
Bare Soil	**84**	**26**	**28**	**2**	**18**	1	1	**0**		0	**1**	0	1
Sample Size	33	7	48	14	13	11	8	8	6	9	6	3	27

Table 145. Mean plant cover by coastal ecotypes within the Arctic Network. Numbers with an underline are dominent and differential species; bold indicates species frequency >60%; and zeros have trace values <0.5%.

Taxon	Coastal Nearshore Water	Coastal Tidal River	Coastal Brackish Water	Coastal Wet Barrens	Coastal Saline Sedge–Grass Meadow	Coastal Brackish Sedge–Grass Meadow	Coastal Brackish Willow Shrub	Coastal Dry Barrens	Coastal Brackish Dunegrass Meadow	Coastal Crowberry Dwarf Shrub
Water	**100**	**100**	**100**	**1**	1	0	**2**	1		
Puccinellia phryganodes					**8**					
Carex subspathacea				**1**	6					
Chrysanthemum ssp. *arcticum*				**0**	**7**		**1**		0	
Carex ramenskii					**19**	**26**	**5**			
Potentilla egedii				**0**	**8**	2		0		
Stellaria humifusa				**0**	**0**	**4**				
Calamagrostis deschampsioides					2	3	**5**			
Calamagrostis holmii						2				
Cochlearia officinalis						2		0		
Rumex arcticus						**0**	**0**			
Dupontia fischeri						**2**	**3**			
Salix ovalifolia						2	**12**	0		0
Deschampsia caespitosa						1	**6**		0	
Pedicularis sudetica							**2**	0		
Eriophorum angustifolium							**2**			
Cochlearia officinalis ssp. *arctica*							**1**			
Campylium sp.							**2**			
Carex canescens							**1**			
Campylium polygamum							**7**			
Saxifraga exilis							**2**			
Puccinellia borealis							1			
Elymus arenarius ssp. *mollis*				**0**	**4**		**0**	2	**25**	**2**
Lathyrus maritimus ssp. *maritimus*							0	0	**18**	1
Honckenya peploides								1	**1**	
Artemisia tilesii								0	**1**	0
Senecio pseudoarnica								0	3	
Mertensia maritima								0	0	
Conioselinum chinense									1	
Bromus sp.									1	
Cnidium cnidiifolium									**2**	
Saussurea nuda					0				0	
Bryum sp.							**2**		0	2
Festuca rubra								0	1	1
Bupleurum triradiatum ssp. *arcticum*									0	0
Chrysanthemum bipinnatum						0			0	0
Empetrum nigrum							**0**			**34**
Armeria maritima										**0**
Flavocetraria cucullata										**6**
Vaccinium uliginosum										**2**
Betula nana										**3**
Rhytidium rugosum										**2**
Thamnolia vermicularis										**1**
Sphaerophorus globosus										**1**
Flavocetraria nivalis										**3**
Vaccinium vitis-idaea										**2**
Trisetum spicatum ssp. *spicatum*										**0**
Salix planifolia ssp. *pulchra*								0		**1**
Epilobium latifolium										2
Stereocaulon sp.										2
Cladina arbuscula										2
Bryocaulon divergens										3
Alectoria nigricans										1
Hierochloe alpina										1
Salix reticulata										1
Ledum decumbens										1
Arctostaphylos alpina										1
Poa arctica						0			1	0
Artemisia arctica ssp. *arctica*										0
Bare Soil				**98**	**4**	**11**	**1**	**92**	**6**	**4**
Sample Size	2	2	3	1	6	5	3	7	4	6

Wet Sedge Meadow and Lacustrine Bluejoint Meadow, and between Lacustrine Marestail Marsh and Lowland Lake.

Riverine ecotypes were diverse because of differences in fluvial regime, climate (mountain vs. lowland), and successional stage. The most distinct ecotypes include Riverine Barrens, Riverine Dryas Dwarf Shrub, Riverine White Spruce–Alder Forest, and Riverine Forb Marsh (Figure 17a). High similarity occurred between Riverine Poplar Forest and Riverine Moist Tall Willow Shrub and between late-successional spruce forest ecotypes.

Coastal ecotypes had a few ecotypes with distinct separation in species assemblages (Figure 17b). There was little overlap among any of the ecotypes. The highest similarity occurred between Coastal Saline Sedge–Grass Meadow and Coastal Brackish Sedge–Grass Meadow.

Sorted Tables

Sorted vegetation tables (Tables 140–145) were constructed to provide a more direct means of comparing similarities and differences in the floristic composition of closely associated ecotypes (horizontal order) and for evaluating the association of species along environmental gradients (vertical order). The tables, however, only include species that are abundant or of relatively high frequency within each ecotype. These tables associate common species within an ecotype. Similarities and differences in species composition on the sorted tables are consistent with the NMDS results.

Landcover Mapping

Three sets of map products were developed by the mapping effort: (1) a new set of landcover maps for NOAT and KOVA developed through spectral analysis and processing; (2) a region-wide landcover map across all five parks in ARCN that integrates the existing BELA, CAKR, and GAAR maps with the new NOAT-KOVA map; and (3) soil landscape maps of NOAT and KOVA and for the entire ARCN based on analysis of vegetation-soil relationships. The first two map sets are described separately below, while the soil landscapes are described in a later section.

Noatak and Kobuk Landcover Maps

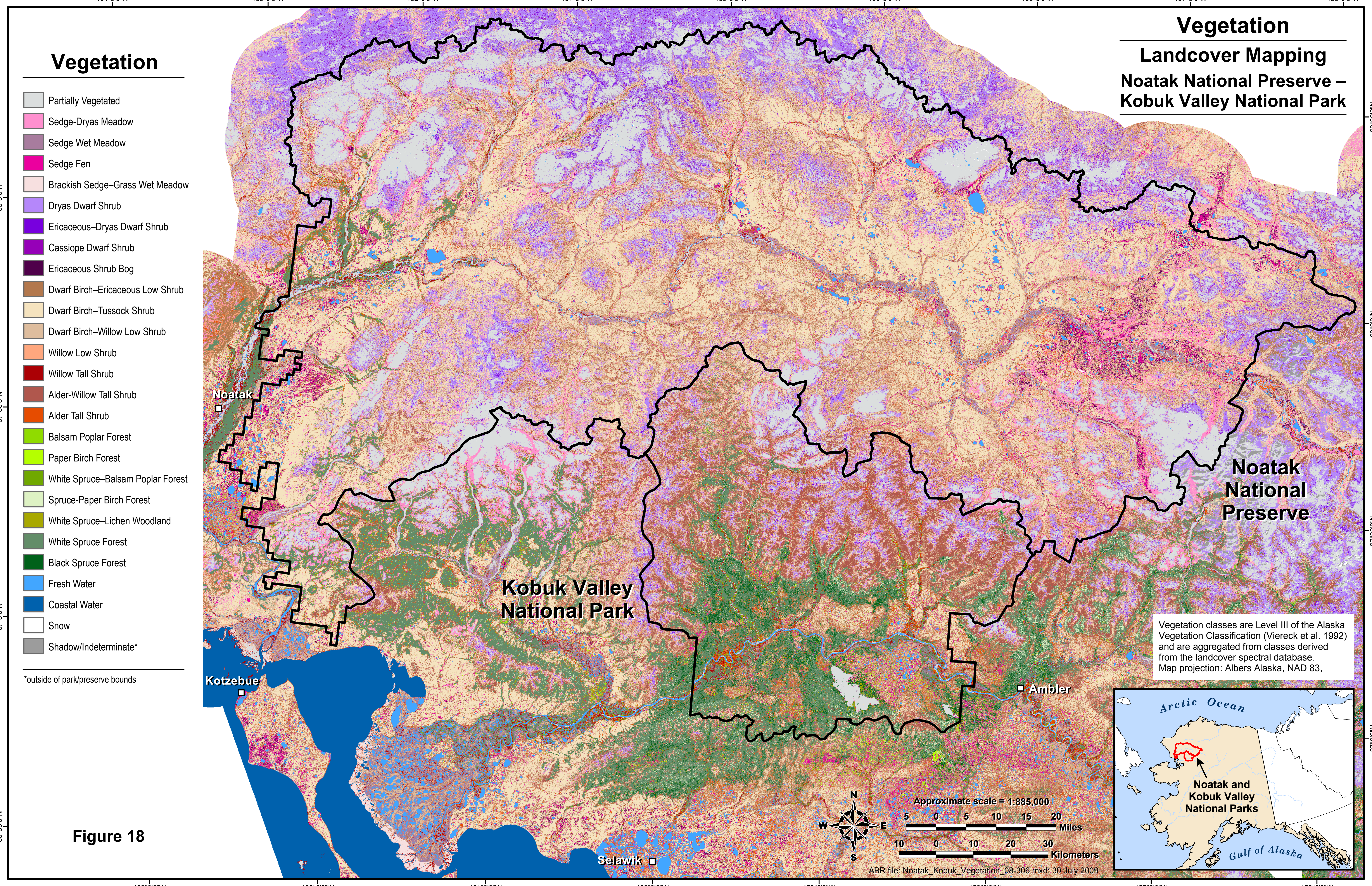
Abundance and Distribution

The landcover mapping differentiated 24 vegetation types and 41 ecotypes (Figures 18 and 19), based on a supervised classification of spectral characteristics of Landsat TM images and modeling and image segmentation using the physiography and bedrock associated with ecosubsection maps and digital elevation models. In the final map, eight ecotypes identified by the ground data were combined with other classes because they could not be mapped separately. The most abundant ecotypes within the park boundaries include Alpine Alkaline Barrens (4% of area), Alpine Acidic Dryas Dwarf Shrub (8%), Upland Birch–Willow Low Shrub (9%), Upland Dwarf Birch–Tussock Shrub (27%), Upland Sedge–Dryas Meadow (7%), and Upland Alder–Willow Tall Shrub (6%) (Table 146). On the vegetation map, which was derived from the ecotype map and differentiates only AVC classes independent of landscape associations, the most abundant vegetation types were Partially Vegetated (13% of area), Dryas Dwarf Shrub (10%), Dwarf Birch–Ericaceous Low Shrub (7%), Dwarf Birch–Willow Low Shrub (10%), Dwarf Birch–Tussock Shrub (27%), Willow Low Shrub (6%), Sedge–Dryas Meadow (7%), and Alder–Willow Tall Shrub (6%) (Table 147).

ARCN Region-wide Landcover Maps

Abundance and Distribution

Landcover mapping for the entire group of arctic parks covered 81,462 square kilometers. The pre-existing mapping for GAAR did not allow us to apply the



Vegetation
Landcover Mapping
Noatak National Preserve –
Kobuk Valley National Park
Vegetation
Partially Vegetated
Sedge-Dryas Meadow
Sedge Wet Meadow
Sedge Fen
Brackish Sedge–Grass Wet Meadow
Dryas Dwarf Shrub
Ericaceous–Dryas Dwarf Shrub
Cassiope Dwarf Shrub
Ericaceous Shrub Bog
Dwarf Birch–Ericaceous Low Shrub
Dwarf Birch–Tussock Shrub
Dwarf Birch–Willow Low Shrub
Willow Low Shrub
Willow Tall Shrub
Alder-Willow Tall Shrub
Alder Tall Shrub
Balsam Poplar Forest
Paper Birch Forest
White Spruce–Balsam Poplar Forest
Spruce-Paper Birch Forest
White Spruce–Lichen Woodland
White Spruce Forest
Black Spruce Forest
Fresh Water
Coastal Water
Snow
Shadow/Indeterminate*
*outside of park/preserve bounds
Noatak
Kotzebue
Selawik
Ambler
Kobuk Valley National Park
Noatak National Preserve
Vegetation classes are Level III of the Alaska Vegetation Classification (Viereck et al. 1992) and are aggregated from classes derived from the landcover spectral database.
Map projection: Albers Alaska, NAD 83,
Arctic Ocean
Gulf of Alaska
Noatak and Kobuk Valley National Parks
Approximate scale = 1:885,000
Miles
Kilometers
N
S
E
W
ABR file: Noatak_Kobuk_Vegetation_08-306.mxd; 30 July 2009

Figure 18

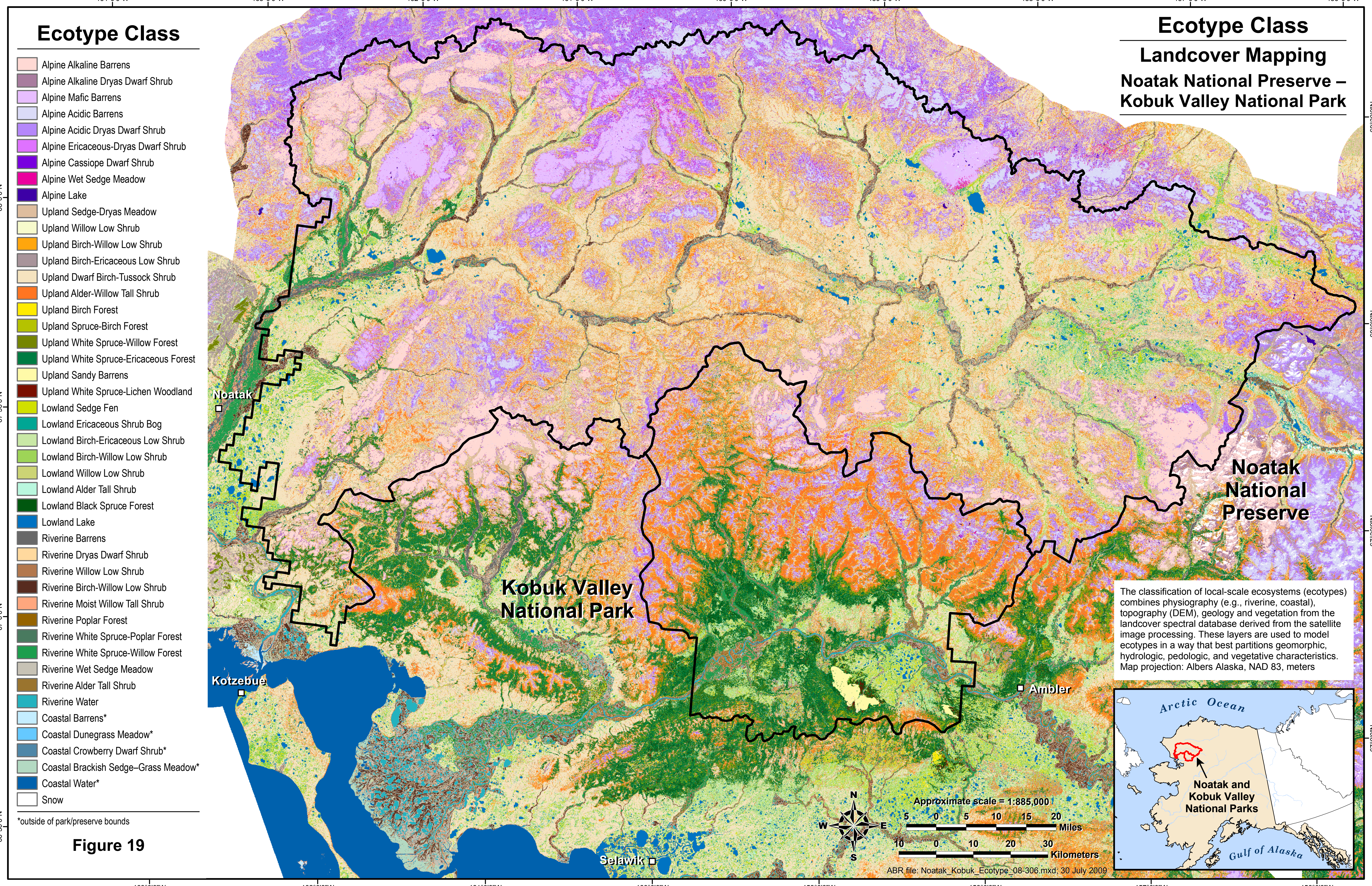

Ecotype Class
Alpine Alkaline Barrens
Alpine Alkaline Dryas Dwarf Shrub
Alpine Mafic Barrens
Alpine Acidic Barrens
Alpine Acidic Dryas Dwarf Shrub
Alpine Ericaceous-Dryas Dwarf Shrub
Alpine Cassiope Dwarf Shrub
Alpine Wet Sedge Meadow
Alpine Lake
Upland Sedge-Dryas Meadow
Upland Willow Low Shrub
Upland Birch-Willow Low Shrub
Upland Birch-Ericaceous Low Shrub
Upland Dwarf Birch-Tussock Shrub
Upland Alder-Willow Tall Shrub
Upland Birch Forest
Upland Spruce-Birch Forest
Upland White Spruce-Willow Forest
Upland White Spruce-Ericaceous Forest
Upland Sandy Barrens
Upland White Spruce-Lichen Woodland
Lowland Sedge Fen
Lowland Ericaceous Shrub Bog
Lowland Birch-Ericaceous Low Shrub
Lowland Birch-Willow Low Shrub
Lowland Willow Low Shrub
Lowland Alder Tall Shrub
Lowland Black Spruce Forest
Lowland Lake
Riverine Barrens
Riverine Dryas Dwarf Shrub
Riverine Willow Low Shrub
Riverine Birch-Willow Low Shrub
Riverine Moist Willow Tall Shrub
Riverine Poplar Forest
Riverine White Spruce-Poplar Forest
Riverine White Spruce-Willow Forest
Riverine Wet Sedge Meadow
Riverine Alder Tall Shrub
Riverine Water
Coastal Barrens*
Coastal Dunegrass Meadow*
Coastal Crowberry Dwarf Shrub*
Coastal Brackish Sedge–Grass Meadow*
Coastal Water*
Snow
*outside of park/preserve bounds
Ecotype Class
Landcover Mapping
Noatak National Preserve –
Kobuk Valley National Park
Noatak National Preserve
Kobuk Valley National Park
Noatak
Kotzebue
Ambler
Selawik
The classification of local-scale ecosystems (ecotypes) combines physiography (e.g., riverine, coastal), topography (DEM), geology and vegetation from the landcover spectral database derived from the satellite image processing. These layers are used to model ecotypes in a way that best partitions geomorphic, hydrologic, pedologic, and vegetative characteristics. Map projection: Albers Alaska, NAD 83, meters
Arctic Ocean
Noatak and Kobuk Valley National Parks
Gulf of Alaska
Approximate scale = 1:885,000
5 0 5 10 15 20 Miles
10 0 10 20 30 Kilometers
N S E W
ABR file: Noatak_Kobuk_Ecotype_08-306.mxd; 30 July 2009
164°0'0"W 163°0'0"W 162°0'0"W 161°0'0"W 160°0'0"W 159°0'0"W 158°0'0"W 157°0'0"W 156°0'0"W
163°0'0"W 162°0'0"W 161°0'0"W 160°0'0"W 159°0'0"W 158°0'0"W 157°0'0"W 156°0'0"W
68°30'0"N 68°0'0"N 67°30'0"N 67°0'0"N 66°30'0"N
Figure 19

Table 146. Areal extent of ecotypes within Kobuk Valley National Park and Noatak National Preserve.

	KOVA		NOAT		Total	
Ecotype	ha	%	ha	%	ha	%
Alpine Acidic Barrens	21966	3.1	187557	7.1	209524	6.2
Alpine Acidic Dryas Dwarf Shrub	36733	5.2	229676	8.6	266409	7.9
Alpine Alkaline Barrens	7990	1.1	114883	4.3	122873	3.7
Alpine Alkaline Dryas Dwarf Shrub	2740	0.4	34167	1.3	36907	1.1
Alpine Cassiope Dwarf Shrub	6362	0.9	32815	1.2	39177	1.2
Alpine Ericaceous–Dryas Dwarf Shrub	4444	0.6	27993	1.1	32437	1.0
Alpine Lake	14	<0.1	162	<0.1	176	<0.1
Alpine Mafic Barrens	0	<0.1	35596	1.3	35596	1.1
Alpine Wet Sedge Meadow	6026	0.9	31234	1.2	37259	1.1
Lacustrine Wet Sedge Meadow	231	<0.1	1190	<0.1	1421	<0.1
Lowland Alder Tall Shrub	9102	1.3	11400	0.4	20502	0.6
Lowland Birch–Ericaceous Low Shrub	11755	1.7	27703	1.0	39458	1.2
Lowland Birch–Willow Low Shrub	7438	1.0	21632	0.8	29070	0.9
Lowland Black Spruce Forest	21557	3.0	511	<0.1	22069	0.7
Lowland Ericaceous Shrub Bog	755	0.1	17883	0.7	18638	0.6
Lowland Lake	2734	0.4	22262	0.8	24996	0.7
Lowland Sedge Fen	4719	0.7	35324	1.3	40043	1.2
Lowland Willow Low Shrub	881	0.1	7047	0.3	7928	0.2
River	1005	0.1	1263	<0.1	2268	0.1
Riverine Alder Tall Shrub	3783	0.5	597	<0.1	4380	0.1
Riverine Barrens	3267	0.5	25996	1.0	29263	0.9
Riverine Birch–Willow Low Shrub	2366	0.3	15824	0.6	18190	0.5
Riverine Dryas Dwarf Shrub	348	<0.1	15094	0.6	15442	0.5
Riverine Lake	2759	0.4	2319	0.1	5078	0.2
Riverine Moist Willow Tall Shrub	12703	1.8	14886	0.6	27589	0.8
Riverine Poplar Forest	4185	0.6	697	<0.1	4883	0.1
Riverine Wet Sedge Meadow	749	0.1	9230	0.3	9979	0.3
Riverine White Spruce–Poplar Forest	1857	0.3	724	<0.1	2581	0.1
Riverine White Spruce–Willow Forest	22209	3.1	13165	0.5	35374	1.1
Riverine Willow Low Shrub	1403	0.2	27724	1.0	29127	0.9
Snow	146	<0.1	977	<0.1	1123	<0.1
Upland Alder-Willow Tall Shrub	117731	16.6	88409	3.3	206139	6.1
Upland Birch Forest	4751	0.7	1605	0.1	6355	0.2
Upland Birch–Ericaceous Low Shrub	48389	6.8	146868	5.5	195257	5.8
Upland Birch–Willow Low Shrub	68788	9.7	227934	8.6	296722	8.8
Upland Dwarf Birch–Tussock Shrub	57789	8.2	857912	32.3	915701	27.2
Upland Sandy Barrens	8003	1.1	13910	0.5	21913	0.7
Upland Sedge–Dryas Meadow	24841	3.5	195178	7.3	220019	6.5
Upland Spruce–Aspen Forest	1449	0.2	100	<0.1	1549	<0.1
Upland Spruce–Birch Forest	13552	1.9	1300	<0.1	14852	0.4
Upland White Spruce–Ericaceous Forest	94747	13.4	15293	0.6	110040	3.3
Upland White Spruce–Lichen Woodland	4884	0.7	1765	0.1	6650	0.2
Upland White Spruce–Willow Forest	33967	4.8	9777	0.4	43744	1.3
Upland Willow Low Shrub	27577	3.9	129553	4.9	157130	4.7
Total	708698	100	2657134	100	3365831	100

Table 147. Areal extent of mapped vegetation types within Kobuk Valley National Park and Noatak National Preserve.

Vegetation Class	KOVA ha	%	NOAT ha	%	Total ha	%
Dwarf Birch-Tussock Shrub	57789	8.2	857912	32.3	915701	27.2
Partially Vegetated	41227	5.8	377942	14.2	419169	12.5
Dwarf Birch-Willow Low Shrub	78592	11.1	265390	10.0	343982	10.2
Dryas Dwarf Shrub	39821	5.6	278937	10.5	318758	9.5
Dwarf Birch-Ericaceous Low Shrub	60144	8.5	174571	6.6	234715	7.0
Sedge-Dryas Meadow	24841	3.5	195178	7.3	220019	6.5
Alder-Willow Tall Shrub	117731	16.6	88409	3.3	206139	6.1
Willow Low Shrub	29861	4.2	164324	6.2	194185	5.8
White Spruce Forest	150923	21.3	38235	1.4	189158	5.6
Sedge Wet Meadow	7006	1.0	41654	1.6	48659	1.4
Sedge Fen	4719	0.7	35324	1.3	40043	1.2
Cassiope Dwarf Shrub	6362	0.9	32815	1.2	39177	1.2
Fresh Water	6513	0.9	26006	1.0	32519	1.0
Ericaceous-Dryas Dwarf Shrub	4444	0.6	27993	1.1	32437	1.0
Willow Tall Shrub	12703	1.8	14886	0.6	27589	0.8
Alder Tall Shrub	12885	1.8	11996	0.5	24882	0.7
Black Spruce Forest	21557	3.0	511	0.0	22069	0.7
Ericaceous Shrub Bog	755	0.1	17883	0.7	18638	0.6
Spruce-Paper Birch Forest	13552	1.9	1300	0.0	14852	0.4
White Spruce-Lichen Woodland	4884	0.7	1765	0.1	6650	0.2
Paper Birch Forest	4751	0.7	1605	0.1	6355	0.2
Balsam Poplar Forest	4185	0.6	697	0.0	4883	0.1
White Spruce-Balsam Poplar Forest	1857	0.3	724	0.0	2581	0.1
Spruce-Quaking Aspen Forest	1449	0.2	100	0.0	1549	0.0
Snow	146	0.0	977	0.0	1123	0.0
Total	708698	100.0	2657134	100.0	3365831	100.0

ecotype classification developed for NOAT and KOVA for all classes, therefore some consolidation of ecotypes was necessary for region-wide mapping (Appendix 8). Forty-four ecotypes were mapped, the most common of which were Alpine Acidic Barrens (9% of area), Alpine Dryas Dwarf Shrub (14%), Upland Birch–Ericaceous–Willow Low Shrub (11%), Upland Dwarf Birch–Tussock Shrub (20%), Upland Sedge–Dryas Meadow (6%), and Upland White Spruce Forest (6%) (Figure 20, Table 148). The region-wide mapping added 5 coastal ecotypes in BELA and CAKR as well as Lowland Sedge–Dryas Meadow, (most common on the coastal plain of BELA), Upland Mafic Barrens (BELA), and Human Modified Barrens (CAKR).

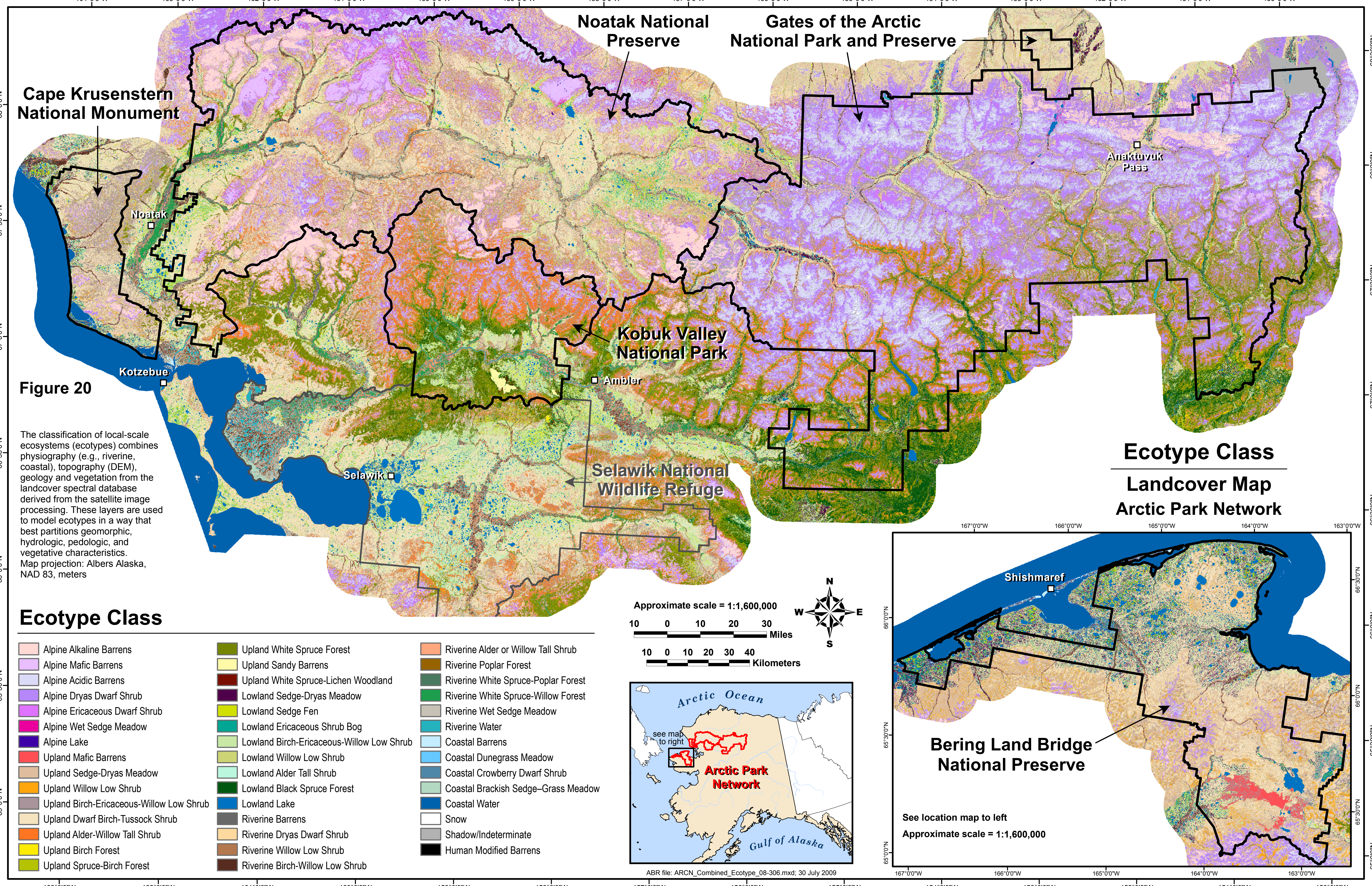


Figure 20

The classification of local-scale ecosystems (ecotypes) combines physiography (e.g., riverine, coastal), topography (DEM), geology and vegetation from the landcover spectral database derived from the satellite image processing. These layers are used to model ecotypes in a way that best partitions geomorphic, hydrologic, pedologic, and vegetative characteristics. Map projection: Albers Alaska, NAD 83, meters

Table 148. Areal extent of ecotypes within the Arctic Network.

	Area (ha)						
Ecotype	**KOVA**	**GAAR**	**NOAT**	**BELA**	**CAKR**	**Total**	**% Area**
Alpine Acidic Barrens	17349	580748	117689	5900	730	722416	8.9
Alpine Alkaline Barrens	15561	89623	179398	6732	9039	300354	3.7
Alpine Dryas Dwarf Shrub	36118	878675	217081	33522	8857	1174254	14.4
Alpine Ericaceous Dwarf Shrub	9353	96028	57437	0	0	162818	2.0
Alpine Lake	102	2104	870	0	0	3076	0.0
Alpine Mafic Barrens	0	16750	85647	0	0	102398	1.3
Alpine Wet Sedge Meadow	7347	7985	40384	0	0	55716	0.7
Coastal Barrens	0	0	0	3017	645	3662	0.0
Coastal Brackish Sedge–Grass	0	0	0	2651	887	3538	0.0
Coastal Crowberry Dwarf Shrub	0	0	0	2179	1352	3531	0.0
Coastal Dunegrass Meadow	0	0	0	390	311	701	0.0
Coastal Water	0	0	0	10460	11234	21693	0.3
Human Modified Barrens	0	0	0	0	174	174	0.0
Lowland Alder Tall Shrub	13471	15031	21813	2242	2267	54825	0.7
Lowland Birch-Ericaceous-Willow Low Shrub	43121	55434	94677	57561	16338	267131	3.3
Lowland Black Spruce Forest	28013	91650	0	0	0	119663	1.5
Lowland Ericaceous Shrub Bog	656	3672	25244	51759	3706	85036	1.0
Lowland Lake	2563	17156	21539	58580	2126	101963	1.3
Lowland Sedge Fen	8208	4660	52343	33874	3657	102743	1.3
Lowland Sedge-Dryas Meadow	0	20653	0	84440	7414	112507	1.4
Lowland Willow Low Shrub	2312	2202	19451	39477	9761	73203	0.9
Riverine Alder or Willow Tall Shrub	14259	9231	14184	7443	2183	47301	0.6
Riverine Barrens	3260	15153	25917	5200	1417	50948	0.6
Riverine Birch-Willow Low Shrub	2941	10600	23880	5907	3553	46880	0.6
Riverine Dryas Dwarf Shrub	202	4862	6326	0	0	11389	0.1
Riverine Poplar Forest	3630	1522	1095	0	0	6247	0.1
Riverine Water	3780	11217	3701	3662	200	22560	0.3
Riverine Wet Sedge Meadow	6856	2097	25598	0	16	34568	0.4
Riverine White Spruce-Poplar Forest	1952	1625	907	0	0	4484	0.1
Riverine White Spruce-Willow Forest	19091	7879	10562	0	2	37533	0.5
Riverine Willow Low Shrub	708	1706	10922	0	29	13366	0.2
Shadow/Indeterminate	0	163541	0	0	0	163541	2.0
Snow	149	19773	978	0	0	20900	0.3
Upland Alder-Willow Tall Shrub	115273	202875	81955	0	5	400108	4.9
Upland Birch Forest	5977	20793	2161	0	0	28931	0.4
Upland Birch-Ericaceous-Willow Low Shrub	101980	373802	326033	64033	56137	921985	11.3
Upland Dwarf Birch-Tussock Shrub	60206	226656	886139	394573	78974	1646548	20.2
Upland Mafic Barrens	0	0	0	22439	0	22439	0.3
Upland Sandy Barrens	6600	0	0	0	0	6600	0.1
Upland Sedge-Dryas Meadow	21410	126863	168109	151054	28557	495994	6.1
Upland Spruce-Birch Forest	13250	17599	1001	0	0	31850	0.4
Upland White Spruce Forest	109189	321481	23716	0	1018	455404	5.6
Upland White Spruce-Lichen Woodland	3102	0	3202	0	0	6304	0.1
Upland Willow Low Shrub	28580	6630	109499	43313	10889	198911	2.4
Total	706572	3428278	2659458	1090406	261479	8146193	100

Accuracy Assessment

No independent accuracy assessment was done of the overall mapping (including BELA, GAAR, CAKR, and SELA) so we developed three proxies that provide approximate guidance as to the accuracy of the map based on the spectral classification for NOAT, KOVA and SELA. First we quantified the fidelity of the signatures to themselves during supervised classification. Second, the clustering of spectral characteristics and cross-tabulation of clusters of similar signatures with ecotypes were used to assess how variable the spectral characteristics are of an ecotype. Third, we cross-tabulated the ecotypes of pixels within training polygons with their mapped ecotypes.

Signature evaluation prior to supervised classification showed the fidelity of signatures to themselves (percentage of pixels within signature areas correctly classified to themselves) was very high (≥90%) for 49%, high (80–89%) for 27%, moderately high (60–79%) for 17%, and low (<60%) for 7% of signatures. Overall, 76% of the signatures self-classify (80% of pixels within signatures) and are therefore distinct and separable. The ability of the signatures to classify to the correct signature ecotype (percentage of pixels within a signature area classifying to the correct vegetation type) was very high (≥90%) for 80%, high (80–89%) for 18%, and moderately high (70–79%) for 2% of the training areas. This indicates that the 879 signatures used in the supervised classification were highly reliable; the signature ecotype was classified correctly (≥80% of pixels within signature) in 98% of the training signatures.

Spectral characteristics of ecotypes were evaluated by cross-tabulating spectral clusters and ecotype determinations from ground data (Appendix 9). The spectral clusters were created by calculating means of band reflectance for every band for each training polygon and then clustering the 6 band means. This helps evaluates how variable the spectral characteristics are for each ecotype and how well individual spectral clusters associate with individual ecotypes. Ecotypes with distinct spectral characteristics include alpine barren types, dryas dwarf shrub types, Upland Dwarf Birch–Tussock Shrub, alder types, white spruce forest types, and water. Ecotypes where unique spectral characteristics were not evident include Upland Sedge–Dryas Meadow, dwarf birch–ericaceous and dwarf birch–willow types, deciduous and mixed forest types, and wet meadow types. Overall, for 65% of observations there was a strong association of spectral characteristics and ecotypes.

We evaluated map accuracy of individual ecotypes by comparing the mapping results within training polygons with the original ground data. The cross-tabulation revealed that 86% of pixels in 879 training polygons were mapped to the correct ecotype (Appendix 10). These training polygons represented the ground points used to create map signatures for which good vegetation assessments and locations were available. After weighting the calculation to reflect the relative abundance of ecotypes in the region from which training polygons primarily were derived, NOAT, KOVA and SELA, map accuracy was 80%. The cross- tabulation of 25 mapped vegetation types reveals that 94% of training polygon pixels were mapped correctly (Appendix 11). After removing 2 water classes and weighting remaining classes for abundance, accuracy was 86%. Three vegetation classes had map accuracies below 65%, Alder Tall Shrub, Sedge Fen, and Sedge–Dryas Meadow. This resulted from confusion among Alder Tall Shrub, Alder–Willow Tall Shrub and Balsam Poplar and Sedge Fen, dwarf shrub classes, and Sedge–Dryas Meadow. Inconsistencies for ecotypes were due to similar errors, plus prevalent problems with differentiating physiography based on model rules. For example, alpine elevation definitions caused errors in alpine versus lowland lake designations and alpine versus lowland sedge meadows and there was confusion among riverine, lowland, and upland low willow classes based on rules defining those physiographic units. An unknown portion of this error also was due to spatial registration where the ground plot did not correspond to the respective map pixel because of both GPS and satellite positional error.

The cross-tabulations of agreement between the map and ground classification provide an approximate upper limit of the accuracy of the map, while the evaluation of the spectral uniqueness of the mapped ecotypes provides an approximate lower limit of map accuracy. We also recognize that there are potential misclassifications associated with physiographic distinctions generated by the classification strata. Chemistry of bedrock, elevation models, and features differentiating upland and lowland classes are not homogenous and are prone to some errors of scale that are not readily determined without a full accuracy assessment. However, based on the proxy methods we have evaluated the accuracy of the 44 mapped ecotypes, which were derived from both spectral characteristics and modeling to reduce error, accuracy is probably between 65% and 80%.

Soil Landscapes

Classification and Description of Soil Types

Gelisols

Histels

Typic Fibristels (n=37)

General Site Characteristics

The Typic Fibristels subgroup is a common soil type in ARCN, and was found in all of the parks except KOVA. This soil subgroup is located on sites ranging from sea level to approximately 900 m elevation (avg. 200 m). Sites were typically low gradient, ranging in slope between 0–9°, with an average gradient of <1°.

Geomorphology

Typic Fibristels occurred most frequently in lowland environments, such as bogs, fens, and abandoned overbank deposits along meandering rivers. They also occasionally occurred in upland and lacustrine environments.

Vegetation

Wet Sedge Meadow Tundra is a common vegetation type associated with Typic Fibristels in fens and abandoned overbank deposits. Characteristic species include *Carex aquatilis*, *C. chordorrhiza*, *Eriophorum angustifolium*, and *Limprichtia revolvens*. Surface water commonly is present. Subarctic Lowland Sedge–Moss Bog Meadow is associated with this soil type in bogs. Common species include *Betula nana*, *Vaccinium uliginosum*, *Salix fuscescens*, *Carex aquatilis*, and *Sphagnum* sp. Surface water also is commonly present in this vegetation type, although the coverage is less than that found in Wet Sedge Meadow Tundra.

Soils

Typic Fibristels are characterized by permafrost in the upper meter of soil, a thick (typically >40 cm) organic mat consisting of slightly decomposed sedge or moss fibers overlying mineral soil, and soil saturation for 30 or more cumulative days. The mineral horizons are typically loamy with no coarse fragments in the upper meter of soil. Frost boils, surface fragments, and loess caps are typically absent. Soil pH is acidic to circum-neutral. Electrical conductivity is generally low (<ca. 200 μS/cm). The soils are typically poorly to very poorly drained, and feature a very shallow water table.

Typical Pedon

NOAT_T08_02_2005

Oi1—0 to 10 cm: slightly decomposed sphagnum peat; acidic; clear wavy boundary.

Oi2—10 to 36 cm: slightly decomposed mixed sedge and sphagnum peat; acidic; clear, wavy boundary.

Oi3—36 to 52 cm: slightly decomposed sedge peat, acidic.

Oif—52+ cm: permafrost.

Typic Hemistels (n=13)

General Site Characteristics

The Typic Hemistels subgroup was sampled most frequently in BELA and CAKR, and rarely in KOVA and GAAR. The soil subgroup is located on sites ranging between 2–900 m elevation (avg. 100 m). Slope gradient was typically <3°.

Geomorphology

Typic Hemistels occurred most frequently in lowland environments, including fens, abandoned riverine overbank deposits, and glacial till. When occasionally found in uplands, Typic Hemistels occurred in bogs.

Vegetation

Open Low Shrub Birch–Willow is a vegetation type commonly associated with Typic Hemistels. Characteristic species include *Betula nana*, *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Ledum decumbens*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Carex aquatilis*, and *Sphagnum* sp. Tussock Tundra often co-occurs with this soil type in bogs. A typical species assemblage includes *Eriophorum* *vaginatum*, *Betula nana*, *Ledum decumbens*, *Rubus chamaemorus*, *Carex bigelowii*, *Sphagnum* sp., *Cladina mitis*, and *Flavocetraria cucullata*.

Soils

Typic Hemistels are characterized by permafrost in the upper meter of soil, a thick (>40 cm) surface organic horizon dominated by moderately decomposed plant material, and semi-permanent to permanent saturation. Cryoturbation or other signs of frost action are uncommon. Soils are dominated by organic soil in the upper 50 cm. Frost boils, surface fragments, and loess caps are generally absent. Soil pH is acidic to circumneutral. Electrical conductivity is generally low (<200 µS/cm). The soils are typically very poorly drained to somewhat poorly, and feature a shallow water table.

Typical Pedon

KOVA_T61_01_2007

Oi—0 to 10 cm: slightly decomposed sphagnum peat; strongly acid; clear wavy boundary.

Oe—10 to 48 cm: moderately decomposed sphagnum peat.

Oef—48+ cm: permafrost.

TURBELS

Typic Histoturbels (n=14)

General Site Characteristics

The Typic Histoturbels subgroup was found most often in GAAR, KOVA, and NOAT, and less often in BELA and CAKR. This soil subgroup was located on sites ranging between 20–900 m elevation (avg. 400 m). In upland environments, average slope gradient was 10°, and ranged as high as 30°. In lowland environments, average slope gradient was 3°, and ranged as high as 8°. Across all environments, sites encompassed a wide range of aspects.

Geomorphology

Typic Histoturbels were common in both lowland and upland environments. In lowlands, Typic Histoturbels occurred most commonly on retransported deposits on lower backslopes and toeslopes, and abandoned overbank deposits along meandering rivers. In upland environments, this soil type occurred most commonly on hillside colluvium and glacial till.

Vegetation

Open Low Shrub Birch–Willow is a common vegetation type associated with Typic Histoturbels in both upland and lowland environments. Characteristic species include *Betula nana*, *Vaccinium uliginosum*, *Carex bigelowii*, *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Eriophorum vaginatum*, *Flavocetraria cucullata*, and *Cladina arbuscula*. Open Low Mixed Shrub–Sedge Tussock Tundra is often associated with this soil type in uplands. *Eriophorum vaginatum*, *Carex bigelowii*, *Ledum decumbens*, *Betula nana*, and *Sphagnum* sp. typically dominate the site. Less abundant, but still common species include *Rubus chamaemorus*, *Cladina rangiferina*, *Aulacomnium palustre*, and *Flavocetraria cucullata*.

Soils

Typic Histoturbels are characterized by permafrost in the upper 2 m of the soil, cryoturbation or other indicators of frost related disturbance in one or more horizons, and a thick organic mat above the mineral horizon. Mineral soils are typically loamy, and occasionally sandy. Frost boils and coarse fragments are uncommon and loess caps are rare. Soil pH is generally acidic to circumneutral. Electrical conductivity is generally low (<200 µS/cm). The soils are typically moderately well drained to somewhat poorly drained, with a shallow water table.

Typical Pedon

NOAT_T04_07_2005

Oi—0 to 8 cm: very dark brown (10YR 2/2) moderately decomposed wood; abrupt wavy boundary.

Oe—8 to 24 cm: very dark brown (10YR 2/2) moderately decomposed plant material; acidic; clear wavy boundary.

Bw—24 to 40 cm: very dark gray (10YR 3/1) silt loam; acidic; abrupt wavy boundary; weak, very fine, granular structure; firm, slightly sticky, slightly plastic; common, coarse, prominent oxidized iron accumulations.

Oeb—40 to 42 cm: moderately decomposed plant material.

Bf—42+ cm: permafrost.

Typic Aquiturbels (n=30)

General Site Characteristics

The Typic Aquiturbels subgroup is a common soil type in ARCN, occurring in all parks with the exception of KOVA. This soil subgroup was located on sites ranging between 5–900 m elevation (avg. 400 m). Slope gradient was typically low to moderate, and ranged between 0° and 17° (avg. 3.4°). Across all environments, sites encompassed a wide range of slope aspects.

Geomorphology

Typic Aquiturbels occurred most frequently in lowland and upland environments, and less frequently in alpine environments. In alpine and upland environments, this soil type occurred most commonly on hillside colluvium, glacial till, and loess over hillside colluvium or glacial till. In lowlands, Typic Aquiturbels occurred most commonly on loess over glacial till, abandoned overbank deposits along meandering rivers, drained lake basins, and thaw basins.

Vegetation

Open Low Mixed Shrub–Sedge Tussock Tundra is a common vegetation type associated with Typic Aquiturbels in uplands and lowlands. Characteristic species include *Betula nana*, *Ledum decumbens*, *Eriophorum vaginatum*, *Carex bigelowii*, and *Flavocetraria cucullata*. In uplands, Moist Sedge–Shrub Tundra often co-occurs with this soil subgroup. Common species include *Dryas integrifolia*, *Salix arctica*, *Salix reticulata*, *Arctostaphylos rubra* (syn: *Arctous rubra*), *Carex bigelowii*, *Carex membranacea*, and *Tomentypnum nitens*. Open Low Mesic Shrub Birch–Ericaceous Shrub is another common vegetation type associated with Typic Aquiturbels. This vegetation type is dominated by *Betula nana*, *Ledum decumbens*, and *Vaccinium vitis-idaea*. Frequent understory species include *Rubus chamaemorus*, *Arctagrostis latifolia*, *Carex bigelowii*, *Eriophorum vaginatum*, *Dicranum* sp., *Cladina rangiferina*, and *Peltigera aphthosa*.

Soils

Typic Aquiturbels are characterized by permafrost in the upper 2 m of the soil, cryoturbation or other indicators of frost related disturbance in one or more horizons, a thin to moderately thick organic mat overlying mineral soil, and semi-permanent to permanent saturation. Mineral soils are typically loamy. Coarse fragments are generally rare in the upper meter of the soil profile, with the exception of some soils derived from hillside colluvium or glacial till. Frost boils and loess caps are common, while surface fragments, with the exception of some soils formed from colluvium or glacial till, are rare. Soil pH is acidic to circumneutral. Electrical conductivity is generally low (<200 µS/cm). The soils are typically somewhat poorly to poorly drained, and feature a shallow water table.

Typical Pedon

NOAT_T17_05_2005

Oi1—0 to 15 cm: slightly decomposed sphagnum peat; circumneutral; abrupt wavy boundary.

Oi2—15 to 25 cm: slightly decomposed sedge peat; abrupt wavy boundary.

Bw/Oi—25 to 27 cm: dark grayish brown (2.5Y 4/2) silt loam with discontinuous bodies of slightly decomposed sedge peat; abrupt broken boundary; weak, fine, granular structure; firm, non-sticky, moderately plastic; common, medium, prominent oxidized iron accumulations.

Oib—27 to 33 cm: slightly decomposed sedge peat; circumneutral; abrupt wavy boundary.

Bw—33 to 38 cm: dark gray (2.5Y 4/1) silt loam; weak, fine, granular structure; very firm, non-sticky, moderately plastic; common, medium, prominent oxidized iron accumulations.

Bf—38+ cm: permafrost.

Typic Haploturbels (n=23)

General Site Characteristics

The Typic Haploturbels subgroup is a common soil type in ARCN, and was sampled in all parks except NOAT. This soil subgroup was located on sites ranging between 50–1,100 m elevation (avg. 600 m). Sites were typically low to moderately steep, ranging between 0–35°, with an average slope gradient of 8°.

Geomorphology

Typic Haploturbels occurred most frequently in alpine and upland environments, and less frequently in lowland environments. This soil occurred on hillside colluvium, older glacial moraines, and loess.

Vegetation

Open Low Shrub Birch–Willow is a common vegetation type associated with Typic Haploturbels. Characteristic species include *Betula nana*, *Vaccinium uliginosum*, *Carex bigelowii*, *Arctagrostis latifolia*, *Polygonum bistorta* (syn: *Bistorta plumosa*), *Hylocomium splendens*, and *Aulacomnium palustre*. Open Low Mesic Shrub Birch–Ericaceous Shrub is another vegetation type associated with this soil. Species distinctive of this type include *Betula nana*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Hylocomium splendens*, *Tomentypnum nitens*, and *Flavocetraria cucullata*. Dryas–Sedge Dwarf Shrub Tundra often co-occurs with this soil type. Species frequently occurring in this vegetation type include *Dryas octopetala* or *D. integrifolia*, *Cassiope tetragona*, *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Hierochloe alpina*, *Polygonum viviparum* (syn: *Bistorta vivipara*), *Thamnolia vermicularis*, and *Flavocetraria cucullata*. Bare soil and surface fragments are common.

Soils

Typic Haploturbels are characterized by permafrost in the upper 2 m of soil, cryoturbation or other indicators of frost related disturbance in one or more horizons, and a thin organic mat above the mineral horizon. Mineral horizons are typically loamy. Coarse fragments are common in the upper meter of the soil profile. Frost boils and surface fragments also are common, while loess caps are rare. Soil pH is acidic to circumneutral. Electrical conductivity is generally low (<200 µS/cm). The soils are typically well drained to somewhat poorly drained, and feature a moderately deep to deep water table.

Typical Pedon

NOAT_T13_08_2005

Oe—0 to 6 cm: black (10YR 2/1); moderately decomposed plant material; abrupt smooth boundary.

AB—6 to 20 cm: very dark grayish brown (10YR 3/2) silt loam; circumneutral; abrupt broken boundary; weak, medium, granular structure; 25 percent subangular gravels.

Bw—20 to 30 cm: very dark grayish brown (10YR 4/2) silt loam; circumneutral; gradual smooth boundary; weak, medium, granular structure; 15 percent subangular gravels.

C—30 to 46+ cm: very dark grayish brown (10YR 4/2) silt loam; common, fine, prominent oxidized iron accumulations; 40 percent subangular gravels.

Orthels

Typic Historthels (n=45)

General Site Characteristics

The Typic Historthels subgroup was one of the most commonly sampled soils in ARCN, and was found in all 5 parks. This soil subgroup was located on sites ranging between 1–900 m elevation (avg. 200 m). Sites included a wide range of slope gradients, ranging between 0–18°, but were typically low gradient (avg. 3°), and included a wide range of aspects.

Geomorphology

Typic Historthels occurred most frequently in lowland and upland environments, and less frequently in coastal and lacustrine environments. Hillside colluvium and glacial till were the most common geomorphic units on sites with slope gradients greater than 5°. Thaw basins, drained lake basins, bogs, and fens were most common at low gradient sites. In coastal environments, this soil subgroup was associated with inactive tidal flats.

Vegetation

Wet Sedge Meadow Tundra is a common vegetation type associated with Typic Historthels in drained lake basins and fens. This vegetation type is characterized by *Carex aquatilis*, *C. chordorrhiza*, *Eriophorum angustifolium*, and *Sphagnum* sp. Surface water is commonly present, at least in portions of the area. Open Low Mixed Shrub–Sedge Tussock Tundra is associated with Typic Historthels on a variety of geomorphic units, including drained lake basins, thaw basins, glacial till, and hillside colluvium. Common species in this vegetation type include *Betula nana*, *Ledum decumbens*, *Eriophorum vaginatum*, *Carex bigelowii*, and *Sphagnum* sp. In lowland environments, on glacial till and hillside colluvium, Open Black Spruce Forest is a common forested vegetation type associated with Typic Historthels. This vegetation type is characterized by *Picea mariana*, *Rubus chamaemorus*, *Ledum decumbens*, *Carex bigelowii*, and *Cladina rangiferina*.

Soils

Typic Historthels are characterized by permafrost in the upper meter of soil, and a moderately thick (18–30 cm) organic horizon above mineral soil. Mineral horizons are typically loamy with few coarse fragments in the upper meter of soil. Frost boils, surface fragments, and loess caps are typically absent. Soil pH is acidic to circumneutral. Electrical conductivity is generally low (<500 µS/cm), except in coastal environments where it ranges between 8,000–9,000 µS/cm. Soils are typically somewhat poorly to very poorly drained, and feature a shallow water table.

Typical Pedon

KOVA_T79_07_2007

Oi1—0 to 23 cm: dark reddish brown (5YR 3/3) slightly decomposed sphagnum peat; strongly acid; abrupt wavy boundary.

Oi2—23 to 31 cm: very dark brown (7.5YR 2.5/3) slightly decomposed sedge peat; strongly acid; abrupt smooth boundary.

Bg—31 to 49 cm: dark grayish brown (2.5Y 4/2) silt loam; moderate, very fine, granular structure; firm, slightly sticky, slightly plastic; 2–75-mm unspecified fragments (3%).

Bf—49+ cm: permafrost.

Fluvaquentic Aquorthels (n=15)

General Site Characteristics

The Fluvaquentic Aquorthels subgroup was sampled most frequently in BELA, and less frequently in KOVA, NOAT, GAAR, and CAKR. This soil subgroup was located on sites ranging between 0–300 m elevation (avg. 50 m). Slope gradient was always <1°.

Geomorphology

Fluvaquentic Aquorthels occurred in coastal and riverine environments. In coastal environments, this soil type occurred on active and inactive tidal flats. In riverine environments, Fluvaquentic Aquorthels occurred on inactive overbank and fine inactive channel deposits along meandering rivers, and on moderately steep headwater floodplains.

Vegetation

Halophytic Sedge–Grass Wet Meadow is commonly associated with Fluvaquentic Aquorthels in coastal environments. *Carex ramenskii*, *Chrysanthemum arcticum*, and *Puccinellia phryganodes* are the dominant species typical of this vegetation type. Other important species include *Elymus arenarius* var. *mollis* (syn: *Leymus mollis*), *Calamagrostis deschampsioides*, and *Stellaria humifusa*. In riverine environments, Open Tall Alder Shrub–Willow Shrub frequently co-occurs with this soil type. Characteristic species include *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Rubus acrticus*, *Carex aquatilis*, and *Calliergon* sp.

Soils

Fluvaquentic Aquorthels are characterized by permafrost in the upper meter of soil, a thin organic horizon overlying mineral soil, at least one buried organic horizon, redox depletions within the upper 50 cm of the soil profile, and saturated conditions for a significant time period during the growing season. Mineral horizons are loamy or sandy, with little to no coarse fragments in the upper meter of soil. Frost boils, surface fragments, and loess caps never occur in this soil type. Soil pH is acidic to circumneutral. In riverine environments, electrical conductivity is generally low to moderately low (60–1,100 µS/cm, avg. 335). In coastal environments, electrical conductivity is generally high to very high (590-30,700 µS/cm, avg. 12,247). The soils are typically somewhat poorly to very poorly drained, and feature a shallow water table.

Typical Pedon

NOAT_T48_04_2006

Oi—0 to 2 cm: slightly decomposed plant material; abrupt wavy boundary.

C1—2 to 3 cm: silt loam; abrupt wavy boundary; structureless, massive.

Oib—3 to 5 cm: slightly decomposed plant material; abrupt wavy boundary.

C2—5 to 20 cm: silt loam with pockets of very fine sand; circumneutral; clear wavy boundary; structureless, massive; common, coarse, distinct oxidized iron accumulations.

C3/Oeb—20 to 27 cm: very fine sand with many thin (<0.5 cm) interbeds of moderately decomposed organic material; clear wavy boundary; structureless, single-grained; common, coarse, distinct oxidized iron accumulations.

C4—27 to 46 cm: loamy very fine sand with pockets of very fine sand; structureless, massive; common, coarse, distinct oxidized iron accumulations.

Cf—42+ cm: permafrost.

Typic Aquorthels (n=45)

General Site Characteristics

The Typic Aquorthels subgroup was one of the most commonly sampled soils in the study area, including all 5 parks. This soil subgroup occurred between 10–900 m elevation (avg. 250 m). In alpine and upland environments, average slope gradient was 8°. In lowland and lacustrine environments, average slope gradient was 1°. Across all environments, sites encompassed a wide range of aspects.

Geomorphology

Typic Aquorthels occurred most frequently in lowland, upland, and lacustrine environments, and less frequently in alpine and riverine environments. In alpine and upland environments, and on lower hillside positions in lowland environments, this soil occurred most commonly on hillside colluvium, loess over glacial till, and glacial till. In lowland and riverine environments, Typic Aquorthels occurred commonly on inactive and abandoned overbank and channel deposits along meandering and braided rivers. In lacustrine environments, this soil type occurred in drained lake basins and thaw basins.

Vegetation

Open Low Willow Shrub is a common vegetation type that co-occurs with Typic Aquorthels. Characteristic species included *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *Carex aquatilis*, *Vaccinium uliginosum*, and *Hylocomium splendens*. Wet Sedge Meadow Tundra is another vegetation type often associated with this soil subgroup. Common species include *Eriophorum vaginatum*, *Carex aquatilis*, *Arctagrostis latifolia*, *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), and *Aulacomnium palustre*. Surface water and bare soil are common, although the coverage is low. In ice-poor thaw basin centers, Bluejoint–Herb Meadow is commonly associated with Typic Aquorthels. Frequently occurring species include *Calamagrostis canadensis*, *Petasites frigidus*, *Polemonium acutiflorum*, *Rumex arcticus*, *Valeriana capitata*, and *Aulacomnium palustre*.

Soils

Typic Aquorthels are characterized by permafrost in the upper meter of soil, a thin to moderately thick organic horizon overlying mineral soil, redox depletions within the upper 50 cm of the soil profile, and saturated conditions for a significant time period during the growing season. Mineral horizons are typically loamy, with few coarse fragments in the upper meter. Frost boils never occur in this soil type. Surface fragments and loess caps are uncommon, but when loess caps occur they tend to be thick (approx. 40 cm). Soil pH is acidic to circumneutral, and rarely basic. Electrical conductivity is generally low (<200 µS/cm). The soils are typically somewhat poorly to very poorly drained, and feature a shallow water table.

Typical Pedon

NOAT_T17_07_2005

Oi—0 to 3 cm: slightly decomposed brown fen mosses.

Oe—8 to 13 cm: moderately decomposed sedge peat.

Bw—13 to 18 cm: very dark grayish brown (10YR 3/2) silt; moderate, fine, platy structure; very firm, slightly-sticky, non-plastic.

Bg—18 to 67 cm: very dark gray (2.5Y 3/1) silt; weak, fine, angular block structure; firm, slightly-sticky, non-plastic.

Bf—67 cm: permafrost.

Fluaquentic Haplorthels (n=9)

General Site Characteristics

The Fluvaquentic Haplorthels subgroup was sampled most frequently in BELA, but was also occasionally encountered in CAKR. This soil subgroup was located on sites ranging between 0–40 m elevation (avg. 10 m). Slope gradient was always <1°.

Geomorphology

Fluvaquentic Haplorthels occurred in riverine environments on active and inactive overbank deposits along meandering rivers.

Vegetation

Closed Low Shrub Birch–Willow was frequently associated with Fluvaquentic Haplorthels on inactive overbank deposits along meandering rivers. Frequently occurring species include *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Betula nana*, *Vaccinium uliginosum*, *Petasites frigidus*, *Arctagrostis latifolia*, *Carex bigelowii*, *Sphagnum* sp., and *Hylocomium splendens*.

Soils

Fluvaquentic Haplorthels are characterized by permafrost in the upper meter of soil, a thin organic horizon overlying mineral soil, at least one buried organic horizon, redox depletions within the upper 75 cm of the soil profile, and saturated conditions for a significant time period during the growing season. Mineral horizons are loamy or sandy, with little to no coarse fragments in the upper meter of soil. Frost boils, surface fragments, and loess caps never occur in this soil type. Soil pH is circumneutral. Electrical conductivity is generally low (<200 µS/cm). The soils are typically moderately well to somewhat poorly drained, and feature a shallow to moderately deep water table.

Typical Pedon

NA

Typic Haplorthels (n=21)

General Site Characteristics

The Typic Haplorthels subgroup is a common soil type in ARCN, occurring in all 5 parks. This soil subgroup was located on sites ranging in elevation between 50–900 m. In alpine and upland environments, the average gradient was 12°, but ranged as high as 30°. In lowland and riverine environments, the average slope gradient was 2°, ranging up to 5°. Across all environments, sites encompassed a wide range of aspects.

Geomorphology

Typic Haplorthels occurred most frequently in alpine and upland environments, and less frequently in lowland and riverine environments. In alpine and upland environments this soil type occurred on hillside colluvium, glacial till, and solufluction deposits. In lowlands, this type occurred in glacial till along lower backslopes and toeslopes. In riverine environments, Typic Haplorthels occurred on inactive overbank deposits along meandering rivers.

Vegetation

Open Low Willow Shrub is a commonly associated with Typic Haplorthels in upland environments. *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*) and *Vaccinium uliginosum* form an open to moderately closed low shrub layer. Common understory species include *Salix reticulata*, *Petasites frigidus*, *Equisetum arvense*, and *Hylocomium splendens*. Open Black Spruce Forest is often associated with this soil type in lowlands. Characteristic species include *Picea mariana*, *Ledum decumbens*, *Vaccinium uliginosum*, *Carex bigelowii*, *Cladina rangiferina*, and *Pleurozium schreberi*. In alpine environments, Dryas–Lichen Dwarf Shrub Tundra often occurs on Typic Haplorthels. Typical species include *Dryas octopetala*, *Cassiope tetragona*, *Pedicularis capitata*, *Silene acaulis*, *Alectoria* sp., *Bryoria nitidula*, and *Flavocetraria cucullata*.

Soils

Typic Haplorthels are characterized by permafrost in the upper 1 m of soil, a lack of cryoturbation, and a thin organic mat overlying mineral soil. The mineral horizons are typically loamy, and coarse fragments are common in the upper meter of the soil profile. Frost boils and surface fragments are absent, and loess caps are uncommon. Soil pH is primarily acidic to circumneutral. Electrical conductivity is generally low (<100 µS/cm). The soils are typically somewhat excessively to moderately well drained, and feature a deep to moderately deep water table.

Typical Pedon

NOAT_T12_08_2005

Oi—0 to 8 cm: slightly decomposed plant material; acidic; clear wavy boundary.

Oe—8 to 13 cm: moderately decomposed plant material; clear smooth boundary.

Bw—13 to 52 cm: dark grayish brown (10YR 3/2) silt loam; acidic; common, medium, faint oxidized iron accumulations.

Bf—52+ cm: permafrost.

Histosols

Fibrists

Typic Cryofibrists (n=12)

General Site Characteristics

The Typic Cryofibrists subgroup occurred in GAAR and KOVA. This soil subgroup was located on sites ranging between 15–300 m elevation (avg. 170 m). Slope gradient was always <1%.

Geomorphology

Typic Cryofibrists occurred exclusively in lacustrine environments, in fens, and occasionally, in bogs.

Vegetation

Typic Cryofibrists are often associated with Subarctic Lowland Sedge Wet Meadow in swales and along lake margins. This fen type is characterized by *Carex limosa*, *Menyanthes trifoliata*, *Carex aquatilis*, *C. chordorrhiza*, *Andromeda polifolia*, and *Limprichtia revolvens*. Surface water is almost always present. Subarctic Lowland Herb Bog Meadow is another vegetation type that is frequently associated with this soil type. Typical species include *Menyanthes trifoliata*, *Potentilla palustris* (syn: *Comarum palustre*), *Utricularia minor*, *Equisetum fluviatile*, *Warnstorfia exannulata*, and *Sphagnum riparium*. Surface water is always present.

Soils

Typic Cryofibrists are characterized by a thick to very thick surface organic horizon (>40 cm), semi-permanent to permanent saturation, a lack of permafrost in the upper meter of the soil profile, an average annual soil temperature >0° C, and an average summer soil temperature of <8° C. Soils comprise a surface organic horizon at least 40 cm thick; thus, the underlying mineral horizon was rarely sampled. Frost boils, surface fragments, and loess caps are absent. Soil pH is typically circumneutral, and occasionally acidic. Electrical conductivity is generally low (<200 µS/cm). The soils are poorly to very poorly drained, and the water table is very shallow to above ground.

Typical Pedon

GAAR_T113_09_2008

Oi1—0 to 16 cm: slightly decomposed moss fibers; circumneutral; clear smooth boundary.

Oi2—16 to 33 cm: slightly decomposed moss and graminoid fibers; clear smooth boundary.

Oi3—33 to 55 cm: slightly decomposed moss and graminoid fibers.

Oi4—55 to 130+ cm: slightly decomposed plant material.

Inceptisols

Gelepts

Typic Eutrogelepts (n=63)

General Site Characteristics

The Typic Eutrogelepts subgroup was one of the most commonly sampled soils in the study area, including all 5 parks. This soil subgroup occurred between 9–900 m elevation (avg. 400 m). Sites were typically moderately steep to steep, ranging between 0–34°, with an average slope gradient of 10°, and included a wide range of aspects.

Geomorphology

Typic Eutrogelepts occurred most frequently in alpine and upland environments, and less frequently in lowland, riverine, and lacustrine environments. On upper slope positions, with gradients greater than approximately 3°, this soil subgroup occurred on hillside colluvium, talus, loess over colluvium or bedrock, and solufluction deposits. On lower gradient sites, geomorphic units were typically weathered bedrock on crests, and abandoned alluvial fan deposits, abandoned riverine deposits, and glacial till on lower slope positions.

Vegetation

Dryas Dwarf Shrub Tundra is a common vegetation type associated with Typic

Eutrogelepts on upper slope positions in hillside colluvium, talus, and weathered bedrock. Characteristic species include *Dryas octopetala*, *Carex scirpoidea*, *Polygonum viviparum* (syn: *Bistorta vivipara*), *Minuartia arctica*, and *Saxifraga oppositifolia*. Bare soil and surface fragments are always present. Barrens (0-5% vegetation) and Partially Vegetated Barrens (5-30% vegetation) are two additional vegetation types that also occur on upper slope positions and correspond with this soil type. Common species include *Dryas octopetala*, *Saxifraga oppositifolia*, *Minuartia arctica*, *Lesquerella arctica*, and *Potentilla uniflora*. Coarse surface fragments are abundant. Cassiope Dwarf Shrub Tundra often occurs on hillside colluvium associated with Typic Eutrogelepts. Common species include *Cassiope tetragona*, *Dryas octopetala*, *Carex scirpoidea*, *Papaver macounii*, and *Dactylina arctica*. At late snowbed sites, *Boykinia richardsonii* and *Salix rotundifolia* often occur at low to moderately high abundance. Open White Spruce Forest is associated with this soil subgroup in upland environments on backslopes and footslopes in colluvium and loess over colluvium. Common species include *Picea glauca*, *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *Arctostaphylos rubra* (syn: *Arctous rubra*), and *Hylocomium splendens*.

Soils

Typic Eutrogelepts are characterized by a thin surface organic horizon, weak to moderate soil structure, a lack of permafrost in the upper meter of the soil profile, a pH greater than approximately 5.5, and a mean annual soil temperature of 0° C or colder. The mineral horizons are typically loamy with many coarse fragments in the upper meter of soil. Frost boils, surface fragments, and loess caps are common. Soil chemistry is typically circumneutral to alkaline. Electrical conductivity is generally low (<200 µS/cm). The soils are excessively to moderately well drained, and the water table is deep to very deep.

Typical Pedon

NOAT_T19_04_2005

Oe—0 to 4 cm: black (10YR 2/1) moderately decomposed plant material; 70 percent angular gravels.

Bw—4 to 30 cm: dark brown (10YR 3/3) silt loam; alkaline; weak, very fine, granular structure; friable, slightly-sticky, slightly-plastic; 70 percent angular gravels.

BC—30 to 50 cm: dark brown (10YR 3/3) silt loam; alkaline; weak, very fine, granular structure; friable, slightly-sticky, slightly-plastic; 90 percent angular gravels.

Typic Dystrogelepts (n=46)

General Site Characteristics

The Typic Dystrogelepts subgroup was one of the most commonly sampled soils in the study area, including all 5 parks. This soil subgroup occurred between 4–800 m elevation (avg. 500 m). Sites were typically moderately steep to steep, ranging between 0–35°, with an average slope gradient of 10°, and included a wide range of aspects.

Geomorphology

Typic Dystrogelepts occurred most frequently in alpine and upland environments, on upper slope positions in hillside colluvium, talus, or glacial till. This subgroup was less frequently associated with lowland and riverine environments.

Vegetation

In alpine environments, Dryas–Lichen Dwarf Shrub Tundra is a common vegetation type associated with Typic Dystrogelepts. Characteristic species include *Dryas octopetala*, *Salix phlebophylla*, *Minuartia arctica*, *Hierochloe alpina*, *Antennaria friesiana*, *Alectoria ochroleuca*, and *Sphaerophorus* sp. Cover by bare soil and surface fragments is commonly >50%. In upland environments, Open Low Mesic Shrub Birch–Ericaceous Shrub is often supported by this soil type. Common species include *Betula nana*, *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Flavocetraria cucullata*, and *Masonhalea richardsonii*.

Soils

Typic Dystrogelepts are characterized by a thin surface organic horizon, weak to moderate soil structure, a lack of permafrost in the upper meter of the soil profile, a pH <5.5, and a mean annual soil temperature of 0° C or colder. Mineral soil horizons are typically loamy with many coarse fragments in the upper meter of soil. Frost boils and loess caps are rare, while surface fragments are common and abundant. Soil chemistry is typically circumneutral to acidic. Electrical conductivity is generally low (<ca. 200 µS/cm). The soils are excessively to moderately well drained, and the water table is very deep.

Typical Pedon

KOVA_T81_04_2007

> *Oi—0 to 4 cm:* black (10YR 2/1) slightly decomposed wood; irregular clear boundary.
>
> *Bw—2 to 7 cm:* very dark grayish brown (10YR 3/2) sandy loam; acidic; moderate, fine, subangular blocky structure; friable, slightly-sticky, non-plastic; 60 percent angular flagstones.
>
> *C—7 to 35+ cm:* dark gray (2.5Y 4/1) sandy loam; weak, fine, subangular blocky structure; friable, slightly-sticky, non-plastic; 96 percent angular flagstones.

Cryepts

Typic Dystrocryepts (n=20)

General Site Characteristics

The Typic Dystrocryepts subgroup was limited in ARCN to KOVA and GAAR. This soil subgroup occurred between 40–600 m elevation (avg. 250 m). Sites were typically moderately steep to steep, with a slope ranging between 3–34° (avg. 18°), and included a wide range of aspects.

Geomorphology

Typic Dystrocryepts occurred exclusively in upland environments and occurred most commonly on upper slope positions in hillside colluvium, loess over colluvium, glacial till, and inactive sand dunes.

Vegetation

White Spruce Woodland is commonly associated with Typic Dystrocryepts on loess, sand dunes, and hillside colluvium. *Picea glauca* forms the overstory beneath which *Spiraea beauverdiana* (syn: *S. stevenii*), *Vaccinium uliginosum*, and *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*) form a moderately dense shrub layer. Common understory species include *Calamagrostis canadensis*, *Lycopodium annotinum*, *Hylocomium splendens*, *Pleurozium schreberi*, and *Cladina rangiferina*. Open Spruce–Paper Birch Forest is often associated with this soil subgroup on hillside colluvium, glacial till, and sand dunes. *Betula papyrifera* (syn: *B. neoalaskana*) and *Picea glauca* form a mixed deciduous and needleleaf canopy. Characteristic understory species include *Spiraea beauverdiana* (syn: *S. stevenii*), *Vaccinium vitis-idaea*, *Empetrum nigrum*, *Linnaea borealis*, *Equisetum sylvaticum*, and *Cladina rangiferina*. Open Tall Alder Shrub also commonly occurs in conjunction with Typic Dystrocryepts on hillside colluvium and loess. *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*) and *Spiraea beauverdiana* (syn: *S. stevenii*) form a moderately dense shrub layer. Typical understory species include *Artemisia arctica*, *Calamagrostis canadensis*, *Linnaea borealis*, *Lycopodium alpinum* (syn: *Diphasiastrum alpinum*), *Trientalis europaea* var. *arctica*, *Festuca altaica*, *Carex podocarpa*, and *Stereocaulon* sp.

Soils

Typic Dystrocryepts are characterized by a thin surface organic horizon, weak to moderate soil structure, a lack of permafrost in the upper meter of the soil profile, a pH <5.5, an average annual soil temperature >0° C, and an average summer soil temperature of <8° C. Mineral soil materials are loamy or sandy. Coarse fragments are common and abundant in the upper meter of soil, with the exception of soils formed in loess or Eolian sand deposits. Frost boils and surface fragments are rare. Loess caps are uncommon, however when they are present they tend to be thick (avg. 22 cm). Soil chemistry is acidic, and electrical conductivity is generally low (<ca. 100 µS/cm). The soils are excessively to well drained, and the water table is very deep.

Typical Pedon

KOVA_T79_05_2007

Oe—0 to 3 cm: very dark brown (7.5YR 2.5/3) moderately decomposed wood; abrupt wavy boundary.

Oa—3 to 5 cm: very dark brown (7.5YR 2.5/2) highly decomposed wood; clear wavy boundary.

A—5 to 13 cm: black (10YR 2/1) silt loam; acidic; gradual, wavy boundary; moderate, medium, granular structure; friable, non-sticky, non-plastic.

Bw—13 to 20 cm: very dark grayish brown (10YR 3/2) loamy sand; abrupt wavy boundary; moderate, medium, granular structure; friable, slightly-sticky, slightly-plastic; 50 percent angular channers.

BC—20 to 35 cm: dark reddish brown (5YR 3/2) loamy sand; acidic; gradual wavy boundary; moderate, medium, granular structure; friable, slightly-sticky, slightly-plastic; 60 percent angular channers.

C—35 to 70+ cm: loamy sand; structureless; 80 percent angular channers.

Typic Haplocryepts (n=12)

General Site Characteristics

The Typic Haplocryepts subgroup was found only in KOVA and GAAR. This soil subgroup occurred between 36–900 m elevation (avg. 200 m). Sites were typically moderately steep to steep, ranging between 0–38° slope, with an average slope gradient of 15°. Slopes were typically south- or west-facing.

Geomorphology

Typic Dystrocryepts occurred in alpine and upland environments. This soil type occurred most commonly at steep upper and lower slope positions on hillside colluvium and inactive sand deposits, and at flatter sites on active and inactive sand dunes.

Vegetation

Open Spruce–Paper Birch Forest is commonly associated with Typic Haplocryepts. *Betula papyrifera* (syn: *B. neoalaskana)* and *Picea glauca* form an open, mixed deciduous and needleleaf tree canopy. *Salix bebbiana* commonly occurs in the tall shrub layer. Typical understory species include *Vaccinium vitis-idaea*, *Ledum decumbens*, *Geocaulon lividum*, *Cladina rangiferana*, *Hylocomium splendens*, and *Pleurozium schreberi*. Open White Spruce Forest is another vegetation type that often co-occurs with this soil type. Characteristic species include *Picea glauca*, *Juniperus communis*, *Salix reticulata*, *Empetrum nigrum*, *Vaccinium uliginosum*, *Solidago multiradiata*, and *Hylocomium splendens*.

Soils

Typic Haplocryepts are characterized by a thin surface organic horizon, weak to moderate soil structure, a lack of permafrost in the upper meter of the soil profile, a pH >5.5, an average annual soil temperature > 0° C, and an average summer soil temperature of <8° C. Mineral soil materials are typically sandy. Coarse fragments are common and abundant in the upper meter of soil, except those soils formed in sand dunes and eolian sand deposits. Frost boils and loess caps are absent. Surface fragments are common on soils formed from hillside colluvium. Soil chemistry is circumneutral to alkaline. Electrical conductivity is generally low (<ca. 100 µS/cm). The soils are excessively to moderately well drained, and the water table is very deep.

Typical Pedon

GAAR_T92_06_2008

> *Oi—0 to 1 cm:* black (5YR 2.5/1) slightly decomposed plant material; abrupt wavy boundary.
>
> *Oe—3 to 5 cm:* very dark brown (7.5YR 2.5/2) moderately decomposed plant material; abrupt smooth boundary.
>
> *BC—5 to 16 cm:* dark gray (2.5Y 4/1) loamy fine sand; circumneutral; clear smooth boundary; 40 percent angular channers.
>
> *C—16 to 40+ cm:* dark gray (2.5Y 4/1) loamy fine sand; 50 percent angular channers.

ENTISOLS

Psamments

Oxyaquic Cryopsamments (n=9)

General Site Characteristics

The Oxyaquic Cryopsamments subgroup was found most often in BELA and CAKR and less often in KOVA and GAAR. This soil subgroup was located on sites ranging between 0–900 m elevation (avg. 100 m). The slope is typically low gradient, ranging between 0–4°.

Geomorphology

Oxyaquic Cryopsamments occurred most frequently in riverine and coastal environments, and less frequently in lowland environments. In coastal environments, this soil type occurred on active marine beaches. In riverine environments, this soil type occurred most commonly on active overbank deposits, and coarse and fine active channel deposits along meandering rivers, and less commonly on inactive fine channel deposits. In lowland environments, this soil type was located on glacial till.

Vegetation

Oxyaquic Cryopsamments are often associated with unvegetated sandy beaches in coastal environments, and riverine barrens on active sand bars. Open Tall Willow Shrub is a common vegetation type that occurs with this soil type on active overbank deposits along meandering rivers. Characteristic species include *Salix alaxensis*, *Galium boreale*, *Aster sibiricus* (syn: *Eurybia sibirica*), *Equisetum arvense*, *Equisetum variegatum*, *Parnassia palustris*, and *Pohlia* sp. Sand is often exposed at the soil surface.

Soils

Oxyaquic Cryopsamments are characterized by little to no surface organics, a lack of soil structure, <35% coarse fragments, a lack of permafrost in the upper meter of the soil profile, soil saturation within the upper meter of soil for 20 or more consecutive days or 30 or more cumulative days during the growing season, an average annual soil temperature >0° C, and an average summer soil temperature of <15° C. The soil texture is always sandy with few coarse fragments in the upper meter of soil. Frost boils, surface fragments, and loess caps are always absent. Soil pH is most often alkaline to circumneutral. Electrical conductivity is generally low (<100 µS/cm), except at coastal sites influenced by sea water where it is moderately high to high (avg. 4,741 µS/cm). The soils are excessively to well drained, and feature a shallow to moderately deep water table.

Typical Pedon

BELA_T21_03_2002

> *C—0 to 40+ cm:* variegated sands; circumneutral; structureless, single-grained; loose, non-sticky, non-plastic.

Typic Cryopsamments (n=35)

General Site Characteristics

The Typic Cryopsamments subgroup is a common soil type in ARCN. This soil class was found most often in KOVA, and less often in GAAR, NOAT, CAKR, and BELA. This soil subgroup was located on sites ranging between 0–500 m elevation (avg. 100 m). Sites were typically low to moderate gradient, ranging between 0–24°, with an average slope gradient of 4°, and included a wide range of slope aspects.

Geomorphology

Typic Cryopsamments occurred most frequently in upland and riverine environments, and less frequently in coastal environments. In the areas surrounding the Greater Kobuk Sand Dunes and Little Kobuk Sand Dunes, this soil type occurred in moderately steep to steep upland environments on active and inactive sand dunes. In riverine environments, Typic Cryopsamments were common on active and inactive channel and overbank deposits along meandering and braided rivers, and on active and inactive riverine sand dunes. In coastal environments, this soil type occurred on active marine beaches and active coastal dunes.

Vegetation

Barrens and Partially Vegetated Barrens are common vegetation types associated with Typic Cryopsamments on active sand dunes in the Greater Kobuk Sand Dunes, Little Kobuk Sand Dunes, and other, smaller active dune fields in ARCN. Although bare sand is the predominant cover (90%), species include *Bromus pumpellianus*, *Calamagrostis purpurascens*, *Cnidium cnidiifolium*, *Oxytropis kobukensis*, *Senecio ogotorukensis* (syn: *Packera ogotorukensis*), and *Artemisia furcata*. White Spruce Woodland is a forested vegetation type is associated with this soil subgroup on inactive sand dunes in areas surrounding active sand Dunes. *Picea glauca* forms a sparse tree canopy above a lichen dominated understory, including *Stereocaulon* sp., *Cladonia* sp., *Abietinella abietina*, and *Flavocetraria nivalis*. Common vascular species include *Arctostaphylos uva-ursi*, *Solidago multiradiata*, and *Astragalus aboriginum*. Bare sand is almost always present. In riverine environments, Open and Closed Tall Willow Shrub are common vegetation types associated with Typic Cryopsamments. These vegetation types are typically dominated by *Salix alaxensis*, with an understory of *Equisetum arvense*, *Aster sibiricus* (syn: *Eurybia sibirica*), *Artemisia tilesii*, and *Calamagrostis canadensis*. Bare riverine silts and sands also are present. In coastal environments, Elymus Meadow grows on this soil type on coastal sand dunes. Characteristic species include *Elymus arenarius* var. *mollis* (syn: *Leymus mollis*), *Lathyrus maritimus* var. *maritimus*, *Cnidium cnidiifolium*, and *Honckenya peploides*. Bare sand is always present.

Soils

Typic Cryopsamments are characterized by little to no surface organics, a lack of soil structure, <35% coarse fragments, a lack of permafrost in the upper meter of the soil profile, an average annual soil temperature >0° C, and an average summer soil temperature of <15° C. The soil is always sandy with few coarse fragments in the upper meter of soil. Frost boils, surface fragments, and loess caps are generally absent. Soil pH is most often alkaline to circumneutral. Electrical conductivity is generally low (<300 µS/cm). The soils are excessively to well drained, and feature a deep to very deep water table.

Typical Pedon

KOVA_T66_02_2007

> *C—0 to 50+ cm:* pale yellow (2.5Y 7/4) fine sand; alkaline; massive, single-grained structure; loose, non-sticky, non-plastic.

Orthents

Oxyaquic Gelorthents (n=15)

General Site Characteristics

The Oxyaquic Gelorthents subgroup was found in NOAT, CAKR, and KOVA. This soil subgroup was located on sites ranging between 10–600 m elevation (avg. 200 m). Sites were typically low gradient, ranging between 0–2°.

Geomorphology

Oxyaquic Gelorthents occurred almost exclusively in riverine environments, but occasionally also occurred in lacustrine environments in ice-poor thaw basins. In riverine environments, this soil occurred most commonly on active overbank and coarse active channel deposits along braided and meandering rivers, and moderately steep headwater floodplains and channel deposits.

Vegetation

Oxyaquic Gelorthents are often associated with Barrens or Partially Vegetated Barrens on sand and gravel bars. Open Low Willow Shrub is commonly associated with this soil type on braided coarse active channel deposits, moderately steep headwater floodplains, and braided active overbank deposits. Characteristic species include *Salix alaxensis*, *Epilobium latifolium*, *Aster sibiricus* (syn: *Eurybia sibirica*), *Astragalus alpinus*, and seedlings of *Populus balsamifera*. Bare sand and silt are always present. Open Tall Willow Shrub is often associated with Oxyaquic Gelorthents on active overbank deposits along braided and meandering rivers, and moderately steep headwater floodplains and channel deposits. *Salix alaxensis* and *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*) form a moderately dense tall shrub layer. Typical understory species include *Salix reticulata*, *Aster sibiricus* (syn: *Eurybia sibirica*), *Artemisia tilesii*, *Hedysarum alpinum* (syn: *Hedysarum hedysaroides*), *Anemone parviflora*, and *Equisetum arvense*. Bare sand and silt are always present.

Soils

Oxyaquic Cryorthents are characterized by little to no surface organics, a lack of soil structure, >35% coarse fragments, soil saturation within the upper meter of soil for 20 or more consecutive days or 30 or more cumulative days during the growing season, a lack of permafrost in the upper meter of the soil profile, and a mean annual soil temperature of 0° C or colder. Soils are typically loamy or sandy with many coarse fragments in the upper meter of soil. Frost boils and loess caps are absent, and surface fragments are common. Soil pH is most often alkaline to circumneutral. Electrical conductivity is generally low (<200 µS/cm). The soils are excessively to well drained, and feature a shallow to moderately deep water table.

Typical Pedon

NOAT_T10_03_2005

> *C1—0 to 25 cm:* olive brown (5Y 2.5/2) silt loam; alkaline; structureless, single-grained; loose, non-sticky, non-plastic.
>
> *C2—25 to 40+ cm:* very dark gray (2.5YR 3/1) fine sand; structureless, single-grained; 50 percent subrounded cobbles; loose, non-sticky, non-plastic.

Typic Gelorthents (n=74)

General Site Characteristics

The Typic Gelorthents subgroup was one of the most commonly sampled soils in the study area. This soil class was found most often in NOAT, and less often in CAKR, GAAR, and KOVA. This soil subgroup occurred between 4–1,300 m elevation (avg. 397 m). In alpine environments, sites encompassed a wide range of slope aspects. Sites were typically moderately steep to very steep, with slope gradients ranging between 2–55° (avg. 20º). In riverine and lacustrine environments, slope gradients were almost always <1 º.

Geomorphology

Typic Gelorthents occurred most frequently in alpine and riverine environments, and less frequently in lacustrine environments. In alpine environments this soil occurred on talus and hillside colluvium. In riverine environments this soil occurred on active and inactive overbank and channel deposits along braided and meandering rivers, and on moderately steep headwater floodplains.

Vegetation

In alpine environments, Dryas Dwarf Shrub Tundra is a common vegetation type associated with Typic Gelorthents. Characteristic species include *Dryas octopetala*, *Salix phlebophylla*, *Geum glaciale*, *Silene acaulis*, *Pedicularis capitata*, *Lycopodium selago* (syn: *Huperzia selago*), and *Dactylina arctica*. Bare soil and surface fragments are always present with an average cover of 33%. Barrens and Partially Vegetated Barrens were also commonly associated with this soil type in alpine environments, and were characterized by *Salix arctica*, *Saxifraga oppositifolia*, *Minuartia arctica*, *Androsace chamaejasme*, *Racomitrium* sp.. Bare soil and surface fragments are always present with an average cover of 89%. In riverine environments, Open Tall Willow Shrub is commonly associated with Typic Gelorthents. This vegetation type is dominated by *Salix alaxensis*. Characteristic understory species include *Aster sibiricus* (syn: *Eurybia sibirica*), *Artemisia tilesii*, and *Equisetum arvense*. Bare soil and surface fragments are almost always exposed with an average cover of 24%. Open Balsam Poplar Forest is another vegetation type associated with Typic Gelorthents in riverine environments. *Populus balsamifera* forms an open deciduous canopy, with *Picea glauca* often found in the understory. *Shepherdia canadensis* and *Salix alaxensis* are commonly found in the shrub layer. Characteristic herbaceous species include *Aster sibiricus* (syn: *Eurybia sibirica*), *Artemisia tilesii*, and *Hedysarum alpinum* (syn: *Hedysarum hedysaroides*).

Soils

Typic Gelorthents are characterized by a very thin surface organic horizon, little to no soil structure, a lack of permafrost in the upper meter of the soil profile, and a mean annual soil temperature of 0° C or colder. The mineral horizons are typically loamy or sandy with many coarse fragments in the upper meter of soil. Frost boils and surface fragments are common, while loess caps are rare. Soil pH was circumneutral to basic. Electrical conductivity is generally low (<100 µS/cm). The soils are excessively to moderately well drained, and the water table is deep to very deep.

Typical Pedon—Riverine

NOAT_T10_07_2005

Oi—0 to 3 cm: black (10YR 2/1) slightly decomposed feather moss; abrupt smooth boundary.

Oe—3 to 8 cm: black (10YR 2/1) moderately decomposed wood; abrupt smooth boundary.

Bw—8 to 15 cm: very dark grayish brown (10YR 3/2) silt loam; circumneutral; moderate, very fine, granular structure; friable, non-sticky, non-plastic; few, fine, distinct oxidized iron accumulations.

C1—15 to 26 cm: olive brown (2.5YR 4/3) silt loam; structureless.

C2—26 to 35 cm: olive brown (2.5YR 4/3) fine sand; alkaline; structureless.

C3—35 to 50+ cm: very dark grayish brown (2.5YR 3/2) fine sand; structureless; 30 percent 2- to 75-millimeter subrounded fragments.

Typical Pedon— Alpine

NOAT_G03_02_2005

C1—0 to 12 cm: pale yellow (2.5Y 7/4) fine sand; circumneutral; structureless; 80 percent 2- to 75-millimeter angular fragments.

C2—12 to 40+ cm: olive brown (2.5YR 4/3) fine sand; circumneutral; structureless; 80 percent 2- to 75-millimeter angular fragments.

Oxyaquic Cryorthents (n=29)

General Site Characteristics
The Oxyaquic Cryorthents subgroup is a common soil type in ARCN, and was sampled in all parks, with the exception of CAKR. This soil subgroup was located on sites ranging 23–500 m in elevation (avg. 200 m). Sites were typically low gradient, ranging between 0–7° (avg 1°).

Geomorphology
With one exception, Oxyaquic Cryorthents occurred almost exclusively in riverine environments, most commonly on active overbank deposits along braided rivers, and coarse active channel deposits along braided and meandering rivers. Less frequently, we found it associated with inactive channel and overbank deposits along braided and meandering rivers and old alluvial fans. The one non-riverine site occurred in a lowland environment on a recently burned glacial moraine.

Vegetation
Oxyaquic Cryorthents are often associated with Barrens on unvegetated sand and gravel bars. Some sites also included Partially Vegetated Barrens, featuring bare alluvium along with scattered *Salix alaxensis*, *Populus balsamifera*, *Epilobium latifolium*, *Aster sibiricus* (syn: *Eurybia sibirica*), and *Hedysarum alpinum* (syn: *Hedysarum hedysaroides*). Seral Herbs is another vegetation type commonly associated with Oxyaquic Cryorthents. Characteristic species include *Salix alaxensis*, *Epilobium latifolium*, *Artemisia borealis*, *Bromus pumpellianus*, and *Oxytropis campestris*. Similar to the other vegetation types, cover by bare sand is prominent.

Soils
Oxyaquic Cryorthents are characterized by little to no surface organics, a lack of soil structure, >35% coarse fragments, soil saturation within the upper meter of soil for 20 or more consecutive days or 30 or more cumulative days during the growing season, a lack of permafrost in the upper meter of the soil profile, an average annual soil temperature >0° C, and an average summer soil temperature of <15° C. Mineral horizons are typically sandy or loamy with many coarse fragments in the upper meter of soil. Frost boils and loess caps are absent, and surface fragments are common and abundant. Soil pH is most often alkaline to circumneutral. Electrical conductivity is generally low (<300 µS/cm). The soils were excessively to well drained, and featured a shallow to moderately deep water table.

Typical Pedon
NOAT_T02_02_2005

C—0 to 43+ cm: variegated sands; alkaline; structureless, single-grained; loose, non-sticky, non-plastic; 65 percent rounded gravels.

Typic Cryorthents (n=17)

General Site Characteristics
The Typic Cryorthents subgroup was found only in KOVA and GAAR. This soil subgroup occurred between 29–800 m elevation (avg. 350 m). In alpine and upland environments, this soil type typically occurred on south- and west-facing slopes. Sites were typically moderately steep to very steep, with slope gradient ranging between 0–32° (avg. 20°). In riverine and lowland environments, slope gradient was almost always <1°.

Geomorphology
Typic Cryorthents occurred most frequently in alpine and riverine environments, and less frequently in upland and lacustrine environments. In alpine and upland environments this soil occurred on talus, hillside colluvium, and glacial till. In riverine environments, Typic Cryorthents occurred on active and inactive overbank and channel

deposits along braided and meandering rivers. The one occurrence of this soil in a lacustrine environment occurred in an ice-poor thaw basin.

Vegetation
In riverine environments, Open Balsam Poplar Forest is a common vegetation type associated with Typic Cryorthents, primarily on active fluvial surfaces. *Populus balsamifera* was the dominant species in these stands, with *Salix alaxensis* and *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*) forming the tall shrub layer beneath. *Picea glauca* seedlings and saplings often occurred in the understory at low abundance. Characteristic understory species include *Shepherdia canadensis*, *Equisetum arvense*, *Hedysarum alpinum* (syn: *Hedysarum hedysaroides*), *Pyrola asarifolia*, *Artemisia tilesii*, and *Cypripedium passerinum*. Bare alluvium is almost always present. Open Spruce–Balsam Poplar Forest is associated with this soil type on inactive fluvial surfaces. *Picea glauca* and *Populus balsamifera* form the overstory in these mid-successional stands. *Salix alaxensis* and *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*) always occurred in the tall shrub layer beneath. Frequent understory species include *Rosa acicularis*, *Shepherdia canadensis*, *Equisetum arvense*, *Pyrola secunda* (syn: *Orthilia secunda*), *Artemisia tilesii*, *Aster sibiricus* (syn: *Eurybia sibirica*), *Calamagrostis canadensis*, *Platanthera obtusata*, and *Hylocomium splendens*. In alpine environments, on hillside colluvium and talus, Dryas Dwarf Shrub Tundra occurs in conjunction with Typic Cryorthents. Either *Dryas integrifolia* or *Dryas octopetala* dominated these sites. Other characteristic species include *Saxifraga oppositifolia*, *Carex scirpoidea*, *Senecio resedifolius* (syn: *Packera cymbalaria*), and *Trisetum spicatum*. Bare soil and surface fragments are always present.

Soils
Typic Cryorthents are characterized by a very thin surface organic horizon, little to no soil structure, a lack of permafrost in the upper meter of the soil profile, an average annual soil temperature >0° C, and an average summer soil temperature of <15° C. Mineral horizons are typically loamy or sandy with many coarse fragments in the upper meter of soil. Frost boils and loess caps are always absent, while surface fragments are rare. Site pH is either alkaline or acidic. Electrical conductivity is generally low (<100 µS/cm). The soils are excessively to well drained, and the water table is deep to very deep.

Typical Pedon—Riverine
GAAR_T114_04_2008

> *C1—0 to 60 cm:* dark gray (2.5YR 4/1) silt loam with inclusions of fine sand; alkaline; structureless, massive.
>
> *C2—60 to 70+ cm:* variegated sands; structureless, single-grained; 60 percent rounded gravels.

Summary of Soil Characteristics

Soils from six orders of soil taxonomy were encountered during field sampling, including Entisols, Inceptisols, Gelisols, Histosols, Mollisols, and Spodosols. Entisols (poorly developed soils) included 15 observed subgroups and comprised 28% of observations. They occurred most frequently in rocky alpine and rocky to loamy early successional riverine environments. Inceptisols (weakly developed soils) occurred primarily in alpine and upland environments. Inceptisols accounted for 16 observed subgroups and comprised 25% of observations, with 9 of the 16 subgroups having permafrost below 1 m. Gelisols (permafrost affected soils) included 27 observed subgroups and comprised 42% of observations. They were widely distributed across all physiographic environments from the alpine to the coast. Histosols (thick peats) included 7 subgroups and comprised 4% of observations. These non-permafrost soils occurred most frequently in bogs and fens formed after permafrost degradation. Mollisols (well developed soils with thick A horizons) were rare and included only 2 soil subgroups that were observed at 4 sites (<1% of observations). Spodosols (well developed soils with strong leaching) included only 1 soil subgroup that was observed at 2 locations (<1% of observations).

Overall, 68 soil subgroups were identified during field sampling (n = 730), although 30 soil subgroups were rare (≤3 observations) and therefore were excluded from the analysis and mapping. The ten most common subgroups were Typic Cryorthents (10%), Typic Eutrogelepts (9%), Typic Dystrogelepts (7%), Typic Aquorthels (6%), Typic Historthels (6%), Typic Fibristels (5%), Typic Cryopsamments (5%), Typic Aquiturbels (4%), Oxyaquic Cryorthents (4%), and Typic Haploturbels (3%). Together these ten soil types comprised 59% of observations.

The soil classification was effective at partitioning the variability of numerous soil properties because the classification is based in large part on thaw depths, depth to water, organic thickness, and base saturation status as inferred from pH (Figures 21 and 22). For example, soils with measurable thaw depths were associated with the Gelisols, while non-permafrost soils with organic horizons >40 cm thick were associated with the Histosols. Rock depths <20 cm were commonly associated with the great groups Cryorthents and Gelorthents (within the Entisol order), and Eutrocryepts, Eutrogelepts, and Dystrogelepts (within the Inceptisol order). Water depths within 30 cm of the surface were associated with the great groups Cryohemists and Cryofibrists (Histosols), and Cryaquepts (Inceptisols). Soil pH values <5.5 were associated with the Dystrocryepts great group of the Inceptisol order. Electrical conductivity values >200 µS/cm were associated with the Cryofluvents great group of the Entisols order, and with the wet soils of the Cryaquepts and Cryohemists great groups. Finally, the pH gradients from 10–30 cm depths were steepest for the Dystrocryepts and Haplocryods great groups (Inceptisols and Spodosols, respectively), indicating substantial leaching and translocation of cations.

In a few instances, the use of the newly revised Gelisols order failed to separate soils with distinctly different characteristics. For example, both alkaline (eutric) and acidic (dystric) soils were included in the Typic Haploturbels subgroup, despite important differences in A-horizon development and species composition. In contrast, few differences in soil properties and vegetation relationships were evident between Typic Haplorthels and Typic Haploturbels. Properties also were similar among Typic Historthels, Typic Aquiturbels, and Typic Aquorthels.

Soil chemistry and lithology were strongly influenced by bedrock type, as was evident in soils collected from the C horizon in barren to partially vegetated alpine ecosystems (Table 149). Limestone had lower sand content, and higher pH, C%, Ca, and $CaCO_3$% equivalent than other soils. Shale had lower pH, electrical conductivity, NO_3 and extractable K and Zn than other soils, but substantially higher weakly extractable P. Mafic rocks (i.e., basalt, gabbro) had relatively low P, but high Cu, Mn, Cr, and B. Ultramafic rocks (i.e., serpentine, dunite) had extremely low total P and Ca, but unusually high concentrations of Mg, Ni, Cr, and Se. We suspect that the almost total lack of plant growth on ultramafic soils was due to the lack of P, rather than to toxicity of trace elements such as Se. Comparison of

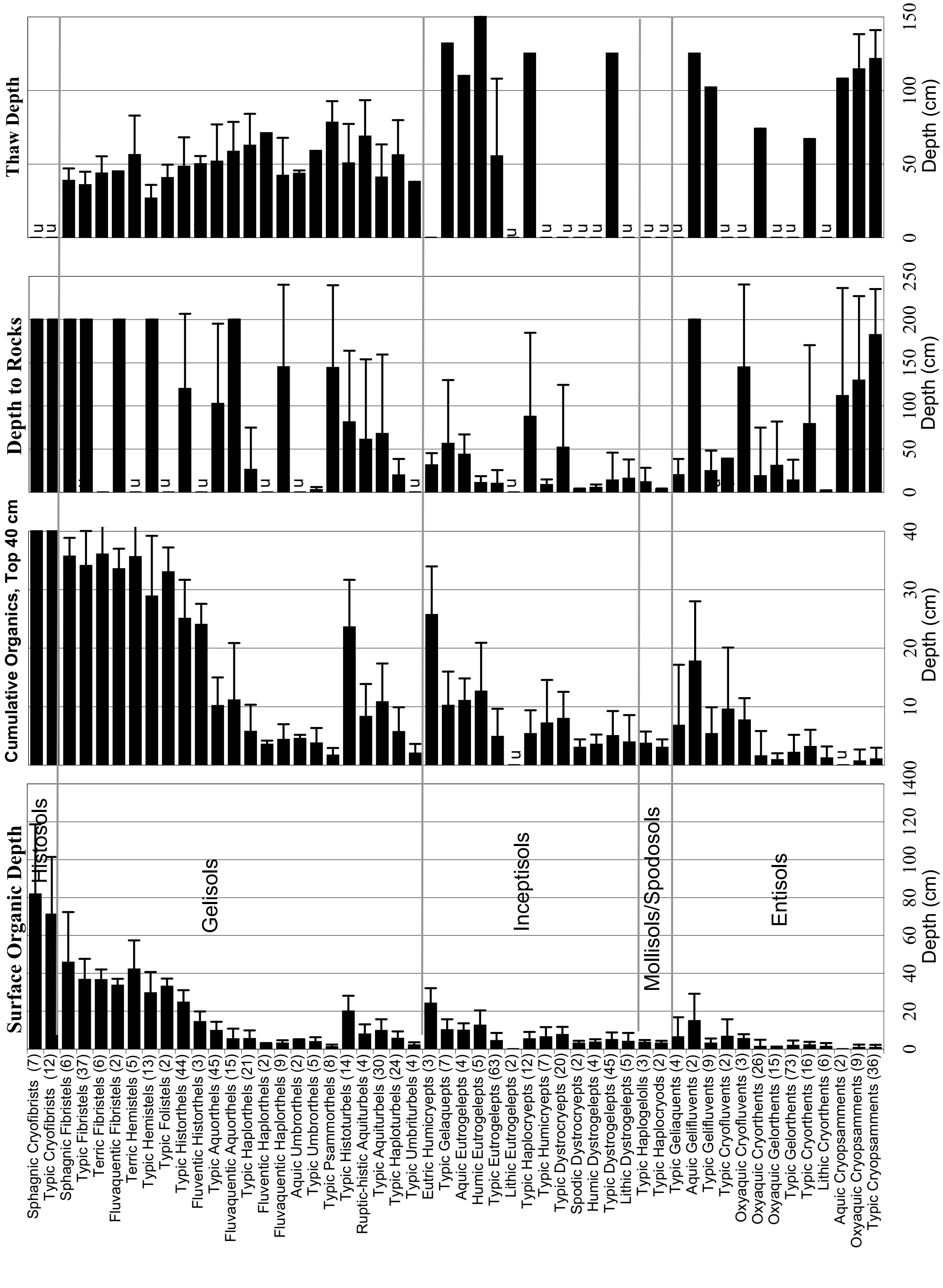


Figure 21. Mean (± SD) thickness of the surface organic layer, cumulative organic thickness within the top 40 cm, depth to rock (>15% coarse fragments) and depth of thaw for common soil subgroups in the Arctic Network. Sample size in parenthesis after name.

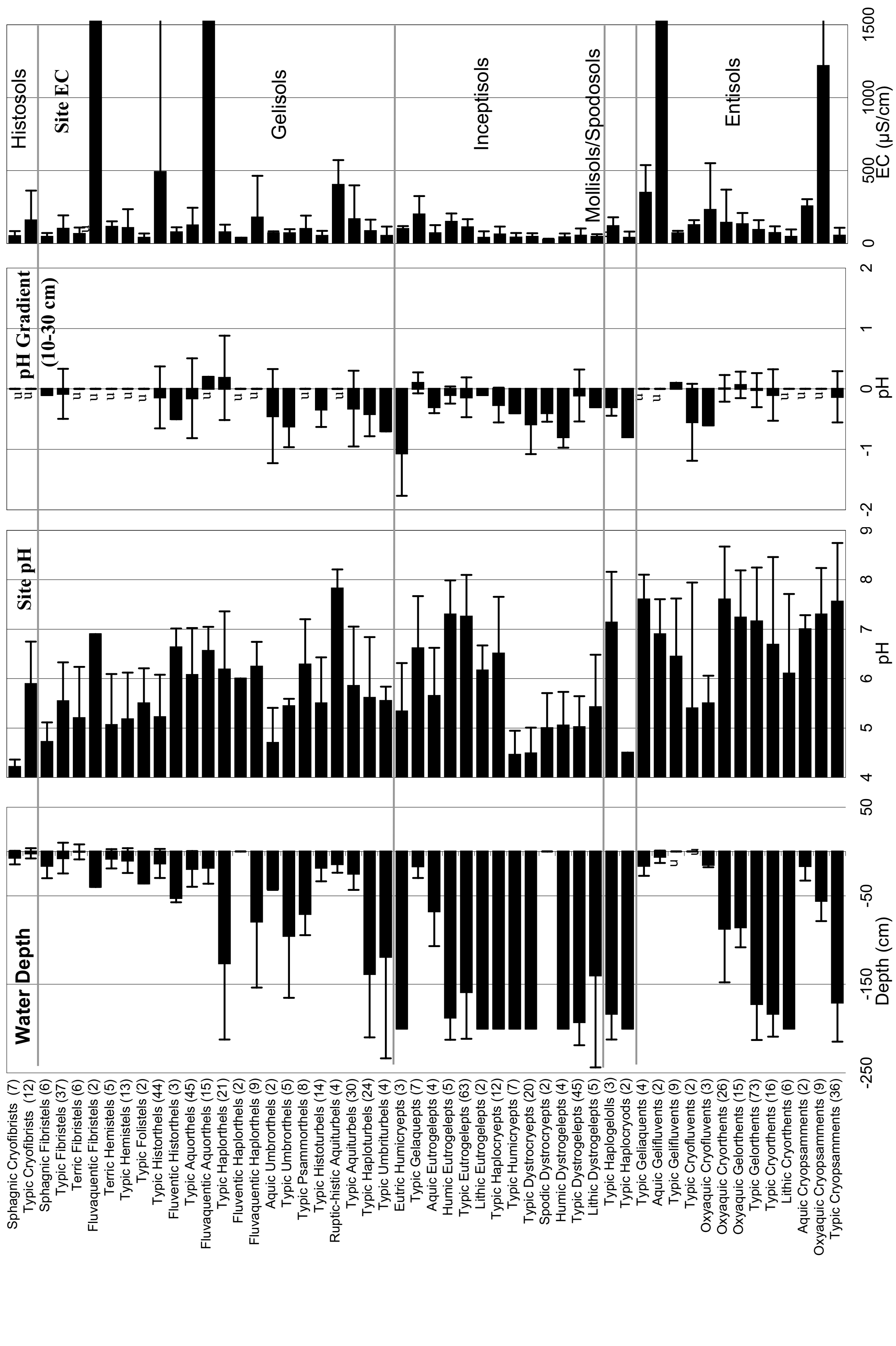


Figure 22. Mean (± SD) water depth above or below the ground surface, site pH (soil water or saturated paste), electrical conductivity (EC) and pH gradient (pH at 10cm minus pH at 30 cm, positive indicates leaching) for common soil subgroups in the Arctic Network. Sample size in parenthesis after name.

Table 149. Mean properties of surface soils (C horizon) from bedrock types within Noatak National Preserve, Gates of the Arctic National Park, and Kobuk Valley National Park, 2005–2008. Unusually high or low values in bold.

Property	Eolian Sand	Glacial diamicton	Limestone	Shale	Phyllite	Sandstone	Schist	Granite	Mafic	Ultramafic
Sample Size	2	2	7	9	1	2	6	1	3	6
Particle Size (%)										
Sand %	89.0	89.5	45.7	65.7	79.0	66.0	59.3	71.0	53.7	60.8
Silt %	5.0	2.0	36.7	18.6	13.0	20.0	31.7	20.0	21.0	27.0
Clay %	6.0	8.5	17.6	15.8	8.0	14.0	9.0	9.0	25.3	12.2
pH	**7.8**	4.3	**7.4**	5.5	5.6	4.1	4.9	**3.6**	6.2	6.8
EC (µmhos/cm)	318	78	1267	318	648	108	256	120	463	632
Exchangeable (AB-DTPA)(ppm)										
NO3-N	0.7	0.4	**7.1**	0.8	1.0	**0.2**	1.2	2.5	2.9	2.8
P	2.3	2.9	1.4	2.4	1.8	5.0	2.4	1.5	0.5	0.9
K	10.0	14.2	**53.5**	**41.0**	15.2	16.6	22.3	12.3	**41.4**	20.8
Zn	0.1	0.2	1.6	0.8	0.2	0.3	0.6	0.1	1.5	0.5
Fe	16.3	92.3	40.6	79.5	98.1	83.9	186.6	**369.8**	46.5	64.5
Mn	2.2	1.9	5.6	5.5	1.2	1.6	5.3	0.4	2.1	3.8
Cu	2.4	2.2	3.2	2.8	2.8	2.1	4.3	0.4	4.3	2.5
Organic Mat. %	0.1	0.9	9.3	5.6	1.0	1.6	4.1	3.7	6.2	8.8
Total C %	0.9	0.4	**6.0**	1.5	0.5	0.6	1.6	1.9	1.0	0.8
Total N %	0.02	0.06	0.19	0.15	0.11	0.11	0.16	0.15	0.09	0.08
Total Extractable (ppm)										
P	0.06	0.05	**34.9**	15.96	0.12	0.04	0.07	0.02	0.03	**28.91**
K	1.22	1.00	**500.9**	**451.3**	3.76	1.00	2.07	1.85	0.51	**540.4**
Ca	5.5	0.5	**12387**	150.8	0.5	0.0	**0.9**	**0.2**	4.3	**3427**
Mg	0.2	0.2	271.4	427	3.9	0.1	1.6	0.1	6.2	**13396**
Na	1.6	1.1	**310.6**	205.3	1.6	0.4	2.0	1.1	0.9	**932.3**
Al	4.7	3.8	**1649**	**1752**	16.4	3.0	8.9	3.1	6.2	**4863**
Fe	3.3	2.6	**1031**	1491	8.6	3.4	6.3	2.0	4.1	**6331**
Mn	0.09	0.04	26.19	36.83	0.19	0.03	0.12	0.02	0.11	**124.2**
Ti	0.49	0.22	68.62	75.52	0.87	0.30	0.53	0.13	0.30	**188.6**
Cu	18.2	44.9	14.8	44.6	112.1	51.2	68.1	23.3	67.6	16.6
Zn	44.9	59.2	46.5	83.2	239.2	83.4	132.8	38.1	36.0	31.4
Ni	10.0	19.1	24.1	33.0	126.6	24.6	39.8	6.6	57.6	**496.4**
Mo	0.43	0.58	1.09	1.42	1.35	0.65	0.85	0.82	0.15	0.18
Cd	3.37	1.81	2.09	3.06	13.26	2.41	7.58	1.27	3.85	3.30
Cr	20.6	35.8	33.4	43.5	202.7	58.9	82.3	26.2	155.6	**789.2**
Sr	175.4	102.0	**272.0**	39.4	144.3	53.4	79.3	40.8	67.7	19.7
B	0.0	0.0	121	509	0.0	0.0	0.0	0.0	**1524**	74.2
Ba	255.9	424.6	152.7	393.7	**1014**	361.6	758.0	292.6	112.3	73.3
Be	0.01	0.15	0.12	0.01	0.01	0.01	0.03	0.20	0.00	0.00
Pb	0.01	2.08	1.47	2.00	0.11	7.31	1.50	9.51	0.01	0.29
V	0.0	0.0	14.9	76.1	0.0	0.0	0.0	0.0	**115.1**	4.1
Se	0.00	13.52	0.26	**71.76**	0.00	**216.80**	11.20	40.06	0.01	0.80
S	7.20	0.00	**238.25**	0.00	24.42	0.00	116.92	0.00	0.00	0.00
Si Total %	32.6	0.0	20.2	20.4	16.1	0.0	15.6	0.0	26.8	20.9
CaCO3 % equiv.	7.4	0.1	**30.6**	0.1	2.0	0.1	0.8	0.1	0.0	0.2
SO4-S (mg/kg)	6.1	8.9	**82.5**	14.0	35.1	10.1	26.5	20.3	42.3	23.3

chemistry of residual soils, however, is complicated by analytical techniques requiring some caution in interpreting results. Laboratory analyses using a weak extractant (AB-DTPA appropriate for circumneutral-alkaline soils), to approximate plant available elements, versus a strong extractant (HNO3), to approximate long-term availability of elements from weathering, generated some unusual results. For example, the single granite sample had relatively high exchangeable Fe, but low total digestable Fe. Limestone had relatively high values for many elements, presumable because the strong acidic digestion solubilized most of the soil material.

Classification and Description of Soil Landscapes

Alpine Lakes

This soil landscape occurs in mountain cirques, and in depressions in bedrock or glacial moraines. It is found in mountainous regions throughout our study area and includes shallow (<1.5 m) to deep (≥1.5 m) lakes, usually above 400 m elevation. Soils are permanently flooded. Alpine Lake is typically unvegetated. However, aquatic species occasionally occur, including *Ranunculus hyperboreus*, *Warnstorfia sarmentosa*, and *Warnstorfia exannulata*.

Alpine Rocky Wet Meadow

The Alpine Rocky Wet Meadow soil landscape comprises a single ecotype: Alpine Wet Sedge Meadow. The terrain includes hillside colluvium over non-carbonate sedimentary, mafic, and ultra-mafic bedrock on moderately steep (avg. 7°) slopes between 500–800 m elevation (avg. 600 m). Soils are predominantly rubbly, gravelly, or blocky, circumneutral, and very poorly to somewhat poorly drained. Permafrost is often difficult to determine in the rocky soils. Common soils include Typic Aquorthels and Typic Aquiturbels. Wet Sedge Meadow Tundra is the most common vegetation type in this soil landscape. Typical species include *Carex bigelowii*, *Eriophorum angustifolium*, *Arctagrostis latifolia*, *Carex capillaris*, *Juncus biglumis*, and *Pedicularis sudetica*. Bare soil and surface fragments are always present with low to moderate cover.

Alpine Rocky Acidic Barrens and Shrub

This soil landscape comprises three ecotypes: Alpine Acidic Barrens, Alpine Acidic Dryas Dwarf Shrub, and Alpine Ericaceous–Dryas Dwarf Shrub. The terrain includes hillside colluvium, talus, older glacial moraines, and residual soils on moderately steep to very steep (avg. 13°) slopes between 250–1200 m elevation (avg. 660 m). Bedrock geology tends to be igneous intrusive or noncarbonate sedimentary. Soils are predominantly rubbly or blocky; circumneutral to acidic; and excessively to moderately well drained. Permafrost is often difficult to determine in the rocky soils. Common soil types associated with this soil landscape include Typic Dystrogelepts, Typic Haploturbels, Typic Gelorthents, Typic Eutrogelepts, and Lithic Cryorthents. Uncommon soil types include: Typic Haplorthels, Typic Umbriturbels, Humic Dystrogelepts, and Lithic Dystrogelepts. Dryas–Lichen Dwarf Shrub Tundra was often associated with this soil landscape. Characteristic species include *Dryas octopetala*, *Hierochloe alpina*, *Antennaria friesiana*, *Minuartia arctica*, *Flavocetraria nivalis*, *Flavocetraria cucullata*, *Thamnolia vermicularis*, *Bryocaulon divergens*, and *Racomitrium lanuginosum*. Bare soil and surface fragments always occurred with low to moderate cover. Dryas Dwarf Shrub Tundra is another common vegetation type that occurs in the alpine rocky acidic barrens and shrub soil landscape. Frequently occurring species include *Dryas octopetala*, *Salix phlebophylla*, *Vaccinium uliginosum*, *Hierochloe alpina*, *Saxifraga bronchialis*, *Flavocetraria nivalis*, and *Rhytidium rugosum*. Bare soil and surface fragments occur in low to moderate abundance.

Alpine Rocky Alkaline Barrens and Shrub

This soil landscape comprises four ecotypes: Alpine Alkaline Dryas Dwarf Shrub, Alpine Alkaline Barrens, Alpine Cassiope Dwarf Shrub, Alpine Mafic Barrens. The terrain includes hillside colluvium, talus, and residual soils on moderately steep to very steep (avg. 19°) slopes between 100–1400 m elevation (avg. 600 m). Bedrock geology is mafic- and ultramafic-igneous intrusive or carbonate sedimentary. Soils are predominantly rubbly or blocky; circumneutral to alkaline; and well to excessively well drained. Permafrost is often difficult to determine in the rocky soils. Common soil types include Typic Gelorthents, Typic Eutrogelepts, Typic Haplorthels, and Typic Cryorthents. Uncommon soils include Typic Haploturbels, Humic Eutrogelepts, Lithic Eutrogelepts, and Typic Haplogelolls. Dryas Dwarf Shrub Tundra is a common vegetation type that occurs in the alpine rocky alkaline barrens and shrub soil landscape. Typical species include *Dryas octopetala*, *Saxifraga oppositifolia*, *Androsace chamaejasme*, *Carex scirpoidea*, *Silene acaulis*, *Dactylina arctica*, and *Thamnolia vermicularis*. Bare soil and surface fragments have low to moderate cover. Barrens is another vegetation type that commonly occurs in this soil landscape. Bare soil and surface fragments dominate this vegetation type, but a low cover of a rich assemblage of vascular and nonvascular species also occur, including *Dryas octopetala*, *Salix arctica*, *Saxifraga oppositifolia*, *Androsace chamaejasme*, *Minuartia arctica*, *Potentilla uniflora*, *Androsace chamaejasme*, *Lesquerella arctica*, *Vulpicida tilesii*, *Thamnolia vermicularis*, and *Racomitrium lanuginosum*. The lichens *Flavocetraria nivalis*, and *Flavocetraria cucullata* also are commonly present.

Upland Sandy Barrens

This soil landscape comprises a single ecotype, Upland Sandy Barrens, and is limited in its spatial extent to the Greater Kobuk Sand Dunes, Little Kobuk Sand Dunes, and other small dune fields within ARCN. The upland sandy barrens soil landscape occur on low to moderate gradient (avg. 3°) active sand dunes between 50–100 m elevation (avg. 80 m). Soils are predominantly sandy with very few to no coarse fragments in the upper meter of soil; circumneutral to alkaline; and excessively drained. Permafrost is always >1 m below the soil surface. This soil landscape was affiliated with only one soil type, Typic Cryopsamments. Barrens and Partially Vegetated Barrens were common vegetation types associated with this soil landscape and include the species *Bromus pumpellianus*, *Calamagrostis purpurascens*, *Cnidium cnidiifolium*, *Oxytropis kobukensis*, *Senecio ogotorukensis*, and *Artemisia furcata*. Bare sand provided 70–100% cover.

Upland Sandy Forest

This soil landscape comprises two ecotypes, Upland White Spruce–Dryas Woodland, and Upland White Spruce–Lichen Woodland. The upland sandy forest soil landscape occurred on low gradient (avg. 3°) inactive and active sand dunes between 50–100 m elevation (avg. 70 m). Soils are predominantly sandy with very few to no coarse fragments in the upper meter of soil; acidic to alkaline; and excessively to somewhat excessively drained. Soils on inactive sand dunes were more developed, including Typic Haplocryepts and Typic Dystrocryepts, than those on active dunes, which included Typic Cryopsamments. Open White Spruce Forest and White Spruce Woodland are common vegetation types associated with this soil landscape. *Picea glauca* forms an open needleleaf canopy. On alkaline sites, characteristic understory species include *Dryas integrifolia*, *Arctostaphylos rubra* (syn: *Arctous rubra*), *Arctostaphylos uva-ursi*, *Shepherdia canadensis*, *Juniperus communis*, *Solidago multiradiata*, *Oxytropis kobukensis*, *Stereocaulon* sp., and *Abietinella abietina*. On acidic sites, frequent understory species include *Vaccinium uliginosum*, *Empetrum nigrum*, *Geocaulon lividum*, *Betula nana*, *Cladina stellaris*, and *Stereocaulon* sp. At all sites, bare sand was commonly present with low to moderate cover.

Upland Rocky–Loamy Circumalkaline Low Shrublands and Forests

This soil landscape comprises three ecotypes: Upland Willow Low Shrub, Upland Sedge–Dryas Meadow, and Upland White Spruce–Willow Forest. The terrain includes low to moderately steep (avg. 9° slope) hillside colluvium, old glacial moraines, retransported deposits, and alluvial fan deposits between 75–800 m elevation (avg. 290 m). Bedrock geology tends to be carbonate sedimentary. Soils are predominantly loamy, rubbly, or blocky; circumneutral to alkaline; and well drained to somewhat poorly drained. Permafrost is often difficult to determine in soils with high rock fragment content. At well and moderately well drained sites, soils were Typic Eutrogelepts, Typic Haplorthels, and Typic Histoturbels. Soils at somewhat poorly drained sites include Typic Aquorthels, Typic Aquiturbels, and Ruptic-histic Aquiturbels. Uncommon soils include Humic Eutrogelepts, Typic Historthels, Typic Gelaquepts, Typic Haploturbels, and Typic Haplogelolls. Open White Spruce Forest frequently occurs in this soil landscape on well drained sites. This vegetation type is characterized by an open canopy of *Picea glauca* overtopping *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Vaccinium uliginosum*, *Arctostaphylos rubra* (syn: *Arctous rubra*), *Salix reticulata*, *Festuca altaica, Saussurea angustifolia*, and *Hylocomium splendens*. Open Low Willow Shrub also commonly occurs on well drained sites in this soil landscape. Dominant species include *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *Salix reticulata*, *Vaccinium uliginosum*, *Cassiope tetragona*, *Equisetum arvense*, *Festuca altaica*, *Valeriana capitata*, and *Tomentypnum nitens*. Moist Sedge–Dryas Tundra is often associated with this soil landscape at poorly drained sites. Typical species include *Dryas integrifolia*, *Salix lanata* ssp. *richardsonii* (syn: *S. richardsonii*), *Salix arctica*, *Lagotis glauca*, *Saxifraga hirculus*, *Thalictrum alpinum*, *Carex bigelowii*, *Carex scirpoidea*, *Arctagrostis latifolia*, *Flavocetraria cucullata*, and *Tomentypnum nitens*.

Upland Rocky–Loamy Circumacidic Tall Shrublands and Forests

This soil landscape comprises six ecotypes: Upland Alder–Willow Tall Shrub, Upland Bluejoint Meadow, Upland Willow Tall Shrub, Upland White Spruce–Ericaceous Forest, Upland Birch Forest, and Upland Spruce–Birch Forest. The terrain includes moderately steep to steep (avg. 17° slope) hillside colluvium, inactive sand dunes, loess, old glacial moraines, and retransported deposits between 30–800 m elevation (avg. 300 m). Bedrock geology tends to be non-carbonate metamorphic, non-carbonate sedimentary, and igneous intrusive. Soils are predominantly loamy, rubbly, or blocky; circumneutral to acidic; and somewhat excessively to moderately well drained. Permafrost is often difficult to determine in the rocky soils. Common soil types include Typic Dystrocryepts, Typic Eutrogelepts, Typic Haplocryepts, Typic Haplorthels, and Eutric Humicryepts. Uncommon soils include Typic Aquorthels, Typic Historthels, Typic Cryopsamments, Typic Haplocryods, and Typic Haplocryolls. Open White Spruce Forest and White Spruce Woodland are common vegetation types associated with this soil landscape. Characteristic species include *Picea glauca*, *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Empetrum nigrum*, *Calamagrostis canadensis*, *Ledum decumbens*, *Hylocomium splendens*, and *Pleurozium schreberi*. Open Tall Alder Shrub and Closed Tall Alder Shrub often occur in this soil landscape. Typical species include *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Spiraea beauverdiana* (syn: *S. stevenii)*, *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Vaccinium uliginosum*, *Calamagrostis canadensis*, *Epilobium angustifolium* (syn: *Chamerion angustifolium*), *Polemonium acutiflorum*, and *Aconitum delphinifolium*. Open Paper Birch Forest frequently occurs in this soil landscape on old glacial moraines and loess. A typical stand features an open canopy of *Betula papyrifera* (syn: *B. neoalaskana*) with *Picea glauca* seedlings below. The understory typically includes *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Vaccinium vitis-idaea*, *Spiraea beauverdiana* (syn: *S. stevenii)*, *Calamagrostis canadensis*, and *Poytrichum juniperinum*.

Upland Rocky–Loamy Acidic Low Shrublands

This soil landscape comprises three ecotypes: Upland Birch–Willow Low Shrub, Upland Birch–Ericaceous Low Shrub, Upland Spiraea Low Shrub. The terrain includes moderately steep to steep (avg. 11°) hillside colluvium, loess, old glacial moraines, and solifluction deposits between 30–1100 m elevation (avg. 450 m). Bedrock geology tends to be non-carbonate metamorphic, non-carbonate sedimentary, and igneous intrusive. Soils are predominantly loamy, blocky, or rubbly; circumneutral to acidic; and well to somewhat poorly drained. Permafrost is often difficult to determine in the rocky soils. At well drained sites, common soil types include Typic Dystrogelepts, Typic Haplorthels, Typic Haploturbels, and Typic Dystrocryepts. At poorly drained sites, common soils include Typic Historthels, Typic Aquorthels, and Typic Aquiturbels. Both Open and Closed Low Mesic Shrub Birch–Ericaceous Shrub communities commonly occur in this soil landscape on well-drained sites. Characteristic species include *Betula nana*, *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Ledum decumbens*, *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Empetrum nigrum*, and *Carex bigelowii*. Open Low Willow Shrub is a common vegetation type on poorly drained sites in this soil landscape. Frequently occurring species include *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Salix reticulata*, *Vaccinium uliginosum*, *Arctagrostis latifolia*, *Carex bigelowii*, *Poa arctica*, and *Aulacomnium palustre*.

Upland Loamy Wet Tussock Shrublands

This soil landscape comprises one ecotype: Upland Dwarf Birch-Tussock Shrub. This soil landscape encompasses an array of terrain units. The most common include bogs, old glacial moraines, hillside colluvium, loess, thaw basins, drained lake basins, and abandoned riverine overbank deposits. This soil landscape occurs between 5–100 m elevation (avg. 260 m). Slope gradient in this soil landscape is generally low to very low (avg. <2°). Soils typically feature a thick, organic-rich surface layer above loamy mineral soils. The soils are poorly to somewhat poorly drained largely due to the shallow depth to permafrost. Major soils include Typic Aquiturbels, Typic Historthels, Typic Fibristels, and Typic Hemistels. Minor soils include Typic Histoturbels, Typic Haploturbels, Terric Fibristels, and Terric Hemistels. Open Low Mixed Shrub–Sedge Tussock tundra is the most common vegetation type associated with this soil landscape. This vegetation type is characterized by *Betula nana*, *Eriophorum vaginatum*, *Ledum decumbens*, *Vaccinium vitis-idaea*, *Carex bigelowii*, and *Sphagnum* spp. Tussock Tundra is another common vegetation type is this soil landscape. The species composition is similar to the above vegetation type with <25% cover of shrubs. Typical species include *Eriophorum vaginatum*, *Betula nana*, *Ledum decumbens*, *Rubus chamaemorus*, *Vaccinium uliginosum*, and *Sphagnum* spp.

Lowland Bogs and Fens

This soil landscape comprises three ecotypes: Lowland Sedge–Willow Fen, Lowland Sedge Fen, and Lowland Ericaceous Shrub Bog. This soil landscape includes a wide range of terrain units, the most common are fens, bogs, abandoned riverine overbank deposits, drained lake basins, and thaw basins. This soil landscape occurs between sea level and 1000 m elevation (avg. 200 m). Slope gradient in this soil landscape is generally flat (avg. <1°), but may range as high as 4°. Soils typically feature thick peat above loamy or sandy mineral soil. The soils are very poorly to somewhat poorly drained, the water table is very shallow to above ground, and permafrost often occurs within one meter of the soil surface. Major soils include Typic Fibristels and Typic Historthels. Minor soils include Terric Fibristels, Sphagnic Cryofibrists, Sphagnic Fibristels, and Typic Aquorthels. Subarctic Lowland Sedge–Moss Bog Meadow is the most common vegetation type that occurs in this soil landscape. Characteristic species include *Carex aquatilis*, *Betula nana*, *Andromeda polifolia*, *Eriophorum russeolum*, and *Sphagnum* sp. Wet Sedge Meadow Tundra is another vegetation type that frequently occurs in this soil landscape. Typical species include *Carex aquatilis*, *Eriophorum angustifolium*, *Carex chordorrhiza*, *Carex rotundata*, *Betula nana*, and *Salix fuscescens*. Cover by surface water often occurs at moderately high levels in both vegetation types.

Lowland Organic-rich Shrub and Forests

This soil landscape comprises five ecotypes: Lowland Birch–Ericaceous Low Shrub, Lowland Birch–Willow Low Shrub, Lowland Alder Tall Shrub, Lowland Willow Low Shrub, and Lowland Black Spruce Forest. The terrain includes low to very low gradient (avg. 3°) landforms, including hillside colluvium, old glacial moraines, abandoned riverine overbank deposits, loess over glacial till, thaw basins, and drained lake basins between sea level and 1000 m elevation (avg. 230 m). Soils are very poorly to moderately well drained and composed of predominantly organic-rich loams and silt loams with a moderately thick to thick organic cap. Permafrost commonly occurs within one meter of the soil surface. Common soils include Typic Aquorthels, Typic Historthels, Typic Aquiturbels, Typic Hemistels, and Typic Histoturbels. Uncommon soils include Typic Gelaquepts, Typic Dystrogelepts, Typic Haplorthels, and Typic Haploturbels. Open Low Shrub Birch-Willow Shrub commonly occurs in this soil landscape on poorly drained sites. Characteristic species include *Betula nana*, *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Vaccinium uliginosum*, *Ledum decumbens*, *Carex bigelowii*, *Eriophorum vaginatum*, *Petasites frigidus*, *Cladina arbuscula*, *Hylocomium splendens*, and *Aulacomnium palustre*. On sites with better drainage, Open Black Spruce Forest is common. Typical species include *Picea mariana*, *Ledum decumbens*, *Empetrum nigrum*, *Vaccinium uliginosum*, *Betula nana*, *Rubus chamaemorus*, *Carex bigelowii*, and *Cladina rangiferina*.

Riverine Gravelly-Loamy Forests

This soil landscape comprises four ecotypes: Riverine Poplar Forest, Riverine White Spruce–Poplar Forest, Riverine White Spruce–Alder Forest, Riverine White Spruce–Willow Forest. This soil landscape typically occurs on very low gradient sites (avg. <1°) on fluvial surfaces, including active and inactive overbank deposits along braided and meandering rivers, inactive coarse channels deposits along braided rivers and on fluvial fans, and inactive fine channel deposits along meandering rivers. This soil landscape ranges in elevation between 15–500 m. The soils are sandy, loamy, or gravelly with many thin buried horizons and a thin organic surficial horizon. The soils are somewhat excessively to moderately well drained, and circumneutral to alkaline.

Permafrost rarely occurs in the upper meter of the soil profile. Common soil types include Typic Gelorthents, Typic Cryorthents, Typic Gelifluvents, Typic Cryopsamments, and Typic Cryofluvents. Uncommon soils include Typic Haplorthels, Aquic Haplorthels, and Typic Aquorthels. Open White Spruce Forest is a common vegetation type in this soil landscape. Characteristic species include *Picea glauca*, *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Arctostaphylos rubra* (syn: *Arctous rubra*), *Rosa acicularis*, *Mertensia paniculata*, *Equisetum arvense*, *Calamagrostis canadensis*, and *Peltigera aphthosa*. Open Balsam Poplar Forest is another common vegetation type that occurs in the riverine gravelly-loamy forest soil landscape. Typical species include *Populus balsamifera*, *Salix alaxensis*, *Shepherdia canadensis*, *Aster sibiricus*, *Artemisia tilesii*, *Hedysarum alpinum*, and *Cypripedium passerinum*. Riverine sands and silts often are exposed at the soil surface in moderately high abundance.

Riverine Gravelly Barrens and Shrublands

This soil landscape comprises four ecotypes: Riverine Barrens, Riverine Moist Willow Tall Shrub Riverine, Willow Low Shrub, and Riverine Dryas Dwarf Shrub. It occurs on very low gradient (avg. <1°) fluvial terrain, including active coarse and fine channel deposits, and active overbank deposits along braided and meandering rivers between sea level and 600 m elevation (avg. 170 m). The soils are sandy, gravelly, or bouldery, and typically lack a surficial organic horizon. The soils are excessively to moderately well drained, and circumneutral to alkaline. Depth to permafrost, if present, was difficult to determine given the rocky soils. Common soil subgroups include Oxyaquic Cryorthents, Typic Gelorthents, Oxyaquic Gelorthents, Typic Cryopsamments, and Oxyaquic Cryopsamments. Less common soils include Fluvaquentic Haplorthels, Typic Eutrogelepts, Typic Gelaquents, and Typic Cryorthents. Barrens and Partially Vegetated Barrens were common vegetation types in this soil landscape. These sites are dominated by riverine sands and gravels at the soil surface. Vegetation includes scattered individuals of *Salix alaxensis*, *Epilobium latifolium*, *Aster sibiricus*, *Artemisia tilesii*, *Hedysarum alpinum*, *Astragalus alpinus*, *Wilhelmsia physodes*, and *Populus balsamifera* seedlings. Open Tall Willow Shrub also commonly occurs in this soil landscape. The species composition is similar to the above vegetation type with a higher abundance of shrubs and herbaceous species, and less bare ground. Additional species include *Shepherdia canadensis*, *Arctostaphylos rubra* (syn: *Arctous rubra*), *Equisetum arvense*, and *Galium boreale*. Dryas Dwarf Shrub Tundra is a less common vegetation type in the riverine gravel barrens and shrublands soil landscape. Characteristic species include *Dryas drummondii*, *Aster yukonensis*, *Artemisia borealis*, *Bromus pumpellianus*, *Oxytropis campestris*, and *Senecio ogotorukensis* (syn: *Packera ogotorukensis*).

Riverine Loamy Meadows and Shrublands

This soil landscape comprises four ecotypes: Riverine Birch–Willow Low Shrub, Riverine Alder Tall Shrub, Riverine Wet Willow Tall Shrub, and Riverine Bluejoint Meadow. This soil landscape occurs on very low gradient (avg. <1°) fluvial sites, including inactive overbank deposits along braided and meandering rivers, inactive fine channel deposits along meandering rivers and fluvial fans, and on floodplains along headwater streams. Elevation ranges from sea level to approximately 600 m (avg. 90 m). The soils are loamy, with a thin surficial organic horizon. The soils are somewhat poorly to well drained, and circumalkaline to acidic. We assume permafrost occurs in the upper 1–2 m of the soil profile. Common soils at poorly drained sites in this soil landscape include Fluvaquentic Haplorthels and

Fluvaquentic Aquorthels. At sites with better drainage, Typic Dystrogelepts, Typic Gelifluvents, and Typic Gelorthents are common. Open Tall Willow Shrub and Closed Tall Willow Shrub are common vegetation types in this soil landscape. *Picea glauca* seedlings are commonly found beneath a tall shrub layer composed of *Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*) and *Salix alaxensis*. Additional understory species include *Vaccinium uliginosum*, *Rubus arcticus*, and *Calamagrostis canadensis*. Closed Tall Alder Shrub is another common vegetation type in the Riverine Loamy Meadows and Shrublands soil landscape. Characteristic species include *Alnus crispa* (syn: *A. viridis* ssp. *fruticosa*), *Salix alaxensis*, *Spiraea beauverdiana* (syn: *S. stevenii*), *Rubus arcticus*, *Calamagrostis canadensis*, *Polemonium acutiflorum*, and *Aconitum delphinifolium*.

Riverine Loamy Wet Meadows and Marshes

This soil landscape comprises two ecotypes: Riverine Wet Sedge Meadow and Riverine Forb Marsh. This soil landscape occurs on flat and concave fluvial surfaces, including inactive overbank deposits along meandering rivers, inactive coarse channel deposits along braided streams, and shallow riverine lakes between sea level and 250 m elevation (avg. 80 m). The soils are loamy, and occasionally sandy with a thin organic horizon at the surface. The soils range from flooded to moderately well drained, and from alkaline to brackish closer to the coast. Permafrost often occurred below the maximum depth sampled (1 m), and we assumed in these cases it occurred between one and two meters below the soil surface. The most common soil subgroups are Typic Gelaquents. A less common subgroup is Fluvaquentic Aquorthels. Wet Sedge Meadow Tundra is a frequently occurring vegetation type in this soil landscape. Common species include *Carex aquatilis*, *Carex saxatilis*, *Carex capitata*, *Eriophorum angustifolium*, *Polemonium acutiflorum*, *Saxifraga hirculus*, and *Scorpidium scorpioides*. Other common vegetation types in this soil landscape are Emergent Horsetail and Fresh Pondweed. Characteristic species include *Equisetum fluvatile*, *Potamogeton pectinatus*, *Potamogeton vaginatus*, *Hippuris vulgaris*, *Eleocharis acicularis*, *Caltha palustris*, and *Scorpidium scorpioides*. Cover by surface water and mineral soil always occurs at moderately high levels.

Rivers

Rivers, including non-glacial upper and lower perennial rivers and mountain headwater streams, are common throughout ARCN. Examples of perennial rivers include the Kobuk R., Noatak R., Koyukuk R., and Kilikmak Cr., while examples of mountain headwater streams include Tobuk and Kanaktok Creeks. Slope gradient of upper and lower perennial rivers averaged <1°, while mountain headwater streams had an average slope of 3.0°. Hydrology is strongly linked to annual snow pack, with peak discharge occurring in June when snow-melt is occurring most rapidly. Precipitation plays a secondary role in the hydrology of these streams and rivers later in the summer when peak rain fall occurs in August. Water chemistry is circumneutral to alkaline, and electrical conductivity is low.

Riverine Lakes

Riverine lakes occur on floodplains along meandering non-glacial lower perennial rivers in the study area. The hydrology of these lakes is intimately linked to the hydrology of the associated rivers as they receive fresh river water inputs each year during flood events. Riverine lakes occur in the deeper portions of inactive channels and in oxbows cut off from the main channel. Water chemistry is circumneutral to alkaline, and electrical conductivity is low. Aquatic vegetation commonly occurs along the edges of these lakes, and may include *Equisetum fluvatile*, *Utricularia vulgaris*, *Sparganium* sp., *Myriophyllum verticillatum*, *Potamogeton alpinus* ssp. *tenuifolius*, *Potamogeton zosterifolius*, *Hippuris vulgaris*, *Scorpidium scorpioides*.

Lowland Lakes

Lowland lakes are abundant throughout the study area and occupy both deep and shallow kettle and thermokarst depressions. Dune lakes are a unique type of lowland lake that occur in depressions in the Kobuk Sand Dunes and on sand dunes near the coast. Water chemistry is circumneutral to alkaline, and electrical conductivity is low. Aquatic vegetation may occur in the shallower sections of lowland lakes, and may include *Sparganium* sp., *Menyanthes trifoliata*, *Hippuris vulgaris*, *Utricularia minor*, *Potamogeton alpinus* ssp. *tenuifolius* (syn: *P. alpinus*), *Potamogeton perfoliatus* ssp. *richardsonii* (syn: *P. richardsonii*), *Potamogeton filiformis* (*syn: Stuckenia filiformis*), *Lemna trisulca*, and *Eleocharis acicularis*.

Lacustrine Marshes

This soil landscape comprises four ecotypes: Lacustrine Pendent Grass Marsh, Lacustrine Marestail Marsh, Lacustrine Pondlily Lake, and Lacustrine Horsetail Marsh. This soil landscape occurs in shallow and deep thaw lakes and kettle lakes between 5–1000 m elevation (avg. 200 m). Soils are permanently flooded, and permafrost is typically greater than one meter below the soil surface. Water chemistry is circumneutral, and electrical conductivity is low. The vegetation type Common Marestail frequently occurs in this soil landscape. Typical species include *Hippuris vulgaris*, *Utricularia vulgaris*, *Menyanthes trifoliata*, *Potentilla palustris* (syn: *Comarum palustris*), and *Arctophila fulva*. Another common vegetation type in the lacustrine marshes soil landscape is Fresh Grass Marsh. Characteristic species include *Arctophila fulva*, *Hippuris vulgaris*, and *Caltha palustris*.

Lacustrine Loamy Barrens, Meadows, and Shrublands

This soil landscape comprises three ecotypes: Lacustrine Bluejoint Meadow, Lacustrine Willow Shrub, and Lacustrine Barrens. It occurs on low gradient sites (avg. 1°) in drained lake basins and thaw basins between 10–900 m elevation (avg. 200 m). Soils are loamy with a thin organic horizon at the surface. Permafrost often occurs within the upper meter of the soil profile. Common soil types include Typic Aquorthels, Typic Umbrorthels, and Aquic Umbrorthels. Barrens and Partially Vegetated Barrens are common vegetation types in recently drained lake basins in this soil landscape. These sites are dominated by exposed mineral soil, but scattered plants are present. Typical species include *Epilobium latifolium*, *Epilobium palustre*, *Eriophorum angustifolium*, *Carex aquatilis*, *Arctophila fulva*, and *Caltha palustris*. Bluejoint Meadow is another common vegetation type older drained lake basins and thaw basins. Characteristic species include *Calamagrostis canadensis*, *Equisetum arvense*, *Polemonium acutiflorum*, *Potentilla palustris* (syn: *Comarum palustris*), and *Stellaria longipes*.

Lacustrine Organic-rich Wet Meadows

This soil landscape comprises two ecotypes: Lacustrine Wet Sedge Meadow and Lacustrine Buckbean Fen. This soil landscape occurs in fens, drained lake basins, and along the margins of thaw lakes between 5–450 m elevation (avg. 100 m). Soils feature thick peat over loam, are very poorly to somewhat poorly drained, and are acidic to circumneutral. Permafrost sometimes occurs in the upper meter of the soil profile. Common soil types include Typic Aquorthels, Typic Historthels, and Typic Cryofibrists. Subarctic Lowland Herb Bog Meadow is a common vegetation type is this soil landscape. Characteristic species include *Menyanthes trifoliata*, *Potentilla palustris* (syn: *Comarum palustris*), *Carex limosa*, *Carex chordorrhiza*, *Cicuta mackenzieana* (syn: *C. virosa*), and *Sphagnum obtusum*.

Wet Sedge Meadow Tundra is another vegetation type that frequently occurs in this soil landscape. Typical species include *Carex chordorrhiza*, *Eriophorum angustifolium*, *Carex aquatilis*, *Potentilla palustris* (syn: *Comarum palustris*), *Sphagnum* sp., and *Calliergon giganteum*.

Coastal Loamy Barrens, Meadows, and Shrub

This soil landscape comprises four ecotypes: Coastal Wet Barrens, Coastal Saline Sedge–Grass Meadow, Coastal Brackish Willow Shrub, and Coastal Brackish Sedge–Grass Meadow. This soil landscape occurs on active and inactive tidal flats along the ocean waters of Bering Strait, Kotzebue Sound, and the Chukchi Sea. In ARCN, this soil landscape is restricted to coastal areas in BELA and CAKR. Soils are loamy and occasionally sandy with a thin to moderately thick surficial organic horizons, very poorly to somewhat poorly drained, and brackish to saline. Permafrost is commonly found in the upper meter of the soil profile. Common soil types include Typic Aquorthels, Fluvaquentic Fibristels, and Typic Historthels. Halophytic Sedge–Grass Wet Meadow is a common vegetation type in this soil landscape. Characteristic species include *Carex ramenskii*, *Stellaria humifusa*, *Potentilla egedii*, *Chrysanthemum arcticum* (syn: *Hulteniella integrifolia*), and *Puccinellia phryganodes*. Barrens is another common vegetation type in this soil landscape.

Coastal Sandy Barrens, Meadow, and Shrub

This soil landscape comprises three ecotypes: Coastal Dry Barrens, Coastal Crowberry Dwarf Shrub, and Coastal Brackish Dunegrass Meadow. This soil landscape occurs on inactive and active marine beaches and coastal sand dunes along the Bering Strait, Kotzebue Sound, and the Chukchi Sea. In ARCN, this soil landscape is restricted to coastal areas in BELA and CAKR. The soils are sandy with little to no surface organics, circumneutral to alkaline, and excessively to somewhat excessively well drained. Electrical conductivity ranges from low to moderately high. Permafrost is commonly found in the upper 2 m of the soil profile in this soil landscape. Common soil types include Typic Psammorthels, Typic Cryopsamments, and Oxyaquic Cryopsamments. Barrens and Partially Vegetated Barrens are two common vegetation types is this soil landscape. These sites are dominated by exposed sand with sparse vegetation cover. A typical community includes scattered individuals or colonies of *Elymus arenarius* ssp. *mollis* (syn: *Leymus mollis*), *Artemisia tilesii*, *Honckenya peploides*, *Lathyrus maritimus* ssp. *maritimus*, *Salix ovalifolia* , and *Ceratodon purpureus*. Crowberry Dwarf Shrub Tundra is another vegetation type typical of older, stabilized sand dunes in this soil landscape. Characteristic species include *Empetrum nigrum*, *Vaccinium vitis-idaea*, *Betula nana*, *Elymus arenarius* ssp. *mollis* (syn: *Leymus mollis*), *Armeria maritima*, and *Flavocetraria cucullata*.

Coastal Brackish Water

Coastal Brackish Water comprises estuarine waters and lakes on the coast that are influenced by both fresh and nearshore brackish water. In ARCN, this soil landscape is restricted to coastal areas in BELA and CAKR. These waters are flooded periodically with saltwater during high tides or storm surges, subsequently resulting in fluctuations in salinity levels. Some lakes have distinct outlets or have been tapped and partially drained through erosional processes. Shallow lakes (<1.5 m deep) freeze to the bottom during winter. This soil landscape is predominantly non-vegetated, however shallow coastal ponds are occasionally occupied by *Hippurus tetraphylla*.

Coastal Nearshore Water

This soil landscape includes the ocean waters of Bering Strait, Kotzebue Sound and Chukchi Sea. This soil landscape is unvegetated, the soils are perennially flooded, and the water chemistry is circumneutral and highly saline.

Coastal Tidal River

This soil landscape occurs infrequently at the outlets of rivers to the ocean in BELA and CAKR. These rivers and tidal guts are a mixing zone between saline and fresh waters. Waters are brackish but the actual salinity fluctuates with the tide. This soil landscape is unvegetated and the soils are permanently flooded.

Soil Landscapes Mapping

The maps of soil landscapes were developed by aggregating and recoding the ecotypes into a reduced set of 24 closely related soil subgroups and ecotypes (Figure 23; Tables 150–151). The soil landscapes are named by their physiography, soil texture, and dominant vegetation structure. This layer is intended for users who require a reduced set of classes with relatively high map accuracy, that are particularly relevant to the management of a wide range of natural resources. Accuracy is presumed to be high because closely related classes within physiographic regions, which tend to be highly interspersed spatially, are grouped.

Seventeen soil landscapes were mapped in NOAT and KOVA; commonly occurring classes were Upland Loamy Wet Tussock Shrublands (28% of total area), Alpine Rocky Acidic Barrens and Shrublands (12%), Upland Rocky–Loamy Acidic Low Shrublands (13%), Upland Rocky–Loamy Circumalkaline Low Shrublands and Forests (11%), Upland Rocky–Loamy Circumacidic Tall Shrublands and Forests (9%), and Alpine Rocky Alkaline Barrens and Shrublands (10%) (Table 152). Together, the four riverine soil landscapes covered 5% of the area.

The region-wide mapping identified 24 soil landscapes (Figure 24, Table 152). The common classes were similar to those for NOAT and KOVA alone, although the relative areas covered were somewhat different. GAAR contains much more mountainous terrain than the other arctic parks, resulting in a higher proportion of Alpine Rocky Acidic Barrens and Shrublands on the region-wide map (22%) than for NOAT and KOVA alone (12%). Conversely, Upland Loamy Wet Tussock Shrublands occupied only 20% of the total area on the region-wide map, compared to 28% for NOAT and KOVA alone. Additional soil landscapes found only on the region-wide map included five coastal types in CAKR and BELA, Upland Rocky Barrens in BELA and undetermined areas mapped as shadow in GAAR.

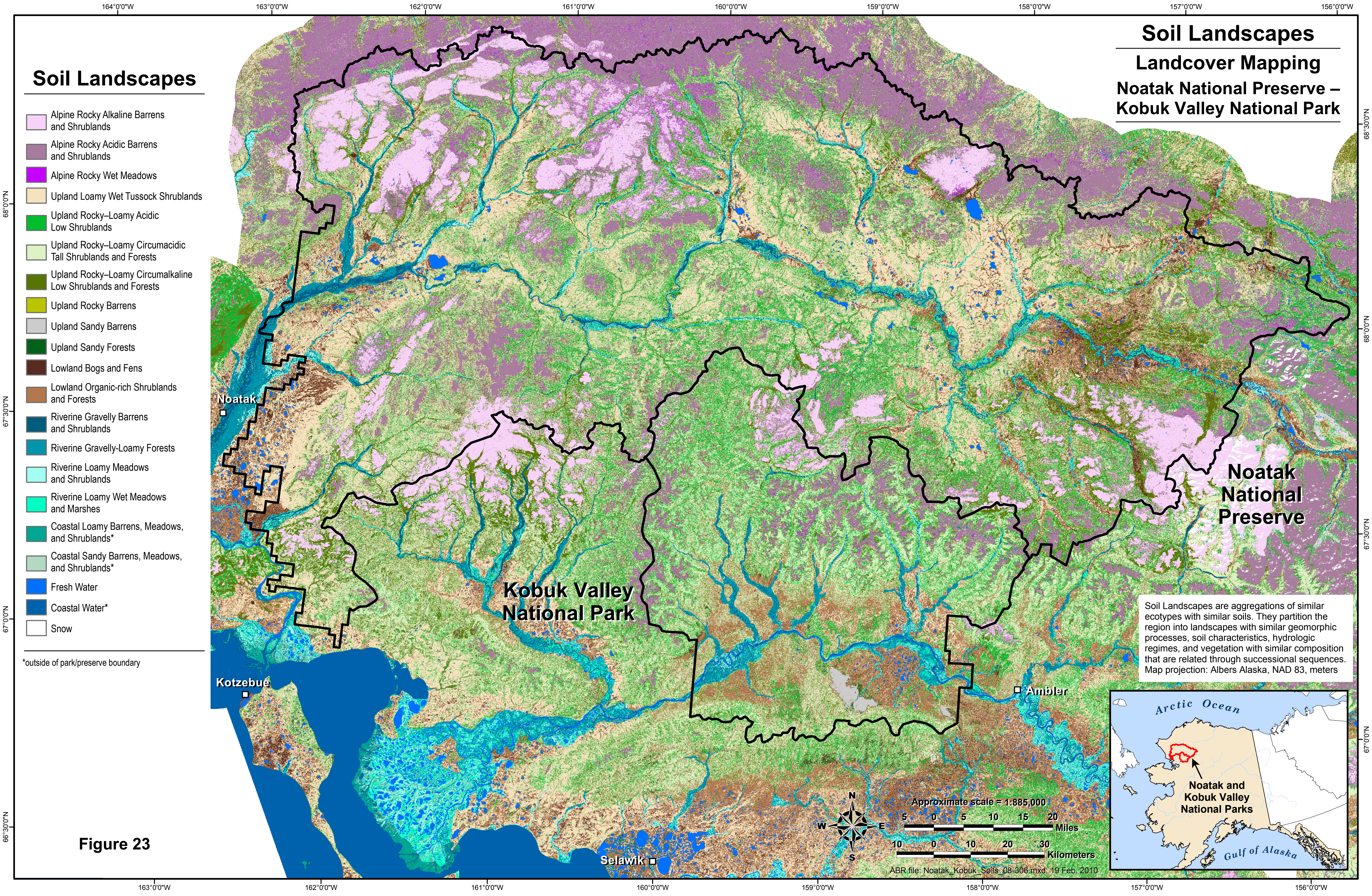

Soil Landscapes
Landcover Mapping
Noatak National Preserve – Kobuk Valley National Park
Soil Landscapes
Alpine Rocky Alkaline Barrens and Shrublands
Alpine Rocky Acidic Barrens and Shrublands
Alpine Rocky Wet Meadows
Upland Loamy Wet Tussock Shrublands
Upland Rocky–Loamy Acidic Low Shrublands
Upland Rocky–Loamy Circumacidic Tall Shrublands and Forests
Upland Rocky–Loamy Circumalkaline Low Shrublands and Forests
Upland Rocky Barrens
Upland Sandy Barrens
Upland Sandy Forests
Lowland Bogs and Fens
Lowland Organic-rich Shrublands and Forests
Riverine Gravelly Barrens and Shrublands
Riverine Gravelly-Loamy Forests
Riverine Loamy Meadows and Shrublands
Riverine Loamy Wet Meadows and Marshes
Coastal Loamy Barrens, Meadows, and Shrublands*
Coastal Sandy Barrens, Meadows, and Shrublands*
Fresh Water
Coastal Water*
Snow
*outside of park/preserve boundary
Noatak
Kotzebue
Selawik
Ambler
Kobuk Valley National Park
Noatak National Preserve
Soil Landscapes are aggregations of similar ecotypes with similar soils. They partition the region into landscapes with similar geomorphic processes, soil characteristics, hydrologic regimes, and vegetation with similar composition that are related through successional sequences. Map projection: Albers Alaska, NAD 83, meters
Arctic Ocean
Noatak and Kobuk Valley National Parks
Gulf of Alaska
Approximate scale = 1:885,000
5 0 5 10 15 20 Miles
10 0 10 20 30 Kilometers
ABR file: Noatak_Kobuk_Soils_08-306.mxd, 19 Feb. 2010
164°0'0"W
163°0'0"W
162°0'0"W
161°0'0"W
160°0'0"W
159°0'0"W
158°0'0"W
157°0'0"W
156°0'0"W
68°30'0"N
68°0'0"N
67°30'0"N
67°0'0"N
66°30'0"N

Figure 23

Table 150. Soil landscapes (highlighted in boxes) identified by cross-tabulation of similar soil subgroups (soil associations) with closely associated ecotypes. Bolded values indicate the soil subgroups most closely associated with each ecotype.

Soil Subgroup	Lithic Dystrogelepts	Lithic Cryorthent	Typic Gelorthents	Typic Eutrogelepts	Humic Eutrogelepts	Typic Umbriturbels	Typic Humicryepts	Typic Dystrogelepts	Typic Haploturbels	Typic Haplorthels	Typic dystrocryepts	Typic Haplocryepts	Typic Cryopsamments	Typic Psammorthels	Typic Gelaquepts	Typic Aquiturbels	Typic Historthels	Typic Hemistels	Typic Histoturbels	Typic Aquorthels	Typic Umbrorthels	Oxyaquic Cryorthents	Oxyaquic Gelorthents	Oxyaquic Cryopsamments	Typic Geliaquents	Typic Cryorthent	Typic Gelifluvents	Fluvaquentic Haplorthels	Fluvaquentic Aquorthels	Sphagnic Cryofibrists	Sphagnic Fibristels	Typic Cryofibrists	Typic Fibristels	Terric Fibristels	Terric Hemistels	Total
Upland Mafic Barrens	1																																			1
Alpine Mafic Barrens			15	1																																18
Alpine Alkaline Barrens		2	8	8						1																1										20
Alpine Alkaline Dryas Dwarf Shrub			2	15	2				2	2		1														2										26
Alpine Cassiope Dwarf Shrub			2	8		1		1																												12
Alpine Acidic Barrens	1	1	4					1	1																											9
Alpine Acidic Dryas Dwarf Shrub		3				1	1	10	2																	1										18
Alpine Ericaceous–Dryas Dwarf Shrub	1		3	4		1	1	13	4	2		1									1															33
Upland Birch–Ericaceous Low Shrub	1			1			1	4	3	1		1				1	3		1																	17
Upland Birch–Willow Low Shrub				2				6	6	3						2	1		1	2	1															26
Upland Spiraea Low Shrub							1	2		1	4															1										10
Upland White Spruce–Ericaceous Forest				3						3	6		1																				1			16
Upland Spruce–Birch Forest										1	3	2		1					1																	9
Upland Birch Forest											2	1																								3
Upland Alder–Willow Tall Shrub				5			3	2			4	1				1	2			2																21
Upland Bluejoint Meadow				1				1												1																3
Upland Sedge–Dryas Meadow				2					1						2	5	1			1																16
Upland White Spruce–Willow Forest				6	3					3		2					1																			15
Upland Willow Low Shrub				3					1	1					1		1			3																13
Upland Sandy Barrens													13																							13
Upland White Spruce–Dryas Woodland												3	3																							6
Upland White Spruce–Lichen Woodland											1		3																							4
Lowland Black Spruce Forest								2	2	1					1	1	3		1			1				1										13
Lowland Alder Tall Shrub								1											2	2																5
Lowland Birch–Ericaceous Low Shrub																1	2	3	1	2													1		1	11
Lowland Birch–Willow Low Shrub	1			1											1	4	1	2	2	5													2			19
Lowland Willow Low Shrub										1					1	1	3			4												1				11
Upland Dwarf Birch–Tussock Shrub						1			2							12	9	4	3	1													5	1	1	39
Lacustrine Barrens			1																		1		1													3
Lacustrine Bluejoint Meadow																				3	1					1										5

Table 150. Continued.

Soil Subgroup	Lithic Dystrogelepts	Lithic Cryorthent	Typic Gelorthents	Typic Eutrogelepts	Humic Eutrogelepts	Typic Umbriturbels	Typic Humicryepts	Typic Dystrogelepts	Typic Haploturbels	Typic Haplorthels	Typic dystrocryepts	Typic Haplocryepts	Typic Cryopsamments	Typic Psammorthels	Typic Gelaquepts	Typic Aquiturbels	Typic Historthels	Typic Hemistels	Typic Histoturbels	Typic Aquorthels	Typic Umbrorthels	Oxyaquic Cryorthents	Oxyaquic Gelorthents	Oxyaquic Cryopsamments	Typic Geliaquents	Typic Cryorthent	Typic Gelifluvents	Fluvaquentic Haplorthels	Fluvaquentic Aquorthels	Sphagnic Cryofibrists	Sphagnic Fibristels	Typic Cryofibrists	Typic Fibristels	Terric Fibristels	Terric Hemistels	Total
Lacustrine Willow Shrub				1																4	1															6
Riverine Barrens			3										3									16	5	2	1	1		1								32
Riverine Dryas Dwarf Shrub			2	1																		2	1	1												7
Riverine Moist Willow Tall Shrub			11										4									5	6	2		1		1								30
Riverine Willow Low Shrub			5	2				1														1	1		1			1	1							13
Riverine Poplar Forest			6										1										1			4	1									13
Riverine White Spruce–Alder Forest			1																	1							2									6
Riverine White Spruce–Poplar Forest			5							1			1													3	1									11
Riverine White Spruce–Willow Forest			4										1														2									7
Riverine Alder Tall Shrub			1					1																			1	2								5
Riverine Birch–Willow Low Shrub			1					1														1						4	2							9
Riverine Bluejoint Meadow																						1					2									3
Riverine Wet Willow Tall Shrub																													2							2
Coastal Brackish Sedge–Grass Meadow																	2												2							4
Coastal Brackish Willow Shrub																													3							3
Coastal Saline Sedge–Grass Meadow																													3							3
Coastal Wet Barrens																													1							1
Coastal Brackish Dunegrass Meadow													3	1																						4
Coastal Crowberry Dwarf Shrub														6																						6
Coastal Dry Barrens													3											3												6
Riverine Forb Marsh																									1											1
Riverine Wet Sedge Meadow																									1				1							2
Alpine Wet Sedge Meadow															1	2				5																8
Lacustrine Buckbean Fen																	1															3				4
Lacustrine Wet Sedge Meadow																	3			5												1	1			10
Lowland Ericaceous Shrub Bog																	4	2	1											7	6	2	5	2		29
Lowland Sedge Fen																	8		1													2	11	3	3	28
Lowland Sedge–Willow Fen																		2		3				1								3	11	1		21
Lacustrine Pendent Grass Marsh																				1																1
Total	5	6	74	64	5	4	7	46	24	21	20	12	36	8	7	30	45	13	14	45	5	27	15	9	4	16	9	9	15	7	6	12	37	7	5	690

Table 151. Crosswalk of soil subgroups and their equivalent soil landscape in the Arctic Network.

Soil Subgroup	Upland Rocky Circumalkaline Barrens	Alpine Rocky Alkaline Barrens and Shrub	Alpine Rocky Acidic Barrens and Shrub	Upland Rocky-loamy Acidic Low Shrublands	Upland Rocky-loamy Circumacidic Tall Shrublands and Forests	Upland Rocky-loamy Circumalkaline Low Shrublands and Forests	Upland Sandy Barrens	Upland Sandy Forest	Lacustrine Loamy Barrens Mead, and Shrub.	Riverine Gravelly Barrens and Shrublands	Riverine Gravelly-Loamy Forests	Riverine Loamy Meadows and Shrublands	Coastal Loamy Barrens, Meadow, and Shrub	Coastal Sandy Barrens, Meadow, and Shrub	Riverine Loamy Wet Meadows and Marshes	Alpine Rocky Wet Meadow	Lacustrine Organic-rich Wet Meadows	Upland Loamy Wet Tussock Shrublands	Lowland Organic-rich Shrub and Forests	Lowland Bogs and Fens	Grand Total
Lithic Dystrogelepts	1		2	1															1		5
Typic Umbriturbels		1	2															1			4
Typic Cryorthent		3	1	1					1	2	7								1		16
Lithic Cryorthent		2	4																		6
Typic Eutrogelepts		32	4	3	9	11			1	3									1		64
Typic Gelorthents		27	7						1	21	16	2									74
Typic Dystrogelepts		1	24	12	3					1		2							3		46
Typic Haploturbels		2	7	9		2												2	2		24
Typic Haplorthels		3	2	5	4	4					1								2		21
Typic dystrocryepts				4	15			1													20
Typic Haplocryepts		1	1	1	4	2		3													12
Humic Eutrogelepts		2				3															5
Humic Dystrogelepts			2	1	1																4
Typic Humicryepts			2	2	3																7
Aquic Eutrogelepts				2		2															4
Spodic dystrocryepts				1	1																2
Typic Haplocryods					2																2
Typic Cryopsamments					1		13	6		7	3			6							36
Ruptic-histic Aquiturbels						4															4
Typic Aquiturbels				3	1	5										2		12	7		30
Typic Aquorthels				2	3	4			7		1					5	5	1	13	3	44
Typic Umbrorthels			1	1					3												5
Aquic Umbrorthels									2												2
Oxyaquic Cryofluvent									1			1			1						3
Fluventic Haplorthels												2									2
Typic Psammorthels					1									7							8
Oxyaquic Cryopsamments										5				3						1	9
Oxyaquic Cryorthents										24		2							1		27
Oxyaquic Gelorthents									1	13	1										15
Typic Cryofluvent											2										2
Typic Gelifluvents											6	3									9
Fluvaquentic Haplorthels										3		6									9
Fluvaquentic Aquorthels										1		4	9		1						15
Fluvaquentic Fibristels													2								2
Fluvaquentic Historthels													1								1
Aquic Cryopsamments										1				1							2
Typic Geliaquents										2					2						4
Aquic Gelifluvents										1			1								2
Typic Folistels																			1	1	2
Typic Gelaquepts						3										1			3		7
Typic Histoturbels				2	1													3	6	2	14
Typic Hemistels																		4	5	4	13
Typic Fibristels					1												1	5	3	27	37
Typic Historthels				4	2	3							2				4	9	9	12	45
Typic Cryofibrists																	4		1	7	12
Terric Fibristels																		1		6	7
Sphagnic Cryofibrists																				7	7
Sphagnic Fibristels																				6	6
Terric Hemistels																		1	1	3	5
Grand Total	1	74	59	54	52	43	13	10	17	84	37	22	15	17	4	8	14	39	60	79	702

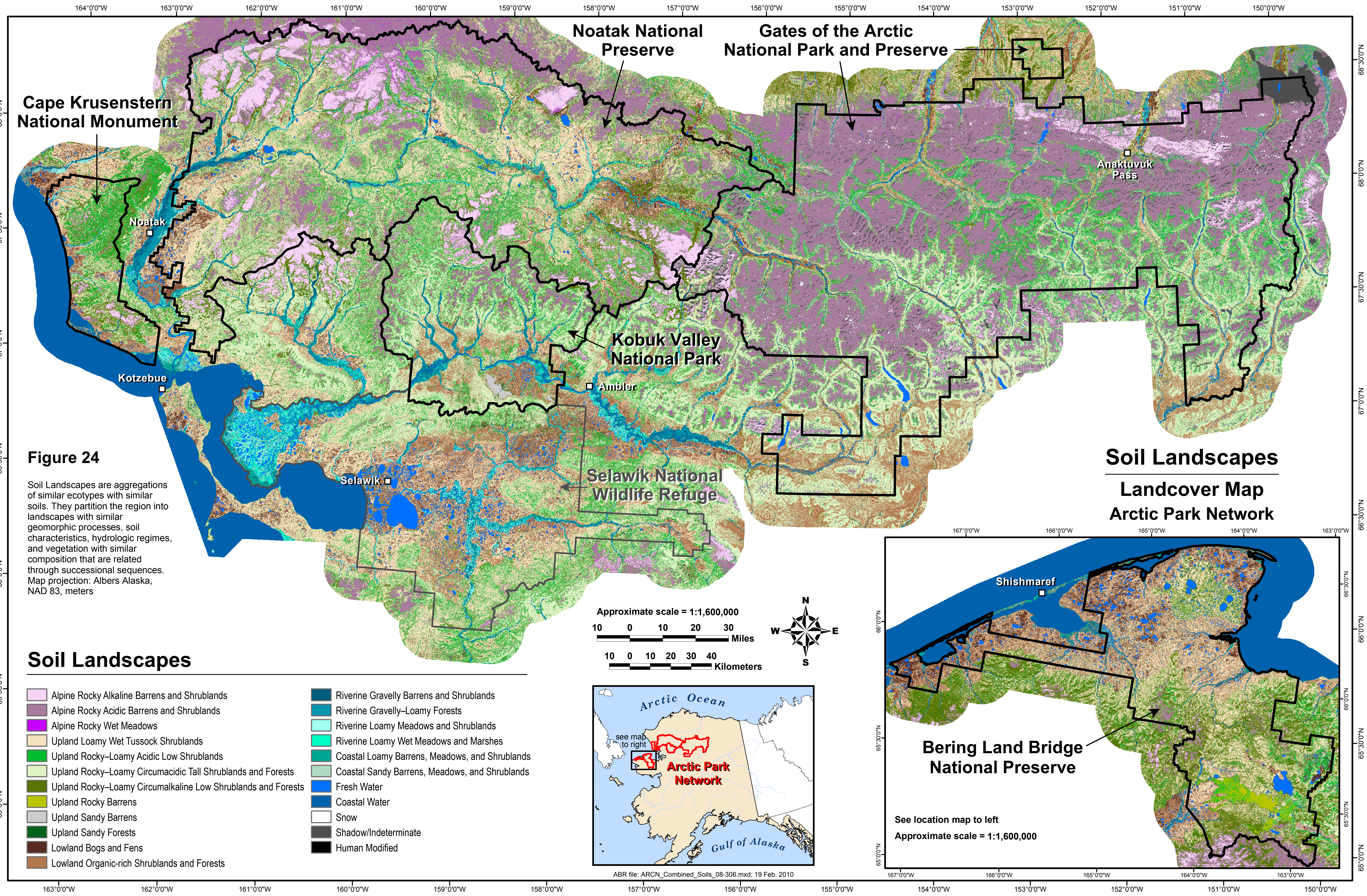


Figure 24

Soil Landscapes are aggregations of similar ecotypes with similar soils. They partition the region into landscapes with similar geomorphic processes, soil characteristics, hydrologic regimes, and vegetation with similar composition that are related through successional sequences. Map projection: Albers Alaska, NAD 83, meters

Table 152. Areal extent of soil landscapes within the Arctic Network.

	Area (ha)						
Soil Landscape	**KOVA**	**NOAT**	**BELA**	**CAKR**	**GAAR**	**Total**	**% Area**
Coastal Water	0	0	10460	11234	0	21693	0.3
Fresh Water	6445	26110	62241	2326	30477	127599	1.6
Alpine Rocky Acidic Barrens and Shrublands	56996	355021	20828	2377	1397199	1832421	22.5
Alpine Rocky Alkaline Barrens and Shrublands	21386	302232	25327	16249	264625	629819	7.7
Alpine Rocky Wet Meadows	7347	40384	0	0	7985	55716	0.7
Coastal Loamy Barrens, Meadows, and Shrublands	0	0	5669	1531	0	7200	0.1
Coastal Sandy Barrens, Meadows, and Shrublands	0	0	2569	1663	0	4232	0.1
Human Modified	0	0		174	0	174	0.0
Lowland Bogs and Fens	8864	77586	85634	7363	8331	187778	2.3
Lowland Organic-rich Shrublands and Forests	86918	135941	183719	35781	184970	627330	7.7
Riverine Gravelly Barrens and Shrublands	13991	55767	12643	3629	26308	112338	1.4
Riverine Gravelly-Loamy Forests	24673	12563		2	11027	48264	0.6
Riverine Loamy Meadows and Shrublands	7379	25462	5907	3554	15244	57546	0.7
Riverine Loamy Wet Meadows and Marshes	6856	25598	0	16	2097	34568	0.4
Shadow/Indeterminate			0	0	163541	163541	2.0
Snow	149	978	0	0	19773	20900	0.3
Upland Loamy Wet Tussock Shrublands	60206	886139	394573	78974	226656	1646548	20.2
Upland Rocky Barrens			22439	0	0	22439	0.3
Upland Rocky-Loamy Acidic Low Shrublands	101980	326033	64033	56137	373802	921985	11.3
Upland Rocky-Loamy Circumacidic Tall Shrublands and Forests	214902	101047		5	560568	876522	10.8
Upland Rocky-Loamy Circumalkaline Low Shrublands and Forests	78778	285394	194367	40464	135673	734676	9.0
Upland Sandy Barrens	6600	0	0	0	0	6600	0.1
Upland Sandy Forests	3102	3202	0	0	0	6304	0.1
Total	706572	2659458	1090406	261479	3428278	8146193	100.0

Factors Affecting Landscape Evolution and Ecosystem Development

The structure and function of ecosystems are regulated largely along gradients of energy, moisture, nutrients, and disturbance. These gradients are affected by climate, tectonic effects on physiography, and parent material as controlled by bedrock geology and geomorphology (Swanson et al. 1988, ECOMAP 1993, Bailey 1996). Thus, these large-scale ecosystem components can be viewed as state factors that affect ecological organization (Jenny 1941, Van Cleve et al. 1990, Vitousek 1994, Bailey 1996). Information on how these landscape components have affected ecosystem patterns and processes in ARCN were synthesized from our results and relevant literature.

Climate

Climate is a dominant factor affecting ecosystem distribution (Walter 1979). Long-term weather stations surrounding ARCN reveal strong gradients in temperature and precipitation. Mean annual air temperature (MAAT) ranged from −3.2°C at Nome (1949–1999) in the south, to –6.0°C at Wales (1949–1999) –5.8°C at Kotzebue, –5.8°C at Kobuk, –8.1°C at Cape Lisburne, and –11.8°C at Umiat in the north (WRCC 2001). When the modeled effects of elevation are included, the coldest MAATS is –13°C in the high mountains of northeast GAAR (Figure 25). Mean annual precipitation (MAP) ranged from 408 mm at Nome in the south, to 240 mm at Kotzebue, 241 mm at Kobuk, and 139 mm at Umiat (north). In addition, there was a west to east precipitation gradient, with 288 mm occurring at Cape Lisburne and 291 mm at Wales in the west, to 424 mm at Kobuk in the east. When the modeled effects of elevation are included, the highest MAP at approx. 800 mm is in the high mountains of northeast GAAR (Figure 26). Note, however, that precipitation can be underestimated as a result of problems with measuring blowing snow in the Arctic. All stations follow similar seasonal patterns: summers are short (June through August), winters are long, and most of the precipitation falls during July, August, and September. Additionally, there is an elevational gradient in temperature, with cooler summers and generally warmer and windier winters at higher elevations, the latter due to the pooling of cold air in valleys. Hammond and Yarie (1996) estimate that growing season temperatures at high elevations in the western Brooks Range average 2 to 3° C cooler than in adjacent valley bottoms. Limited data from Racine (1979) also indicate that air temperatures during the summer are colder in coastal areas compared to inland areas.

These strong climatic gradients have resulted in a wide range of ecological responses evident on the ecotype maps. Most of the area is in the polar domain, while some portions are included in the boreal domain (Nowacki et al. 2002). Because of low summer temperatures, vegetation over most of the area (polar domain), is dominated by graminoids, low and dwarf shrubs, mosses, and lichens. At intermediate elevations in the eastern margins of ARCN, relatively high summer temperatures (12–13°C July mean) allow for the growth of the northwestern-most needleleaf trees in North America. Consequently, spruce forests occur only in the eastern portions of the parks. At higher elevations, summer temperatures are lower and winds are stronger; as a result alpine areas frequently are barren or support only a sparse cover of lichens, mosses, and a few vascular species.

Climatic conditions also have varied considerably over time. Stable isotope analysis of ice cores from Greenland and Antarctica reveal numerous large, rapid shifts in climate during the Pleistocene (Bradley 1999). These changes have

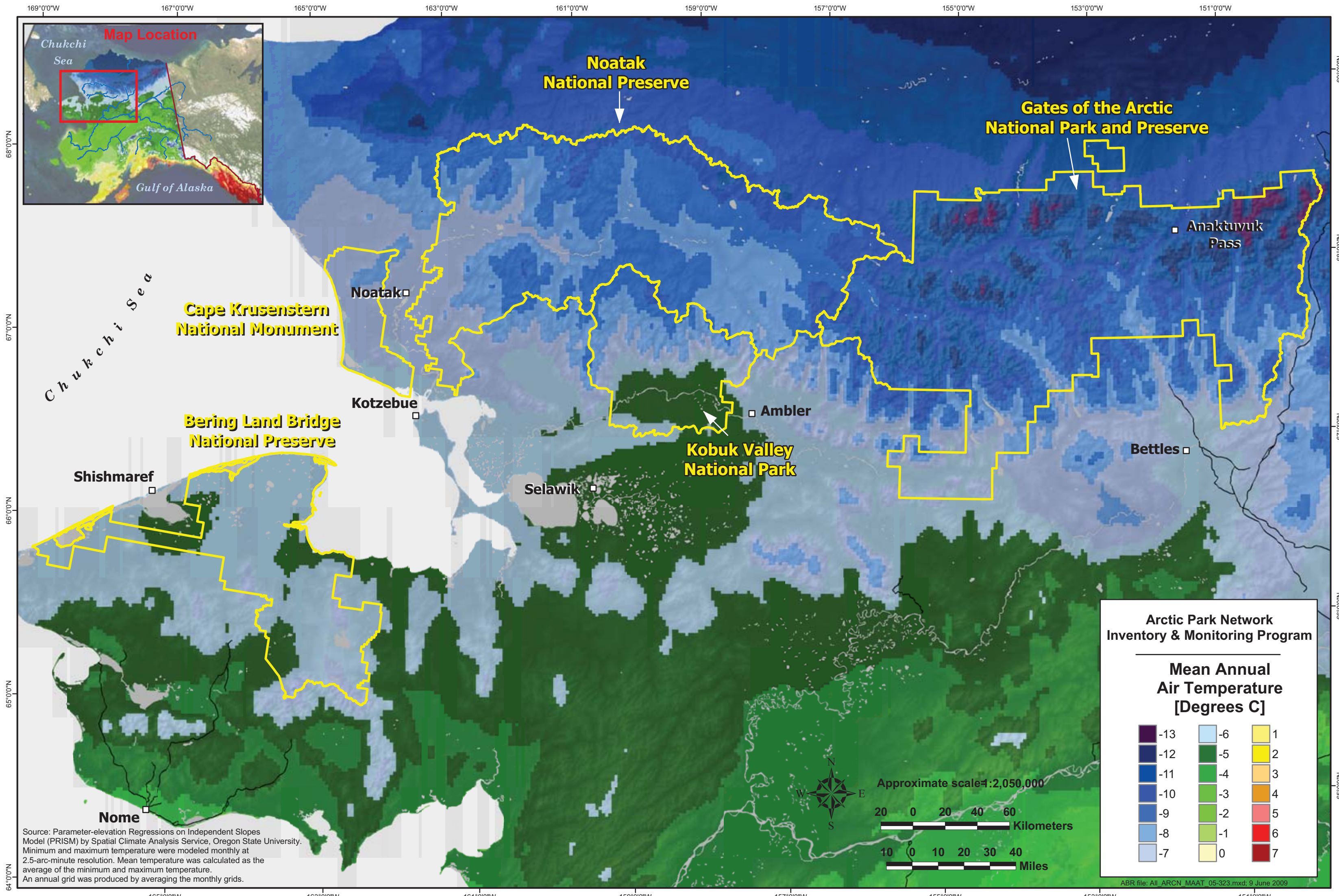


Figure 25. Mean annual air temperatures across the Arctic Network from the Parameter-elevation Regressions on Independent Slopes Model (PRISM), by Spatial Climate Analysis Service, Oregon State University.

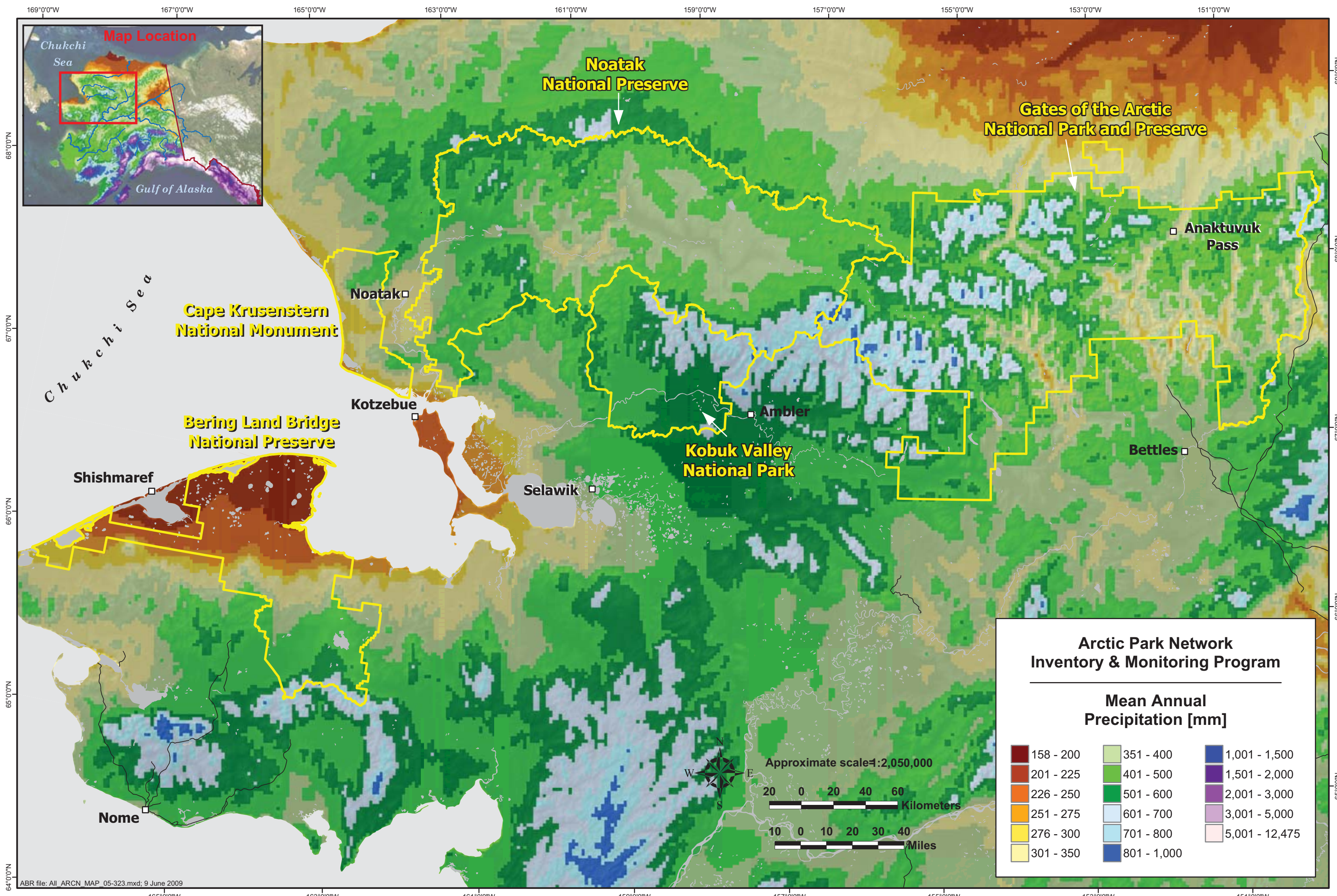


Figure 26. Mean annual precipitation values across the Arctic Network from the Parameter-elevation Regressions on Independent Slopes Model (PRISM), by Spatial Climate Analysis Service, Oregon State University.

resulted in multiple episodes of glaciation, associated loess deposition, and sea-level fluctuations (Hopkins 1982), and have been documented in numerous geomorphic and paleoecological studies in the Bering Land Bridge area (Smith 1933, Matthews 1974, McCulloch and Hopkins 1966, Hopkins 1967, Hopkins 1982, Hamilton and Brigham-Grette 1991, Mann and Hamilton 1995). During the late Pleistocene, buried calcareous paleosols in northern BELA indicate that the climate was cold and dry around 16,000–19,000 years ago and loess deposition was heavy (Höfle and Ping 1996). During the early Holocene, white spruce macrofossils, ice-wedge casts, and buried soils indicate that the climate was much warmer 8,300–10,000 years before present (ybp) (McCulloch and Hopkins 1966).

Fossil insect and pollen records (Elias et al. 1999) indicate that during the last interglacial period (about 130,000 ybp), the climate in the Noatak Valley was similar to, or slightly warmer than it is today. This interglacial was followed by a prolonged period of lower temperatures, when the vegetation was dominated by herbaceous plants. About 13,000–14,000 ybp the climate warmed, probably to conditions similar to those at present, allowing colonization of the Noatak Valley by shrubs (and localized trees) over the next few thousand years (Anderson 1988, Eisner and Colinvaux 1992, Anderson and Brubaker 1994). On the basis of beetle fossils assemblages, Elias et al. (1999) estimated that mean summer temperatures were approx. 2° C below and above current temperatures during glacial and interglacial periods, respectively. White spruce fossil remains, ice-wedge casts, and buried soils indicate that the climate in northwestern Alaska 8,300–10,000 ybp was warmer than at present (McCulloch and Hopkins 1966).

More recently, historical records and analyses of proxy indicators indicate that mean annual temperatures were substantially (approx. 1° C) lower during the Little Ice Age (ending around 1850) than at present, and that temperatures during the last decade (1990–2000) were the warmest in the last 400 years (Overpeck et al. 1997). This recent warming has enhanced tree growth in the Noatak Valley and allowed some expansion of spruce forest into the tundra (Suarez et al. 1999). Future temperature increases expected as a result of global warming likely will lead to further expansion of the forest, but the change is likely to be very slow because of the topographic barrier presented by the Brooks Range (Rupp et al. 2001).

Oceanography

The western coast of ARCN abuts the Bering Strait and the southern margin of the Chukchi Sea, a rectangular embayment of the Arctic Ocean. At Shishmaref, mean high tides reach 0.8 m, and the highest tidal drift line is only 1.0 m above mean sea level (amsl) (Naidu and Gardner 1988). At Cape Espenberg, storm debris extends to 2.3 m amsl (Mason et al. 1997). Current direction and thus, sediment transport, is northward along the coast. Drifting pack and shorefast ice covers the entire Chukchi Sea for 7–8 months. Sea depths extend to only approx. 80 m in the Bering Strait.

Large fluctuations in sea level, however, have accompanied the climatic changes described above. During maximum glaciation in the late Pleistocene (approx. 18,000 ybp), sea level fell to approx. 100 m below current sea level. This drop exposed a broad land bridge across the Bering continental shelf (Hopkins 1967). By approx. 11,000 ybp the land bridge was again inundated and the migration corridor for plants and animals, including humans, closed (Elias et al. 1992). Sea level reached nearly its present level (within 2–3 m) around 5,000 ybp (Mason et al. 1995), and sediment transport and storm events have contributed to the development of extensive barrier islands, spits, and beach ridge complexes along the Bering Strait (McCullough 1967, Jordan 1988, Mason and Jordan 1991, Mason et al. 1997).

Sea level also has been much higher in the past, and marine transgressions during the Pleistocene have created the broad coastal plain across the northern portion of the Seward Peninsula. The Pelukian transgression during the last interglacial (isotope stage 5e) occurred approx. 125,000 ybp and left beach ridge deposits that outcrop at elevations of 8–10 m above mean sea level (Sainsbury 1967, Hamilton and Brigham-Grette 1991, Brigham-Grette and Hopkins 1995). The Pelukian transgression is recorded by a well-defined wave-cut scarp and marine terrace that can be traced along much of the coast of the northern Bering Sea and southern Chukchi Sea (Sainsbury 1967, Hopkins 1973). During the middle Pleistocene, two marine transgressions, the Kotzebuan (approx. 175,000 ybp) and Einahnuhtan (approx. 225,000 ybp) have been described, although their sea-level history has been difficult to reconstruct (Hopkins 1967, Hopkins 1973). Sea level during the later transgression reached a maximum elevation of approx. 35 m amsl. Marine transgressions during the Pliocene may have been as high as 70 m (Brigham-Grette and Carter 1992). These transgressions left marine beach and coastal deposits of silt, sand, and gravel across the coastal plain. Ancient barrier bars are occasionally evident, comprised of well-sorted sand forming linear ridges (Till et al. 1986).

Tectonic Setting and Physiography

ARCN is within a moderately active seismic zone connected to the Brooks Range and is characterized as having a relatively thin crust, scattered Quaternary volcanism, and relatively high heat flow (Thenhaus et al. 1982). The coastal plain on the northern portion of the Seward Peninsula is a subsiding basin comprised of Cenozoic sediments several thousand meters thick that are crosscut by several east/west faults just south of Cape Espenberg (Tolson 1987). The geologic structure and physiography of the region is dominated by thrust faulting of two different ages. Probably beginning in the mid-Cretaceous, Precambrian and Paleozoic rocks were thrust eastward creating north-trending folds (Sainsbury 1972). Later in the Cretaceous, unmetamorphosed rocks in the York Mountains moved northward into their present position. At the end of the Cretaceous, isolated blocks of granite intruded the thrust sheets and several normal faults developed. Tertiary tectonism is responsible for prominent, high-angle faulting and the volcanic activity in the Imaruk Basin. Little uplift or subsidence has occurred during the Holocene, however, and isostatic rebound is unlikely because the northern coastal plain was not glaciated during the Pleistocene.

ARCN has been affected by the tectonic uplifting that produced the Brooks Range. Uplifting probably began in the mid-Jurassic and was active into the Cretaceous within the area (Moore et al. 1994). This uplifting occurred when a thick piece of the earth's crust that now composes most of the Brooks Range, known as the Arctic Alaska Terrane, collided with and then fused with other terranes to the south (Mull 1982, Box 1985, Mayfield et al. 1983, Karl and Long 1990, Moore 1992). The quiet-water, marine sedimentary rocks of the Arctic Alaska Terrane were initially forced southward (subducted) beneath a section of oceanic crust known as the Angayucham Terrane, then uplifted and eroded. As a result, bedrock in ARCN consists mostly of sedimentary rock, including a substantial amount of carbonate rock.

These tectonic forces and the resulting physiography in the parks have exerted strong influences on ecosystem distribution and successional development through their effects on regional climate (Hammon and Yarie 1996, Van Cleve et al. 1990), microclimate and drainage (Bailey 1996), and plant migration and life-history patterns (Suarez et al. 1999, Rupp et al. 2001). In addition, lower temperatures at higher elevations create conditions for glacier expansion into low-lying areas (Péwé 1975), resulting in substantial alteration of surficial materials that form the substrate for supporting plant growth.

Bedrock Geology

The bedrock geology within ARCN is highly complex and includes a wide variety of sedimentary, metamorphic, volcanic, and intrusive rocks (Sainsbury 1972, Hudson 1977, Beikman 1980, Nelson and Nelson 1982, Curtis et al. 1984, Ellersieck et al. 1984, Mayfield et al. 1984, Till et al. 1986, Karl et al. 1989, Till and Dumoulin 1994, Moore et al. 1994). This complexity and interspersion of rock types greatly influenced the diverse range of high-elevation ecotypes identified in this study. In addition, vegetation composition varies greatly among areas with different bedrock types, due to differences in soil pH and potential phytotoxic effects of soluble metals (described below). Acidic soils, typically associated with noncarbonate sedimentary and metamorphic rocks, usually are dominated by acid tolerant plants such as *Betula nana, Dryas octopetala*, *Empetrum nigrum*, *Eriophorum vaginatum*, *Ledum decumbens, Rubus chamaemorus, Salix planifolia* ssp. *pulchra* (syn: *S. pulchra*), *Sphagnum* spp., and *Vaccinium uliginosum* (Hanson 1953, Young 1974, Walker et al. 1994). In contrast, plants commonly associated with alkaline soils include *Dryas integrifolia, Equisetum scirpoides, Lupinus arcticus, Parrya nudicaulis, Salix arctica, S. lanata* ssp. *richardsonii* (syn: *S. richardsonii*), and *S. reticulata* (Young 1974, Walker et al. 1994). Some of the principal differences among carbonate, noncarbonate, felsic-intrusive, and mafic extrusive (volcanic) rocks, and their influence on soil and vegetation, are described below.

Carbonate or calcareous rocks, such as limestone, dolostone, marble, and calcareous schists are common in the Baird and Delong Mountains (Dumoulin and Harris 1987, Moore et al. 1994). The relatively high pH and abundance of calcium in the alkaline soils formed by these rocks result in reduced availability of phosphorus and poor absorption and utilization of phosphorus by plants (Bohn et al. 1985). These nutrient availability problems may explain the lower plant cover apparent on satellite imagery for carbonate rock regions in ARCN. Alkaline soils also tend to be rich in humus, are often associated with more active cryoturbation, and tend to have deeper active layers (Ping et al. 1998).

Noncarbonate sedimentary (mostly shale, chert, sandstone, and conglomerate) and metamorphic (mostly schist) rocks are the most common rock types throughout the Brooks Range and the study area (Moore et al. 1994, Brosgé et al. 1983). Topography generally is gentler on shales than other rock types in ARCN. Because of reduced carbonate and calcium concentrations in the soil, the soils tend to be strongly acidic. Vegetation cover is distinctly greater on these rocks than either carbonate sedimentary rocks or ultramafic igneous rocks.

Felsic intrusive igneous rocks occur in the Bendeleben and Darby Mountains and in other isolated locations, such as the Arrigetch Peaks. These granitic rocks are dominated by light-colored minerals, such as quartz, alkali feldspars (orthoclase), and muscovite mica, and are rich in aluminum silicates, with little to no calcium, magnesium, and iron. The high aluminum and low calcium– magnesium content contributes to development of strongly acidic soils and high soluble aluminum concentrations. The elevated aluminum, in turn, can lead to plant growth problems because root growth can be stopped by Al concentrations as low as 1 mg/l (Bohn et al. 1985). Phosphorus predominantly is fixed as aluminum and iron phosphates in the acid soils, but is still more available than in alkaline soils. To reduce aluminum toxicity, many plants generate organic acids, such as tannins, that act as chelating agents in the rhizosphere for protection (Rendig and Taylor 1989). Thus, ericaceous plants, which are better adapted to these conditions, tend to dominate.

Mafic volcanic rocks are prevalent in the Imuruk Plateau and around the Devil Mountain Lakes. The Imuruk Plateau basically was formed from basaltic lava flows of Tertiary and Quaternary age (Till et al. 1986). While the Tertiary flows are mostly covered by eolian silt and colluvium, the Lost Jim and Gosling lava flows of Quaternary age are mostly barren. Farther north, the shield volcanoes that form Devil Mountain occur at the northern limit of late Cenozoic volcanism in Alaska (Hopkins 1988). Explosive eruptions during the last 200,000 years have created a large region of basaltic ash, massive pyroclastic flows, and explosion breccia (Begét et al. 1996). These barren areas tend to be dominated by fruticose and crustose lichens.

Geomorphology

Pleistocene glaciations have affected the geomorphology of ARCN. Glaciers extended from source areas in high mountainous areas during the early and middle Pleistocene. They extended to the eastern portion of ARCN, and covered some of the Noatak basin entirely during the latest (Wisconsin) glacial period (Smith 1912, Péwé 1975, Hamilton 1994, Hamilton, 2001). Glacial moraines deposited in pre-Wisconsin glaciations have been modified greatly by subsequent thermokarst and gelifluction, so that the moraine morphology is now indistinct. Glaciations during the middle to late Pleistocene also covered the Bendeleben, Darby, western York, and Kiwalik mountains, but effects within BELA are limited (Matthews 1974, Hopkins et al. 1983, Kaufman and Hopkins 1986, Kaufman et al. 1991). The Nome River glaciation (approx. 280,000–580,000 ybp) extended into the Bendeleben Northern Foothills, but little can be found in the fossil record regarding ecosystem development on the glacial deposits. The many cirque lakes present in the Bendeleben Mountains originated from this glacial activity.

Eolian activity during dry, full glacial periods has deposited thick beds of eolian silt (loess) over much of the northern Seward Peninsula (Mathews 1974, Hopkins 1982). Near Imuruk Lake, eolian deposits up to 6-m thick have been observed (Holowaychuk and Smeck 1979). In contrast, late Pleistocene eolian deposits that occur on top of volcanic ash deposited approx.17,500 ybp are only approx.0.5 m thick (Holowaychuk and Smeck 1979). Much of the silt probably blew off glaciofluvial outwash plains associated with the Illinoian glaciation, which extended as far west as the terminal moraine now forming the Baldwin Peninsula (Matthews 1974). Loess accumulation during the Wisconsin glaciation (maximum at approx. 18,000 ybp) probably was much less because outwash streams were blocked by the Baldwin Peninsula. Chemical analysis of loess in northern BELA buried during the late Pleistocene (approx. 16,000–19,000 ybp) indicates it remained calcareous throughout the profile because the climate was cold and dry (Höfle and Ping 1996). While the frozen loess beneath the active layer of modern soils tends to remain alkaline, surface organic horizons usually are strongly acidic on the Imuruk Plateau and northern BELA (Holowaychuk and Smeck 1979, Höfle and Ping 1996), presumably due to leaching and paludification under a wetter climatic regime.

The long, gentle slopes of the hills and low mountains in the parks probably were formed, and continue to be modified, by gelifluction. This is the movement of saturated soil material downslope over permafrost (Washburn 1973). Gelifluction lobes are even visible on many rather steep, vegetated mountain slopes.

Alluvial processes in narrow mountain and broad lowland valleys in the parks have created a dynamic landscape characterized by active erosion and deposition. Channel migration erodes and recycles surficial deposits, while deposition follows a predictable sequence from gravelly deposits in active channels, to sandy active floodplains adjacent to the active channel, to peat-covered loamy soils on inactive floodplains (Ugolini and Walters 1974, Binkley et al. 1997, Jorgenson et al. 1998). In the latter stages of this sequence, ice-rich permafrost aggrades in the silty cover alluvium and greatly modifies the surface with ice-wedge polygons. In higher gradient streams in the mountains, bedrock control and heavy bedload result in confined headwaters and gravelly braided floodplains. On lower gradient streams in the lowlands, sandy deposits with meandering morphology are common. The floodplains provide connectivity between regions, because water is a conduit for the movement of sediments and nutrients, as well as fish, invertebrates, and plant materials.

Permafrost distribution is nearly continuous throughout the region because of low air temperatures (Jorgenson et al. 2008b). Permafrost in the lowlands generally is extremely ice-rich due to the thick loess deposits and long period of development, whereas upland areas underlain by bedrock have little ground ice as indicated by the lack of thermokarst features. Most of the massive ice that has accumulated in the lowlands appears to have developed during the mid-late Pleistocene and is in the form of massive ice wedges similar to the "yedoma" described in Russia (Yuri Shur, pers. comm.). Ice-wedge development, which occurs in areas where mean annual air temperatures have been $< -6°C$ (Péwé 1975) during the Holocene, also has contributed to the ice-rich permafrost. With the onset of a warmer and moister climate during the early Holocene, thermokarst of the ice-rich terrain has resulted in an abundance of thaw lakes (Heiser and Hopkins 1995). On the coastal plain, thaw basins are up to 25 m deep, indicating the ground ice volume is extremely high (Hopkins and Kidd 1988, Kidd 1990). Collapse of permafrost into thaw lakes, and subsequent aggradation of ground ice in exposed lacustrine sediments has lead to a "thaw-lake cycle" and occasional development of ice-cored mounds or "pingos" (Hopkins 1949).

Permafrost also greatly affects ecosystem development by altering soil processes. First, permafrost forms an impermeable layer beneath the active layer, causing the surface soils to become saturated in low-lying areas and on gentle slopes (Ford and Bedford 1987). Soil saturation, in turn, reduces soil oxygen and microbial decomposition and thereby increases organic matter accumulation (Höfle et al. 1998). Second, the impermeable layer eliminates subsurface leaching, so that solute removal is slowed down and occurs laterally. This lateral movement through the active layer creates distinct branching pattern of "water-tracks" on slopes and enhances plant growth in the drainages (Walker et al. 1989, Kane et al. 1992). Finally, freezing and thawing processes associated with permafrost contribute to cryoturbation (mixing of soil horizons) and development of patterned ground features, such as frost boils and ice-wedge polygons, which provide a range of wet and moist microsites. These processes all alter the

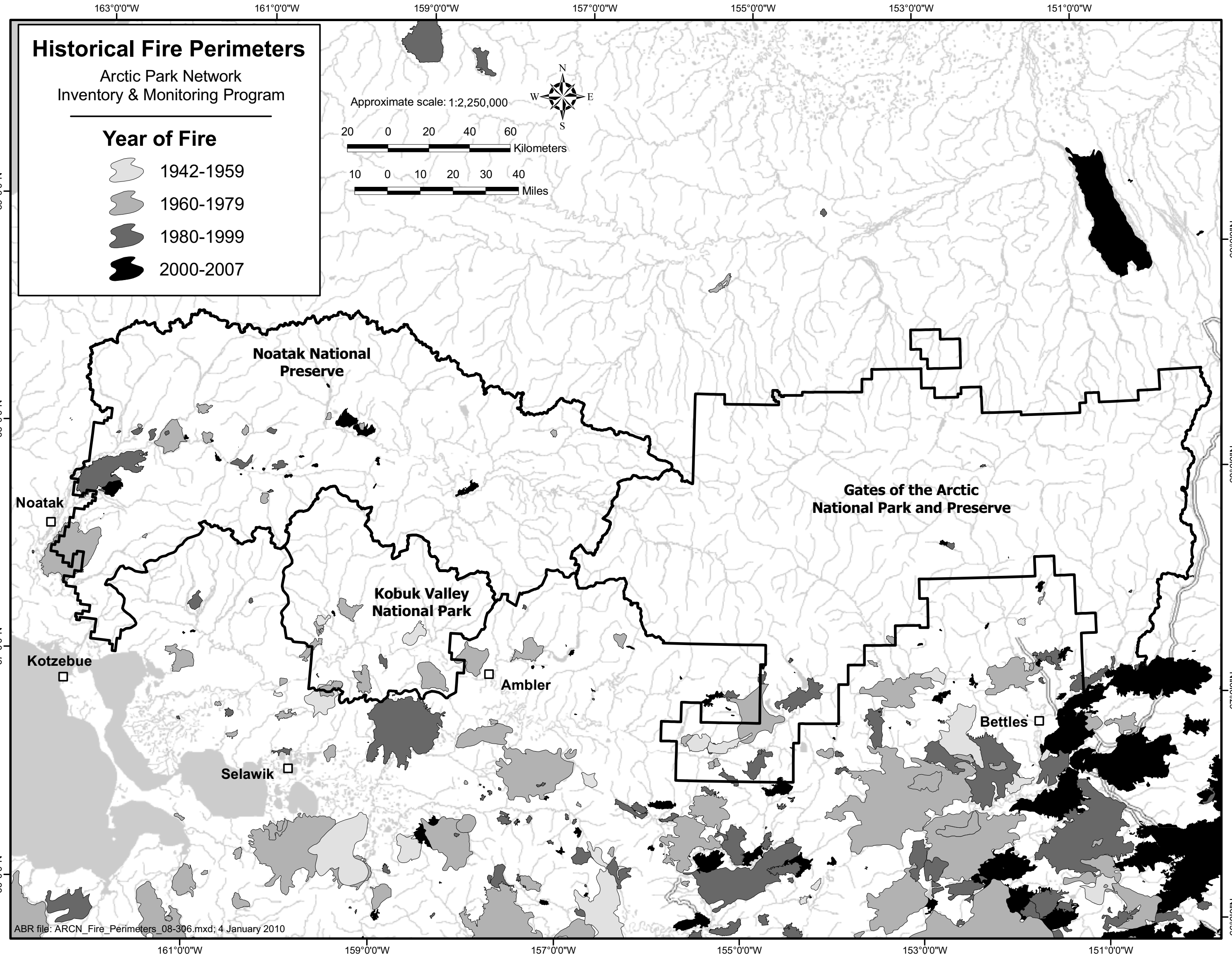


Figure 27. Map of historical fire perimeters in the Arctic Network from 1942–2007.

composition of vegetation that can grow on the cold, saturated soils.

Fire

Fire is not considered to be an important disturbance factor in tundra ecosystems due to the lack of fuel (Patterson and Dennis 1981), but periodic summer droughts and thunderstorms have produced several major fires in BELA and NOAT during the last several decades (Melchior 1979, Wein 1976, Racine 1981, Racine et al. 1983). Small fires have also occurred in black spruce forests in KOVA and GAAR (Figure 27). Fires are uncommon in the coastal plain region. While the effects of fire are variable in this landscape, they can be locally important since they increase the depth of the active layer and initiate permafrost degradation (Racine 1981, Racine et al. 1983).

Summary and Conclusions

This report presents the results of an ecological land survey (ELS) that inventoried and classified ecosystems in the Arctic Network. By analyzing the dynamic physical processes associated with coastal, riverine, lowland, upland and mountainous environments, and the abundance and distribution of their diverse ecological resources, this study contributes to ecosystem management in national parklands in Alaska.

Through field surveys at 763 intensive plots during 2005–2008, we collected information on the geomorphic, topographic, hydrologic, pedologic, and vegetative characteristics of ecosystems across the entire range of environmental gradients across the parks. Individual ecological components (e.g., geomorphic unit, AVC vegetation type) were determined using standard classification schemes for Alaska, but modified when necessary to differentiate unique characteristics of the study area. We developed 64 plant associations through multivariate classification techniques. We used the hierarchical relationships among ecological components to develop 70 ecotypes (local-scale ecosystems) that best partition the variation in ecological characteristics across the entire range of aquatic and terrestrial environments.

Soils described at 881 plots were classified into 73 soil types (subgroup level), of which 32 were rare occurrences and were not used in the analysis of soil-vegetation relationships. The most commonly observed types were Typic Eutrogelepts (10% of 881 observations), Typic Gelorthents (9%), Typic Dystrogelepts (7%), Typic Aquorthels (7%), and Typic Historthels (6%). The classification was effective at partitioning the variability of numerous soil properties, including organic-layer thickness, depth to rocks, thaw depths, depth to water, pH, and EC. Soil landscapes were developed by cross-tabulating soil types with the ecotypes assigned for each plot. The cross-tabulation revealed that 2–5 closely related soil types usually were associated with 2–3 ecotypes. These groupings were used to identify 24 soil landscape classes with broad application for resource management.

Multiple environmental site factors contributed to the distribution of ecotypes and their associated plant species. Mean surface organic-horizon thickness, an indicator of land surface age, anaerobic soil conditions and disturbance, ranged from 0 cm in alpine, coastal and riverine barrens to 130 cm in Lacustrine Wet Sedge Meadow, Lowland Ericaceous Shrub Bog and Lowland Sedge–Willow Fen. Mean depth to rock, an indicator of surficial deposit depth and drainage, ranged from 0 cm in alpine barrens to >200 cm in numerous ecotypes that occurred on thick, eolian surficial deposits. Areas where permafrost occurred at >1.5 m depth or was absent included in alpine areas, uplands, coastal dry barrens, younger riverine ecotypes , and lacustrine fens. In other areas, particularly lowland areas and upland tussock communities, permafrost was usually present at 20–130 cm depth, with a minimum depth of 13 cm. Mean water depth (negative when below ground) for terrestrial ecotypes ranged from >-2 m in many upland and riverine ecotypes to 80 cm in Lacustrine Pendent Grass Marsh. Mean pH, which affects nutrient availability and ion exchange, ranged from 3.3 in Lowland Black Spruce Forest to 9.4 in Coastal Brackish Water. Mean electrical conductivity (EC), important for osmotic regulation in plants, ranged from 10 µS/cm in several upland ecotypes to 46,400 µS/cm in Coastal Nearshore Water (the highest mean EC value for a terrestrial ecotype was 1,220 µS/cm in Upland Alder–Willow Tall Shrub).

Ecotype distribution was greatly affected by numerous landscape-level factors. Climatic gradients in temperature and precipitation resulted in strong differences among ecotypes distributed across the arctic and boreal climatic domains. Oceanographic conditions and Quaternary sea-level changes have resulted in the occurrence of salt-affected ecotypes along the coast and the prevalence of lowland ecotypes on the coastal plain. Soil pH and nutrient status are strongly affected by underlying bedrock types and geomorphology, particularly carbonate sedimentary, intrusive felsic, and ultramafic bedrock. Geomorphic environments associated with sediment erosion and deposition create a wide range of soil conditions and disturbance regimes. Areas underlain by permafrost have impeded subsurface drainage, and the varying volumes of ground ice affect the magnitude of permafrost degradation. Fires modify the dynamics of some ecosystems, particularly in boreal areas primarily vegetated by black spruce, and less frequently in tundra.

Three landcover map products were developed based on spectral classification of Landsat imagery: ecotypes, vegetation, and soil landscapes. The process involved: (1) compiling and preprocessing (including terrain correction, resampling, radiometric normalization, edge masking, radiometric calibration and mosaicking) Landsat ETM+ scenes from a nearly cloud-free period in late July and early August 2002; (2) developing an unsupervised classification of the scenes to guide development of the supervised training set; (3) developing training areas by digitizing polygons on IKONOS imagery according to specific criteria; (4) developing a spectral database that included both spectral, vegetation and geological characteristics; (5) evaluating signature fidelity and separability, and performing spectral cluster analysis; (6) stratifying the classification area based on physiography, geology, topographic metrics, and treeline layers; (7) performing a supervised classification of all the scenes using the classified signatures; (8) and reducing errors in the resulting scenes through rule-based modeling.

We developed landcover maps from rule-based modeling. First, a map of ecotypes for NOAT and KOVA was developed. The region was partitioned by climatic subregions, physiography (floodplains, alpine, coastal, etc), elevation (alpine and subalpine), treeline, and slope (to differentiate a subset of upland and lowland). These variables were used to generate a matrix defining the conditions under which each ecotype could occur. Pixels that were not classified at 99% confidence level or higher were re-classified using the entire signature set and ecotypes were assigned based on a matrix. Second, we used the ecotype classification to produce a map of vegetation classes. Third, we developed a soil landscapes map with 17 classes derived from aggregating similar ecotypes with similar soils, based on relationships developed from the landscape-relationships analysis using field plot data. We then applied these map classifications to pre-existing mapping for BELA, CAKR, and GAAR, using crosswalks and simple strata definitions to produce region-wide ecotype and soil landscape maps for ARCN. Ecotypes were simplified for some classes where pre-existing mapping was less detailed than mapping for NOAT and KOVA. These maps were limited in extent to a 10-mile buffer created around the boundary of ARCN and the Selawik National Wildlife Refuge.

The most abundant ecotypes in NOAT and KOVA were Alpine Acidic Dryas Dwarf Shrub, Upland Birch–Willow Low Shrub, and Upland Dwarf Birch–Tussock Shrub. In ARCN the corresponding simplified ecotypes were most abundant: Alpine Dryas Dwarf Shrub, Upland Birch–Ericaceous–Willow Low Shrub, and Upland Dwarf Birch–Tussock Shrub. Both for the region-wide mapping and for NOAT and KOVA alone, the most abundant soil landscapes were Upland Loamy Wet Tussock Shrublands, Alpine Rocky Acidic Barrens and Shrublands, and Upland Rocky–Loamy Acidic Low Shrublands , though the alpine class is more prevalent on the ARCN map.

The ecological land survey approach to understanding landscape processes and their influence on ecosystem functions provides three main benefits. First, landscapes are analyzed as ecological systems with functionally related parts, recognizing the importance of geomorphic and hydrologic processes to disturbance regimes, the flow of energy and material, and ecosystem development. This hierarchical approach, which incorporates numerous ecological components into ecotypes with co-varying properties, allows users to partition the variability of a wide range of ecological characteristics. Second, the analysis of vegetation distribution across the landscape is facilitated by developing a spectral database that integrates spectral and field vegetation information for use in satellite image processing. Finally, the linkage of landcover maps to climatic, physiographic, and topographic variables to develop ecosystem maps improves our ability to predict the response of ecosystems to human impacts and facilitates the production of thematic maps for resource management applications and analyses.

Literature Cited

Adler, D. and D. Murdoch. 2008. rgl: 3D visualization device system (OpenGL). R package version 0.81. http://rgl.neoscientists.org

Alaska Division of Geological and Geophysical Surveys (ADGGS). 1983. Engineering geology mapping classification system. Fairbanks, AK. Alaska Division of Geology and Geophysical Surveys. 76 pp.

Alaska Natural Heritage Program (AKNHP). 2007. Rare vascular plant tracking list, April 2007. Alaska Natural Heritage Program, University of Alaska Anchorage, Anchorage, AK. (http://aknhp.uaa.alaska.edu)

Allen, T. E. H., and T. B. Starr. 1982. Hierarchy: perspectives for ecological complexity. University of Chicago;. Chicago, IL.

Anderson, P. M. 1988. Late Quaternary pollen records from the Kobuk and Noatak river drainages, northwestern Alaska. Quaternary Research 29(3): 263–276.

Anderson, P. M., and L. B. Brubaker. 1994. Vegetation history of north-central Alaska: A mapped summary of Late-Quaternary pollen data. Quaternary Science Reviews 13:71–92.

Austin, M. P., and P. C. Heyligers. 1989. Vegetation survey design for conservation: gradsect sampling of forests in northeastern New South Wales. Biological Conservation 50:13–32.

Bailey, R. G. 1996. Ecosystem geography. Springer-Verlag, New York. 199 pp.

———. 1998. Ecoregions: the ecosystem geography of the oceans and continents. Springer, New York.

Barnes, B.V., K. S. Pregitzer, T. A. Spies, and V. H. Spooner. 1982. Ecological forest site classification. Journal of Forestry 80:493–498.

Begét, J. E., D. M. Hopkins, and S. D. Charron. 1996. The largest known maars on Earth, Seward Peninsula, Northwest Alaska . Arctic 49:62–69.

Beikman, H. M. 1980. Geologic map of Alaska. U.S. Geological Survey, Reston, VA.

Binkley, D., F. Suarez, R. Stottlemyer, and B. Caldwell. 1997. Ecosystem development on terraces along the Kugururok River, northwest Alaska. Ecoscience 4: 311–318.

Boggs, K., A. Garibaldi, J. L. Stevens, and T. Helt. 1999. Landsat derived map and landcover descriptions for Gates of the Arctic National Park and Preserve. Natural Resource Technical Report NPS/GAAR/NRTR—1999/001. National Park Service, Fort Collins, Colorado. D-48.

Bohn, H. L., B. L. McNeal, and G. A. O'Connor. 1985. Soil chemistry. Wiley & Sons, New York, NY. 341 pp.

Box, S. E. 1985. Early Cretaceous orogenic belt in northeastern Alaska: internal organization, lateral extent, and tectonic interpretation. Pages 137–145 *in* D. G. Howell, ed., Tectonostratigraphic terranes of the circum-Pacific region. Circum-Pacific Council for Energy and Mineral Resources, Earth Science Series no. 11.

Bradley, R. S. 1999. Paleoclimatology (International Geophysics Series vol . 64). Academic Press, Ltd., New York. 612 pp.

Bray, J. R., and J. T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecological Monographs 27:325 015–349.

Bret-Harte, M. S., M. Sommerkon, G. R. Goldsmith, P. M. Ray, K. D. Tape, L. Sufke, L. S. Brosius, A. W. Balser, K. Rattenbury, A. McCarthy, J. M. Potts, and D. Sanzone. 2007. Obtaining baseline data to assess the potential for tree-line and shrub advance in Gates of the Arctic National Park and Preserve and Noatak National Preserve. Project report to the ARCN, US NPS.

Brigham-Grette, J., and L. D. Carter. 1992. Pliocene marine transgressions of northern Alaska: circumarctic correlations and paleoclimatic interpretations. Arctic 45:78–89.

Brigham-Grette, J., and D. M. Hopkins. 1995. Emergent marine record and paleoclimate of the last Interglaciation along the northwest Alaskan coast. Quaternary Research 43:159–173.

Brosgé, W. P., T. H. Nilsen, T. E. Moore, and T. J. Dutro, Jr. 1988. Geology of the upper Devonian and lower Mississippian (?) Kanayut conglomerate in the central and eastern Brooks Range. Pages 299–316 *in* Geology and exploration of the National Petroleum Reserve in Alaska. U.S. Geological Survey, Washington, DC. Prof. Pap. 1399.

Brown, J., O. J. Ferrians Jr., J. A. Heginbottom, and E. S. Melnikov. 1997. Circum-arctic map of permafrost and ground-ice conditions. U.S. Geological Survey, Washington, DC. Map CP-45.

Chander, G., B. L. Markham, and D. L. Helder. 2009. Summary of current radiometric calibration coefficients for Landsat MSS, TM, ETM+, and EO-1 ALI sensors. Remote Sensing of Environment 113: 893–903.

Cleland, D. T., P. E. Avers, W. H. McNab, M. E. Jensen, R. G. Bailey, T. King, W. E. Russell. 1997. National hierarchical framework of ecological units. Published in, M . S. Boyce and A. Haney, ed. 1997. Ecosystem management applications for sustainable forest and wildlife resources. Yale UniversityPress, New Haven, CT. 181–200 pp.

Colby, Jeffrey D. 1991. Topographic normalization in rugged terrain. Photogrammetric Engineering & Remote Sensing 57 (5): 531–537.

Cooper, D. J., 1983. Arctic-alpine tundra ecosystems of the Arrigetch Creek valley, central Brooks Range, Alaska. Ph.D. thesis. University of Colorado, 2 vols .

Curtis, S. M., I. Ellersieck, C. F. Mayfield, and I. L. Tailleur. 1984. Reconnaissance geologic map of southwestern Micheguk Mountain quadrangle, Alaska. U.S. Geological Survey, Reston, VA. Miscellaneous Investigations Series Map I-1502.

Delcourt, H. R., and P. A. Delcourt. 1988. Quaternary landscape ecology: relevant scales in space and time. Landscape Ecology 2:23–44.

Driscoll, R. S., D. L. Merkel, D. L. Radloff, D. E. Snyder, and J. S. Hagihara. 1984. An ecological land classification framework for the United States. U.S. Dept. of Agriculture, Washington, DC. Misc. Publ. 1439. 56 pp.

Dumoulin, J. A., and A. G. Harris. 1987. Lower Paleozoic carbonate rocks of the Baird Mountains quadrangel, western Brooks Range, Alaska. Pages 311–329 *in* I. Tailleur, and P. Weimer, eds., Alaskan North Slope Geology. Alaska Geological Society, Anchorage, Ak.

Eisner, W. R., and P. A. Colinvaux. 1992. Late Quaternary pollen records from Oil Lake and Feniak Lake, Alaska, USA. Arctic and Alpine Research 24: 56–63.

Elias, S. A., T. D. Hamilton, M. E. Edwards. 1999. Late Pleistocene environments of the western Noatak Basin, northwestern Alaska. Geological Society of America Bulletin 111: 769–789.

Elias, S. E., S. R. Short, and R. L. Phillips. 1992. Paleoecology of late glacial peats from the Bering Land Bridge, Chukchi Shelf region, northwest Alaska. Quaternary Research 38:371–378.

Ellersieck, I., S. M. Curtis, C. F. Mayfield, and I. L. Tailleur. 1984. Reconnaissance geologic map of south-central Misheguk Mountain quadrangle, Alaska. U.S. Geological Survey, Reston, VA. Miscellaneous Investigations Series Map I-1504.

Ellert, B. H., M. J. Clapperton, and D. W. Anderson. 1997. An ecosystem perspective of soil quality. Pages 115–141 *in* E. G. Gregorich, and M. R. Carter, Soil quality for crop production and ecosystem health. Developments in Soil Science, Elsevier Science Publ B V, Sara Burgerhartstraat 25/PO Box 211/1000 AE Amsterdam/Netherlands.

Everett, K. R. 1978. Some effects of oil on the physical and chemical characteristics of wet tundra soils. Arctic 31:260–276.

Fitter, A. H., and R. K. M. Hay. 1987. Environmental physiology of plants. Academic Press, San Diego, CA. 423 pp.

Ford, J., and B. L. Bedford. 1987. The hydrology of Alaskan wetlands, U.S.A.: a review. Arctic and Alpine Research 19:209–229.

Forman, R. T. 1995. Land mosaics: the ecology of landscapes and regions. Cambridge University Press, Cambridge, UK.

Hall, D. K., G. A. Riggs and V. V. Salomonson. 1995. Development of methods for mapping global snow cover using moderate resolution imaging spectroradiometer data. Remote Sensing of Environment 54:127–140.

Hamilton, T. D. 2001. Quaternary glacial, lacustrine, and fluvial interactions in the western Noatak Basin, northwest Alaska. Quaternary Science Reviews 20: 371–391.

———. 1994. Late Cenozoic glaciation in Alaska. Pages 813–844 *in* G. Plafker, and H. C. Berg, eds., The geology of Alaska. The Geological Society of America, Denver, CO. The Geology of North America, Vol. G-1.

Hamilton, T. D., and J. Brigham-Grette. 1991. The last interglaciation in Alaska: stratigraphy and paleoecology of potential sites. Quaternary International 10-12:49–71.

Hammond, T., and J. Yarie. 1996. Spatial prediction of climatic state factor regions in Alaska. Ecoscience 3: 490–501.

Hanson, H. C. 1953. Vegetation types in northwestern Alaska and comparisons with communities in other arctic regions. Ecology 34:111–140.

Heiser, P. A., and D. M. Hopkins. 1995. Landscape development on the coastal plain of the Bering Land Bridge National Park, northwest Alaska. Pages 23 *in* Program and Abstracts, 46th Arctic Division Science Conference, 19–22 Sept. 1995. University of Alaska, Fairbanks, AK.

Höfle. C., and C. L. Ping. 1996. Properties and soil development of late-Pleistocene paleosols from Seward Peninsula, northwest Alaska. Geoderma 71:219–243.

Höfle, C., M. E. Edwards, D. M. Hopkins, D. H. Mann, and C. L. Ping. 1998. The full-glacial environment of the Bering Land Bridge reconstructed from a 18,000 yr old soil on Seward Peninsula, northwest Alaska. Quaternary Research.

Holowaychuk, N., and N. E. Smeck. 1979b. Soils of the Chucki-Imuruk area. Pages 114-192 *in* H. R. Melchior, ed., Biological survey of the Bering Land Bridge National Monument. Alaska Cooperative Park Studies Unit, Univ. of Alaska, Fairbanks, AK. 283 pp.

Hopkins, D. M. 1988. The Espenberg Maars: a record of explosive volcanic activity in the Devil Mtn.-Cape Espenberg, Seward Peninsula, Alaska. Pages 262-321 *in* J. Schaff, ed., The Bering Land National Preserve: an archeological survey. National Park Service, Anchorage, AK.

———. 1982. Aspects of the paleogeography of Beringia during the late Pleistocene. Pages 3–28 *in* D. M. Hopkins, J. V. Matthews Jr., C. E. Schweger, and S. B. Yount, eds., Paleoecology of Beringia. Academic Press, New York.

———. 1973. Sea level history in Beringia during the last 250,000 years. Quaternary Research 3:520– 540.

———. 1967. The Bering Land Bridge. Stanford University Press, Stanford, CA.

———. 1949. Thaw lakes and thaw sinks in the Imuruk Lake area, Seward Peninsula, Alaska. Journal of Geology 57:119–131.

Hopkins, D. M., and J. G. Kidd. 1988. Thaw lake sediments and sedimentary environments. Pages 790– 795 *in* Proc. Fifth Intern. Conf. on Permafrost. TAPIR Publishers, Trondheim, Norway.

Hopkins, D. M., R. Pratt, R. E. Nelson, and C. L. Powell II. 1983. Glacial sequence, southwestern Seward Peninsula. Pages 45–50 *in* R. M. Thorson, and T. D. Hamilton, eds., Glaciation in Alaska, extended abstracts. Univ. of Alaska Museum, Fairbanks, AK.

Hudson, T. 1977. Geology map of Seward Peninsula, Alaska. U.S. Geological Survey, Washington, DC. Open File Rep. 77-796A.

Hultén, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, CA. 1,008 pp.

Jennings, M. D., D. Faber-Langendoen, O. L. Loucks, R. K. Peet, and D. Roberts. 2009. Standards for associations and alliances of the U.S. national vegetation classification. Ecological Monographs 79: 173–199.

Jenny, H. 1941. Factors of soil formation. McGraw-Hill Book Co., New York. 281 pp.

Jordan, J. W. 1988. Erosion characteristics and retreat rates along the north coast of Seward Peninsula. Pages 322–362 *in* J. Schaff, ed., The Bering Land National Preserve: an archeological survey. National Park Service, Anchorage, AK.

Jorgenson, M. T. 2001. Landscape-level mapping of ecological units for the Bering Land Bridge National Preserve. Final Rep. Produced for National Park Service, Anchorage, AK by ABR, Inc., Fairbanks, AK. 45 pp.

———. 2000. Hierarchical organization of ecosystems at multiple spatial scales on the Yukon-Kuskokwim Delta, Alaska. Arctic, Antarctic, and Alpine Research 32: 221–239.

Jorgenson, M. T., and M. Heiner. 2003. Ecosystems of northern Alaska. Unpublished map by The Nature Conservancy, Anchorage, AK.

Jorgenson, M. T., Y. Shur, and H. J. Walker. 1998. Factors affecting evolution of a permafrost dominated landscape on the Colville River Delta, northern Alaska. Pages 523–530 *in* A. G. Lewkowicz, and M. Allard, eds., Proceedings of seventh international permafrost conference. Universite Laval, Sainte- Foy, Quebec.

Jorgenson, M. T., D. K. Swanson, and M. Macander. 2002. Landscape-level mapping of ecological units for the Noatak National Preserve, Alaska. Final Rep. prepared for National Park Service, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 54 pp.

Jorgenson, M. T., J. E. Roth, M. Emers, W. Davis, S. F. Schlentner, and M. J. Macander. 2004. Landcover mapping for Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska. Natural Resource Technical Report NPS/ARCN/NRTR—2004/001. National Park Service, Fort Collins, Colorado. D-41. 129 pp.

Jorgenson, M. T., J. E. Roth, S. F. Schlentner, E. R. Pullman, M. Macander, and C. H. Racine. 2003a. An ecological land survey for Fort Richardson, Alaska. Hanover, NH, U.S. Army Cold Regions .

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

Jorgenson, M. T., J. E. Roth, M. D. Smith, S. Schlentner, W. Lentz, E. R. Pullman, and C. H. Racine. 2001. An ecological land survey for Fort Greely, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory. Tech. Rep. 01-4. 85 pp.

Jorgenson, M. T., J. E. Roth, M. Emers, S. Schlentner, D. K. Swanson, E. Pullman, J. Mitchell, and A. A. Stickney. 2003b. An ecological land survey for the northeast planning area of the National Petroleum Reserve – Alaska, 2002. Final Report prepared for ConocoPhillips, Anchorage, AK, by ABR, Inc., Fairbanks, AK. 128 pp.

Jorgenson, M. T., J. E. Roth, E. R. Pullman, R. M. Burgess, M. Raynolds, A. A. Stickney, M. D. Smith, and T. Zimmer. 1997. An ecological land survey for the Colville River Delta, Alaska, 1996. Unpubl. Rep. prepared for ARCO Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK. 160 pp.

Jorgenson, M. T., J. E. Roth, P. F. Loomis, E. R. Pullman, T. C. Cater, M. S. Duffy, W. A. Davis, M. J. Macander, and J. Grunblatt. 2008. An ecological land survey for landcover mapping of Wrangell-St. Elias National Park and Preserve. Natural Resource Technical Report NPS/WRST/NRTR—2008/094. National Park Service, Fort Collins, Colorado. D-100.

Jorgenson, M.T., K. Yoshikawa, M. Kaveskiy, Y. L. Shur, V. Romanovsky, S. Marchenko, G. Grosse, J. Brown, and B. Jones. Permafrost characteristics of Alaska. Kane, D. and Hinkel K. 2008b. Proceedings Ninth International Conference on Permafrost, Fairbanks, AK. Fairbanks, AK, University of Alaska. 121–122 pp.

Jorgenson, M. T., J. E. Roth, P. F. Miller, M. J. Macander, M. S. Duffy, E. R. Pullman, E. A. Miller, L.B. Attanas, A. F. Wells, and S. Talbot. 2009. An ecological land survey and landcover map of the Selawik National Wildlife Refuge. In prep. for U.S. Fish and Wildlife Service, Kotzebue, AK, by ABR, Inc., Fairbanks, AK.

Kane, D. L., L. D. Hinzman, M. Woo, and K. R. Everett. 1992. Arctic hydrology and climate change. Pages 35–58 *in* Arctic ecosystems in a changing climate. Academic Press, San Diego, CA. 469 pp.

Karl, S. M., and C. L. Long. 1990. Folded Brookian thrust faults: implications of three geologic/geophysical transects in the western Brooks Range, Alaska. Journal of Geophysical Research 95:8581–8592.

Karl, S. M., J. A. Dumoulin, I. Ellersieck, A. G. Harris, and J. M. Schmidt. 1989. Preliminary geologic map of the Baird Mountains quadrangle, Alaska. Open-File Report 89-551, U.S. Geological Survey, Menlo Park, CA.

Kaufman, D. S., and D. M. Hopkins. 1986. Glacial history of the Seward Peninsula. Pages 51–77 *in* T. D. Hamilton, K. M. Reed and R. M. Thorson, eds., Glaciation in Alaska: the geologic record. Alaska Geological Society, Anchorage, AK.

Kaufman, D. S., R. C. Walter, J. Brigham-Grette, and D. M. Kopkins. 1991. Middle Pleistocene age of the Nome River glaciation, northwestern Alaska. Quaternary Research 36:277–293.

Kidd, J. G. 1990. The effect of thaw-lake development on the deposition and preservation of plant macrofossils–a comparison with the local vegetation. Univ. of Alaska, Fairbanks. M.S. Thesis. 48 pp.

Klijn, F., and H. A. Udo de Haes. 1994. A hierarchical approach to ecosystem and its implication for ecological land classification. Landscape Ecology 9:89–104.

Kreig, R. A., and Reger, R. D. 1982. Air-photo analysis and summary of landform soil properties along the route of the trans-Alaska pipeline system. Alaska Div. of Geological and Geophysical Surveys.

Kruskal, J. B. 1964a. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika. 29:1–27.

———. 1964b. Nonmetric multidimensional scaling: a numerical method. Psychometrika. 29: 115–129.

Lee, C., and E. Choi. 2000. Bayes error of the Gaussian ML classifier. IEEE Transactions on Geoscience and Remote Sensing 38 (3):1471–1475.

Lu, Dengsheng, Hongli Ge, Shizhen He, Aijun Xu, Guomo Zhou, and Huaqiang Du. 2008. Pixel-based Minnaert correction method for reducing topographic effects on a Landsat ETM+ Image. Photogrammetric Engineering & Remote Sensing 74 (11):1343–1350.

Mann, D. H., and T. D. Hamilton. 1995. Late-Pleistocene and Holocene paleoenvironments of the North Pacific coast. Quaternary Science Review 14:449–471.

Mason, O. K., and J. W. Jordan. 1991. A proxy late Holocene climate record deduced from NW Alaska beach ridges. Pages 649–657 *in* G.Weller et al., eds., Proceedings, international conference on the role of the polar regions in global change. Geophysical Institute, University of Alaska, Fairbanks, AK.

Mason, O. K., D. M. Hopkins, and L. Plug. 1997. Chronology and paleoclimate of storm-induced erosion and episodic dune growth across Cape Espenberg Spit, Alaska, U.S.A. Journal of Coastal Research 13:770–797.

Mason, O. K., J. W. Jordan, and L. Plug. 1995. Late Holocene storm and sea-level history in the Chukchi Sea. Journal of Coastal Research Special Issue No. 17:173–180.

Matthews Jr., J. V. 1974. Quaternary environments at Cape Deceit (Seward Peninsula, Alaska): Evolution of a tundra ecosystem. Geol. Soc. Amer. Bull. 85:1353–1384.

Mayfield, C. F., I. L. Tailleur, and I. Ellersieck. 1983. Stratigraphy, structure, and palispastic synthesis of the western Brooks Range, northwestern Alaska. Pages 143–186 *in* Geology and exploration of the national petroleum reserve in Alaska. U.S. Geological Survey, Washington, DC. Prof. Pap. 1399.

Mayfield, C. F., S. M. Curtis, I. Ellersieck, and I. L. Tailleur. 1984. Reconnaissance geologic map of southeastern Misheguk Mountain quadrangle, Alaska. U.S. Geological Survey, Denver, CO. Miscellaneous Investigations Series Map I-1503.

McCullough, D. S. 1967. Quaternary geology of the Alaskan shore of Chuckchi Sea. Pages 91–120 *in* D. M. Hopkins, ed., The Bering land bridge. Stanford University Press, Stanford, CA.

McCulloch, D. S., and D. M. Hopkins. 1966. Evidence for a warm interval 10,000 to 8,300 years ago in northwestern Alaska. Geol. Soc. Amer. Bull. 77:1089–1108.

Melchior, H. R. 1979. Mining, reindeer, climate, and fire: major historical factors affecting the Chucki-Imuruk environment. Pages 10–23 *in* H. R. Melchior, ed., Biological survey of the Bering Land Bridge National Monument. Alaska Cooperative Park Studies Unit, University of Alaska Fairbanks, Fairbanks, AK. 283 pp.

Moore, T. E. 1992. The Arctic Alaska superterrane. U.S. Geological Survey Bulletin 2041:238–244.

Moore, T. E., W. K. Wallace, K. J. Bird, S. M. Karl, C. G. Mull, and J. T. Dillon. 1994. Geology of northern Alaska. Pages 49–140 *in* G. Plafker, and H. C. Berg, eds., The geology of Alaska. The Geological Society of America, Denver, CO. The Geology of North America, Vol. G-1.

Mueller-Dombois, D., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York, NY. 547 pp.

Mull, C. G. 1982. The tectonic evolution and structural style of the Brooks Range, Alaska: an illustrated summary. Pages 1–45 in R. B. Powers, ed., Geological studies of the Cordilleran thrust belt. Rocky Mountain Association of Geologists, Denver, CO. Vol. 1.

Naidu, A. S., and G. Gardner. 1988. Marine geology. Pages 11–28 *in* M. J. Hameedi, and A. S. Naidu, eds., The environment and resources of the southeastern Chukchi Sea. Mineral Management Service Service, Anchorage, AK. OCSEAP Study 87-0113.

National Park Service (NPS). 2005. Alaska region National Park Service FirePro vegetation dataset. Alaska Regional Office, Anchorage, Alaska.

Natural Resource Conservation Service (NRCS). 2003. Keys to soil taxonomy. Ninth Edition. Washington, D.C., U.S. Department of Agriculture.

Nelson, S. W., and W. H. Nelson. 1982. Geology of the Siniktanneyak Mountain ophiolite, Howard Pass quadrangle, Alaska. Reston, VA: U.S. Geological Survey. Misc. Field Studies Map MF-1441.

Nowacki, G., P. Spencer, T. Brock, M. Fleming, and T. Jorgenson. 2002. Ecoregions of Alaska and neighboring territories. U.S. Geological Survey, Washington, D.C. Open File Rep. 02-297 (map)

Oberbauer, S. F., S. J. Hastings, J. L. Beyers, and W. C. Oechel. 1989. Comparative effects of downslope water and nutrient movement of plant nutrition, photosynthesis, and growth in Alaskan tundra. Holarctic Ecology 12:324–334.

Oksanen, J., R. Kindt, P. Legendre, B. O'Hara, G. L. Simpson, P. Solymos, M. Henry, H. Stevens, and H. Wagner. 2008. Vegan: community ecology package. R package version 1.15-0. http://cran.r-project.org/, http://vegan.r-forge.r-project.org/

O'Neil, R. V., D. L. DeAngelis, J. B. Waide, and T. F. H. Allen. 1986. A hierarchical concept of ecosystems. Princeton Univ. Press, Princeton, NJ.

Overpeck, J., K. Hughen, D. Hardy, R. Bradley, R. Case, M. Douglas, B. Finney, K. Gajewski, G. Jacoby, and others. 1997. Arctic environmental change of the last four centuries. Science 278:1251–1256.

Parker, C. L. 2006. Vascular plant inventory of Alaska's arctic national parklands; Bering Land Bridge NP, Cape Krusenstern NM, Gates of the Arctic NPP, Kobuk Valley NP, and Noatak NP. Tech. Rep. NPS/AKRARCN/NRTR-2006/01. 142 pp.

Patterson III, W. A., and J. G. Dennis. 1981. Tussock replacement as a means of stabilizing fire breaks in tundra vegetation. Arctic 34:188–189.

Péwé, T. L. 1975. Quaternary geology of Alaska. U.S. Geological Survey, Geol. Surv. Prof. Pap. 835. 145 pp.

Pickett, S.T., J. Kolasa, J. J. Armesto, and S. L. Collins. 1989. The ecological concept of disturbance and its expression at various hierarchical levels. Oikos 54:129–136.

Ping, C. L., J. G. Bockheim, J. M. Kimble, and G. J. Walker D. A. Michaelson. 1998. Characteristics of cryogenic soils along a latitudinal transect in arctic Alaska. Journal of Geophysical Research. 103(D22): 28,917–28,928.

R Development Core Team. 2008. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Racine, C. H. 1981. Tundra fire effects on soils and three plant communities along a hill-slope gradient in the Seward Peninsula, Alaska. Arctic 34:71–84.

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

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

Rendig, V. V., and H. M. Taylor. 1989. Principles of soil-plant interrelationships. McGraw-Hill, New York. 275 pp.

Roberts, D.W. 2007. labdsv: ordination and multivariate analysis for ecology. R package version 1.3-1. http://ecology.msu.montana.edu/labdsv/R

Rupp, T. S., F. S. Chapin III, and A. M. Starfield. 2001. Modeling the influence of topographic barriers on treeline advance at the forest-tundra ecotone in northwestern Alaska. Climatic Change 48: 399–416.

Sainsbury, C. L. 1972. Geologic map of the Teller Quadrangle, Western Seward Peninsula, Alaska. U.S. Geological Survey, Washington, D.C. Map I-685. 4 pp. plus map.

———. 1967. Quaternary geology of Western Seward Peninsula. Pages 121–143 *in* D. M. Hopkins, ed., The Bering Land Bridge. Stanford University Press, Stanford, CA.

Schoeneberger, P. L., P. A. Wysocki, E. C. Benham, and W. D. Broderson. 1998. Fieldbook for describing and sampling soils. National Soil Survey Center, Natural Resource Conservation Service, U.S. Dept. of Agriculture, Lincoln, NE.

Shepard, R. N. 1962a. The analysis proximities: multidimensional scaling with an unknown distance function, I. Psychometrika. 27:125–140.

———. 1962b. The analysis proximities: multidimensional scaling with an unknown distance function, II. Psychometrika. 27: 219–246.

Smith, P. S. 1933. Geographic and geologic evidence relating to the connection of Siberia and northwestern Alaska. Pages 753–758 *in* 5th Pacific Science Congress, Canada 1933, Proceedings. Vol. 1.

———. 1912. Glaciation in northwestern Alaska. Geol. Soc. of Amer. Bulletin 23: 563–570.

Soil Survey Staff (SSS). 2003. Keys to soil taxonomy, ninth edition. U.S. Department of Agriculture, Washington, D.C.

Suarez, F., D. Binkley, M.W. Kaye, and R. Stottlemyer. 1999. Expansion of forest stands into tundra in the Noatak National Preserve, northwest Alaska. Écoscience 6: 465–470.

Swanson, D. K. 2001. Ecological units of Cape Krusenstern National Monument, Alaska. Fairbanks, AK: National Park Service.

———. 1995. Landscape ecosystems of the Kobuk Preserve Unit: Gates of the Arctic National Park, Alaska. Technical Report, NPS/ARRNR/NRTR-95/22U.S. National Park Service. Alaska Regional Office, Anchorage, AK. 291 pp.

Swanson, F. J., T. K. Kratz, N. Caine, and R. G. Woodmansee. 1988. Landform effects on ecosystem patterns and processes. Bioscience 38:92–98.

Thenhaus, P. C., J. I. Zion, W. H. Diment, M. G. Hopper, D. M. Perkins, S. L. Hanson, and S. T. Aigermissen. 1982. Probalistic estimates of maximum seismic horizontal ground motion on rock in Alaska and the adjacent outer continental shelf. Pages 5–8 *in* U.S. Geological Survey in Alaska: Accomplishments during 1980. U.S. Geological Survey, Washington, D.C. USGS Circular 844.

Till, A. B., and J. A. Dumoulin. 1994. Geology of Seward Peninsula and Saint Lawrence Island. Pages 141–152 in Plafker, G. and Berg, H. C., eds., The geology of Alaska. The Geology of North America, Vol. G-1. The Geological Society of America, Denver, CO.

Till, A. B., J. A. Dumoulin, B. M. Gamble, D. S. Kaufman, and P. I. Carroll. 1986. U.S. Geological Survey, Washington, D.C. Open-File Rep. 86-276. 8 pp., plus maps.

Tolson, R. B. 1987. Structure and stratigraphy of the Hope Basin, southern Chukchi Sea, Alaska. Pages 59–71 *in* D. W. Scholl et al., eds. Geology and resource potential of the continental margin of western North America and adjacent ocean basins—Beaufort Sea to Baja, California. Circum-Pacific Council for Energy and Minerals, Houston, TX. Earth Science Series, Vol. 6.

Ugolini, F. C., and J. Walters. 1974. Pedological survey of the Noatak River Valley, Alaska. Pages 86–157 *in* S. B. Young, ed., The environment of the Noatak River Basin, Alaska: results of the center for northern studies biological survey of the Noatak River Valley, 1973. Center for Northern Studies, Wolcott, VT.

United States Department of Agriculture (USDA). 2008. The PLANTS database. National Plant Data Center, Baton Rouge, LA. (http://plants.usda.gov).

United States Geological Survey (USGS). 2006. Multi-resolution land characteristics 2001 (MRLC2001) image preprocessing procedure. Revised January 9, 2006. Website: http://landcover.usgs.gov/pdf/image_preprocessing.pdf.

Van Cleve, K., F. S. Chapin III, C. T. Cyrness, and L. A. Viereck. 1990. Element cycling in taiga forests: state-factor control. Bioscience 41:78–88.

Vegetation Subcommittee (VS). 2008. National vegetation classification standard, version 2. Federal Geographic Data Committee, Secretariat, U.S. Geological Survey. Reston, VA. , Washington, D.C. FGDC-STD-005-2008 (Version 2) 126 pp.

Viereck, L. A., and E. L. Little. 1972. Alaska trees and shrubs. U.S. Government Printing Office, Washington, D.C.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. Pacific Northwest Research Station, U.S. Forest Service, Portland, OR. Gen. Tech. Rep. PNW-GTR-286. 278 pp.

Vitousek, P. M. 1994. Factors controlling ecosystem structure and function. Pages 87–97 *in* R. Amundsen, J. Harden, and M. Singer, eds., Factors of soil formation: a fiftieth anniversary retrospective. Soil Science Society of America, Madison, WI.

Wahrhaftig, C. 1965. Physiographic divisions of Alaska. U.S. Geological Survey, Waqshington, D.C. Professional Paper 482. 52 pp., 6 pl.

Walker, D. A. 1999. An integrated vegetation mapping approach for northern Alaska (1:4 M scale). Int. Journ. Remote Sensing 20:2895–2920.

———. 1983. A hierarchical tundra vegetation classification especially designed for mapping in northern Alaska. Pages 1332-1337 in Permafrost Fourth International Conference Proceedings. National Academy Press Washington, D.C.

———. 1981. The vegetation and environmental gradients of the Prudhoe Bay region, Alaska. University of Colorado, Boulder, Colorado.

Walker, D. A., and M. D. Walker. 1991. History and pattern of disturbance in Alaskan arctic terrestrial ecosystems: a hierarchical approach to analyzing landscape change. J. Appl. Ecol. 28:244–276.

Walker, D. A., K. R. Everett, P. J. Webber, and J. Brown. 1980. Geobotanical atlas of the Prudhoe Bay region, Alaska. U.S. Army Corps of Engineers Cold Regions Research and Engineering, Hanover, NH. Laboratory Report 80-14. 69 pp.

Walker, D. A., W. A Gould, H. A. Meier, and M. K. Raynolds. 2002. The circumpolar arctic vegetation map. International Journal of Remote Sensing. 23:2552–2570.

Walker, M. D., D. A. Walker, and N. A. Auerbach. 1994. Plant communities of a tussock tundra landscape in the Brooks Range foothills, Alaska. Journal of Veg. Sci. 5:843–866.

Walker, M. D., D. A. Walker, and K. A. Everett. 1989. Wetland soils and vegetation, arctic foothills, Alaska. U.S. Fish and Wildlife Service, Wash., D.C. Biol. Rep. 89 (7). 89 pp.

Walter, H. 1979. Vegetation of the Earth, and ecological systems of the geobiosphere. Springer-Verlag, New York. 274 pp.

Washburn, A. L. 1973. Periglacial processes and environments. Edward Arnold, London. 320 pp. Watt, A. S. 1947. pattern and process in the plant community. Journal of Ecology 35:1–22.

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

Wiken, E. B. 1981. Ecological land classification: analysis and methodologies. Ottawa, Canada, Lands Directorate, Environment Canada.

Wiken, E. B., and G. Ironside. 1977. The development of ecological (biophysical) land classification in Canada. Landscape Planning 4:273–275.

Western Regional Climate Center (WRCC). 2001. Alaska climate summaries. Western Regional Climate Center, Desert Research Institute, Reno, NV. (Website (http://www.wrcc.dri.edu/summary/climsmak.html).

Young, S. B., ed. 1974. The Environment of the Noatak River Basin, Alaska. Center for Northern Studies, Wolcott, VT. 584 pp.

Appendix 1. Coding system for characterizing ecological characteristics of field plots.

TERRAIN UNITS

Bxw	**Bedrock, weathered (undiffer.)**
If	Intrusive-felsic
Ii	Intrusive-intermediate
Im	Intrusive-mafic
Iu	Intrusive ultra mafic
Vfy	Volcanic-felsic-younger
Vfo	Volcanic-felsic-older
Viy	Volcanic-intermediate, younger
Vio	Volcanic-intermediate, older
Vmy	Volcanic-mafic-younger
Vmo	Volcanic-mafic-older
Vp	Volcanic-pyroclastics
Sc	Sedimentary, carbonate
Sn	Sedimentary, noncarbonate
Nc	Metamorphic-carbonate
Nn	Metamorphic-noncarbonate
C	**Colluvial Deposits**
Ch	Hillslope Colluvium
Cl	Landslide Deposit
Cs	Solifluction Deposits
Ct	Talus
Ell	**Lowland Loess**
Elu	Upland Loess
Esa	Eolian Active Sand
Esi	Eolian Inactive Sand
Fdr	**Delta Channel Deposit**
Fdo	Delta Overbank Deposit
Fmrac	**Meand Coarse Active Channel**
Fmric	Meand Coarse Inactv Chan. Dep.
Fmraf	Meander Fine Active Chan Dep.
Fmrif	Meander Fine Inactive Chan Dep.
Fmo	Meander Overbank Deposit
Fmoa	Meander Active Overbank Dep
Fmoi	Meander Inactive Overbank Dep
Fmob	Mean. Abandoned Overbank Dep
Fbrac	**Braided Coarse Active Chanl**
Fbric	Braided Coarse Inact. ChanDep.
Fboa	Braided Active Overbank Deposit
Fboi	Braided Inactive Overbank Dep
Fbob	Braided Abandoned Ovrbank Dep
Fhl	**Headwater Lowland Floodplain**
Fhm	Mod Steep Headwater Fldplain
Fhmo	Mod Steep Headwtr Overbnk Dep
Fto	**Old Terrace** (lower terraces)
Ff	**Alluvial Fan**
Ffi	Alluvial Fan Inactive Deposit
Ffb	Alluvial Fan Abandoned Deposit
Gmo	**Older Moraine**
Gmy	Younger Moraine
Gto	Older Till Sheet
Gty	Younger Till Sheet
GFo	**Glaciofluvial Outwash**
GFoo	Glacfluvial Outwsh, Older
GFk	Kame Deposits
GFt	Glacflvl Outwsh, Terrace
GL	**Glaciolacustrine Deposits**
L	**LACUSTRINE DEPOSITS**
Ldnc	**Drained Basin, Ice-poor center**
Ldnm	Drained Basin, Ice-poor margin
Ldnu	Drained basin, Ice-poor undiff
Ldic	Drained Basin, Ice-rich center
Ldim	Drained Basin, Ice-rich margin
Ldiu	Drained basin, Ice-rich undiff
Ldip	Drained Basin Pngo
Of	**Organic Fens (0rg >40cm)**
Ob	Bogs
Wrhm	**Mountain Headwater Stream**
Wrln	Lower Perennial, non-glacial
Wrlg	Lower Perennial, glacial
Wrun	Upper Perennial, Non-glacial
Wrug	Upper Perennial, Glacial
Wldc	**Deep Connected Lake**
Wldcm	Deep Connected Lake, Morainal
Wldir	Deep Isolated Lake, Riverine
Wldit	Deep Isolated Lake, Thaw
Wldim	Deep Isolated Lake, Morainal
Wlsc	Shallow Connected Lake
Wlscv	Shallow Connected Beaver Pnd
Wlsi	Shallow Isolated Lake
Wlsir	Shallow Isolated Lake, Riverine
Wlsit	Shallow Isolated Lake, Thaw
Wlsim	Shallow Iso Lake, Morainal

MACROTOPOGRAPHY:

C	**Top, Crest, Summit Or Ridge**
Fh	**Plateau (High Flats)**
Fpp	Permafrost Plateau
Sh	**Shoulder Slope**
Steep Slopes	
Sb	Bluff or Bank (unconsolidated)
Sbs	Steep bluff south facing
Sc	Cliff (rocky)
Su	**UPPER SLOPE** (convex, creep)
Suc	Concave (water gathering)
Suv	Convex (water shedding)
Suvs	Convex, south-facing
Sup	Plane
Sl	**LOWER SLOPE** (concave)
Slc	Concave (water gathering)
Slch	Nivation hollows, Snowbanks,
Slv	Convex (water shedding)
Slp	Plane
T	**TOE Slope**
D	**Drainage** or Water Track
B	**BASINS OR DEPRESSIONS**
Bd	Drained Basin
Bk	Kettle
F	**FLAT/FLUVIAL RELATED**
Fn	Nonpatterned
Fm	Flats margins (transition)
Fc	Channel, swale or gut,
Fi	Interfluv or flat bank
Fl	Levee
Fb	Bar (undifferentiated)
Fbp	Point Bar
Fs	Crevasse splay
Ft	Terrace
Ff	Flood Basin (behind levee)
W	**WATERBODIES**
Wi	Islands Present
Lm	Lake Margins
Lb	Wave cut bench (shore)
R	**RIVER OR STREAM**
Rp	Deep Pools (>1.5 m)
Rs	Shallow Runs (<1.5 m)
Ri	Riffles,
Rr	Rapids
XC	**CHANNEL COMPLEX**
Xp	Pingo
Xm	Morraine Complx, undulating
E	**Eolian Patterns**
H	**Human modified**

MICROTOPOGRAPHY:

N	**NONPATTERNED**
FROST FEATURES	
Fh	Hummocks (mineral cored)
Fr	Reticulate
Ff	Frost Scars and Boils
Fc	Circles (non-sorted, sorted)
Fs	Stripes (non-sorted, sorted)
Fn	Nets (non-sorted, sorted)
Ft	Steps (non-sorted, sorted)
MOUNDS (ice and peat related)	
Mi	Ice-cored mounds
Mpm	Peat mounds
Ms	String (strang)
Mg	Gelifluction lobes (saturated flow)
Mrb	Rocks, Blockfields
Mrm	Rocky Mounds/Outcrops
Mrs	Soil covered rocks
Mw	Mounds caused by wildlife
Ml	Tree mounds (dwnd logs/root balls)
Mu	Undifferentiated mounds (distinct)
DRAINAGE or EROSION RELATED	
Dt	Water tracks (non-incised)
Dr	Ripples
Dc	Riverbed cobbles, boulders
Ds	Scour channels-ridges
EOLIAN RELATED	
Es	Small dune
POLYGONS (ice aggradation)	
Pd	Disjunct polygon rims
Phh	High-centered polygons, high-relief
Phl	High-centered polygons, low-relief (and flat centered)
Plll	Low-center., Low relief, low-dens.
Tm	Mixed pits and polygons
W	**WATER**
Wi	Islands present
Lp	Polygonized margin (>10%)

ECOTYPE VEG STRUCT Code:

BP	barrens or Partially vegetated
FA	Aquatic Forb
SE	Sedge Emergent (Marsh)
GE	Graminoid Emergent (Marsh)
FE	Forb Emergent (Marsh)
SM	Sedge Meadow
GM	Grass Meadow
FM	Forb Meadow
TM	Tussock Meadow
KM	Salt-killed Meadow
DS	dwarf scrub (<20cm)
LS	low scrub (20–150cm)
TS	tall scrub (>150cm)
BF	broadleaf forest
MF	mixed forest
NF	needleleaf forest
RW	River (flowing water)
LW	Lake (still water)
CW	Coastal (saline)

VEGETATION CLASSES (IV):

Bbg	Barrens (<5% veg)
Bpv	Partially Vegetated (5–30)
Fbcb	Closed Paper Birch Forest
Fbcba	Closed Paper Birch-Aspen Forest
Fboa	Open Quaking Aspen Forest
Fbob	Open Paper Birch Forest
Fbop	Open Balsam Poplar Forest
Fbwb	Paper Birch Woodland
Fbwp	Balsam Poplar Woodland
Fbwt	Broadleaf–Tall Scrub Woodland
Fmcas	Closed Quaking Aspen-Spruce
Fmcsb	Closed Spruce-Paper Birch Forest
Fmoas	Open Quaking Aspen-Spruce
Fmosb	Open Spruce-Paper Birch Forest
Fmosp	Open Spruce-Balsam Poplar
Fncbs	Closed Black Spruce
Fnobs	Open Black Spruce Forest
Fnows	Open White Spruce Forest
Fnwbs	Black Spruce Woodland
Fnwws	White Spruce Woodland
Sfobs	Open Dwarf Black Spruce
Sfows	Open Dwarf White Spruce
Hafm	Common Marestail
Hafp	Fresh Pondweed
Hbbd	Dry Bryophyte
Hbl	Lichen
Hfmm	Mixed Herbs
Hfwhb	Subarc Lowlnd Herb Bog Mead.
Hgmb	Bluejoint Meadow
Hgmbh	Bluejoint-Herb
Hgmbs	Bluejoint-Shrub
Hgmsd	Moist Sedge-Dryas Tundra
Hgmsgt	Moist Sedge-Grass .Tundra
Hgmss	Moist Sedge-Shrub Tundra
Hgmswt	Moist Sedge-Willow Tundra
Hgmt	Tussock Tundra
Hgwfg	Fresh Grass Marsh
Hgwfs	Fresh Sedge Marsh
Hgwsb	Subarc Lowlnd Sedge Bog Mead
Hgwsbt	Wet Sedge-Birch Tundra
Hgwsl	Subarc Lowlnd Sedge Wet Mead
Hgwsmb	Sub Lowl Sedge-Moss Bog Mea
Hgwss	Sub Lowl Sedge-Shrub Wet Mead
Hgwst	Wet Sedge Meadow Tundra
Hgwswt	Wet Sedge-Willow Tundra
Sddf	Dryas-Forb Dwarf Shrub Tundra
Sddl	Dryas-Lichen Dwarf Shrb Tundra
Sdds	Dryas-Sedge Dwarf Shrub Tundra
Sddt	Dryas Dwarf Shrub Tundra
Sdeb	Bearberry Dwarf Shrub Tundra
Sdec	Cassiope Dwarf Shrub Tundra
Sdee	Crowberry Dwarf Shrub Tundra
Sdel	Ericaceous-Lichen Dwf ShrbTund
Sdet	Ericaceous Dwarf Shrub Tundra
Sdev	Vaccinium Dwarf Shrub Tundra
Sdwt	Willow Dwarf Shrub Tundra
Slcb	Closed Low Shrub Birch
Slcbe	Closed Shrub Birch-Ericaceous
Slcbw	Closed Low Shrub Birch-Willow
Slce	Closed Low Ericaceous Shrub
Slcw	Closed Low Willow
Sloaw	Open Low Alder-Willow
Slobb	Open Shrub Birch-Eric Shrb Bog
Slobe	Open Mesic Shrub Birch-Ericac
Slobw	Open Low Shrub Birch-Willow
Slocg	Open Sweetgale-Graminoid Bog
Sloe	Open Low Ericaceous Shrub
Sloeb	Open Low Ericaceous Shrub Bog
Slol	Open Low Silverberry Shrub
Slotb	Open Mixed Shrub Tussock Bog
Slott	Open Mixed Shrub Tussk Tundra
Slow	Open Low Willow
Stca	Closed Tall Alder
Stcaw	Closed Tall Alder-Willow
Stcbw	Closed Tall Shrub Birch-Willow
Stcw	Closed Tall Willow
Stoa	Open Tall Alder
Stoaw	Open Tall Alder-Willow
Stow	Open Tall Willow
W	Water
nd	no data

DISTURBANCE CLASS LEV2

A	**ABSENT (mature vegetation)**
N	**Naturally occurring**
Nf	Fire
Ng	Geomorphic Process
Nw	Weather Processes (e.g. wind)
H	**Human generated**
Hd	Human Developed Sites (urban complex)
Hf	Fill
He	Excavation/Pits (undifferentiated)
Hc	Clearings (Non-agricultural or undifferentiated)
Ha	Agricultural Field
Ht	Trail
Hs	Structures and Debris
Hw	Waterbodies, Man-made
Hp	Pollutants/Contaminants
DC	Disturbance complex
nd	no data

ENVIRONMENTAL PLOT DATA
NoData=999
PLotID: Unique Identifier
Date: mm/dd/yy (ck)
Observers: Initials of Observer
Plot Photos: Camera Name
(Photos:verticle, oblique, soil)
GeogLandMark: river, mountain, etc
PinPrick: enter "y" after marked
PlotRadius(m): Usually 10
Physiography:
A Alpine
S Subalpine
U Upland
L Lowland
G Glacial
P Lacustrine (ponded)
R Riverine
C Coastal
H Human
SurfGeomorph: see Terrain Unit codes
SubGeomorph: see Terrain Unit codes
Slope(deg):
Aspect(deg):
Macrotopography: see codes
Microtopog: see codes
Microrelief (cm):
NWI Water Regime:
U Upland
Ts Subtidal
Te Irregularly exposed
Tr Regularly flooded
Ti Irregularly flooded
Np Permanently flooded
Nei Intermittently exposed
Nsp Semipermanently flooded
Nse Seasonally flooded
Nsa Saturated (S)
Nt Temporarily flooded
Ni Intermittently flooded
Na Artificially flooded
WaterDep: (+/-, or >pit depth)
A/B soilSurf : water above or below
Saturat<30: y,n,u (unknown)
WaterPH: to 0.1 pH units
WaterEC: (uS/cm)
Drainage:
E Excessively drained
Es Somewhat excess. drained
W Well drained
Wm Moderately well drained
Ps Somewhat poorly drained
P Poorly drained
Pv Very poorly drained
F Flooded
SoilMoist: Dry, **M**oist, **W**et (field cap. to sat.), **A**quatic (>10cm, perm water)
LowMottDep: depth cm to chr=2 or less
LowMatrDepth: depth cm to chr=1, no mottling, full gley
HydricSoil: y, n, u (unknown)
Permfrst: y, n, u (unknown)

Drained Depth (cm):
CryoTurb: **P**resent, **A**bsent, unknown
SurfOrg: depth of top Org layer (cm)
CumOrg40: total org in top 40
Loess Thick (cm): eolian silt thickness
DomMineral40: dominant mineral text. in top 40 cm
K Blocky (angular, >76 mm, >15%)
B Boldery (rounded, >76 mm, >15%)
R Rubbly (angl, 15-60% , 2-76 mm)
G Gravelly (rounded, 15-60%, 2-76 mm)
S Sandy (grSa to l Sa; <15% gravel)
L Loamy (CL to SL)
C Clayey (SC to C)
P Peat (if no mineral, ~40 cm thick)
DomText40: dominant text. top 40cm, as above, + O = organic (<40cm thick)
Frost Boils (%):
SurfaceFrag: coarse frags on soil surf (%)
RockDepth: depth to coarse frags >15%
RootDepth: cm, dep. to common rt (1-5/cm² for fine (1-2 mm); 1-5/dm² for medium (2-5 mm); >5/m² for coarse
SoilPH10: to 0.1 units in paste (10 cm)
SoilPH30: to 0.1 units in paste (30 cm)
SoilEC: uS/cm from paste (10cm)
Soil Strat: form done? (y/n/u)
SampMeth (Sampling Method):
Pit p**L**ug **A**uger
Corer bank **E**xposure
Surface **M**etal probe
LM plug + probe **LA** plug + auger
MaxObsDepth: Max depth plug/probe
SoilClass: NRCS 9th ed
Veg Completeness: Complete, **P**artial , **D**ominants only, **nd**
VegClass4: Viereck Level IV
AltVeg: cutpoint veg class, if applicable
EcoType: sequencial coding for Physiograph, DomTex40, SoilMoist, Soil Chemisty (circumneut pH=5.6-7.3, brackish (e)>800uS), Veg Structure
DstbClass2: Disturbance Class, see codes
GPS X-Y-Z: enter UTM, verifies data
NOTES: record codes not on drop lists
SOIL PROFILE FORM
Lithofacies:
B Blocky (angular>380 mm, >60%)
R Rubble (angular, 2-380 mm, >60%)
S Stony (rounded, >250 mm, >60%)
Gm Gravel (rounded, massive, >60%)
Gfm Gravel, with fine, massive,15-60%
Gsm Gravel, with sand, massive
Gl Gravel (2-250 mm), layered
Sm Sands, massive
Si Sands, inclined
Sl Sands, layerd
Soi Sands with org, inclined
Sr Sands, rippled
Sor – sands with org, inclined
Sgm Sands w/tr gravel, massive
Sgmt Sands w/tr gravel, turbated
Om Organic, massive
Ol Organic, layered (> 10% organic)
Olt Organic, layered, turbated
Oa Organic, limnic
Fm Fines massive
Fom Fines with organics, massive
Fomt Fines with organics, massive, turbated
Fgm Fines w/tr gravel (tr-15% gravel)
Fl Fines, layered
Fr Fines, rippled
For Fines with organics, rippled
Fcm Fines with clay, massive
Fcl Fines with clay, layered
Fa Fines with algae, limnic
TopDepth; cm from surf (exc live moss)
BotDepth: cm
Horizon: used NRCS codes
Master horizon:O, A, AB, AE, A/B, A/E,A/C, AC, E, E/A, BA B, BC, B/C, C, L, W, R,
Horizon suffixes
a, b, c, co, d, di, e, f, ff, g, h, i, j, jj, k, m, ma, n, o, p, q, r, s, ss, t, v, w, y, z,

Boundary: (combine, e.g. As)
Distinctness:
Abrupt (<2 cm); **C**lear (2–5 cm)
Gradual (5–15 cm) **D**iffuse (>15 cm)
Topography:
Smooth **W**avy
Irregular (deeper than wide) **B**roken
Coarse fragment content class:
Combine content + size (sgr, xby)
0%, no crs frag modifier
s trace to 15 % (grssil)
15 to 35 %; no content modifier
v 35 to 60 % (cbssil)
x 60-90 % (grxSiL)
>90%; use crs frg alone (eg. gr)
Crse fragment size class (>2mm); largest
fl flagstones (flat, 150-380 mm)
cn channery (flat, 2-150 mm)
by boulder (round, > 600 mm)
st stone (round, 250 – 600 mm)
cb cobble (round, 75 – 250 mm)
gr gravel (round, 2 – 75 mm)
Fine fraction codes
s sand
vcos very coarse sand (1–2 mm)
cos coarse sand (0.5–1 mm)
ms medium sand (0.25-0.5 mm)
fs fine sand (0.1–.25 mm)
vfs very fine sand (0.05–0.1 mm)
lcos loamy coarse sand
ls loamy sand
lfs loamy fine sand
lvfs loamy very fine sand
cosl coarse sandy loam
sl sandy loam
fsl fine sandy loam
vfsl very fine sandy loam
l loam
sil silt loam
si silt (0.002–0.05 mm)
scl sandy clay loam
cl clay loam
sicl silty clay loam
sc sandy clay loac
sic silty clay
c clay (<0.02 mm)
Organic Soils
Oi slightly decomposed
Oe intermediate decomposition.
Oa highly decomposed
mk mucky peat (>10% OM,<17% fibers
Coarse Fragment Content: %
Coarse Fragment Size: maximum (mm)
Coarse Fragment Shape:
Av very angular,
A angular,
As subangular
Rs subrounded,
R rounded
Rw well rounded
Peat Types (Peat):
G Graminoid or sedge
Gf Gramin., fine (<2 mm wide)
Gc Gram, coarse (>2 mm wide)
H Herbaceous
A Allochtonous (drifted)
Mf feathermoss
Ms Sphag
Md dicranum/Polytrichum
Ml Live mosses
W Woody
S Sedimentary (algal, coprogen.)
ColorMatrix: Munsell chart
Mottles (combine.g., ffd)
Abundance:
n none
f few (< 2% area)
c common (2 – 20 %)
m many (> 20 % area)
Size:
f fine (< 2 mm)
m medium (2 to 5 mm)
c coarse (5 - 20 mm)
v very coarse (20 – 76 mm)
e extremely coarse (>76 mm)
Contrast: (change in value, chroma)
f faint (hue, chroma similar)
d distinct (value 2-4, >1 chroma)
p prominent (value > 4)
Redox Kind:
Reduced matrix; redox **d**epletions; concentration-**m**asses; concentration **n**odules; concentration-**c**oncretions; **s**urface coats
Structure:
Grade
g structureless (single-**g**rained)
w weak (barely visible)
m moderate (easily observable)
s strongly
Size (mm)
vf very fine (g-p <1; c-r-p <10; a-s <5mm)
f fine (g-p 1–2; c-r-p 10–20; a-s 5–10)
m med. (g-p 2–5; c-r-p 20–50; a-s 10–20)
co crse (g-p 5–10/c-r-p 50–100/a-s 20–50)
vc very crse g-p >10/c-r-p 100–500/a-s>50
ec extr. coarse (c-r-p >500 mm)
Type (shape)
g granular; p platy
r prismatic c columnar
a angular blocky
s subangular blocky
w wedge g single grained
m massive l c**l**ods
Rupture Resistance: (moist)
l loose
fr friable vfr very friable
fi firm vfi very firm
efi extremely firm sr slightly rigid
r rigid vr very rigid
Stickiness and Plasticity::
None **S**lightly **M**oderately **V**ery
VEGETATION STRUCTURE
Crown Class
O overtopping; D Dominant
C Codominant I Intermediate
U Understory
Size Class (typical)
Seedling; s**A**pling (<5cm DBH)
Pole(5-15) **T**imber (15-30)
Large timber (>30cm)

Appendix 2. Complete species list for the Arctic Network based on data from ABR, Parker (2006), and the NPS Fire Program. Taxonomy folllows Hultén (1968) and Vierek and Little (1972) for trees and shrubs. Current synonyms are listed after each taxon.

Adoxaceae
- Adoxa moschatellina L.

Araceae
- Calla palustris L.

Aspidiaceae
- Dryopteris dilatata (Hoffm.) A.Gray ssp. americana (Fisch.) Hult.
  - Dryopteris expansa
- Dryopteris fragrans (L.) Schott
- Gymnocarpium dryopteris (L.) Newm.
- Polystichum lonchitis (L.) Roth

Athyriaceae
- Athyrium filix-femina (L.) Roth
- Cystopteris fragilis (L.) Bernh.
- Cystopteris montana (Lam.) Bernh.
- Woodsia alpina (Bolton) S.F. Gray
- Woodsia glabella R. Br.
- Woodsia ilvensis (L.) R. Br.

Betulaceae
- Alnus crispa (Ait.) Pursh
  - Alnus fruticosa Rupr.
  - Alnus viridus ssp. fruticosa (Rupr.) Nyman
- Alnus sinuata (Regel) Rydb.
  - Alnus sinuata (Regel ex DC.) Rydb
- Alnus tenuifolia Nutt.
  - Alnus incana (L.) DC. ssp. tenuifolia (Nutt.) Breitung
  - Alnus tenuifolia Nutt.
- Betula glandulosa Michx.
- Betula hybrids
- Betula nana L.
- Betula occidentalis Hooker
- Betula papyrifera Marsh.
  - Betula neoalaskana Sarg.

Boraginaceae
- Eritrichium aretioides (Cham.) DC.
- Eritrichium chamissonis DC.
- Eritrichium splendens Kearney
- Mertensia maritima (L.) S.F. Gray ssp. maritima
- Mertensia paniculata (Ait.) G. Don
- Myosotis alpestris F. W. Schmidt ssp. asiatica Vestergr.

Callitrichaceae
- Callitriche anceps Fern.
  - Callitriche heterophylla Pursh ssp. Heterophylla
- Callitriche hermaphroditica L.
- Callitriche palustris L.
  - Callitriche verna L. emend. Lonnr.
- Callitriche verna L. emend. Lonnr.
  - Callitriche palustris L.

Campanulaceae
- Campanula aurita Greene
- Campanula lasiocarpa Cham.
- Campanula uniflora L.
- Lomatogonium rotatum (l.) E. Fries

Caprifoliaceae
- Linnaea borealis L.
- Linnaea borealis L. ssp. americana (Forbes) Hult.
- Viburnum edule (Michx.) Raf.

Caryophyllaceae
- Arenaria capillaris Poir.
  - Eremogone capillaris (Poiret) Fenzl
- Arenaria chamissonis Maguire
  - Stellaria dicranoides (Cham. & Schltdl.) Fenzl
- Arenaria longipedunculata
- Cerastium beeringianum Cham. & Schlecht. var. beeringianum
- Cerastium beeringianum Cham. & Schlecht. var. grandiflorum (Fenzl.) Hult.
- Cerastium jenisejense Hult.
- Dianthus repens Willd.
- Gastrolychnis apetala (L.) Tolm & Koz.
  - Silene uralensis (Ruprecht) Bocquet ssp. uralensis
- Honckenya peploides (L.) Ehrh.
- Melandrium affine J. Vahl
  - Silene involucrata (Chamis. & Schlecht.) Bocquet ssp. involucrata
- Melandrium apetalum (L.) Fenzl.
  - Silene uralensis (Rupr.) Bocquet ssp. uralensis
- Melandrium macrospermum Pors.
  - Gastrolychnis macrosperma (Porsild) Tolm. & Kozhanch.
  - Silene uralensis ssp. porsildii Bocquet
- Melandrium taimyrense Tolm.
  - Gastrolychnis ostenfeldii (Porsild) Petrovsky
  - Silene involucrata (Chamis. & Schlecht.) Bocquet ssp. tenella
- Minuartia arctica (Stev.) Aschers. & Graebn
- Minuartia biflora (L.) Sching & Thell.
- Minuartia dawsonensis (Britt.) Mattf.
- Minuartia elegans (Cham. & Schlecht.) Schischk.
  - Minuartia rossii (R.Br. ex Rich.) Graebn. ssp. elegans (Cham. & Schlt.) Rebrist.
- Minuartia macrocarpa (Pursh) Ostenf.
- Minuartia obtusiloba (Rydb.) House
- Minuartia rossii (R. Br.) Graebn.
- Minuartia rubella (Wahlenb.) Graebn.
- Minuartia stricta (Sw.) Hiern
- Minuartia yukonensis Hult.
- Moehringia lateriflora (L.) Fenzl
- Sagina intermedia Fenzl
  - Sagina nivalis (Lindblom) Fries
- Sagina saginoides (L.) Karst.
- Silene acaulis L.
- Silene repens Patrin

Appendix 2. Continued.

Stellaria alaskana Hult.
Stellaria borealis Bigelow
Stellaria calycantha (Ledeb.) Bong.
Stellaria calycantha (Ledeb.) Bong. ssp. isophylla (Fern.) Fern.
    Stellaria borealis Bigel. ssp. borealis
Stellaria crassifolia Ehrh.
Stellaria edwardsii R. Br.
    Stellaria longipes Goldie ssp. longipes
Stellaria humifusa Rottb.
Stellaria laeta Richards.
    Stellaria longipes Goldie ssp. longipes
Stellaria longifolia Muhl. ex Willd.
Stellaria longipes Goldie
Stellaria monantha Hult.
    Stellaria longipes Goldie ssp. longipes
Stellaria umbellata Turcz.
Wilhelmsia physodes (Fisch.) McNeill

Chenopodiaceae

Atriplex gmelini C.A. Meyer
Chenopodium glaucum

Compositae (Asteraceae)

Achillea sibirica Ledeb.
    Achillea alpina L.
Antennaria alpina (L.) Gaertn.
    Antennaria pallida E. E. Nelson
Antennaria friesiana (Trautv.) Ekman
Antennaria isolepis Greene
    Antennaria rosea Greene ssp. pulvinata (Greene) Bayer
Antennaria monocephala DC.
Antennaria pulcherrima (Hook.) Greene
    Antennaria pulcherrima (Hook.) Greene var. angustisquama Porsild
Antennaria rosea E. Greene
Arnica alpina (L.) Olin ssp. angustifolia (M. Vahl) Maguire
    Arnica angustifolia Vahl in Oeder et al.
Arnica frigida C.A. Mey.
    Arnica griscomii Fernald ssp. frigida (Meyer ex Iljin) Wolf
Arnica lessingii Greene
Artemisia alaskana Rydb.
Artemisia arctica Less.
    Artemisia norvegica Fr. var. saxatilis (Besser) Jeps.
Artemisia borealis Pall.
Artemisia frigida Willd.
Artemisia furcata Bieb.
    Artemisia hyperborea Rydb.
Artemisia globularia Bess.
Artemisia glomerata Ledeb.
Artemisia senjavinensis Bess.
Artemisia tilesii Ledeb.
Aster junciformis Rydb.
    Symphyotrichum boreale (Torr. & Gray) Löve & Löve
Aster sibiricus L.
    Eurybia sibirica (L.) G.L. Nesom
Aster yukonensis Cronq.
    Symphyotrichum yukonense (Cronquist) Nesom
Chrysanthemum arcticum L.
    Arctanthemum arcticum (L.) Tzvelev s. lat
Chrysanthemum bipinnatum L.
    Tanacetum bipinnatum (L.) Schultz-Bipontinus
Chrysanthemum integrifolium
    Hulteniella integrifolia (Richardson) Tzvelev
Crepis elegans Hook.
Crepis nana Richards.
Erigeron acris L.
Erigeron caespitosus Nutt.
Erigeron elatus Greene
Erigeron eriocephalus J. Vahl
    Erigeron uniflorus Linnaeus var. eriocephalus (J. Vahl) B. Boivin
Erigeron humilis Graham
Erigeron hyperboreus
Erigeron lonchophyllus Hook.
Erigeron pallens Cronq.
    Erigeron purpuratus Greene pro parte
Erigeron porsildii G. L. Nesom & D. F. Murray
    Erigeron grandiflorus Hook. ssp. arcticus A.E. Porsild
Erigeron purpuratus Greene
Hieracium triste Willd.
Petasites frigidus (L.) Franchet
Petasites hyperboreus Rydb.
    Petasites frigidus (L.) Fr. var. frigidus
Saussurea angustifolia (Willd.) DC.
Saussurea nuda Ledeb.
Saussurea triangulata Trautv. & C.A.Mey.
Saussurea viscida Hultén var. yukonensis (Porsild) Hultén
    Saussurea angustifolia (L.) de Candolle var. yukonensis Porsild
Senecio atropurpureus (Ledeb.) Fedtsch.
    Tephroseris atropurpurea (Ledeb.) Holub
Senecio atropurpureus (Ledeb.) Fedtsch. ssp. frigidus (Richards.) Hult.
    Tephroseris frigida (Richardson) Holub
Senecio congestus (R. Br.) DC.
    Tephroseris palustris (L.) Reichenbach
Senecio conterminus Greenm.
    Packera contermina (Greenman) Bain
Senecio fuscatus (Jord. & Fourr.) Hayek
    Tephroseris lyndstroemii
Senecio hyperborealis Greenm.
    Packera hyperborealis (Greenman) Löve & Löve
Senecio kjellmanii Porsild
    Tephroseris kjellmanii (Porsild) Holub
Senecio lugens Richardson
Senecio ogotorukensis Packer
    Packera ogotorukensis (Packer) Löve & Löve
Senecio pseudoarnica Less.

Appendix 2. Continued.

Senecio resedifolius Less.
    Packera cymbalaria (Pursh) Weber & Löve
Senecio yukonensis Pors.
    Tephroseris yukonensis (Porsild) Holub
Solidago multiradiata Ait.
Taraxacum alaskanum Rydb.
    Taraxacum kamtschaticum Dahlstedt
Taraxacum ceratophorum (Ledeb.) DC.
    Taraxacum lateritium Dahlstedt
Taraxacum kamtschaticum Dahlstedt
    Taraxacum alaskanum Rydb.
Taraxacum phymatocarpum J. Vahl
Tripleurospermum phaeocephalum (L.) W.D.J. Koch

Cornaceae

Cornus canadensis L.
Cornus suecica L.

Crassulaceae

Sedum rosea (L.) Scop. ssp. integrifolium (Raf.) Hult.
    Rhodiola intefrigolia Raf.

Cruciferae (Brassicaceae)

Aphragmus eschscholtzianus Andrz.
Arabis drummondii Gray
Arabis hirsuta (L.) Scop. ssp. pycnocarpa (M. Hopkins) Hult.
Arabis lyrata L. ssp. kamchatica (Fisch.) Hult.
    Arabis kamchatica (Fisch. ex DC.) Ledeb.
Barbarea orthoceras Ledeb.
Braya glabella Richards. ssp. glabella
    Braya bartlettiana Jordal
    Braya henryae sensu Hulten
Braya humilis (C.A. Mey.) Robins.
    Torularia humilis (C. A. Mey.) Schulz
Braya purpurascens (R. Br.) Bunge
    Braya glabella Richards. ssp. purpurascens (R. Br.) Cody
Cardamine bellidifolia L.
Cardamine hyperborea O.E. Schulz
    Cardamine digitata Richardson
Cardamine microphylla Adams
Cardamine pratensis L. ssp. angustifolia (Hook.) O.E. Schultz
Cardamine purpurea Cham. & Schlecht
Cardamine umbellata Greene
Cochlearia officinalis L.
    Cochlearia arctica
Cochlearia officinalis L. ssp. arctica
    Cochlearia arctica Schltdl.
Descurainia sophioides (Fisch.) O.E. Shultz
Draba alpina L.
    Draba pilosa DC
Draba borealis DC.
Draba cana Rydb.
    Draba lanceolata auct., non Royle
Draba cinerea Adams
Draba corymbosa R. Br.
Draba exalata Ekman
    Draba ruaxes Payson & St. John
Draba fladzinensis Wulf
Draba glabella Pursh
Draba juvenilis Komarov
Draba lactea Adams
Draba lonchocarpa Rydb.
Draba macounii O.E. Schultz
Draba nivalis Liljebl.
Draba palanderiana Kjellm.
Draba pilosa DC
    Draba alpina
Draba stenoloba Ledeb.
Draba stenopetala Trautv.
Erysimum cheiranthoides L.
Erysimum inconspicuum (S. Wats.) MacM.
Erysimum pallasii (Pursch) Fern.
Eutrema edwardsii R. Br.
Halimolobos mollis (Hook.) Rollins
Lesquerella arctica (Wormsk.) S. Wats.
Parrya nudicaulis (L.) Regel
Rorippa hispida (Desv.) Britt.
    Rorippa palustris (L.) Besser ssp. hispida (Desv.) Jonsell
Rorippa islandica (Oeder) Borbás ssp. fernaldiana (Butters & Abbe) Hultén
    Rorippa palustris (L.) Besser ssp. fernaldiana (Butters & Abbe) Jonsell
Smelowskia borealis (Greene) Drury & Rollins
Smelowskia calycina (Steph.) C.A. Mey. integrifolia (Seem.) Hult.
    Smelowskia spathulatifolia Velichkin
Smelowskia calycina (Steph.) C.A. Mey. var porsildii (Drury & Rollins)
    Smelowskia porsildii (Drury & Rollins) Yurtsev
Subularia aquatica L.
Thlaspi arcticum Pors.
    Noccaea arctica (Porsild) Holub.

Cryptogrammaceae

Cryptogramma crispa (L.) R. Br. var. sitchensis (Rupr.) Christens.
Cryptogramma stelleri (S.G. Gmel.) Prantl

Cupressaceae

Juniperus communis L.

Cyperaceae

Carex albo-nigra Mack.
Carex amblyorhynca Krecz.
    Carex marina Dewey
Carex aquatilis Wahlenb. ssp. aquatilis
Carex arcta Boott.
Carex atrofusca Schkuhr
Carex aurea Nutt.
Carex bicolor All.
Carex bigelowii Torr.
Carex brunnescens (Pers.) Poir.
Carex canescens L.
Carex capillaris L.

Carex capitata Soland. In L.
Carex chordorrhiza Ehrh.
Carex concinna R. Br.
Carex deflexa Hornem.
Carex diandra Schrank
Carex dioica ssp. gynocrates (Wormsk.) Hult.
    Carex gynocrates Wormskjöld ex Drejer
Carex filifolia Nutt.
Carex franklinii Boott
    Carex petricosa Dewey var. petricosa
Carex garberi Fern. ssp. bifaria (Fern.) Hult.
Carex glacialis Mack.
Carex glareosa Wahlenb. ssp. glareosa
Carex gmelinii Hook. & Arn.
Carex heleonastes Ehrh.
Carex holostoma Drej.
Carex interior Bailey
Carex kelloggii W. Boott
    Carex lenticularis var lipocarpa
Carex krausei Boeck.
Carex lachenalii Schkuhr.
Carex lapponica Lang
Carex leptalea Wahlenb.
Carex limosa L.
Carex livida (Wahlenb.) Willd.
Carex loliacea L.
Carex lugens Holm
    Carex bigelowii Torr. ex Schwein. ssp. lugens (Holm) Egorova
Carex lyngbyaei Hornem.
Carex mackenziei V. Krecz.
Carex magellanica Lam. ssp. irrigua (Wahlenb.) Hult.
Carex maritima Gunn.
Carex media R. Br.
Carex membranacea Hook.
Carex microchaeta Holm.
Carex microglochin Walenb.
Carex misandra R. Br.
    Carex fuliginosa Schkuhr
Carex nardina E. Fries
    Carex hepburnii Boott
Carex nesophila Holm.
    Carex microchaeta Holm ssp. nesophila (Holm) Murray
Carex obtusata Lilj.
Carex oederi Retz. ssp. viridula (Michx.) Hult.
    Carex viridula Michaux var. viridula
Carex petricosa Dewey
Carex pluriflora Hult.
Carex podocarpa C. B. Clarke
Carex praticola Rydb.
Carex pyrenaica Wahlenb. ssp. micropoda (C. A. Meyer) Hult.
    Carex micropoda Mey.
Carex ramenskii Kom.
Carex rariflora (Wahlenb.) Smith
Carex rostrata Stokes
Carex rotundata Wahlenb.
Carex rupestris All.
Carex saxatilis L.ssp. laxa (Trautv.) Kalela
Carex scirpoidea Michx.
Carex stylosa C. A. Mey
Carex subspathacea Wormsk.
Carex supina Willd. ssp. spaniocarpa (Steud.) Hultén
Carex tenuiflora Wahlenb.
Carex utriculata F. Boott
Carex vaginata Tausch
Carex williamsii Britt.
Eleocharis acicularis (L.) Roem. & Schult.
Eleocharis kamtschatica (C.A. Meyer) V. Komarov
Eleocharis palustris (L.) Roem. & Schult.
Eleocharis quinqueflora (F. Hartmann) O. Schwarz
Eriophorum angustifolium Honck. ssp. subarcticum (V. Vassiljev) Hult.
Eriophorum brachyantherum Trautv. & Mey.
Eriophorum callitrix Cham.
Eriophorum gracile Koch
Eriophorum russeolum Fries
    Eriophorum chamissonis C. A. Meyer in C. F. Ledebour
Eriophorum scheuchzeri Hoppe
Eriophorum vaginatum L.
Eriophorum viridi-carinatum (Englem.) Fern.
Kobresia myosuroides (Vill.) Fiori & Paol.
Kobresia sibirica Turcz.
Kobresia simpliciuscula (Wahlenb.) Mack.
Trichophorum alpinum (L.) Pers.
Trichophorum caespitosum (L.) Hartm.

Diapensiaceae
  Diapensia lapponica L.

Droseraceae
  Drosera anglica Huds.
  Drosera rotundifolia L.

Elaegnaceae
  Shepherdia canadensis (L.) Nutt.

Empetraceae
  Empetrum nigrum L.
    Empetrum hermaphroditum Hagerup

Equisetaceae
  Equisetum arvense L.
  Equisetum fluviatile L. ampl. Ehrh.
  Equisetum palustre L.
  Equisetum pratense L.
  Equisetum scirpoides Michx.
  Equisetum sylvaticum L.
  Equisetum variegatum Schleich.

Ericaceae
  Andromeda polifolia L.
  Arctostaphylos alpina (L.) Spreng.
    Arctous alpina (L.) Nied.

Appendix 2. Continued.

Arctostaphylos rubra (Rehd. & Wilson) Fern.
    Arctous rubra (Rehder & Wilson) Nakai & Koidz.
Arctostaphylos uva-ursi (L.) Sprengel
Cassiope tetragona (L.) D. Don
Chamaedaphne calyculata (L.) Moench
Ledum decumbens (Ait.) Lodd.
Ledum groenlandicum Oeder
Loiseleuria procumbens (L.) Desv.
Oxycoccus microcarpus Turcz. ex Rupr.
Rhododendron camtschaticum Pallas
    Therorhodion camtschaticum (Pall.) Small
Rhododendron lapponicum (L.) Wahlenb.
Vaccinium uliginosum L.
Vaccinium vitis-idaea L.

Fumariaceae

Corydalis pauciflora (Steph.) Pers.
    Corydalis arctica Popov.
Corydalis sempervirens (L.) Pers.

Gentianaceae

Gentiana glauca Pallas
Gentiana propinqua Richards. ssp. propinqua
    Gentianella propinqua (Richards.) Gillett
Gentiana prostrata Haenke
Gentiana tenella Rottb.
    Gentianella tenella (Rottb.) Borner

Graminae (Poaceae)

Agropyron boreale (Turcz.) Drobov ssp. alaskanum (Scribn. & Merr.) Melderis
    Elymus alaskanus (Scribn. & Merr.) Löve ssp. latiglumis (Scribn. & Sm.) Löve
Agropyron boreale (Turcz.) Drobov ssp. hyperarcticum
    Elymus alaskanus (Scribn. & Merr.) Löve ssp. hyperarcticus (Polunin) Löve
Agropyron macrourum (Turcz.) Drobov
    Elymus macrourus (Turcz.) Tzvelev
Agropyron pauciflorum (Schwein.) Hitchc.
    Elymus trachycaulus (Link) Gould ex Shinners
Agropyron violaceum (Hornem.) Lange ssp. andinum (Scribn. & J.G. Sm.) Melderis
    Elymus trachycaulus (Link) Gould ex Shinners ssp. trachycaulus
Agropyron violaceum (Hornem.) Lange ssp. violaceum
    Elymus alaskanus (Scribn. & Merr.) Löve ssp. latiglumis (Scribn. & Sm.) Löve
Agrostis scabra Willd.
    Agrostis geminata Trin.
Alopecuris aequalis Sobol.
Alopecuris alpinus Sm. ssp. alpinus
    Alopecurus borealis Trin.
Arctagrostis latifolia (R. Br.) Griseb.
Arctophila fulva (Trin.) Anderss.
Beckmannia erucaeformis (L.) Host ssp. baicalensis (Kusn.) Hult.
    Beckmannia syzigachne (Steud.) Fernald
Bromus ciliatus L.
Bromus pumpellianus SL
    Bromopsis pumpellianus (Scribn.) Holub.
Calamagrostis canadensis (Michx.) Beauv.
Calamagrostis deschampsioides Trin.
Calamagrostis holmii Lange
Calamagrostis inexpansa Gray
    Calamagrostis stricta (Timm) Koeler ssp. inexpansa (A.Gray) C.W.Greene
Calamagrostis lapponica (Wahlenb.) Hartman. F.
Calamagrostis neglecta (Ehrh.) P.G. Gaertn., B. Mey. & Scherb.
    Calamagrostis stricta (Timm) Koeler ssp. stricta (Timm) Koeler
Calamagrostis nutkaensis (C. Presl) Steudel
Calamagrostis purpurascens R. Br. ssp. purpurascens
Colpodium vahlianum (Liebm.) Nevski
    Puccinellia vahliana (Liebm.) Scribn. & Merr.
Colpodium wrightii Scribn. & Merr.
    Puccinellia wrightii (Scribn. & Merr.) Tzvelev
Deschampsia brevifolia R. Br.
Deschampsia caespitosa (L.) P. Beauv.
Dupontia fischeri R.Br.
Elymus alaskanus (Scribn. & Merr.) A. Loeve ssp. alaskanus
    Agropyron boreale (Turcz.) Drobov ssp. alaskanum (Scribn. & Merr.) Melderis
Elymus arenarius L. ssp. mollis (Trin.) Hult.
    Leymus mollis (Trin.) Pilg. ssp. mollis
Elymus innovatus Beal
    Leymus innovatus
Elymus trachycaulis SL
    Agropyron violoceum s. lat.
Festuca altaica Trin.
Festuca baffinensis Polunin
Festuca brachyphylla Schult.
Festuca brevissima Yurtsev
Festuca lenensis Drobow
Festuca richardsonii Hook.
Festuca rubra L.
Festuca saximontana Rydb.
Festuca vivipara (L.) Smith
    Festuca viviparoidea Krajina ex Pavlick
Glyceria pulchella (Nash) Schum.
Glyceria striata (Lam.) A. Hitchc. ssp. stricta (Scribn.) Hult.
Hierchloe alpina (Sw.) Roem. & Schult.
Hierochloe odorata (L.) P. Beauv.
Hierochloe pauciflora R. Br.
Hordeum jubatum L.
Phippsia algida (Soland.) R. Br.
Poa abbreviata R. Br.
Poa alpigena (E. Fries) Lindm.
    Poa pratensis L. ssp. alpigena (Fr. ex Blytt) Hiitonen
Poa alpina L.
Poa arctica R. Br.
Poa eminens Presl
Poa glauca M. Vahl.

Poa lanata Scribn. & Merr.
  Poa arctica R. Br. ssp. lanata (Scribn.) Soreng
Poa palustris L.
Poa paucispicula Scribn. & Merr.
Poa pratensis L.
Poa pseudoabbreviata Roshev.
Puccinellia borealis Swallen
  Puccinellia arctica (Hook.) Fernald
Puccinellia phryganodes (Trin.) Scribner & Marr.
Puccinellia vaginata (Lange) Fern. & Weath.
Schizachne purpurascens (Torr.) Swallen
Trisetum spicatum (L.) Richter ssp. molle (Michx.) Hult.
Trisetum spicatum (L.) Richter ssp. spicatum

Haloragaceae
Hippuris tetraphylla L.F.
Hippuris vulgaris L.
Myriophyllum spicatum L.
Myriophyllum verticillatum L.

Iridaceae
Iris setosa Pall. ssp. setosa

Isoetaceae
Isoetes echinospora Durieu

Juncaceae
Juncus alpinus Villers
  Juncus alpinoarticulatus Chaix
Juncus arcticus Willd.
Juncus arcticus Willd. ssp. alaskanus Hult.
Juncus biglumis L.
Juncus bufonius L.
Juncus castaneus Sm. ssp. castaneus
Juncus filiformis L.
Juncus stygius L. ssp. americanus (Buchenau) Hult.
Juncus triglumis L.
Juncus triglumis L. ssp. albescens (Lange) Hulten
Luzula arctica Blytt.
  Luzula nivalis (Laest.) Beurling
Luzula arcuata (Wahlenb.) Sw.
Luzula arcuata (Wahlenb.) Sw. ssp. unalaschensis (Buchenau) Hult.
Luzula confusa Lindeb.
Luzula multiflora (Retz.) Lej.
Luzula multiflora (Retz.) Lej. ssp. multiflora var. kjellmaniana (Miyabe & Kudo) Sam.
Luzula parviflora (Ehrh.) Desv.
Luzula rufescens Fisch.
Luzula tundricola Gorodk.
  Luzula kjellmaniana Miyabe & Kudo
Luzula wahlenbergii Rupr. ssp. wahlenbergii

Juncaginaceae
Triglochin maritimum L.
Triglochin palustris L.

Leguminosae (Fabaceae)
Astragalus aboriginum Richards.
Astragalus alpinus L.
Astragalus eucosmus Hornem. ssp. sealei (LePage) Hult
  Astragalus eucosmus Rob.
Astragalus nutzotinensis Rousseau
Astragalus polaris Benth.
Astragalus umbellatus Bunge
Hedysarum alpinum L.
  Hedysarum hedysaroides (L.) Schinz & Thell.
Hedysarum hedysaroides (L.) Schinz & Thell.
  Hedysarum alpinum L.
Hedysarum mackenzii Richards.
Lathyrus maritimus L. ssp. maritimus
  Lathyrus japonicus Willd.
Lupinus arcticus S. Wats.
Lupinus kuschei Eastw.
Oxytropis arctica R. Br.
Oxytropis borealis DC.
Oxytropis bryophila (E. Greene) Yurtsev
  Oxytropis gorodkovi Jurtzev
Oxytropis campestris (L.) DC.
Oxytropis campestris (L.) DC. ssp. jordalii (Porsild) Hultén
  Oxytropis jordalii Porsild
Oxytropis campestris (L.) DC. ssp. varians (Rydb.) Cody
  Oxytropis tananensis Yurtzev
  Oxytropis varians (Rydb.) Schum.
Oxytropis deflexa (Pall.) DC.
Oxytropis huddelsonii Pors.
Oxytropis kobukensis Welsh
Oxytropis kokrinensis Porsild
Oxytropis koyukukensis Pors.
  Oxytropis arctica R.Br. var. koyukukensis (Porsild) Welsh
Oxytropis maydelliana Trautv.
Oxytropis mertensiana Turcz.
Oxytropis nigrescens (Pall.) Fisch.
Oxytropis nigrescens (Pallas) Fisch. ssp. pygmaea (Pallas) Hultén
  Oxytropis gorodkovii Jurtzev
Oxytropis scammaniana Hultén
Oxytropis viscida Nutt.
Vicia cracca L.

Lemnaceae
Lemna trisulca L.

Lentibulariaceae
Pinguicula villosa L.
Pinguicula vulgaris L.
Utricularia intermedia Hayne
Utricularia minor L.
Utricularia vulgaris L. ssp. macrorhiza (LeConte) Clauson
  Utricularia macrorhiza Leconte

Liliaceae
Allium schoenoprasum L.
Tofieldia coccinea Richards.
Tofieldia pusilla (Michx.) Pers.
Veratrum album L. ssp. oxysepalum (Turcz.) Hult.

Appendix 2. Continued.

Zygadenus elegans Pursh

Linaceae

Linum perenne L. ssp. lewisii

Linum lewisii Pursh

Lycopodiaceae

Lycopodium alpinum L.

Diphasiastrum alpinum (Linnaeus) Holub

Lycopodium annotinum L.

Lycopodium clavatum L.

Lycopodium complanatum L.

Diphasiastrum complanatum (Linnaeus) Holub

Lycopodium dendroideum Michx.

Lycopodium selago L.

Huperzia selago (Linnaeus) Bernhardi ex Schrank & Martius

Menyanthaceae

Menyanthes trifoliata L.

Myricaeae

Myrica gale L.

Nymphaceae

Nuphar polysepalum Engelm.

Onagraceae

Circaea alpina L.

Epilobium adenocaulon Haussk.

Epilobium anagallidifolium Lam.

Epilobium angustifolium L.

Chamerion angustifolium (L.) Holub

Epilobium behringianum Haussk.

Epilobium ciliatum Raf.

Epilobium davuricum Fisch.

Epilobium glandulosum Lehm.

Epilobium hornemannii Reichb. ssp. hornemannii

Epilobium latifolium L.

Chamerion latifolium (L.) Holub

Epilobium palustre L.

Ophioglossaceae

Botrychium lunaria (L.) Sw.

Botrychium minganense Victorin

Orchidaceae

Amerorchis rotundifolia (Banks) Hult.

Coeloglossum viride (L.) Hartm. ssp. viride var. (Lindl.) Schulze

Corallorrhiza trifida Chatel.

Cypripedium parviflorum L.

Cypripedium passerinum Richards

Goodyera repens (L.) R. Br. var. ophioides Fern.

Hammarbya paludosa (L.) Ktze.

Malaxis paludosa (Linnaeus) Swartz

Listera borealis Morong

Listera cordata (L.) R. Br.

Lloydia serotina (L.) Rchb.

Platanthera hyperborea (L.) Lindl.

Platanthera obtusata (Pursh) Lindl.

Lysiella obtusata (Banks ex Pursh) Rydb.

Spiranthes romanzoffiana Cham.

Orobanchaceae

Boschniakia rossica (Cham & Schldl.) B. Fedtsch.

Papaveraceae

Papaver alaskanum Hultén

Papaver mcconnellii Hulten

Papaver gorodkovi Tolmatchew & V.V. Petrovsky

Papaver hultenii Knaben

Papaver lapponicum (Tolm.) Nordh.

Papaver hultenii Knaben

Papaver lapponicum (Tolm.) Nordh. ssp. porsildii Knaben

Papaver radicatum ssp. radicatum

Papaver macounii Greene

Papaver radicatum Rottb. ssp. radicatum

Papaver walpolei Pors.

Pinaceae

Picea glauca (Moench) Voss

Picea mariana (Mill.) Britt., Sterns & Pogg

Plantaginaceae

Plantago canescens Adams

Plumbaginaceae

Armeria maritima (Mill.) Willd. ssp. arctica (Cham.) Hult.

Polemoniaceae

Phlox sibirica L. ssp. sibirica

Phlox alaskensis Jordal

Polemonium acutiflorum Willd.

Polemonium boreale Adams

Polygonaceae

Koenigia islandica L.

Oxyria digyna (L.) Hill

Polygonum alaskanum (Small) Wight

Aconogonon alaskanum (Small) Soják

Polygonum amphibium L.

Persicaria amphibia (L.) Gray

Polygonum aviculare L.

Polygonum bistorta L. ssp. plumosum (Small) Hult.

Bistorta plumosa (Small) Greene

Polygonum caurianum Robins.

Polygonum humifusum Merck ex. Koch ssp. caurianum (Robins.) Costea & Tardif

Polygonum lapathifolium L.

Persicaria lapathifolia (L.) Gray

Polygonum viviparum L.

Bistorta vivipara (L.) Delarbre

Rumex acetosa L. ssp. alpestris (Scop.) Love

Rumex acetosella L. ssp. acetosa

Rumex arcticus Trautv.

Rumex crispus L.

Polypodiaceae

Polypodium vulgare L.

Polypodium sibiricum Sipliv.

Portulacaceae

Claytonia acutifolia Pall. ssp. graminifolia Hultén

Claytonia eschscholtzii Cham.

Claytonia sarmentosa C. Meyer
    Montia sarmentosa (C.A. Mey.) Rob.
Claytonia tuberosa Pall.
Montia fonata L. ssp. fontana

Portulaceae

Claytonia scammaniana Hulten

Potamogetonaceae

Potamogeton alpinus Balbis ssp. tenuifolius (Raf.) Hultén
Potamogeton berchtoldii Fieber
    Potamogeton pusillus ssp. tenuissimus (Mertens & Koch) Haynes & Hellquist
Potamogeton epihydrus Raf.
Potamogeton filiformis Pers.
    Stuckenia filiformis (Pers.) Böerner
Potamogeton friesii Rupr.
Potamogeton gramineus L.
Potamogeton pectinatus L.
    Stuckenia pectinata (L.) Borner
Potamogeton perfoliatus L. ssp. richardsonii (Benn.) Hultén
    Potamogeton richardsonii (Bennett) Rydberg
Potamogeton praelongus Wulf.
Potamogeton subsibiricus Hagstr.
Potamogeton vaginatus Turcz.
    Stuckenia vaginata (Turczaninow) Holub
Potamogeton zosterifolius Schum.
Zannichellia palustris L.

Primulaceae

Androsace chamaejasme Host ssp. lehmannia (Spreng.) Hult.
Androsace septentrionalis L.
Dodecatheon frigidum Cham. & Schlecht.
Dodecatheon pulchellum (Raf.) Merr.
Douglasia arctica Hook
Douglasia ochotensis (Willd.) Hult.
Primula anvilensis S. Kelso
Primula borealis Duby
Primula egaliksensis Wormsk.
Primula mistassinica Michx.
Primula sibirica Jacq.
    Primula nutans Georgi
Primula stricta Hornem.
Primula tschuktschorum Kjellm. var. arctica (Koidz.) Fern.
Trientalis europaea L.
Trientalis europaea L. ssp. arctica (Fisch.) Hult.

Pyrolaceae

Moneses uniflora (L.) Gray
Pyrola asarifolia Michx.
Pyrola chlorantha Sw.
Pyrola grandiflora Radius
Pyrola minor L.
Pyrola secunda L.
    Orthilia secunda (L.) House

Ranunculaceae

Aconitum delphinifolium DC.
Anemone drummondii S. Wats.
Anemone multiceps (Greene) Standl.
Anemone narcissiflora L.
Anemone parviflora Michx.
Anemone richardsonii Hook.
Caltha natans Pall.
Caltha palustris L.
Delphinium brachycentrum Ledeb.
    Delphinium chamissonis Pritz. ex Walp.
Delphinium glaucum S. Wats.
Pulsatilla patens (L.) Mill ssp. multifida (Pritz.) Zamels
    Anemone patens var. multifida Pritzel
Ranunculus eschscholtzii Schlecht.
Ranunculus gelidus Kar. & Kir. ssp. grayi (Britt.) Hultén
Ranunculus glacialis L. ssp. chamissonis (Schlecht.) Hult.
    Ranunculus glacialis L. var. camissonis (Schltdl.) Benson
Ranunculus gmelini DC. ssp. gmelini
Ranunculus hyperboreus Rottb.
Ranunculus lapponicus L.
    Coptidium lapponicum (L.) Tzvelev
Ranunculus nivalis L
Ranunculus pallasii Schlect.
Ranunculus pedatifidus Sm. ssp. affinis (R. Br.) Hult.
Ranunculus pygmaeus Wahl.
Ranunculus reptans L.
    Ranunculus flammula var. reptans (L.) E. Meyer
Ranunculus sulphureus Soland. var. intercedens Hultén
Ranunculus trichophyllus Chaix
    Ranunculus aquatilis var. diffusus Withering
Ranunculus trichophyllus Chaix var. hispidulus (E. Drew) W. Drew
    Ranunculus aquatilis var. aquatilis
Thalictrum alpinum L.
Thalictrum sparsiflorum Turcz.

Rosaceae

Dryas drummondii Richards.
Dryas integrifolia Vahl.
Dryas integrifolia var. sylvatica Hulten
Dryas octopetala L.
Dryas octopetala L. ssp. alaskensis (Pors.) Hult.
    Dryas alaskensis
Geum glaciale Adams
    Novosieversia glacialis (J. E. Adams) Bolle
Geum rossii (R. Br.) Ser.
    Acomostylis rossii (R. Br.) Greene
Potentilla biflora Willd.
Potentilla egedii Wormsk. ssp. grandis (Torr. & Gray) Hult.
Potentilla elegans Cham. & Schlecht.
Potentilla fruticosa L.
    Dasiphora fruticosa (L.) Rydb.
Potentilla hookeriana Lehm.
Potentilla hyparctica Malte
Potentilla nivea L.

Potentilla norvegica L.
Potentilla palustris (L.) Scop.
    Comarum palustre L.
Potentilla pennsylvanica L.
Potentilla rubricaulis Lehm.
Potentilla stipularis L.
Potentilla uniflora Ledeb.
    Potentilla gorodkovii
Potentilla vahliana Lehm.
Potentilla villosa Pall.
Potentilla virgulata Nels.
    Potentilla litoralis Rydb.
Rosa acicularis Lindl.
Rubus arcticus L. ssp. arcticus
Rubus arcticus L. ssp. stellatus (Sm.) Boiv. Emend. Hulten
Rubus chamaemorus L.
Rubus idaeus L.
Sanguisorba officinalis L.
Sibbaldia procumbens L.
Sorbus scopulina Greene
Spiraea beauverdiana Schneid.
    Spiraea stevenii (C.K. Schneid.) Rydb.

Rubiaceae
Galium boreale L.
Galium brandegei Gray
Galium trifidum L. ssp. trifidum

Salicaceae
Populus balsamifera L.
Populus balsamifera L. ssp. trichocarpa (Torr. & Gray) Brayshaw
Populus tremuloides Michx.
Salix alaxensis (Anderss.) Cov.
Salix arbusculoides Anderss.
Salix arctica Pall.
Salix barclayi Anderss.
Salix bebbiana Sarg.
Salix brachycarpa Nutt. ssp. niphoclada (Rydb.) Argus
    Salix niphoclada Rydb.
Salix chamissonis Anderss.
Salix fuscescens Anderss.
Salix glauca L.
Salix hastata L.
Salix interior Rowlee
Salix lanata L. ssp. richardsonii (Hook.) Skvort.
    Salix richardsonii Hook.
Salix monticola Bebb
    Salix pseudomonticola Ball
Salix ovalifolia Trautv.
Salix phlebophylla Anderss.
Salix planifolia Pursch. ssp.pulchra (Cham.) Argus
    Salix pulchra Cham.
Salix polaris Wahlenb. ssp. pseudopolaris (Flod.) Hult.
Salix reticulata L.
Salix rotundifolia Trautv.
Salix rotundifolia Trautv. ssp. dodgeana (Rydb.) Argus
Salix scouleriana Barratt
Salix sphenophylla A. Skvortz.

Santalaceae
Geocaulon lividum (Richards.) Fern.

Saxifragaceae
Boykinia richardsonii (Hook.) Gray
Chrysosplenium tetrandrum (Lund) T. Fries
Chrysosplenium wrightii Fr. And Sav.
Parnassia kotzebuei Cham. & Schlecht.
Parnassia palustris L.
Ribes triste Pall.
Saxifraga bronchialis L.
Saxifraga bronchialis L. ssp. funstonii (Small) Hult.
Saxifraga caespitosa L.
Saxifraga calycina Sternb.
Saxifraga cernua L.
Saxifraga davurica Willd. ssp. grandipetala (Engler & Irmsch.) Hult.
Saxifraga eschscholtzii Sternb.
Saxifraga exilis Steph.
Saxifraga flagellaris Willd.
Saxifraga flagellaris Willd. ssp. setigera (Pursh.) Tolm.
Saxifraga foliolosa R. Br.
Saxifraga hieracifolia Waldst. & Kit.
Saxifraga hirculis L.
Saxifraga nivalis L.
Saxifraga nudicaulis D. Don
Saxifraga oppositifolia L.
Saxifraga punctata L.
    Saxifraga nelsoniana D.Don.
Saxifraga punctata L. ssp. nelsoniana (D. Don) Hult.
Saxifraga reflexa Hook.
Saxifraga rivularis L.
Saxifraga serpyllifolia Pursh
Saxifraga spicata D. Don
Saxifraga tricuspidata Rottb.

Scrophulariaceae
Castilleja caudata (Pennell) Rebr.
    Castilleja pallida (L.) Spreng. ssp. caudata Pennell
Castilleja elegans Malte
Castilleja hyperborea Pennell
Lagotis glauca Gaertn. ssp. glauca
Lagotis glauca Gaertn. ssp. minor (Willd.) Hult.
Limosella aquatica L.
Pedicularis capitata Adams.
Pedicularis kanei Durand ssp. kanei
    Pedicularis lanata Cham. & Schltdl.
Pedicularis labradorica Wirsing
Pedicularis langsdorffii Fisch. ssp.arctica (R. Br.) Pennell
Pedicularis langsdorffii Fisch. ssp.langsdorffii
Pedicularis lapponica L.
Pedicularis oederi M. Vahl
Pedicularis parviflora J.E. Sm. ssp. parviflora

Pedicularis parviflora J.E. Sm. ssp. pennellii (Hult.) Hult.
    Pedicularis pennellii Hulten
Pedicularis sudetica Willd. ssp. albolabiata Hultén
    Pedicularis albolabiata (Hultén) Kozhanch.
Pedicularis sudetica Willd. ssp. interior Hult.
    Pedicularis interior (Hultén) Molau & Murray
Pedicularis sudetica Willd. ssp. pacifica Hult.
    Pedicularis pacifica (Hultén) Kozh
Pedicularis verticillata L.
Veronica wormskjoldii Roem & Schult.

Selaginellaceae

Selaginella selaginoides (L.) Link
Selaginella sibirica (Milde) Hieron.

Sparganiaceae

Sparganium angustifolium Michx.
Sparganium hyperboreum Laest.
Sparganium minimum (Hartm.) E. Fries
    Sparganium natans Linnaeus

Thelypteridaceae

Thelypteris phegopteris (L.) Slosson
    Phegopteris connectilis (Michaux) Watt

Umbelliferae (Apiaceae)

Angelica lucida L.
Bupleurum triradiatum Adams ssp. arcticum (Regel) Hult.
    Bupleurum americanum J.M. Coult. & Rose
Cicuta virosa L.
Cnidium cnidiifolium (Turcz.) Schischk.
Conioselinum chinense L. BSP.
    Conioselinum gmelinii (Cham. & Schltdl.) Steud.
Heracleum lanatum Michx.
Ligusticum scoticum L. ssp. hultenii (Fern.) Cald. & Tayl.
Podistera macounii (Coult. & Rose) Math. & Const.

Valerianaceae

Valeriana capitata Pall.

Violaceae

Viola biflora L.
Viola epipsila Ledeb. ssp. repens (Turcz.) Becker
Viola langsdorffii Fisch.
Viola renifolia Gray
Viola selkirkii Pursh

Lichen

Acarospora schleicheri (Ach.) A. Massal.
Agonimia tristicula (Nyl.) Zahlbr.
Alectoria nigricans (Ach.) Nyl.
Alectoria ochroleuca (Hoffm.) A. Massal.
Alectoria sp.
Allantoparmelia almquistii
Arctoparmelia centrifuga
Arctoparmelia separata (Th. Fr.) Hale
Arctoparmelia sp.
Asahinea chrysantha (Tuck.) Culb. & C. Culb.
Asahinea scholanderi
Asahinea sp.
Baeomyces rufus (Huds.) Rebent.
Brodoa oroarctica (Krog) Goward
Bryocaulon divergens (Ach.) Kärnefelt
Bryocaulon sp.
Bryonora castanea (Hepp) Poelt
Bryoria chalybeiformis (L.) Brodo & D. Hawksw.
Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw.
Bryoria sp.
Buellia insignis(Naeg. ex Hepp) Th. Fr.
Buellia punctata (Hoffm.) Massal.
Caloplaca ammiospila (Wahlenb.) H. Olivier
Caloplaca fraudans (Th. Fr.) H. Olivier
Caloplaca holocarpa (Hoffm. ex Ach.) M. Wade
Caloplaca tetraspora (Nyl.) H. Olivier
Caloplaca tiroliensis Zahlbr.
Candelaria sp.
Catapyrenium lachneum (Ach.) R. Sant.
Cetraria aculeata (Schreber) Fr.
Cetraria commixta
Cetraria ericetorum Opiz
Cetraria hepatizon (Ach.) Vain.
Cetraria islandica (L.) Ach.
Cetraria islandica (L.) Ach. ssp. islandica
Cetraria islandica ssp. crispiformis (Räsänen) Kärnefelt
Cetraria kamczatica Savicz
Cetraria laevigata Rass.
Cetraria muricata (Ach.) Eckfeldt
Cetraria nigricans Nyl.
Cetraria pinastri (Scop.) S. Gray
    Vulpicida pinastri
Cetraria sp.
Cetraria tilesii
Cetrariella delisei (Bory ex Schaerer) Kärnefelt & Thell
    Cetraria delisei
    Cetraria hiascens
Cetrariella fastigiata (Delise ex Nyl.) Kärnefelt & Thell
Cladina arbuscula (Wallr.) Hale & Culb.
Cladina mitis (Sandst.) Hustich
Cladina rangiferina (L.) Nyl.
Cladina sp.
Cladina stellaris (Opiz) Brodo
Cladina stygia (Fr.) Ahti
Cladonia aberrans (Abbayes) Hale & Culb.
Cladonia acuminata (Ach.) Norrlin
Cladonia alaskana A. Evans
Cladonia amaurocraea (Flörke) Schaerer
Cladonia bellidiflora (Ach.) Schaerer
Cladonia botrytes (Hag.) Willd.
Cladonia cariosa (Ach.) Spreng.
Cladonia carneola (Fr.) Fr.
Cladonia cenotea (Ach.) Schaer.
Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel
Cladonia coccifera (L.) Willd. s. lat.
Cladonia cornuta (L.) Hoffm.
Cladonia crispata (Ach.) Flot.
Cladonia decorticata (Flörke) Spreng.

Appendix 2. Continued.

Cladonia deformis (L.) Hoffm.
Cladonia ecmocyna Leighton
Cladonia fimbriata (L.) Fr.
Cladonia furcata (Hudson) Schrader
Cladonia gracilis (L.) Willd.
Cladonia gracilis (L.) Willd. ssp. elongata (Jacq.) Vainio
Cladonia gracilis (L.) Willd. ssp. vulnerata Ahti
Cladonia macilenta Hoffm.
Cladonia macrophylla (Schaerer) Stenh.
Cladonia maxima (Asahina) Ahti
Cladonia metacorallifera Asah.
Cladonia nipponica Asah.
Cladonia pleurota (Flörke) Schaerer
Cladonia pocillum (Ach.) Grognot
Cladonia pyxidata (L.) Hoffm.
Cladonia scabriuscula (del.) Leight.
Cladonia sp.
Cladonia squamosa Hoffm.
Cladonia stricta (Nyl.) Nyl.
Cladonia subfurcata (Nyl.) Arnold
Cladonia subulata (L.) F.H. Wigg.
Cladonia sulphurina (Michaux) Fr.
Cladonia symphycarpia (Ach.) Fr.
Cladonia uncialis (L.) F. H. Wigg.
Cladonia verticillata (Hoffm.) Schaerer
Cornicularia divergens
Dactylina arctica (Richardson) Nyl.
Dactylina beringica C. D. Bird & J. W. Thomson
Dactylina madreporiformis (Ach.) Tuck.
Dactylina ramulosa (Hook.) Tuck.
Dactylina sp.
Diploschistes scruposus (Schreb.) Norman
Evernia perfragilis Llano
Flavocetraria cucullata (Bellardi) Kärnefelt & Thell
Flavocetraria nivalis (L.) Kärnefelt & Thell
Flavocetraria sp.
Fulgensia bracteata (Hoffm.) Rasanen
Hypogymnia austerodes (Nyl.) Rasanen
Hypogymnia physodes (L.) Nyl.
Hypogymnia sp.
Hypogymnia subobscura (Vainio) Poelt
Icmadophila ericetorum (L.) Zahlbr.
Lasallia pensylvanica (Hoffm.) Llano
Lecanora beringii Nyl.
Lecanora circumborealis Brodo & Vitik.
Lecanora epibryon (Ach.) Ach.
Lecanora sp.
Leptogium gelatinosum (With.) J. R. Laundon
Leptogium saturninum (Dicks.) Nyl.
Leptogium sp.
Lobaria hallii (Tuck.) Zahlbr.
Lobaria linita (Ach.) Rabenh.
Lobaria sp.
Lopadium pezizoideum (Ach.) Körb.
Masonhalea richardsonii (Hook.)
Massalongia carnosav (Dickson) Korber
Megaspora verrucosa (Ach.) Hafellner & V. Wirth
Melanelia commixta (Nyl.) Thell
Melanelia stygia (L.) Essl.
Nephroma arcticum (L.) Torss.
Nephroma expallidum (Nyl.) Nyl.
Nephroma helveticum Ach.
Nephroma parile (Ach.) Ach.
Nephroma resupinatum (L.) Ach.
Nephroma sp.
Ochrolechia frigida (Sw.) Lynge
Ochrolechia inaequatula (Nyl.) Zahlbr.
Ochrolechia sp.
Ochrolechia upsaliensis (L.) A. Massal.
Ophioparma lapponica (Räsänen) Hafellner & R. W. Rogers
Pannaria pezzizoides (G. Web.) Trev.
Parmelia omphalodes (L.) Ach.
Parmelia saxatilis (L.) Ach.
Parmelia sp.
Parmelia sulcata Taylor
Parmeliopsis ambigua (Wulfen) Nyl
Parmeliopsis hyperopta (Ach.) Arnold
Peltigera aphthosa (L.) Willd.
Peltigera canina (L.) Willd.
Peltigera collina (Ach.) Schrader
Peltigera didactyla var. extenuata (Nyl. ex Vainio) Goffinet & Hastings
Peltigera leucophlebia (Nyl.) Gyelnik
Peltigera malacea (Ach.) Funck
Peltigera membranacea (Ach.) Nyl.
Peltigera neckeri Hepp ex Müll. Arg.
Peltigera neopolydactyla (Gyelnik) Gyelnik
Peltigera polydactylon (Neck.) Hoffm.
Peltigera rufescens (Weiss) Humb.
Peltigera scabrosa Th. Fr.
Peltigera sp.
Peltigera venosa (L.) Hoffm.
Pertusaria bryontha (Ach.) Nyl.
Pertusaria dactylina (Ach.) Nyl.
Pertusaria panyrga (Ach.) A. Massal.
Pertusaria sp.
Pertusaria subobducens Nyl.
Physconia muscigena (Ach.) Poelt
Placynthiella uliginosa (Schrad.) Coppins & P. James
Pseudephebe Choisy
Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw.
Pseudephebe pubescens (L.) Choisy
Psora decipiens (Hedwig) Hoffm.
Psora rubiformis (Ach.) Hook.
Psoroma hypnorum (Vahl) Gray
Ramalina almquistii Vainio
Ramalina dilacerata (Hoffm.) Hoffm.
Rhizocarpon geographicum (L.) DC.

Appendix 2. Continued.

Rhizocarpon sp.
Rhizocarpon umbilicatum (Ramond) Flagey
Rinodina roscida (Sommerf.) Arnold
Rinodina turfacea (Wahlenb.) Körber
Solorina bispora Nyl.
Solorina crocea (L.) Ach.
Solorina octospora (Arnold) Arnold
Solorina saccata (L.) Ach.
Solorina sp.
Sphaerophorus fragilis (L.) Pers.
Sphaerophorus globosus (Hudson) Vainio
Sphaerophorus sp.
Spilonema revertens Nyl.
Squamarina lentigera (Weber) Poelt
Stereocaulon alpinum Laurer ex Funck
Stereocaulon apocalypticum Nyl. (saxicolous)
Stereocaulon botryosum Ach.
Stereocaulon dactylophyllum Flörke
Stereocaulon glareosum (Savicz) H. Magn.
Stereocaulon grande (H. Magn.) H. Magn.
Stereocaulon groenlandicum (A.E. Dahl) I.M. Lamb
Stereocaulon paschale (L.) Hoffm.
Stereocaulon sp.
Stereocaulon subcoralloides (Nyl.) Nyl.
Stereocaulon tomentosum Fr.
Thamnolia sp.
Thamnolia subuliformis (Ehrh.) Culb.
    Thamnolia subvermicularis Asah.
    Thamnolia vermicularis var. subuliformis
Thamnolia vermicularis (Sw.) Ach. ex Schaerer
Toninia sedifolia (Scop.) Timdal
Toninia tristis (Th. Fr.) Th. Fr.
Trapeliopsis granulosa (Hoffm.) Lumbsch
Umbilicaria caroliniana Tuck.
Umbilicaria cinereorufescens (Schaerer) Frey
Umbilicaria hyperborea (Ach.) Hoffm.
Umbilicaria proboscidea (L.) Schrader
Umbilicaria sp.
Umbilicaria torrefacta (Lightf.) Schrad.
Usnea sp.
Varicellaria rhodocarpa (Körber) Th. Fr.
Vulpicida pinastri (Scop.) J.-E. Mattsson & M. J. Lai
Vulpicida sp.
Vulpicida tilesii (Ach.) J.-E. Mattsson & M. J. Lai
Xanthoria elegans (Link) Th. Fr.
Xanthoria sp.

Liverwort

Anastrophyllum minutum (Schreb.) R.M. Schust.
Anastrophyllum saxicola (Schrad.) R.M. Schust.
Chandonanthus setiformis (Ehrh.) Lindb.
Gymnocolea inflata (Huds.) Dumort.
Gymnomitrion corallioides Nees
Hepaticae
Mylia anomala (Hook.) S. Gray
Radula prolifera S.W. Arnell
Tetralophozia setiformis (Ehrh.) Schljakov

Moss

Abietinella abietina (Hedw.) Fleisch.
    Thuidium abietinum (Hedw.) Schimp.
Amphidium mougeotii (Bruch & Schimp.) Schimp.
Andreaea rupestris Hedw.
Andreaea sp.
Andreaeobryum macrosporum Steere & B.M. Murray
Aongstroemia longipes (Somm.) B.S.G.
Aulacomnium acuminatum (Lindb. & Arnell) Kindb.
Aulacomnium palustre (Hedw.) Schwaegr.
Aulacomnium sp.
Aulacomnium turgidum (Wahlenb.) Schwaegr.
Barbula convoluta Hedw. var. gallinula R.H. Zander
Bartramia pomiformis Hedw.
Blepharostoma trichophyllum (L.) Dum.
Brachythecium coruscum Hag.
Brachythecium erythrorrhizon Schimp. in B.S.G.
Brachythecium mildeanum (Schimp.) Schimp. ex Milde
Brachythecium nelsonii Grout
Brachythecium reflexum (Starke in Web.et Mohr) Schimp.
Brachythecium rivulare Schimp. in B.S.G.
Brachythecium salebrosum (Web. et Mohr) B.S.G.
Brachythecium sp.
Bryobrittonia longipes (Mitt.) Horton
Bryoerythrophyllum recurvirostre (Hedw.) Chen
Bryum argenteum Hedw.
Bryum caespiticium Hedw.
    Bryum submuticum
Bryum capillare Hedw.
Bryum cryophilum Mårtensson
Bryum lisae De Not.
Bryum pallescens Schleich. exSchwaegr.
Bryum pseudotriquetrum (Hedw.) Gaertn. et al.
Bryum sp.
Bryum subneodamense Kindb.
Calliergon cordifolium (Hedw.) Kindb.
Calliergon giganteum (Schimp.) Kindb.
Calliergon sp.
Calliergon stramineum (Brid.) Kindb.
Campylium arcticum Williams
Campylium halleri (Hedw.) Lindb.
Campylium longicuspis (Lindb. etH.Arnell) Hedenaes
Campylium polygamum (B.S.G.) C.Jens.
    Drepanocladus poligamus (B.S.G.) Hedenaeas
Campylium sp.
Campylium stellatum (Hedw.) C.Jens.
Catoscopium nigritum (Hedw.) Brid.
Ceratodon purpureus (Hedw.) Brid.
Ceratodon sp.
Cinclidium arcticum B.S.G.
Cinclidium latifolium Lindb.
Cinclidium subrotundum Lindb.
Cirriphyllum cirrosum (Schwaegr.) Grout

Appendix 2. Continued.

Cirriphyllum piliferum (Hedw.) Grout
Climacium dendroides (Hedw.) Web. et Mohr.
Conocephalum sp.
Ctenidium procerrimum (Mol.) Lindb.
Cynodontium polycarpon (Hedw.) Schimp.
Cynodontium strumiferum (Hedw.) Lindb.
Cyrtomnium hymenophyllum (B.S.G.) Holmen
Dicranella sp.
Dicranella subulata (Hedw.) Schimp.
Dicranoweisia crispula (Hedw.) Lindb. ex Milde
Dicranum acutifolium (Lindb. et H.Arnell) C. Jens.
Dicranum alaevdens Williams
Dicranum angustum Lindb.
Dicranum bonjeanii De Not
Dicranum elongatum Schleich. ex Schwaegr.
Dicranum fuscescens Turner.
Dicranum groenlandicum Brid.
Dicranum laevidens Williams
    Dicranum angustum Lindb.
Dicranum majus Sm.
Dicranum polysetum SW.
Dicranum scoparium Hedw.
Dicranum sp.
Dicranum spadiceum Zett.
Dicranum undulatum Brid.
    Dicranum bergeri Bland. in Sturm
Didymodon asperifolius (Mitt.) Crum et al.
Didymodon rigidulus Hedw. var. gracilis (Schleich. ex Hook. & Grev.) R.H. Zander
Didymodon sp.
Distichium capillaceum (Hedw.) B.S.G.
Distichium inclinatum (Hedw.) B.S.G.
Ditrichum flexicaule (Schwaegr.) Hampe
Ditrichum sp.
Drepanocladus aduncus (Hedw.) Warnst. s.l.
Drepanocladus brevifolius (Lindb.) Warnst.
    Pseudocalliergon brevifolium (Lindb.) Hedenaes
Drepanocladus capillifolius (Warnst) Warnst.
    Drepanocladus aduncus capillifolius
Drepanocladus revolvens (Sw.) Warnst.
    Limprichtia revolvens (Sw.) Loeske
Drepanocladus sendtneri (Schimp. ex C.Muell.) Warnst.
Drepanocladus sp.
Encalypta sp.
Eurhynchium pulchellum (Hedw.) Jenn.
Fissidens osmundioides Hedw.
Grimmia affinis Hoppe & Hornsch. ex Hornsch.
Hamatocaulis vernicosus (Mitt.) Hedenaes
Homalothecium sp.
Hylocomiastrum pyrenaicum (Spruce) Fleisch.
Hylocomium splendens (Hedw.) B.S.G.
Hymenostylium recurvirostre (Hedw.) Dix.
Hypnum bambergeri Schimp.
Hypnum dieckei Renauld & Cardot
Hypnum hamulosum Schimp.
Hypnum holmenii Ando
Hypnum lindbergii Mitt.
Hypnum plicatulum (Lindb.) Jaeg.
Hypnum pratense Koch ex Spruce
Hypnum revolutum (Mitt.) Lindb.
Hypnum sp.
Hypnum vaucheri Lesq.
Isopterygiopsis pulchella (Hedw.) Iwats.
Leptobryum pyriforme (Hedw.) Wils.
Limprichtia cossoni (Schimp.) Anderson et al.
Limprichtia revolvens (Sw.) Loeske
Loeskypnum badium (Hartm.) Paul
Lophozia sp.
Marchantia polymorpha L
Marchantia sp.
Meesia triquetra (Richter) Aongstr.
Meesia uliginosa Hedw.
Mnium blyttii B. S.G.
Mnium sp.
Mnium spinulosum Bruch & Schimp.
Mnium thomsonii Schimp.
Myurella julacea (Schwaegr.) B.S.G.
Myurella sibirica (Müll. Hal.) Reim.
Oncophorus wahlenbergii Brid.
Orthothecium chryseon (Schwaegr. ex Schultes) Schimp.
Orthotrichum speciosum Nees
Paludella squarrosa (Hedw.) Brid.
Philonotis fontana (Hedw.) Brid.
Philonotis tomentella Molendo
Plagiomnium curvatulum (Lind.) Schljakov
    Plagiothecium laetum Schimp.
Plagiomnium ellipticum (Brid.) T.Kop.
Plagiomnium medium (Bruch & Schimp. in B.S.G.) T. Kop.
Plagiomnium sp.
Plagiothecium berggrenianum Frisvoll
Plagiothecium cavifolium (Brid.) Iwats.
Plagiothecium denticulatum (Hedw.) B.S.G.
Pleurozium schreberi (Brid.) Mitt.
Pohlia cruda (Hedw.) Lindb.
Pohlia nutans (Hedw.) Lindb.
Pohlia sp.
Pohlia wahlenbergii (Web. & Mohr) Andrews
Polytrichastrum alpinum (Hedw.) G.L.Sm.
Polytrichum commune Hedw.
Polytrichum formosum Hedw.
Polytrichum hyperboreum R.Br.
Polytrichum jensenii Hag.
Polytrichum juniperinum Hedw.
Polytrichum piliferum Hedw.
Polytrichum sp.
Polytrichum strictum Brid.
Preissia quadrata (Scop.) Nees
Pseudocalliergon turgescens (T.Jens.) Loeske

Appendix 2. Continued.

Pseudoleskeella sibirica (Arnell) P. Wilson & Norris
Pseudoleskeella tectorum (Funck ex Brid.) Kindb.
Psilopilum laevigatum (Wahlenb.) Lindb.
Ptilidium ciliare (L.) Hampe
Ptilidium pulcherrimum (G. Web.) Vain.
Ptilium crista-castrensis (Hedw.) De Not.
Racomitrium canescens (Hedw.) Brid.
Racomitrium elongatum Ehrh. ex Frisv.
Racomitrium ericoides (Web. ex Brid.) Brid.
Racomitrium lanuginosum (Hedw.) Brid.
Racomitrium sp.
Racomitrium sudeticum (Funck) Bruch & Schimp.
Rhizomnium andrewsianum (Steere) T. Kop.
Rhizomnium sp.
Rhytidiadelphus sp.
Rhytidiadelphus squarrosus (Hedw.) Warnst.
Rhytidiadelphus triquetrus (Hedw.) Warnst.
Rhytidium rugosum (Hedw.) Kindb.
Rhytidium sp.
Sanionia sp.
Sanionia uncinata (Hedw.) Loeske
Scapania paludicola Loeske & Müll. Frib.
Schistidium apocarpum (Hedw.) Bruch & Schimp.
Schistidium cf. andreaeopsis (C.Muell.) Lazar.
Schistidium papillosum Culm.
Schistidium sp.
Schistidium tenerum (J.E. Zetterst.) Nyholm
Scorpidium scorpioides (Hedw.) Limpr.
Sphagnum angustifolium (Russ. ex Russ.) C.Jens
Sphagnum aongstroemii C.Hartm.
Sphagnum balticum (Russ.) Russ. ex C.Jens.
Sphagnum capillifolium (Ehrh.) Hedw.
Sphagnum compactum DC. in Lam. et DC.
Sphagnum fimbriatum Wils.
Sphagnum fuscum (Schimp.) Klinggr.
Sphagnum girgensohnii Russ.
Sphagnum imbricatum Hornsch. ex Russ.
Sphagnum jensnii H. Lindb.
Sphagnum lenense H.Lindb. ex Pohle
Sphagnum lindbergii Schimp. ex Lindb.
Sphagnum magellanicum Brid.
Sphagnum obtusum Warnst.
Sphagnum orientale Sav.-Ljub.
Sphagnum riparium Ångstr.
Sphagnum rubellum Wils.
Sphagnum russowii Warnst.
Sphagnum sp.
Sphagnum squarrosum Crome
Sphagnum steerei R.E. Andrus
Sphagnum subsecundum Nees ex Sturm
Sphagnum teres (Schimp.) Ångstr. in Hartm.
Sphagnum warnstorfii Russ.
Sphenolobus minutus (Schreb.) Berggr.
Splachnum luteum
Splachnum sp.
Splachnum sphaericum Hedw
Stegonia latifolia (Schwägr.) Vent. ex Broth.
Syntrichia norvegica Web.
Syntrichia ruralis (Hedw.) Web. et Mohr
Thuidium recognitum (Hedw.) Lindb.
Thuidium sp.
Timmia austriaca Hedw.
Timmia megapolitana Hedw.
Tomentypnum nitens (Hedw.) Loeske
Tortella arctica (Arnell) Crundw. & Nyholm
Tortella fragilis (Hook. et Wils. in Drumm.) Limpr.
Tortella inclinata (R. Hedw.) Limpr.
Tortella sp.
Tortella tortuosa (Hedw.) Limpr.
Tortula norvegica (Web.f.) Wahlenb. ex Lindb.
Tortula ruralis (Hedw.) Gaertn., Meyer, & Scherb.
Warnstorfia exannulata (Guemb. in B.S.G.) Loeske
Warnstorfia fluitans (Hedw.) Loeske
Warnstorfia pseudostraminea (C. Muell.) Tuom. et T. Kop.
Warnstorfia sarmentosa (Wahlenb.) Hedenaes

Appendix 3. Newly documented species for GAAR, based on data collected by ABR in 2008 and data collected during the NPS floristic inventory (Parker 2006). Vouchers exist only for records that have been verified..

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
Araceae	*Calla palustris* L.		GAAR_T112_08_2008	N. Fork R near Florence Lake		C. Parker	M. Duffy
Athyriaceae	*Cystopteris montana* (Lam.) Bernh.		GAAR_T90_05_2008	Walker Lake			M. Duffy
			GAAR_T90_08_2008	Walker Lake			M. Duffy
			GAAR_T90_09_2008	Walker Lake			M. Duffy
			GAAR_T92_07_2008	vic. Kaluluktok Cr.			M. Duffy
Callitrichaceae	*Callitriche anceps* Fern.	*Callitriche heterophylla* Pursh ssp. *heterophylla*	GAAR_T113_12_2008	N. Fork R near Florence Lake			M. Duffy
Campanulaceae	*Lomatogonium rotatum* (l.) E. Fries		GAAR_T94_07_2008	vic. Island Lake, Tobuk Cr.		M. Duffy	T. Miller
			GAAR_T94_08_2008	vic. Island Lake, Tobuk Cr.		C. Parker	T. Miller
Caryophyllaceae	*Silene repens* Patrin		GAAR_T90_12_2008	Walker Lake		C. Parker	M. Duffy
			GAAR_T90_14_2008	Walker Lake			M. Duffy
			GAAR_T90_16_2008	Walker Lake			M. Duffy
Compositae (Asteraceae)	*Antennaria rosea* E. Greene		GAAR_T90_14_2008	Walker Lake		C. Parker	M. Duffy
	Chrysanthemum arcticum L.	*Arctanthemum arcticum* (L.) Tzvelev s. lat	GAAR_T94_08_2008	vic. Island Lake, Tobuk Cr.			T. Miller
	Erigeron lonchophyllus Hook.		GAAR_T114_03_2008	N. Fork R near Florence Lake			M. Duffy
Cornaceae	*Cornus canadensis* L.		GAAR_T90_06_2008	Walker Lake			M. Duffy
			GAAR_T90_08_2008	Walker Lake			M. Duffy
Cruciferae (Brassicaceae)	*Arabis drummondii* Gray	*Boechera drummondii* (A.Gray) A.Love & D.Love	GAAR_T90_13_2008	Walker Lake	Range extension northward from Broad Pass	C. Parker	M. Duffy
	Braya purpurascens (R. Br.) Bunge	*Braya glabella* Richards. ssp. *purpurascens* (R. Br.) Cody	GAAR_T114_03_2008	N. Fork R near Florence Lake			M. Duffy
Cryptogrammaceae	*Cryptogramma crispa* (L.) R. Br. var. *sitchensis* (Rupr.) Christens.		GAAR_T90_13_2008	Walker Lake		C. Parker	M. Duffy
Cyperaceae	*Carex deflexa* Hornem.		GAAR_T90_01_2008	Walker Lake	G5 S1S2	C. Parker	M. Duffy
			GAAR_T90_08_2008	Walker Lake	G5 S1S2	C. Parker	M. Duffy
			GAAR_T90_16_2008	Walker Lake			M. Duffy

Appendix 3. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
	Carex magellanica Lam. ssp. *irrigua* (Wahlenb.) Hult.		GAAR_T93_04_2008	vic. Arrigetch Peaks			M. Duffy
	Carex microglochin Walenb.		GAAR_T94_08_2008	vic. Island Lake, Tobuk Cr.		C. Parker	T. Miller
	Carex praticola Rydb.		GAAR_T90_13_2008	Walker Lake		C. Parker	M. Duffy
	Carex pyrenaica Wahlenb. ssp. *micropoda* (C. A. Meyer) Hult.	*Carex micropoda* C.A. Mey.	GAAR_T92_02_2008	Walker Lake			M. Duffy
			GAAR_T96_06_2008	vic. Island Lake, Tobuk Cr.		M. Duffy	T. Miller
Graminae (Poaceae)	*Hordeum jubatum* L.		GAAR_T112_03_2008	N. Fork R near Florence Lake			M. Duffy
			GAAR_T114_03_2008	N. Fork R near Florence Lake			M. Duffy
Juncaceae	*Juncus alpinus* Villers	*Juncus alpinoarticulatus* Chaix	GAAR_T108_08_2008	Gates of the Arctic			G Frost
			GAAR_T108_09_2008	Gates of the Arctic			G Frost
			GAAR_T108_12_2008	Gates of the Arctic			G Frost
	Luzula rufescens Fisch.		GAAR_T98_15_2008	vic. Upper Gedeke Lake		M. Duffy	T. Miller
	Luzula wahlenbergii Rupr. ssp. *wahlenbergii*		GAAR_T98_14_2008	vic. Upper Gedeke Lake		C. Parker	T. Miller
Leguminosae (Fabaceae)	*Oxytropis viscida* Nutt.		GAAR_T108_04_2008	Gates of the Arctic		C. Parker	G Frost
			GAAR_T108_07_2008	Gates of the Arctic			G Frost
			GAAR_T108_13_2008	Gates of the Arctic			G Frost
			GAAR_T109_06_2008	Gates of the Arctic			J. Roth
			GAAR_T109_07_2008	Gates of the Arctic			J. Roth
Lemnaceae	*Lemna trisulca* L.		GAAR_T113_12_2008	N. Fork R near Florence Lake			M. Duffy
Lentibulariaceae	*Pinguicula villosa* L.		GAAR_T113_04_2008	N. Fork R near Florence Lake			M. Duffy
			GAAR_T113_11_2008	N. Fork R near Florence Lake			M. Duffy
			GAAR_T93_01_2008	vic. Arrigetch Peaks			M. Duffy
Orchidaceae	*Hammarbya paludosa* (L.) Ktze.	*Malaxis paludosa* (Linnaeus) Swartz	GAAR_T93_07_2008	vic. Arrigetch Peaks	G4 S3		M. Duffy
	Listera borealis Morong		GAAR_T108_06_2008	Gates of the Arctic		C. Parker	G Frost
			GAAR_T108_10_2008	Gates of the Arctic			G Frost
			GAAR_T108_11_2008	Gates of the Arctic			G Frost
			GAAR_T108_13_2008	Gates of the Arctic			G Frost

Appendix 3. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
			GAAR_T110_01_2008	Gates of the Arctic		M. Duffy	G Frost
			GAAR_T114_09_2008	N. Fork R near Florence Lake			M. Duffy
			GAAR_T90_05_2008	Walker Lake		C. Parker	M. Duffy
Potamogetonaceae	*Potamogeton berchtoldii* Fieber	*Potamogeton pusillus* ssp. *tenuissimus* (Mertens & W. D. J. Koch) R. R. Haynes & Hellquist	GAAR_T113_05_2008	N. Fork R near Florence Lake		C. Parker	M. Duffy
			GAAR_T93_02_2008	vic. Arrigetch Peaks		C. Parker	M. Duffy
	Potamogeton epihydrus Raf.		GAAR_T113_05_2008	N. Fork R near Florence Lake			M. Duffy
Pyrolaceae	*Pyrola chlorantha* Sw.	*Pyrola virens* Schreb.	GAAR_T90_08_2008	Walker Lake		C. Parker	M. Duffy
Rosaceae	*Potentilla vahliana* Lehm.		GAAR_T100_01_2008	Upper Alatna River Drainage		C. Parker	T. Miller
	Sorbus scopulina Greene		GAAR_T90_13_2008	Walker Lake		C. Parker	M. Duffy
Salicaceae	*Salix scouleriana* Barratt		GAAR_T113_08_2008	N. Fork R near Florence Lake			M. Duffy
			GAAR_T113_09_2008	N. Fork R near Florence Lake			M. Duffy
			GAAR_T113_10_2008	N. Fork R near Florence Lake			M. Duffy
			GAAR_T90_03_2008	Walker Lake			M. Duffy
			GAAR_T90_08_2008	Walker Lake			M. Duffy
Umbelliferae (Apiaceae)	*Cicuta mackenzieana* Raup	*Cicuta virosa* L.	GAAR_T112_08_2008	N. Fork R near Florence Lake		M. Duffy	M. Duffy
			GAAR_T113_13_2008	N. Fork R near Florence Lake			M. Duffy
Violaceae	*Viola biflora* L.		GAAR_T90_08_2008	Walker Lake		M. Duffy	M. Duffy
			GAAR_T92_05_2008	vic. Kaluluktok Cr.			M. Duffy
	Viola langsdorffii Fisch.		GAAR_T92_05_2008	vic. Kaluluktok Cr.			M. Duffy
	Viola renifolia Gray		GAAR_T101_05_2008	vic. Anguneleechak Pass			M. Duffy
			GAAR_T90_05_2008	Walker Lake		C. Parker	M. Duffy
			GAAR_T90_08_2008	Walker Lake			M. Duffy
	Viola selkirkii Pursh		GAAR_T90_05_2008	Walker Lake	G5 S3	C. Parker	M. Duffy
			GAAR_T90_08_2008	Walker Lake	G5 S3	C. Parker	M. Duffy
			GAAR_T90_09_2008	Walker Lake	G5 S3		M. Duffy
			GAAR_T90_13_2008	Walker Lake	G5 S3		M. Duffy
			GAAR_T90_15_2008	Walker Lake	G5 S3		M. Duffy

Appendix 4. Newly documented species for KOVA, based on data collected by ABR in 2007 and data collected during the NPS floristic inventory (Parker 2006). Vouchers exist only for records that have been verified.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
Aspidiaceae	*Gymnocarpium dryopteris* (L.) Newm.		KOVA_T81_05_2007	S of Kitlik River			M. Duffy
			KOVA_T81_06_2007	S of Kitlik River			M. Duffy
			KOVA_T81_07_2007	S of Kitlik River			M. Duffy
Athyriaceae	*Cystopteris montana* (Lam.) Bernh.		KOVA_T75_08_2007	vic. Akillik R Baird Mts		C. Parker	T. Miller
			KOVA_T83_08_2007	vic. Upper Tutuksuk R		C. Parker	T. Miller
Betulaceae	*Alnus tenuifolia* Nutt.	*Alnus tenuifolia* Nutt.	KOVA_T57_04_2007	Kobuk River Slough			J. Roth
			KOVA_T57_05_2007	Kobuk River Slough			J. Roth
			KOVA_T58_04_2007	Salmon R-Hunt R Floodplains			J. Roth
			KOVA_T62_04_2007	Kobuk Floodplain			M. Duffy
			KOVA_T62_11_2007	Kobuk Floodplain		C. Parker	M. Duffy
			KOVA_T74_06_2007	N toe of Jade Mt			T. Miller
Betulaceae	*Betula occidentalis* Hooker		KOVA_T56_08_2007	Hunt Cr. Burn			T. Miller
			KOVA_T65_08_2007	Little Kobuk Sand Dunes			T. Miller
			KOVA_T65_09_2007	Little Kobuk Sand Dunes			T. Miller
Caryophyllaceae	*Melandrium taimyrense* Tolm.	*Silene involucrata* (Chamisso & Schlechtendal) Bocquet ssp. *tenella*	KOVA_T62_04_2007	Kobuk Floodplain			M. Duffy
	Stellaria crassifolia Ehrh.		KOVA_T62_02_2007	Kobuk Floodplain			M. Duffy
			KOVA_T62_07_2007	Kobuk Floodplain			M. Duffy
	Stellaria longifolia Muhl. ex Willd.		KOVA_T56_04_2007	Hunt Cr. Burn			T. Miller
			KOVA_T74_07_2007	N toe of Jade Mt			T. Miller
Compositae (Asteraceae)	*Arnica alpina* (L.) Olin ssp. *angustifolia* (M. Vahl) Maguire	*Arnica angustifolia* Vahl in G.C. Oeder et al.	KOVA_T62_05_2007	Kobuk Floodplain			M. Duffy
			KOVA_T75_02_2007	vic. Akillik R Baird Mts			T. Miller
			KOVA_T75_04_2007	vic. Akillik R Baird Mts			T. Miller
	Arnica lessingii Greene		KOVA_T78_02_2007	vic. Kaliguricheark R.			J. Roth
			KOVA_T81_04_2007	S of Kitlik River		C. Parker	M. Duffy
	Artemisia glomerata Ledeb.		KOVA_T83_02_2007	vic. Upper Tutuksuk R		C. Parker	T. Miller
	Senecio congestus (R. Br.) DC.	*Tephroseris palustris* (L.) Reichenbach	KOVA_T66_15_2007	Kobuk Dunes			M. Duffy
			KOVA_T70_10_2007	vic. Ahnewetut Cr			J. Roth
Cruciferae (Brassicaceae)	*Descurainia sophioides* (Fisch.) O.E. Shultz		KOVA_T62_02_2007	Kobuk Floodplain		C. Parker	M. Duffy
	Draba fladzinensis Wulf		KOVA_T80_06_2007	E of Kanaktok Cr		C. Parker	T. Miller
Cyperaceae	*Carex arcta* Boott.		KOVA_T62_07_2007	Kobuk Floodplain	Range extension	C. Parker	M. Duffy
			KOVA_T62_08_2007	Kobuk Floodplain	Range extension		M. Duffy

Appendix 4. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
			KOVA_T71_07_2007	Nigeruk Cr S Tributary of Kobuk	Range extension	C. Parker	T. Miller
	Carex leptalea Wahlenb.		KOVA_T62_12_2007	Kobuk Floodplain		C. Parker	M. Duffy
	Carex livida (Wahlenb.) Willd.		KOVA_T57_05_2007	Kobuk River Slough			J. Roth
			KOVA_T57_09_2007	Kobuk River Slough			J. Roth
			KOVA_T70_05_2007	vic. Ahnewetut Cr			J. Roth
			KOVA_T70_06_2007	vic. Ahnewetut Cr			J. Roth
			KOVA_T70_07_2007	vic. Ahnewetut Cr			J. Roth
			KOVA_T70_08_2007	vic. Ahnewetut Cr			J. Roth
			KOVA_T70_09_2007	vic. Ahnewetut Cr			J. Roth
	Carex loliacea L.		KOVA_T59_11_2007	Kobuk Flats		C. Parker	M. Duffy
			KOVA_T72_01_2007	E. of Elaroniluk Cr			J. Roth
	Carex magellanica Lam. ssp. *irrigua* (Wahlenb.) Hult.		KOVA_T59_09_2007	Kobuk Flats			M. Duffy
	Carex microchaeta Holm.		KOVA_T67_04_2007	Waring Mts			J. Roth
			KOVA_T68_01_2007	Waring Mts vic. Elaroniluk Cr		C. Parker	G Frost
			KOVA_T74_01_2007	N toe of Jade Mt			T. Miller
			KOVA_T78_01_2007	vic. Kaliguricheark R.			J. Roth
			KOVA_T84_01_2007	vic. Tutuksuk R. Headwater			T. Miller
	Carex nesophila Holm.	*Carex microchaeta* T. Holm ssp. *nesophila* (T. Holm) E. Murray	KOVA_T75_10_2007	vic. Akillik R Baird Mts		C. Parker	T. Miller
	Carex williamsii Britt.		KOVA_T63_02_2007	Ahnewetut Wetlands		C. Parker	J. Roth
			KOVA_T63_03_2007	Ahnewetut Wetlands		C. Parker	J. Roth
			KOVA_T63_04_2007	Ahnewetut Wetlands			J. Roth
			KOVA_T64_04_2007	Kobuk Dunes			J. Roth
	Kobresia sibirica Turcz.		KOVA_T64_03_2007	Kobuk Dunes			J. Roth
			KOVA_T64_05_2007	Kobuk Dunes			J. Roth
Ericaceae	*Ledum groenlandicum* Oeder		KOVA_T57_08_2007	Kobuk River Slough			J. Roth
			KOVA_T70_04_2007	vic. Ahnewetut Cr			J. Roth
			KOVA_T78_06_2007	vic. Kaliguricheark R.			J. Roth
Graminae (Poaceae)	*Elymus alaskanus* (Scribn. & Merr.) A. Loeve ssp. *alaskanus*		KOVA_T62_02_2007	Kobuk Floodplain			M. Duffy
			KOVA_T62_03_2007	Kobuk Floodplain			M. Duffy
			KOVA_T62_04_2007	Kobuk Floodplain			M. Duffy
			KOVA_T80_06_2007	E of Kanaktok Cr		C. Parker	T. Miller
	Festuca brevissima Yurtsev	*Festuca ovina* L. ssp. *alaskana* Holmen	KOVA_T84_01_2007	vic. Tutuksuk R. Headwater			T. Miller
	Festuca rubra L.		KOVA_T58_03_2007	Salmon R-Hunt R Floodplains			J. Roth
			KOVA_T64_01_2007	Kobuk Dunes	CLP: rubra ssp. rubra	C. Parker	J. Roth

Appendix 4. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
			KOVA_T64_02_2007	Kobuk Dunes			J. Roth
			KOVA_T64_05_2007	Kobuk Dunes			J. Roth
	Festuca saximontana Rydb.		KOVA_T66_11_2007	Kobuk Dunes		C. Parker	M. Duffy
	Poa abbreviata R. Br.		KOVA_T83_01_2007	vic. Upper Tutuksuk R		C. Parker	T. Miller
Haloragaceae	*Myriophyllum spicatum* L.		KOVA_T63_05_2007	Ahnewetut Wetlands			J. Roth
	Myriophyllum verticillatum L.		KOVA_T62_11_2007	Kobuk Floodplain		C. Parker	M. Duffy
Juncaceae	*Juncus filiformis* L.		KOVA_T71_09_2007	Nigeruk Cr S Tributary of Kobuk		C. Parker	T. Miller
Leguminosae (Fabaceae)	*Astragalus polaris* Benth.		KOVA_T83_02_2007	vic. Upper Tutuksuk R		C. Parker	T. Miller
Lentibulariaceae	*Pinguicula villosa* L.		KOVA_T59_01_2007	Kobuk Flats		C. Parker	M. Duffy
Orchidaceae	*Listera cordata* (L.) R. Br.		KOVA_T81_07_2007	S of Kitlik River		C. Parker	M. Duffy
Polygonaceae	*Polygonum aviculare* L.		KOVA_T62_02_2007	Kobuk Floodplain		C. Parker	M. Duffy
	Polygonum lapathifolium L.	*Persicaria lapathifolia* (L.) Gray	KOVA_T62_02_2007	Kobuk Floodplain		C. Parker	M. Duffy
	Rumex acetosa L		KOVA_T66_11_2007	Kobuk Dunes			M. Duffy
Potamogetonaceae	*Potamogeton berchtoldii* Fieber	*Potamogeton pusillus* ssp. *tenuissimus* (Mertens & W. D. J. Koch) R. R. Haynes & Hellquist	KOVA_T59_07_2007	Kobuk Flats		C. Parker	M. Duffy
			KOVA_T61_03_2007	Akilik Wetlands		C. Parker	M. Duffy
			KOVA_T61_04_2007	Akilik Wetlands			M. Duffy
	Potamogeton subsibiricus Hagstr.		KOVA_T61_03_2007	Akilik Wetlands		C. Parker	M. Duffy
Primulaceae	*Dodecatheon pulchellum* (Raf.) Merr.		KOVA_T75_08_2007	vic. Akillik R Baird Mts			T. Miller
Primulaceae			KOVA_T83_07_2007	vic. Upper Tutuksuk R		C. Parker	T. Miller
Primulaceae			KOVA_T83_08_2007	vic. Upper Tutuksuk R			T. Miller
Primulaceae	*Primula anvilensis* S. Kelso		KOVA_T83_06_2007	vic. Upper Tutuksuk R		T. Kelso	T. Miller
Pyrolaceae	*Pyrola minor* L.		KOVA_T66_13_2007	Kobuk Dunes		C. Parker	M. Duffy
Pyrolaceae			KOVA_T75_08_2007	vic. Akillik R Baird Mts			T. Miller
Ranunculaceae	*Ranunculus pallasii* Schlect.		KOVA_T61_09_2007	Akilik Wetlands			M. Duffy
Rosaceae	*Sorbus scopulina* Greene		KOVA_T81_07_2007	S of Kitlik River		C. Parker	M. Duffy
Salicaceae	*Salix arbusculoides* Anderss.		KOVA_T56_04_2007	Hunt Cr. Burn			T. Miller
Salicaceae			KOVA_T56_06_2007	Hunt Cr. Burn			T. Miller
Salicaceae			KOVA_T57_06_2007	Kobuk River Slough			J. Roth
Salicaceae			KOVA_T57_07_2007	Kobuk River Slough			J. Roth
Salicaceae			KOVA_T61_05_2007	Akilik Wetlands			M. Duffy
Salicaceae			KOVA_T68_03_2007	Waring Mts vic. Elaroniluk Cr			G Frost
Salicaceae			KOVA_T70_10_2007	vic. Ahnewetut Cr			J. Roth
Salicaceae	*Salix barclayi* Anderss.		KOVA_T57_04_2007	Kobuk River Slough			J. Roth
Salicaceae			KOVA_T57_05_2007	Kobuk River Slough			J. Roth
Salicaceae			KOVA_T57_06_2007	Kobuk River Slough			J. Roth
Salicaceae			KOVA_T57_08_2007	Kobuk River Slough			J. Roth
Salicaceae			KOVA_T57_09_2007	Kobuk River Slough			J. Roth
Salicaceae			KOVA_T58_02_2007	Salmon R-Hunt R Floodplains			J. Roth

Appendix 4. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
Salicaceae	*Salix interior* Rowlee		KOVA_T62_02_2007	Kobuk Floodplain		C. Parker	M. Duffy
Salicaceae	*Salix monticola* Bebb	Salix pseudomonticola C.R. Ball	KOVA_T65_09_2007	Little Kobuk Sand Dunes			T. Miller
Salicaceae	*Salix scouleriana* Barratt		KOVA_T56_04_2007	Hunt Cr. Burn			T. Miller
Salicaceae			KOVA_T58_04_2007	Salmon R-Hunt R Floodplains			J. Roth
Salicaceae			KOVA_T58_05_2007	Salmon R-Hunt R Floodplains			J. Roth
Salicaceae			KOVA_T69_01_2007	E of Waring Peak VABM 2102		C. Parker	G Frost
Saxifragaceae	*Saxifraga foliolosa* R. Br.		KOVA_T80_06_2007	E of Kanaktok Cr			T. Miller
Saxifragaceae	*Saxifraga tricuspidata* Rottb.		KOVA_T80_06_2007	E of Kanaktok Cr			T. Miller
Scrophulariaceae	*Limosella aquatica* L.		KOVA_T62_02_2007	Kobuk Floodplain	G5 S3	C. Parker	M. Duffy
Scrophulariaceae	*Pedicularis lapponica* L.		KOVA_T64_07_2007	Kobuk Dunes			J. Roth
Selaginellaceae	*Selaginella selaginoides* (L.) Link		KOVA_T83_07_2007	vic. Upper Tutuksuk R		C. Parker	T. Miller
Sparganiaceae	*Sparganium angustifolium* Michx.		KOVA_T56_07_2007	Hunt Cr. Burn		C. Parker	T. Miller
Sparganiaceae	*Sparganium minimum* (Hartm.) E. Fries	*Sparganium natans* L.	KOVA_T62_10_2007	Kobuk Floodplain		C. Parker	M. Duffy
Sparganiaceae			KOVA_T62_11_2007	Kobuk Floodplain		C. Parker	M. Duffy
Thelypteridaceae	*Thelypteris phegopteris* (L.) Slosson	*Phegopteris connectilis* (Michaux) Watt	KOVA_T81_05_2007	S of Kitlik River		C. Parker	M. Duffy

Appendix 5. Newly documented species for NOAT, based on data collected by ABR in 2008 and data collected during the NPS floristic inventory (Parker 2006). Vouchers exist only for records that have been verified.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
Callitrichaceae	*Callitriche verna* L. emend. Lonnr.	*Callitriche palustris* L.	NOAT_T05_07_2005				T. Miller
Campanulaceae	*Lomatogonium rotatum* (l.) E. Fries		NOAT_T07_04_2005	Uvgoon creek		D. Murray	T. Miller
			NOAT_T10_04_2005	Lower Noatak Floodplain			M. Duffy
Caryophyllaceae	*Minuartia dawsonensis* (Britt.) Mattf.		NOAT_T18_01_2005			D. Murray	M. Duffy
Compositae (Asteraceae)	*Antennaria alpina* (L.) Gaertn.	*Antennaria pallida* E. E. Nelson	NOAT_T21_03_2005	Kagvik ridge			J. Roth
			NOAT_T21_04_2005	Kagvik ridge			J. Roth
	Antennaria isolepis Greene	*Antennaria rosea* Greene subsp. *pulvinata* (Greene) R. J. Bayer	NOAT_T54_04_2006	Near Natmotirak Creek			M. Duffy
	Aster junciformis Rydb.	*Symphyotrichum boreale* (Torr. & A. Gray) A. Löve & D. Löve	NOAT_T31_05_2005	Noatak canyon		D. Murray	M. Duffy
	Chrysanthemum arcticum L.	*Arctanthemum arcticum* (L.) Tzvelev s. lat	NOAT_T76_03_2007	NOAT-KOVA Border & Cutler R Headwater			M. Duffy
	Erigeron caespitosus Nutt.		NOAT_G02_03_2005			D. Murray	M. Duffy
Cruciferae (Brassicaceae)	*Aphragmus eschscholtzianus* Andrz.		NOAT_T42_02_2006	Knoll W Feniak	G3 S3		M. Duffy
	Cardamine umbellata Greene		NOAT_T06_08_2005	Eli River Mtns			M. Duffy
			NOAT_T10_06_2005	Lower Noatak Floodplain			M. Duffy
	Draba nivalis Liljebl.		NOAT_G02_03_2005			D. Murray	M. Duffy
			NOAT_G03_03_2005	SW Avan Mtns		D. Murray	M. Duffy
			NOAT_T06_02_2005	Eli River Mtns		D. Murray	M. Duffy
			NOAT_T20_04_2005	Avan Mtns		D. Murray	J. Roth
			NOAT_T20_05_2005	Avan Mtns			J. Roth
			NOAT_T22_01_2005				T. Miller
			NOAT_T22_02_2005				T. Miller
			NOAT_T27_01_2005	Mishiguk Ultramafic Mtns		C. Parker	T. Miller
			NOAT_T27_02_2005	Mishiguk Ultramafic Mtns		C. Parker	T. Miller
			NOAT_T28_02_2005	Mt Bastille		D. Murray	T. Miller
			NOAT_T40_01_2006	vic. Feniak Lake		C. Parker	T. Miller
			NOAT_T40_02_2006	vic. Feniak Lake		C. Parker	T. Miller
			NOAT_T42_02_2006	Knoll W Feniak		C. Parker	M. Duffy
			NOAT_T42_07_2006	Knoll W Feniak			M. Duffy
	Smelowskia calycina (Steph.) C.A. Mey. *integrifolia* (Seem.) Hult.	*Smelowskia spathulatifolia* Velichkin	NOAT_T25_01_2005	Poktovik Mts.		D. Murray	J. Roth
	Thlaspi arcticum Pors.		NOAT_G03_01_2005	SW Avan Mtns	G3 S3	D. Murray	M. Duffy
			NOAT_G03_03_2005	SW Avan Mtns			M. Duffy
Cyperaceae	*Carex canescens* L.		NOAT_T42_20_2006	Mts E of Feniak Lake			J. Roth

Appendix 5. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
	Carex dioica gynocrates (Wormsk.) Hult.	*Carex gynocrates* Wormskjöld ex Drejer	NOAT_T17_09_2005			D. Murray	T. Miller
	Carex glareosa Wahlenb. ssp. *glareosa*		NOAT_T40_02_2006	vic. Feniak Lake		C. Parker	T. Miller
			NOAT_T53_02_2006	Kavachuruk Limestone Mtns		M. Duffy	M. Duffy
	Carex kelloggii W. Boott	*Carex lenticularis* Michx. var *lipocarpa* (T. Holm) L.A. Standl.	NOAT_T40_07_2006	vic. Feniak Lake			T. Miller
	Carex limosa L.		NOAT_T12_06_2005	VABM- Bone			T. Miller
			NOAT_T12_07_2005	VABM- Bone			T. Miller
			NOAT_T23_06_2005	Hogback			M. Duffy
			NOAT_T46_02_2006	Upper Noatak Basin			J. Roth
			NOAT_T47_05_2006	Middle Noatak drained lake			T. Miller
	Carex loliacea L.		NOAT_T76_06_2007	NOAT-KOVA Border & Cutler R Headwater		C. Parker	M. Duffy
			NOAT_T76_07_2007	NOAT-KOVA Border & Cutler R Headwater			M. Duffy
	Carex magellanica Lam. ssp. *irrigua* (Wahlenb.) Hult.		NOAT_T04_08_2005	Noatak Flats		D. Murray	J. Roth
	Carex pluriflora Hult.		NOAT_T50_08_2006	Aniuk River			M. Duffy
	Carex stylosa C. A. Mey		NOAT_T06_08_2005	Eli River Mtns			M. Duffy
			NOAT_T13_07_2005				J. Roth
			NOAT_T53_05_2006	Kavachuruk Limestone Mtns			M. Duffy
	Carex utriculata F. Boott		NOAT_T04_02_2005	Noatak Flats			J. Roth
			NOAT_T17_06_2005			C. Parker	T. Miller
	Eleocharis acicularis (L.) Roem. & Schult.		NOAT_T10_06_2005	Lower Noatak Floodplain			M. Duffy
			NOAT_T10_11_2005	Lower Noatak Floodplain			M. Duffy
			NOAT_T31_08_2005	Noatak R. Canyon		D. Murray	M. Duffy
	Eriophorum brachyantherum Trautv. & Mey.		NOAT_T23_01_2005	Hogback			M. Duffy
			NOAT_T23_06_2005	Hogback			M. Duffy
			NOAT_T48_10_2006	Middle Noatak River			M. Duffy
			NOAT_T50_08_2006	Aniuk River			M. Duffy
			NOAT_T50_09_2006	Aniuk River			M. Duffy
			NOAT_T76_07_2007	NOAT-KOVA Border & Cutler R Headwater			M. Duffy
			NOAT_T76_10_2007	NOAT-KOVA Border & Cutler R Headwater			M. Duffy
	Eriophorum viridi-carinatum (Englem.) Fern.		NOAT_T51_02_2006	Atongarak Cr.	G5 S2		T. Miller
			NOAT_T51_03_2006	Atongarak Cr.			T. Miller
	Trichophorum caespitosum (L.)		NOAT_T48_08_2006	Middle Noatak River			M. Duffy

Appendix 5. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
	Hartm.						
Dryopteridaceae	*Woodsia alpina* (Bolton) S.F. Gray		NOAT_T06_03_2005	Eli River Mtns			M. Duffy
			NOAT_T22_02_2005				T. Miller
			NOAT_T22_07_2005				T. Miller
			NOAT_T42_07_2006	Knoll W Feniak			M. Duffy
			NOAT_T76_03_2007	NOAT-KOVA Border & Cutler R Headwater			M. Duffy
Ericaceae	*Arctostaphylos uva-ursi* (L.) Sprengel		NOAT_T01_04_2005				J. Roth
	Ledum groenlandicum Oeder		NOAT_T08_01_2005	VABM- Dry			J. Roth
			NOAT_T08_04_2005	VABM- Dry			J. Roth
			NOAT_T13_04_2005				J. Roth
			NOAT_T45_02_2006	Nimiuktuk River			J. Roth
Graminae (Poaceae)	*Alopecuris alpinus* Sm. ssp. *alpinus*		NOAT_T42_01_2006	Knoll W Feniak			M. Duffy
			NOAT_T42_02_2006	Knoll W Feniak		C. Parker	M. Duffy
	Calamagrostis inexpansa Gray	*Calamagrostis stricta* (Timm) Koeler ssp. *inexpansa* (A.Gray) C.W.Greene	NOAT_T12_08_2005	VABM- Bone			T. Miller
			NOAT_T15_01_2005	Kelley River			T. Miller
			NOAT_T23_04_2005	Hogback			M. Duffy
			NOAT_T48_03_2006	Middle Noatak River		M. Duffy, C. Parker	M. Duffy
	Calamagrostis nutkaensis (C. Presl) Steudel		NOAT_T23_05_2005	Hogback			M. Duffy
	Elymus arenarius L. ssp. *mollis* (Trin.) Hult.	*Leymus mollis* (Trin.) Pilg. ssp. *mollis*	NOAT_T02_03_2005				J. Roth
			NOAT_T02_07_2005				J. Roth
			NOAT_T02_09_2005				J. Roth
	Poa abbreviata R. Br.		NOAT_T43_02_2006	Siniktanneyak Mtn		C. Parker	M. Duffy
	Poa lanata Scribn. & Merr.	*Poa arctica* R. Br. ssp. *lanata* (Scribn.) Soreng	NOAT_T13_04_2005				J. Roth
			NOAT_T18_06_2005			D. Murray	M. Duffy
			NOAT_T29_08_2005	Sisiak creek			M. Duffy
Juncaceae	*Juncus bufonius* L.		NOAT_T29_08_2005	Sisiak creek			M. Duffy
Juncaginaceae	*Triglochin maritimum* L.		NOAT_T50_08_2006	Aniuk River			M. Duffy
Leguminosae (Fabaceae)	*Oxytropis huddelsonii* Pors.		NOAT_T19_03_2005	Ampitheater Mtn	G3 S2S3	C. Parker	T. Miller
Lentibulariaceae	*Pinguicula villosa* L.		NOAT_T05_01_2005	Eli River lowlands			T. Miller
			NOAT_T05_05_2005	Eli River lowlands			T. Miller
			NOAT_T47_02_2006	Middle Noatak drained lake			T. Miller
Menyanthaceae	*Menyanthes trifoliata* L.		NOAT_T04_01_2005	Noatak Flats			J. Roth
			NOAT_T04_10_2005	Noatak Flats			J. Roth

Appendix 5. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
			NOAT_T17_03_2005				T. Miller
			NOAT_T23_04_2005	Hogback			M. Duffy
			NOAT_T23_05_2005	Hogback			M. Duffy
			NOAT_T23_08_2005	Hogback			M. Duffy
Papaveraceae	*Papaver gorodkovii* Tolmatchew & V.V. Petrovsky		NOAT_T22_03_2005			C. Parker	T. Miller
			NOAT_T28_02_2005	Mt Bastille		D. Murray	T. Miller
	Papaver hultenii Knaben	*Papaver lapponicum* (Tolm.) Nordh.	NOAT_T51_02_2006	Atongarak Cr.			T. Miller
			NOAT_T51_03_2006	Atongarak Cr.			T. Miller
Portulacaceae	*Claytonia tuberosa* Pall.		NOAT_T03_03_2005				M. Duffy
Potamogetonaceae	*Potamogeton friesii* Rupr.		NOAT_T54_04_2006	Near Natmotirak Creek			M. Duffy
			NOAT_T54_07_2006	Near Natmotirak Creek			M. Duffy
	Potamogeton pectinatus L.	*Stuckenia pectinata* (L.) Borner	NOAT_T10_06_2005	Lower Noatak Floodplain		D. Murray	M. Duffy
			NOAT_T10_11_2005	Lower Noatak Floodplain		D. Murray	M. Duffy
	Potamogeton praelongus Wulf.		NOAT_T48_09_2006	Middle Noatak River		M. Duffy, C. Parker	M. Duffy
Primulaceae	*Primula stricta* Hornem.		NOAT_T22_08_2005			D. Murray	T. Miller
Pyrolaceae	*Pyrola minor* L.		NOAT_T03_07_2005	Asik Mountain			M. Duffy
			NOAT_T18_07_2005				M. Duffy
			NOAT_T47_10_2006	Middle Noatak drained lake			T. Miller
Ranunculaceae	*Caltha natans* Pall.		NOAT_T23_05_2005	Hogback		D. Murray	M. Duffy
			NOAT_T23_10_2005	Hogback			M. Duffy
			NOAT_T31_08_2005	Noatak R. Canyon			M. Duffy
	Delphinium glaucum S. Wats.		NOAT_T21_02_2005	Kagvik ridge			J. Roth
	Ranunculus eschscholtzii Schlecht.		NOAT_T42_09_2006	Knoll W Feniak		C. Parker	M. Duffy
	Ranunculus trichophyllus Chaix	*Ranunculus aquatilis* var. *diffusus* Withering	NOAT_T10_06_2005	Lower Noatak Floodplain			M. Duffy
			NOAT_T17_03_2005				T. Miller
	Ranunculus trichophyllus Chaix var. *hispidulus* (E. Drew) W. Drew	*Ranunculus aquatilis* var. *aquatilis*	NOAT_T48_09_2006	Middle Noatak River			M. Duffy
Rosaceae	*Potentilla elegans* Cham. & Schlecht.		NOAT_T29_02_2005	Sisiak creek		D. Murray	M. Duffy
			NOAT_T42_01_2006	Knoll W Feniak		C. Parker	M. Duffy
			NOAT_T42_03_2006	Knoll W Feniak			M. Duffy
Rubiaceae	*Galium trifidum* L. ssp. *trifidum*		NOAT_T08_08_2005	VABM- Dry			J. Roth
			NOAT_T10_06_2005	Lower Noatak Floodplain			M. Duffy
			NOAT_T48_09_2006	Middle Noatak River			M. Duffy
Salicaceae	*Salix barclayi* Anderss.		NOAT_T24_04_2005	Kukururok River		D. Murray	J. Roth
			NOAT_T24_05_2005	Kukururok River			J. Roth
	Salix monticola Bebb	*Salix pseudomonticola* C.R. Ball	NOAT_T07_04_2005	Uvgoon Creek		D. Murray	T. Miller
			NOAT_T10_02_2005	Lower Noatak Floodplain			M. Duffy

Appendix 5. Continued.

Family	Taxon	Synonym	Plot ID	Locality	Notes	Verifed by	Botanist
			NOAT_T10_07_2005	Lower Noatak Floodplain			M. Duffy
			NOAT_T10_09_2005	Lower Noatak Floodplain			M. Duffy
			NOAT_T10_10_2005	Lower Noatak Floodplain			M. Duffy
			NOAT_T15_02_2005	Kelley River			T. Miller
			NOAT_T15_04_2005	Kelley River			T. Miller
			NOAT_T15_05_2005	Kelley River			T. Miller
			NOAT_T15_07_2005	Kelley River			T. Miller
			NOAT_T15_10_2005	Kelley River			T. Miller
			NOAT_T25_08_2005				J. Roth
			NOAT_T31_07_2005	Noatak R. Canyon			M. Duffy
Salicaceae	*Salix ovalifolia* Trautv.		NOAT_T17_09_2005				T. Miller
Violaceae	*Viola biflora* L.		NOAT_T03_07_2005	Asik Mountain			M. Duffy

Appendix 6. Rare species documented within the Arctic Network, 2005-2008, based on the Alaska Natural Heritage Program's Rare Plant Tracking List.

Taxon	Synonym	Botanist	Verifed by	Plot ID	Locality	AKNHP Rank
Aphragmus eschscholtzianus Andrz.		M. Duffy		NOAT_T42_02_2006	Knoll W Feniak	S3
Arenaria chamissonis Maguire	*Stellaria dicranoides* (Cham. & Schltdl.) Fenzl	J. Roth		NOAT_T25_01_2005	Poktovik Mts.	G3 S3
		T. Miller	C. Parker	KOVA_T83_01_2007	vic. Upper Tutuksuk R	G3 S3
		M. Duffy		NOAT_T54_01_2006	Near Natmotirak Creek	G3 S3
		M. Duffy		NOAT_T53_02_2006	Kavachuruk Limestone Mtns	G3 S3
		M. Duffy	C. Parker	NOAT_T53_01_2006	Kavachuruk Limestone Mtns	G3 S3
		M. Duffy		NOAT_T43_02_2006	Siniktanneyak Mtn	G3 S3
		M. Duffy		NOAT_T42_07_2006	Knoll W Feniak	G3 S3
		M. Duffy		NOAT_T42_03_2006	Knoll W Feniak	G3 S3
		M. Duffy		NOAT_T41_03_2006	Feniak Lake north beach	G3 S3
		T. Miller		NOAT_T40_05_2006	vic. Feniak Lake	G3 S3
		T. Miller		NOAT_T40_02_2006	vic. Feniak Lake	G3 S3
		T. Miller	C. Parker	NOAT_T40_01_2006	vic. Feniak Lake	G3 S3
		T. Miller		KOVA_T75_04_2007	vic. Akillik R Baird Mts	G3 S3
		T. Miller		NOAT_T27_02_2005	Mishiguk Ultramafic Mtns	G3 S3
		T. Miller		KOVA_T83_04_2007	vic. Upper Tutuksuk R	G3 S3
		T. Miller		NOAT_T22_03_2005		G3 S3
		T. Miller		NOAT_T22_02_2005		G3 S3
		M. Duffy		NOAT_T09_05_2005		G3 S3
		M. Duffy		NOAT_T09_04_2005		G3 S3
		M. Duffy		NOAT_T09_03_2005		G3 S3
		M. Duffy		NOAT_T09_02_2005		G3 S3
		M. Duffy	D. Murray	NOAT_T09_01_2005		G3 S3
		M. Duffy		NOAT_T06_02_2005	Eli River Mtns	G3 S3
		M. Duffy		NOAT_T03_04_2005		G3 S3
		M. Duffy		NOAT_T03_01_2005		G3 S3
		M. Duffy		NOAT_G03_02_2005	SW Avan Mtns	G3 S3
		M. Duffy		NOAT_G03_01_2005	SW Avan Mtns	G3 S3

Appendix 6. Continued.

Taxon	Synonym	Botanist	Verifed by	Plot ID	Locality	AKNHP Rank
		T. Miller		NOAT_T27_03_2005	Mishiguk Ultramafic Mtns	G3 S3
		M. Duffy		NOAT_T76_01_2007	NOAT-KOVA BorderCutler R Headwater	G3 S3
		M. Duffy		NOAT_T76_03_2007	NOAT-KOVA BorderCutler R Headwater	G3 S3
Aster yukonensis Cronq.	*Symphyotrichum yukonense* (Cronquist) G.L. Nesom	J. Roth	C. Parker	KOVA_T64_05_2007	Kobuk Dunes	G3 S3
		M. Duffy	M. Duffy, C. Parker	NOAT_T48_02_2006	middle Noatak River	G3 S3
		T. Miller		GAAR_T94_08_2008	vic. Island Lake, Tobuk Cr.	G3 S3
		T. Miller	C. Parker	GAAR_T94_07_2008	vic. Island Lake, Tobuk Cr.	G3 S3
		T. Miller		GAAR_T94_05_2008	vic. Island Lake, Tobuk Cr.	G3 S3
		T. Miller	C. Parker	GAAR_T94_02_2008	vic. Island Lake, Tobuk Cr.	G3 S3
Campanula aurita Greene		T. Miller	M. Duffy	GAAR_T96_06_2008	vic. Island Lake, Tobuk Cr.	G4 S3S4
		T. Miller	M. Duffy	GAAR_T96_05_2008	vic. Island Lake, Tobuk Cr.	G4 S3S4
Carex deflexa Hornem.		M. Duffy	C. Parker	GAAR_T90_08_2008	Walker Lake	G5 S1S2
		M. Duffy		GAAR_T90_16_2008	Walker Lake	G5 S1S2
		M. Duffy	C. Parker	GAAR_T90_01_2008	Walker Lake	G5 S1S2
Carex holostoma Drej.		J. Roth		NOAT_T25_05_2005	Poktovik Mts.	G4? S3
Carex lapponica Lang		T. Miller	C. Parker	GAAR_T95_10_2008	vic. Island Lake, Tobuk Cr.	G4G5Q S2
		M. Duffy		GAAR_T114_04_2008	N. Fork R near Florence Lake	G4G5Q S2
		T. Miller		KOVA_T84_03_2007	vic. Tutuksuk R. Headwater	G4G5Q S2
Colpodium vahlianum (Liebm.) Nevski	*Puccinellia vahliana* (Liebm.) Scribn. & Merr.	M. Duffy	C. Parker	NOAT_T42_02_2006	Knoll W Feniak	G4 S2S3
		M. Duffy	C. Parker	NOAT_T42_06_2006	Knoll W Feniak	G4 S2S3
Cryptogramma stelleri (S.G. Gmel.) Prantl		M. Duffy		NOAT_G02_04_2005	Noatak Canyon	G5 S2S3
Erigeron porsildii	*Erigeron grandiflorus* Hook. ssp. *arcticus* A.E. Porsild	M. Duffy	D. Murray	NOAT_G02_03_2005		G3G4 S3
Eriophorum viridi-carinatum (Englem.) Fern.		M. Duffy	C. Parker	GAAR_T93_07_2008	vic. Arrigetch Peaks	G5 S2
		T. Miller		NOAT_T51_02_2006	Atongarak Cr.	G5 S2

Appendix 6. Continued.

Taxon	Synonym	Botanist	Verifed by	Plot ID	Locality	AKNHP Rank
		T. Miller		NOAT_T51_03_2006	Atongarak Cr.	G5 S2
Festuca lenensis Drobowi		M. Duffy	D. Murray	NOAT_G02_03_2005		G4G5 S3
Glyceria pulchella (Nash) Schum.		M. Duffy	C. Parker	KOVA_T62_07_2007	Kobuk Floodplain	G5 S2S3
		M. Duffy		KOVA_T62_08_2007	Kobuk Floodplain	G5 S2S3
		M. Duffy		KOVA_T62_10_2007	Kobuk Floodplain	G5 S2S3
		J. Roth	C. Parker	KOVA_T57_07_2007	Kobuk River Slough	G5 S2S3
Hammarbya paludosa (L.) Ktze.	*Malaxis paludosa* (Linnaeus) Swartz	M. Duffy		GAAR_T93_07_2008	vic. Arrigetch Peaks	G4 S3
Limosella aquatica L.		M. Duffy	C. Parker	KOVA_T62_02_2007	Kobuk Floodplain	G5 S3
Lupinus kuschei Eastw.		M. Duffy	C. Parker	KOVA_T66_02_2007	Kobuk Dunes	G3 S2
		M. Duffy		KOVA_T66_03_2007	Kobuk Dunes	G3 S2
		M. Duffy		KOVA_T66_08_2007	Kobuk Dunes	G3 S2
		M. Duffy		KOVA_T66_07_2007	Kobuk Dunes	G3 S2
		T. Miller	C. Parker	KOVA_T65_02_2007	Little Kobuk Sand Dunes	G3 S2
		T. Miller		KOVA_T65_03_2007	Little Kobuk Sand Dunes	G3 S2
		T. Miller		KOVA_T65_05_2007	Little Kobuk Sand Dunes	G3 S2
Minuartia yukonensis Hult.		M. Duffy	D. Murray	NOAT_G02_03_2005		G4? S3
Myriophyllum verticillatum L.		M. Duffy	C. Parker	KOVA_T62_11_2007	Kobuk Floodplain	G5 S3
Oxytropis huddelsonii Pors.		T. Miller	C. Parker	NOAT_T19_03_2005	Ampitheater Mtn	G3 S2S3
Oxytropis kobukensis Welsh		J. Roth	C. Parker	KOVA_T64_03_2007	Kobuk Dunes	G2 S2
		M. Duffy		KOVA_T66_09_2007	Kobuk Dunes	G2 S2
		M. Duffy		KOVA_T66_07_2007	Kobuk Dunes	G2 S2
		T. Miller		KOVA_T65_04_2007	Little Kobuk Sand Dunes	G2 S2
		T. Miller	C. Parker	KOVA_T65_01_2007	Little Kobuk Sand Dunes	G2 S2
		M. Duffy	C. Parker	KOVA_T66_02_2007	Kobuk Dunes	G2 S2
		M. Duffy	C. Parker	KOVA_T66_04_2007	Kobuk Dunes	G2 S2
		J. Roth	C. Parker	KOVA_T64_02_2007	Kobuk Dunes	G2 S2
		M. Duffy		KOVA_T66_05_2007	Kobuk Dunes	G2 S2
		J. Roth	C. Parker	KOVA_T64_01_2007	Kobuk Dunes	G2 S2
		M. Duffy		KOVA_T66_06_2007	Kobuk Dunes	G2 S2
		M. Duffy		KOVA_T66_03_2007	Kobuk Dunes	G2 S2
Oxytropis kokrinensis Porsild		T. Miller	C. Parker	KOVA_T84_01_2007	vic. Tutuksuk R. Headwater	G3 S3

Appendix 6. Continued.

Taxon	Synonym	Botanist	Verifed by	Plot ID	Locality	AKNHP Rank
		J. Roth	D. Murray	NOAT_T25_01_2005	Poktovik Mts.	G3 S3
		M. Duffy	C. Parker	KOVA_T81_01_2007	S of Kitlik River	G3 S3
		M. Duffy	C. Parker	NOAT_T42_01_2006	Knoll W Feniak	G3 S3
		T. Miller	C. Parker	KOVA_T75_04_2007	vic. Akillik R Baird Mts	G3 S3
		M. Duffy		NOAT_T42_04_2006	Knoll W Feniak	G3 S3
		J. Roth		KOVA_T78_01_2007	vic. Kaliguricheark R.	G3 S3
		J. Roth	C. Parker	NOAT_T46_07_2006	Upper Noatak Basin	G3 S3
Oxytropis campestris (L.) DC. ssp. *varians* (Rydb.) Cody		M. Duffy	D. Murray	NOAT_T31_06_2005	Noatak Canyon	G2G3Q S2S3
Papaver gorodkovii Tolmatchew & V.V. Petrovsky		T. Miller	D. Murray	NOAT_T28_02_2005	Mt Bastille	G3 S2S3
		T. Miller	C. Parker	NOAT_T22_03_2005		G3 S2S3
Papaver walpolei Pors.		M. Duffy	C. Parker	NOAT_T53_03_2006	Kavachuruk Limestone Mtns	G3 S3
		M. Duffy		NOAT_T76_03_2007	NOAT-KOVA BorderCutler R Headwater	G3 S3
		M. Duffy	C. Parker	NOAT_T76_01_2007	NOAT-KOVA BorderCutler R Headwater	G3 S3
		M. Duffy		NOAT_T06_03_2005	Eli River Mtns	G3 S3
		M. Duffy	D. Murray	NOAT_T06_02_2005	Eli River Mtns	G3 S3
		M. Duffy	C. Parker	NOAT_T53_01_2006	Kavachuruk Limestone Mtns	G3 S3
		M. Duffy		NOAT_T53_02_2006	Kavachuruk Limestone Mtns	G3 S3
Potentilla rubricaulis Lehm.		M. Duffy	D. Murray	NOAT_G02_03_2005		G4 S2?
Potamogeton subsibiricus Hagstr.		M. Duffy	C. Parker	KOVA_T61_03_2007	Akilik Wetlands	G3 S3
Schizachne purpurascens (Torr.) Swallen		M. Duffy		GAAR_T90_16_2008	Walker Lake	G5 S2
		M. Duffy		GAAR_T90_14_2008	Walker Lake	G5 S2
		M. Duffy	C. Parker	GAAR_T90_13_2008	Walker Lake	G5 S2
Thlaspi arcticum Pors.		M. Duffy		NOAT_G03_03_2005	SW Avan Mtns	G3 S3
		M. Duffy	D. Murray	NOAT_G03_01_2005	SW Avan Mtns	G3 S3

Appendix 6. Continued.

Taxon	Synonym	Botanist	Verifed by	Plot ID	Locality	AKNHP Rank
Viola selkirkii Pursh		M. Duffy		GAAR_T90_15_2008	Walker Lake	G5? S3
		M. Duffy		GAAR_T90_09_2008	Walker Lake	G5? S3
		M. Duffy	C. Parker	GAAR_T90_08_2008	Walker Lake	G5? S3
		M. Duffy	C. Parker	GAAR_T90_05_2008	Walker Lake	G5? S3
		M. Duffy		GAAR_T90_13_2008	Walker Lake	G5? S3

Appendix 7a. Landsat ETM+ and TM data used for mosaic and spectral classification of the Arctic Network.

				Landsat Availability (rows)						
Path	**Acquisition Date**	**Path ID**	**Platform**	**NPS**	**GeoCover**	**USGS**	**Area (Sq m)**	**Area (sq. km)**	**Area (% of mosaic)**	**Area Proportion**
74	2002-08-02	741	7			12-13	13362097462	13362.1	11.299%	33.297%
75	2002-07-24	751	7			12-14	7738498844	7738.5	6.544%	19.284%
76	2002-07-31	761	7	12-13		12-14	7772540554	7772.5	6.573%	19.368%
76	2003-07-18	762	7			13	129742077.7	129.7	0.110%	0.323%
77	2002-08-07	771	7			13-14	1306192164	1306.2	1.105%	3.255%
77	2005-07-22	772	5			13-14	133136089.2	133.1	0.113%	0.332%
77	2008-06-28	773	5			13	263800158.2	263.8	0.223%	0.657%
78	2002-07-29	781	7	13-14		12-14	44771660983	44771.7	37.860%	111.567%
78	2008-07-05	782	5			12	6505203.083	6.5	0.006%	0.016%
79	2002-08-05	791	7			13	6066873.079	6.1	0.005%	0.015%
79	1999-07-28	793	7	12.5-13.5		12-13	1808832436	1808.8	1.530%	4.507%
79	2008-07-28	794	5			13	24286724.61	24.3	0.021%	0.061%
80	2002-07-27	801	7			12-13	23857789642	23857.8	20.175%	59.451%
81	2002-08-03	811	7	11-14	12,14	11-13	17075749872	17075.7	14.440%	42.551%

Appendix 7b. Landsat ETM+ and TM scene parameters by data source.

Source	**Resampling**	**Destriping**	**Resolution (multispectral)**	**Geolocation Level**	**Projection**	**Horizontal Datum**
NPS (NLAPS)	NN	Yes	28.5 m	Terrain	Alaska Albers	NAD1927 and NAD1983
GeoCover	NN	No	28.5 m	Precision Terrain	UTM (variable)	WGS1984
USGS	CC	No	30 m	Precision Terrain	UTM (variable)	WGS1984

Appendix 8. Crosswalk between Ecotype, Map Ecotype, the Regional Map Ecotype, Vegetation Class and the Regional Vegetation Class for the Arctic Network, Alaska. Regional classes integrate data for all five parks while the other variables are based on data for NOAT and KOVA.

Ecotype (short name)	**Map Ecotype**	**Regional Map Ecotype (short)**	**Map Vegetation Class**	**Regional Map Vegetation Class**
Alpine Acidic Barrens	Alpine Acidic Barrens	Alpine Acidic Barrens	Partially Vegetated	Partially Vegetated
Alpine Acidic Dryas Dwarf Shrub	Alpine Acidic Dryas Dwarf Shrub	Alpine Dryas Dwarf Shrub	Dryas Dwarf Shrub	Dryas Dwarf Shrub
Alpine Alkaline Barrens	Alpine Alkaline Barrens	Alpine Alkaline Barrens	Partially Vegetated	Partially Vegetated
Alpine Alkaline Dryas Dwarf Shrub	Alpine Alkaline Dryas Dwarf Shrub	Alpine Dryas Dwarf Shrub	Dryas Dwarf Shrub	Dryas Dwarf Shrub
Alpine Cassiope Dwarf Shrub	Alpine Cassiope Dwarf Shrub	Alpine Ericaceous Dwarf Shrub	Cassiope Dwarf Shrub	Ericaceous Dwarf Shrub
Alpine Ericaceous-Dryas Dwarf Shrub	Alpine Ericaceous-Dryas Dwarf Shrub	Alpine Ericaceous Dwarf Shrub	Ericaceous-Dryas Dwarf Shrub	Ericaceous Dwarf Shrub
Alpine Lake	Alpine Lake	Alpine Lake	Fresh Water	Fresh Water
Alpine Mafic Barrens	Alpine Mafic Barrens	Alpine Mafic Barrens	Partially Vegetated	Partially Vegetated
Alpine Wet Sedge Meadow	Alpine Wet Sedge Meadow	Alpine Wet Sedge Meadow	Sedge Wet Meadow	Sedge Wet Meadow
Lacustrine Wet Sedge Meadow	Lowland Sedge Fen	Lowland Sedge Fen	Sedge Fen	Sedge Fen
Lowland Alder Tall Shrub	Lowland Alder Tall Shrub	Lowland Alder Tall Shrub	Alder Tall Shrub	Alder or Willow Tall Shrub
Lowland Birch-Ericaceous Low Shrub	Lowland Birch-Ericaceous Low Shrub	Lowland Birch-Ericaceous-Willow Low Shrub	Dwarf Birch-Ericaceous Low Shrub	Dwarf Birch-Ericaceous-Willow Low Shrub
Lowland Birch-Willow Low Shrub	Lowland Birch-Willow Low Shrub	Lowland Birch-Ericaceous-Willow Low Shrub	Dwarf Birch-Willow Low Shrub	Dwarf Birch-Ericaceous-Willow Low Shrub
Lowland Black Spruce Forest	Lowland Black Spruce Forest	Lowland Black Spruce Forest	Black Spruce Forest	Black Spruce Forest
Lowland Ericaceous Shrub Bog	Lowland Ericaceous Shrub Bog	Lowland Ericaceous Shrub Bog	Ericaceous Shrub Bog	Ericaceous Shrub Bog
Lowland Lake	Lowland Lake	Lowland Lake	Fresh Water	Fresh Water
Lowland Sedge Fen	Lowland Sedge Fen	Lowland Sedge Fen	Sedge Fen	Sedge Fen
Lowland Sedge-Willow Fen	Lowland Sedge Fen	Lowland Sedge Fen	Sedge Fen	Sedge Fen
Lowland Willow Low Shrub	Lowland Willow Low Shrub	Lowland Willow Low Shrub	Willow Low Shrub	Willow Low Shrub
River	Riverine Water	Riverine Water	Fresh Water	Fresh Water
Riverine Alder Tall Shrub	Riverine Alder Tall Shrub	Riverine Alder or Willow Tall Shrub	Alder Tall Shrub	Alder or Willow Tall Shrub
Riverine Barrens	Riverine Barrens	Riverine Barrens	Partially Vegetated	Partially Vegetated
Riverine Birch-Willow Low Shrub	Riverine Birch-Willow Low Shrub	Riverine Birch-Willow Low Shrub	Dwarf Birch-Willow Low Shrub	Dwarf Birch-Willow Low Shrub
Riverine Dryas Dwarf Shrub	Riverine Dryas Dwarf Shrub	Riverine Dryas Dwarf Shrub	Dryas Dwarf Shrub	Dryas Dwarf Shrub
Riverine Lake	Riverine Water	Riverine Water	Fresh Water	Fresh Water
Riverine Moist Willow Tall Shrub	Riverine Moist Willow Tall Shrub	Riverine Alder or Willow Tall Shrub	Willow Tall Shrub	Alder or Willow Tall Shrub
Riverine Poplar Forest	Riverine Poplar Forest	Riverine Poplar Forest	Balsam Poplar Forest	Balsam Poplar Forest
Riverine Wet Sedge Meadow	Riverine Wet Sedge Meadow	Riverine Wet Sedge Meadow	Sedge Wet Meadow	Sedge Wet Meadow
Riverine Wet Willow Tall Shrub	Riverine Moist Willow Tall Shrub	Riverine Alder or Willow Tall Shrub	Willow Tall Shrub	Alder or Willow Tall Shrub
Riverine White Spruce-Alder Forest	Riverine White Spruce-Willow Forest	Riverine White Spruce-Willow Forest	White Spruce Forest	White Spruce Forest
Riverine White Spruce-Poplar Forest	Riverine White Spruce-Poplar Forest	Riverine White Spruce-Poplar Forest	White Spruce-Balsam Poplar Forest	White Spruce-Balsam Poplar Forest
Riverine White Spruce-Willow Forest	Riverine White Spruce-Willow Forest	Riverine White Spruce-Willow Forest	White Spruce Forest	White Spruce Forest
Riverine Willow Low Shrub	Riverine Willow Low Shrub	Riverine Willow Low Shrub	Willow Low Shrub	Willow Low Shrub
Upland Alder-Willow Tall Shrub	Upland Alder-Willow Tall Shrub	Upland Alder-Willow Tall Shrub	Alder-Willow Tall Shrub	Alder or Willow Tall Shrub
Upland Birch Forest	Upland Birch Forest	Upland Birch Forest	Paper Birch Forest	Paper Birch Forest
Upland Birch-Ericaceous Low Shrub	Upland Birch-Ericaceous Low Shrub	Upland Birch-Ericaceous-Willow Low Shrub	Dwarf Birch-Ericaceous Low Shrub	Dwarf Birch-Ericaceous-Willow Low Shrub
Upland Birch-Willow Low Shrub	Upland Birch-Willow Low Shrub	Upland Birch-Ericaceous-Willow Low Shrub	Dwarf Birch-Willow Low Shrub	Dwarf Birch-Ericaceous-Willow Low Shrub
Upland Dwarf Birch-Tussock Shrub	Upland Dwarf Birch-Tussock Shrub	Upland Dwarf Birch-Tussock Shrub	Dwarf Birch-Tussock Shrub	Dwarf Birch-Tussock Shrub
Upland Sandy Barrens	Upland Sandy Barrens	Upland Sandy Barrens	Partially Vegetated	Partially Vegetated
Upland Sedge-Dryas Meadow	Upland Sedge-Dryas Meadow	Upland Sedge-Dryas Meadow	Sedge-Dryas Meadow	Sedge-Dryas Meadow
Upland Spiraea Low Shrub	Upland Birch-Willow Low Shrub	Upland Birch-Ericaceous-Willow Low Shrub	Dwarf Birch-Willow Low Shrub	Dwarf Birch-Ericaceous-Willow Low Shrub
Upland Spruce-Birch Forest	Upland Spruce-Birch Forest	Upland Spruce-Birch Forest	Spruce-Paper Birch Forest	Spruce-Paper Birch Forest
Upland White Spruce-Dryas Woodland	Upland White Spruce-Lichen Woodland	Upland White Spruce-Lichen Woodland	White Spruce-Lichen Woodland	White Spruce-Lichen Woodland
Upland White Spruce-Ericaceous Forest	Upland White Spruce-Ericaceous Forest	Upland White Spruce Forest	White Spruce Forest	White Spruce Forest
Upland White Spruce-Lichen Woodland	Upland White Spruce-Lichen Woodland	Upland White Spruce-Lichen Woodland	White Spruce-Lichen Woodland	White Spruce-Lichen Woodland
Upland White Spruce-Willow Forest	Upland White Spruce-Willow Forest	Upland White Spruce Forest	White Spruce Forest	White Spruce Forest
Upland Willow Low Shrub	Upland Willow Low Shrub	Upland Willow Low Shrub	Willow Low Shrub	Willow Low Shrub

Appendix 9. Cross-tabulation of clustering of spectral characteristics of training polygons and ecotypes.

SpecClust99	Alpine Rocky Dry Mafic Barrens	Upland Sandy Dry Alkaline Barrens	Alpine Rocky Dry Alkaline Barrens	Alpine Rocky Dry Acidic Barrens	Riverine Gravelly Moist Circumalkaline Barrens	Alpine Rocky Dry Alkaline Dryas Dwarf Shrub	Alpine Rocky Dry Acidic Dryas Dwarf Shrub	Riverine Gravelly Dry Alkaline Dryas Dwarf Shrub	Upland Rocky-loamy Moist Alkaline Sedge-Dryas Meadow	Alpine Rocky-loamy Moist Circumneutral Willow Dwarf Shrub	Alpine Rocky Moist Circumacidic Ericaceous-Dryas Dwarf Shrub	Alpine Rocky Moist Circumneutral Cassiope Dwarf Shrub	Coastal Sandy Moist Circumacidic Crowberry Dwarf Shrub	Upland Organic-rich Moist Acidic Dwarf Birch-Tussock Shrub	Upland Rocky Moist Acidic Spiraea Low Shrub	Lowland Organic-rich Wet Acidic Birch-Ericaceous Low Shrub	Upland Rocky-loamy Moist Acidic Birch-Ericaceous Low Shrub	Lowland Organic-rich Wet Circumacidic Birch-Willow Low Shrub	Riverine Loamy Moist Circumacidic Birch-Willow Low Shrub	Upland Rocky-loamy Moist Circumacidic Birch-Willow Low Shrub	Upland Loamy Moist Circumalkaline Willow Low Shrub	Riverine Gravelly-loamy Moist Circumalkaline Willow Low Shrub	Lowland Organic-rich Wet Circumacidic Willow Low Shrub	Lacustrine Loamy Wet Circumacidic Bluejoint Meadow	Upland Rocky-loamy Moist Circumacidic Bluejoint Meadow	Upland Loamy Moist Circumacidic Willow Tall Shrub	Riverine Loamy Wet Circumacidic Willow Tall Shrub	Riverine Gravelly-loamy Moist Circumalkaline Willow Tall Shrub	Upland Rocky-loamy Moist Circumacidic Alder-Willow Tall Shrub	Lowland Organic-rich Wet Circumacidic Alder Tall Shrub	Riverine Loamy Moist Circumacidic Alder Tall Shrub	Upland Sandy Dry Circumneutral Aspen Forest	Upland Rocky-loamy Moist Circumacidic Birch Forest	Riverine Gravelly-loamy Moist Circumalkaline Poplar Forest	Upland Rocky-Loamy Moist Circumneutral Spruce-Aspen Forest	Upland Rocky-loamy Moist Circumacidic Spruce-Birch Forest	Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Poplar	Upland Rocky-loamy Moist Circumalkaline White Spruce-Willow Forest	Upland Rocky-loamy Moist Circumacidic White Spruce-Ericaceous Fores	Upland Sandy Dry Circumalkaline White Spruce-Dryas Woodland	Upland Sandy Dry Acidic White Spruce-Lichen Woodland	Lowland Organic-rich Wet Acidic Black Spruce Forest	Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Willow	Riverine Gravelly-loamy Moist Circumacidic White Spruce-Alder Forest	Coastal Loamy Wet Brackish Sedge-Grass Meadow	Coastal Loamy Wet Saline Sedge-Grass Meadow	Lowland Circumacidic Sedge-Willow Fen	Lowland Acidic Ericaceous Shrub Bog	Lowland Circumacidic Sedge Fen	Alpine Rocky Circumneutral Wet Sedge Meadow	Lacustrine Organic-rich Wet Circumacidic Sedge Meadow	Riverine Loamy Wet Circumacidic Wet Sedge Meadow	Lacustrine Circumneutral Horsetail Marsh	Alpine Lake	River	Riverine Circumalkaline Lake	Lowland Lake	Coastal Brackish Water	Coastal Nearshore Water	Grand Total
92				1			1				1																																							1										4
93	1			1																																																								2
94				4																																																								4
95				8																																																								8
96	1			2			1																																																					4
97				1																																																								1
98			2																																																									2
99				1		1																																																						2
100			2																																																									2
114				1																																																								1
116				1																																																								1
117				1	1																																																							2
118				3																																																								3
119			1		3																																																							4
120			1	3																																																								4
121	1		1	1																																																								3
122	2		1	2													1																																											6
123	2		1																																																									3
124					1																																																							1
125					1																																																							1
126		5																																																										5
127		5																																																										5
128					1																																																							1
129			2																																																									2
130			2																																																									2
131			1																																																									1
133			3																																																									3
134			4	1																																																								5
135			5																																																									5
136			3																																																									3
137			1																																																									1
140					2																																																							2
143			2	1																																																								3
145			1																																																									1
141			1		2																																																							3
142			1		4																																																							5
144			1																																																									1
146			1																																																									1
147			2																																																									2
148			1																																																									1
113			1		1																																																							2
112			1		1																																																							2
111			2		2																																																							4
110				2																																																								2
109			1	2																																																								3
108			2			2																																																						4
107			1	1																																																								2
106						1			1																																																			2
105						2		1			1																																																	4
138						1																																																						1
139						1																																																						1
132						2																																																						2
101				2			3																																																					5
102				2		1	4		1		2	1																																																11
103							2		1		1																																						1											5
104							2		1			1																																																4
46							2																																																					2
47							2		1																																										1									4
70						1	5	2	1			1		1			1																																											12
71							6	1	4			1		1						1	1																																							15
72							1		2					1																																														4
73							1		1		1																																						1											4
85							2	1		1								1			1																										1		2											9
86						1			2			1																																																4
87				1					2													1														2		1																						7
68											1			1			2																			1					1																			6
67						1	1	1	3													1																									1	2												10
69						3	1		5				1							1																												1												12
50							3		3	1				1							2																																							10
51									5					11																																														16
49									1					2																																														3
48							1		1			1		8			1				1																																							13
64									4		1			8			1				1																																							15
65									1					2				1			2																																							6
66							3		2					2		2					1	1	1																								1	1												14
43						1	2							14						1																																								18
45						1	1				1			12																																														15
44														12			1			1	1																																							15

Appendix 9. Continued.

SpecClust99	Alpine Rocky Dry Mafic Barrens	Upland Sandy Dry Alkaline Barrens	Alpine Rocky Dry Alkaline Barrens	Alpine Rocky Dry Acidic Barrens	Riverine Gravelly Moist Circumalkaline Barrens	Alpine Rocky Dry Alkaline Dryas Dwarf Shrub	Alpine Rocky Dry Acidic Dryas Dwarf Shrub	Riverine Gravelly Dry Alkaline Dryas Dwarf Shrub	Upland Rocky-loamy Moist Alkaline Sedge-Dryas Meadow	Alpine Rocky-loamy Moist Circumneutral Willow Dwarf Shrub	Alpine Rocky Moist Circumacidic Ericaceous-Dryas Dwarf Shrub	Alpine Rocky Moist Circumneutral Cassiope Dwarf Shrub	Coastal Sandy Moist Circumacidic Crowberry Dwarf Shrub	Upland Organic-rich Moist Acidic Dwarf Birch-Tussock Shrub	Upland Rocky Moist Acidic Spiraea Low Shrub	Lowland Organic-rich Wet Acidic Birch-Ericaceous Low Shrub	Upland Rocky-loamy Moist Acidic Birch-Ericaceous Low Shrub	Lowland Organic-rich Wet Circumacidic Birch-Willow Low Shrub	Riverine Loamy Moist Circumacidic Birch-Willow Low Shrub	Upland Rocky-loamy Moist Circumacidic Birch-Willow Low Shrub	Upland Loamy Moist Circumalkaline Willow Low Shrub	Riverine Gravelly-loamy Moist Circumalkaline Willow Low Shrub	Lowland Organic-rich Wet Circumacidic Willow Low Shrub	Lacustrine Loamy Wet Circumacidic Bluejoint Meadow	Upland Rocky-loamy Moist Circumacidic Bluejoint Meadow	Upland Loamy Moist Circumacidic Willow Tall Shrub	Riverine Loamy Wet Circumacidic Willow Tall Shrub	Riverine Gravelly-loamy Moist Circumalkaline Willow Tall Shrub	Upland Rocky-loamy Moist Circumacidic Alder-Willow Tall Shrub	Lowland Organic-rich Wet Circumacidic Alder Tall Shrub	Riverine Loamy Moist Circumacidic Alder Tall Shrub	Upland Sandy Dry Circumneutral Aspen Forest	Upland Rocky-loamy Moist Circumacidic Birch Forest	Riverine Gravelly-loamy Moist Circumalkaline Poplar Forest	Upland Rocky-Loamy Moist Circumneutral Spruce-Aspen Forest	Upland Rocky-loamy Moist Circumacidic Spruce-Birch Forest	Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Poplar	Upland Rocky-loamy Moist Circumalkaline White Spruce-Willow Forest	Upland Rocky-loamy Moist Circumacidic White Spruce-Ericaceous Forest	Upland Sandy Dry Circumalkaline White Spruce-Dryas Woodland	Upland Sandy Dry Acidic White Spruce-Lichen Woodland	Lowland Organic-rich Wet Acidic Black Spruce Forest	Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Willow	Riverine Gravelly-loamy Moist Circumacidic White Spruce-Alder Forest	Coastal Loamy Wet Brackish Sedge-Grass Meadow	Coastal Loamy Wet Saline Sedge-Grass Meadow	Lowland Circumacidic Sedge-Willow Fen	Lowland Acidic Ericaceous Shrub Bog	Lowland Circumacidic Sedge Fen	Alpine Rocky Circumneutral Wet Sedge Meadow	Lacustrine Organic-rich Wet Circumacidic Sedge Meadow	Riverine Loamy Wet Circumacidic Wet Sedge Meadow	Lacustrine Circumneutral Horsetail Marsh	Alpine Lake	River	Riverine Circumalkaline Lake	Lowland Lake	Coastal Brackish Water	Coastal Nearshore Water	Grand Total
79									1					11						2																														1										15
78							2							9				1		1																												1												14
39														7			2				1							1																																11
35									1					8							1								2																														12
75							1							2																																														3
80														5			2													1								1																						9
82														6			3			1									1																															11
90														1																																			1											2
77														1			2	1	1			1																																						6
74																1																																												1
84														1		1	1											1																	1		1	1				1									8
12														1		1						2											1														1		1											7
13						1										1	2																																											4
14																2	3	1		2																													1											9
15																		1		1			1							1			1						1	1				1						1											9
16																	1			1	1							1										2																						6
17																			1	1						1		1	2																															6
18														1		1	2	1		2									1									1																						9
81																				5	1																																							6
76										1	1			5			1			9	1																																							18
40														6			1	2		4	1								1																															15
41															1		3		2	4	2								2										2																					16
42																	1			2		1																																						4
38																				2	2	1		1																																				6
83						1			1												3											1						1	1										1			1									10
11																			1	1		3														1						2																		8
26																						1																																						1
60															1																																													1
63																								1																								1												2
62																	1			1					1			1	2																															6
59																				1						1		2	1					1																										6
61															1					1									4																															6
37																				1									4																															5
36																	1			2								1	5																															9
52											1								1	1	1								3	1																														8
53																			1			1							3					1																										6
54																												1	7		1					1		1																						11
55																												1	5		2					1																								9
56																													5																															5
57																						1							6		1		2	1																										11
58																													5																														5
32																										1								3																										4
91																	1																2								1																			4
115																																	2																											2
31																											1	3	1					2				1	1			1																		10
33																											1									1		3	3				1																	9
1																																							4			3	1	1																9
2																																							2			4	1																	7
3																																				2		2				3																		7
4																																				2			3			1	1																	7
5																																			1		1		3	1		1																		7
6																																				1	2						2																	5
7																																							2				3	2									1							8
8																																							1	1			1																	3
19																		1	1			1						1		1								2	3													1								11
20																	1									1				1								3	5			2	2																	15
21																											1											2	4								1													8
22																						1																	1			2	1																	5
23																			1																				1		1		2																	5
24																																				1		1	7					1																10
25																																						2	3		1	2	2																	10
88																																									2																				2
89														1																			1						1						1			4	2	2											12
9																																											1						1											2
10																																														1														1
34																																															1												1
27																																															1												1
28																										1																1	2								1	1									6
29																						1																											1			1									3
30					1																														1						1							1				1									5
149																																																							2		1	2		5
150																																																								4			4
151																												1																												1			2
152																																																							1			3		4
153																																																						2						2
154																																																						1						1
155																																																								1	4			5
156																																																						1			10	1	1	13
157																																																							2		2	1	2	7
158																																																									8	1	2	11
Gran	7	10	48	43	19	21	47	6	45	3	11	6	1	##	3	9	35	10	9	49	24	17	2	2	1	5	3	15	60	5	4	1	9	8	2	13	3	24	48	2	7	22	21	4	2	1	6	14	13	4	2	6	1	4	5	1	30	8	5	927

Appendix 10. Map accuracy assessed by tabulating mapped ecotype against ground plots used to create the map.

Trarining Polygon Ecotype	Alpine Lake	Alpine Rocky Circumneutral Wet Sedge Meadow	Alpine Rocky Dry Acidic Barrens	Alpine Rocky Dry Acidic Dryas Dwarf Shrub	Alpine Rocky Dry Alkaline Barrens	Alpine Rocky Dry Alkaline Dryas Dwarf Shrub	Alpine Rocky Dry Mafic Barrens	Alpine Rocky Moist Circumacidic Ericaceous-Dryas Dwarf Shrub	Alpine Rocky Moist Circumneutral Cassiope Dwarf Shrub	Coastal Loamy Wet Brackish Sedge-Grass Meadow	Coastal Water	Lowland Acidic Ericaceous Shrub Bog	Lowland Circumacidic Sedge Fen	Lowland Lake	Lowland Organic-rich Wet Acidic Birch-Ericaceous Low Shrub	Lowland Organic-rich Wet Acidic Black Spruce Forest	Lowland Organic-rich Wet Circumacidic Alder Tall Shrub	Lowland Organic-rich Wet Circumacidic Birch-Willow Low Shrub	Lowland Organic-rich Wet Circumacidic Willow Low Shrub	Riverine Gravelly Dry Alkaline Dryas Dwarf Shrub	Riverine Gravelly Moist Circumalkaline Barrens
Alpine Lake	139													27							
Alpine Rocky Circumneutral Wet Sedge Meadow		89										18	39								
Alpine Rocky Dry Acidic Barrens			1874	4																	
Alpine Rocky Dry Acidic Dryas Dwarf Shrub			3	945	2			6	1				5								
Alpine Rocky Dry Alkaline Barrens			213	1	1393	4	614														
Alpine Rocky Dry Alkaline Dryas Dwarf Shrub			1	16		181						34	15		7			1			
Alpine Rocky Dry Mafic Barrens			2				216														
Alpine Rocky Moist Circumacidic Ericaceous-Dryas Dwarf Shrub				1				152					1				2	2			
Alpine Rocky Moist Circumneutral Cassiope Dwarf Shrub				3					114												
Coastal Loamy Wet Brackish Sedge-Grass Meadow										44											
Coastal Water											9499										
Lowland Acidic Ericaceous Shrub Bog												220	7		33						
Lowland Circumacidic Sedge Fen		30		5				2		23		7	247		17			2		1	
Lowland Lake	2684													14226							
Lowland Organic-rich Wet Acidic Birch-Ericaceous Low Shrub												4	2		197	3					
Lowland Organic-rich Wet Acidic Black Spruce Forest															3	343					
Lowland Organic-rich Wet Circumacidic Alder Tall Shrub																	22				
Lowland Organic-rich Wet Circumacidic Birch-Willow Low Shrub		2		18				3					1		2		1	121	1		
Lowland Organic-rich Wet Circumacidic Willow Low Shrub															1				23		
Riverine Gravelly Dry Alkaline Dryas Dwarf Shrub													14							31	
Riverine Gravelly Moist Circumalkaline Barrens																					486
Riverine Gravelly-loamy Moist Circumalkaline Poplar Forest																	45				
Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Poplar Forest																5					
Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Willow Forest													1			82		6			

Trarining Polygon Ecotype	Riverine Gravelly-Loamy Moist Circumalkaline Poplar Forest	Riverine Gravelly-Loamy Moist Circumalkaline White Spruce-Poplar	Riverine Gravelly-Loamy Moist Circumalkaline White Spruce-Willow	Riverine Gravelly-Loamy Moist Circumalkaline Willow Low Shrub	Riverine Gravelly-Loamy Moist Circumalkaline Willow Tall Shrub	Riverine Loamy Moist Circumacidic Alder Tall Shrub	Riverine Loamy Moist Circumacidic Birch-Willow Low Shrub	Riverine Loamy Wet Circumacidic Wet Sedge Meadow	Riverine Water	Upland Loamy Moist Circumalkaline Willow Low Shrub	Upland Organic-rich Moist Acidic Dwarf Birch-Tussock Shrub	Upland Rocky-Loamy Moist Acidic Birch-Ericaceous Low Shrub	Upland Rocky-Loamy Moist Alkaline Sedge-Dryas Meadow	Upland Rocky-Loamy Moist Circumacidic Alder-Willow Tall Shrub	Upland Rocky-Loamy Moist Circumacidic Birch Forest	Upland Rocky-Loamy Moist Circumacidic Birch-Willow Low Shrub	Upland Rocky-Loamy Moist Circumacidic Spruce-Birch Forest	Upland Rocky-Loamy Moist Circumacidic White Spruce-Ericaceous Forest	Upland Rocky-Loamy Moist Circumalkaline White Spruce-Willow Forest	Upland Sandy Dry Acidic White Spruce-Lichen Woodland	Upland Sandy Dry Alkaline Barrens
Alpine Lake																					
Alpine Rocky Circumneutral Wet Sedge Meadow											6		5								
Alpine Rocky Dry Acidic Barrens													56								
Alpine Rocky Dry Acidic Dryas Dwarf Shrub										11	11	25	30			2					
Alpine Rocky Dry Alkaline Barrens											8		53							1	
Alpine Rocky Dry Alkaline Dryas Dwarf Shrub										3	14		324			32		1	2		
Alpine Rocky Dry Mafic Barrens													7								
Alpine Rocky Moist Circumacidic Ericaceous-Dryas Dwarf Shrub										10	14	9	24			1					
Alpine Rocky Moist Circumneutral Cassiope Dwarf Shrub											3	1	10			2					
Coastal Loamy Wet Brackish Sedge-Grass Meadow																					
Coastal Water																					
Lowland Acidic Ericaceous Shrub Bog								1			5				1						
Lowland Circumacidic Sedge Fen				6	1		1	32			9			1							
Lowland Lake									222												
Lowland Organic-rich Wet Acidic Birch-Ericaceous Low Shrub											7	5						1	4		
Lowland Organic-rich Wet Acidic Black Spruce Forest			13					1									46	153	14	4	
Lowland Organic-rich Wet Circumacidic Alder Tall Shrub				2	8	51	8	1		1											
Lowland Organic-rich Wet Circumacidic Birch-Willow Low Shrub										2	14	1		3		20					
Lowland Organic-rich Wet Circumacidic Willow Low Shrub										9	2					1					
Riverine Gravelly Dry Alkaline Dryas Dwarf Shrub								1					11								
Riverine Gravelly Moist Circumalkaline Barrens													63								
Riverine Gravelly-loamy Moist Circumalkaline Poplar Forest	56				3																
Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Poplar Forest		29	1														5	1			
Riverine Gravelly-loamy Moist Circumalkaline White Spruce-Willow Forest		3	440					6							1		1	73	28	4	

Appendix 10. Continued.

Trarining Polygon Ecotype	Alpine Lake	Alpine Rocky Circumneutral Wet Sedge Meadow	Alpine Rocky Dry Acidic Barrens	Alpine Rocky Dry Acidic Dryas Dwarf Shrub	Alpine Rocky Dry Alkaline Barrens	Alpine Rocky Dry Alkaline Dryas Dwarf Shrub	Alpine Rocky Dry Mafic Barrens	Alpine Rocky Moist Circumacidic Ericaceous-Dryas Dwarf Shrub	Alpine Rocky Moist Circumneutral Cassiope Dwarf Shrub	Coastal Loamy Wet Brackish Sedge-Grass Meadow	Coastal Water	Lowland Acidic Ericaceous Shrub Bog	Lowland Circumacidic Sedge Fen	Lowland Lake	Lowland Organic-rich Wet Acidic Birch-Ericaceous Low Shrub	Lowland Organic-rich Wet Acidic Black Spruce Forest	Lowland Organic-rich Wet Circumacidic Alder Tall Shrub	Lowland Organic-rich Wet Circumacidic Birch-Willow Low Shrub	Lowland Organic-rich Wet Circumacidic Willow Low Shrub	Riverine Gravelly Dry Alkaline Dryas Dwarf Shrub	Riverine Gravelly Moist Circumalkaline Barrens	Riverine Gravelly-Loamy Moist Circumalkaline Poplar Forest	Riverine Gravelly-Loamy Moist Circumalkaline White Spruce-Poplar	Riverine Gravelly-Loamy Moist Circumalkaline White Spruce-Willow	Riverine Gravelly-Loamy Moist Circumalkaline Willow Low Shrub	Riverine Gravelly-Loamy Moist Circumalkaline Willow Tall Shrub	Riverine Loamy Moist Circumacidic Alder Tall Shrub	Riverine Loamy Moist Circumacidic Birch-Willow Low Shrub	Riverine Loamy Wet Circumacidic Wet Sedge Meadow	Riverine Water	Upland Loamy Moist Circumalkaline Willow Low Shrub	Upland Organic-rich Moist Acidic Dwarf Birch-Tussock Shrub	Upland Rocky-Loamy Moist Acidic Birch-Ericaceous Low Shrub	Upland Rocky-Loamy Moist Alkaline Sedge-Dryas Meadow	Upland Rocky-Loamy Moist Circumacidic Alder-Willow Tall Shrub	Upland Rocky-Loamy Moist Circumacidic Birch Forest	Upland Rocky-Loamy Moist Circumacidic Birch-Willow Low Shrub	Upland Rocky-Loamy Moist Circumacidic Spruce-Birch Forest	Upland Rocky-Loamy Moist Circumacidic White Spruce-Ericaceous Forest	Upland Rocky-Loamy Moist Circumalkaline White Spruce-Willow Forest	Upland Sandy Dry Acidic White Spruce-Lichen Woodland	Upland Sandy Dry Alkaline Barrens
Riverine Gravelly-loamy Moist Circumalkaline Willow Low Shrub								1				11	8		5			7	26						159						11	9	5	2	20		10					
Riverine Gravelly-loamy Moist Circumalkaline Willow Tall Shrub															5		15					6				254	3		1				8		47		2	2	9	8		
Riverine Loamy Moist Circumacidic Alder Tall Shrub																										2	120															
Riverine Loamy Moist Circumacidic Birch-Willow Low Shrub													9				1	24										78	1		4	10	18		1		23					
Riverine Loamy Wet Circumacidic Wet Sedge Meadow													1												2				85													
Riverine Water																														108 3												
Upland Loamy Moist Circumalkaline Willow Low Shrub				4				2				7	11		14		1	4	26												484	29	5	7	2		11					
Upland Organic-rich Moist Acidic Dwarf Birch-Tussock Shrub		1		4				2				5	3		8				3									26	1		10	335 5	4	12	5		18		7			
Upland Rocky-loamy Moist Acidic Birch-Ericaceous Low Shrub				9								1	5		49	1	4	12														20	561		8		9		68	3		
Upland Rocky-loamy Moist Alkaline Sedge-Dryas Meadow		5		50				7	4			17	107					1													7	31		983			4				10	
Upland Rocky-loamy Moist Circumacidic Alder-Willow Tall Shrub																	16					14			5	12	32	2			2	7	5		161 8	17	40	1		4		
Upland Rocky-loamy Moist Circumacidic Birch Forest													3		2																	2			2	265						
Upland Rocky-loamy Moist Circumacidic Birch-Willow Low Shrub				1		6		1							1		4	40													22	28	26	12	19		993		3	10		
Upland Rocky-loamy Moist Circumacidic Spruce-Birch Forest												13			1			27															1					228	9	5	1	
Upland Rocky-loamy Moist Circumacidic White Spruce-Ericaceous Forest													7		37	24	4	4														4	29		1			11	896	22	6	
Upland Rocky-loamy Moist Circumalkaline White Spruce-Willow Forest													4		2																3		3		10	4	18	13	33	481		
Upland Sandy Dry Acidic White Spruce-Lichen Woodland													56			2																				2		1	8		164	
Upland Sandy Dry Alkaline Barrens																																										521
Total pixels	282 3	127	209 3	106 1	139 5	191	830	176	119	67	949 9	337	546	14253	384	460	115	251	79	32	486	76	32	454	174	280	206	115	130	130 5	579	358 8	706	159 9	173 7	290	118 6	308	126 2	581	190	521
% Correct	5%	70 %	90 %	89 %	100 %	95 %	26 %	86 %	96 %	66 %	100 %	65 %	45 %	100%	51 %	75 %	19 %	48 %	29 %	97 %	100 %	74 %	91 %	97 %	91 %	91 %	58 %	68 %	65 %	83 %	84 %	94 %	79 %	61 %	93 %	91 %	84 %	74 %	71 %	83 %	86 %	100 %

Appendix 11. Map accuracy assessed by tabulating mapped vegetation type against ground plots used to create the map.

Training Polygon Vegetation Class	Alder Tall Shrub	Alder-Willow Tall Shrub	Balsam Poplar Forest	Black Spruce Forest	Brackish Sedge-Grass Wet Meadow	Cassiope Dwarf Shrub	Coastal Water	Dryas Dwarf Shrub	Dwarf Birch-Ericaceous Low Shrub	Dwarf Birch-Tussock Shrub	Dwarf Birch-Willow Low Shrub	Ericaceous Shrub Bog	Ericaceous-Dryas Dwarf Shrub	Fresh Water	Paper Birch Forest	Partially Vegetated	Sedge Fen	Sedge Wet Meadow	Sedge-Dryas Meadow	Spruce-Paper Birch Forest	White Spruce Forest	White Spruce-Balsam Poplar Forest	White Spruce-Lichen Woodland	Willow Low Shrub	Willow Tall Shrub
Alder Tall Shrub	193										8							1						3	10
Alder-Willow Tall Shrub	48	1618	14						5	7	42				17					1	4			7	12
Balsam Poplar Forest	45		56																						3
Black Spruce Forest				343					3									1		46	180		4		
Brackish Sedge-Grass Wet Meadow					44																				
Cassiope Dwarf Shrub						114		3	1	3	2								10						
Coastal Water							9499																		
Dryas Dwarf Shrub						1		1173	32	25	35	34	6			6	34	1	365		3			14	
Dwarf Birch-Ericaceous Low Shrub	4	8		4				9	812	27	21	5					7				76				
Dwarf Birch-Tussock Shrub		5						4	12	3355	44	5	2				3	2	12		7			13	
Dwarf Birch-Willow Low Shrub	6	23						25	48	52	1299		4				10	3	12		13			29	
Ericaceous Shrub Bog									33	5		220			1		7	1							
Ericaceous-Dryas Dwarf Shrub	2							1	9	14	3		152				1		24					10	
Fresh Water														18381											
Paper Birch Forest		2							2	2					265		3								
Partially Vegetated								9		8						5319			179				1		
Sedge Fen		1			23			6	17	9	3	7	2				247	62						6	1
Sedge Wet Meadow										6		18					40	174	5					2	
Sedge-Dryas Meadow						4		50		31	5	17	7				107	5	983				10	7	
Spruce-Paper Birch Forest									2		27	13								228	14		1		
White Spruce Forest	4	11		106					71	4	28				5		12	6		25	1973	3	10	3	
White Spruce-Balsam Poplar Forest				5																5	2	29			
White Spruce-Lichen Woodland				2											2		56			1	8		164		
Willow Low Shrub	1	22						4	30	40	33	18	3				19		9					738	
Willow Tall Shrub	18	47	6						13		2							1		2	17				254
Total pixels	321	1737	76	460	67	119	9499	1284	1090	3588	1552	337	176	18381	290	5325	546	257	1599	308	2297	32	190	832	280
% Correct	60%	93%	74%	75%	66%	96%	100%	91%	74%	94%	84%	65%	86%	100%	91%	100%	45%	68%	61%	74%	86%	91%	86%	89%	91%

NPS/953/100695, October 2009

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov