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Landcover Mapping for Bering Land Bridge National Preserve and Cape Krusenstern National Monument, Northwestern Alaska

Natural Resource Technical Report NPS/ARCN/NRTR—2004/001

ON THE COVER
Burnt tussocks on Bering Land Bridge National Preserve plot V516.
Photograph by: ABR, Inc.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

INTRODUCTION

Ecological field surveys and landcover mapping are essential to evaluating land resources and developing management strategies that are appropriate to the varying conditions of the landscape. More specifically, land classification and mapping can be used to more 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. To satisfy this wide range of needs for the Bering Land Bridge National Preserve (BELA) and Cape Krusenstern National Monument (CAKR), the National Park Service (NPS) is pursuing an integrated "bottom up" approach for inventorying and classifying ecological characteristics, and a "top down" approach to landcover mapping using satellite image processing and environmental modeling to incorporate numerous environmental characteristics. In this effort we combined the areas for BELA and CAKR into one mapping effort because the the ecological characteristics were similar, both areas were covered by a single satellite scene, and it was more efficient to do them together.

To enhance the landcover mapping, which is based primarily on spectral characteristics, we used a multi-step process to better partition the variability in vegetation and other ecological characteristics. These included: (1) an integrated ecological land survey to characterize vegetation, soils, and other ecological characteristics; (2) classification of plant communities (floristic associations), soils, and local-scale ecosystems (termed "ecotypes") that integrate covarying ecological properties; (3) analysis of relationships among ecological components; (4) spectral classification of vegetation structure and dominant plants; and (5) rule-based modeling to better identify and separate the plant communities associated with alpine, riverine, and coastal physiographic regions. Using this integrated ecological land survey approach, we produced a landcover map that has accompanying attributes for vegetation, soils, ecotypes, and a suite of environmental properties. In this report, we emphasize the ecotype component of the landcover map, because it provides the most discrete basis for organizing relationships among vegetation, soils, physiography, and other environmental properties.

In an ecological land survey and classification (ELS), landscapes are viewed not as aggregations of independent biological and physical resources, but as ecological systems with functionally related parts (Rowe 1961; Wiken and Ironside 1977; Bailey 1980, 1996; Driscoll et al. 1984). The goal of an ELS is to provide a consistent conceptual framework for modeling, analyzing, interpreting, and applying ecological knowledge. To provide the information required for such a wide range of applications, an ELS includes three phases: (1) an ecological land inventory that surveys and analyzes data obtained in the field; (2) an ecological land classification that classifies and maps ecosystem distribution; and (3) an ecological land evaluation that assesses the capabilities and sensitivities of the land to various land management practices. This three-phased approach of linking ecological characteristics within a landcover map and spatial database improves our ability to predict the response of ecosystems to human impacts and facilitates the production of thematic maps for specialized engineering and environmental applications.

The structure and function of natural ecosystems are regulated largely along gradients of energy, moisture, nutrients, and disturbance. These gradients are affected by climate, physiography, geomorphology, soils, hydrology, vegetation, and fauna, and are referred to as ecological components (in this report) or '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). Based on the landscape relationships developed from the "bottom up," we integrated satellite remote sensing of vegetation characteristics, physiographic maps, and Digital Elevation Model (DEM) topography to model the distribution of landcover types from the "top down." The resulting landcover maps, which integrate co-varying biological and physical characteristics, provide a comprehensive information base that can be used for ecosystem management.

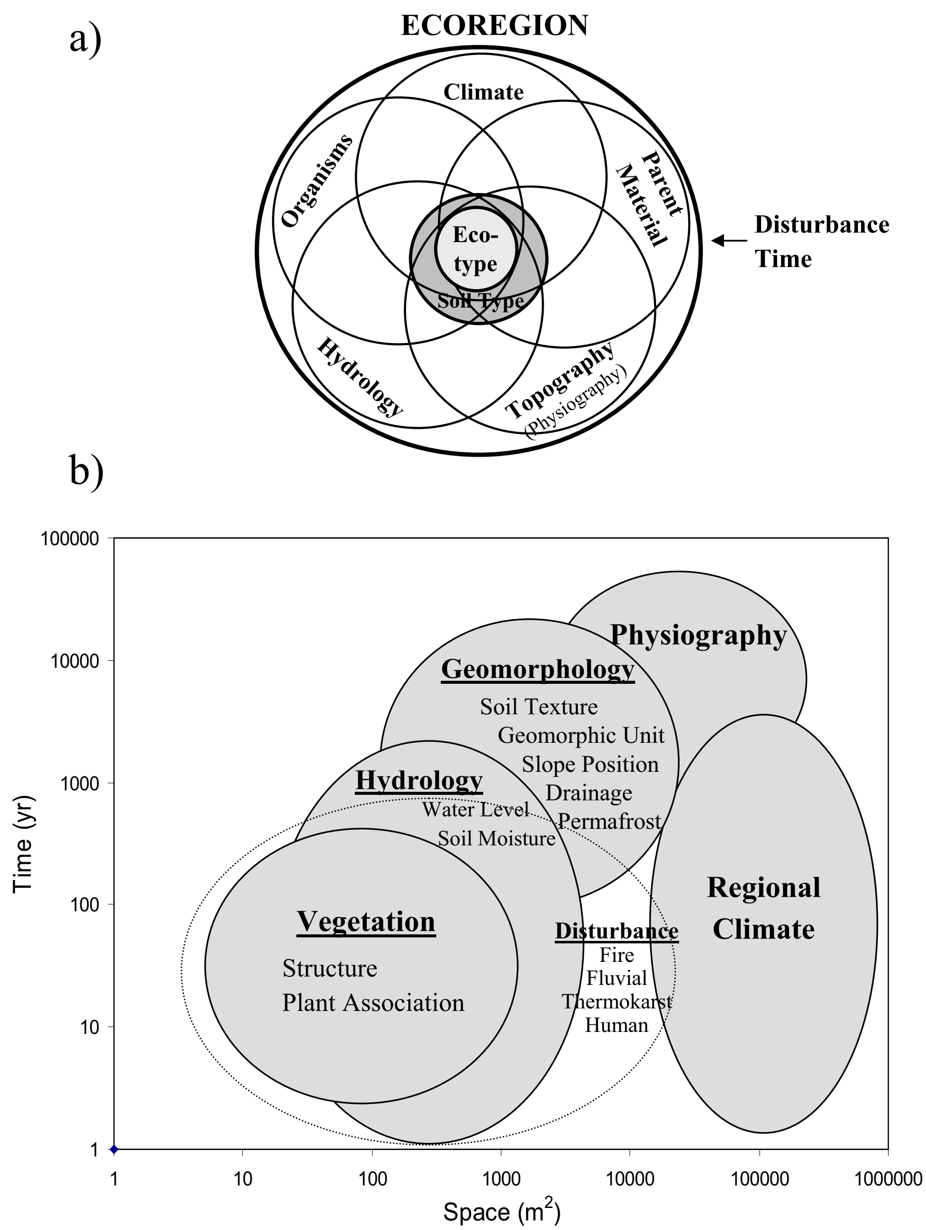


Figure 1. Interaction of interrelated state factors that control the structure and function of ecosystems (a) and the scales at which they operate (b).

An ecological land classification also involves the organization of ecological components within a hierarchy of spatial and temporal scales (Wiken 1981, Allen and Starr 1982, 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 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 (ECOMAP 1993) 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 land cover was developed for northern Alaska by Everett and Walker (Everett et al. 1978; Walker 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. 2003), the entire North Slope (Walker 1999, Jorgenson and Heiner 2003), Yukon-Kuskokwim Delta (Jorgenson 2000), interior Alaska (Jorgenson et al. 1999, Jorgenson et al. 2001), and south-central Alaska (Jorgenson et al. 2003). The ITU approach also has been used for mapping circumpolar arctic vegetation (Walker et al. 2002).

In implementing the ecological land classification portion of landcover mapping, we used a simplified ITU approach that incorporated three components that are readily mapped or modeled, including physiographic units derived from the existing landscape-level ecological maps (subsections) for BELA (Jorgenson 2001) and CAKR (Swanson 2001) that are closely related to surficial geology and geomorphology, surface forms derived from the DEM (primarily slope-related features), and vegetation from the landcover spectral classification. This ITU approach, along with the landscape relationships developed from the analysis of the field survey information, allowed us to develop an enhanced set of landcover types from remote sensing that essentially differentiate ecosystems at the ecotype level of ecological land classification. This integrated approach has several benefits: it recognizes the important effects of geomorphic processes on natural disturbance regimes (e.g., flooding, thermokarst) and the flow of energy and material, it preserves the diversity of environmental characteristics, and 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 landcover types, and used these relationships to develop a map of soil associations. Thus, the landcover map can serve as the spatial database with differing ecological components to aid resource managers evaluate ecological impacts and develop land management strategies appropriate for a diversity of landscape conditions.

Accordingly, the specific objectives of this ecological land survey and landcover mapping for BELA and CAKR were to:

1) conduct a field survey of ecosystem components, including geomorphology (surficial geology), topography, soils, hydrology, and vegetation within the study area;
2) evaluate the relationships among ecosystem components;
3) classify landcover types (local-scale ecosystems or ecotypes) based on quantitative analysis of field data;
4) map landcover types through processing of Landsat TM satellite imagery and rule-based modeling; and
5) use the map database and ecological relationships to derive maps of soil distribution.

METHODS

FIELD SURVEYS

Field surveys were conducted in BELA during 10–15 July 2002 and in CAKR during 11–16 July 2003 (Figures 2 and 3) to collect ecosystem component data. A gradient-directed sampling scheme (Austin and Heyligers 1989) was used to sample the range of ecological conditions and to provide the spatially-related data needed to interpret ecosystem development. Intensive sampling was done primarily along transects (toposequences) located within major physiographic environments, including coastal, riverine, lacustrine, lowland, upland, and alpine areas. Along each transect, 6–14 plots were sampled, each in a distinct vegetation type or spectral signature identifiable on aerial photographs. Data were collected at 231 plots along 32 toposequences. An additional 257 verification sites were sampled off transects for characterizing vegetation structure and dominant plants for use during mapping. 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 intensive plot (~10-m radius), descriptions or measurements of geology, surface form (micro- and macrotopography), hydrology, soil stratigraphy, and vegetation cover were recorded (Appendices 1–3). Photos were taken at all sample locations. Data and photos are archived at ABR and NPS.

Geologic and surface-form variables recorded included 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 depths were measured with a ruler and water-quality measurements (pH and EC) were made with Oakton or Cole-Palmer portable meters that were calibrated daily with standard solutions.

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 intensive plots, the dominant mineral texture, the depth of surface organic matter, cumulative thickness of all organic horizons, percentage of coarse fragments, 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. Within a subset of plots, however, a more complete soil stratigraphy was described using standard methods (SSDS 1993).

Vegetation structure and composition were assessed semiquantitatively. Cover of each species was visually estimated to the nearest 1%, if cover was <10% or >90%, and to the nearest 5% for cover ≥10–90%. Isolated individuals or species with very low cover were assigned a cover value of 0.1%. A species list was compiled that included all vascular plants and the dominant nonvascular plants observed in the plot. 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 then 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 followed Viereck and Little (1972) for shrubs and Hultén (1968) for other vascular plants, with the exception of shrub birch. We did not distinguish between *Betula glandulosa* and *Betula nana*, but called both *B. nana*. We also used a draft floristic inventory of the Seward Peninsula (Kelso et al. 1997) and CAKR (Carolyn Parker, Univ. Alaska Museum, unpublished data 2003) for guidance. Nomenclature for bryophytes and lichens followed the National Plants Database (NRCS 2001). 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 Appendices 4 and 5.

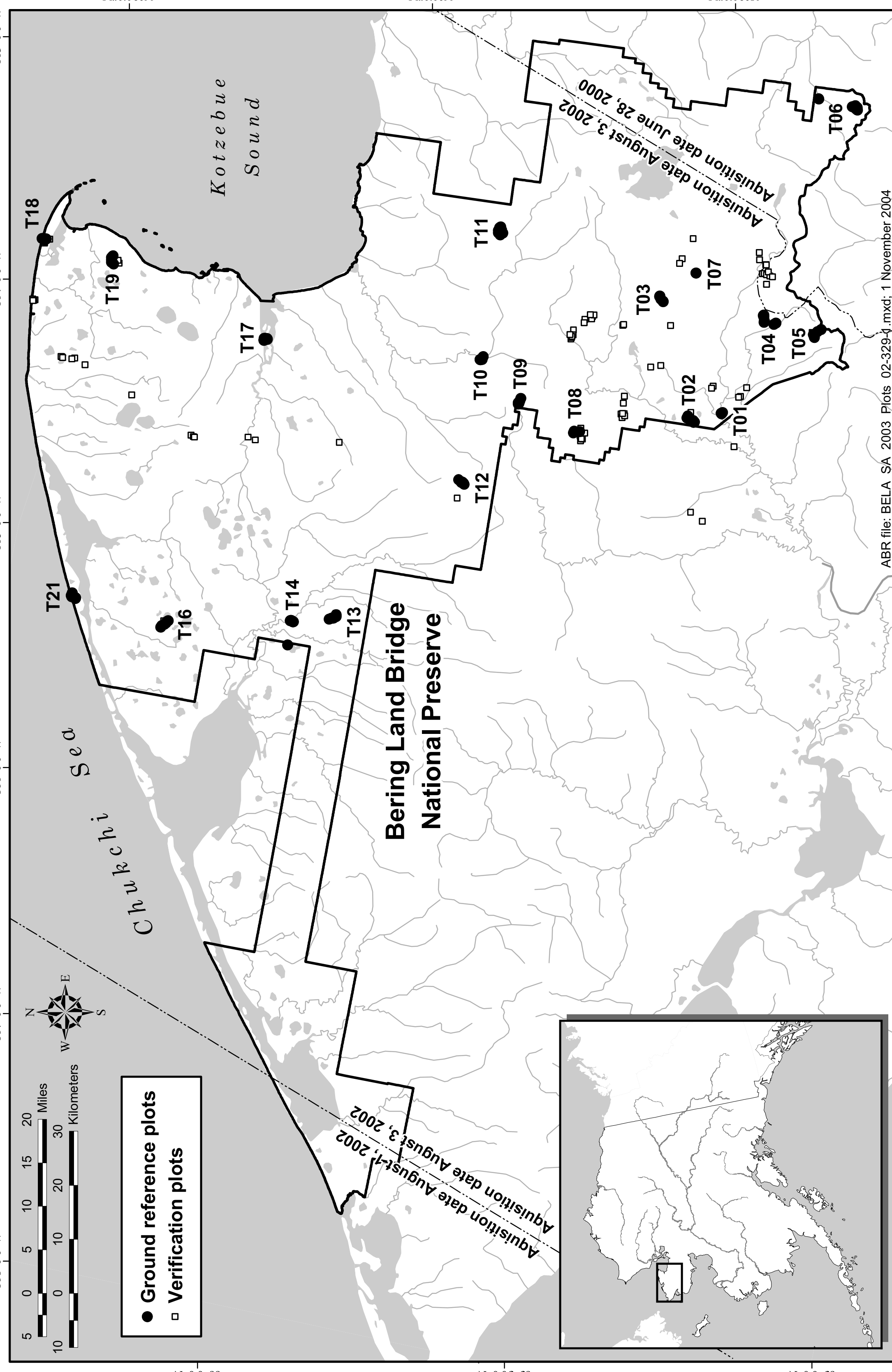


Figure 2. Sampling locations for the ecological land survey (2002–2003) and Landsat scene boundaries for spectral classification, for the Bering Land Bridge National Preserve, northwestern Alaska.

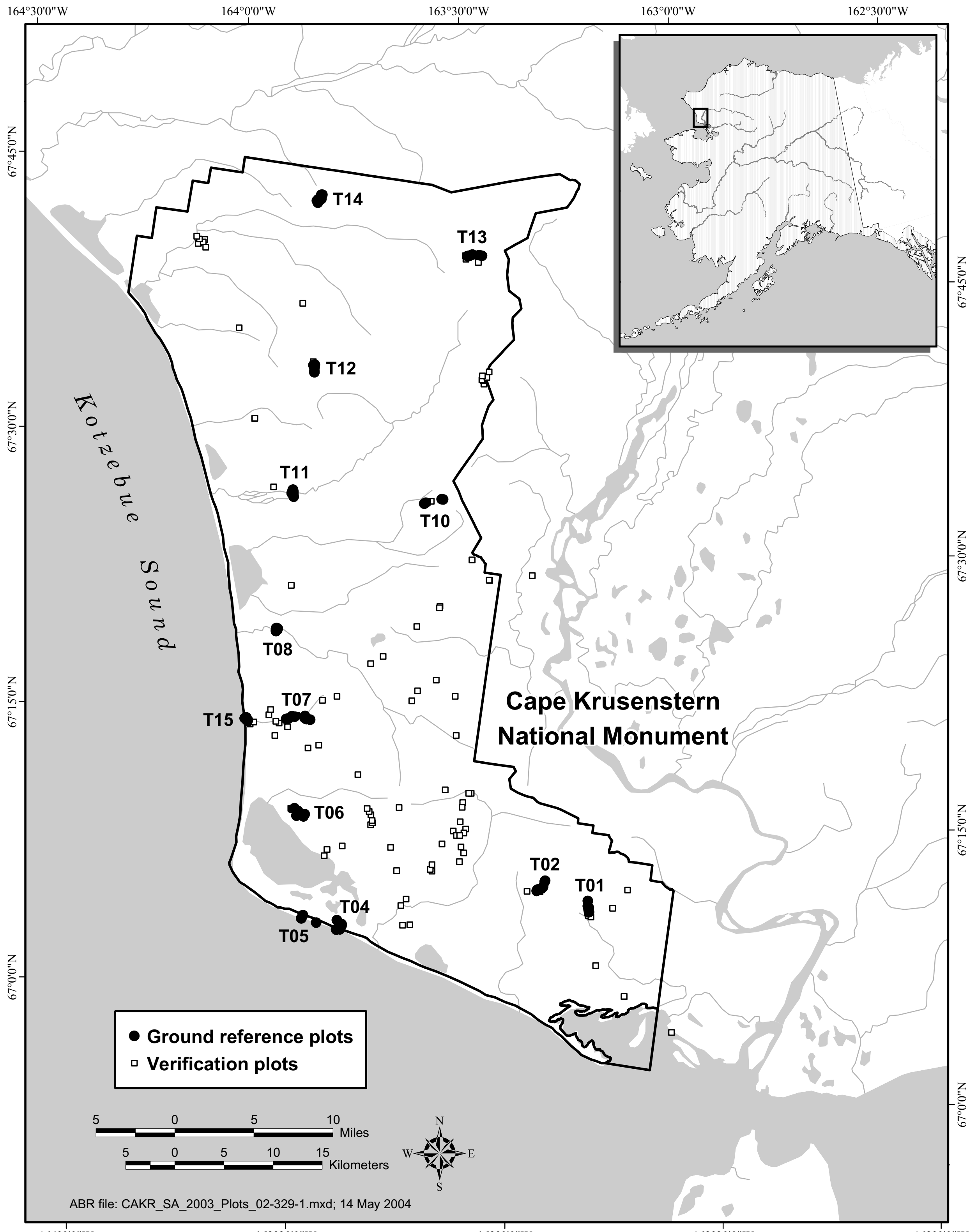


Figure 3. Sampling locations for the ecological land survey in Cape Krusenstern National Monument, northwestern Alaska, 2003. The entire monument was included within one Landsat scene acquired 3 August 2002.

ECOLOGICAL CLASSIFICATION

Ecosystem classification was undertaken 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 BELA (Jorgenson 2001) and CAKR (Swanson 2001) as a guide to our identification of geomorphic and geologic units. We made slight modifications to these maps, however, to extend some of the floodplain mapping farther upstream, and revised some of the coastal and floodplain boundaries to better coregister with the image. 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 was classified in the field to Level 4 of the Alaska Vegetation Classification (AVC) developed by Viereck et al. (1992), with slight modifications previously developed for tundra and coastal classes (Jorgenson et al. 1997). After fieldwork was completed and unknown specimens were identified, plant associations were developed through numeric analyses to further identify plant communities. First, vegetation data (species cover by plot) were ordered into species groups using TWINSPAN (PCOrd 4.17, MjM Software Designs). Second, sorted table analyses (Mueller-Dombois and Ellenberg 1974) were used to refine the groups and identify potential outlier plots. Finally, detrended correspondence analysis 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 a dominant and characteristic species.

ECOTYPES

Classification of ecotypes (local-scale ecosystems) 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 (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 Alaska Vegetation Classification (Viereck et al. 1992), because they are readily identifiable on aerial photographs. Some textural classes were grouped (e.g., sandy and loamy) 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. Ecotype names were then based on the aggregated ecological components.

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 unusual (outliers). The resulting final ecotypes were used for mapping and to summarize the ground data.

LANDCOVER MAPPING

IMAGERY AND ANCILLARY DATA SETS

Three terrain-corrected Landsat TM scenes (28.5 m pixel resolution) were used to create the map. The main scene, acquired 3 August 2002 (Path 81, Rows 12-14), covered all of CAKR and the central 91% of BELA. The image was essentially cloud-free, though some haze obscured the Bendeleben Mountains. Scenes for the peripheral eastern and western edges of BELA were acquired 28 June 2000 (Path 79, Row 14) and 1 August 2002 (Path 83, Row 14), respectively. The western image was cloud-free in the area of interest, and the eastern image had a few small clouds along the southern edge of the study area. After a position analysis based on USGS digital maps and GPS locations acquired in the field, images were shifted 17 m west and 23 m north. Based on GPS data, the horizontal positional accuracy of the image is less than 1 pixel (28.5 m).

In addition to the TM imagery, several layers were used to differentiate specific landscape and vegetation features during post-classification modeling. Existing ecosubsection mapping (Jorgenson 2001, Swanson 2001) was used to define major physiographic and geologic regions. Some modification was made to region boundaries to extend floodplain delineations and correct positional errors. Digital elevation models from the National Elevation Dataset also were used for modeling. Finally, vector layers were created to partition a few specific features, such as areas of cloud and shadow on flat terrain, forested patches in BELA, and the road to the Red Dog Mine.

SIGNATURE EVALUATION AND SPECTRAL DATABASE DEVELOPMENT

Satellite image processing was done using ERDAS 8.6 software. Spectral signatures were generated by overlaying a point file of ground truth sites on the imagery and using region growing tools (seeding) to group pixels of similar spectral characteristics with associated ground-truth sites. In addition to the 488 sites surveyed in this study, ground data collected from the NPS Intensive Mapping Area Survey, 1991–1993 were used. Region-growing parameters varied with the characteristics associated with the ground-truth sites, but a conservative approach was used to restrict pixels to areas that the mapper easily recognized as belonging to the same vegetation type as the ground truth site. The spectral Euclidian distance and total number of pixels within the region were used as primary parameters. Euclidian distances commonly were between 5 and 10, though some particularly homogenous areas were lower, and seeded regions typically were less than 20 pixels. Small, distinct features such as beach fringe or gravel bars were allowed larger Euclidian distances, and large homogenous areas, such as large water bodies, were allowed larger regions. A minimum of seven pixels was required for a valid signature. Seeded regions were added to a signature file if they met these basic parameters and appeared to represent a homogenous photo signature on the satellite image and airphotos for the ground class. A total of 574 signatures were created using ground data and photo interpretation. Of the 60 vegetation classes identified in the ground data, spectral signatures were assigned to 56. The four classes not included in the signature file were Four-leaf Marestail, Dry Forb Meadow, Mixed Herbs, and Open Dwarf White Spruce. The few examples of these classes described by the ground data were either in areas too small or too heterogeneous to generate good signatures. One class was added based on the NPS Intensive Mapping Area Survey data, Open Tall Alder–Willow, yielding spectral signatures for 57 vegetation classes based on ground data.

A spectral database was created by exporting the spectral data for each signature, including mean and standard deviation for each spectral band, into an ACCESS database. Ground data associated with each signature, including plot identifier, vegetation class, ecotype class, vegetation cover by canopy structure, organic layer depth, slope, and percent cover of the most abundant 70 species in the region were added where available. A normalized difference vegetation index (NDVI) also was calculated for each signature and added to the database.

Signatures were evaluated by testing the inherent quality of the spectral information associated with the signature and by assessing the relationships of the signatures to vegetation classes. Analyses used in the signature evaluation included analysis of: (1) the variability of spectral bands for each signature, (2) the fidelity of the signature to the ground information, (3) the central tendencies and overlap of signatures within preliminary ground vegetation classes using principal components analysis, and (4) the association of ground vegetation classes within and among spectral clusters. The results were incorporated into the database.

To assess the spectral variability of each signature, a mean coefficient of variation was calculated for each band for each signature and the results averaged. Signatures with <10% mean variation were judged acceptable the remaining signatures were identified for further evaluation. Exceptions were made for signatures describing Water and Partially Vegetated areas as these classes have high inherent variability. All signatures with coefficients >10% were evaluated by case and retained or excluded based on the results of the analysis described below.

To assess the fidelity of the signature to the ground information, a contingency table was generated based on a maximum likelihood classification of all signature areas using ERDAS signature evaluation routines. The number of pixels classified to the same signature as that developed from the corresponding signature area was calculated. The resulting matrix of input signature by classified signature area provided a measure of the ability of signatures to map correctly to themselves. We extended this analysis to show signature fidelity to the vegetation classes assigned to them based on the ground data. Signatures where >80% of the pixels classified to the correct vegetation class within a signature area were considered acceptable. A few signatures of infrequently occurring ground vegetation classes that had less fidelity to their vegetation class were retained on a case by case basis because they classified accurately to a closely related class. We preserved these signatures because we anticipated the need of merging unusual classes with those classes more frequently observed. Examples of these low fidelity signatures included a signature for Moist Sedge–Willow Meadow that mapped well to Moist Sedge–Dryas Meadow, and a signature for Closed Low Willow that mapped well to Open Low Willow. The two analysis of spectral quality resulted in the elimination of 117 signatures.

To assess the central tendencies and overlap of spectral characteristics of signatures among the initial 57 ground vegetation classes, principal components analysis (PCA) was used in conjunction with cluster analysis (PCOrd 4.17, MjM Software Designs). Results were then used to aggregrate ground vegetation classes with similar spectral and vegetative characteristics into a reduced set of signature vegetation classes. A PCA of the signatures using band data with NDVI was conducted on the 457 signatures remaining after the basic signature evaluation to reduce the variability in signatures to two dimensions and identify outliers within ground vegetation classes. The center of each vegetation class was calculated based on the first two PCA axes, and a distance from the center in axis space was calculated for each signature within the vegetation class. The signatures for each vegetation class were ranked according to their proximity to the center of the vegetation class. The 20% of signatures with the lowest rank (farthest from the center of each vegetation group) were identified as potential outliers. The potential outliers were evaluated for spectral (see cluster analysis below) and plant association (see Ecological Components) similarity and compared with the main characteristics of the vegetation class. While we recognize that some legitimate signatures may have been lost through this analysis, we believe it more important to reduce the potential for misclassifying pixels in the neighborhood of vegetation class outliers than to preserve the outliers themselves.

As another measure for assessing how unique the spectral characteristics were for each ground vegetation class, cluster analysis of band data and NDVI (PCOrd 4.17) was used to group the spectral characteristics of all 574 signatures into clusters, or nodes. A dendrogram with hierarchical linkages partitioned the variability into 66 nodes. The nodes then were cross-tabulated with the ground vegetation classes to identify the frequency with which vegetation types were associated with individual spectral nodes. Signatures within nodes that were strongly associated with a particular vegetation class (the dominant vegetation type for the node) were considered valid. Signatures for vegetation classes not consistent with the dominant vegetation type represented by the node were identified for further evaluation. Plant associations, PCA, and cluster analysis nodes were used to group poorly differentiated ground vegetation classes with the most appropriate class or to reject signatures as invalid. Sixty-five signatures were eliminated after the PCA and cluster analysis.

Based on the results of these multivariate analyses of spectral characteristics, the similarity of species composition, and the relative abundance of the vegetation types in the study area, we consolidated the original 57 ground vegetation classes (AVC Level 4) into 18 signature vegetation classes. Signatures with ground vegetation classes poorly defined by the multivariate analysis were merged with other vegetation classes of similar species composition, landscape position, and spectral characteristics. Four ground vegetation classes were eliminated through the signature verification process because the signatures associated with them did not self classify (Cassiope Dwarf Shrub Tundra, Vaccinium Dwarf Shrub Tundra, Open Low Alder, Open Low Alder–Willow) and one class was eliminated because signatures did not self classify or were defined as outliers by the PCA (Wet Sedge–Birch Tundra). Major vegetation class consolidations included merging 13 low shrub classes into 4, 7 dwarf shrub classes into 2, and 5 lowland wet sedge classes into 2 (Appendix 6). Some ground vegetation classes were split among several signature vegetation classes as dictated by their spectral characteristics and results of the multivariate analysis. For example, the ground vegetation class Dryas–Sedge Dwarf Shrub Tundra was merged with either Dryas Dwarf Shrub Tundra or Moist Sedge–Dryas Tundra, depending upon each signature plant association and results of the multivariate analysis. The final classification set included 389 spectral signatures and 18 signature vegetation classes. The original 574 signatures, however, were retained in the complete spectral database.

IMAGE CLASSIFICATION

Supervised classification of the main scene was done with a fuzzy classification using the 389-signature classification set. We chose to use a fuzzy classification and convolution because we wanted to minimize the occurance of isolated, single pixels that might result from the classification of pixels with mixed spectral signatures. The reduced graininess produced from this supervised classification method makes the map more amenable for analysis and land management. An initial maximum likelihood classification resulted in a highly pixelated map that appeared, in some areas, to impart diversity that was not observed on the ground. Much of this pixelation is due to overlap in spectral characteristics among similar vegetation classes and the spectral diversity within classes. The fuzzy classification and convolution routines provided a method by which secondary as well as best classifications for each pixel could be considered and weighed against surrounding pixels to provide a more useful classification. The fuzzy classification was based on a maximum likelihood routine and classified the 3 best classes per pixel. A fuzzy convolution was performed on the resulting classification using 2 fuzzy classification layers and a 3 × 3 pixel window. The window used a 0.34 equal weighting factor for all 8 adjoining pixels. We selected the parameters of our fuzzy classification and convolution conservatively to allow mixed pixels to be classified with similar neighbor pixels while preserving the classification of individual pixels with strong spectral signatures dissimilar from their neighbors. After the fuzzy convolution was completed, we recoded the classification using the 18 signature vegetation classes to produce a vegetation classification based on the relationships between signatures and vegetation classes identified in the spectral database.

RULE-BASED MODELING

Rule-based modeling (ERDAS Knowledge Engineer) was used to reclassify the supervised classification into 29 ecotypes (Appendices 7 and 8). Inputs to the rules included the classes resulting from the fuzzy convolution, the signature vegetation classification created by recoding the fuzzy convolution, ecosubsection regions, DEM analyses, and specifically generated vector layers (see above). Each ecotype was defined as a collection of signature vegetation classes and/or fuzzy convolution classes within a particular group of physiographic regions. In this way, the vegetation class Open Low Willow Shrub was defined as Lowland Moist Low Willow on coastal plains and in small drainages, Riverine Moist Low and Tall Willow Shrub on floodplain deposits, and Upland Moist Low Willow on upper slopes. Signature vegetation classes such as Halophytic Sedge–Grass Wet Meadow were redefined in non-coastal areas, and shadows on alpine slopes, frequently classified as Water, were redefined using a slope rule. Results of the multivariate analysis, particularly the principal components cluster nodes, were used along with photo interpretation to assign an appropriate ecotype to signature vegetation classes that occurred outside their normally associated region. Occasionally, ecotype classes were assigned to individual fuzzy classes when their associated signature vegetation class was broadly distributed. We classified the road to the Red Dog mine in CAKR, by digitizing the road and designating the Partially Vegetated class within that region as Human Modified Barrens. The completed knowledge-based rule file defines each mapped ecotype by its associated signature vegetation class or fuzzy convolution class, the associated physiographic region, and any pertinent DEM or vector layers. After the knowledge-based classification was finished and the ecotype map was completed, we generated a vegetation map derived from the ecotype classes in order to create a vegetation layer corrected by the rule-based modeling. Seventeen classes are presented in the ecotype-derived vegetation map, compared with 18 signature vegetation classes, because low and tall willow classes were combined in the Riverine Moist Low and Tall Willow Shrub ecotype.

PERIPHERAL IMAGE CLASSIFICATION

The classification of the peripheral images was done through correlation of the spectral classes of the peripheral image with those in the main image. This method was used because the the two peripheral areas were relatively small, their vegetation was similar, and fieldwork to develop full training sets was not practical because of funding and logistical constraints. The peripheral east and west scenes for BELA were classified using a combination of unsupervised and rule-based classification. Each scene was classified into 100 classes using an unsupervised (ISODATA) classification. In the areas of overlap between the main scene and the peripheral images, a contingency matrix was generated, and each unsupervised class was assigned the most common class from the fuzzy convolution in the main image. The unsupervised classifications were recoded with the fuzzy convolution classes from the main scene and also with signature vegetation classes. The east and west scenes were run through the rule-based classification generated for the main scene and the results examined for consistency with the main image. New knowledge-base files were created for east and west images and fine-tuned to minimize inconsistencies among images. Finally, a minimal cluster size was specified for each edge scene based on consistency of appearance with the main classification, 2 pixels for the west and 3 for the east, with smaller pixel size groups eliminated. The peripheral scenes were then merged with the main image.

ACCURACY ASSESSMENT

We assessed the quality and consistency of the classification process using four methods. First, after applying region growing tools, signature quality was determined by how well the signatures classified to themselves (e.g., the number of pixels within the seeded area for signature 180 classified as 180) and to the ground vegetation type (e.g., signature 180 was correctly classified as Dryas Dwarf Shrub Tundra) prior to the supervised classification (see section above on signature evaluation). Second, the results of the principal components analysis were reviewed to assess the separability of the signatures or overlap among signature vegetation types. Third, spectral nodes generated from cluster analysis (aggregations of signatures) were cross-tabulated with signature vegetation classes to assess the degree to which signature vegetation was consistently associated with certain spectral signatures. Finally, the ecotypes and mapped vegetation types were cross-tabulated with the field survey data to quantify the consistency of the map with the ground data. Although we did not have independent points to assess the true accuracy of the mapping, we believe the combination of validating the relationships between spectral characteristics and vegetation and assessing the consistency of the mapping with a large set of widely distributed data points, provide good measures for approximating the overall accuracy of the classification and mapping effort. A full, independent accurary assessment was not done because of funding constraints.

RESULTS

CLASSIFICATION AND DESCRIPTION OF ECOTYPES AND PLANT ASSOCIATIONS

Descriptions of the 33 ecotypes and their respective plant associations are given below and include information on distribution and landscape setting, soil characteristics, plant associations and dominant plant species. Vegetation cover values are provided after the ecotype descriptions in Tables 1–30. Usually, each ecotype corresponds to a unique plant association, however, 4 ecotypes had two plant associations. Tables with the vegetation cover separated by plant association within ecotype are provided in Appendix 14. There were a total of 31 plant associations.

ALPINE ALKALINE DRY BARRENS

Plant Associations:

Dryas octopetala–Potentilla uniflora

Barren (<5% cover) to partially vegetated (5–30%) areas on exposed carbonate bedrock and unstable colluvial slopes at high elevations (~>700 m). Bedrock includes both sedimentary (limestone, dolostone) and metamorphic (marble) carbonate rocks. Soils are thin, rocky, well to excessively drained, and alkaline (pH 7.4). There is no surface organic horizon.

Scattered vegetation is dominated by dwarf shrubs including *Dryas octopetala, Dryas integrifolia,* and lichens, particularly *Evernia perfragilis* and *Flavocetraria* spp. Associated species include *Saxifraga oppositifolia, Lesquerella arctica, Potentilla uniflora, Hedysarum mackenzii,* and *Oxytropis nigrescens.*

Table 1. Vegetation cover and frequency for Alpine Alkaline Dry Barrens (n=6).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	22.2	6.7	100
Total Vascular Cover	15.8	3.4	100
Total Evergreen Shrub Cover	9.7	0.8	100
Dryas integrifolia	1.3	3.3	17
Dryas octopetala	8.3	4.1	83
Total Deciduous Shrub Cover	0.1	0.1	50
Salix arctica	0.0	0.0	17
Salix rotundifolia	0.0	0.0	17
Total Forb Cover	4.9	2.4	100
Androsace chamaejasme	0.0	0.1	33
Artemisia furcata	0.2	0.4	83
Artemisia senjavinensis	0.0	0.1	33
Bupleurum triradiatum	0.1	0.1	50
Hedysarum mackenzii	0.6	0.8	83
Lesquerella arctica	0.1	0.0	83
Minuartia arctica	0.2	0.4	33
Oxytropis arctica	0.4	0.5	50
Oxytropis nigrescens	0.3	0.4	50
Phlox sibirica sibirica	0.4	0.5	67
Potentilla uniflora	0.8	0.4	83
Saussurea angustifolia	0.2	0.4	50
Saxifraga oppositifolia	0.9	0.9	100
Taraxacum phymatocarpum	0.0	0.1	33
Total Grass Cover	0.0	0.0	17
Total Sedge Cover	1.1	0.9	100
Carex petricosa	0.3	0.8	17
Carex rupestris	0.2	0.4	33
Carex scirpoidea	0.0	0.1	33
Carex sp.	0.4	0.5	50
Kobresia sp.	0.2	0.4	17
Total NonVascular Cover	6.4	5.2	100
Total Moss Cover	0.3	0.4	67
Ctenidium procerrimum	0.0	0.1	17
Distichium capillaceum	0.0	0.0	17
Total Lichen Cover	6.1	5.0	100
Alectoria nigricans	0.2	0.4	17
Alectoria ochroleuca	0.4	0.5	50
Asahinea chrysantha	0.1	0.1	33
Bryocaulon divergens	0.2	0.4	17
Cetraria tilesii	0.2	0.4	67
Cladina sp.	0.1	0.2	17
Evernia perfragilis	0.2	0.4	50
Flavocetraria cucullata	0.2	0.4	67
Flavocetraria nivalis	0.5	0.5	67
Nephroma arcticum	0.2	0.4	33
Ochrolechia frigida	0.8	1.3	33
Pertusaria sp.	0.2	0.4	17
Thamnolia subuliformis	0.7	1.6	17
Thamnolia vermicularis	1.2	1.3	83
Total Bare Ground	88.5	3.6	100
Soil	85.0	4.5	100

ALPINE ALKALINE DRY DRYAS SHRUB

Plant Associations:
Dryas integrifolia–Rhododendron lapponicum;
Dryas octopetala–Potentilla uniflora

Areas on carbonate bedrock and relatively stable slopes at high elevations (~>700m) dominated by dwarf shrub vegetation. Soils are alkaline (pH 7.4), rocky, and well drained with a thin organic horizon.

Vegetation is dominated by dwarf shrubs and lichens including *Dryas integrifolia* (mostly south slopes), or *D. octopetala, Thamnolia vermicularis, Ochrolechia frigida, Nephroma arcticum, Flavocetraria cucullata,* and *F. nivalis*. Other species include *Cassiope tetragona*, *Potentilla uniflora*, *Arctostaphylos rubra, Rhytidium rugosum,* and *Tomentypnum nitens.*

The first plant association is dominated by *Dryas integrifolia* and differentiated by the common occurrence of *Rhododendron lapponicum*. Other common species include *Salix arctica, Salix reticulata, Arctostaphylos rubra, Carex scirpoidea, Tomentypnum nitens* and *Rhytidium rugosum.* The second plant association is dominated by *Dryas octopetala* and differentiated by the presence of *Potentilla uniflora.* Other common species include *Saxifraga oppositifolia, Artemisia furcata, Hedysarum mackenzii*, and *Lesquerella arctica*.

This ecotype is similar to Alpine Nonalkaline Dry Dryas Shrub, but lacks the acidiphilic species *Salix phlebophylla* and *Hierochloe alpina*.

Table 2. Vegetation cover and frequency for Alpine Alkaline Dry Dryas Shrub (n=13).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	96.1	46.8	100
Total Vascular Cover	60.8	20.0	100
Total Evergreen Shrub Cover	44.1	15.2	100
Cassiope tetragona	2.6	4.3	54
Dryas integrifolia	14.6	20.4	38
Dryas octopetala	21.2	23.5	54
Rhododendron lapponicum	0.6	1.4	54
Total Evergreen Tree Cover	0.4	1.4	8
Picea glauca	0.4	1.4	8
Total Deciduous Shrub Cover	5.2	5.8	69
Andromeda polifolia	0.2	0.4	31
Arctostaphylos rubra	1.8	2.1	54
Salix arctica	1.9	2.6	54
Salix reticulata	0.8	1.4	46
Total Forb Cover	7.3	2.5	100
Androsace chamaejasme	0.0	0.1	46
Artemisia furcata	0.1	0.3	54
Equisetum variegatum	0.2	0.6	31
Hedysarum alpinum	0.5	1.0	31
Hedysarum mackenzii	0.4	0.9	46
Lagotis glauca	0.1	0.3	23
Minuartia sp.	0.1	0.3	31
Oxytropis nigrescens	0.1	0.3	23
Pedicularis capitata	0.1	0.3	54
Phlox sibirica sibirica	0.2	0.6	23
Polygonum viviparum	0.1	0.3	62
Potentilla biflora	0.4	1.0	23
Potentilla uniflora	0.1	0.3	23
Saussurea angustifolia	0.2	0.4	38
Saxifraga oppositifolia	1.2	0.9	77
Silene acaulis	0.2	0.4	62
Tofieldia coccinea	0.1	0.3	38
Tofieldia pusilla	0.2	0.4	38
Total Grass Cover	0.3	0.6	62
Arctagrostis latifolia	0.1	0.3	8
Festuca altaica	0.2	0.6	8
Total Sedge Cover	3.5	2.4	100
Carex bigelowii	0.3	0.7	23
Carex membranacea	0.2	0.4	23
Carex nardina	0.3	0.6	38
Carex scirpoidea	1.2	1.9	54
Eriophorum angustifolium	0.2	0.4	23
Total NonVascular Cover	35.3	32.3	100
Total Moss Cover	7.2	9.0	77
Hylocomium splendens	1.2	3.0	15
Rhytidium rugosum	1.9	3.7	46
Tomentypnum nitens	2.6	5.5	38
Total Lichen Cover	28.1	29.0	100
Alectoria ochroleuca	0.9	1.6	38
Bryocaulon divergens	0.3	0.9	23
Cetraria islandica cf	2.6	8.2	46
Cetraria tilesii	0.2	0.4	38
Dactylina arctica	0.4	0.9	46
Flavocetraria cucullata	5.7	9.6	77
Flavocetraria nivalis	1.9	1.8	69
Masonhalea richardsonii	0.2	0.4	23
Nephroma arcticum	3.2	11.1	23
Ochrolechia frigida	2.6	4.7	46
Thamnolia vermicularis	3.7	4.3	92
Vulpicida tilesii	0.3	0.6	31
Total Bare Ground	44.5	26.7	100
Soil	25.0	27.0	100
Litter alone	19.5	19.6	100

ALPINE NONALKALINE DRY BARRENS

Plant Association:

Dryas octopetala–Salix phlebophylla– Hierochlöe alpina

Barren to partially vegetated (<30% cover) areas on exposed noncarbonate bedrock and talus slopes at high elevations (~>700 m). Bedrock includes felsic intrusive, noncarbonate metamorphic, and noncarbonate sedimentary rocks that generally have low calcium and magnesium and high aluminum concentrations that lead to acidic soils. Soils are thin, rocky, well to excessively drained, lacking in surface organic accumulations, and acidic to circumneutral (pH <7.4).

The vegetation is dominated by lichens and has a wide variety of colonizing plants. Common species include *Dryas octopetala, Salix phlebophylla, Hierochlöe alpina, Carex podocarpa, Geum glaciale, Alectoria ochroleuca, Sphaerophorus globosus, Thamnolia vermicularis*, and *Cladonia* spp.

This ecotype is similar to Alpine Alkaline Dry Barrens, but lacks the calciphilic species *Saxifraga oppositifolia, Potentilla uniflora, Hedysarum mackenzii,* and *Oxytropis nigrescens.*

Table 3. Vegetation cover and frequency for Alpine Nonalkaline Dry Barrens (n=7).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	51.1	30.1	100
Total Vascular Cover	5.7	5.3	85
Total Evergreen Shrub Cover	1.6	2.1	71
Cassiope tetragona	0.4	0.7	42
Diapensia lapponica	0.4	0.8	42
Dryas octopetala	0.6	1.0	28
Total Deciduous Shrub Cover	1.1	1.2	85
Arctostaphylos alpina	0.1	0.4	14
Salix phlebophylla	0.9	1.2	71
Total Forb Cover	1.6	1.9	71
Artemisia arctica arctica	0.3	0.8	14
Geum glaciale	0.3	0.8	28
Saxifraga sp.	0.2	0.4	42
Selaginella selaginoides	0.1	0.4	14
Silene acaulis	0.3	0.5	28
Total Grass Cover	0.2	0.4	42
Hierochlöe alpina	0.2	0.4	42
Total Sedge Cover	1.2	1.8	71
Carex bigelowii	0.3	0.5	28
Carex podocarpa	0.9	1.9	42
Total NonVascular Cover	45.4	30.1	100
Total Moss Cover	2.6	4.3	85
Eurhynchium pulchellum	0.1	0.4	14
Hylocomium splendens	0.3	0.8	14
Hypnum holmenii	0.1	0.4	14
Plagiomnium curvatulum	0.1	0.4	14
Polytrichum sp.	0.7	1.9	42
Racomitrium lanuginosum	0.7	1.9	14
Total Lichen Cover	42.8	27.8	100
Alectoria nigricans	0.2	0.4	42
Alectoria ochroleuca	0.6	1.1	57
Cetraria islandica cf	0.6	1.1	28
Cetraria nigricans	0.2	0.4	42
Cetraria sp.	0.2	0.4	14
Cladina rangiferina	0.1	0.4	14
Cladina stygia	0.4	1.1	28
Cladonia coccifera	0.0	0.1	14
Cladonia gracilis	0.0	0.1	14
Cladonia sp.	0.3	0.5	71
Dactylina arctica	0.0	0.1	28
Flavocetraria cucullata	0.6	1.1	28
Flavocetraria nivalis	0.2	0.4	28
Ochrolechia frigida	0.5	1.1	28
Parmelia omphalodes	3.0	7.5	28
Rhizocarpon geographicum	1.0	1.2	57
Sphaerophorus fragilis	0.1	0.4	14
Sphaerophorus globosus	0.1	0.1	57
Thamnolia vermicularis	0.3	0.5	71
Umbilicaria sp.	0.2	0.4	28
Umbilicaria torrefacta	1.4	2.4	28
Unknown crustose lichen	13.7	19.1	71
Unknown foliose lichen	14.3	25.1	28
Xanthoria sp.	1.1	1.9	42
Total Bare Ground	67.0	24.8	100
Soil	65.7	23.9	100
Litter alone	1.3	1.8	71

ALPINE NONALKALINE DRY DRYAS SHRUB

Plant Association:
Dryas octopetala–Salix phlebophylla–Hierochlöe alpina

Crests and slopes at high elevations (~>700 m) on noncarbonate bedrock and colluvium dominated by dwarf shrub vegetation. Soils are rocky, well to excessively drained, have very thin surface organic accumulations, and are strongly acidic (pH <6).

Vegetation is dominated by dwarf shrubs, sedges, and lichens including *Dryas octopetala*, *Salix phlebophylla, Loiseleuria procumbens,* and *Carex podocarpa.* Associated species include *Salix planifolia pulchra, Hierochlöe alpina*, *Sphaerophorus globosus, Nephroma arcticum,* and *Flavocetraria cucullata*.

This ecotype differs from Alpine Alkaline Dry Dryas Shrub by lacking the calciphilic species *Saxifraga oppositifolia, Potentilla uniflora, Hedysarum mackenzii,* and *Oxytropis nigrescens.* It differs from Upland Moist Dwarf Birch–Ericaceous Shrub by lacking *Betula nana* and *Ledum decumbens*.

Table 4. Vegetation cover and frequency for Alpine Nonalkaline Dry Dryas Shrub (n=8).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	82.7	19.0	100
Total Vascular Cover	44.6	16.2	100
Total Evergreen Shrub	23.1	12.3	100
Cassiope tetragona	2.1	3.6	50
Diapensia lapponica	2.1	2.5	50
Dryas octopetala	13.8	14.1	87
Empetrum nigrum	0.5	0.8	37
Ledum decumbens	0.4	0.7	37
Loiseleuria procumbens	3.3	5.3	62
Vaccinium vitis-idaea	0.9	1.8	37
Total Deciduous Shrub	10.4	6.9	100
Salix phlebophylla	6.8	4.0	100
Salix planifolia pulchra	0.5	0.5	75
Vaccinium uliginosum	1.7	3.5	62
Total Forb Cover	4.5	3.8	100
Anemone narcissiflora	0.4	0.5	62
Antennaria friesiana	0.3	0.4	50
Arnica lessingii	0.2	0.3	37
Artemisia arctica arctica	0.5	0.8	37
Castilleja hyperborea	0.2	0.3	37
Oxytropis arctica	0.3	0.7	37
Polygonum bistorta	0.2	0.3	37
Selaginella selaginoides	1.0	1.6	37
Total Grass Cover	1.2	1.3	100
Hierochlöe alpina	0.8	1.0	100
Trisetum spicatum	0.2	0.3	37
Total Sedge Cover	5.3	5.2	100
Carex bigelowii	0.8	1.2	37
Carex microchaeta	0.5	1.1	25
Carex podocarpa	3.0	5.6	50
Luzula sp.	0.2	0.4	37
Total NonVascular Cover	38.2	20.7	100
Total Moss Cover	6.6	4.7	100
Dicranum sp.	1.1	1.4	50
Polytrichum sp.	1.6	1.9	50
Polytrichum strictum	1.0	1.8	37
Racomitrium lanuginosum	0.4	0.7	25
Rhizomnium sp.	1.3	2.3	25
Total Lichen Cover	31.6	17.8	100
Alectoria ochroleuca	0.3	0.5	37
Asahinea chrysantha	0.3	0.7	25
Bryocaulon divergens	0.4	0.7	50
Cetraria islandica cf	0.9	1.8	25
Cladina mitis	1.4	2.4	37
Cladina rangiferina	1.3	1.9	37
Cladina stygia	0.9	2.5	25
Cladonia sp.	0.5	0.8	37
Flavocetraria cucullata	2.3	3.5	87
Flavocetraria nivalis	0.8	1.0	62
Nephroma arcticum	0.4	0.7	50
Parmelia omphalodes	5.3	9.9	37
Pertusaria dactylina	0.4	0.5	37
Pertusaria subobducens	3.1	4.6	37
Rhizocarpon geographicum	1.3	3.5	12
Sphaerophorus globosus	1.3	1.0	87
Stereocaulon sp.	0.6	0.9	37
Thamnolia vermicularis	0.8	0.7	87
Umbilicaria spp.	0.6	1.8	25
Unknown crustose lichen	1.1	2.1	25
Unknown lichen	2.3	3.7	37
Total Bare Ground	58.8	17.6	100
Soil	35.3	25.7	100
Litter alone	23.3	19.1	100

UPLAND DRY LICHEN BARRENS

Plant Association:
Betula nana–Ledum decumbens–Loiseleuria procumbens

Crests and slopes of colluvial material or recent volcanic deposits at moderate elevations with less than 30% cover of vascular plants. In the study area the largest expanse of Upland Dry Lichen Barrens is found within the Imuruk Lava Flows in BELA. Exposed rocks are alkali olivine basalt and vent deposits, there is little soil development. Soils on colluvial slopes are rocky, excessively to well drained, circumneutral and have little to no organic horizons. On lava flows, soils are lacking or limited to small lower microsites.

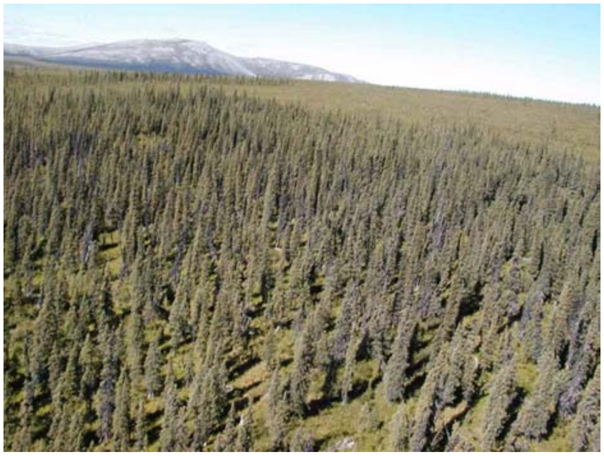
Vegetation is dominated by foliose and fruticose lichens with only low cover of vascular plants. Frequently occurring species include *Betula nana, Ledum decumbens, Loiseleuria procumbens, Empetrum nigrum, Vaccinium uliginosum, Racomitrium lanuginosum, Umbilicaria hyperborea, Cladina stellaris, Flavocetraria* spp., and *Alectoria ochroleuca.*

This ecotype differs from Alpine Nonalkaline Dry Dryas Shrub by lacking the common alpine species *Salix phlebophylla, Hierochlöe alpina* and *Selaginella selaginoides*. It differs from Upland Moist Dwarf Birch–Ericaceous Shrub by lacking *Salix planifolia pulchra* and high cover of *Cladina stellaris, Ochrolechia* spp., and *Umbilicaria* spp.

Table 5. Vegetation cover and frequency for Upland Dry Lichen Barrens (n=4).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	109.7	10.4	100
Total Vascular Cover	7.3	11.7	100
Total Evergreen Shrub Cover	2.7	3.7	100
Empetrum nigrum	0.8	0.9	100
Ledum decumbens	0.3	0.5	75
Loiseleuria procumbens	1.6	2.3	100
Total Deciduous Shrub Cover	4.0	7.4	100
Alnus crispa	0.5	1.0	50
Betula nana	2.5	5.0	25
Salix planifolia pulchra	0.3	0.5	25
Vaccinium uliginosum	0.6	1.0	100
Total Forb Cover	0.1	0.1	75
Potentilla fruticosa	0.1	0.1	50
Saxifraga bronchialis	0.0	0.1	25
Saxifraga tricuspidata	0.0	0.1	25
Total Grass Cover	0.4	0.6	75
Festuca rubra	0.0	0.1	25
Hierochlöe alpina	0.3	0.5	50
Total Sedge Cover	0.1	0.1	75
Carex sp.	0.1	0.1	50
Total NonVascular Cover	102.5	11.1	100
Total Moss Cover	0.4	0.4	100
Polytrichum hyperboreum	0.0	0.1	25
Racomitrium lanuginosum	0.3	0.5	100
Total Lichen Cover	102.1	11.3	100
Alectoria nigricans	1.3	2.5	50
Alectoria ochroleuca	3.8	4.8	75
Bryocaulon divergens	2.0	2.4	75
Cetraria islandica cf	0.8	1.0	50
Cetraria nigricans	0.1	0.1	50
Cetrariella delisei	0.3	0.5	25
Cladina arbuscula	0.8	1.5	50
Cladina mitis	0.3	0.5	25
Cladina sp.	0.5	1.0	25
Cladina stellaris	14.5	23.8	75
Cladina stygia	1.3	2.5	25
Cladonia coccifera	1.0	1.4	50
Cladonia nipponica	0.5	0.6	50
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
Pseudephebe pubescens	1.3	2.5	25
Rhizocarpon geographicum	2.5	2.9	50
Thamnolia vermicularis	1.0	0.8	100
Umbilicaria hyperborea	16.3	26.3	50
Unknown crustose lichen	16.3	29.3	50
Unknown foliose lichen	6.3	9.5	50
Xanthoria sp.	7.5	9.6	50
Total Bare Ground	13.8	9.3	100
Soil	12.5	9.6	100
Litter alone	1.3	0.5	100

UPLAND MOIST SPRUCE FOREST



Plant Association:
Picea glauca–Salix planifolia pulchra

Gentle to steep, upper and lower slopes on colluvial glacial till deposits, but most often associated with carbonate bedrock. The soils are rocky to loamy, moderately well to poorly drained, alkaline to circumneutral and have moderately thick organic horizons and active-layer thickness. The forests occur only along the eastern boundaries of CAKR and BELA.

The vegetation has an open to woodland canopy of *Picea glauca* and a shrub understory dominated by *Salix planifolia pulchra* and *Salix lanata richardsonii*. Other common species include *Salix glauca, Equisetum arvense, Petasites frigidus, Carex bigelowii, Hylocomium splendens, Tomentypnum nitens*, and *Aulacomnium palustre*. The plant association is poorly understood and probably can be subdivided into an upland alkaline type and a lowland willow-dominated type.

This ecotype differs from all others by the presence of at least 10% white spruce in the canopy. There may be some shrub ecotypes where scattered trees are present but tree cover never exceeds 10%.

Table 6. Vegetation cover and frequency for Upland Moist Spruce Forest (n=3).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	169.0	43.7	100
Total Vascular Cover	112.3	15.0	100
Evergreen Tree	18.3	2.9	100
Picea glauca	18.3	2.9	100
Total Evergreen Shrub Cover	5.3	5.0	67
Dryas integrifolia	1.7	2.9	33
Empetrum nigrum	1.7	1.5	67
Vaccinium vitis-idaea	0.7	1.2	33
Total Deciduous Shrub Cover	46.3	17.1	100
Arctostaphylos alpina	3.3	5.8	33
Betula nana	3.3	5.8	33
Salix glauca	5.0	8.7	33
Salix lanata richardsonii	10.0	8.7	67
Salix planifolia pulchra	20.0	13.2	100
Salix reticulata	1.3	1.5	67
Vaccinium uliginosum	3.3	2.9	67
Total Forb Cover	34.8	27.2	100
Anemone richardsonii	1.0	1.7	67
Epilobium angustifolium	0.7	0.5	100
Equisetum arvense	10.0	17.3	33
Equisetum scirpoides	0.1	0.1	67
Petasites frigidus	8.3	7.6	67
Polygonum viviparum	0.4	0.6	67
Potentilla fruticosa	3.3	5.8	33
Rubus chamaemorus	5.7	8.1	67
Saussurea angustifolia	0.7	1.2	33
Valeriana capitata	0.4	0.6	67
Zygadenus elegans	1.0	1.7	33
Total Grass Cover	0.8	0.6	100
Calamagrostis canadensis	0.4	0.6	67
Total Sedge Cover	6.7	7.2	100
Carex bigelowii	5.7	8.1	67
Carex krausei	1.0	1.7	33
Total NonVascular Cover	56.7	28.7	100
Total Moss Cover	55.0	30.0	100
Aulacomnium palustre	8.3	10.4	67
Brachythecium erythrorrhizon	0.7	1.2	33
Dicranum angustum	0.7	1.2	33
Dicranum sp.	1.7	2.9	33
Drepanocladus sp.	1.0	1.7	33
Hylocomium splendens	18.3	18.9	100
Paludella squarrosa	1.0	1.7	33
Pleurozium schreberi	2.0	2.6	67
Ptilidium ciliare	2.0	2.6	67
Rhizomnium sp.	1.7	2.9	33
Sanionia uncinata	1.7	2.9	33
Tomentypnum nitens	15.0	15.0	67
Total Lichen Cover	1.7	2.0	100
Cladonia sp.	1.0	1.7	33
Peltigera aphthosa	0.7	0.5	100
Total Bare Ground	22.2	7.4	100
Soil	0.4	0.6	67
Water	0.2	0.3	33
Litter alone	21.7	7.6	100

UPLAND MOIST LOW WILLOW SHRUB

Plant Association:
Salix glauca–Dryas integrifolia

Gentle to moderate slopes on well-drained, weathered bedrock, colluvium, and glacial till with vegetation dominated by low shrubs (0.2–1.5 m tall). Soils are rocky to loamy, moderately well drained, circumneutral, and have thin to moderately thick organic horizons and moderately deep (40–80 cm) active layers.

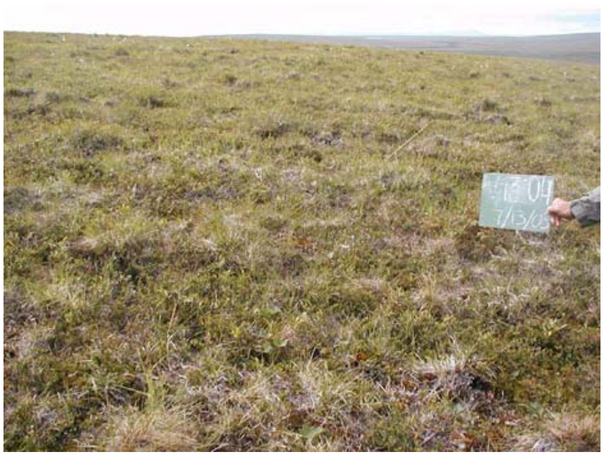
Vegetation has an open to closed canopy of *Salix glauca* and/or *S. planifolia pulchra*. Other common plants include *Dryas integrifolia, Dryas octepetela, Vaccinium uliginosum, Salix reticulata,* and *Carex bigelowii.* Common mosses and lichens include *Hylocomium splendens, Cladina arbuscula*, and *Cetraria islandica.*

This ecotype differs from Lowland Moist Low Willow Shrub by lacking *Petasites frigidus, Polemonium acutiflorum,* and *Carex aquatilis*. It differs from Upland Dwarf Birch–Ericaceous Shrub by lacking *Ledum decumbens* and *Rubus chamaemorus*. It differs from Upland Moist Sedge–Dryas Meadow by the abundance of *Salix planifolia pulchra*.

Table 7. Vegetation cover and frequency for Upland Moist Low Willow Shrub (n=2).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	132.0	61.5	100
Total Vascular Cover	110.8	71.3	100
Total Evergreen Shrub Cover	19.0	1.4	100
Cassiope tetragona	2.0	1.4	100
Dryas integrifolia	7.5	10.6	50
Dryas octopetala	7.5	10.6	50
Empetrum nigrum	1.0	1.4	50
Rhododendron lapponicum	1.0	1.4	50
Total Deciduous Shrub Cover	62.5	46.0	100
Arctostaphylos rubra	1.0	1.4	50
Betula nana	2.5	3.5	50
Salix arctica	2.5	3.5	50
Salix glauca	12.5	17.7	50
Salix lanata richardsonii	10.0	14.1	50
Salix planifolia pulchra	17.5	10.6	100
Salix reticulata	15.0	21.2	50
Vaccinium uliginosum	1.5	2.1	50
Total Forb Cover	25.9	28.4	100
Aconitum delphinifolium	0.6	0.6	100
Anemone richardsonii	0.5	0.7	50
Artemisia arctica arctica	0.6	0.6	100
Aster sibiricus	0.5	0.7	50
Castilleja caudata	0.5	0.7	50
Epilobium angustifolium	1.5	2.1	50
Equisetum arvense	10.0	14.1	50
Equisetum scirpoides	0.1	0.1	50
Galium sp.	0.5	0.7	50
Hedysarum alpinum	0.5	0.7	50
Mertensia paniculata	3.5	4.9	50
Pedicularis capitata	0.6	0.6	100
Potentilla fruticosa	1.5	2.1	50
Valeriana capitata	1.0	0.0	100
Zygadenus elegans	1.5	2.1	50
Total Grass Cover	1.5	1.2	100
Arctagrostis latifolia	0.3	0.4	50
Festuca altaica	0.6	0.6	100
Total Sedge Cover	2.0	2.8	50
Carex bigelowii	1.5	2.1	50
Carex podocarpa	0.5	0.7	50
Total NonVascular Cover	21.2	9.8	100
Total Moss Cover	10.7	3.7	100
Distichium capillaceum	1.5	2.1	50
Hylocomium splendens	5.0	0.0	100
Pleurozium schreberi	1.5	2.1	50
Tomentypnum nitens	2.5	3.5	50
Total Lichen Cover	10.6	13.5	100
Cetraria islandica cf	5.0	7.1	50
Cladina arbuscula	1.5	2.1	50
Cladina rangiferina	0.5	0.7	50
Cladina stygia	2.5	3.5	50
Thamnolia vermicularis	0.5	0.7	50
Total Bare Ground	38.5	16.3	100
Soil	0.5	0.7	50
Water	0.5	0.7	50
Litter alone	37.5	17.7	100

UPLAND MOIST DWARF BIRCH–ERICACEOUS SHRUB



<u>Plant Association</u>:
Betula nana–Ledum decumbens–Loiseleuria procumbens

Upper and middle slopes on rocky colluvial material and fine-grained eolian or old alluvial marine coastal plain deposits with vegetation dominated by dwarf birch and ericaceous shrubs. This ecotype is abundant in both parks and usually occurs at moderate elevations. The soils typically are rocky to loamy, moderately well to poorly drained, acidic to circumneutral, and have thin to moderately thick surface organic layers and a thin active layer. Permafrost is always present.

Vegetation is dominated by *Betula nana, Ledum decumbens, Vaccinium uliginosum,* and *Vaccinium vitis-idaea*. Frequently occurring species include *Salix planifolia pulchra, Empetrum nigrum, Hylocomium splendens, Sphagnum* spp., *Cladina rangiferina,* and *C. stygia.*

This class is similar to many other ecotypes because of the prominence of ericaceous species typical of acidic habitats. It differs from Moist Dwarf Shrub-Tussock Shrub by lacking abundant *Eriophorum vaginatum* cover. It differs from Upland Dry Lichen Barrens by lacking high cover of *Cladina stellaris, Ochrolechia* spp., and *Umbilicaria* spp. It differs from Alpine Nonalkaline Dry Dryas Shrub by lacking *Dryas octopetala*. Lowland Moist Dwarf-Birch–Willow Shrub has much more *Salix planifolia pulchra* and lacks *Ledum decumbens*.

Table 8. Vegetation cover and frequency for Upland Moist Dwarf Birch–Ericaceous Shrub (n=8).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	136.3	56.7	100
Total Vascular Cover	74.4	40.8	100
Total Evergreen Shrub Cover	27.9	24.2	100
Empetrum nigrum	4.1	5.2	78
Ledum decumbens	14.2	17.1	100
Loiseleuria procumbens	2.1	4.0	33
Vaccinium vitis-idaea	7.3	6.4	100
Total Deciduous Shrub Cover	30.6	20.6	100
Arctostaphylos alpina	1.3	2.7	22
Betula nana	15.7	18.7	100
Salix arctica	1.7	3.5	22
Salix planifolia pulchra	3.8	6.3	78
Vaccinium uliginosum	7.6	6.8	89
Total Forb Cover	6.1	8.6	67
Petasites frigidus	3.0	5.2	44
Rubus chamaemorus	2.2	3.0	56
Saxifraga punctata	0.2	0.4	44
Total Grass Cover	0.9	1.7	67
Total Sedge Cover	8.9	10.4	78
Carex aquatilis	1.1	3.3	11
Carex bigelowii	3.3	3.6	78
Eriophorum angustifolium	1.9	5.0	22
Eriophorum vaginatum	1.6	2.7	33
Total NonVascular Cover	61.8	24.6	100
Total Moss Cover	28.1	23.9	89
Aulacomnium palustre	1.3	1.8	44
Aulacomnium turgidum	0.6	0.9	33
Dicranum groenlandicum	1.7	5.0	11
Dicranum sp.	1.4	2.2	33
Hylocomium splendens	7.4	8.7	56
Pleurozium schreberi	0.6	1.7	22
Polytrichum sp.	1.2	1.8	44
Polytrichum strictum	0.4	1.0	22
Sphagnum lenense	3.3	10.0	22
Sphagnum sp.	6.8	18.2	33
Total Lichen Cover	33.8	23.6	100
Cetraria islandica cf	1.0	1.8	44
Cladina arbuscula	2.0	3.5	44
Cladina mitis	1.4	3.4	22
Cladina rangiferina	5.1	6.5	67
Cladina stellaris	6.1	18.3	11
Cladina stygia	6.1	6.9	67
Cladonia sp.	0.9	1.7	56
Dactylina arctica	0.2	0.4	22
Flavocetraria cucullata	5.0	4.4	78
Flavocetraria nivalis	0.6	0.7	44
Peltigera aphthosa	0.6	1.1	33
Pertusaria sp.	0.4	0.7	33
Sphaerophorus globosus	0.3	0.5	33
Thamnolia vermicularis	1.4	1.3	89
Total Bare Ground	37.2	22.7	100
Soil	5.9	12.9	78
Water	0.8	1.6	33
Litter alone	30.6	24.0	100

UPLAND MOIST DWARF BIRCH–TUSSOCK SHRUB

Plant Association:
Betula nana–Eriophorum vaginatum

Moderate to gentle slopes at moderate and lower elevations on loess, colluvium, and raised areas of drained basins with vegetation dominated by tussock-forming sedges. Soils are loamy moderately well to poorly drained, acidic, and have moderately thick surface organics and shallow active layers (<40 cm). Permafrost is always present and probably ice-rich. This ecotype is the most abundant ecotype in both parks and is prone to fire.

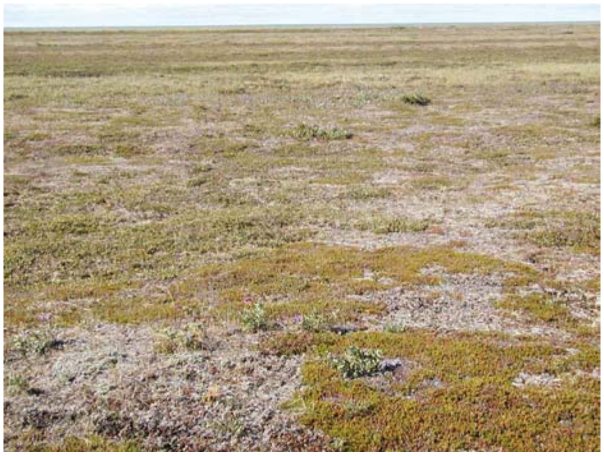
Vegetation is dominated by *Eriophorum vaginatum, Betula nana, Ledum decumbens,* and *Empetrum nigrum.* Other common species include *Rubus chamaemorus, Carex bigelowii, Salix planifolia pulchra, Vaccinium uliginosum, Flavocetraria cucullata,* and *Cladina rangiferina. Sphagnum* mosses are abundant and diverse.

This ecotype is very similar to Upland Moist Dwarf Birch–Ericaceous Shrub, Lowland Moist Dwarf Birch–Willow Shrub and Lowland Wet Dwarf Birch–Ericaceous Shrub but differs by the prevalence (>12% cover) of *Eriophorum vaginatum* and the lack of *Carex aquatilis*. This tussock class, at least the acidic type described here, is unusual in that species composition is very similar among plots within the type.

Table 9. Vegetation cover and frequency for Upland Moist Dwarf Birch–Tussock Shrub (n=8).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	142.2	23.4	100
Total Vascular Cover	71.4	17.6	100
Total Evergreen Shrub Cover	24.5	13.1	88
Empetrum nigrum	5.8	3.5	88
Ledum decumbens	11.9	7.0	88
Vaccinium vitis-idaea	6.8	4.4	88
Total Deciduous Shrub Cover	18.3	14.2	100
Arctostaphylos rubra	0.5	1.1	25
Betula nana	9.1	6.1	100
Salix glauca	0.3	0.7	13
Salix lanata richardsonii	0.6	1.8	13
Salix planifolia pulchra	2.9	5.0	100
Salix reticulata	0.3	0.7	25
Vaccinium uliginosum	4.6	3.7	100
Total Forb Cover	8.3	9.2	100
Petasites frigidus	1.8	3.5	50
Rubus chamaemorus	5.6	3.9	88
Total Grass Cover	0.5	1.4	13
Arctagrostis latifolia	0.5	1.4	13
Total Sedge Cover	19.8	4.0	100
Carex bigelowii	4.5	3.1	100
Eriophorum angustifolium	1.1	1.7	50
Eriophorum vaginatum	14.0	3.3	100
Total NonVascular Cover	70.8	9.3	100
Total Moss Cover	50.4	20.7	100
Aulacomnium palustre	3.4	3.5	63
Aulacomnium turgidum	4.4	4.2	63
Dicranum elongatum	2.5	5.3	25
Dicranum groenlandicum	1.3	3.5	13
Dicranum sp.	1.1	1.9	38
Hylocomium splendens	8.8	13.8	50
Pleurozium schreberi	1.3	3.5	13
Polytrichum sp.	0.4	0.7	25
Sphagnum balticum	9.4	11.2	50
Sphagnum capillifolium	3.1	8.8	13
Sphagnum fuscum	4.4	8.2	25
Sphagnum girgensohnii	0.6	1.8	13
Sphagnum lenense	1.3	3.5	13
Sphagnum sp.	6.6	13.8	38
Tomentypnum nitens	1.4	3.5	25
Total Lichen Cover	20.4	16.0	88
Cetraria islandica cf	0.4	0.7	38
Cladina arbuscula	3.0	5.2	50
Cladina mitis	2.5	5.2	38
Cladina rangiferina	4.8	4.5	75
Cladina stygia	1.7	3.5	38
Cladonia sp.	0.3	0.5	38
Flavocetraria cucullata	2.8	3.6	63
Nephroma arcticum	0.6	1.2	25
Peltigera aphthosa	1.3	1.7	63
Thamnolia vermicularis	1.4	1.7	63
Total Bare Ground	36.7	18.4	100
Soil	0.4	0.5	50
Water	0.0	0.0	13
Litter alone	36.3	18.7	100

UPLAND DRY CROWBERRY SHRUB



Plant Association:
Empetrum nigrum–Elymus arenarius mollis

Exposed ridges and upper slopes of inactive dunes and gravel beaches along the coast with vegetation dominated by Crowberry. Soils are sandy to gravelly, excessively to well-drained, and circumneutral, and have very thin organics and deep thaw depths. This ecotype is limited to coastal areas, and while the soils are nonsaline, some halophytic species persist. In BELA the beach ridges are sandy, whereas, in CAKR the beach ridges are gravelly. Bare, wind-scoured patches are common in BELA.

Vegetation is dominated by *Empetrum nigrum, Arctostaphylos rubra, Betula nana, Flavocetraria cucullata,* and *Cladina arbuscula.* Halophytic species that have persisted from earlier successional stages include *Elymus arenarius mollis, Lathyrus maritimus, Armeria maritima,* and *Salix ovalifolia.* Other common species include *Epilobium latifolium, Rhytidium rugosum, Flavocetraria nivalis, Thamnolia vermicularis,* and *Stereocaulon* sp.

This ecotype differs from Upland Moist Dwarf Birch–Ericaceous Shrub and Lowland Moist Dwarf Birch–Willow Shrub by the dominance of *Empetrum nigrum*, the presence of *Elymus arenarius mollis,* and its occurrence in coastal areas.

Table 10. Vegetation cover and frequency for Upland Dry Crowberry Shrub (n=5).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	92.4	23.0	100
Total Vascular Cover	54.8	9.9	100
Total Evergreen Shrub Cover	34.8	8.1	100
Cassiope tetragona	0.4	0.9	40
Empetrum nigrum	31.0	11.4	100
Ledum decumbens	0.8	1.3	40
Loiseleuria procumbens	0.2	0.4	20
Vaccinium vitis-idaea	2.4	4.3	60
Total Deciduous Shrub Cover	10.9	9.6	80
Arctostaphylos alpina	1.0	2.2	40
Arctostaphylos rubra	3.0	6.7	20
Betula nana	2.6	4.2	60
Salix alaxensis	0.4	0.9	20
Salix glauca	0.6	1.3	40
Salix lanata richardsonii	0.2	0.4	20
Salix ovalifolia	0.6	1.3	20
Salix planifolia pulchra	0.2	0.4	60
Salix reticulata	0.6	0.9	60
Vaccinium uliginosum	1.6	2.1	60
Total Forb Cover	6.0	4.8	100
Armeria maritima	0.3	0.4	100
Epilobium latifolium	1.6	3.6	20
Lathyrus maritimus	1.2	1.1	60
Oxytropis maydelliana	0.4	0.5	60
Potentilla uniflora	1.0	2.2	20
Saxifraga bronchialis	0.4	0.9	20
Total Grass Cover	2.8	1.1	100
Elymus arenarius mollis	2.0	1.4	100
Trisetum spicatum	0.2	0.4	60
Total Sedge Cover	0.3	0.4	80
Luzula multiflora	0.2	0.4	40
Total NonVascular Cover	37.6	20.5	100
Total Moss Cover	8.5	7.0	100
Bryum sp.	1.8	2.0	60
Dicranum acutifolium	2.0	4.5	20
Dicranum sp.	2.0	4.5	20
Hylocomium splendens	0.4	0.9	20
Pleurozium schreberi	0.2	0.4	40
Ptilidium ciliare	0.4	0.9	40
Rhytidium rugosum	1.4	2.1	60
Sanionia uncinata	0.2	0.4	20
Total Lichen Cover	29.1	15.7	100
Alectoria nigricans	1.6	2.3	40
Bryocaulon divergens	1.2	2.2	40
Bryoria nitidula	1.0	2.2	40
Cetraria islandica cf	0.6	0.9	40
Cetraria laevigata	0.8	1.3	40
Cladina arbuscula	3.0	4.1	60
Cladina rangiferina	2.2	4.4	40
Cladonia sp.	0.6	1.3	20
Flavocetraria cucullata	6.4	6.1	80
Flavocetraria nivalis	2.8	4.1	60
Lobaria linita	0.1	0.1	60
Ochrolechia frigida	0.4	0.9	40
Pertusaria sp.	3.0	6.7	20
Sphaerophorus fragilis	0.4	0.9	20
Sphaerophorus globosus	0.8	1.3	60
Stereocaulon sp.	2.0	4.5	40
Thamnolia vermicularis	1.4	2.1	60
Total Bare Ground	29.4	24.1	100
Soil	4.4	3.4	100
Litter alone	25.0	25.7	100

UPLAND MOIST SEDGE–DRYAS MEADOW

Plant Association:
Dryas integrifolia–Carex bigelowii–Senecio atropurpureus

Moderate to gentle, middle to upper slopes at moderate elevations on colluvium and glacial till with vegetation co-dominated by sedges and dwarf shrubs. Soils are loamy, somewhat poorly drained, circumneutral to alkaline, and have moderately thick surface organics and moderately deep (40–80 cm) thaw depths. The water table typically is 15–30 cm below the soil surface. This ecotype is abundant in both parks and commonly occurs on slopes below carbonate bedrock.

Dominant plants include *Dryas integrifolia, Salix arctica, Salix reticulata, Carex bigelowii*, and *Tomentypnum nitens.* Other common species include *Salix lanata richardsonii, Arctostaphylos rubra, Equisetum arvense, Hylocomium splendens*, and *Flavocetraria cucullata*.

This ecotype is very similar to Lowland Moist Sedge–Dryas Meadow but lacks *Betula nana*, and has lower cover of *Equisetum arvense.* During mapping, this ecotype was restricted to upland and mountainous areas, whereas, Lowland Moist Sedge–Dryas Meadows was restricted to the coastal plains and drainages.

Table 11. Vegetation cover and frequency for Upland Moist Sedge–Dryas Meadow (n=10).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	147.5	25.6	100
Total Vascular Cover	81.6	15.6	100
Total Evergreen Shrub Cover	30.9	19.0	100
Cassiope tetragona	1.2	1.7	50
Dryas integrifolia	27.0	19.3	80
Rhododendron lapponicum	1.8	2.4	50
Total Deciduous Shrub Cover	22.1	7.5	100
Andromeda polifolia	0.6	1.6	30
Arctostaphylos rubra	3.9	2.8	90
Salix arctica	5.2	3.5	90
Salix lanata richardsonii	2.6	3.3	80
Salix planifolia pulchra	0.3	0.9	40
Salix reticulata	6.0	6.2	60
Vaccinium uliginosum	1.9	3.1	60
Total Forb Cover	12.2	4.8	100
Astragalus umbellatus	0.3	0.5	50
Equisetum arvense	3.8	4.4	60
Equisetum scirpoides	0.2	0.6	30
Equisetum variegatum	0.3	0.7	30
Hedysarum alpinum	0.2	0.4	50
Lagotis glauca	0.1	0.3	50
Pedicularis langsdorffii arctica	0.2	0.4	20
Petasites frigidus	0.8	1.3	30
Pinguicula vulgaris	0.2	0.3	60
Polygonum viviparum	0.2	0.4	60
Potentilla biflora	0.3	0.5	30
Potentilla fruticosa	0.4	0.7	30
Saussurea angustifolia	0.3	0.5	70
Saxifraga hirculus	0.3	0.5	70
Saxifraga oppositifolia	1.4	3.2	40
Senecio atropurpureus	0.2	0.4	60
Silene acaulis	0.1	0.3	40
Total Grass Cover	1.5	1.7	80
Arctagrostis latifolia	0.6	1.0	40
Festuca altaica	0.5	1.1	20
Poa arctica SL	0.2	0.4	40
Total Sedge Cover	15.0	5.2	100
Carex atrofusca	1.1	1.7	40
Carex bigelowii	5.1	7.1	60
Carex membranacea	1.2	2.0	40
Carex misandra	0.6	1.1	40
Carex rotundata	0.9	1.7	40
Carex scirpoidea	1.8	2.6	60
Eriophorum angustifolium	0.7	1.1	40
Eriophorum vaginatum	0.2	0.4	40
Total NonVascular Cover	65.9	21.9	100
Total Moss Cover	52.9	27.3	100
Aulacomnium acuminatum	3.5	6.7	30
Aulacomnium palustre	0.9	1.4	30
Hylocomium splendens	15.5	21.4	70
Hypnum bambergeri	2.0	3.5	30
Ptilidium ciliare	2.0	2.3	50
Rhytidium rugosum	4.4	5.1	70
Tomentypnum nitens	17.3	19.3	80
Total Lichen Cover	13.0	7.8	100
Asahinea chrysantha	0.8	1.5	40
Cetraria islandica cf	0.3	0.5	30
Flavocetraria cucullata	3.8	2.5	100
Flavocetraria nivalis	0.9	0.9	60
Pertusaria sp.	1.5	2.2	50
Thamnolia vermicularis	2.0	2.2	70
Total Bare Ground	38.5	22.1	100
Soil	2.3	2.9	80
Water	0.7	1.0	60
Litter alone	35.5	20.2	100

LOWLAND MOIST TALL ALDER–WILLOW SHRUB

Plant Association:
Alnus crispa–Salix planifolia pulchra–Rubus arcticus

Lower slopes and drainages on hillside colluvium with vegetation dominated by tall (≥1.5m) shrubs. Soils typically are loamy, moderately well to somewhat poorly drained, and circumneutral. Thaw depths are generally >50 cm and soil organic horizons are thin.

Vegetation is dominated by an open or closed canopy of *Salix planifolia pulchra* and/or *Alnus crispa*. Areas dominated by *Alnus crispa* have *Salix planifolia pulchra* as a co-dominant or in the understory. Other understory species include *Rubus arcticus, Equisetum arvense, Artemisia tilesii, Mertensia paniculata, Galium boreale, Arctagrostis latifolia,* and *Calamagrostis canadensis*. Due to heavy litterfall mosses have low cover.

This ecotype differs from Riverine Moist Tall Alder–Willow Shrub by lacking *Salix alaxensis, S. barclayi,* and *S. arbusculoides*. It differs from Lowland Moist Low Willow Shrub by lacking *Salix lanata richardsonii, S. reticulata, Tomentypnum nitens,* and *Hylocomium splendens.*

Table 12. Vegetation cover and frequency for Lowland Moist Tall Alder–Willow Shrub (n=5).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	116.3	23.0	100
Total Vascular Cover	112.2	24.1	100
Total Evergreen Shrub Cover	0.8	1.3	40
Dryas octopetala	0.4	0.9	20
Juniperus communis	0.2	0.4	20
Linnaea borealis	0.2	0.4	20
Total Deciduous Shrub Cover	72.8	19.9	100
Alnus crispa	57.0	21.7	100
Salix lanata richardsonii	1.0	2.2	20
Salix planifolia pulchra	13.0	14.4	80
Salix reticulata	0.6	1.3	20
Spiraea beauverdiana	0.6	1.3	40
Vaccinium uliginosum	0.2	0.4	40
Total Forb Cover	25.7	19.8	100
Aconitum delphinifolium	0.4	0.5	80
Angelica lucida	1.0	1.2	60
Artemisia arctica arctica	0.4	0.5	40
Artemisia tilesii	2.2	2.6	60
Epilobium angustifolium	1.0	2.2	20
Equisetum arvense	7.0	5.7	100
Galium boreale	2.6	4.3	40
Iris setosa	0.6	1.3	20
Lycopodium annotinum	1.2	1.6	40
Mertensia paniculata	2.4	4.3	40
Petasites frigidus	1.2	1.3	60
Potentilla fruticosa	1.0	2.2	20
Rubus arcticus	1.6	2.1	80
Valeriana capitata	1.0	1.2	80
Total Grass Cover	11.8	14.2	100
Arctagrostis latifolia	6.0	13.4	20
Calamagrostis canadensis	5.2	8.3	80
Total Sedge Cover	1.1	2.2	80
Carex atrofusca	1.0	2.2	20
Total NonVascular Cover	4.1	2.8	80
Total Moss Cover	3.7	2.3	80
Brachythecium reflexum	0.6	0.9	40
Brachythecium sp.	1.2	2.2	40
Climacium dendroides	0.2	0.4	20
Hylocomium splendens	0.2	0.4	20
Plagiomnium ellipticum	0.2	0.3	40
Sanionia uncinata	0.2	0.4	40
Total Lichen Cover	0.4	0.7	60
Total Bare Ground	78.0	19.6	100
Soil	2.0	4.5	20
Water	0.0	0.0	0
Litter alone	76.0	23.8	100

LOWLAND MOIST LOW WILLOW SHRUB

Plant Association: *Salix planifolia pulchra–Calamagrostis canadensis*

Low-lying flats and lower slopes within drained-lake basins, on abandoned floodplains, and on colluvium with vegetation dominated by low willows (0.2–1.5 m tall). Soils typically are loamy, saturated, poorly drained, alkaline to circumneutral, and underlain by permafrost at moderate depths. Surface organics are thin on slopes and moderately thick on flats.

Vegetation is an open to closed low shrub canopy dominated by *Salix planifolia pulchra*. Other common species include *Salix lanata richardsonii*, *Betula nana, Salix reticulata, Festuca altaica, Calamagrostis canadensis, Equisetum arvense, Polemonium acutiflorum, Eriophorum angustifolium, Valeriana capitata, Tomentypnum nitens,* and *Hylocomium splendens*.

This ecotype differs from closely related Upland Moist Low Willow Shrub by lacking *Salix glauca* and *Cassiope tetragona* and having *Calamagrostis canadensis*. While species composition is similar, the fine-grained soil associated with ice-rich permafrost is considerably different from the rocky soil with presumably ice-poor permafrost on upland hillsides.

Table 13. Vegetation cover and frequency for Lowland Moist Low Willow Shrub (n=10).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	213.8	48.2	100
Total Vascular Cover	162.7	30.8	100
Total Evergreen Shrub Cover	2.9	6.4	50
Dryas integrifolia	2.0	6.3	10
Empetrum nigrum	0.3	0.5	40
Total Deciduous Shrub Cover	81.5	15.0	100
Arctostaphylos rubra	2.5	6.3	20
Betula nana	0.8	1.0	50
Salix hastata	7.5	23.7	10
Salix lanata richardsonii	13.5	20.0	50
Salix planifolia pulchra	38.0	34.6	70
Salix reticulata	16.8	22.1	70
Spiraea beauverdiana	0.3	0.5	30
Vaccinium uliginosum	1.3	1.8	60
Total Forb Cover	63.8	24.7	100
Aconitum delphinifolium	0.7	0.8	60
Anemone parviflora	1.2	3.1	30
Anemone richardsonii	0.8	1.0	50
Artemisia arctica arctica	2.3	3.4	50
Cardamine pratensis	0.2	0.6	40
Dodecatheon frigidum	0.7	0.8	60
Equisetum arvense	26.4	31.9	90
Myosotis alpestris asiatica	0.7	1.3	30
Petasites frigidus	15.4	25.7	70
Polemonium acutiflorum	3.7	9.3	100
Polygonum bistorta	0.5	1.0	30
Potentilla fruticosa	0.9	1.7	30
Rubus arcticus	1.3	3.1	50
Rubus chamaemorus	1.1	3.1	20
Saxifraga punctata	0.2	0.4	40
Senecio lugens	0.3	0.7	30
Stellaria sp.	0.1	0.1	40
Valeriana capitata	3.5	2.8	100
Total Grass Cover	9.7	10.6	100
Arctagrostis latifolia	0.2	0.6	20
Calamagrostis canadensis	3.3	5.1	50
Festuca altaica	5.1	10.7	60
Poa arctica SL	0.6	1.3	40
Trisetum spicatum	0.1	0.3	40
Total Sedge Cover	4.8	6.3	90
Carex aquatilis	1.9	3.6	40
Carex bigelowii	0.6	1.6	30
Carex scirpoidea	0.2	0.4	20
Eriophorum angustifolium	1.4	2.8	30
Total NonVascular Cover	51.1	25.6	100
Total Moss Cover	49.3	25.3	100
Aulacomnium palustre	5.3	8.0	60
Brachythecium coruscum	1.0	3.2	10
Brachythecium salebrosum	1.5	4.7	10
Brachythecium sp.	0.6	1.3	20
Bryum pseudotriquetrum	1.0	3.2	10
Calliergon stramineum	4.0	12.6	10
Campylium stellatum	1.0	3.2	10
Dicranum sp.	1.6	3.1	40
Hylocomium splendens	15.7	22.6	70
Plagiomnium ellipticum	1.5	4.7	20
Pleurozium schreberi	0.6	1.6	20
Tomentypnum nitens	6.8	12.3	70
Unknown moss	3.6	9.4	30
Total Lichen Cover	1.8	3.4	80
Peltigera aphthosa	0.4	0.7	60
Total Bare Ground	41.8	21.0	100
Soil	0.3	0.5	30
Water	0.5	0.7	40
Litter alone	41.0	21.2	100

LOWLAND MOIST DWARF BIRCH–WILLOW SHRUB

Plant Association:
Betula nana–Salix planifolia pulchra–Pyrola grandiflora

Lower slopes and flats on low-lying alluvial-marine deposits and drained basins with vegetation dominated by shrub birch. Soils are loamy to organic, poorly drained, acidic, and have moderately thick surface organics and shallow (<40 cm) active-layer. Water depths typically are <20 cm below the soil surface.

Vegetation has an open to closed canopy of *Betula nana, Salix planifolia pulchra* is present and may be co-dominant. Other species include the shrubs *Ledum decumbens, Vaccinium vitis-idaea, V. uliginosum, Empetrum nigrum,* and the mosses *Aulacomnium turgidum, A. palustre,* and *Hylocomium splendens*.

This ecotype differs from the closely related Upland Moist Low Dwarf Birch–Ericaceous Shrub by having *Carex aquatilis, Eriophorum angustifolium,* and more *Salix planifolia pulchra*. It differs from Riverine Moist Dwarf Birch–Willow Shrub and Lowland Moist Low Willow Shrub by lacking *Salix glauca* and having *Ledum decumbens*, and *Empetrum nigrum*.

Table 14. Vegetation cover and frequency for Lowland Moist Dwarf Birch–Willow Shrub (n=8).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	155.6	49.3	100
Total Vascular Cover	99.1	29.0	100
Total Evergreen Shrub Cover	10.5	11.8	88
Empetrum nigrum	1.8	3.4	63
Ledum decumbens	4.5	4.8	75
Vaccinium vitis-idaea	4.3	5.5	63
Total Deciduous Shrub Cover	67.5	25.3	100
Alnus crispa	0.6	1.8	25
Arctostaphylos rubra	0.1	0.4	13
Betula nana	24.1	16.0	100
Salix barclayi	0.6	1.8	13
Salix chamissonis	0.3	0.7	13
Salix planifolia pulchra	28.4	14.3	100
Spiraea beauverdiana	0.9	1.7	38
Vaccinium uliginosum	12.5	17.4	100
Total Forb Cover	7.6	5.5	100
Equisetum arvense	0.4	0.7	25
Petasites frigidus	4.3	4.4	75
Pyrola grandiflora	1.0	1.3	50
Rubus chamaemorus	1.3	2.4	50
Total Grass Cover	1.8	1.5	75
Arctagrostis latifolia	0.6	1.2	38
Calamagrostis canadensis	0.6	1.2	25
Poa arctica SL	0.3	0.4	50
Total Sedge Cover	11.7	20.0	88
Carex aquatilis	5.4	14.0	25
Carex bigelowii	1.4	2.0	38
Carex podocarpa	0.6	1.8	13
Eriophorum angustifolium	3.9	7.4	38
Eriophorum vaginatum	0.4	1.1	38
Total NonVascular Cover	56.5	31.6	100
Total Moss Cover	53.1	29.2	100
Aulacomnium acuminatum	0.6	1.8	25
Aulacomnium palustre	8.1	13.9	63
Aulacomnium turgidum	2.0	3.7	38
Dicranum sp.	2.9	4.5	50
Drepanocladus sp.	0.1	0.4	13
Hylocomium splendens	14.4	25.4	63
Hypnum plicatulum	2.5	7.1	13
Polytrichum juniperinum	1.9	3.7	25
Sanionia uncinata	0.6	1.2	25
Sphagnum fuscum	0.6	1.8	13
Sphagnum sp.	8.5	17.5	50
Sphagnum squarrosum	5.0	14.1	13
Tomentypnum nitens	3.8	10.6	13
Total Lichen Cover	3.3	5.5	88
Cetraria laevigata	0.3	0.7	13
Cladina arbuscula	0.4	1.1	13
Cladina stygia	0.4	1.1	25
Cladonia furcata	0.6	1.8	13
Cladonia sp.	0.3	0.7	38
Peltigera aphthosa	0.4	0.5	63
Stereocaulon tomentosum	0.1	0.4	13
Total Bare Ground	41.7	27.8	100
Soil	1.4	3.5	38
Water	0.9	1.8	38
Litter alone	39.4	27.3	100

LOWLAND WET DWARF BIRCH–ERICACEOUS SHRUB

Plant Association:
Betula nana–Vaccinium vitis-idaea–Carex aquatilis

Flat areas on drained-lake basins, abandoned floodplain, and coastal plain deposits dominated by dwarf shrubs (<0.2 m tall) and mosses. Soils are organic-rich, poorly drained, acidic, and have shallow thaw depths. Ground water usually is less than 20 cm below the soil surface. Permafrost is always present and low-centered polygons occur on some sites in this class.

Vegetation is dominated by the shrub species *Vaccinium uliginosum, V. vitis-idaea, Ledum decumbens, Empetrum nigrum,* and *Betula nana.* Other common species include *Carex aquatilis, Aulacomnium turgidum,* and numerous species of *Sphagnum* including *S. balticum, S. fuscum, S. warnstorfii,* and *S. perfoliatum*.

This ecotype is similar to Lowland Moist Dwarf Birch–Willow Shrub but has much more *C. aquatilis* and *Sphagnum* spp. and much less *Salix planifolia pulchra*. It differs from Lowland Sedge–Moss Fen by having a high shrub cover and the presence of *Hylocomium splendens*.

Table 15. Vegetation cover and frequency for Lowland Wet Dwarf Birch–Ericaceous Shrub (n=10).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	169.1	52.8	100
Total Vascular Cover	94.8	35.6	100
Total Evergreen Shrub Cover	36.3	27.6	100
Chamaedaphne calyculata	1.0	3.2	10
Empetrum nigrum	9.8	12.1	100
Ledum decumbens	14.5	16.7	100
Oxycoccus microcarpus	0.2	0.4	20
Vaccinium vitis-idaea	10.8	12.0	90
Total Deciduous Shrub Cover	36.4	21.2	100
Andromeda polifolia	2.4	6.2	30
Betula nana	21.8	18.4	100
Salix fuscescens	0.5	1.6	30
Salix planifolia pulchra	2.1	4.6	70
Vaccinium uliginosum	8.8	7.9	80
Total Forb Cover	2.2	2.5	70
Pedicularis sudetica	0.1	0.3	30
Rubus chamaemorus	1.8	2.4	40
Total Grass Cover	0.2	0.4	20
Total Sedge Cover	19.6	23.7	100
Carex aquatilis	14.9	19.7	90
Carex bigelowii	0.2	0.4	30
Carex rariflora	1.0	2.1	20
Eriophorum angustifolium	2.4	6.3	40
Eriophorum russeolum	0.6	1.6	20
Total NonVascular Cover	74.3	30.6	100
Total Moss Cover	66.1	28.8	100
Aulacomnium palustre	6.4	7.1	70
Aulacomnium turgidum	5.0	6.2	70
Calliergon stramineum	0.5	1.6	10
Dicranum acutifolium	0.5	1.6	10
Dicranum elongatum	4.0	8.0	40
Dicranum groenlandicum	0.8	1.8	20
Dicranum laevidens	0.5	1.6	20
Dicranum majus	0.7	1.6	20
Dicranum sp.	1.0	1.8	30
Hepaticae	0.5	1.6	20
Hylocomium splendens	5.2	9.3	60
Limprichtia revolvens	0.3	0.7	30
Polytrichum juniperinum	1.5	3.4	30
Ptilidium ciliare	0.4	1.0	30
Scorpidium scorpioides	0.5	1.6	10
Sphagnum angustifolium	1.0	3.2	10
Sphagnum balticum	12.5	28.4	30
Sphagnum fuscum	2.5	6.3	20
Sphagnum girgensohnii	1.5	4.7	10
Sphagnum perfoliatum	1.0	3.2	10
Sphagnum rubellum	1.0	3.2	10
Sphagnum sp.	3.0	7.9	20
Sphagnum squarrosum	5.5	15.7	30
Sphagnum warnstorfii	2.1	3.8	30
Tomentypnum nitens	1.7	4.7	30
Total Lichen Cover	8.2	10.3	90
Cetraria islandica cf	0.3	0.7	20
Cladina arbuscula	2.2	4.6	50
Cladina rangiferina	1.1	1.9	40
Cladina stygia	1.1	3.1	30
Flavocetraria cucullata	0.8	1.6	60
Thamnolia vermicularis	0.4	0.7	30
Total Bare Ground	29.2	19.6	100
Soil	0.1	0.3	10
Water	0.8	1.2	40
Litter alone	28.3	20.3	100

LOWLAND MOIST SEDGE–DRYAS MEADOW

Plant Association:
Dryas integrifolia–Equisetum arvense

Moderate to gentle, lower slopes at lower elevations on colluvium, glacial till, and coastal plain deposits with vegetation co-dominated by sedges and dwarf shrubs. Soils are loamy, somewhat poorly drained, circumneutral to alkaline, and have moderately thick surface organics and moderately deep (40–80 cm) thaw depths. The water table typically is 15–30 cm below the soil surface. This ecotype is abundant in both parks.

Dominant plants include *Dryas integrifolia, Dryas octopetala, Salix reticulata, Salix arctica, Equisetum arvense*, and *Hylocomium splendens.* Other common species include *Salix lanata richardsonii, Arctostaphylos rubra, Carex bigelowii*, *Tomentypnum nitens*, and *Flavocetraria cucullata*.

This ecotype is very similar to Upland Moist Sedge–Dryas Meadow but has more *Equisetum arvense.* During mapping, this ecotype was restricted to the coastal plains and drainages, whereas, Upland Moist Sedge–Dryas Meadow was restricted to upland and mountainous areas. Of particular interest in differentiating upland and lowland types is the likelihood of ice-rich permafrost in the loamy lowlands and ice-poor permafrost in the rocky uplands.

Table 16. Vegetation cover and frequency for Lowland Moist Sedge–Dryas Meadow (n=3).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	146.5	8.2	100
Total Vascular Cover	83.9	10.2	100
Total Evergreen Shrub Cover	28.0	15.1	100
Cassiope tetragona	0.7	1.2	33
Dryas integrifolia	16.7	20.8	67
Dryas octopetala	10.0	17.3	33
Total Deciduous Shrub Cover	24.7	8.0	100
Arctostaphylos rubra	2.3	2.5	67
Betula nana	0.7	1.1	67
Salix arctica	3.3	1.5	100
Salix lanata richardsonii	2.0	2.6	67
Salix planifolia pulchra	0.7	0.6	67
Salix reticulata	13.3	7.6	100
Vaccinium uliginosum	1.7	2.9	33
Total Forb Cover	18.5	2.9	100
Artemisia arctica arctica	1.0	1.7	33
Dodecatheon frigidum	1.3	1.5	67
Equisetum arvense	9.3	8.0	100
Petasites frigidus	2.0	2.6	67
Polygonum bistorta	0.7	0.5	100
Polygonum viviparum	0.7	0.5	100
Saxifraga hirculus	0.1	0.1	67
Saxifraga punctata	0.1	0.1	67
Valeriana capitata	0.4	0.6	67
Total Grass Cover	4.3	5.9	67
Arctagrostis latifolia	1.3	1.5	67
Festuca altaica	1.0	1.7	33
Poa arctica SL	1.3	1.5	67
Trisetum spicatum	0.7	1.2	33
Total Sedge Cover	8.3	4.0	100
Carex bigelowii	4.7	2.5	100
Carex podocarpa	1.0	1.7	33
Carex scirpoidea	0.7	1.2	33
Luzula multiflora	0.7	0.6	67
Total NonVascular Cover	62.7	2.1	100
Total Moss Cover	57.0	2.0	100
Aulacomnium acuminatum	5.0	8.7	33
Aulacomnium palustre	3.3	5.8	33
Aulacomnium turgidum	0.7	1.2	33
Dicranum sp.	4.0	1.7	100
Drepanocladus sp.	1.7	2.9	33
Hylocomium splendens	20.0	10.0	100
Hypnum sp.	3.3	5.8	33
Rhytidium rugosum	3.3	5.8	33
Sanionia uncinata	1.0	1.7	33
Tomentypnum nitens	12.7	11.2	100
Unknown moss	1.7	2.9	33
Total Lichen Cover	5.7	0.6	100
Cetraria islandica cf	1.7	0.6	100
Cladonia sp.	0.7	0.6	67
Flavocetraria cucullata	1.3	1.2	67
Peltigera aphthosa	0.7	0.6	67
Total Bare Ground	44.1	29.5	100.0
Soil	0.4	0.6	66.7
Water	0.4	0.6	66.7
Litter alone	43.3	28.9	100.0

LOWLAND SEDGE–MOSS FEN MEADOW

Plant Association:
Carex aquatilis–Salix fuscescens–Sphagnum

Flat areas, primarily in drained-lake basins, with vegetation dominated by sedges and Sphagnum mosses. Soils are organic-rich (20–40 cm of organics), poorly drained, acidic, and have shallow active-layer depths. Water usually is within 10 cm of the surface. This ecotype is common on the coastal plains of both parks.

Vegetation is dominated by *Carex aquatilis, Salix fuscescens*, and numerous *Sphagnum* spp. Other common species include *Betula nana, Ledum decumbens, Eriophorum angustifolium,* and *Aulacomnium palustre.*

This ecotype differs from closely related Lowland Sedge Fen Meadow by the presence of *Salix fuscescens, Sphagnum*, and *Betula nana*. It differs from Lowland Wet Dwarf Birch–Ericacous Shrub by the low cover of shrubs and by the lack of *Hylocomium splendens*.

Table 17. Vegetation cover and frequency for Lowland Sedge–Moss Fen Meadow (n=9).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	113.6	33.0	100
Total Vascular Cover	45.4	18.6	100
Total Evergreen Shrub Cover	5.4	6.5	89
Empetrum nigrum	1.2	1.7	67
Ledum decumbens	2.8	3.4	89
Oxycoccus microcarpus	0.6	1.0	33
Vaccinium vitis-idaea	0.8	1.7	33
Total Deciduous Shrub Cover	8.8	6.3	100
Andromeda polifolia	0.7	1.1	33
Betula nana	2.8	3.1	100
Salix fuscescens	1.6	1.7	67
Salix planifolia pulchra	1.3	3.3	22
Vaccinium uliginosum	2.3	2.6	89
Total Forb Cover	2.2	4.5	78
Pedicularis sudetica	0.2	0.4	22
Petasites frigidus	0.3	1.0	22
Potentilla palustris	1.2	3.3	44
Rubus chamaemorus	0.3	0.7	22
Total Grass Cover	1.1	2.0	44
Calamagrostis canadensis	0.7	1.7	33
Hierochloe pauciflora	0.4	0.7	33
Total Sedge Cover	27.9	17.1	100
Carex aquatilis	16.3	17.6	100
Carex bigelowii	1.1	3.3	11
Carex chordorrhiza	0.6	1.7	11
Carex rariflora	2.1	3.4	56
Carex rotundata	0.1	0.3	22
Eriophorum angustifolium	4.7	5.7	56
Eriophorum russeolum	1.0	1.7	33
Eriophorum scheuchzeri	1.3	2.2	33
Eriophorum vaginatum	0.3	0.7	22
Luzula arcuata	0.1	0.3	11
Total NonVascular Cover	68.1	21.5	100
Total Moss Cover	67.3	21.0	100
Aulacomnium palustre	3.9	7.0	44
Campylium stellatum	0.6	1.7	11
Dicranum sp.	1.3	3.3	33
Polytrichum juniperinum	0.4	0.7	33
Sphagnum balticum	2.2	6.7	11
Sphagnum capillifolium	4.4	13.3	11
Sphagnum compactum	1.7	5.0	11
Sphagnum fuscum	8.9	20.3	22
Sphagnum imbricatum	3.9	7.8	22
Sphagnum lenense	5.6	11.3	22
Sphagnum lindbergii	1.7	5.0	11
Sphagnum obtusum	1.1	3.3	11
Sphagnum sp.	11.1	19.6	33
Sphagnum squarrosum	15.6	16.5	56
Sphagnum subsecundum	2.0	5.0	22
Sphagnum warnstorfii	2.8	6.7	22
Total Lichen Cover	0.8	1.6	44
Cladina arbuscula	0.4	1.3	11
Cladonia sp.	0.1	0.3	11
Total Bare Ground	47.4	22.0	100
Soil	0.1	0.3	22
Water	7.8	11.2	78
Litter alone	39.4	15.9	100

LOWLAND SEDGE FEN MEADOW

Plant Association:
Carex aquatilis–Carex chordorrhiza

Organic-rich sites on low-lying flats, on coastal plain deposits, abandoned floodplains, and within drained-lake basins with vegetation dominated by sedges. Soils are saturated, very poorly drained, have thick organic horizons, and are acidic to circumneutral. Ground water is close to the soil surface and active later depths are moderate to shallow (<40 cm). Ice-wedge development in older landscapes creates distinctive low-centered polygons. The surface generally is flooded during early summer (depth <30 cm) and drains later in the growing season.

Vegetation is dominated by *Carex aquatilis, Eriophorum angustifolium*, and *C. chordorrhiza*. Aquatic mosses *Scorpidium scorpioides, Limprichtia revolvens*, and *Calliergon giganteum* often are present. Low and dwarf shrubs may be present but cover is very low.

This ecotype is similar to Lowland Sedge–Moss Fen but lacks *Sphagnum, Salix fuscescens*, and ericaceous shrubs. It differs from Lacustrine Marestail Marsh by lacking *Hippurus vulgaris*. In this area, fen meadows quickly acidify during lake-basin succession.

Table 18. Vegetation cover and frequency for Lowland Sedge Fen Meadow (n=11).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	65.6	43.7	100
Total Vascular Cover	45.2	26.3	100
Total Deciduous Shrub Cover	1.1	1.2	73
Andromeda polifolia	0.2	0.4	18
Betula nana	0.2	0.4	27
Salix fuscescens	0.4	0.5	55
Salix planifolia pulchra	0.4	0.7	27
Salix sp.	0.0	0.0	9
Total Forb Cover	7.8	17.5	91
Caltha palustris	0.9	2.0	36
Cardamine pratensis	0.0	0.0	9
Galium trifidum	0.0	0.0	9
Hippuris vulgaris	0.0	0.0	9
Menyanthes trifoliata	0.1	0.3	9
Pedicularis parviflora pennellii	0.1	0.3	27
Pedicularis sudetica	0.3	0.6	36
Petasites frigidus	0.0	0.0	9
Polemonium acutiflorum	0.0	0.0	9
Potentilla palustris	4.8	15.0	36
Ranunculus pallasii	0.6	1.5	27
Rumex arcticus	0.1	0.3	9
Saxifraga hirculus	0.1	0.3	9
Utricularia sp.	0.0	0.0	9
Utricularia vulgaris	0.3	0.9	9
Utricularia vulgaris macrorhiza	0.4	0.8	18
Total Grass Cover	0.5	1.0	27
Calamagrostis canadensis	0.4	0.9	18
Dupontia fischeri	0.2	0.6	9
Total Sedge Cover	35.7	14.6	100
Carex aquatilis	15.2	12.8	100
Carex chordorrhiza	6.8	9.2	64
Carex membranacea	0.5	0.8	36
Carex rariflora	0.5	1.5	18
Carex rotundata	0.4	0.9	18
Carex saxatilis laxa	1.4	4.5	9
Eriophorum angustifolium	8.5	7.4	91
Eriophorum russeolum	1.7	1.7	64
Eriophorum scheuchzeri	0.5	1.5	9
Eriophorum vaginatum	0.0	0.0	9
Total NonVascular Cover	20.4	28.3	82
Total Moss Cover	20.4	28.3	82
Aulacomnium turgidum	0.5	1.5	18
Calliergon giganteum	1.9	6.0	18
Campylium stellatum	0.5	1.5	9
Cinclidium latifolium	0.5	1.5	9
Limprichtia revolvens	4.5	11.9	45
Mnium sp.	0.0	0.0	9
Rhizomnium sp.	0.5	1.5	9
Scorpidium scorpioides	11.4	21.9	36
Sphagnum sp.	0.5	1.5	9
Unknown liverwort	0.3	0.9	9
Total Bare Ground	90.1	42.4	100
Soil	1.8	6.0	9
Water	57.5	28.2	100
Litter alone	30.7	26.1	100

LOWLAND WATER

Shallow (<1.5 m) and deep (≥1.5 m) lakes primarily resulting from thawing of ice-rich permafrost on the coastal plain and distal portions of abandoned floodplains. These lakes lack riverine influences. In shallow ponds, water freezes to the bottom during winter, thaws by early to mid-June, and is warmer than water in deep lakes. In deep lakes, water does not freeze to the bottom during winter in deeper portions of the lake. Sediments are loamy to sandy. The alpine lakes in the Bendeleben Mountains are included in this class because they are relatively rare.

Table 19. Vegetation cover and frequency for Lowland Water (n=4).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	1.5	3.0	25
Total Vascular Cover	1.3	2.5	25
Total Forb Cover	0.5	1.0	25
Hippuris vulgaris	0.3	0.5	25
Potentilla palustris	0.3	0.5	25
Total Grass Cover	0.3	0.5	25
Arctophila fulva	0.3	0.5	25
Total Sedge Cover	0.5	1.0	25
Carex aquatilis	0.3	0.5	25
Eriophorum angustifolium	0.3	0.5	25
Total Moss Cover	0.3	0.5	25
Calliergon giganteum	0.3	0.5	25
Total Bare Ground	100.0	0.0	100
Water	100.0	0.0	100

LACUSTRINE MARESTAIL MARSH

Plant Associations: *Hippurus vulgaris–Potamogeton* spp.*; Carex aquatilis–Caltha palustris; Arctophila fulva*

Shallow water with emergent vegetation. Although the plant associations are distinct they were combined because they are uncommon and sampling was inadequate. This class was included in the Lowland Water class for mapping. Dominant species include *Hippuris vulgaris* and *Carex aquatilis*, while *Caltha natans, Arctophila fulva,* and *Potentilla palustris* often occur in differing circumstances.

Table 20. Vegetation cover and frequency for Lacustrine Maresail Marsh (n=5).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	34.3	23.5	100
Total Vascular Cover	30.5	19.0	100
Total Deciduous Shrub Cover	0.2	0.4	20
Salix fuscescens	0.2	0.4	20
Total Forb Cover	19.9	16.9	100
Caltha natans	3.0	6.7	20
Caltha palustris	0.8	1.3	40
Hippuris vulgaris	8.6	8.5	80
Menyanthes trifoliata	0.4	0.9	20
Myriophyllum spicatum	0.6	1.3	40
Potamogeton sp.	0.4	0.5	60
Potentilla palustris	5.0	8.7	40
Ranunculus hyperboreus	0.6	1.3	40
Ranunculus pallasii	0.4	0.9	20
Total Grass Cover	4.2	8.8	40
Arctophila fulva	4.2	8.8	40
Total Sedge Cover	6.2	13.3	40
Carex aquatilis	3.2	6.6	40
Eriophorum angustifolium	3.0	6.7	20
Total Moss Cover	3.8	6.9	40
Limprichtia revolvens	2.0	4.5	20
Scorpidium scorpioides	1.0	2.2	20
Sphagnum cf. jensnii	0.2	0.4	20
Sphagnum squarrosum	0.6	1.3	20
Total Bare Ground	105.0	27.1	100
Water	86.8	18.4	100
Litter alone	18.2	40.1	40

LACUSTRINE MOIST BLUEJOINT MEADOW

Plant Association:
Calamagrostis canadensis–Rumex arcticus

Flat areas in recently drained-lake basins dominated by Bluejoint grass. Soils are loamy, somewhat poorly drained, circum-neutral, and have thin surface organics and shallow active-layer depths. Permafrost is always present and presumably ice-poor because of the recent degradation. Ice wedges have yet to develop and surfaces are not polygonized. This ecotype is uncommon but is found in both parks.

Vegetation is dominated by *Calamagrostis canadensis* and forbs. Associated species include *Poa arctica, Petasites frigidus, Valeriana capitata, Polemonium acutiflorum, Rumex arcticus, Drepanocladus* sp., and *Aulacomnium palustre*.

This ecotype is unusual because of the high *Calamagrostis* cover and because it is restricted to recently drained-lake basins. While intensive sampling was insufficient to thoroughly characterize this ecotype, it also was documented in numerous verification plots.

Table 21. Vegetation cover and frequency for Lacustrine Moist Bluejoint Meadow (n=2).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	115.3	18.0	100
Total Vascular Cover	51.7	13.2	100
Total Deciduous Shrub Cover	0.6	0.8	50
Betula nana	0.1	0.1	50
Salix planifolia pulchra	0.5	0.7	50
Total Forb Cover	17.1	5.5	100
Arnica alpina	0.5	0.7	50
Artemisia tilesii	0.5	0.7	50
Ligusticum scoticum	0.1	0.1	50
Petasites frigidus	11.0	5.7	100
Polemonium acutiflorum	2.0	1.4	100
Rumex arcticus	1.0	0.0	100
Stellaria sp.	0.1	0.1	50
Valeriana capitata	2.0	1.4	100
Total Grass Cover	33.5	9.2	100
Calamagrostis canadensis	27.5	3.5	100
Poa arctica SL	6.0	5.7	100
Total Sedge Cover	0.5	0.7	50
Carex aquatilis	0.5	0.7	50
Total Nonvascular Cover	63.7	4.7	100
Total Lichen Cover	0.1	0.1	50
Nephroma sp.	0.1	0.1	50
Peltigera aphthosa	0.1	0.1	50
Total Moss Cover	63.6	4.9	100
Aulacomnium palustre	57.5	3.5	100
Aulacomnium turgidum	0.1	0.1	50
Drepanocladus sp.	4.0	1.4	100
Pohlia nutans	0.5	0.7	50
Polytrichum juniperinum	0.5	0.7	50
Polytrichum sp.	0.5	0.7	50
Total Bare Ground	57.6	24.8	100
Water	0.1	0.1	50
Litter alone	57.5	24.7	100

RIVERINE BARRENS

Plant Association:
Epilobium latifolium–Agropyron macrourum

Barren or partially vegetated (<30% cover) areas on active river channel deposits associated with meandering or braided rivers. Frequent sedimentation and scouring restricts establishment and growth of vegetation. Soils are well to excessively drained, sandy to gravelly, alkaline to circumneutral and lack surface organics. Permafrost is always present and active-layer depths are deep (>80 cm). Water usually is found at the bottom of the active layer.

Typical pioneering plants include *Salix alaxensis, S. planifolia pulchra, Festuca rubra, Elymus arenarius mollis, Artemisia arctica arctica, Epilobium latifolium,* and *Oxytropis borealis*.

This ecotype is relatively uncommon because of the riverine setting and lack of vegetation. While it has many of the species found in Riverine Tall Willow Shrub, its shrub cover is much lower. It has some species in common with Coastal Barrens, particularly *Elymus arenarius mollis, Artemisia tilesii,* and *Deschampsia caespitosa.*

Table 22. Vegetation cover and frequency for Riverine Barrens (n=6).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	16.2	21.6	150
Total Vascular Cover	15.9	21.6	150
Total Deciduous Shrub Cover	3.5	5.3	133
Salix alaxensis	1.5	1.7	117
Salix arbusculoides	0.1	0.3	17
Salix barclayi	1.0	3.2	33
Salix hastata	0.1	0.3	33
Salix niphoclada	0.4	1.3	17
Salix planifolia pulchra	0.3	0.7	50
Vaccinium uliginosum	0.0	0.0	17
Total Forb Cover	3.9	4.4	150
Artemisia arctica arctica	0.2	0.6	33
Artemisia glomerata	0.0	0.0	17
Artemisia tilesii	0.2	0.4	50
Aster sibiricus	0.4	0.7	83
Astragalus alpinus	0.0	0.0	50
Epilobium angustifolium	0.1	0.3	17
Epilobium ciliatum	0.0	0.0	17
Epilobium latifolium	1.6	2.5	117
Hedysarum alpinum	0.1	0.3	33
Linum perenne	0.1	0.3	17
Oxytropis borealis	0.5	1.6	17
Potentilla fruticosa	0.1	0.3	33
Rumex sp.	0.1	0.3	33
Stellaria sp.	0.0	0.1	33
Wilhelmsia physodes	0.0	0.1	67
Total Grass Cover	8.5	15.8	117
Agropyron boreale	0.0	0.0	33
Agropyron macrourum	0.1	0.3	17
Agropyron sp.	0.1	0.3	50
Arctagrostis latifolia	0.1	0.3	50
Bromus pumpellianus	0.1	0.3	17
Calamagrostis sp.	0.0	0.0	33
Deschampsia caespitosa	0.1	0.3	33
Elymus arenarius mollis	5.5	15.7	50
Festuca rubra	1.0	1.8	83
Poa alpigena	0.1	0.3	17
Poa alpina	0.1	0.3	33
Poa sp.	0.8	2.5	33
Trisetum spicatum	0.3	0.7	50
Total Sedge Cover	0.0	0.0	33
Carex bigelowii	0.0	0.0	17
Juncus castaneus	0.0	0.0	17
Total NonVascular Cover	0.4	0.8	67
Total Moss Cover	0.3	0.7	67
Ceratodon purpureus	0.2	0.6	17
Hylocomium splendens	0.0	0.0	17
Racomitrium lanuginosum	0.0	0.0	17
Rhytidium rugosum	0.0	0.0	17
Sanionia uncinata	0.0	0.1	17
Sphagnum obtusum	0.0	0.1	17
Total Bare Ground	86.4	20.0	167
Soil	82.1	23.3	167
Litter alone	4.3	5.0	133

RIVERINE MOIST TALL ALDER–WILLOW SHRUB

Plant Association:

Alnus crispa–Salix barclayi

Flat areas on active and inactive-floodplain deposits subject to occasional flooding and dominated by tall (≥1.5 m) alder shrubs. Soils are composed of interbedded layers of riverine silts, sands, gravels, and organics, are seasonally saturated, moderately well drained, and circumneutral. Permafrost is always present and the active-layer is shallow. This ecotype is rare and most notably found on the Serpentine River in BELA. It appears to be expanding along floodplains through water-born movement of seeds.

Vegetation is dominated by an open cover of *Alnus crispa, Salix barclayi,* and other willows. Common associated species include *Salix glauca, Salix alaxensis, Petasites frigidus*, *Arctagrostis latifolia*, and *Climacium dendroides*.

This ecotype is distinctive because of the presence of alder on river floodplains. It differs from Riverine Tall Willow Shrub by the abundance of *Alnus crispa* and *Arctagrostis latifolia* and the lack of *Aster sibiricus.* This class was merged with other early successional riverine shrubs and mapped as Riverine Moist Low and Tall Willow Shrub.

Table 23. Vegetation cover and frequency for Riverine Moist Tall Alder–Willow Shrub (n=3).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	158.1	25.2	100
Total Vascular Cover	143.4	11.3	100
Total Deciduous Shrub Cover	92.7	14.5	100
Alnus crispa	60.0	40.0	100
Salix alaxensis	7.3	11.0	67
Salix arbusculoides	2.7	2.5	67
Salix barclayi	10.7	16.8	67
Salix glauca	6.7	11.5	33
Salix lanata richardsonii	1.0	1.7	33
Salix niphoclada	1.7	2.9	33
Salix planifolia pulchra	1.7	2.9	33
Spiraea beauverdiana	0.3	0.6	33
Vaccinium uliginosum	0.7	1.2	33
Total Forb Cover	17.3	10.2	100
Aconitum delphinifolium	0.1	0.1	67
Anemone richardsonii	0.3	0.6	33
Artemisia tilesii	2.0	1.7	67
Aster sibiricus	0.0	0.1	33
Equisetum arvense	0.7	0.5	100
Galium sp.	0.0	0.1	33
Petasites frigidus	10.7	12.5	100
Polemonium acutiflorum	0.7	0.5	100
Ranunculus sp.	0.0	0.1	33
Rubus arcticus	1.3	0.6	100
Saxifraga punctata	0.7	0.6	67
Stellaria sp.	0.1	0.1	67
Valeriana capitata	0.7	1.2	33
Total Grass Cover	33.3	15.3	100
Arctagrostis latifolia	33.3	15.3	100
Total Sedge Cover	0.0	0.1	33
Luzula sp.	0.0	0.1	33
Total NonVascular Cover	14.8	14.2	100
Total Moss Cover	13.8	14.2	100
Brachythecium mildeanum	1.7	2.9	67
Brachythecium sp.	0.1	0.1	67
Climacium dendroides	7.7	10.8	67
Plagiomnium ellipticum	2.0	2.6	67
Sanionia uncinata	2.3	2.5	67
Total Lichen Cover	1.0	1.0	67
Parmelia sp.	1.0	1.0	67
Total Bare Ground	81.7	2.9	100
Soil	23.3	40.4	33
Water	0.0	0.0	0
Litter alone	58.3	37.5	100

RIVERINE MOIST TALL WILLOW SHRUB

<u>Plant Association</u>:
Salix alaxensis–Aster sibiricus

Flat areas on active and inactive floodplain deposits subject to frequent flooding and dominated by tall (≥1.5 m) willow shrubs. Active floodplain sites have sandy, well-drained soils, are circumneutral and lack organic horizons. On inactive floodplain deposits, soils are composed of interbedded layers of riverine silts and sands, seasonally saturated, well to somewhat poorly drained, circumneutral, and usually lack surface organic layers. Permafrost is always present and active-layer depths are the deepest of any ecotype. This type is widespread in narrow zones along rivers but is uncommon overall.

Vegetation is dominated by a closed to open canopy of the tall shrub *Salix alaxensis*. Other species include *S. lanata richardsonii, Equisetum arvense, Galium boreale, Artemisia tilesii, Aster sibiricus, Petasites frigidus, Potentilla fruticosa, Calamagrostis canadensis,* and *Arctagrostis latifolia*.

This ecotype is most similar to Riverine Moist Tall Willow shrub but lacks *Alnus crispa*. It differs from Riverine Moist Low Willow Shrub and Lowland Moist Low Willow Shrub by the lack of *Salix planifolia pulchra*. This class was merged with other early successional riverine shrubs and mapped as Riverine Moist Low and Tall Willow Shrub.

Table 24. Vegetation cover and frequency for Riverine Moist Tall Willow Shrub (n = 6).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	160.3	68.0	100
Total Vascular Cover	139.4	59.6	100
Total Evergreen Shrub Cover	0.3	0.5	33
Empetrum nigrum	0.3	0.5	33
Total Deciduous Shrub Cover	81.5	31.2	100
Arctostaphylos rubra	4.8	9.9	50
Salix alaxensis	42.5	16.0	100
Salix arbusculoides	3.5	8.1	33
Salix glauca	2.0	1.9	67
Salix hastata	1.4	2.1	50
Salix lanata richardsonii	14.7	24.3	50
Salix niphoclada	5.8	12.0	33
Salix planifolia pulchra	1.2	1.9	50
Salix reticulata	3.4	8.2	33
Total Forb Cover	45.8	42.1	100
Artemisia arctica arctica	1.0	2.0	33
Artemisia tilesii	2.0	2.4	67
Aster sibiricus	2.2	2.2	100
Astragalus alpinus	0.4	0.5	50
Castilleja caudata	1.2	2.0	33
Epilobium latifolium	1.8	2.1	50
Equisetum arvense	6.7	9.6	100
Equisetum variegatum	1.3	2.8	33
Galium boreale	15.2	30.4	83
Mertensia paniculata	1.7	4.1	17
Parnassia palustris	0.5	0.8	50
Pedicularis verticillata	0.4	0.8	67
Petasites frigidus	2.5	6.1	17
Polemonium acutiflorum	0.2	0.4	67
Polygonum viviparum	0.4	0.5	67
Potentilla fruticosa	3.0	3.0	67
Solidago multiradiata var. *multiradiata*	1.0	1.5	33
Valeriana capitata	0.2	0.4	67
Total Grass Cover	10.1	6.3	100
Arctagrostis latifolia	1.3	1.4	67
Calamagrostis canadensis	2.5	3.9	50
Festuca altaica	1.2	2.0	33
Festuca rubra	2.5	2.9	83
Poa alpina	0.8	1.0	50
Poa arctica SL	0.2	0.4	33
Trisetum spicatum	0.4	0.5	50
Total Sedge Cover	1.2	2.0	50
Carex aquatilis	0.8	2.0	17
Luzula multiflora	0.2	0.4	17
Luzula parviflora	0.2	0.4	17
Total Deciduous Tree Cover	0.5	0.8	33
Populus balsamifera	0.5	0.8	33
Total NonVascular Cover	20.9	20.5	100
Total Moss Cover	19.0	20.8	100
Brachythecium reflexum	2.5	6.1	17
Brachythecium sp.	7.0	16.2	50
Hylocomium splendens	1.0	2.0	33
Pohlia sp.	1.7	4.1	17
Polytrichum juniperinum	0.7	1.2	33
Racomitrium lanuginosum	1.3	2.2	33
Sanionia uncinata	1.3	3.3	17
Total Lichen Cover	1.9	2.9	33
Peltigera aphthosa	0.2	0.4	17
Stereocaulon alpinum	0.8	2.0	17
Stereocaulon sp.	0.8	2.0	17
Total Bare Ground	41.4	28.5	100
Soil	6.4	7.6	83
Litter alone	35.0	30.8	100

RIVERINE MOIST LOW WILLOW SHRUB

Plant Association:
Salix lanata richardsonii–Festuca altaica

Flat areas on inactive floodplain deposits subject to infrequent flooding with vegetation dominated by low shrubs. Soils are interbedded alluvial silts, sands, and organics, moderately well to somewhat poorly drained, and circumneutral. Permafrost is always present and the active layer is moderately deep (40–80 cm).

Vegetation is dominated by an open or closed canopy of low willows, most commonly a mixture of *Salix lanata richardsonii, S. glauca, S. planifolia pulchra, S. alaxensis,* and *S. arbusculoides.* Other species present include *Betula nana, Salix reticulata, Arctostaphylos rubra, Valeriana capitata, Festuca altaica, Calamagrostis canadensis, Carex bigelowii, Tomentypnum nitens,* and *Hylocomium splendens.*

This ecotype is similar to Lowland Moist Low Willow Shrub, Riverine Moist Dwarf Birch–Willow Shrub, and Upland Moist Low Willow Shrub but differs by having *Salix alaxensis*, *S. arbusculoides,* and *S. niphoclada.* This class was merged with other early successional riverine shrubs and mapped as Riverine Moist Low and Tall Willow Shrub.

Table 25. Vegetation cover and frequency for Riverine Moist Low Willow Shrub (n=6).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	173.6	57.2	100
Total Vascular Cover	127.4	53.4	100
Total Evergreen Shrub Cover	7.7	18.3	50
Dryas integrifolia	5.9	14.3	33
Empetrum nigrum	1.7	4.1	17
Ledum decumbens	0.2	0.4	17
Total Deciduous Shrub Cover	94.4	39.2	100
Arctostaphylos rubra	15.3	23.0	83
Betula nana	5.2	4.3	83
Salix alaxensis	9.8	13.4	83
Salix arbusculoides	7.8	15.9	50
Salix glauca	13.3	16.0	83
Salix lanata richardsonii	11.7	14.7	67
Salix niphoclada	5.8	5.8	67
Salix planifolia pulchra	10.8	13.2	67
Salix reticulata	9.2	10.6	83
Vaccinium uliginosum	5.0	8.4	33
Total Forb Cover	11.3	6.8	100
Astragalus alpinus	0.4	0.5	50
Cardamine pratensis	0.1	0.1	50
Equisetum arvense	0.7	1.2	33
Galium boreale	0.4	0.8	33
Hedysarum alpinum	0.4	0.5	50
Lupinus arcticus	1.7	2.6	33
Polemonium acutiflorum	0.2	0.4	50
Potentilla fruticosa	2.3	2.2	83
Rubus arcticus	1.3	2.2	33
Stellaria sp.	0.2	0.4	33
Valeriana capitata	0.6	0.8	83
Total Grass Cover	8.4	6.7	100
Arctagrostis latifolia	0.1	0.1	50
Calamagrostis canadensis	2.8	6.0	33
Festuca altaica	4.7	5.8	67
Poa arctica SL	0.2	0.4	33
Total Sedge Cover	5.7	6.4	83
Carex aquatilis	0.2	0.4	33
Carex bigelowii	3.3	5.2	33
Carex capillaris	0.5	1.2	33
Total NonVascular Cover	46.2	30.3	100
Total Moss Cover	46.2	30.3	100
Aulacomnium acuminatum	1.7	4.1	17
Aulacomnium palustre	2.5	4.2	50
Aulacomnium turgidum	0.8	2.0	17
Bryum sp.	0.9	2.0	33
Campylium polygamum	4.2	10.2	33
Ceratodon purpureus	2.5	4.2	33
Climacium dendroides	0.7	0.8	50
Dicranum sp.	2.0	4.0	33
Hylocomium splendens	9.2	12.0	50
Hypnum lindbergii	0.8	2.0	17
Hypnum pratense	3.3	8.2	17
Sanionia uncinata	1.0	2.0	50
Tomentypnum nitens	15.8	18.8	83
Total Bare Ground	53.7	16.6	100
Soil	0.4	0.5	50
Litter alone	53.3	16.6	100

RIVERINE MOIST DWARF BIRCH–WILLOW SHRUB

Plant Association:
Betula nana–Salix planifolia pulchra–Pyrola grandiflora

Flat areas on inactive floodplain deposits subject to infrequent flooding with vegetation dominated by low shrubs. Soils are interbedded alluvial silts, sands, and organics, moderately well to somewhat poorly drained, circumneutral, and have thin surface organic layers due to occasional sedimentation. Permafrost is always present and the active layer is moderately deep (40–80 cm).

Vegetation is dominated by an open to closed canopy of *Betula nana* and *Salix planifolia pulchra.* Other common species include *Vaccinium uliginosum*, *Petasites frigidus, Calamagrostis canadensis, Arctagrostis latifolia,* and *Hylocomium splendens.*

This ecotype is very similar to Lowland Dwarf Birch–Willow Shrub and they share the same plant association. It differs by having very low cover of the shrubs *Vaccinium vitis-idaea, Ledum decumbens,* and *Empetrum nigrum.* It is a late-successional community that occurs on surficial deposits at the last stages of floodplain development and grades into abandoned overbank floodplain deposits associated with lowland ecotypes.

Table 26. Vegetation cover and frequency for Riverine Moist Dwarf Birch–Willow Shrub (n=6).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	170.5	35.2	100
Total Vascular Cover	116.8	16.6	100
Total Evergreen Shrub Cover	1.9	1.8	83
Ledum decumbens	0.9	1.0	67
Vaccinium vitis-idaea	1.0	2.0	50
Total Deciduous Shrub Cover	87.3	13.4	100
Arctostaphylos rubra	0.8	2.0	17
Betula nana	32.5	27.5	100
Salix barclayi	0.5	1.2	17
Salix glauca	5.5	8.0	67
Salix hastata	0.5	0.8	33
Salix lanata richardsonii	1.7	4.1	17
Salix planifolia pulchra	35.3	31.8	100
Vaccinium uliginosum	10.2	10.2	100
Total Forb Cover	14.3	8.4	100
Equisetum arvense	1.0	1.5	33
Petasites frigidus	6.7	7.3	100
Polemonium acutiflorum	0.2	0.4	83
Polygonum bistorta	0.5	1.2	17
Potentilla fruticosa	1.2	1.5	50
Pyrola grandiflora	1.3	1.0	83
Rubus chamaemorus	2.2	3.5	33
Saussurea angustifolia	0.5	0.8	33
Valeriana capitata	0.5	0.5	83
Total Grass Cover	8.2	3.7	100
Arctagrostis latifolia	2.7	3.8	67
Calamagrostis canadensis	2.5	4.2	33
Calamagrostis sp.	0.5	1.2	17
Festuca altaica	1.0	1.3	50
Festuca rubra	0.3	0.5	33
Poa arctica SL	1.2	1.9	50
Total Sedge Cover	5.2	9.8	67
Carex aquatilis	0.2	0.4	17
Carex bigelowii	2.2	3.9	67
Eriophorum angustifolium	1.2	2.0	33
Eriophorum vaginatum	1.7	4.1	17
Total NonVascular Cover	53.7	27.9	100
Total Moss Cover	51.6	26.5	100
Aulacomnium acuminatum	2.5	6.1	17
Aulacomnium palustre	4.2	7.8	83
Aulacomnium turgidum	1.2	1.5	67
Calliergon giganteum	0.3	0.8	17
Dicranum sp.	0.7	1.2	33
Hylocomium splendens	20.0	24.3	83
Pleurozium schreberi	3.3	8.2	17
Polytrichum juniperinum	0.7	1.2	33
Sanionia uncinata	1.9	4.0	50
Sphagnum spp.	4.2	10.2	17
Tomentypnum nitens	10.5	19.5	67
Total Lichen Cover	2.1	1.9	83
Cetraria islandica cf	0.2	0.4	17
Cladina rangiferina	0.2	0.4	33
Peltigera aphthosa	1.2	2.0	33
Total Bare Ground	31.7	21.6	100
Soil	0.0	0.0	0
Litter alone	31.7	21.6	100

RIVERINE WATER

Permanently flooded channels of freshwater rivers and lakes on well-developed floodplains. River water is alkaline and sediments are gravelly. Most mappable areas in the parks are low-gradient meandering rivers that reach peak flood in late spring. High-gradient headwater streams at upper elevations typically are too narrow to be mappable. Lakes on floodplains are included in this class because they are subject to periodic flooding and usually have fish communities similar to those of adjacent rivers.

COASTAL BARRENS

Plant Associations:
Elymus arenarius mollis–Lathyrus maritimus; Carex ramenskii–Puccinellia phryganodes

Barren or partially vegetated (<30% cover), salt-affected areas on tidal flats, deltas, dunes, and beaches along the coast that may be frequently inundated or affected by storm surges. Soils are sandy, lack surface organics, brackish, and have deep (>80 cm) active layers. Permafrost is always present and presumably ice-poor.

Common colonizing plants on dry brackish sites include *Elymus arenarius mollis, Honkenya peploides, Artemisia tilesii,* and *Lathyrus maritimus*. Plants on saline wet sites include *Carex subspathacea, Potentilla egedii,* and *Chrysanthemum arcticum*; species that also are typical of the *Carex ramenskii–Puccinellia phryganodes* plant association of more vegetated sites.

This class also includes tundra that has been killed by saltwater intrusions from storm surges and is being colonized by salt-tolerant plants. Newly deposited sediments typically are found on top of a thick organic horizon. These areas have low pH, high salinity, and shallow thaw depths.

Table 27. Vegetation cover and frequency for Coastal Barrens (n=7).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	3.6	6.1	57
Total Vascular Cover	3.4	6.1	42
Total Deciduous Shrub Cover	0.0	0.1	14
Salix ovalifolia	0.0	0.0	14
Total Forb Cover	1.4	2.4	42
Artemisia tilesii	0.0	0.0	14
Chrysanthemum arcticum	0.0	0.0	14
Honckenya peploides	0.9	1.5	28
Lathyrus maritimus	0.2	0.4	28
Mertensia maritima	0.3	0.8	14
Potentilla Egedii	0.0	0.0	14
Senecio sp.	0.0	0.0	14
Stellaria humifusa	0.0	0.0	14
Total Grass Cover	1.9	3.8	42
Elymus arenarius mollis	1.9	3.8	42
Festuca rubra	0.0	0.0	14
Total Sedge Cover	0.1	0.4	14
Carex subspathacea	0.1	0.4	14
Total NonVascular Cover	0.1	0.2	42
Total Moss Cover	0.1	0.2	42
Bryum pseudotriquetrum	0.0	0.1	14
Ceratodon purpureus	0.0	0.1	14
Dicranum spadiceum	0.0	0.1	14
Leptobryum pyriforme	0.0	0.1	14
Total Bare Ground	98.4	3.7	100
Soil	96.0	6.0	100
Water	0.1	0.4	14
Litter alone	2.3	3.9	57

COASTAL DRY DUNEGRASS MEADOW

Plant Association:
Elymus arenarius mollis–Lathyrus maritimus

Coastal dunes and beach fringes with vegetation dominated by grasses. Soils are sandy, excessively drained, unstable and circumneutral with no organic horizon. Permafrost is always present and active-layers are deep (>80 cm).

Vegetation is dominated by *Elymus arenarius mollis,* with scattered individuals of *Artemisia tilesii, Chrysanthemum bipinnatum,* and *Deschampsia caespitosa*.

This class is similar to Coastal Barrens but differs by having >30% vegetation cover. It differs from Upland Dry Crowberry Tundra, which occurs on inactive dunes and is a late-successional ecotype that develops from Coastal Dry Dunegrass Meadow by lacking *Empetrum nigrum*.

Table 28. Vegetation cover and frequency for Coastal Dry Dunegrass Meadow (n=4).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	55.5	28.7	100
Total Vascular Cover	55.3	28.7	100
Total Forb Cover	26.2	18.2	100
Artemisia tilesii	1.3	1.4	100
Aster sp.	0.3	0.5	25
Astragalus eucosmus sealei	0.3	0.5	25
Bupleurum triradiatum	0.3	0.5	50
Chrysanthemum arcticum	0.0	0.1	25
Chrysanthemum bipinnatum	0.0	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	17.5	15.0	75
Mertensia maritima	0.5	1.0	25
Papaver lapponicum	0.0	0.1	25
Saussurea nuda	0.0	0.1	25
Saxifraga bronchialis	0.0	0.1	25
Senecio pseudoarnica	2.5	5.0	25
Stellaria sp.	0.3	0.5	25
Total Grass Cover	29.0	11.8	100
Bromus sp.	0.8	1.5	25
Deschampsia caespitosa	0.0	0.1	25
Elymus arenarius mollis	25.0	7.1	100
Festuca rubra	0.8	1.5	25
Festuca sp.	1.3	2.5	25
Poa arctica SL	1.3	2.5	25
Total Sedge Cover	0.0	0.1	25
Triglochin maritimum	0.0	0.1	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	72.6	35.7	100
Soil	6.3	7.4	100
Water	0.0	0.0	0
Litter alone	66.3	37.5	100

COASTAL BRACKISH WET SEDGE–GRASS MEADOW

Plant Associations:
Carex ramenskii–Dupontia fisheri
Salix ovalifolia–Deschampsia caespitosa

Flat areas on active and inactive tidal flats along the coast with vegetation dominated by halophytic sedges and dwarf shrubs. Soils are loamy, poorly drained, brackish, and have little to no surface organic layers. Permafrost is always present and presumably ice-poor due to frequent sedimentation. This type is common along the coast, particularly at deltas, but rare overall.

Vegetation on lower, wetter sites is dominated by *Carex ramenskii, Dupontia fisheri,* and *Calamagrostis deschampsioides.* On moderately well drained sites, particularly on low, indistinct levees along the sloughs, *Salix ovalifolia, Deschampsia caespitosa, Elymus arenarius mollis,* and *Stellaria humifus* occur. The plant associations with these varying dominant species were grouped into one ecotype because they are highly interspersed and could not be mapped separately.

This ecotype is similar to Coastal Saline Wet Sedge–Grass Meadow but differs by the lack of *Puccinellia phryganodes* and the presence of *Dupontia fisheri* and/or *Salix ovalifolia.* The two halophytic wet meadows were merged for mapping as Coastal Wet Sedge–Grass Meadow.

Table 29. Vegetation cover and frequency for Coastal Brackish Wet Sedge–Grass Meadow (n=7).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	52.7	14.7	100
Total Vascular Cover	48.1	11.4	100
Total Evergreen Shrub Cover	0.2	0.4	29
Empetrum nigrum	0.2	0.4	29
Total Deciduous Shrub Cover	5.0	7.5	71
Salix fuscescens	0.1	0.4	14
Salix ovalifolia	4.9	7.6	57
Total Forb Cover	8.4	4.9	100
Androsace chamaejasme	0.0	0.0	14
Castilleja elegans	0.1	0.4	14
Chrysanthemum arcticum	0.3	0.5	29
Chrysanthemum bipinnatum	0.0	0.0	14
Cochlearia officinalis arctica	1.6	2.0	43
Lathyrus maritimus	0.1	0.4	14
Melandrium apetalum	0.0	0.0	14
Pedicularis langsdorffii arctica	0.1	0.4	14
Pedicularis sudetica	0.6	1.0	29
Polygonum sp.	0.0	0.0	14
Potentilla egedii	1.6	3.7	43
Potentilla sp.	0.0	0.1	43
Primula borealis	0.0	0.0	14
Rumex arcticus	0.2	0.3	86
Saxifraga exilis	0.7	1.9	14
Sedum rosea	0.0	0.0	14
Stellaria humifusa	2.9	3.6	71
Total Grass Cover	11.7	6.9	100
Arctagrostis latifolia	0.7	1.9	14
Calamagrostis deschampsioides	4.3	4.5	57
Calamagrostis holmii	1.7	3.7	29
Deschampsia caespitosa	2.4	3.8	43
Dupontia fisheri	2.1	2.1	71
Elymus arenarius mollis	0.2	0.4	29
Poa arctica SL	0.3	0.8	14
Total Sedge Cover	22.9	6.7	100
Carex amblyorhynca	0.7	1.9	14
Carex aquatilis	0.4	0.8	29
Carex canescens	0.3	0.8	14
Carex ramenskii	20.7	9.8	100
Eriophorum angustifolium	0.3	0.8	29
Juncus albescens	0.4	1.1	14
Total NonVascular Cover	4.6	10.1	29
Total Moss Cover	4.6	10.1	29
Aulacomnium palustre	0.3	0.8	14
Bryum pallescens	0.7	1.9	14
Bryum sp.	1.1	2.0	29
Campylium polygamum	0.7	1.9	14
Campylium sp.	1.1	2.0	29
Leptobryum pyriforme	0.7	1.9	14
Total Bare Ground	66.6	21.7	100
Soil	8.4	18.4	86
Water	0.3	0.5	57
Litter alone	57.9	21.0	100

COASTAL SALINE WET SEDGE–GRASS MEADOW

Plant Association: *Carex ramenskii–Puccinellia phryganodes*

Low-lying, salt-affected areas on active tidal flats and deltas along the coast that are frequently to irregularly flooded and have vegetation dominated by halophytic sedges and grasses. The vegetated surface is nonpatterned but small tidal ponds frequently are interspersed within the meadows. Soils are saline (>16,000 µS/cm), very poorly drained, and sandy to loamy with variable organic horizon depths. Permafrost is always present and the active layer is moderately thick.

Vegetation is dominated by *Carex ramenskii, Puccinellia phryganodes, Calamagrostis deschampsioides, Elymus arenarius mollis, Chrysanthemum arcticum,* and *Potentilla egedii*. Mapped as Coastal Wet Sedge–Grass Meadow.

Table 30. Vegetation cover and frequency for Coastal Saline Wet Sedge–Grass Meadow (n=6).

	Cover		Freq
	Mean	SD	(%)
Total Live Cover	55.8	9.5	100
Total Vascular Cover	55.7	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	0.4	0.8	33
Stellaria humifusa	0.1	0.0	100
Total Graminoid Cover	14.2	7.8	83
Calamagrostis deschampsioides	2.5	4.2	33
Elymus arenarius mollis	4.0	4.3	83
Puccinellia phryganodes	7.7	6.1	83
Carex ramenskii	19.3	10.3	100
Carex subspathacea	5.8	10.2	33

COASTAL WATER

Nearshore Water

Coastal Lake

Coastal Water is comprised of nearshore marine and estuarine waters and coastal lakes. Nearshore water includes open waters of Bering Strait, Chukchi Sea and Kotzebue Sound. Coastal Lakes are flooded periodically with saltwater during high tides or storm surges. Salinity levels often are increased by subsequent evaporation of impounded saline water. The substrate is sandy to loamy and occasionally contains peat. Shorelines usually have halophytic vegetation. Some Coastal Lakes have distinct outlets or have been partially drained (tapped) through erosion of river banks. Shallow lakes (<1.5m) freeze to the bottom during winter. *Hippuris tetraphylla* occasionally is present in coastal ponds.

HUMAN MODIFIED BARRENS

Plant Association: None

Barren or partially (<30% cover) vegetated areas that have been disturbed by human activity. Roads, airstrips, buildings, mines, and clearings are included in this class. Partially vegetated areas have pioneering indigenous species. In the study area, this ecotype was mapped only along the road to the Red Dog mine, although other barren areas such as airstrips and old mine sites are known to occur. Areas adjacent to the road are affected by dust, making the mapping of vegetation types along the road unreliable.

UNUSUAL ECOTYPES

Unusual ecotypes that were insufficiently sampled to reliably classify include: Alpine Lake, Riverine Moist Broadleaf Forest, Riverine Dry Dryas Shrub, Riverine Moist Sedge–Dryas Meadow, Riverine Dry Grass Meadow, and Coastal Forb Marsh. In addition to being rare, these types also were too small to map.

Alpine Lakes occur at high elevations, are oligotrophic, lack submergent and emergent vascular plants, and are noted by the clear blue or turquoise color of the water. Alpine Lakes are restricted to the Bendeleben-Darby Mountains and were included in the Lowland Water class for mapping.

Riverine Moist Broadleaf Forest occurs on sandy or gravelly point bars along meandering rivers. Vegetation is dominated by *Populus balsamifera, Salix alaxensis, Equisetum arvense, Calamagrostis canadensis, Petasites frigida, Artemisia tilesii, Mertensia paniculata*, and *Galium boreale*. This type was found in the southern portions of both BELA and CAKR and at one hillside spring. It was included in the Riverine Moist Low and Tall Willow Shrub class for mapping.

Riverine Dry Dryas Shrub occurs on dry river terraces. Vegetation is dominated by *Dryas integrifolia* or *Dryas drummondii*. This type was mapped as Riverine Barrens.

Riverine Moist Sedge–Dryas Shrub Meadow occurs on poorly drained organic-rich floodplains. Vegetation is similar to Lowland Moist Sedge–Dryas Meadow. This type was included in the Riverine Moist Dwarf Birch–Willow Shrub class for mapping.

Riverine Dry Grass Meadow occurs on sandy or gravelly point bars along meandering rivers. Vegetation is dominated by *Elymus arenarius mollis, Festuca rubra, Agropyron macrourum, Artemisia tilesi, Aster sibericus,* and *Deschampsia caespitosa.* It was classified as Riverine Barrens or Riverine Moist Low and Tall Willow Shrub during mapping.

Coastal Forb Marsh occurs in shallow brackish coastal ponds. Vegetation is dominated by *Hippurus tetraphylla*. It was mapped as either Coastal Water or Coastal Wet Sedge–Grass Meadow depending on pond size.

KEY TO ECOTYPES

A key was developed to differentiate the ecotypes in the field using vegetation structure (based on Viereck et al. 1992), physiography, and characteristic species (Table 31). Characteristics of unusual ecotypes also are included in the key to assign the most appropriate similar class to these nonmapped ecotypes directly.

Table 31. Key to ecotypes for Bering Land Bridge National Preserve and Cape Krusenstern National Monument, western Alaska.[1,2]

1a. **Permanent waterbody** (water typically >10 cm deep)……………………………………………..….2
1b. Not a permanent waterbody……………………………………………………………….……...…5

2a. Waterbody without emergent vegetation

3a. Site has saline or brackish water (>800 µS/cm) near the coast. ....Coastal Water

3b. Site is a perennial freshwater river (flowing water)...…………………….….Riverine Water

3c. Site is a freshwater lake or pond on the floodplain (flat terrain subject to periodic flooding and sedimentation) of a perennial river. ……….…………………………………Riverine Water

3d. Site is a freshwater lake or pond and not on a floodplain……….…………....Lowland Water

2b. Waterbody with emergent herbaceous vegetation ≥10% cover…………………………….…4

4a. Site is a shallow freshwater lake or lake fringe with vegetation dominated by *Hippuris vulgaris* (uncommon *Carex aquatilis* or *Arctophila fulva* dominated marshes are included, class not mapped)…...………Lacustrine Marestail Marsh

4b. Site is a shallow brackish lake or lake fringe with vegetation dominated by *Hippuris tetraphylla*……………………….........................……………………….Coastal Water

5a. **Barren** or only partially vegetated land with total cover of vascular vegetation <30%..............….6
5b. Vegetation cover ≥30%...7

6a. Site is at high elevation (~>700 m) on carbonate bedrock ….…….Alpine Alkaline Dry Barrens

6b. Site is at high elevation on noncarbonate bedrock …………….Alpine Nonalkaline Dry Barrens

6c. Site is in a low-lying, salt-affected coastal area………….….……………….…Coastal Barrens

6d. Site is on the floodplain of a perennial freshwater river.....................................Riverine Barrens

6e. Site is a rocky slope, ridge, or lava flow below 700m …….………Upland Dry Lichen Barrens

6f. Site has been highly disturbed by humans (roads, pads, airstrips)……Human-Modified Barrens

7a. Needleleaf trees have a canopy ≥10% …………………………..………Upland Moist Spruce Forest
7b. Needleleaf trees have a canopy <10% …………………………………………….………………..8

8a. **Tall shrubs** (≥1.5 m tall) have a canopy cover ≥25 %...9
8b. Tall shrubs have a canopy cover <25 % 10

Table 31. Continued.

9a. Site is on the floodplain of a freshwater river and vegetation is dominated by tall willows (*Salix alaxensis*) without alder (*Aster sibiricus* is common, this class was merged into Riverine Moist Low and Tall Willow Shrub for mapping)……………….... Riverine Moist Tall Willow Shrub

9b. Site is on the floodplain of a freshwater river and vegetation is dominated by tall willows (*Salix alaxensis*) and alder (*Arctagrostis latifolia* is common, this class was merged into Riverine Moist Low and Tall Willow Shrub for mapping) ……Riverine Moist Tall Alder–Willow Shrub

9c. Site is a drainage (sometimes lower slope) and is dominated by tall willows (*Salix planifolia pulchra*) or occasionally alder ……………..……...Lowland Moist Tall Alder–Willow Shrub

10a. **Low shrubs** (0.2–1.5 m tall) have a canopy cover ≥25 % 11
10b. Low shrubs have a canopy cover <25% ….………………………………...…………………..……12

11a. Site is a gentle middle or upper slope (sometimes high-centered polygons on flats) with shrub birch and willows, and cover of whole tussocks (*Eriophorum vaginatum*) >15% ……………………………………………………Upland Moist Dwarf Birch–Tussock Shrub

11b. Site is a middle or upper slope with shrubs dominated by dwarf birch (*Betula nana*), ericaceous shrubs, and lichens (willow <10% cover)………Upland Moist Dwarf Birch–Ericaceous Shrub

11c. Site is a middle or upper slope with shrubs dominated by low willows (*Salix glauca*, *Salix planifolia pulchra*, *Salix lanata richardsonii*) and lacks Sphagnum …………………………………………………...………Upland Moist Low Willow Shrub

11d. Site is a lower slope, flat, drained basin, or abandoned floodplain (surface organics >20cm deep) with vegetation dominated by dwarf birch, willows (*Salix planifolia pulchra*) and Sphagnum …...………………………………...…..Lowland Moist Dwarf Birch–Willow Shrub

11e. Site is a lower slope, flat, drained basin, or abandoned floodplain (surface organics >20cm deep) with vegetation dominated by willows (*Salix planifolia pulchra*) and Sphagnum ……………………………………………………………… Lowland Moist Low Willow Shrub

11f. Site is a wet flat or depression in an organic-rich lowland and vegetation is dominated by *Betula nana,* ericaceous shrubs and Sphagnum (dwarf shrubs are present and may be co-dominant) ..……………………………...Lowland Wet Dwarf Birch–Ericaceous Shrub

11g. Site is on a river floodplain with vegetation dominated by dwarf birch and willows (*Salix planifolia pulchra*) (*Petasites frigidus* is common; this class was merged into Riverine Moist Low and Tall Willow Shrub for mapping) …......… Riverine Moist Dwarf Birch–Willow Shrub

11h. Site is on a river floodplain (soil surface organic horizon is <20 cm) with vegetation dominated by willows (*Salix lanata richardsonii, S. planifolia pulchra*, and *S. alaxensis*) and lacks Sphagnum (*Festuca altaica* is common; this class was merged into Riverine Moist Low and Tall Willow Shrub for mapping) ..………………….………...Riverine Moist Low Willow Shrub

12a. **Dwarf shrubs** (<0.2 m) have a canopy cover ≥25%……………...……………………………...13
12b. Dwarf shrubs have a canopy cover <25%………………………………………………………..16

13a. Elevation is high (usually >700 m) creating severely exposed **alpine conditions** …………….…14

Table 31. Continued.

14a. Bedrock is limestone, marble or other carbonate deposit (soil pH ≥ 7.4) and vegetation is dominated by Dryas and lichens…………..…………………Alpine Alkaline Dry Dryas Shrub

14b. Bedrock is not a carbonate deposit, vegetation is dominated by Dryas …………………………...……….……….……..…….Alpine Nonalkaline Dry Dryas Shrub

13b. Elevation is low (usually <700 m) **without alpine conditions** ……………..………………15

15a. Site is a gentle mid- or upper slope (sometimes high-centered polygons on flats) with dwarf and low shrubs, and cover of whole tussocks (*Eriophorum vaginatum*) >15% ……………………………………………… Upland Moist Dwarf Birch–Tussock Shrub

15b. Site is an inactive sand dune in a coastal area and vegetation is dominated by crowberry (*Empetrum nigrum*)………………………………………...Upland Dry Crowberry Shrub

15c. Site is a wet flat or depression in an organic-rich lowland and vegetation is dominated by dwarf shrubs (*Ledum decumbens, Empetrum nigrum, Oxycoccus microcarpus*) and Sphagnum (*Betula nana* is common and may be co-dominant) ……………………………………Lowland Wet Dwarf Birch–Ericaceous Shrub

16a. **Herbaceous** vegetation co-dominated by **sedges and low and dwarf shrubs** (usually 15–25% cover) and soils are **moist** ....……………….…17
16b. Herbaceous vegetation without substantial low and dwarf shrub cover…………………………..…18

17a. Whole tussocks of *Eriophorum vaginatum* >15%...... Upland Moist Dwarf Birch–Tussock Shrub

17b. Site is moderate hillside slope with vegetation dominated by *Carex bigelowii* and *Dryas integrifolia,* lichens may be abundant ……...……………..Upland Moist Sedge–Dryas Meadow

17c. Site is a gentle to moderate slope in low-lying areas with vegetation dominated by *Carex bigelowii, Equisetum arvense,* and *Dryas integrifolia,* and lichen are sparse ..……………………………..Lowland Moist Sedge–Dryas Meadow

18a. **Herbaceous** vegetation is dominated by s**edges** and soils are **wet**…………..…….….…………19
18b. Herbaceous vegetation is not dominated by sedges…………………………………..…...…….20

19a. Site is a flat, drained basin (surface organics usually >40cm deep) dominated by sedges (*Carex aquatilis, C. chordorrhiza*), and aquatic mosses ……………..Lowland Sedge Fen Meadow

19b. Site is a flat, drained basin, or abandoned floodplain with vegetation dominated by sedges (*Carex aquatilis)* and *Sphagnum* spp, often with scattered ericaceous shrubs ……...……………………………...………………..Lowland Sedge–Moss Fen Meadow

19c. Site is a flat or depression in a saline coastal area with vegetation dominated by sedges (*Carex ramenskii, C. subspathacea*)*,* and grasses (*Puccinellia phryganodes*) ……………………………………………... ......Coastal Saline Wet Sedge–Grass Meadow

19d. Site is a flat or depression in a brackish coastal area with vegetation dominated by *Carex ramenskii* and/or *Dupontia fischeri, Salix ovalifolia, Deschampsia caespitosa* ……………………………………………………..Coastal Brackish Sedge–Grass Meadow

Table 31. Continued.

20. **Herbaceous** vegetation is dominated by **grasses** …………………………..……………………21

21a. Site is a well-drained active sand dune in a salt-affected coastal area and vegetation is dominated by *Elymus arenarius mollis*…………………….……Coastal Dry Dunegrass Meadow

21b. Site is on somewhat well-drained soils in young drained-lake basins with vegetation dominated by *Calamagrostis canadensis*…………………………..…Lacustrine Moist Bluejoint Meadow

Note:
1. Shrub cover cutpoints represent general guidelines and classification decisions should also rely on dominant indicator species and landscape position. For example, Upland Moist Sedge–Dryas Meadow can sometime have 30–35% cover of shrubs, but should still be classified as a sedge–dryas meadow based on dominance of *Carex bigelowii* and *Dryas integrifolia*.
2. Rare ecotypes were not included in mapping and analysis. These include Alpine Lake (mapped as Lowland Lake), Riverine Moist Broadleaf Forest (Riverine Moist Low and Tall Willow Shrub), Riverine Dry Dryas Shrub (Riverine Barrens), Riverine Moist Sedge–Dryas Meadow (Riverine Moist Dwarf Birch–Willow Shrub), Riverine Dry Grass Meadow (Riverine Barrens), Riverine Wet Sedge Tundra (Lowland Sedge Moss Fen) and Coastal Forb Marsh (Coastal Water).

MAPPING

ABUNDANCE AND DISTRIBUTION

The mapping differentiated 18 vegetation types and 29 ecotypes, based on a supervised classification of spectral characteristics of the three Landsat TM scenes and modeling of the physiography and bedrock associated with ecosubsection maps and digital elevation models (Figures 4 and 5). The initial supervised classification of 18 signature vegetation types was subdivided into 29 ecotypes through the rule-based modeling. In the final map, four ecotypes identified by the ground data were combined with other classes because they could not be mapped separately (Appendix 9). The most abundant ecotypes within the park boundaries include Upland Moist Dwarf Birch–Ericaceous Shrub, Upland Moist Dwarf Birch–Tussock Shrub, Upland Moist Sedge–Dryas Meadow, Lowland Moist Sedge–Dryas Meadow, and Lowland Sedge–Moss Fen Meadow (Table 32). To simplify the map and improve map accuracy, the 29 ecotypes also were aggregated into 12 classes based on ecological and spectral similarity.

ACCURACY ASSESSMENT

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 vegetation type (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 389 signatures used in the supervised classification were highly reliable; the signature vegetation was classified correctly (80% of pixels within signature) in 98% of the training signatures.

To assess the variability of signatures for any given signature vegetation type, the values of the first and second axes of the principal components analysis were plotted to identify any overlaps of signatures among the various vegetation types (Figure 6). These axes explained 95% of the

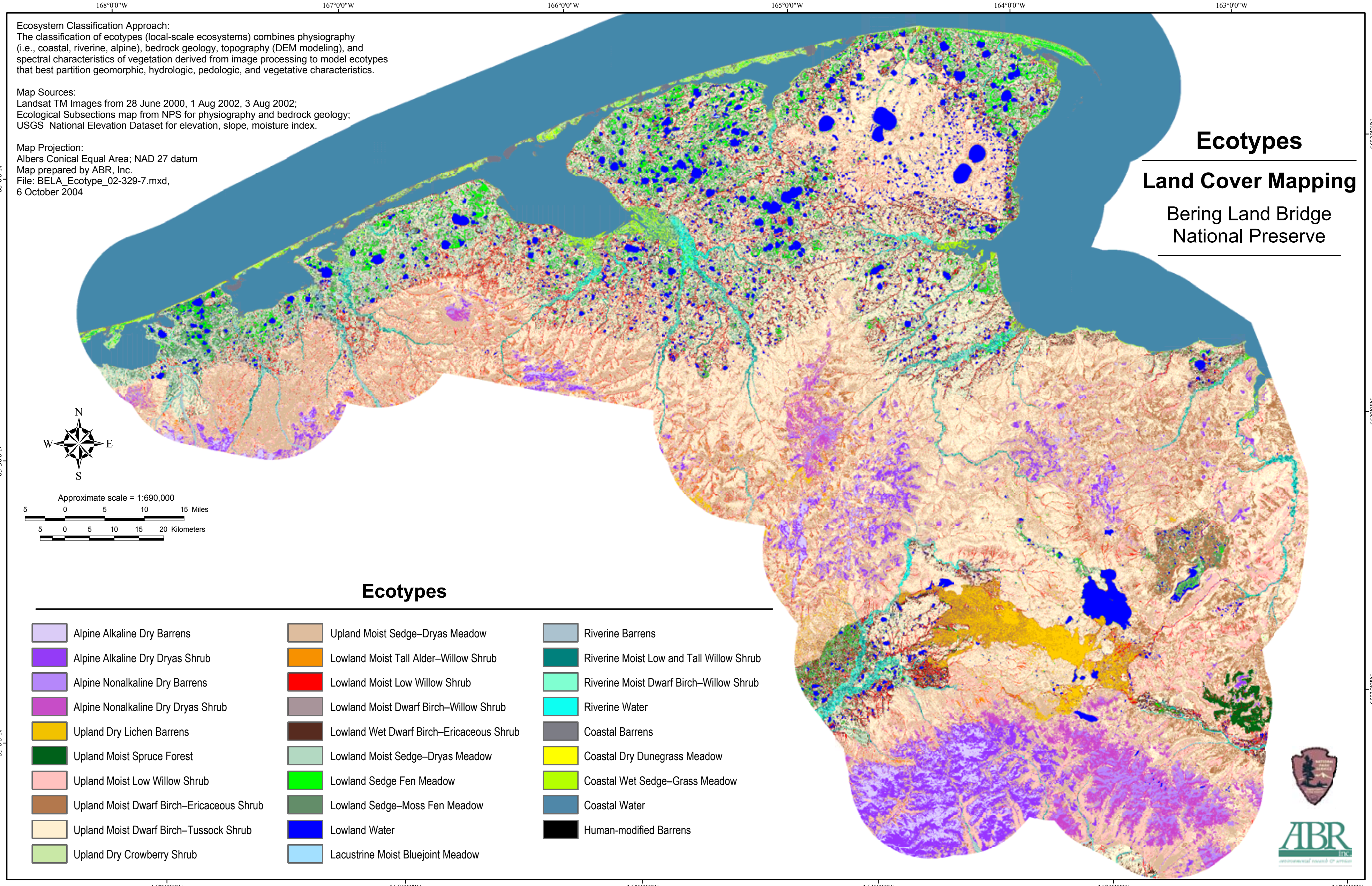
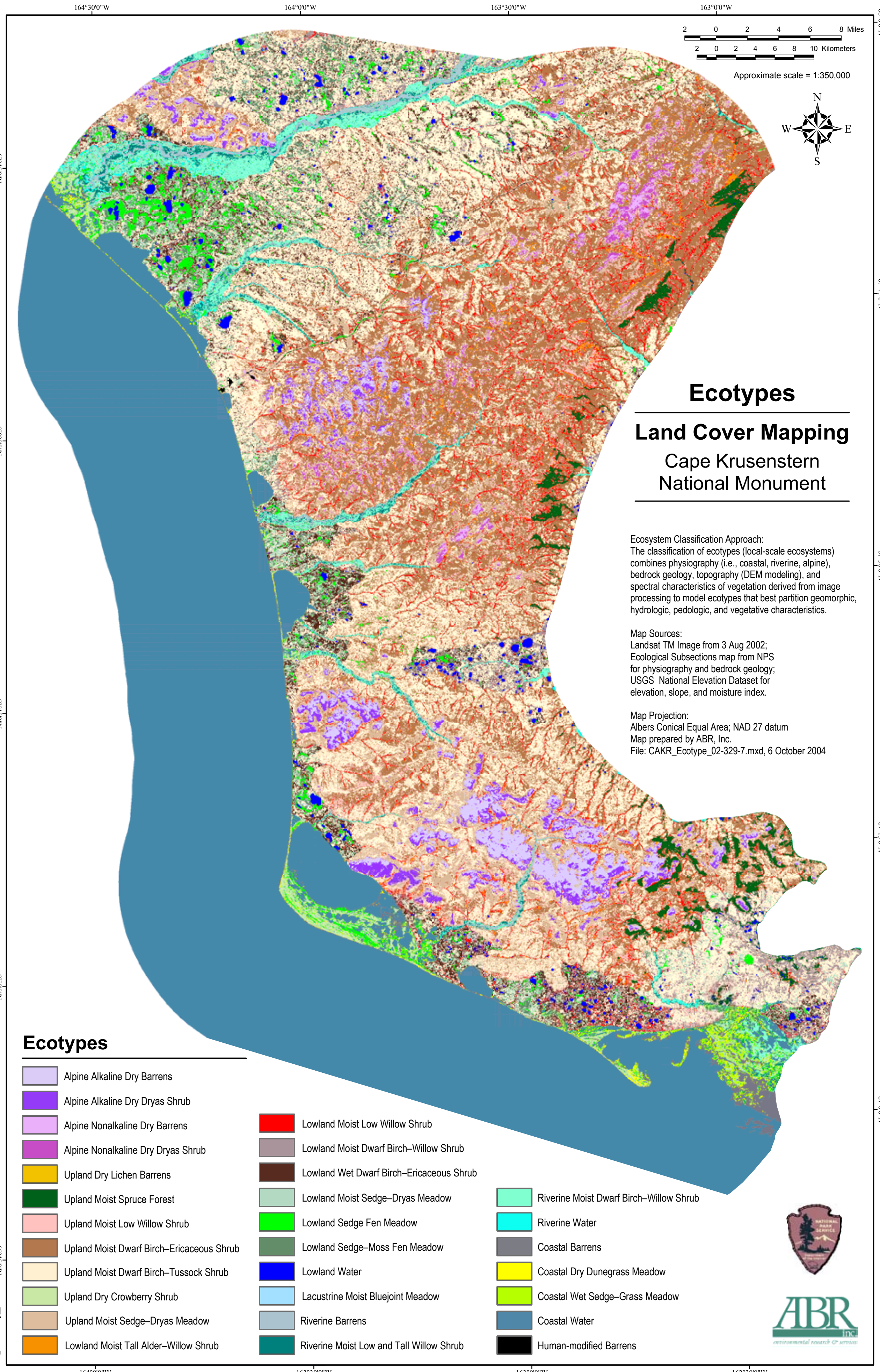

168°0'0"W
167°0'0"W
166°0'0"W
165°0'0"W
164°0'0"W
163°0'0"W
Ecosystem Classification Approach:
The classification of ecotypes (local-scale ecosystems) combines physiography (i.e., coastal, riverine, alpine), bedrock geology, topography (DEM modeling), and spectral characteristics of vegetation derived from image processing to model ecotypes that best partition geomorphic, hydrologic, pedologic, and vegetative characteristics.
Map Sources:
Landsat TM Images from 28 June 2000, 1 Aug 2002, 3 Aug 2002;
Ecological Subsections map from NPS for physiography and bedrock geology;
USGS National Elevation Dataset for elevation, slope, moisture index.
Map Projection:
Albers Conical Equal Area; NAD 27 datum
Map prepared by ABR, Inc.
File: BELA_Ecotype_02-329-7.mxd,
6 October 2004
Ecotypes
Land Cover Mapping
Bering Land Bridge
National Preserve
N
W
E
S
Approximate scale = 1:690,000
5 0 5 10 15 Miles
5 0 5 10 15 20 Kilometers
Ecotypes
Alpine Alkaline Dry Barrens
Alpine Alkaline Dry Dryas Shrub
Alpine Nonalkaline Dry Barrens
Alpine Nonalkaline Dry Dryas Shrub
Upland Dry Lichen Barrens
Upland Moist Spruce Forest
Upland Moist Low Willow Shrub
Upland Moist Dwarf Birch–Ericaceous Shrub
Upland Moist Dwarf Birch–Tussock Shrub
Upland Dry Crowberry Shrub
Upland Moist Sedge–Dryas Meadow
Lowland Moist Tall Alder–Willow Shrub
Lowland Moist Low Willow Shrub
Lowland Moist Dwarf Birch–Willow Shrub
Lowland Wet Dwarf Birch–Ericaceous Shrub
Lowland Moist Sedge–Dryas Meadow
Lowland Sedge Fen Meadow
Lowland Sedge–Moss Fen Meadow
Lowland Water
Lacustrine Moist Bluejoint Meadow
Riverine Barrens
Riverine Moist Low and Tall Willow Shrub
Riverine Moist Dwarf Birch–Willow Shrub
Riverine Water
Coastal Barrens
Coastal Dry Dunegrass Meadow
Coastal Wet Sedge–Grass Meadow
Coastal Water
Human-modified Barrens
ABR Inc.
167°0'0"W
166°0'0"W
165°0'0"W
164°0'0"W
163°0'0"W
162°0'0"W

Figure 4.



Ecotypes
Land Cover Mapping
Cape Krusenstern
National Monument
Ecosystem Classification Approach:
The classification of ecotypes (local-scale ecosystems) combines physiography (i.e., coastal, riverine, alpine), bedrock geology, topography (DEM modeling), and spectral characteristics of vegetation derived from image processing to model ecotypes that best partition geomorphic, hydrologic, pedologic, and vegetative characteristics.
Map Sources:
Landsat TM Image from 3 Aug 2002;
Ecological Subsections map from NPS for physiography and bedrock geology;
USGS National Elevation Dataset for elevation, slope, and moisture index.
Map Projection:
Albers Conical Equal Area; NAD 27 datum
Map prepared by ABR, Inc.
File: CAKR_Ecotype_02-329-7.mxd, 6 October 2004
2 0 2 4 6 8 Miles
2 0 2 4 6 8 10 Kilometers
Approximate scale = 1:350,000
N
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164°30'0"W
164°0'0"W
163°30'0"W
163°0'0"W
162°30'0"W
68°0'0"N
67°45'0"N
67°30'0"N
67°15'0"N
67°0'0"N
66°45'0"N
Ecotypes
Alpine Alkaline Dry Barrens
Alpine Alkaline Dry Dryas Shrub
Alpine Nonalkaline Dry Barrens
Alpine Nonalkaline Dry Dryas Shrub
Upland Dry Lichen Barrens
Upland Moist Spruce Forest
Upland Moist Low Willow Shrub
Upland Moist Dwarf Birch–Ericaceous Shrub
Upland Moist Dwarf Birch–Tussock Shrub
Upland Dry Crowberry Shrub
Upland Moist Sedge–Dryas Meadow
Lowland Moist Tall Alder–Willow Shrub
Lowland Moist Low Willow Shrub
Lowland Moist Dwarf Birch–Willow Shrub
Lowland Wet Dwarf Birch–Ericaceous Shrub
Lowland Moist Sedge–Dryas Meadow
Lowland Sedge Fen Meadow
Lowland Sedge–Moss Fen Meadow
Lowland Water
Lacustrine Moist Bluejoint Meadow
Riverine Barrens
Riverine Moist Low and Tall Willow Shrub
Riverine Moist Dwarf Birch–Willow Shrub
Riverine Water
Coastal Barrens
Coastal Dry Dunegrass Meadow
Coastal Wet Sedge–Grass Meadow
Coastal Water
Human-modified Barrens
ABR inc.
environmental research & services

Figure 5.

Table 32. Areal extent of ecotypes and vegetation types within the Bering Land Bridge National Preserve and Cape Krusenstern National Monument, Alaska.

	Bering Land Bridge		Cape Krusenstern	
	ha	%	ha	%
Map Ecotype				
Alpine Alkaline Dry Barrens	6779	0.6	9038	3.4
Alpine Alkaline Dry Dryas Shrub	18769	1.7	7209	2.7
Alpine Nonalkaline Dry Barrens	6055	0.6	729	0.3
Alpine Nonalkaline Dry Dryas Shrub	15152	1.4	1647	0.6
Upland Dry Lichen Barrens	24275	2.2	1	0.0
Upland Moist Spruce Forest	0	0.0	1018	0.4
Upland Dry Crowberry Shrub	3018	0.3	1502	0.6
Upland Moist Low Willow Shrub	43322	3.9	10900	4.1
Upland Moist Dwarf Birch–Ericaceous Shrub	63932	5.8	56127	21.1
Upland Moist Dwarf Birch–Tussock Shrub	394856	35.9	79007	29.7
Upland Moist Sedge–Dryas Meadow	149507	13.6	28553	10.7
Lowland Moist Tall Alder–Willow Shrub	2263	0.2	2264	0.9
Lowland Moist Low Willow Shrub	39520	3.6	9807	3.7
Lowland Moist Dwarf Birch–Willow Shrub	11355	1.0	4692	1.8
Lowland Wet Dwarf Birch–Ericaceous Shrub	46239	4.2	11699	4.4
Lowland Moist Sedge–Dryas Meadow	83163	7.6	7390	2.8
Lowland Sedge–Moss Fen Meadow	51790	4.7	3712	1.4
Lowland Sedge Fen Meadow	34269	3.1	3741	1.4
Lacustrine Moist Bluejoint Meadow	3104	0.3	233	0.1
Lowland Water	58631	5.3	2127	0.8
Riverine Barrens	5213	0.5	1418	0.5
Riverine Moist Low and Tall Willow Shrub	7464	0.7	2137	0.8
Riverine Moist Dwarf Birch–Willow Shrub	5918	0.5	3284	1.2
Riverine Water	3666	0.3	202	0.1
Coastal Barrens	4949	0.4	918	0.3
Coastal Dry Dunegrass Meadow	713	0.1	507	0.2
Coastal Wet Sedge–Grass Meadow	3664	0.3	768	0.3
Coastal Water	12360	1.1	15064	5.7
Human-modifed Barrens	0	0.0	174	0.1
Map Vegetation Type				
Dryas Dwarf ShrubTundra	33922	3.1	8856	3.3
Lichen	24275	2.2	1	0.0
Partially Vegetated	22996	2.1	12103	4.6
Open White Spruce Forest	0	0.0	1018	0.4
Tall and Low Willow Shrub	92569	8.4	25108	9.4
Crowberry Dwarf Shrub Tundra	3018	0.3	1502	0.6
Low Shrub Birch–Ericaceous Shrub	110171	10.0	67826	25.5
Low Shrub Birch–Willow Shrub	17274	1.6	7976	3.0
Low Mixed Shrub–Tussock Tundra	394856	35.9	79007	29.7
Sedge–Dryas Tundra	232671	21.2	35944	13.5
Bluejoint Meadow	3104	0.3	233	0.1
Lowland Sedge–Moss Bog Meadow	51790	4.7	3712	1.4
Lowland Sedge Bog Meadow	34269	3.1	3741	1.4
Halophytic Sedge–Grass Wet Meadow	3664	0.3	768	0.3
Elymus Meadow	713	0.1	507	0.2
Water	74656	6.8	17394	6.5
Grand Total	1,099,948	100	265869	100

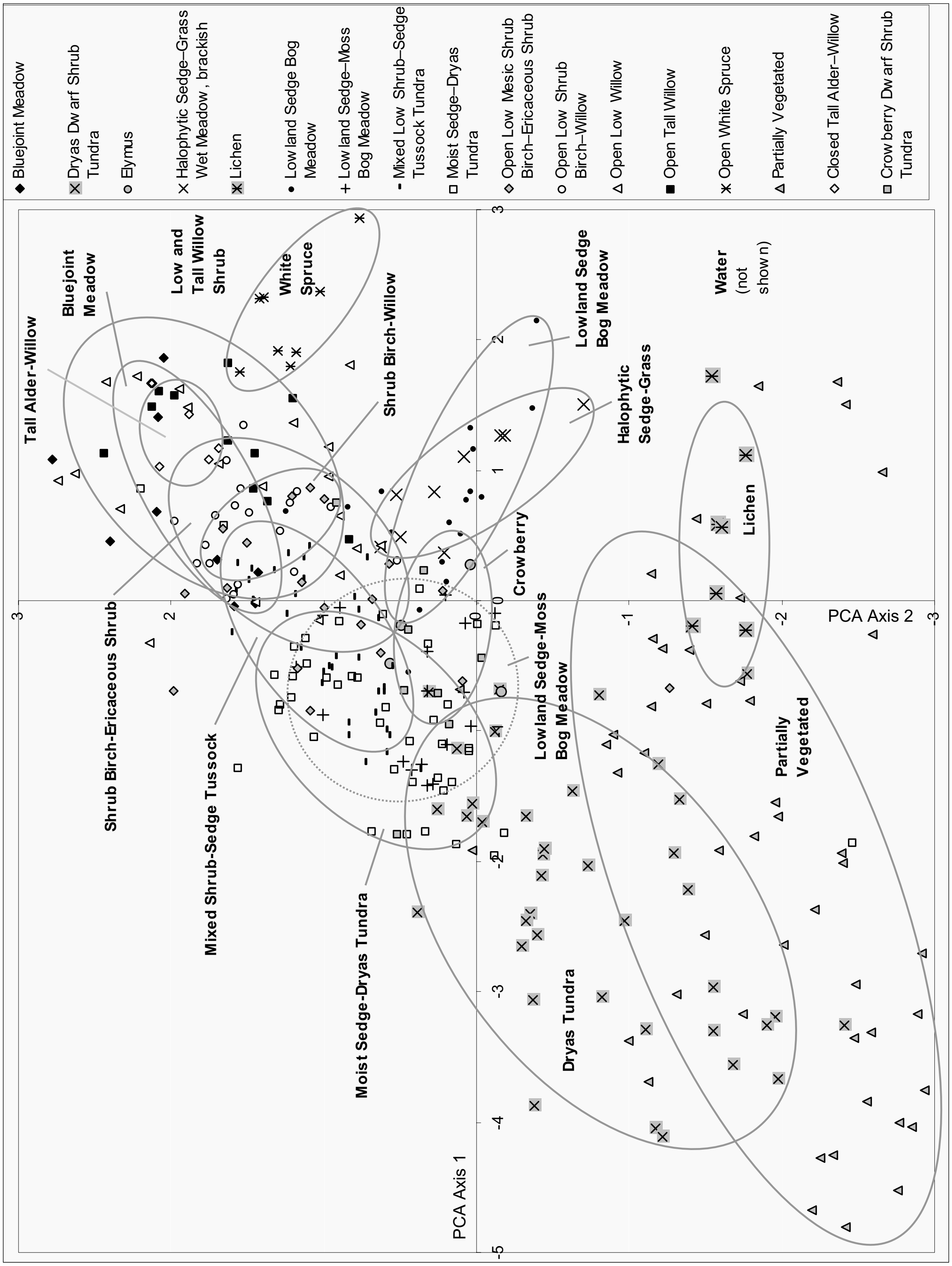


Figure 6. Principal components analysis of the distribution of spectral characteristics of vegetation types. The central tendencies (>90% of points within class) are delineated with hand-fit ellipses.

variation in the 6 spectral bands. When the central tendencies of the signature vegetation types are highlighted with ellipses (>90% of the plots of a vegetation type within an ellipse), the plot reveals substantial overlap in signature characteristics among closely related signature vegetation types. This indicates that after outliers and poor signatures were removed, slightly different vegetation types can still have similar spectral characteristics; thus, spectral characteristics alone limit the extent to which vegetation types can be distinguished. In addition, independent classification of spectral characteristics by cluster analysis cross-tabulated with the ground data revealed that for only 65% of the plots, the signature vegetation was consistently associated with specific spectral nodes (Appendix 10). Together, these analyses demonstrate that even though a specific signature may be unique and classify correctly with its ground data (high signature fidelity), signatures that are highly similar within a cluster can actually be within the range of the spectral variability of several different vegetation types. This indicates that if the map was based solely on spectral characteristics, 35% of the map potentially could be misclassified.

The cross-tabulation of 29 ecotypes after rule-based modeling revealed that 71% of the map pixels were consistent with ground data from 256 plots (Appendix 11). These plots represented the ground points used to create map signatures for which a complete data set was available. The remaining signatures were created from NPS data without specific point locations, were water signatures generated without ground reference data, or were signatures created near ground reference plots. The cross-tabulation of the 17 mapped vegetation types reveals that 85% of the map pixels were consistent with the ground data (Appendix 12). Most of the vegetation errors were associated with confusion between Dryas Tundra and Moist Sedge–Dryas Tundra at high elevations and among the open, low shrub classes at low elevations. Inconsistencies for ecotypes were due to similar errors, plus prevalent problems with differentiating upland and lowland classes based on model rules. 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. When the 29 ecotypes were aggregated into 12 to improve the accuracy of the map, the consistency between ground and map determinations was 88% (Appendix 13).

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 vegetation types provides an approximate lower limit of map accuracy. Thus, the accuracy of the 17 mapped vegetation classes, which were derived from both spectral characteristics and post-classification modeling to reduce error, is probably between 65% and 77%. Given this range, we expect the accuracy to be 70–75%, because substantial effort was made in modeling out many of the errors associated with the signature vegetation (e.g., Lowland Sedge Bog Meadows and Water occurring on north-facing slopes, Halophytic Sedge–Grass Wet Meadows occurring inland). The accuracy of the map of 29 ecotypes, which was derived from the signature vegetation, ecosubsection map, and DEM modeling is probably in the 60 to 70% range. We estimate that aggregation of the ecotypes into 12 classes increased the accuracy to around 80%. Accordingly, the user can select the vegetation, ecotype, or aggregated ecotype fields linked to the landcover map depending on their priorities of partitioning ecological variation (more classes) versus map accuracy (fewer classes).

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 7–11). Vegetation classes follow the AVC. Five ecosubsections within the study area are described below to present some of the main ecological relationships within alkaline alpine-upland, nonalkaline

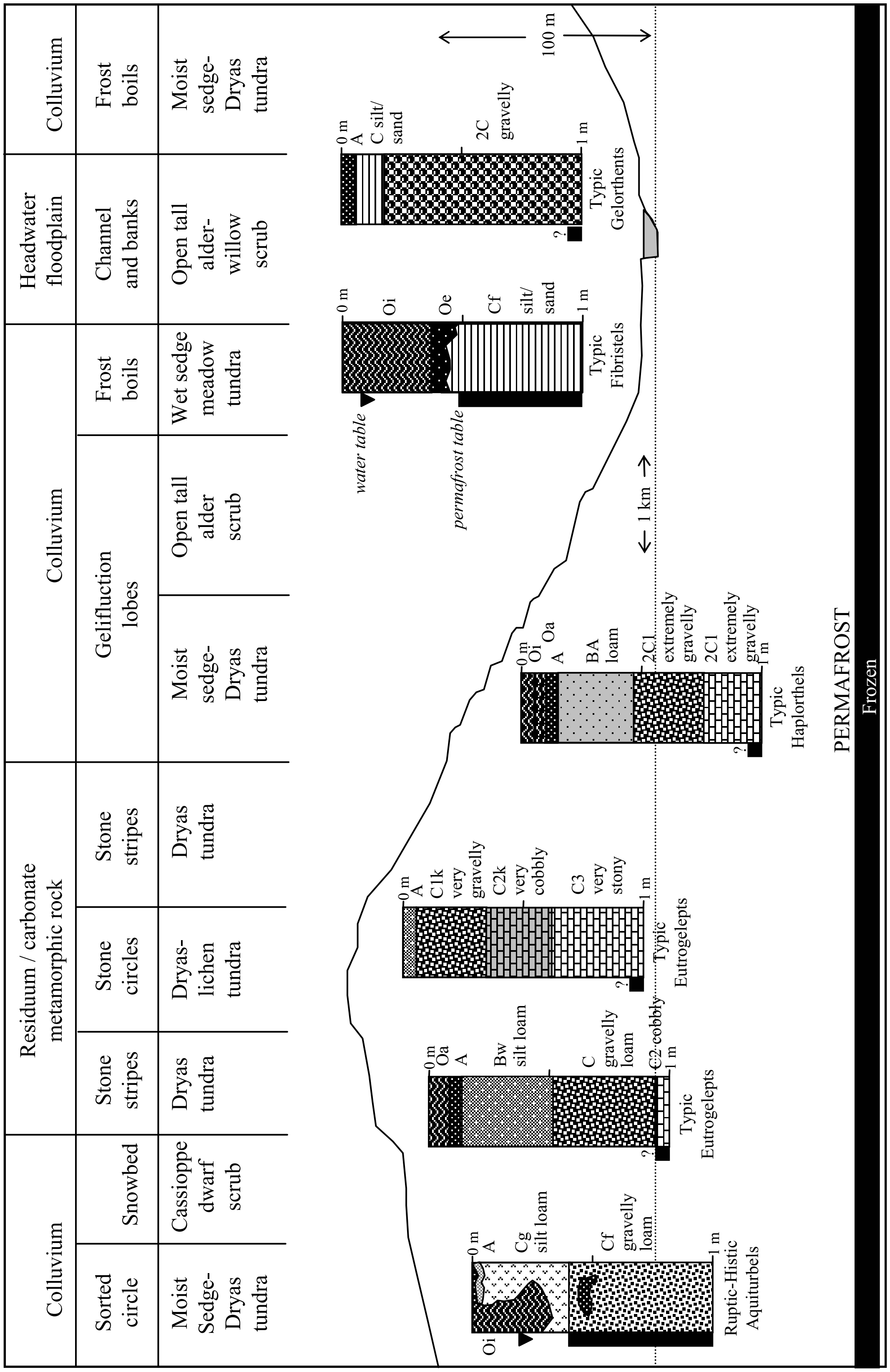


Figure 7. A generalized toposequence for the Goodhope Mountains illustrating geomorphic, topographic, permafrost, soils, and vegetation relationships in alpine and upland alkaline ecotypes.

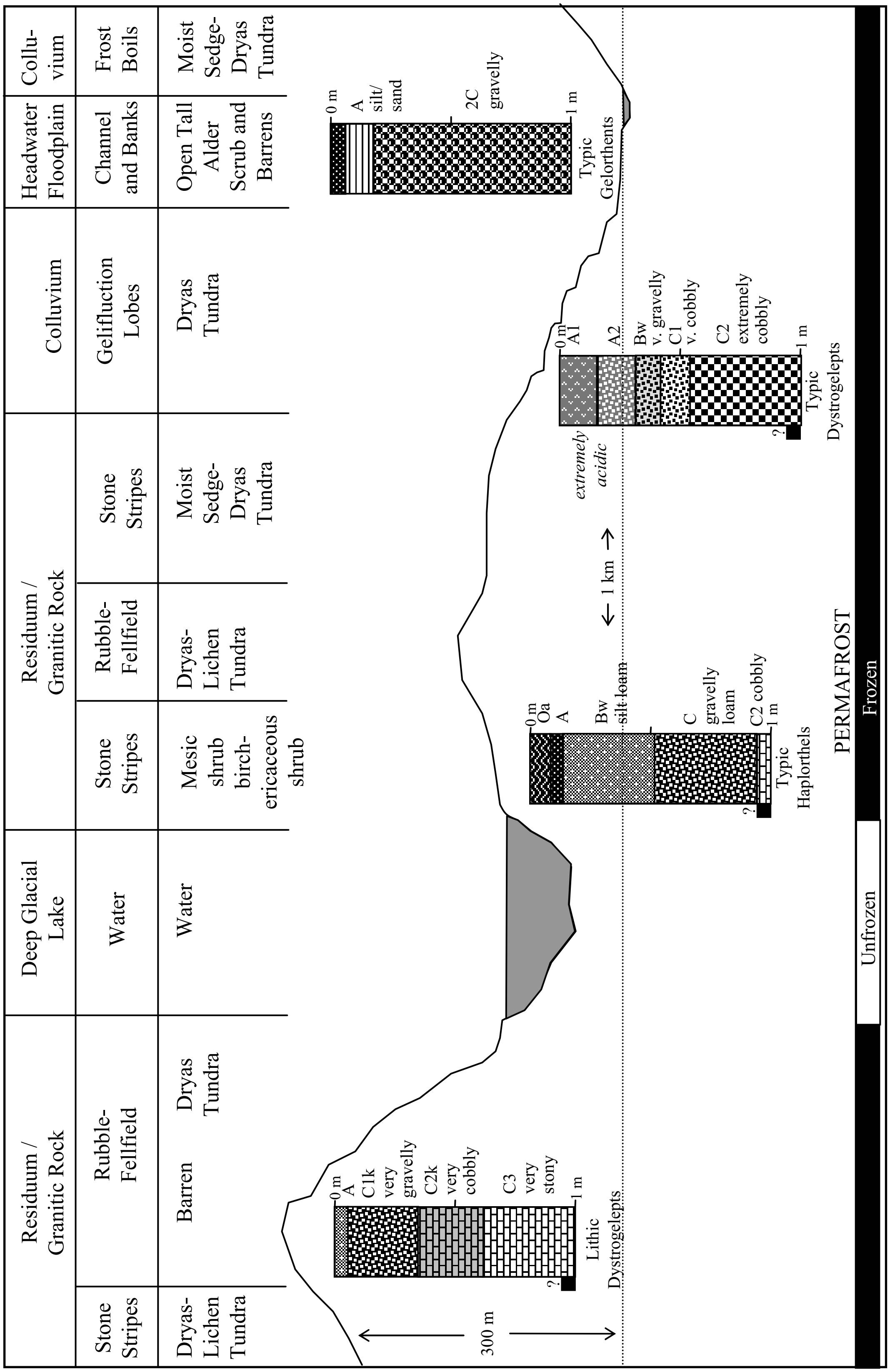


Figure 8. A generalized toposequence for the Bendeleben Eastern Mountains illustrating geomorphic, topographic, permafrost, soils, and vegetation relationships in alpine and upland non alkaline ecotypes.

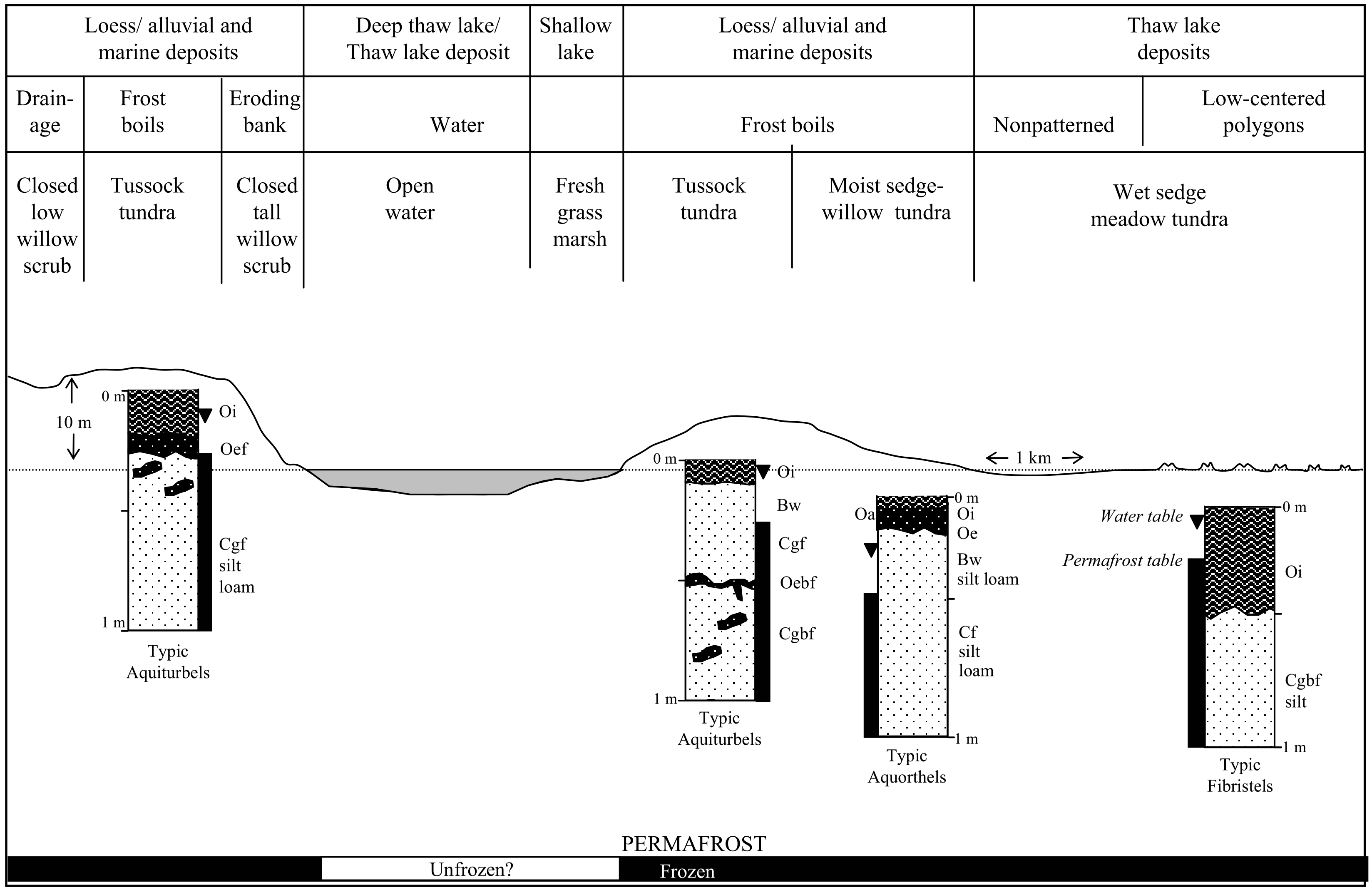


Figure 9. A generalized toposequence for the Bering Strait Upper Coastal Plain illustrating geomorphic, topographic, permafrost, soils, and vegetation relationships in lowland and lacustrine ecotypes.

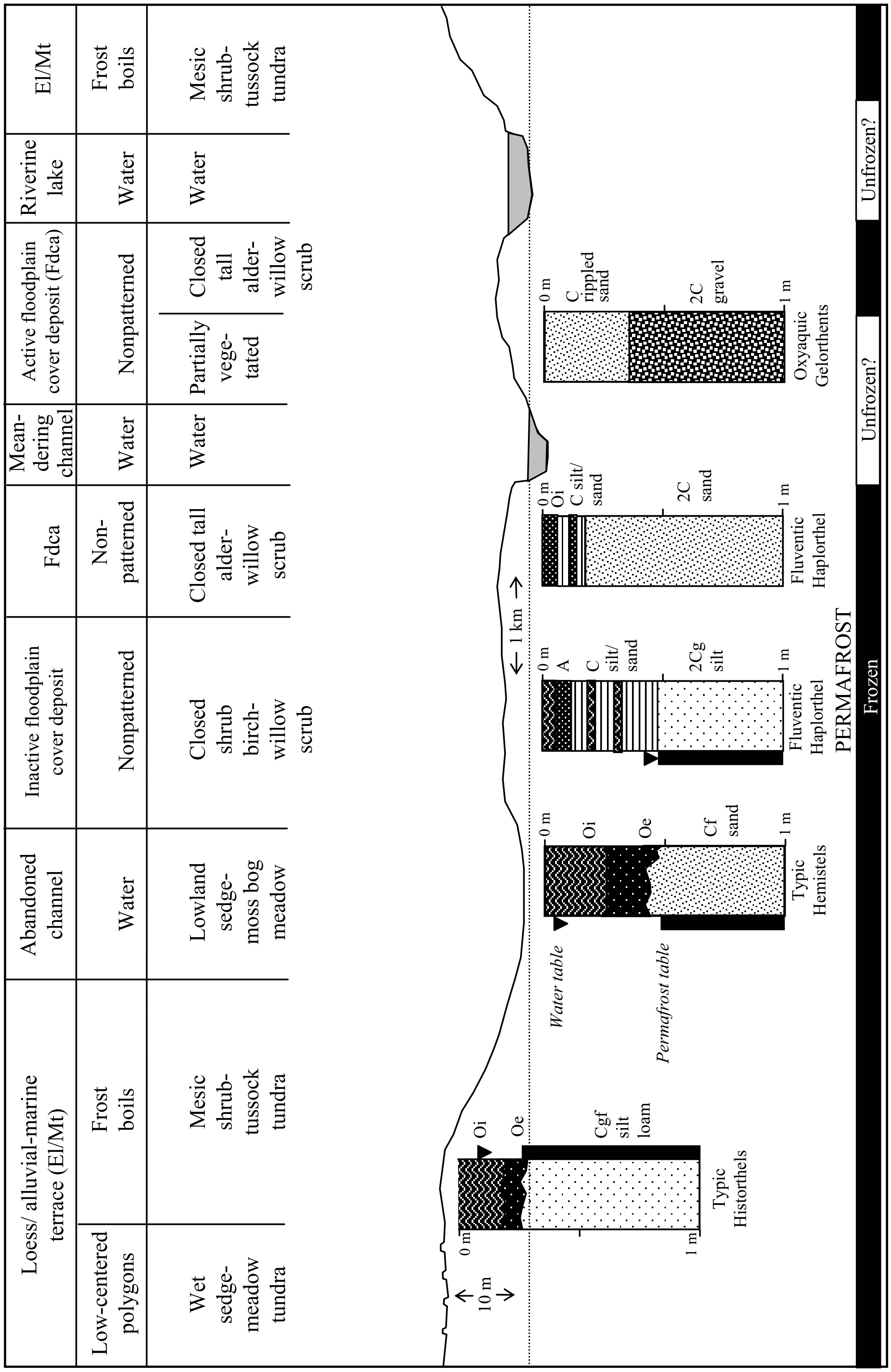


Figure 10. A generalized toposequence for the Bering Strait Lower Floodplains illustrating geomorphic, topographic, permafrost, soils, and vegetation relationships in riverine ecotypes.

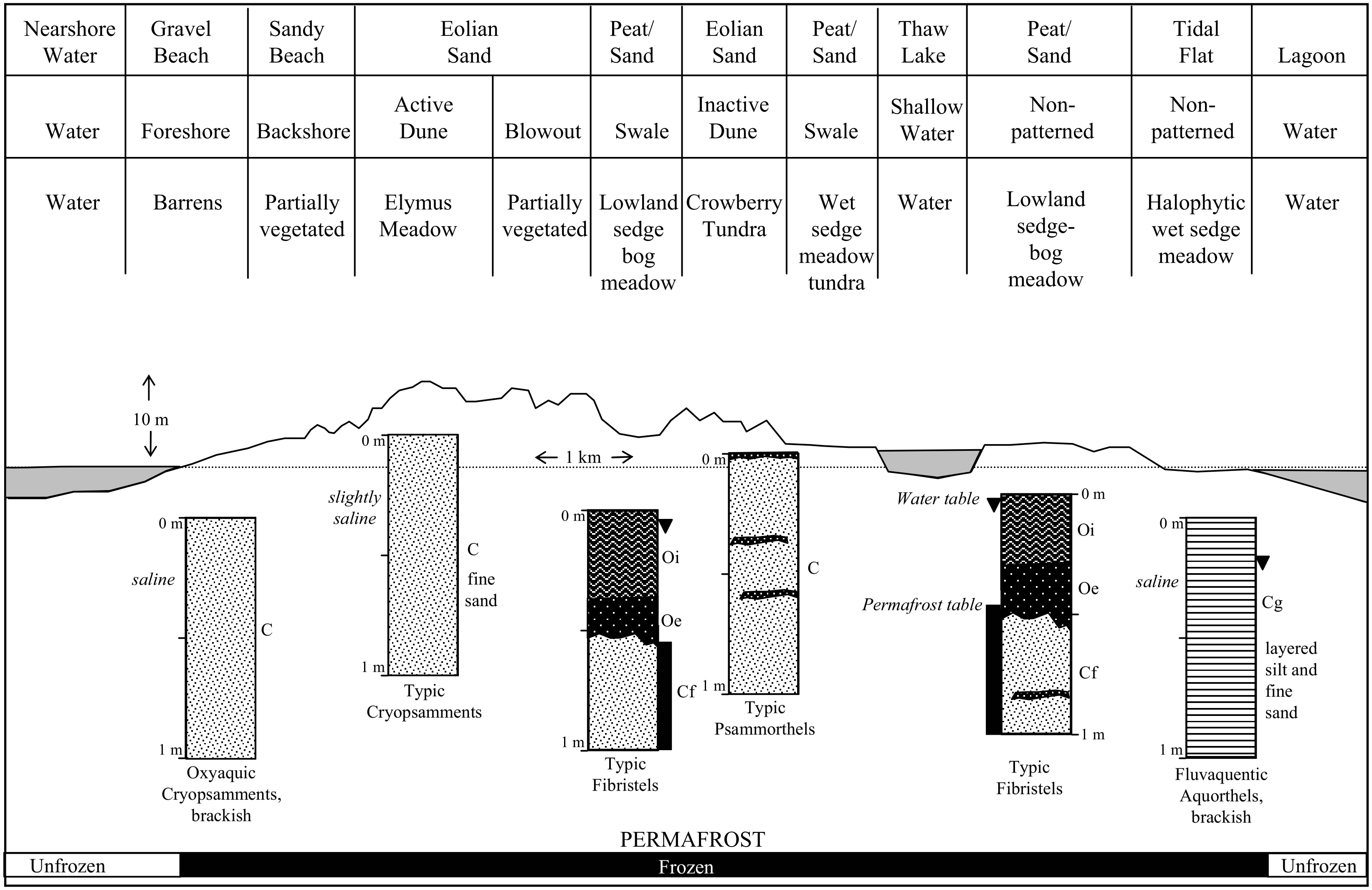


Figure 11. A generalized toposequence for the Espenberg Coast illustrating geomorphic, topographic, permafrost, soils, and vegetation relationships in coastal ecotypes.

alpine-upland, lowland (coastal plain), riverine, and coastal physiographic environments.

On a alkaline alpine and upland toposequence representative of the Goodhope Mountains, which were formed from carbonate sedimentary rock, the geomorphology was dominated by Weathered Bedrock, Hillslope Colluvium, and narrow Headwater Floodplains (Figure 7). Soils on the rounded mountains range from extremely rocky, excessive 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 an alpine and upland toposequence representative of the Bendeleben Eastern Mountains, which were formed from granitic rock, the geomorphology was dominated by Weathered Bedrock, Residual Soils, Hillslope Colluvium, and narrow Headwater Floodplains (Figure 8). Soils on the rounded mountains vary from extremely rocky, excessive drained, strongly acidic 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 trends 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 a lowland and upland toposequence representative of the Bering Strait Upper Coastal Plain, the topography is gently undulating with prominent thermokarst lake basins (Figure 9). Geomorphic units include Loess over Alluvial and Marine Deposits, Ice-poor and Ice-rich Thaw Basins, and Deep and Shallow Lakes. Soils range from poorly drained silt loam soils in drained basins, very poorly drained organic soils in drained basins, to moderately well-drained deposits on gentle upland slopes. In lake basins, vegetation trends from Marestail and Fresh Grass Marshes in shallow water, to Bluejoint Meadows and Open Low Willow Shrub in recently drained basins, to Lowland Sedge Fen Meadows, Lowland 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.

On a riverine toposequence representative of the Bering Strait Lower Floodplains, 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 10). In this transition, 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 nonpatterned 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 richardsonii*, *S. planifolia pulchra*, and *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. planifolia pulchra*, occurs on somewhat poorly drained soils, while Lowland Sedge–Moss Fen Meadows, dominated by *Carex aquatilis* and *Sphagnum*, 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 11). 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 the 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 predominates.

Hierarchical Organization of Ecological Components

We developed hierarchical relationships among ecological components by successively grouping data from the 231 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.

Examination of 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 33). The hierarchical organization of the ecological components reveals how tightly or 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, riverine, and coastal areas (see section on Factors Affecting Landscape Evolution). Identification of 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 for Rule-Based Modeling). Third, knowledge of ecological relationships can be used 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 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, 13% 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 13%) of sites that do not conform to the overall relationships among factors. 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.

ENVIRONMENTAL CHARACTERISTICS

Single-factor Comparisons by Ecotype

Six environmental parameters (surface organic-horizon thickness, cumulative

Table 33. Relationships among landscape components in the Bering Land Bridge National Preserve and Cape Kusenstern National Monument, northwesern Alaska.

Physiography	Soil Texture	Geomorphic Units	Slope Position	Drainage	Soil-water Chemistry	Plant Association	Vegetation Types (Level IV)	Ecotype (aggregated)
Alpine	Rocky	Intrusive Felsic Bedrock, Metamorphic	Crest, Shoulder	Excessive, Well	Acidic (pH ≤ 5.6), Circum-neutral (pH 5.6–7.3)	*Dryas octopetala–Salix phlebophylla–Hierochloe alpina*	Partially Vegetated (5–30% Cover)	Alpine Nonalkaline Dry Barrens
		and Sedimentary Noncarbonate Bedrock, Hillside Colluvium, Talus	Upper Slope (Su)				Dryas–Lichen Tundra, Dryas–Sedge Tundra	Alpine Nonalkaline Dry Dryas Shrub
		Sedimentary and Metamorphic Carbonate Bedrock,	Crest, Shoulder, Su	Excessive Well	Alkaline (pH > 7.3)	*Dryas integrifolia–Rhododendron lapponicum;*	Partially Vegetated (5–30% Cover)	Alpine Alkaline Dry Barrens
		Hillside Colluvium, Talus				*Dryas octopetala–Potentilla uniflora*	Dryas Tundra, Dryas–Lichen Tundra	Alpine Alkaline Dry Dryas Shrub
Upland	Rocky	Hillside Colluvium, Young Mafic Volcanics Old Mafic Volcanics	Crest, Slopes	Excessive, Well	Circum-neutral	*Betula nana–Ledum decumbens–Loiseleuria procumbens*	Partially Vegetated, Crustose and Fruticose Lichen	Upland Dry Lichen Barrens
	Sandy	Coastal Inactive Sand Dunes	Crest, Su	Excessive, Well	Circum-neutral	*Empetrum nigrum–Elymus arenarius mollis*	Crowberry Tundra	Upland Dry Crowberry Shrub
	Rocky, Loamy	Hillside Colluvium, Solifluction Deposits, Loess	Upper Slope,	Moder-ately	Alkaline, CN	*Picea glauca–Salix planifolia pulchra*	Open White Spruce Forest	Upland Moist Spruce Forest
			Lower Slope (Sl)	Well (Wm), Poor		*Salix glauca–Dryas integrifolia*	Open Low Willow, Shrub Birch–Willow	Upland Moist Low Willow Shrub
						Dryas integrifolia–Carex bigelowii–Senecio atropurpureus	Sedge–Dryas Tundra, Dryas–Forb Tundra	Upland Moist Sedge–Dryas Meadow
					Acidic, Circum-neutral	*Betula nana–Ledum decumbens–Loiseleuria procumbens*	Open Mesic Shrub Birch–Ericaceous Shrub	Upland Moist Dwarf Birch–Ericaceous Shrub
	Loamy, Organic	Hillside Colluvium, Loess, Ice-Rich Thaw Basin, Bog	Crest, Slopes	Wm, Poor	Acidic	*Betula nana–Eriophorum vaginatum*	Mixed Shrub Sedge–Tussock Tundra	Upland Moist Dwarf Birch–Tussock Shrub

Table 33. Continued.

Physiography	Soil Texture	Geomorphic Units	Slope Position	Drainage	Soil-water Chemistry	Plant Association	Vegetation Types (Level IV)	Ecotype (aggregated)
Lowland	Rocky, Loamy	Hillside Colluvium	Drainage (Dr)	Well To Poor	Circum-neutral	*Alnus crispa–Salix planifolia pulchra–Rubus arcticus*	Closed and Open Tall Alder–Willow	Lowland Moist Tall Alder–Willow Shrub
	Loamy	Hillside Colluvium, Solifluction Deposit	Drainage. Sl	Wm, Poor	Acidic, CN	*Salix planifolia pulchra–Calamagrostis canadensis*	Closed and Open Low Willow	Lowland Moist Low Willow Shrub
			Lower Slopes	Wm, Poor	CN	*Dryas integrifolia–Equisetum arvense*	Sedge–Dryas Tundra, Dryas–Forb Tundra	Lowland Moist Sedge–Dryas Meadow
	Loamy, Organic	Drained Lake Basins, Lowland Loess,	Basins, Flats,	Poor	Acidic, CN	*Betula nana–Salix planifolia pulchra–Pyrola grandiflora*	Closed and Open Shrub Birch–Willow	Lowland Moist Dwarf Birch-Willow Shrub
		Abandoned Floodplain, Coastal Inactive Dunes	Drainage		Acidic	*Betula nana–Vaccinium vitis-idaea–Carex aquatilis*	Shrub Birch–Ericaceous Shrub Bog	Lowland Wet Dwarf Birch–Ericaceous Shrub
	Organic	Fens, Drained Lake Basins	Basins, Flats	Poor	Acidic	*Carex aquatilis–Salix fuscescens–Sphagnum*	Subartic Lowland edge–Moss Bog Meadow	Lowland Sedge–Moss Fen Meadow
						Carex aquatilis–Carex chorddorhiza	Wet Sedge Meadow Tundra	Lowland Sedge Fen Meadow
Lacustrine	Loamy	Ice-Poor Drained Lake Basin	Basins	Wm, Poor	Circum-neutral	*Calamagrostis canadensis–Rumex arcticus*	Bluejoint Meadow	Lacustrine Moist Bluejoint Tundra
	Water	Shallow water, Ice-Poor Thaw Basins	Basins	Flooded		*Carex aquatilis–Caltha palustris*	Fresh Sedge Marsh	Lacustrine Forb Marsh (merged with Lowland Lake for mapping)
						Arctophila fulva	Fresh Grass Marsh	
						Hippuris vulgaris–Potamogeton spp.	Common Marestail	
		Deep Isolated Lake	Basins	Flooded		Water	Water	Lowland Water
Human-Modified	Rocky	Gravel Fill	Flat	Excessive	Circum-neutral	None	Barren	Human Modified Barrens

Table 33. Continued.

Physio-Graphy	Texture	Geomorphic Units	Slope Position	Drainage	Soil-water Chemistry	Floristic Class	Vegetation Types (Level IV)	Ecotype
Riverine	Rocky, Sandy	Meander Active Channel Deposit	Riverbar	Excessive, Well	Alkaline	*Epilobium latifolium–Agropyron macrourum*	Barren (<5% cover), Partially Vegetated	Riverine Barrens
		Meander Active Overbank, Meander Inactive Channel	Flat, Interfluv	Well	Circum-neutral	*Alnus crispa–Salix barclayi*	Closed and Open, Tall Alder–Willow	Riverine Moist Tall Alder–Willow Shrub[1]
	Sandy, Loamy	Meander Active Overbank Deposit	Interfluv, Flat Bank	Well, Poor	Circum-neutral	*Salix alaxensis–Aster sibiricus*	Closed and Open Tall Willow	Riverine Moist Tall Willow Shrub[1]
		Meander Inactive Overbank Deposit	Interfluv, Flat Bank	Well, Poor	Circum-neutral	*Salix lanata richardsonii–Festuca altaica*	Closed and Open Low Willow	Riverine Moist Low Willow Shrub[1]
						Betula nana–Salix planifolia pulchra–Pyrola grandiflora	Closed and Open Shrub Birch–Willow	Riverine Moist Dwarf Birch–Willow Shrub
	Water	Nonglacial Lower and Upper Perennial Rivers, Lake	Channel	Flooded	Alkaline	Water	Water	Riverine Water
Coastal	Rocky, Sandy	Marine Active Beach,	Beach,	Poor to Well	Brackish,	NA	Barren,	Coastal Barrens
	Sandy	Coastal Active Sand Dunes, Marine Inactive Beach	All Slopes	Excessive To	Slightly Brackish	*Elymus arenarius mollis–Lathyrus maritimus*	Partially Vegetated	
							Elymus	Coastal Dry Dunegrass Meadow
	Sandy, Organic	Active And Inactive Tidal Flats	Levee	Moder-ately Well	Slightly Brackish	*Salix ovalifolia–Deschampsia caespitosa*	Halophytic Dwarf Willow	Coastal Brackish Wet Sedge–Grass Meadow[2]
			Flats,	Poor	Brackish,	*Carex ramenskii–Dupontia fischeri*	Halophytic Sedge Wet Meadow	
					Saline	*Carex ramenskii–Puccinellia phryganodes*	Halophytic Grass Wet Meadow	Coastal Saline Wet Sedge–Grass Mead.[2]
							Barren	Coastal Barrens
	Water	Nearshore Water, Tidal River	Water	Flooded	Saline, Brackish	Water	Water	Coastal Water

Unusual ecotypes that were not adequately sampled to quantify include: Alpine Lake (mapped with Lowland Lake), Riverine Dry Grass Meadow (*Elymus arenarius mollis*), Riverine Moist Broadleaf Forest (*Populus tremuloides*), and Coastal Forb Marsh (*Hippuris tetraphylla*).

[1,2] Classes merged for mapping.

organic-horizon thickness, thaw depth, depth to groundwater, pH, and electrical conductivity) were charted for comparison among ecotypes. Not all ecotypes, however, were included in the charts because data were insufficient in some cases.

The thickness of the surface organic-horizon (an indicator of frequency of sedimentation) showed large differences among sites (Figure 12). Ecotypes where surface organic accumulations were absent ranged from areas with severe climate and soil conditions, such as Alpine Alkaline Dry Barrens, to areas with frequent sediment deposition, such as Riverine Moist Barrens and Riverine Moist Tall Willow Shrub. The thickest surface organic accumulations were found in Lowland Sedge Fen Meadow, indicating that sedimentation events were rare or absent in these ecotypes.

Depth to rocks (soils with >15% rocks) was shallowest on alpine ridges and crests (e.g., Alpine Nonalkaline Dry Dryas Shrub) and in rocky drainages (Lowland Moist Tall Alder–Willow Shrub) and deepest in lowland and coastal areas with fine-grained deposits (e.g. Coastal Barrens, Lowland Sedge–Moss Fen Meadow) (Figure 12). Ecotypes with rock depths ≥ 200 cm represent an estimated minimum depth.

Thaw depths varied four-fold among ecotypes (Figure 12). While permafrost 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 Moist 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 Dry 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 13). Mean water depths were above the soil surface for four ecotypes, and were greatest for Coastal Water and Lowland Water. Ecotypes with the deepest water tables were found in alpine areas with rocky soils (e.g., Alpine Alkaline Dry Dryas Shrub) and riverine areas with sandy soils (e.g., Riverine Moist Tall Alder–Willow Shrub). Values ≥100 cm represent minimum, estimated depths.

Site pH values varied from 5.0 to 8.3 among ecotypes (Figure 13). Ecotypes with the lowest (most acidic) pH values occurred in nonalkaline alpine and upland areas (e.g., Alpine Nonalkaline Dry Dryas Shrub, Upland Moist Dwarf Birch–Tussock Meadow) and in lowland areas (e.g., Lowland Sedge–Moss Fen Meadow, Lowland Wet Dwarf Birch–Ericaceous Shrub) 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 Dry Dryas 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).

Electrical conductivity (EC) measurements indicated that most ecotypes were nonsaline (Figure 13). High mean EC values (>800 µS/cm), indicating brackish or slightly brackish to saline conditions, were limited to coastal areas (e.g., Coastal Saline Wet SedgeGrass Meadow, Coastal Barrens). EC values were low (<300 µS/cm) in all other ecotypes. Variability was low within nonsaline ecotypes and high within saline ecotypes.

Single-factor Comparisons by Plant Species

To determine how the environmental parameters measured influenced the distribution of individual plant and cryptogam species, we calculated the mean value of each parameter for locations where 66 common species occurred. 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 at ground sites (Figure 14). 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*

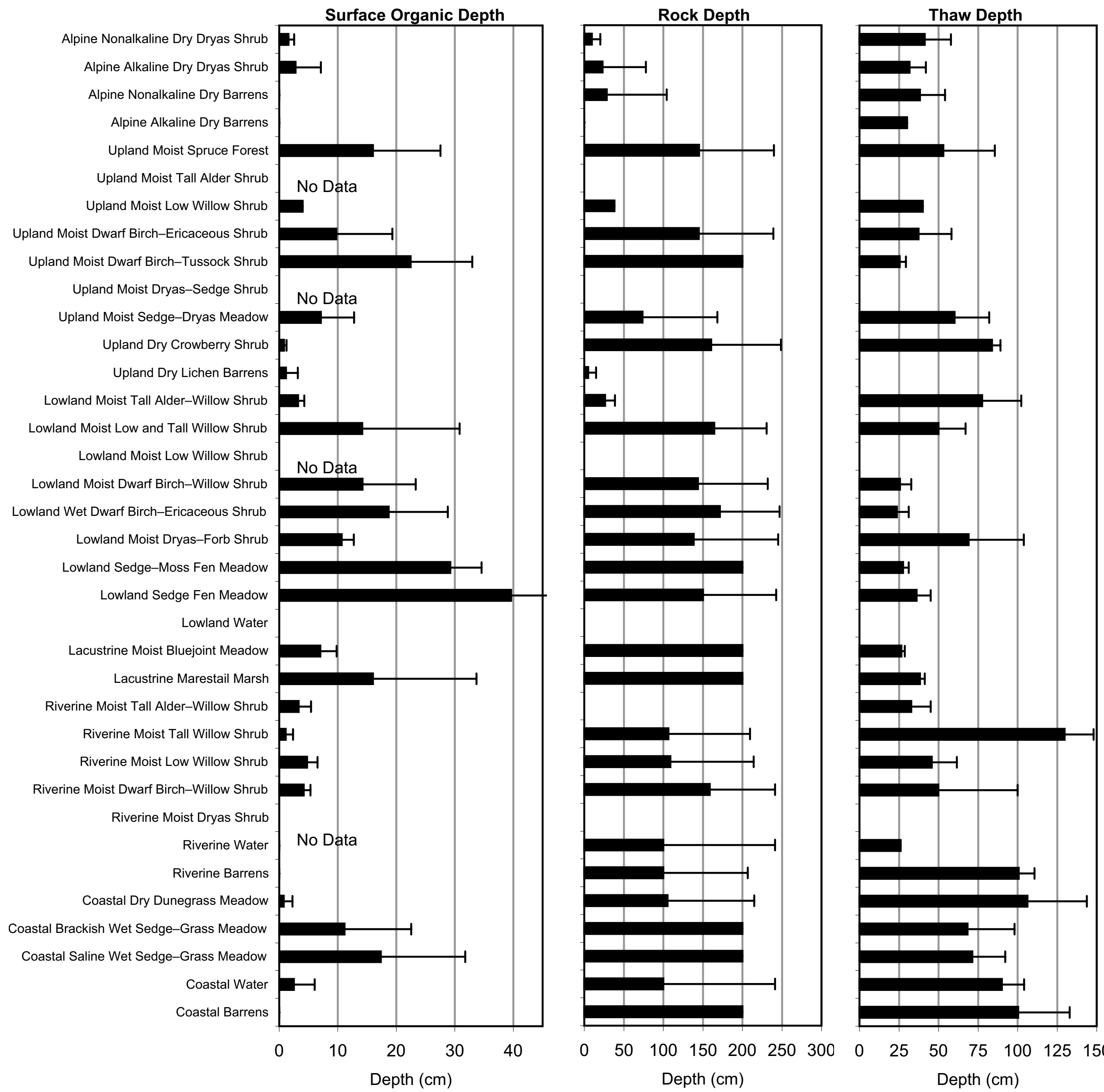


Figure 12. Mean (± SD) surface organic layer thickness, depth to rock (>15 % coarse fragments), and thaw depths of ecotypes in Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

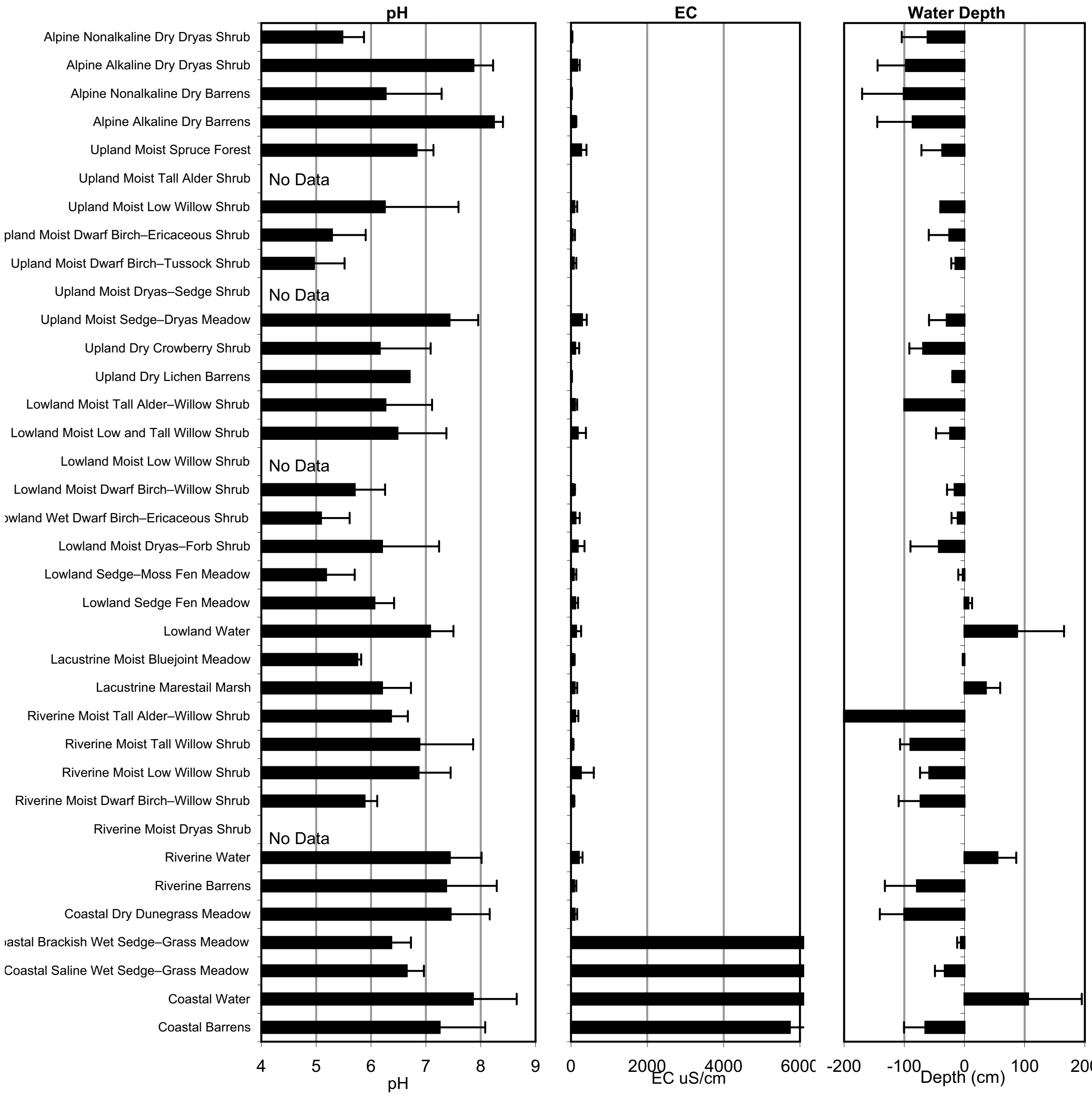


Figure 13. Mean (± SD) pH, electrical conductivity (EC), and water depth (positive when above ground) of ecotypes in Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

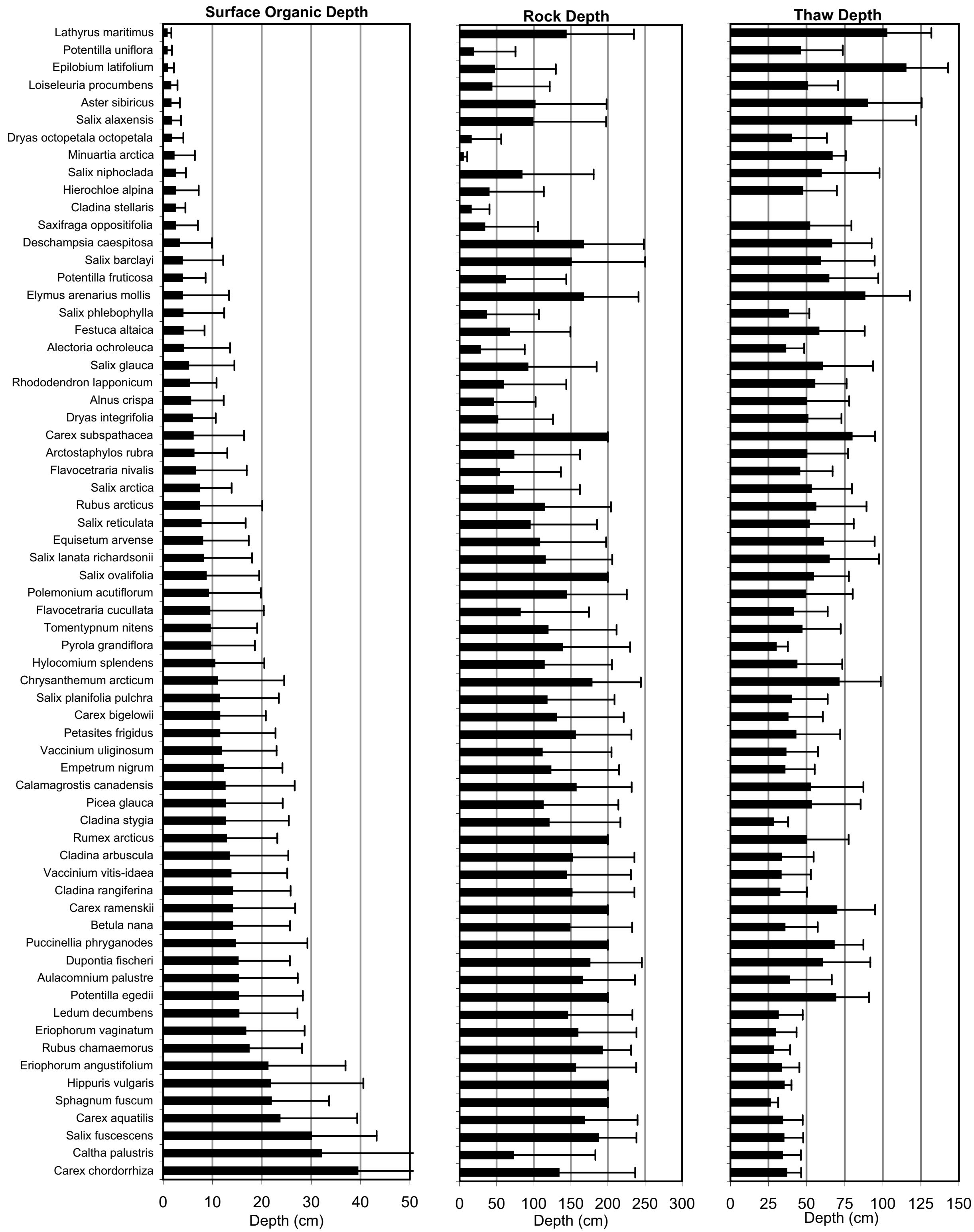


Figure 14. Mean (± SD) surface organic layer thickness, depth to rock (>15 % coarse fragments), and thaw depths for plant and cryptogam species in Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

fuscescens, Carex aquatilis, and *Sphagnum fuscum*. These species typically occurred on wet soils subjected to little or no disturbance.

Depth to rocks also was highly variable among species and within many species (Figure 14). Species commonly associated with rocks near the surface include *Minuartia arctica, Potentilla uniflora, 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 (Figure 14). Species associated with the greatest thaw depths included *Lathyrus maritimus, Epilobium latifolium, Aster sibiricus, Elymus arenarius 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 (Figure 15). Species associated with the greatest water depths above the surface 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 (Figure 15). 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 nonsaline conditions (Figure 15). 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 800–16000 µS/cm) included *Carex ramenskii*, *Deschampsia caespitosa, Salix ovalifolia, Dupontia fischeri, Elymus arenarius mollis, Rumex arcticus,* and *Hippuris tetraphylla.* Their high standard deviations indicate they tolerated a broad range of salinity conditions.

VEGETATION COMPOSITION

Ordination of Vegetation

In addition to the single-factor comparisons, detrended correspondence analysis (DCA) was used to demonstrate the separation of plots by species composition. The combined effects of physiography and various environmental variables were assessed by superimposing the ecotype class for each plot on the ordination (Figure 16).

The DCA robustly separated the ecotypes associated with the various physiographic settings. Coastal ecosystems showed no similarity (overlap) with other ecotypes because of the effects of salinity. Riverine ecotypes are some of the youngest and most frequently disturbed classes, and most are early or mid-successional. The wet lowland ecotypes that are dominated by sedges are distinctly separate from the ecotypes associated with the other physiographic settings. Alpine ecotypes show a transition to upland ecotypes, but also reveal large differences between alkaline and nonalkaline substrata.

In contrast to these distinct ecotypes located around the margins of the DCA plot, there are

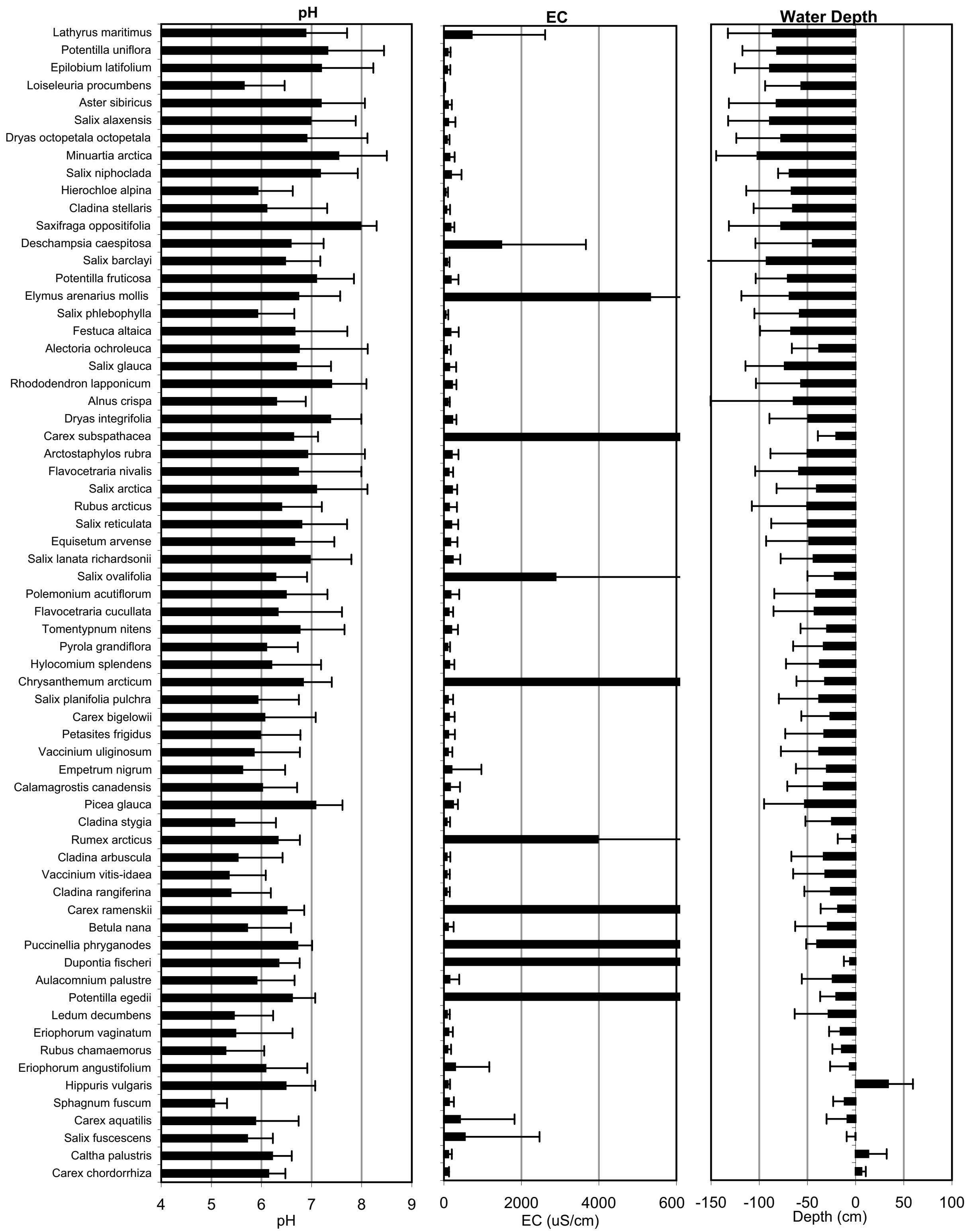


Figure 15. Mean (± SD) pH, electrical conductivity (EC), and water depth (positive when above ground) for abundant species in Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

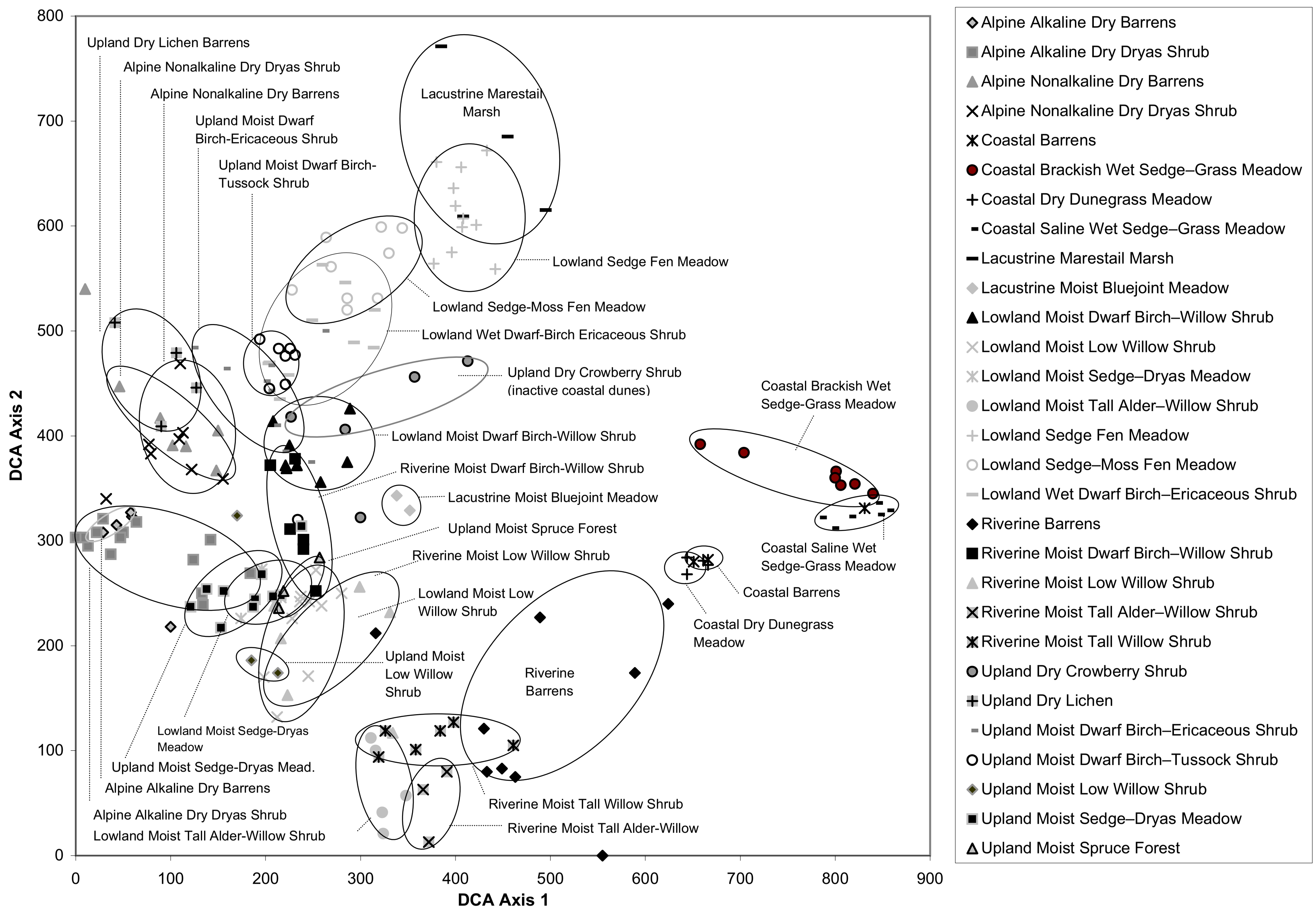


Figure 16. Detrended correspondence analysis of species composition of plots sampled in Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003. Ellipses depict central groupings of ecotypes.

groups of ecotypes in the center that show substantial overlap. The barrens and dryas shrub ecotypes in the alpine are highly similar in composition, when separated for alkaline and nonalkaline soil chemistry, and vary principally in the amount vegetation present. Upland Moist Sedge–Dryas Meadow, Lowland Moist Low Willow Shrub, and Riverine Moist Low Willow Shrub are similar due to the prevalence of calciphilic species. Upland Moist Dwarf Birch–Ericaceous Shrub, Upland Moist Dwarf Birch–Tussock Shrub, Lowland Wet Dwarf Birch–Ericaceous Shrub, Lowland Moist Dwarf Birch–Willow Shrub, and Riverine Moist Dwarf Birch–Willow Shrub (late successional) are similar because they are dominated by *Betula nana* and acidophilic species.

The axes of the DCA as a whole are inconsistently related to specific environmental variables, indicating that non-linear relationships are affecting species distribution. For example, Axis 1 suggests a salinity gradient, though ecotypes in the center have very low EC values, and Axis 2 suggests a pH gradient though the nonalkaline and alkaline alpine classes are not far apart. When considered within physiographic conditions, gradients among physiographically related ecotypes are much more distinct. Coastal ecotypes show a gradient from wet to dry ecotypes along Axis 1. For alpine and upland ecotypes there is a strong moisture and pH gradient along Axis 1 and Axis 2, respectively. For riverine ecotypes, there are similar trends revealing later successional ecotypes getting wetter, more organic, and more acidic. While the moisture gradient along Axis 1 is similar for lowland ecotypes, later successional stages become less wet due to accumulation of organics and ground ice which increases the surface relief.

Sorted Tables

Sorted vegetation tables (Tables 34–36) 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.

SOIL CHARACTERISTICS

Twenty-eight soil types were identified during field sampling, although four soil types had only single observations and were therefore excluded from the analysis and mapping (Table 37). The most common types observed were Typic Fibristels (10% of 198 observations), Typic Aquorthel (9%), Typic Historthel (8%), Typic Hemistel (7%), and Typic Eutrogelepts (7%). Four of the soils were Entisols, which includes poorly developed soils with deep thaw depths. These were associated with active geomorphic environments. Three soils were Incepticols, which includes weakly developed soils with deep thaw depths. These were associated with rocky alpine and upland environments. The remaining 17 soils were Gelisols, which had permafrost near the surface (<1 m). These covered a broad range of environments.

The soil classification was fairly 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 (Table 38). In a few instances, the use of the newly revised Gelisol order did not differentiate some important characteristics, however. For example, Typic Haploturbels did not differentiate between alkaline (euic) and acidic (dysic) soils even though A-horizon development and species composition on the soils were very different. In contrast, there was very little difference in soil properties and vegetation relationships between Typic Haplorthels and Typic Haploturbels. There also was little difference in the properties among Typic Historthels, Typic Aquiturbels, and Typic Aquorthels.

The cross-tabulation of soils with ecotypes indicates that most soil types were associated with 2–3 ecotypes (Table 39). Seven soil types were predominantly restricted to only one ecotype that was associated with a distinctive geomorphic environment. In contrast, six soil types were broadly distributed across five or more ecotypes. The primary and secondary soil types associated with each ecotype are highlighted by dark and light gray boxes, respectively, on Table 38.

These relationships allowed the development of 15 soil associations and two waterbody types by combining the soil types that occured in closely related ecotypes (Table 40). Most soil associations

Table 34. Mean cover (%) of the most abundant species in alpine and upland ecotypes. Bolded numbers represent frequencies >60% within ecotype; blanks indicate species is absent; and 0 indicates cover <0.5%. Italicized fonts denote dominant and differential species used to name plant association.

Taxon	Alpine Alkaline Dry Barrens	Alpine Alkaline Dry Dryas Shrub	Upland Moist Sedge–Dryas Meadow	Upland Moist Low Willow Shrub	Upland Moist Spruce Forest	Upland Moist Dwarf Birch–Tussock Shrub	Upland Moist Dwarf Birch–Ericaceous Shrub	Upland Dry Lichen Barrens	Alpine Nonalkaline Dry Barrens	Alpine Nonalkaline Dry Dryas Shrub
Saxifraga oppositifolia	**1**	**1**	1							
Dryas octopetala	***8***	*21*		8					*1*	***14***
Potentilla uniflora	***1***	*0*								0
Silene acaulis	0	**0**	0						0	0
Carex scirpoidea	0	1	***2***							
Rhododendron lapponicum		*1*	2	1						0
Polygonum viviparum	0	**0**	**0**	0	**0**				0	0
Cassiope tetragona		3	1	**2**				0	0	2
Senecio atropurpureus	0	0	***0***		0					
Anemone richardsonii		0		1	**1**					
Rhytidium rugosum	0	2	**4**			0	1			0
Dryas integrifolia	*1*	*15*	***27***	*8*	2					
Arctostaphylos rubra	0	2	**4**	1		1	0			1
Salix arctica	0	2	**5**	3			2			
Salix reticulata		1	**6**	15	**1**	0	0			0
Tomentypnum nitens	0	3	**17**	3	**15**	1				
Salix lanata richardsonii			**3**	10	**10**	1				
Salix glauca		0	1	*13*	5	0	0	0		0
Saussurea angustifolia	0	0	**0**		1		0			0
Polygonum bistorta		0	0	1		0	0			0
Pedicularis capitata	0	0	0	**1**			0			0
Equisetum arvense		0	***4***	10	10					0
Potentilla fruticosa		0	0	2	3	0		0		
Festuca altaica		0	1	**1**	0					0
Picea glauca		0			***18***					
Aconitum delphinifolium			0	**1**	0					
Calamagrostis canadensis					**0**					
Epilobium angustifolium				2	**1**					
Artemisia arctica arctica		0		**1**					0	1
Valeriana capitata			0	**1**	**0**	0				0
Petasites frigidus			1	0	**8**	2	3			
Poa arctica SL		0	0		**0**	0	0	0	0	0
Flavocetraria nivalis	**1**	**2**	**1**			0	1	2	0	**1**
Thamnolia vermicularis	**1**	**4**	**2**	1		**1**	**1**	**1**	**0**	**1**
Flavocetraria cucullata	**0**	**6**	**4**			**3**	**5**	**1**	1	**2**
Salix planifolia pulchra			*0*	**18**	***20***	***3***	***4***	0	0	**1**
Hylocomium splendens		1	**16**	**5**	**18**	9	7		0	0
Carex bigelowii		0	***5***	2	**6**	**5**	**3**		0	1
Vaccinium uliginosum		0	**2**	2	**3**	**5**	**8**	**1**	0	**2**
Betula nana			*0*	3	3	***9***	***16***	*3*		0
Ledum decumbens		0	0		0	**12**	***14***	***0***	0	0
Empetrum nigrum		0	1	1	**2**	**6**	**4**	**1**	0	1
Cladonia sp.		0	0	1	1	0	1		**0**	1
Aulacomnium palustre			1		**8**	**3**	1			
Rubus chamaemorus			0		**6**	**6**	**2**			
Eriophorum vaginatum		0	0			***14***	2			
Cladina rangiferina			0	1		**5**	**5**		0	1
Vaccinium vitis-idaea			0		1	**7**	*7*	0		1
Cladina stygia			0	3		2	**6**	1	0	1
Cladina stellaris							6	**15**		
Bryocaulon divergens	0	0					0	**2**	0	0
Alectoria ochroleuca	0	1					0	**4**	1	0
Sphaerophorus globosus		0				0	0	0	0	**1**
Salix phlebophylla	0		0				0	0	**1**	*7*
Hierochloe alpina						0	0	0	***1***	0
Loiseleuria procumbens							*2*	***2***	0	**3**
Sample size	6	13	10	2	3	8	9	4	7	8

Table 35. Mean cover (%) of the most abundant species in lowland and lacustrine ecotypes. Bolded numbers represent frequencies >60% within ecotype; blanks indicate species is absent; and 0 indicates cover <0.5%. Italicized fonts denote dominant and differential species used to name plant association.

Taxon	Lacustrine Marestail Marsh	Lowland Sedge Fen Meadow	Lowland Sedge–Moss Fen Meadow	Lowland Wet Dwarf Birch–Ericaceous Shrub	Lowland Moist Dwarf Birch–Willow Shrub	Lowland Moist Sedge-Dryas Meadow	Lacustrine Moist Bluejoint Meadow	Lowland Moist Low Willow Shrub	Lowland Moist Tall Alder–Willow Shrub	Riverine Moist Dwarf Birch–Willow Shrub	Riverine Moist Tall Alder–Willow Shrub	Riverine Moist Low Willow Shrub	Riverine Moist Tall Willow Shrub	Riverine Barrens
Potamogeton sp.	**0**													
Hippuris vulgaris	**9**	0												
Rumex arcticus	0	0					**1**							
Carex chordorrhiza		**7**	1											
Salix fuscescens	0	0	**2**	1				1						
Eriophorum angustifolium	3	**9**	5	2	4	0		1		1				
Carex aquatilis	3	**15**	**16**	**15**	5		1	2		0		0	1	
Vaccinium vitis-idaea			1	**11**	**4**			0		1				
Ledum decumbens			**3**	**15**	**5**					1		0		
Empetrum nigrum			**1**	**10**	**2**	0		0				2	0	
Flavocetraria cucullata			0	**1**	0	**1**		0		0				0
Aulacomnium turgidum		0	0	**5**	2	1	0			**1**		1		
Carex bigelowii			1	0	1	**5**		1		**2**		3		0
Peltigera aphthosa			0	0	**0**	**1**	0	0	0	1			0	
Sanionia uncinata			0	0	1	1		1	0	2	**2**	1	1	0
Polemonium acutiflorum	0	0	0		0		**2**	4	**0**	**0**	**1**	0	**0**	0
Poa arctica SL				0	0	**1**	**6**	1		1		0	0	
Valeriana capitata					0	**0**	**2**	4	**1**	**1**	1	**1**	**0**	
Aulacomnium palustre			4	**6**	**8**	3	**58**	5		**4**		3		
Calamagrostis canadensis		0	1		1		**28**	3	**5**	3		3	3	
Betula nana		0	**3**	**22**	**24**	**1**	0	1		**33**		**5**	0	0
Salix planifolia pulchra		0	1	**2**	**28**	**1**	1	**38**	**13**	**35**	2	**11**	1	0
Vaccinium uliginosum			**2**	**9**	**13**	2		**1**	0	**10**	1	5	1	0
Hylocomium splendens				**5**	**14**	**20**		**16**	0	**20**		9	1	0
Equisetum arvense					0	**9**		**26**	**7**	1	**1**	1	**7**	0
Petasites frigidus		0	0	0	**4**	**2**	**11**	**15**	**1**	**7**	**11**	0	3	0
Alnus crispa					1			0	**57**	0	**60**			0
Arctagrostis latifolia				0	1	**1**		0	6	**3**	**33**	0	1	0
Tomentypnum nitens				2	4	**13**		**7**		**11**		**16**		0
Pyrola grandiflora				0	1			0		**1**		0		
Salix reticulata						**13**		**17**	1	0		**9**	3	
Salix lanata richardsonii						**2**		*14*	1	2	*1*	**12**	15	
Festuca altaica						1		**5**	0	1		**5**	1	
Aconitum delphinifolium						0		**1**	**0**		**0**	0	0	
Rubus arcticus					0			1	**2**		**1**	1	1	0
Salix barclayi					1					1	**11**		1	1
Saxifraga punctata						**0**		0	0	0	**1**		0	
Plagiomnium ellipticum								2	0		**2**		0	
Climacium dendroides									0	2	**8**	1	1	
Salix glauca								0		**6**	7	**13**	**2**	
Arctostaphylos rubra				0	0	**2**		3		1		**15**	5	0
Artemisia tilesii							1	0	**2**		**2**	0	**2**	0
Salix arbusculoides											**3**	8	4	0
Salix niphoclada											2	**6**	6	0
Salix alaxensis											**7**	**10**	**43**	**2**
Festuca rubra								0		0		0	**3**	1
Potentilla fruticosa						0		1	1	1		**2**	**3**	0
Galium boreale								0	3	0		0	**15**	
Aster sibiricus								0	0		0	0	**2**	0
Caltha palustris	*1*	*1*												
Dryas integrifolia								*2*		2		6		
Pedicularis verticillata												0	**0**	
Epilobium latifolium												0	2	**2**
Agropyron macrourum														0
Sphagnum sp.	1	0	**61**	**36**	**14**					5				
Sample size	5	11	9	10	8	3	2	10	5	6	3	6	6	10

Table 36. Mean cover (%) of the most abundant species in coastal ecotypes. Bolded numbers represent frequencies >60% within ecotype; blanks indicate species is absent; and 0 indicates cover <0.5%. Italicized fonts denote dominant and differential species used to name plant association.

Taxon	Coastal Saline Wet Sedge–Grass Meadow	Coastal Brackish Wet Sedge–Grass Meadow	Coastal Barrens	Coastal Dry Dunegrass Meadow	Upland Dry Crowberry Shrub
Puccinellia phryganodes	***8***				
Carex subspathacea	6		0		
Carex ramenskii	***19***	***21***			
Potentilla egedii	**9**	2	0		
Chrysanthemum arcticum	**7**	0	0	0	
Calamagrostis deschampsioides	3	4			
Stellaria humifusa	**0**	**3**	0		
Dupontia fischeri		***2***			
Cochlearia officinalis		1			
Rumex arcticus		**0**			
Salix ovalifolia		*5*	0		1
Deschampsia caespitosa		*2*		0	
Saussurea nuda	0			0	
Honckenya peploides			1	**1**	
Elymus arenarius mollis	**4**	0	*2*	***25***	***2***
Lathyrus maritimus		0	*0*	***18***	**1**
Chrysanthemum bipinnatum		0		0	0
Artemisia tilesii			0	**1**	
Cnidium cnidiifolium				**2**	
Senecio pseudoarnica				3	
Mertensia maritima			0	1	
Festuca rubra			0	1	0
Bryum sp.		1		0	**2**
Castilleja elegans		0			0
Salix planifolia pulchra			0		**0**
Astragalus eucosmus sealei				0	0
Bupleurum triradiatum				0	0
Flavocetraria cucullata					**6**
Empetrum nigrum		0			***31***
Cladina arbuscula					**3**
Flavocetraria nivalis					**3**
Arctostaphylos rubra					3
Betula nana					**3**
Vaccinium vitis-idaea					**2**
Vaccinium uliginosum					**2**
Thamnolia vermicularis					**1**
Rhytidium rugosum					**1**
Sphaerophorus globosus					**1**
Salix reticulata					**1**
Armeria maritima					**0**
Oxytropis maydelliana					**0**
Trisetum spicatum					**0**
Lobaria linita					**0**
Sample size	6	7	7	4	5

Table 37. Classification and description of soil types in the in the Bering Land Bridge National Preserve and Cape Krusenstern National Monument, Alaska.

Soil Class (Subgroup)	Description
ENTISOLS	Poorly developed soils lacking mineral horizon development,
Oxyaquic Gelorthents (Eogo)	Gravelly, excessively or well-drained soils, with deep (>1 m) thaw depths and a fluctuating water table within 100 cm of the surface. They have no surface or buried organic layers. They resemble the more widespread Typic Cryopsamment soils, but are composed of gravel mixed with some sand, rather than pure sand as in Typic Cryopsamments. They are usually barren due to frequent flood scouring.
Typic Gelorthents (Eogt)	Gravelly to sandy, excessively or well-drained soils, with deep (>1 m) thaw depths. Water is absent within 100 cm of the surface. Organic layer is absent or very thin. They occur on marine beaches, active coastal dunes, fluvial channel deposits, and active overbank deposits.
Typic Cryopsamments (Ecpt)	Sandy, excessively or well-drained soils with deep (>1 m) thaw depths. They have little or no organic surface layer, and consist of homogenous sand with few or no dark layers. The soils occur on sand dunes or, less frequently, on sandy river floodplains.
Oxyaquic Cryopsamments (Epco)	Sandy, excessively or well-drained soils, with deep (>1 m) thaw depths and a fluctuating water table within 100 cm of the surface. They occur on sandy channel deposits and on sandy overbank deposits where the water table fluctuates with river discharge.
Oxyaquic Cryopsamments, brackish (Epco, brackish)	Sandy, brackish, excessively or well-drained soils, with deep (>1 m) thaw depths and a fluctuating water table within 100 cm of the surface. They occur on sandy active beach deposits and low-lying active coastal dunes. Soil salinity varies from fresh to brackish (>800 uS/cm) due to varying exposure to tidal fluctuations and storm surge activity.
INCEPTISOLS ORDER	Weakly developed soils with incipient mineral horizon development.
Typic Eutrogelepts (Iget)	Rocky, excessively to well-drained, alkaline soils with deep (>1 m) thaw depths. The surface organic horizon is thin or lacking, but an organic-rich mineral horizon is often present near the surface. Thaw and water depths are unknown because of the rocky soils. They occur on upper slopes and crests of rounded mountains comprised of carbonate bedrock, including limestone, dolomite, and marble.
Typic Dystrogelepts (Igdt)	Rocky, excessively or well-drained, acidic soils with deep (>1 m) thaw depths. The surface organic horizon is thin or lacking, but an organic-rich mineral horizon is often present near the surface. Thaw and water depths are unknown because of the rocky soils. They occur on upper slopes and crests of mountains comprised of noncarbonate igneous, metamorphic, volcanic, and sedimentary bedrock.
Lithic Dystrogelepts (Igdl)	Rocky, excessively or well-drained, acidic to circumneutral soils, with deep (>1 m) thaw depths. Bedrock is within 50 cm of the mineral surface. This soil was commonly associated with the Quaternary lava flows.
GELISOLS ORDER	Cold soils over permafrost that are affected by cryoturbation or ice segregation.
Typic Fibristels (Ghft)	Very poorly drained soils dominated by a thick layer (80% of the top 50 cm) of poorly decomposed organic matter. The water table is almost always near the ground surface, and the depth of thaw in late summer is 25 to 40 cm. These soils occur in areas of low-center polygons or disjunct polygon rims in drained-lake basins, and on abandoned portions of floodplains.
Typic Hemistels, (Ghht)	Very poorly drained soils dominated by a thick layer (80% of the top 50 cm) of moderately decomposed organic matter. The water table is almost always within 20 cm of the ground surface, and the depth of thaw in late summer is 25–40 cm. These broadly distributed soils occur on gently sloping upland areas with colluvium and loess deposits, and on flat low-lying areas in drained-lake
Fluvaquentic Aquorthels, (Goaf)	Poorly drained, wet, stratified, loamy, circumneutral soils with shallow thaw depths (<1 m) above permafrost. Soil layers are not deformed by frost action, which differentiates the Orthel suborder. The water table with usually 20–40 cm below the ground surface and thaw depths are moderately deep (30–50 cm). The soils occur on inactive floodplain overbank deposits subject to infrequent flooding.

Table 38. Mean soil properties of common soil types in the Bering Land Bridge National Preserve and Cape Kusenstern National Monument, Alaska, 2002–2003.

Soil Type (Subgroup Level)	Surface Organic Layer Depth (cm)[1]	Cumulative Organic Layer Depth in Top 40 cm (cm)[1]	Depth to Rocks (cm)[2]	Thaw Depth (cm)[3]	Depth to Water (cm)	Site pH	Site EC (µS/cm)	Sample Size (n)
Typic Eutrogelepts	1	1	4		-100	8.0	128	14
Bedrock-Rubble	0	0	0		-150			5
Lithic Dystrogelepts	6	6	25			6.5	32	3
Typic Dystrogelepts	2	2	27		-98	5.8	30	10
Typic Haplorthels	3	3	59	50	-64	6.9	102	13
Typic Haploturbels	3	3	50	41	-43	5.9	90	10
Typic Histoturbels	18	18	147	51	-23	6.4	187	3
Typic Historthels	22	23	160	38	-14	5.6	149	15
Typic Aquiturbels	7	9	146	35	-21	5.9	165	12
Ruptic-histic Aquiturbels	8	8	104	83	-11	7.7	360	2
Typic Aquorthels	9	9	153	37	-14	6.1	148	17
Typic Hemistels	29	29	180	26	-8	5.5	89	14
Typic Fibristels	34	34	171	32	2	5.7	89	19
Typic Historthels, brackish	22	23	200	70	-11	5.9	8740	2
Fluvaquentic Aquorthels, brackish	4	12	200	67	-12	6.6	13704	8
Oxyaquic Cryopsamments, brackish	0	0	200	100	-40	7.6	4741	2
Typic Cryopsamments	1	1	158	120	-115	7.0	102	10
Typic Psammorthels	1	1	144	78	-71	6.3	109	7
Oxyaquic Gelorthents	0	0	0		-71	7.2	130	3
Oxyaquic Cryopsamments	0	0	150	124	-69	7.9	43	5
Typic Gelorthents	1	1	12	150	-100	6.7	40	4
Fluventic Haplorthels	3	5	159	46	-74	6.4	191	9
Fluvaquentic Aquorthels	8	10	200	42	-22	6.4	414	5
Fluvaquentic Haplorthels	5	11		23		6.4	140	2

[1] Surface and cumulative depths measured only down to permafrost table.
[2] Measurement of values greater than 100 limited by permafrost so true value, which is usually much deeper, is unknown.
[3] Thaw depths for rocky soil are unknown and assumed to be >100 cm.

Table 39. Cross-tabulation of soil types (subgroup level) by map ecotype. Dark gray cells highlight the primary soil type and light gray cells highlight the secondary soil type associated with each ecotype. Black borders (may involve separate rows within grouped columns) surround soils that are grouped into soil associations.

Soil Type (Subgroup Level)	Alpine Alkaline Dry Barrens	Alpine Alkaline Dry Dryas Shrub	Upland Dry Lichen Barrens	Alpine Nonalkaline Dry Barrens	Alpine Nonalkaline Dry Dryas Shrub	Lowland Moist Tall Alder–Willow Shrub	Upland Moist Spruce Forest	Upland Moist Low Willow Shrub	Upland Moist Dwarf Birch–Ericaceous Shrub	Upland Moist Dwarf Birch–Tussock Shrub	Upland Moist Sedge–Dryas Meadow	Lowland Moist Sedge–Dryas Meadow	Lacustrine Moist Bluejoint Meadow	Lowland Moist Low Willow Shrub	Lowland Moist Dwarf Birch–Willow Shrub	Lowland Wet Dwarf Birch–Ericaceous Shrub	Lowland Sedge–Moss Fen Meadow	Lowland Sedge Fen Meadow	Coastal Wet Sedge–Grass Meadow	Coastal Barrens	Coastal Dry Dunegrass Meadow	Upland Dry Crowberry Shrub	Riverine Barrens	Riverine Moist Low and Tall Willow Shrub	Riverine Moist Dwarf Birch–Willow Shrub	Total
Typic Eutrogelepts	5	6				1																		1		13
Bedrock-Rubble			3	3																						6
Lithic Dystrogelepts			1						1						1											3
Typic Dystrogelepts				2	3	2																		1	1	9
Typic Haplorthels	1	4			2		1	1	2		1			1												13
Typic Haploturbels		2		1	3			1	2					1												10
Typic Histoturbels						1	1		1																	3
Typic Historthels						1	1		2	3	1			2	1	2	1									14
Typic Aquiturbels									1	3	4			2		2										12
Ruptic-Histic Aquiturbels											2															2
Typic Aquorthels											2	2	2	3	4	1										15
Typic Hemistels										2				1	2	5	2									12
Typic Fibristels																	6	11								17
Typic Historthels, brackish																			2							2
Fluvaquentic Aquorthels, brackish																			7	1						8
Oxyaquic Cryopsamments,																				2						2
Typic Cryopsamments																				3	3		2	2		10
Typic Psammorthels																					1	5				6
Oxyaquic Gelorthents																							3			3
Oxyaquic Cryopsamments																				1			2	1		4
Typic Gelorthents																								3		3
Fluventic Haplorthels																							1	5	3	9
Fluvaquentic Aquorthels																								1	1	2
Fluvaquentic Haplorthels																								1	1	2
Total	6	1	4	6	8	5	3	2	9	8	1	3	2	1	8	10	9	11	1	7	4	5	8	15	6	18

Uncommon types with single occurrences include: Typic Haplogelolls, Aquic Haplorthels, Fluvaquentic Historthels-brackish, Aquic Gelifluvents-brackish

Table 40. Crosswalk of soil associations and their equivalent landtype associations, associated soils, and associated ecotypes for mapping.

Soil Association	Landtype Association	Associated Soils	Related Ecotypes
Typic Eutrogelepts-Typic Haplorthels, coarse	Rocky Dry Alkaline Alpine	Typic Eutrogelepts, Typic Haplorthels, Typic Haploturbels	Alpine Alkaline Dry Barrens; Alpine Alkaline Dry Dryas Shrub
Typic Dystrogelepts-Bedrock, coarse	Rocky Dry Acidic Upland and Alpine	Typic Dystrogelepts, Bedrock-Rubble, Lithic Dystrogelepts, Typic Haplorthels, Typic Haploturbels	Alpine Nonalkaline Dry Barrens; Alpine Nonalkaline Dry Dryas Shrub; Upland Dry Lichen Barrens
Typic Dystrogelepts-Typic Eutrogelepts, coarse-loamy	Rocky-Loamy Moist Circum-neutral Lowland	Typic Dystrogelepts, Typic Eutrogelepts	Lowland Moist Tall Alder–Willow Shrub
Typic Haplorthels-Typic Haploturbels, coarse-loamy	Rocky-Loamy Moist Circum-neutral Upland	Typic Haplorthels, Typic Haploturbels	Upland Moist Spruce Forest; Upland Moist Low Willow Shrub
Typic Historthels-Typic Aquiturbels, loamy	Loamy Moist Acidic Upland	Typic Haplorthels, Typic Aquiturbels, Typic Haploturbels, Typic Historthels	Upland Moist Dwarf Birch–Ericaceous Shrub; Upland Moist Dwarf Birch–Tussock Shrub
Typic Aquiturbels-Ruptic-Histic Aquiturbels, coarse-loamy	Rocky-Loamy Moist Alkaline Upland	Typic Aquiturbels, Ruptic-histic Aquiturbels, Typic Aquorthels	Upland Moist Sedge–Dryas Meadow
Typic Aquorthels, loamy	Loamy Moist Circum. Lowland	Typic Aquorthels	Lowland Moist Sedge–Dryas Meadow; Lacustrine Moist Bluejoint Meadow
Typic Aquorthels, Typic Historthels, loamy	Organic-rich Moist Circum-neutral Lowland	Typic Aquorthels, Typic Historthels, Typic Hemistels, Typic Aquiturbels,	Lowland Moist Dwarf Birch–Willow Shrub; Lowland Moist Low Willow Shrub;
Typic Hemistels-Typic Fibristels, dysic	Organic Wet Acidic Lowland	Typic Hemistels, Typic Fibristels, Typic Historthels	Lowland Wet Dwarf Birch–Ericaceous Shrub; Lowland Sedge–Moss Fen Meadow
Typic Fibristels, dysic	Organic Wet Circum. Lowland	Typic Fibristels	Lowland Sedge Fen Meadow
Fluvaquentic Aquorthels-Typic Historthels, brackish	Loamy Wet Brackish Coast	Fluvaquentic Aquorthels, brackish; Typic Historthels, brackish	Coastal Wet Sedge–Grass Meadow
Typic Psammorthels, sandy	Sandy Dry Circum. Upland	Typic Psammorthels	Upland Dry Crowberry Shrub
Typic Cryopsamments-Oxyaquic Cryopsam-ments, sandy-brackish	Sandy Dry Brackish Coast	Typic Cryopsamments, Oxyaquic Cryopsamments, brackish	Coastal Barrens; Coastal Dry Dunegrass Meadow
Oxyaquic Gelorthents-Oxyaquic Cryopsam-ments, coarse-sandy	Gravelly-Sandy Moist Alkaline Floodplain	Oxyaquic Gelorthents, Oxyaquic Cryopsamments	Riverine Barrens
Fluventic Haplorthels-Typic Gelorthents, loamy	Sandy-Loamy Moist Circum. Floodplain	Fluvaquentic Haplorthels, Typic Gelorthents, Fluvaquentic Aquorthels, Fluventic Haplorthels	Riverine Moist Low and Tall Willow Shrub; Riverine Moist Dwarf Birch–Willow Shrub
Human-Modified Barrens, coarse	Human-Modified Barrens	Typic Gelorthents	Human-Modified Barrens
Freshwater	Freshwater		Lowland Water; Riverine Water
Coastal Water	Coastal Water		Coastal Water

were comprised of two or less soil types associated with two or less ecotypes. For example, the well-drained, alkaline soils Typic Eutrogelepts and Typic Haplorthels were predominantly associated with Alpine Alkaline Dry Barrens and Alpine Alkaline Dry Dryas Shrub and were therefore combined into the Typic Eutrogelepts–Typic Haplorthels, coarse soil association. The creation of distinctive soil associations in moist upland and lowland areas was problematic, however, due to the wide distribution of similar soil types associated with ecotypes with similar plant species compostion (Table 38). For example, the highly similar Typic Haplorthels and Typic Haploturbels, which were differentiated only by the presence of cryoturbation features, were broadly distributed across well-drained, rocky alpine and upland environments. The highly similar Typic Historthels, Typic Histoturbels, and Typic Aquiturbles, which were differentiated by small differences in organic layer thicknes and presence of turbation, were broadly distributed across 5–9 ecotypes. These later three soils, however, served as the primary soils for three differing soil associations, depending of the frequency of occurrence of other soil types.

Landtype associations, which are landscape-level units of the national ecological land classification (ELC) hierarchy (ECOMAP 1993) also were identified (Table 40). They are identical in concept to soil associations, except the nomenclature for the ELC uses terminology that can be understood by a broader group of users.

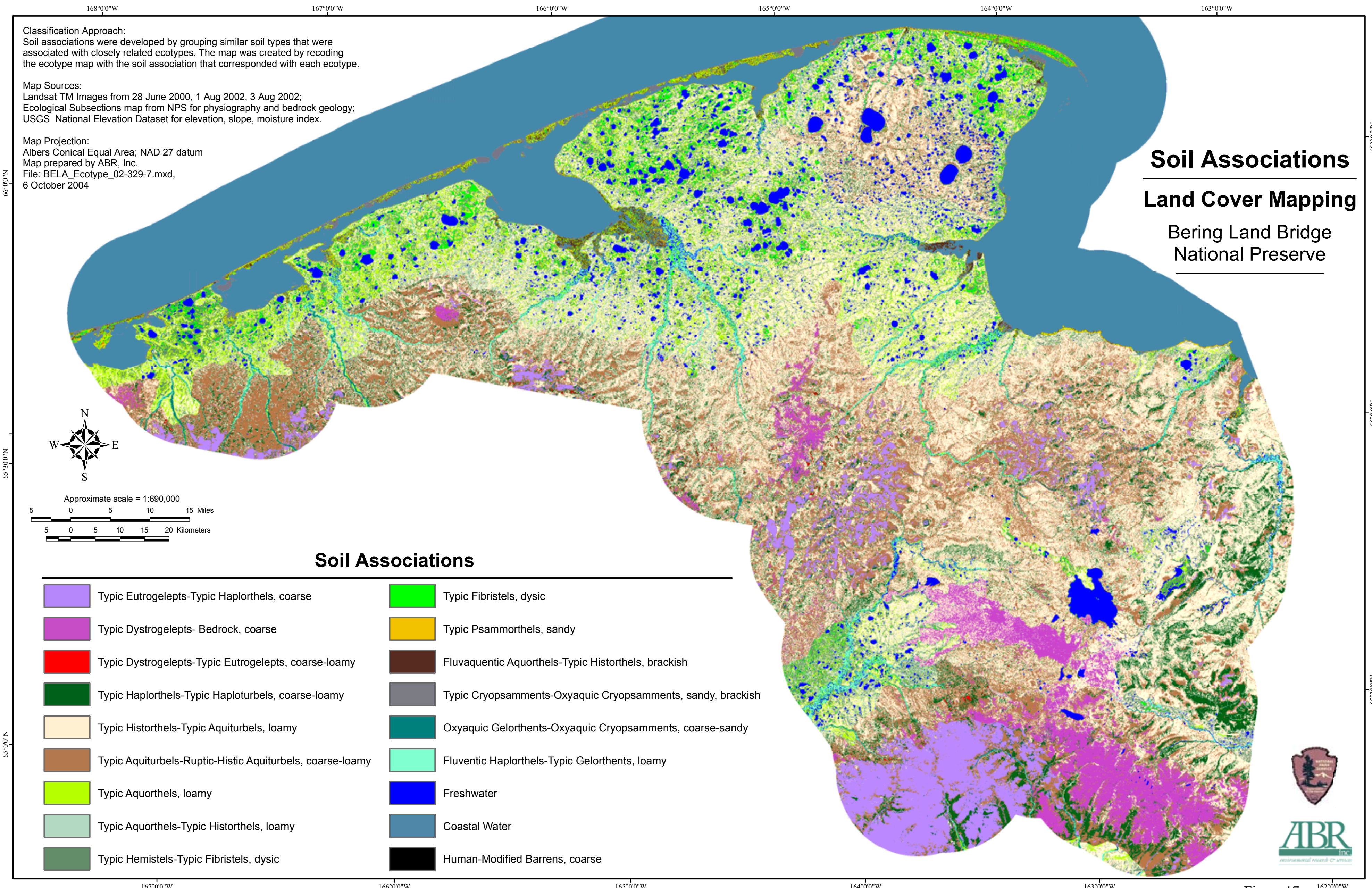
Based on the ecotype-soil relationships, soil association maps were developed by recoding the individual ecotypes to their respective soil associations (Figures 17 and 18). This recoding to soil associations appears to provide a good approximation of the distribution of soil types. Note, however, that the ~30-m pixel scale of the map is not the appropriate scale for soil-association or landtype-association maps and that a standard soil-association map would integrate the variability of soils over broader areas.

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 BELA and CAKR were synthesized from our results and relavent literature.

CLIMATE

Climate is a dominant factor affecting ecosystem distribution (Walters 1979). Long-term weather stations surrounding BELA and CAKR reveal strong gradients in temperature and precipitation. Mean annual air temperature 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). Mean annual precipitation 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. Note, however, that problems with measuring blowing snow can lead to underestimation of precipitation 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



Classification Approach:
Soil associations were developed by grouping similar soil types that were associated with closely related ecotypes. The map was created by recoding the ecotype map with the soil association that corresponded with each ecotype.
Map Sources:
Landsat TM Images from 28 June 2000, 1 Aug 2002, 3 Aug 2002;
Ecological Subsections map from NPS for physiography and bedrock geology;
USGS National Elevation Dataset for elevation, slope, moisture index.
Map Projection:
Albers Conical Equal Area; NAD 27 datum
Map prepared by ABR, Inc.
File: BELA_Ecotype_02-329-7.mxd,
6 October 2004
Soil Associations
Land Cover Mapping
Bering Land Bridge National Preserve
N
S
E
W
Approximate scale = 1:690,000
5 0 5 10 15 Miles
5 0 5 10 15 20 Kilometers
Soil Associations
Typic Eutrogelepts-Typic Haplorthels, coarse
Typic Dystrogelepts- Bedrock, coarse
Typic Dystrogelepts-Typic Eutrogelepts, coarse-loamy
Typic Haplorthels-Typic Haploturbels, coarse-loamy
Typic Historthels-Typic Aquiturbels, loamy
Typic Aquiturbels-Ruptic-Histic Aquiturbels, coarse-loamy
Typic Aquorthels, loamy
Typic Aquorthels-Typic Historthels, loamy
Typic Hemistels-Typic Fibristels, dysic
Typic Fibristels, dysic
Typic Psammorthels, sandy
Fluvaquentic Aquorthels-Typic Historthels, brackish
Typic Cryopsamments-Oxyaquic Cryopsamments, sandy, brackish
Oxyaquic Gelorthents-Oxyaquic Cryopsamments, coarse-sandy
Fluventic Haplorthels-Typic Gelorthents, loamy
Freshwater
Coastal Water
Human-Modified Barrens, coarse
ABR Inc.
168°0'0"W
167°0'0"W
166°0'0"W
165°0'0"W
164°0'0"W
163°0'0"W
162°0'0"W
66°30'0"N
66°0'0"N
65°30'0"N
65°0'0"N

Figure 17.

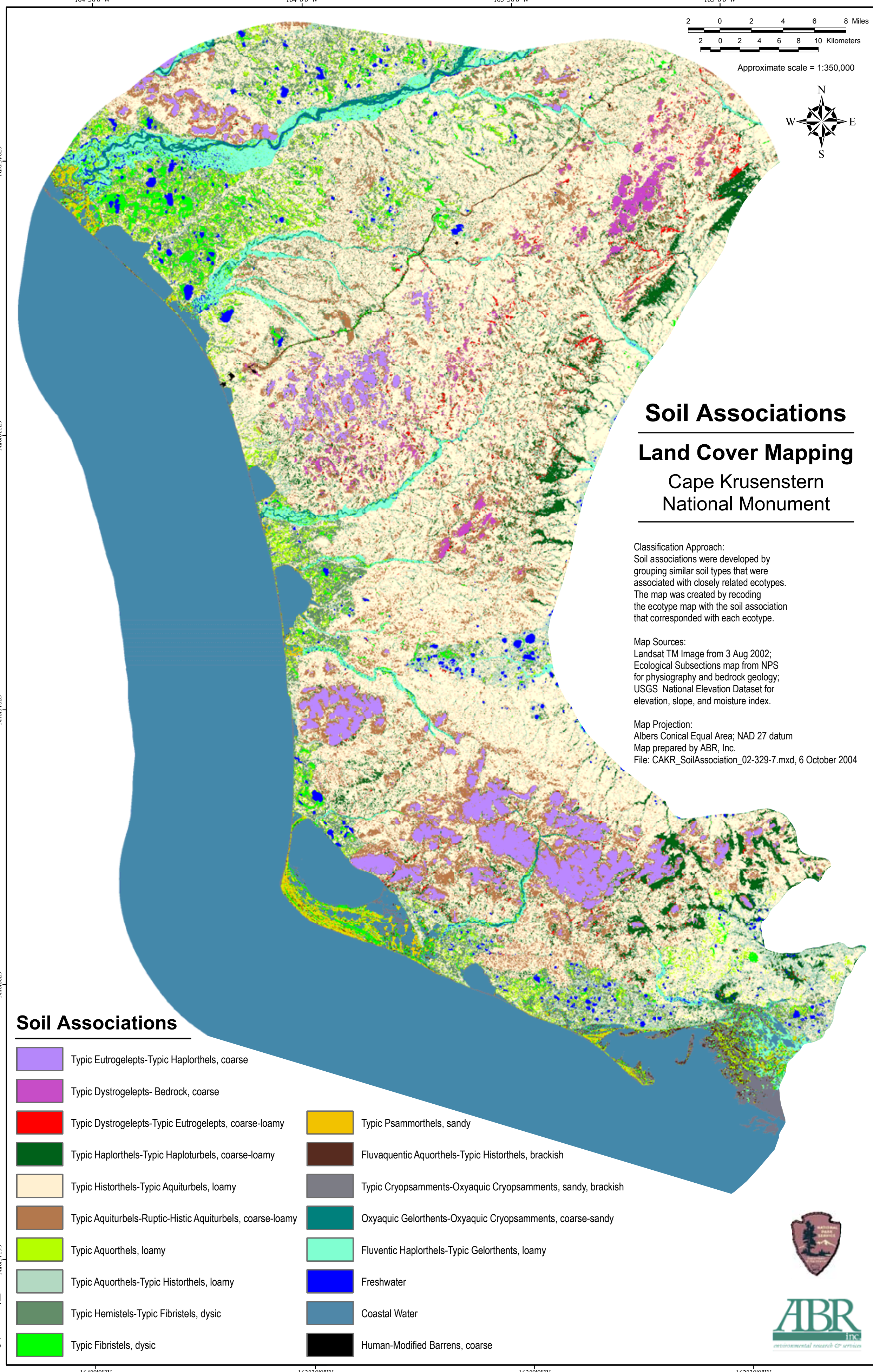

Soil Associations
Land Cover Mapping
Cape Krusenstern
National Monument
Classification Approach:
Soil associations were developed by grouping similar soil types that were associated with closely related ecotypes. The map was created by recoding the ecotype map with the soil association that corresponded with each ecotype.
Map Sources:
Landsat TM Image from 3 Aug 2002;
Ecological Subsections map from NPS for physiography and bedrock geology;
USGS National Elevation Dataset for elevation, slope, and moisture index.
Map Projection:
Albers Conical Equal Area; NAD 27 datum
Map prepared by ABR, Inc.
File: CAKR_SoilAssociation_02-329-7.mxd, 6 October 2004
2 0 2 4 6 8 Miles
2 0 2 4 6 8 10 Kilometers
Approximate scale = 1:350,000
N
W
E
S
164°30'0"W
164°0'0"W
163°30'0"W
163°0'0"W
162°30'0"W
68°0'0"N
67°45'0"N
67°30'0"N
67°15'0"N
67°0'0"N
66°45'0"N
Soil Associations
Typic Eutrogelepts-Typic Haplorthels, coarse
Typic Dystrogelepts- Bedrock, coarse
Typic Dystrogelepts-Typic Eutrogelepts, coarse-loamy
Typic Haplorthels-Typic Haploturbels, coarse-loamy
Typic Historthels-Typic Aquiturbels, loamy
Typic Aquiturbels-Ruptic-Histic Aquiturbels, coarse-loamy
Typic Aquorthels, loamy
Typic Aquorthels-Typic Historthels, loamy
Typic Hemistels-Typic Fibristels, dysic
Typic Fibristels, dysic
Typic Psammorthels, sandy
Fluvaquentic Aquorthels-Typic Historthels, brackish
Typic Cryopsamments-Oxyaquic Cryopsamments, sandy, brackish
Oxyaquic Gelorthents-Oxyaquic Cryopsamments, coarse-sandy
Fluventic Haplorthels-Typic Gelorthents, loamy
Freshwater
Coastal Water
Human-Modified Barrens, coarse
ABR
Inc.
environmental research & services

Figure 18.

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 eastern margins of BELA and CAKR, 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.

The mountains contribute to these gradients by impeding movement of large-scale air masses. The Bendeleben and York Mountains appear to provide a barrier to movement of moist maritime air masses from the Bering Sea, causing precipitation to be two times higher on the southern side of the mountains (Nome) than on the northern side (Kotzebue).

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 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, McColloch 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) (McColloch and Hopkins 1966).

Fossil insect and pollen records (Elias et al. 1999) indicate that during the last interglacial period (about 130,000 years ybp), the climate in the Noatak Valley to the east of CAKR 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 years ybp the climate warmed, probably to conditions similar to those at present, allowing colonization of the Noatak Valley by shrubs (and locally 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 ~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 (McColloch and Hopkins 1966).

More recently, historical records and analyses of proxy indicators indicate that mean annual temperatures were substantially (~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 onto 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 the BELA abuts the Bering Strait and the western portion of CAKR abuts 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 ~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 (~18,000 years ybp), sea level fell to ~100 m below current sea level. This drop exposed a broad land bridge across the Bering continental shelf (Hopkins 1967). By ~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 ~125,000 ybp and left beach ridge deposits that outcrop at elevations of 8–10 m above mean sea level (Sainsbury 1967, Hamilton and Bringham-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 (~175,000 ybp) and Einahnuhtan (~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 ~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

BELA 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.

CAKR 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 CAKR 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 BELA and CAKR 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 pulchra, Sphagnum* spp., and *Vaccinium uliginosum* (Hanson 1953, Young 1974, Walker et al. 1994). In contrast, common plants on alkaline soils typically include *Dryas integrifolia, Equisetum scirpoides, Lupinus arcticus, Parrya nudicaulis, Salix arctica, S. lanata 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 CAKR and BELA. 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 BELA and CAKR. 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 upper Serpentine River and Inmachuk River areas. 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

Despite its strong influence on geomorphology elsewhere in Alaska and North America, the Pleistocene glaciations had only a slight affect on the geomorphology of BELA and CAKR. Glaciers extended into northern CAKR from source areas in the surrounding mountains during the early and middle Pleistocene, but did not cover the valley 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 (~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 ~17,500 ybp are only ~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 ~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 (around 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 in both BELA and CAKR.

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 (Brown et al. 1997) and is >100m thick (Hopkins 1988). 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 sheets similar to the "paloma" 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 composition of vegetation that can grow on the cold, saturated soils.

FIRE

Although fire is not considered to be an important disturbance factor in tundra ecosystems due to the lack of fuel (Patterson and Dennis 1981), periodic summer droughts and thunderstorms have produced several major fires in BELA during the last several decades (Melchior 1979, Wein 1976, Racine 1981, and Racine et al. 1983). Most fires have occurred in the eastern portion of the Seward Peninsula, but several incidences also have occurred near the Kuzitrin River, and to a lesser extent near Imuruk Lake. Fires are notably absent from 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 a landcover mapping and ecological land survey (ELS) effort that inventoried, classified, and mapped ecosystems in the Bering Land Bridge National Preserve and the Cape Krusenstern National Monument. By analyzing the dynamic physical processes associated with coastal, riverine, coastal plain, and hillside environments, and the abundance and distribution of their diverse ecological resources, this study contributes to ecosystem management in national parklands in northwestern Alaska.

Field surveys at 231 intensive plots during July 2002 and 2003 collected information on the geomorphic, topographic, hydrologic, pedologic, and vegetative characteristics of ecosystems across the entire range of environmental gradients across the two parks. An additional 257 verification plots were surveyed to obtain data on vegetation structure and dominant species for use as ground reference plots for mapping. Individual ecological components (e.g., geomorphic unit, vegetation type) were determined using standard classification schemes for Alaska, but modified when necessary to differentiate unique characteristics in the study area. Thirty-one plant associations were developed through multivariate classification techniques. The hierarchical relationships among ecological components were used to derive 33 ecotypes (local-scale ecosystems) that best partition the variation in ecological characteristics across the entire range of aquatic and terrestrial environments.

Mapping was based on the classification of spectral characteristics of three Landsat scenes that covered the area and modeling the physiography associated with ecosubsection (major physiographic and geologic regions) maps and digital elevation models. A spectral database was developed that integrated the spectral, environmental, and vegetative characteristics for 389 ground plots and was used as part of a supervised classification to classify the area into 18 signature vegetation types. Rule-based modeling using the supervised classifcation, ecosubsection maps ,and digital elevations models was used to reclassify signature vegetation into 29 ecotypes. Four ecotypes were aggregated into other classes because they could not be mapped separately. The most abundant ecotypes within the park boundaries include Upland Moist Dwarf Birch–Ericaceous Shrub, Upland Moist Dwarf Birch–Tussock Shrub, Upland Moist Sedge–Dryas Meadow, Lowand Moist Sedge–Dryas Meadow, and Lowland Sedge–Moss Fen Meadow.

Multiple environmental site factors contributed to the distribution of ecotypes and their associated plant species, and there were large differences among ecotypes. Mean surface organic-horizon thickness, an indicator of land surface age and anaerobic soil conditions and disturbance, ranged from 0 cm in Coastal and Riverine Barrens to 40 cm in Lowland Sedge Fen Meadow. Mean depth to rock, an indicator of surficial deposit depth and drainage, ranged from 0 cm in Alpine Alkaline Dry Barrens to >200 cm in numerous ecotypes that occurred on thick eolian or marine surficial deposits. Permafrost was present in all terrestrial ecotypes and mean thaw depths ranged from 26 cm in Moist Dwarf Birch–Tussock Shrub to 130 cm in Riverine Moist Tall Alder–Willow Shrub. Mean depth of water (negative when below ground), ranged from >-2 m in Riverine Moist Tall Alder-Willow Shrub to >1 m in Coastal Water. Mean pH, which affects nutrient availability and ion exchange, ranged from 5.0 in Moist Dwarf Birch–Tussock Shrub to 8.2 in Alpine Alkaline Dry Barrens. Mean electrical conductivity (EC), important for osmotic regulation of plants and animals, ranged from 20 µS/cm in Alpine Nonalkaline Dry Barrens to 22,430 µS/cm in Coastal Saline Wet Sedge–Grass Meadow.

Soils described at 198 plots were classified into 24 soil types for mapping and analysis. The most common types observed were Typic Fibristels (10% of 198 observations), Typic Aquorthel (9%), Typic Historthel (8%), Typic Hemistel (7%), and Typic Eutrogelepts (7%). The classification was fairly effective at partitioning the variability of numerous soil properties, including organic-layer thickness, depth to rocks, thaw depths, depth to water, pH, and EC. Cross-tabulation of soils with the ecotypes assigned for each plot indicates that most soil types were associated with 2–3 ecotypes. These relationships allowed the development of 15 soil associations and two waterbody types by combining the soil types that occured in closely related ecotypes. Based on the ecotype-soil relationships, soil association maps were developed by recoding the individual ecotypes to their respective soil associations.

Ecotype distribution also was greatly affected by landscape-level factors. Strong north-south and east-west climatic gradients have affected the forest-tundra ecotone and modes of permafrost development and degradation. 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. Tectonics and regional mountain building have created barriers to atmospheric movement and topographic climate gradients. Carbonate sedimentary and felsic intrusive bedrock greatly affects soil pH and nutrient status. Geomorphic environments associated with sediment erosion and deposition create a wide range of soil conditions and disturbance regimes. Permafrost acts as a barrier to subsurface drainage and the varying volumes of ground ice result in varying degrees of permafrost degradation. Finally, fires occasionally occur in ecotypes that have developed sufficient evergreen vegetation, litter and woody fuel.

Three main benefits are derived from an ecological land survey approach to understanding landscape processes and their influence on ecosystem functions. First, it analyzes landscapes as ecological systems with functionally related parts and recognizes the importance that geomorphic and hydrologic processes have on 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, developing a spectral database that integrates the spectral, physical, and floristic information for use in satellite image processing facilitates the analysis of numerous environmental characteristics across the landscape. Finally, this linkage of ecological characteristics within a spatial database 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.

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Appendix 1. Coding system for characterizing ecological characteristics of field plots.

TERRAIN UNITS

BEDROCK

- Bxw Bedrock, weathered (undiffer.)
- Sc Sedimentary, carbonate (limestone,dolostone)
- Sn Sedimentary, noncarbonate (shale, siltstone, conglomerate)
- Sm Sedimentary, mixed noncarbonate and carbonate
- Vfy Volcanic-felsic-young
- Vfo Volcanic-felsic-old
- Vmy Volcanic-mafic-young (Quatern.)
- Vmo Volcanic-mafic (dark)-old
- Vp Volcanic-pyroclastics
- If Intrusive-felsic
- Im Intrusive-mafic
- Nc Metamorphic-carbonate
- Nn Metamorphic-noncarbonate
- Mcn Metamorphic-mixed carb/noncarb

COLLUVIAL DEPOSITS

- C Colluvial Deposits
- Ch Hillslope Colluvium
- Cl Landslide Deposit
- Cs Solifluction Deposits

EOLIAN DEPOSITS

- Esa Eolian Active Sand
- Esi Eolian Inactive Sand
- Essi Eolian Inactive Sand Sheet

FLUVIAL DEPOSITS

- **Fu Fluvial, undifferentiated**
- **Fd Delta Floodplain**
- Fdra Delta Active Channel Deposit
- Fdri Delta Inactive Channel Deposit (High-water Channel)
- Fdoa Delta Active Overbank Deposit
- Fdoi Delta Inactive Overbank Deposit
- Fdob Delta Abandoned Overbank Dep
- **Fpm Meander Floodplain**
- Fmr Meander Channel Dep (riverbed)
- Fmrac Meand Course Active Chan. Dep.
- Fmrif Meander Fine Inactive Chan Dep.
- Fmo Meander Overbank Deposit (complex)
- Fmoa Meander Active Overbank Dep
- Fmoi Meander Inactive Overbank Dep
- Fmob Mean. Abandoned Overbank Dep
- **Fb Braided Floodplain**
- Fbr Braided Channel Dep(riverbed)
- Fbrac Braided Course Active ChanDep.
- Fbrif Braided Fine Inactive Chan Dep.
- Fbo Braided Overbank Dep (complex)
- Fboa Braided Active Overbank Deposit
- Fboi Braided Inactive Overbank Dep
- Fbob Braided Abandoned Ovrbank Dep
- **Fhl Headwater Lowland Floodplain**
- **Fto Old Terrace** (lower terraces)
- **Ff Alluvial Fan**

GLACIAL AND NON-G. DEPOSITS

- FGp Alluvial Plain Deposits

GLACIAL DEPOSITS

- Gmo Older Moraine
- Gmy Younger Moraine
- Gto Older Till Sheet
- Gty Younger Till Sheet

GLACIOFLUVIAL DEPOSITS

- GFo Glaciofluvial Outwash
- GFk Kame Deposits

GLACIOLACUSTRINE DEPOSITS

- GL Glaciolacustrine Deposits
- **L LACUSTRINE DEPOSITS**
- Ltn Ice-poor Thaw Basin (young)
- Lti Ice-rich Thaw Basin (old)
- Ltic Ice rich centers
- Ltim Ice rich margins
- Ltip Ice-rich-pingos

MAN-MADE DEPOSITS

- Hfg Fill, gravel
- Hfo Fill, overburden
- Hfp Fill, peat
- He Excavations

MARINE DEPOSITS

- Mb Beach Deposits
- Mta Active Tidal Flat
- Mti Inactive Tidal Flat
- Mp Coastal Plain Deposit
- Mps Sandy coastal plain deposit
- Mpf Fine coastal plain deposit

GLACIOMARINE DEPOSITS

- MG Glaciomarine Deposits

ORGANIC DEPOSITS (0rg >40cm)

- Of Organic Fens
- Ob Bogs

WATER

- **Wr Rivers and Streams**
- Wrln Lower Perennial, non-glacial
- Wrlg Lower Perennial, glacial
- Wrun Upper Perennial, Non-glacial
- Wrug Upper Perennial, Glacial
- Wldcr Deep Connected Lake, Riverine
- Wldct Deep Connected Lake, Thaw
- Wldcm Deep Connected Lake, Morainal
- Wldir Deep Isolated Lake, Riverine
- Wldit Deep Isolated Lake, Thaw
- Wldim Deep Isolated Lake, Morainal
- Wlscr Shallow Connected Pond., River.
- Wlsct Shallow Connected Pond., Thaw
- Wlscm Shal. Connected Pond., Morainal
- Wlsir Shallow Isolated Pond., Riverine
- Wlsit Shallow Isolated Pond., Thaw
- Wlsim Shallow Isolated Pond., Morainal
- **Wm Marine**
- Wmn Nearshore Water
- **We Estuarine**
- Welt Tidal Ponds (affected by tides)
- Wert Tidal River (brackish)
- Weld Brackish Deep Lake
- Wels Brackish Shallow Lake
- **Wh Man-made Waterbodies**
- Whid Drainage Impoundment
- Whir Reserve Pit

MACROTOPOGRAPHY CLASSES:

- **C Top, Crest, Summit Or Ridge**
- **Fh Plateau (High Flats)**
- **Sh Shoulder Slope**
- **XP Pingo**

Steep Slopes

- Sb Bluff or Bank (unconsolidated)
- Sbs Steep bluff south facing
- Sc Cliff (rocky)
- Sbr Riverbanks
- **Su UPPER SLOPE** (convex, creep)
- Suc Concave (water gathering)
- Suv Convex (water shedding)
- 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 OR FLUVIAL RELATED**
- Fn Nonpatterned
- Fm Flats margins (transition)
- Fc Channel, swale or gut,
- Fi Interfluv or flat bank
- Fl Levee
- Fb Bar (point, lateral, mid-channel)
- Fs Crevasse splay
- Ft Terrace
- Ff Flood Basin (behind levee)
- **L LAKES AND OCEAN**
- Wi Islands Present
- Ls Smooth FlatLake Margin
- Fwb Wave cut bench (shore)
- Fwt Wave cut terrace (shore)
- **R RIVER OR STREAM**
- Rp Deep Pools (>1.5 m)
- Rs Shallow Runs (<1.5 m)
- Ri Riffles,
- Rr Rapids
- **XC CHANNEL COMPLEX**
- Xcb Braided channels and interfluvs
- Xcm Meander scrolls
- CR Ridge And Swale Complex
- E Eolian Patterns
- El Eolian linear dunes
- Ep Eolian parabolic dunes
- Hm Human modified

MICROTOPOGRAPHY CLASSES

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)

Polygons

- Pd Disjunct polygon rims
- Plll Low-cent., low-relief, low-density
- Pllh Low-cent., low-relief, high-density
- Plhh Low-cent., high-relief, high-density
- Pm Mixed high and low polygons
- Phl High-cent., low-relief (flat-cent.)
- Phh High-centered, high-relief

Thermokarst

- Tm Mixed thermokarst pits and polygons
- Tb Beaded stream

MOUNDS (ice and peat related)

- Mi Ice-cored mounds
- Mpm Peat mounds
- Ms String (strang)
- Mg Gelifluction lobes (saturated flow)
- Mir Ice-shoved ridge
- Mid Ice-rafted debris
- Mrb Rocks, Blockfields
- Mrm Rocky Mounds (soil covered rocks)
- Mw Mounds caused by wildlife
- Mh Mounds caused by humans
- Mu Undifferentiated mounds (distinct)

DRAINAGE or EROSION RELATED

- Dt Water tracks (non-incised drainages)
- Df Feather pattern (in fens)
- Dr Ripples
- Dd Flow dunes
- Ds Scour channels-ridges

EOLIAN RELATED

- Es Small dune
- Eb Scour depression

W WATER

- Wi Islands present
- Lp Polygonized margin (>10%)

X COMPLEXES

VEGETATION CLASSES (IV):

- Bbg Barrens (<5% veg)
- Bpv Partially Vegetated (5–30)
- Haf Aquatic Fresh Herb
- Hab Aquatic Brachish Herb
- Hame Eelgrass
- Hfm Moist Forb Meadow
- Hfwhh Halophytic Herb Wet Meadow
- Hgdl Elymus (Leymus)
- Hgmb Bluejoint Meadow
- Hgmsw Sedge -willow tundra
- Hgmsd Sedge-dryas tundra
- Hgmt Tussock tundra
- Hgwfg Fresh grass marsh
- Hgwfs Fresh sedge marsh
- Hgwst Wet sedge meadow tundra
- Hgwsw Wet sedge-willow tundra
- Hgwhg Halophytic grass wet meadow
- Hgwhs Halophytic sedge wet meadow tundra
- Hgwk Salt-killed wet meadow
- Hafm Common marestail
- Stca Closed Tall Alder
- Stoa Open Tall Alder
- Stcw Tall closed willow
- Stow Tall open willow
- Slcb Low closed Shrub Birch
- Slcbw Low closed sbrub birch-willow
- Slcbe Closed Shrub Birch-Ericaceous
- Slcw Low closed Willow
- Slow Low open Willow
- Slob Low open Shrub Birch
- Slobw Open Shrub Birch-Willow
- Slobe Open Shrub Birch-Ericaceous
- Slott Mixed shrub-sedge tussock tundra
- Sdee Crowberry Tundra
- Sddt Dryas tundra (little sedge or lichen)
- Sdds Dryas-sedge tundra
- Sddl Dryas-lichen tundra
- Sdec Cassiope tundra
- Sdww Dwarf Willow tundra
- Sdwg Halophytic willow-graminoid
- W Water

Appendix 1. Continued.

ENVIRONMENTAL PLOT DATA

SiteID: Unique Identifier
Date:
Time:
Name: Initials of Observer
GrndPhotoNo.:
SoilPhotoNo.:
GeogLandMark:
Lat(dd83):
Long(dd83):
ElevGPS(m):
AirphotoNo: YY-Roll-Frame
PinPrick: enter "y" after marked
PlotRadius(m): Usually 10
Physiography:
A Alpine
U Upland
L Lowland
P Lacustrine (ponded)
R Riverine
C Coastal
SurfTerrUnit: see Terrain Unit codes
SubTerrUnit: 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)
Saturat<30: yes or **n**o
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)
LowMottDep: depth, **A**bsent, **P**eat, or **ND**, chr=2 or less
LowMatrDepth: depth, **A**bsent, **P**eat, or **ND**, chr=1, no mottling, full gley
HydricSoil: Present or **A**bsent
Thaw Depth (cm):
CryoTurb: **P**resent or **A**bsent
SurfOrg: depth of top layer (cm)
CumOrg40: total org in top 40
DomMineral40: dominant mineral text. in top 40 cm
RE Extremely Rocky (>60% coarse ; >2 mm)
R Rocky (SaGr + 15-60% rocks)
S Sandy (grSa to l Sa; <15% gravel)
L Loamy (CL to SL)
C Clayey (SC to C)
O Organic (used if no mineral)
DomText40: dominant text. (O or M) < 40cm
SurfaceFrag:
0 none
S Stony (<0.1%)
Sv Very Stoney (0.1-3)
Se Extremely Stony, (3 – 15%)
R Rubbly, (15 – 50%)
Re Very Rubbly (>50%)
RockDepth(>15%): cm
SoilPH: to 0.1 units from paste
SoilEC: uS/cm from paste
SampDepth10:
SampMeth (Sampling Method):
P pit
L plug
A auger
C corer
E bank exposure
S surface
M metal probe
LM plug + probe
LA plug + auger
FrostBoil(% cov): % cov. barren active frost boils
SoilClass: NRCS taxonomy 1998
VegClass(L IV): Viereck Level IV
EcoType: sequencial coding for Physiograph, DomMin40, SoilMoist, Veg Structure

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%
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
Horizon: used NRCS codes
Master horizon
O, A, AB, A/B, AC, E, EA, BA B, BC
Horizon suffixes
a, b, c, d, e, f, ff, g, h, i, j jj, k, m, j, o, p, q, r, s, ss, t, v, w, y, z,
Distinctness:
A Abrupt (<2 cm)
C Clear 2–5 cm
G Gradual (5–15 cm)
D Diffuse (>15 cm)
Topography:
S Smooth
W Wavy
I Irregular (deeper than wide)
B Broken
Textural Abbreviations
Fine fraction
s sand
vcos very coarse sand
cos coarse sand
fs fine sand
vfs very fine sand
ls loamy sand
l loam
si silt
c clay
Coarse fragments (>2mm)
boul boulder (> 60 cm)
st stone (25 – 60 cm)
cob cobble (7.5 – 25 cm)
gr gravel (0.2 – 7.5 cm)
Coarse fragment modifiers
sg 0 to 15 %
g 15 to 35 %
vg 35 to 60 %
eg 60-90 % (exgSiL)
G >90%
Organic Soils
Oi slightly decomposed
Oe intermediate decomposition.
Oa highly decomposed
CrsFragSizeMax:
Coarse Fragment Shape:
Av very angular,
A angular,
As subangular
Rs subrounded,
R rounded,
Rw well rounded
ColorMatrix: Munsell chart
ColorMottle: Munsell chart
Mottles (combine.g., ffd)
Abundance:
f few (< 2% area)
c common (2 – 20 %)
m many (> 20 % area)
Size:
f fine (< 2 mm)
m medium (2 to 5 mm)
l 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)
Structure: (Not Used)
Grade
m massive
sg single grained
w weak (barely visible)
m moderate (easily observable)
s strongly (distinctly visible
Size
vf very fine (<1mm)
f fine (1 – 2 mm)
m medium (2 –5mm)
c coarse (5 – 10 mm)
vc very coarse (>10 mm)
Type
gr granular
pl platy
pr prismatic
clr columnar
abk angular blocky
sbk subangular blocky
w wedge
Peat Types (Peat):
G Graminoid or sedge
Gf Gramin., fine (<2 mm wide)
Gc Gram, coarse (>2 mm wide)
Gh Gramin.-Herb
A Allochtonous (drifted)
F feathermoss
S SphaG
D = dicranum/Polytrichum
M = Live mosses
W = woody
L = Limnic (algal)
Ice Structures (IceStr):
Primary Continuity and Bedding
Pn Pore nonvisible (v,f,m,c,l)
Pv Pore, visible
On Organic matrix, nonvisible
Ov Organic matrix, visible
Ce Crustal, entire
Cp Crustal, partial
Vv Vein, vertical
Vi Vein, irregular
Lh Lenticular, horizontal
Li Lenticular, inclined
Lc Lenticular, crossbedded
Lg Lenticular, grouped
Bs Bedded (layered), sparse (<5%)
Bm Bedded, medium (5-25% ice)
Bd Bedded, dense (25-50%)
Rt Reticulate, trapezoidal (prismatic)
Rl Reticulate, lattice (blocky)
Rf Reticulate, foliated (platy)
As Ataxitic, sparse (50-75% ice)
Am Ataxitic, medium (75-95%)
Ad Ataxitic, dense (95-99%)
Sr Solid, columnar
Sh Solid, sheet
Sw Solid, wedge
Secondary Ice Shape:
Lenticular and Bedded
p Planar
w Wavy
c Curved
Ataxitic
r Round
a Angular
b Blocky
Solid
c Clear (c)
q Opaque (o)
d Dirty (<1% soil)
s Porous
Tertiary Ice Size
v Very fine (<0.5 mm)
f Fine (0.5 - <1 mm)
m Medium (1-3 mm)
c Coarse (3-5 mm)
l Large (5-10 mm)
y Very Large (>10 mm)
Ice coding examples: Lhwf, Amb

Appendix 2. Data file listing of ecological components of ground reference and verification plots in the Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

Site ID	Date	LatDD83	LongDD83	Physiog	Slope	Aspect	Geom Unit	Microtopo	MicroRel	VegClass	Ecotype	Floristic Class	Dominant Plants
BELA_T01_01	10/2002	65.4287	-164.107	R	0	0	Wrln	W	0	W	Riverine Water		water
BELA_T01_02	10/2002	65.4294	-164.104	R	1	355	Fmraf	Dr	2	Bbg	Riverine Barrens	epilat-agrmac	soil-rumex-wilphy
BELA_T01_03	10/2002	65.4292	-164.104	R	2	354	Fmoa	Dr	3	Hgdl	Riverine Barrens	epilat-agrmac	soil-poa-elymol-fesrub-agrmac-arttil-astsib-descae
BELA_T01_04	10/2002	65.4291	-164.104	R	1	0	Fmoa	Mu	20	Stow	Riverine Moist Tall Willow Shrub	salala-astsib	salala-salarb-calcan-arttil-astsib-fesrub-elymol
BELA_T01_05	10/2002	65.4287	-164.104	R	0	0	Fmoi	Fh	40	Slcw	Riverine Moist Low Willow Shrub	salpul-calcan	salarb-calcan-betnan-salnip-salpul-vaculi-salala
BELA_T01_06	10/2002	65.4282	-164.103	R	0	0	Fmoi	Fh	30	Slcbe	Riverine Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	betnan-vaculi-Moss-salpul-calcan-poaarc-petfri
BELA_T01_07	10/2002	65.4274	-164.100	L	0	0	Fmob	Plll	25	Hgwsmb	Lowland Sedge–Moss Fen Meadow	betnan-vacvit-caraqu	Moss-carrar-leddec-caraqu-empnig-vacvit-betnan
BELA_T02_01	14/2002	65.4723	-164.152	L	0	0	Ob	N	10	Hgwsmb	Lowland Sedge–Moss Fen Meadow	caraqu-salfus-sphag	Moss-eriang-potpal-calcan-erisch-petfri-salfus
BELA_T02_02	14/2002	65.4713	-164.155	P	0	0	Ltnc	N	15	Hgmbh	Lacustrine Moist Bluejoint Meadow	calcan-rumarc	Moss-calcan-petfri-poaarc-polacu-arttil-rumarc
BELA_T02_03	14/2002	65.4711	-164.155	P	0	0	Wlsi	W	0	Hgwfg	Lacustrine Grass Marsh	caraqu-calpal	arcful-calnat-calpal-hipvul-myrspi-ranhyp-potam
BELA_T02_04	14/2002	65.4728	-164.157	L	0	0	Ob	N	10	Hgwsmb	Lowland Sedge–Moss Fen Meadow	caraqu-salfus-sphag	Moss-caraqu-carcho-salfus-eriang-erisch-calcan
BELA_T02_05	14/2002	65.4736	-164.150	L	0	0	Ltic	Mi	25	Slcbw	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-betnan-salpul-petfri-pyrgra-calcan-empnig
BELA_T02_06	14/2002	65.4779	-164.151	L	0	0	Ltic	Fh	30	Slcbe	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-betnan-leddec-vaculi-vacvit-Lichen-empnig
BELA_T02_07	14/2002	65.4848	-164.143	L	0	0	Ob	Plll	25	Hgwsmb	Lowland Sedge–Moss Fen Meadow	caraqu-salfus-sphag	Moss-caraqu-carrar-erisch-vaculi-leddec-oxymic
BELA_T02_08	14/2002			U	0	0	Ell		25	Slott	Upland Moist Dwarf Birch–Tussock Shrub	erivag-betnan	Lichen-Moss-erivag-leddec-betnan-empnig-vacvit
BELA_T02_09	14/2002	65.4836	-164.134	L	0	0	Ob		5	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	water-Moss-caraqu-erisch-carrot-utrvul-carcho-salf
BELA_T03_01	10/2002	65.5524	-163.698	U	0	0	Vmo	Mrb	30	Hbl	Upland Dry Lichen	betnan-leddec-loipro	Lichen-cargla-castet-empnig-leddec-loipro-Moss
BELA_T03_02	10/2002	65.5531	-163.696	U	0	0	Vmo	Mrm	100	Slobe	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-leddec-loipro	Lichen-leddec-loipro-betnan-Moss-vaculi-vacvit
BELA_T03_03	10/2002	65.5568	-163.689	U	0	0	Vmo	Mrb	75	Hbl	Upland Dry Lichen	betnan-leddec-loipro	Lichen-Moss-empnig-fesrub-hiealp-loipro-potfru
BELA_T03_04	10/2002	65.5597	-163.680	L	0	0	Ell	Mrm	50	Slobw	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	betnan-vaculi-Moss-salpul-Lichen-carbig-leddec
BELA_T03_05	10/2002	65.5595	-163.678	U	0	0	Ob		20	Hgmt	Upland Moist Dwarf Birch–Tussock Shrub	erivag-betnan	Moss-erivag-betnan-carbig-empnig-leddec-rubcha
BELA_T04_01	13/2002	65.3838	-163.692	L	13	40	Ch	Mu	15	Stca	Lowland Moist Tall Alder–Willow Shrub	alncri-salpul-rubarc	alncri-Moss-equarv-salpul-calcan-lycann-valcap
BELA_T04_02	13/2002	65.3845	-163.695	L	6	40	Ch	Mu	15	Stca	Lowland Moist Tall Alder–Willow Shrub	alncri-salpul-rubarc	alncri-equarv-salpul-Moss-calcan-petfri-rubarc
BELA_T04_03	13/2002	65.3839	-163.696	U	12	50	Ch	Mu	15	Hgmsw	Upland Moist Sedge–Dryas Meadow	betnan-salpul-pyrgra	Moss-carbig-salric-vaculi-Lichen-arcalp-betnan
BELA_T04_04	13/2002	65.3830	-163.7	L	8	35	Ch	Mu	10	Stcw	Lowland Moist Low and Tall Willow Shrub	salpul-calcan	salpul-Moss-artarc-vaculi-betnan-fesalt-lycann
BELA_T04_05	13/2002	65.3815	-163.715	L	10	50	Ch	Mu	20	Stow	Lowland Moist Low and Tall Willow Shrub	salpul-calcan	salpul-Moss-equarv-artarc-calcan-valcap-dodfri
BELA_T04_06	13/2002	65.3814	-163.721	U	8	10	Ch	Mu	25	Hgmss	Upland Moist Sedge–Dryas Meadow	dryint-carbig-senatr	Moss-carbig-dryint-salret-equarv-salric-Lichen
BELA_T04_07	13/2002	65.3648	-163.723	U	17	280	Ch	Mu	10	Stoa	Upland Moist Tall Alder Shrub	alncri-salpul-rubarc	alncri-calcan-salpul-equarv-arttil-Moss-galbor
BELA_T04_08	13/2002	65.3619	-163.717	A	32	220	Sc	Mu	10	Sddt	Alpine Alkaline Dry Dryas Shrub	dryoct-potuni	dryoct-Lichen-artem-saxopp-carnar-Moss-oxynig
BELA_T05_01	10/2002	65.2855	-163.716	A	9	253	Ch	Fs	20	Bpv	Alpine Nonalkaline Dry Barrens	dryoct-salphl-hiealp	soil-Lichen-carpod-castet-empnig-loipro-salphl-luz
BELA_T05_02	10/2002	65.2911	-163.727	A	10	284	Ch	Dt	20	Sdds	Alpine Nonalkaline Dry Dryas Shrub	dryoct-salphl-hiealp	soil-Lichen-carpod-salphl-castet-Moss-luzul-empnig
BELA_T05_03	10/2002	65.2971	-163.741	A	12	240	Ch	N	50	Hbl	Alpine Nonalkaline Dry Barrens	dryoct-salphl-hiealp	Lichen-carpod-castet-empnig-loipro-minmac-Moss
BELA_T05_04	10/2002	65.2949	-163.752	A	20	220	Cs	N	10	Sdds	Alpine Nonalkaline Dry Dryas Shrub	dryoct-salphl-hiealp	dryoct-salphl-carpod-Lichen-anemo-anten-fesrub
BELA_T06_01	15/2002	65.3429	-162.812	U	5	90	Ch	N	10	Slobe	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-leddec-loipro	Lichen-betnan-vaculi-Moss-arcalp-carbig-vacvit
BELA_T06_02	15/2002	65.3432	-162.811	L	5	90	Ch	Ds	30	Stoa	Lowland Moist Tall Alder–Willow Shrub	alncri-salpul-rubarc	alncri-salpul-arttil-Moss-calcan-angluc-rubste
BELA_T06_03	15/2002	65.2767	-162.835	A	30	122	Ch	Mrb	40	Hbl	Alpine Nonalkaline Dry Barrens	dryoct-salphl-hiealp	Lichen-arcalp-Moss
BELA_T06_04	15/2002	65.2769	-162.835	A	0	0	Wldim	W	0	W	Alpine Lake		water
BELA_T06_05	15/2002	65.2774	-162.834	A	1	188	Ch	Mrb	30	Sdec	Alpine Nonalkaline Dry Dryas Shrub	dryoct-salphl-hiealp	Lichen-loipro-salphl-castet-carbig-Moss-anemul
BELA_T06_06	15/2002	65.2795	-162.831	L	0	0	Ob	Mu	25	Hgmss	outlier	dryint-carbig-senatr	Moss-Lichen-betnan-caraqu-vaculi-vacvit-carbig
BELA_T06_07	15/2002	65.2778	-162.825	A	0	0	Ch	Mrm	25	Sdds	Upland Moist Dryas–Sedge Shrub	dryoct-salphl-hiealp	Lichen-dryoct-salphl-vaculi-loipro-Moss-carpet
BELA_T06_08	15/2002	65.2812	-162.819	U	10	340	Ch	Ds	20	Slow	Upland Moist Low Willow Shrub	salgla-dryint	salpul-Lichen-dryoct-Moss-salarc-carbig-castet
BELA_T06_09	15/2002	65.2833	-162.823	A	6	5	Ch	Mrb	100	Hbl	Alpine Nonalkaline Dry Barrens	dryoct-salphl-hiealp	Lichen-soil
BELA_T06_10	15/2002	65.286	-162.825	U	6	90	Ch	Mrm	20	Sdet	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-leddec-loipro	Lichen-loipro-arcalp-vaculi-empnig-carbig-carpod
BELA_T07a_01	13/2002	65.5051	-163.566	U	0	0	Vmy	Mrb	30	Hbl	Upland Dry Lichen	betnan-leddec-loipro	Lichen-empnig-loipro-alncri-carex-leddec-Moss
BELA_T07a_02	13/2002	65.5051	-163.566	U	0	0	Vmy	N	50	Hbl	Upland Dry Lichen	betnan-leddec-loipro	Lichen-betnan-loipro-alncri-empnig-vaculi-hiealp

Appendix 2. Continued.

Site ID	Date	LatDD83	LongDD83	Physiog	Slope	Aspect	Geom Unit	Microtopo	MicroRel	VegClass	Ecotype	Floristic Class	Dominant Plants
BELA_T08_01	13/2002	65.6670	-164.269	A	0	0	Sc	N	5	Bpv	Alpine Alkaline Dry Barrens	dryoct-potuni	soil-Lichen-dryoct-saxopp-carex-oxyarc-oxynig-phls
BELA_T08_02	13/2002	65.6674	-164.272	A	8	295	Ch	Ff	20	Sddl	Alpine Alkaline Dry Dryas Shrub	dryint-rholap	Lichen-dryint-Moss-castet-salarc-arcrub-potbif
BELA_T08_03	13/2002	65.6667	-164.265	A	4	120	Ch	Ff	30	Sddl	Alpine Alkaline Dry Dryas Shrub	dryint-rholap	Lichen-dryint-eritr-Moss-salarc-arcrub-carbig
BELA_T08_04	13/2002	65.6606	-164.266	A	8	170	Ch	Ff		Bpv	Alpine Alkaline Dry Barrens	dryoct-potuni	soil-dryoct-Lichen-Moss-carex-carrup-potuni-anemo
BELA_T08_05	13/2002	65.6572	-164.263	U	12	110	Ch	Mw	35	Slow	Upland Moist Low Willow Shrub	salgla-dryint	salret-salgla-equarv-salric-dryint-Moss-salpul
BELA_T09_01	11/2002	65.7655	-164.192	A	15	120	Ch	N	5	Bpv	Alpine Alkaline Dry Barrens	dryoct-potuni	soil-dryoct-Lichen-kobre-potuni-saxopp-Moss-oxynig
BELA_T09_02	11/2002	65.7645	-164.188	A	25	120	Ch	N	5	Sddl	Alpine Alkaline Dry Dryas Shrub	dryoct-potuni	dryoct-Lichen-phlsib-arcrub-artfur-carex-castet
BELA_T09_03	11/2002	65.7658	-164.187	A	10	20	Ch	N	5	Sddt	Alpine Alkaline Dry Dryas Shrub	dryint-rholap	dryint-Moss-Lichen-arcrub-salarc-equarv-potbif
BELA_T09_04	11/2002	65.7639	-164.179	U	20	120	Cs	Ft	15	Sdds	Upland Moist Dryas–Sedge Shrub	dryint-rholap	dryint-Lichen-Moss-salarc-arcrub-castet-rholap
BELA_T09_05	11/2002	65.7629	-164.167	L	10	80	Ch	N	10	Slcw	Lowland Moist Low and Tall Willow Shrub	salric-fesalt	equarv-salhas-Moss-salret-fesalt-potfru-aneric
BELA_T10_01	11/2002	65.8393	-164.038	R	0	0	Wrun	W		W	Riverine Water		water
BELA_T10_02	11/2002	65.8393	-164.037	R	3	350	Fmrac	Dc	5	Bbg	Riverine Barrens	epilat-agrmac	soil-carbig-epilat-salhas-stehum
BELA_T10_03	11/2002	65.8386	-164.038	R	1	355	Fmrac	Dc	10	Bpv	Riverine Barrens	epilat-agrmac	soil-fesrub-oxybor-Moss-artarc-salala-trispi-agrop
BELA_T10_04	11/2002	65.8382	-164.037	R	0	0	Fmoi	N	0	Slcw	Riverine Moist Low Willow Shrub	salala-astsib	Moss-salala-salric-salnip-rubarc-salarb-salgla
BELA_T10_05	11/2002	65.8378	-164.036	R	0	0	Fmoi	Fh	20	Slow	Riverine Moist Low Willow Shrub	salala-astsib	Moss-salala-carbig-salgla-betnan-salpul-salret
BELA_T10_06	11/2002	65.8374	-164.034	L	0	0	Fmob	Fh	30	Hgwsb	outlier	betnan-salpul-pyrgra	Moss-eriang-carbig-carsax-eriop-betnan-salret
BELA_T10_07	11/2002	65.8349	-164.024	U	3	350	Ch	N	30	Hgmt	Upland Moist Dwarf Birch–Tussock Shrub	erivag-betnan	Moss-Lichen-erivag-empnig-leddec-betnan-carbig
BELA_T10_08	11/2002	65.836	-164.036	R	0	0	Fmoi	Fh	15	Hgmss	outlier	dryint-carbig-senatr	Moss-carbig-eriang-dryint-salret-salhas-arcrub
BELA_T11_01	15/2002	65.8391	-163.498	A	4	300	Sc	N	5	Sddt	Alpine Alkaline Dry Dryas Shrub	dryoct-potuni	soil-dryoct-Lichen-carex (2%)-oxyarc-saxopp-artsen
BELA_T11_02	15/2002	65.8376	-163.495	A	12	50	Sc	N	5	Bpv	Alpine Alkaline Dry Barrens	dryoct-potuni	soil-dryoct-Lichen-hedmac-oxyarc-potuni-anemul-arc
BELA_T11_03	15/2002	65.8407	-163.510	U	8	310	Ch	Mu	30	Hgmss	Upland Moist Sedge–Dryas Meadow	dryint-carbig-senatr	Moss-Lichen-salarc-carsci-arcrub-carmem-rholap
BELA_T11_04	15/2002	65.8396	-163.518	L	12	310	Ch	Mg	30	Slow	Lowland Moist Low and Tall Willow Shrub	salric-fesalt	salret-Moss-salric-arcrub-dryint-equarv-fesalt
BELA_T11_05	15/2002	65.8400	-163.52	R	2	190	Fhmo	N	10	Slow	Riverine Moist Low Willow Shrub	salric-fesalt	Moss-salgla-arcrub-fesalt-betnan-potfru-salret
BELA_T11_06	15/2002	65.8399	-163.520	R	2	180	Wrun	W	0	W	Riverine Water		water
BELA_T11_07	15/2002	65.8367	-163.527	U	10	120	Ch	Mg	40	Hgmsd	Upland Moist Sedge–Dryas Meadow	dryint-carbig-senatr	Moss-dryint-saxopp-salarc-arcrub-caratr-carrot
BELA_T11_08	15/2002	65.8328	-163.519	L	4	290	Ch	Fh	20	Stow	Lowland Moist Low and Tall Willow Shrub	salric-fesalt	Moss-salric-fesalt-polacu-salret-equarv-anepar
BELA_T11_09	15/2002	65.8337	-163.518	U	5	270	Ch	Fs	10	Hgmsd	Upland Moist Sedge–Dryas Meadow	dryint-carbig-senatr	dryint-Moss-Lichen-salarc-andpol-arcrub-carmem
BELA_T12_01	15/2002	65.8338	-164.546	A	0	0	Ch	N	15	Bpv	Alpine Nonalkaline Dry Barrens	dryoct-salphl-hiealp	soil-Lichen-dryoct-carbig-salphl-saxif-silaca-anem
BELA_T12_02	15/2002	65.8347	-164.542	A	25	40	Ch	Mrb	30	Bpv	Alpine Nonalkaline Dry Barrens	dryoct-salphl-hiealp	soil-Lichen-Moss-salphl-castet-dialap-dryoct-geugl
BELA_T12_03	15/2002	65.8368	-164.539	A	6	45	Ch	Mrm	20	Sddl	Alpine Nonalkaline Dry Dryas Shrub	dryoct-salphl-hiealp	Lichen-dryoct-castet-Moss-dialap-carbig-geugla
BELA_T12_04	15/2002	65.8381	-164.538	L	6	54	Ch	Mrm	25	Hgwswt	outlier	caraqu-salfus-sphag	Moss-eriang-salret-salarc-caraqu-salpul-petfri
BELA_T12_05	15/2002	65.8388	-164.541	U	2	50	Cs	Mi	35	Slobe	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-Lichen-eriang-betnan-caraqu-salarc-erirus
BELA_T12_06	15/2002	65.8408	-164.536	U	6	80	Cs	Mi	40	Slobe	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-leddec-loipro	Lichen-Moss-betnan-vaculi-carbig-leddec-salarc
BELA_T12_07	15/2002	65.8443	-164.531	L	10	40	Cs	Mi	40	Sdev	outlier	betnan-salpul-pyrgra	Moss-Lichen-vaculi-castet-salpul-vacvit-carpod
BELA_T13_01	12/2002	66.0191	-165.175	L	0	0	Ltim	Mt	20	Slobe	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-leddec-vacvit-betnan-Lichen-rubcha-erivag
BELA_T13_02	12/2002	66.0161	-165.170	L	0	0		Fh	20	Hgwsbt	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-caraqu-Lichen-leddec-empnig-betnan-rubcha
BELA_T13_03	12/2002	66.0147	-165.169	L	15	320	Cs	Mt	30	Slobw	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-betnan-Lichen-empnig-leddec-salpul-vacvit
BELA_T13_04	12/2002	66.0123	-165.168	U	0	0	Ell	Tm	30	Slobe	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Lichen(50)-Moss-leddec-empnig-vacvit-rubcha-erivag
BELA_T13_05	12/2002	66.011	-165.165	U	12	160	Ell	N	20	Slcbe	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-betnan-leddec-vacvit-Lichen-carbig-erivag
BELA_T13_06	12/2002	66.0081	-165.160	L	0	0	Ob	W	5	Hgwsmb	Lowland Sedge–Moss Fen Meadow	caraqu-salfus-sphag	Moss-caraqu-eriang-leddec-Lichen-betnan-vaculi
BELA_T13_07	12/2002	66.0085	-165.152	L	7	1	Cs	N	0	Slcw	Lowland Moist Low and Tall Willow Shrub	salpul-calcan	Moss-equarv-salpul-eriang-vaculi-arclat-betnan
BELA_T13_08	12/2002	66.0088	-165.152	P	0	0	Wlsit	W		W	Lowland Lake	caraqu-calpal	water-arcful-caraqu-eriang-hipvul-Moss-potpal
BELA_T14_01	14/2002	66.0771	-165.209	R	0	0	Wrln	N		W	Riverine Water		water
BELA_T14_02	14/2002	66.0772	-165.209	R	2	160	Fmoa	Dr	4	Bbg	Riverine Barrens	epilat-agrmac	soil-salpul-Moss-agrbor-calam-elymol-epilat-salala
BELA_T14_03	14/2002	66.0774	-165.210	R	0	0	Fmoa	Dr	3	Hgdl	Riverine Barrens	epilat-agrmac	elymol-salbar-salala-salpul-arttil-epiang-agrbor
BELA_T14_04	14/2002	66.0776	-165.21	R	0	0	Fmoa	N	2	Stcaw	Riverine Moist Tall Alder–Willow Shrub	alncri-salbar	salbar-alncri-arclat-salala-Moss-salarb-salpul
BELA_T14_05	14/2003	66.0776	-165.21	R	0	0	Fmoi	N	5	Stca	Riverine Moist Tall Alder–Willow Shrub	alncri-salbar	alncri-arclat-Moss-petfri-arttil-Lichen-salala

Appendix 2. Continued.

Site ID	Date	LatDD83	LongDD83	Physiog	Slope	Aspect	Geom Unit	Microtopo	MicroRel	VegClass	Ecotype	Floristic Class	Dominant Plants
BELA_T14_06	14/2002	66.0778	-165.21	R	0	0	Fmoi	Mu	10	Stoa	Riverine Moist Tall Alder–Willow Shrub	alncri-salbar	alncri-arclat-Moss-petfri-salnip-salarb-salric
BELA_T14_07	14/2002	66.0781	-165.209	R	0	0	Fmoi	Fh	25	Slobw	Riverine Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-salpul-carbig-erivag-salgla-rubcha-arcrub
BELA_T14_08	14/2002	66.0788	-165.209	L	0	0	Fmob	Mu	30	Slobw	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-salpul-caraqu-eriang-betnan-vaculi-alncri
BELA_T14_09	14/2002	66.0799	-165.307	L	0	0	Fmob	Mu	10	Slobb	Lowland Wet Dwarf Birch–Ericaceous Shrub	caraqu-salfus-sphag	Moss-caraqu-andpol-eriang-salpul-betnan-chacal
BELA_T14_10	14/2002	66.0802	-165.207	R	0	0	Fmoi	Mu	15	Slcbw	Riverine Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	salpul-Moss-petfri-arclat-betnan-vaculi-rubcha
BELA_T14_11	14/2002	66.081	-165.206	L	0	0	Fmob	Plll	3	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	Moss-caraqu-carcho-eriang-carex-carmem-andpol
BELA_T14_12	12/2002	66.0819	-165.206	L	0	0	Fmob	W	0	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	Moss-caraqu-carcho-erirus-potpal-dupfis-eriang
BELA_T14_13	14/2002	66.0823	-165.208	R	0	0	Wldir	W	0	W	Riverine Water		water
BELA_T16_01	12/2002	66.283	-165.293	P	0	0	Of	N	5	Hgwsb	Lowland Sedge Fen Meadow	caraqu-calpal	eriang-Moss-calpal-caraqu-calcan-ranpal-rumarc
BELA_T16_02	12/2002	66.2846	-165.296	L	0	0	Ob	Plll	30	Hgwsmb	Lowland Sedge–Moss Fen Meadow	caraqu-salfus-sphag	Moss-caraqu-andpol-erirus-betnan-carrot-empnig
BELA_T16_03	12/2002	66.2862	-165.303	L	0	0	Of	N	5	Hgwfs	Lowland Sedge Fen Meadow	caraqu-carcho	caraqu-eriang-erirus-mentri-salfus-pedpen
BELA_T16_04	12/2002	66.2883	-165.309	U	0	0	Ltic		20	Hgmt	Upland Moist Dwarf Birch–Tussock Shrub	erivag-betnan	Lichen-leddec-Moss-erivag-vacvit-empnig-rubcha
BELA_T16_05	12/2002	66.2919	-165.316	L	0	0	Ltim	M	25	Slcbe	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	betnan-leddec-empnig-Moss-vacvit-vaculi-Lichen
BELA_T16_06	12/2002	66.2932	-165.323	L	0	0	Ltic	Plll	15	Hgwsbt	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Lichen-Moss-caraqu-betnan-empnig-rubcha-leddec
BELA_T17_01	14/2002	66.1951	-164.086	C	0	0	Wertg	W	0	W	Coastal Water		salt water
BELA_T17_02	14/2002	66.1951	-164.087	C	0	0	Mta	N	10	Bbg	Coastal Barrens	carram-pucphr	soil-carsub-Moss-chrarc-elymol-potege-stehum
BELA_T17_03	14/2002	66.1953	-164.087	C	0	0	Mti	Mu	15	Hgwhss	Coastal Saline Wet Sedge–Grass Meadow	carram-pucphr	carram-carsub-chrarc-potege-algae-stehum-chrarc
BELA_T17_04	14/2002	66.1956	-164.084	C	0	0	Mta	N	10	Hgwhsgb	Coastal Saline Wet Sedge–Grass Meadow	carram-pucphr	chrarc-caldes-carsub-elymol-pucphr-carram-stehum
BELA_T17_05	14/2002	66.1964	-164.085	C	0	0	Mti	N	15	Hgwhsgs	Coastal Saline Wet Sedge–Grass Meadow	carram-pucphr	carram-pucphr-chrarc-potege-elymol-stehum
BELA_T17_06	14/2002	66.1984	-164.084	C	0	0	Welt	W		W	Coastal Water		water
BELA_T17_07	14/2002	66.2003	-164.085	C	0	0	Mti	Mu	45	Hgwhsgb	Coastal Saline Wet Sedge–Grass Meadow	carram-pucphr	carram-pucphr-chrarc-potege-elymol-stehum
BELA_T17_08	14/2002	66.2002	-164.091	C	0	0	Mti	N	45	Hgwhsgs	Coastal Saline Wet Sedge–Grass Meadow	carram-pucphr	carram-potege-elymol-chrarc-pucphr-stehum
BELA_T17_09	14/2002	66.2001	-164.093	C	0	0	Mti	N	45	Hgwhsgs	Coastal Saline Wet Sedge–Grass Meadow	carram-pucphr	potege-carram-caldes-chrarc-elymol-pucphr-saunud
BELA_T18_01	11/2002	66.5911	-163.814	C	0	0	Wmn	W	0	W	Coastal Water		water
BELA_T18_02	11/2002	66.5908	-163.814	C	2	340	Mba	N	0	Bbg	Coastal Barrens		soil-Moss
BELA_T18_03	12/2002	66.59	-163.814	C	10	10	Esac	Es	50	Bpv	Coastal Barrens	elymol-latmar	soil-elymol-honpep-Moss-arttil-fesrub-latmar-salov
BELA_T18_04	12/2002	66.5903	-163.814	C	0	0	Esac	Eb	40	Bpv	outlier	elymol-latmar	soil-Moss-junarc-arttil-astsib-casti-cocoff-elymol
BELA_T18_05	12/2002	66.589	-163.816	U	5	180	Esic	Es	100	Sdee	Upland Dry Crowberry Shrub	empnig-elymol	Lichen-empnig-Moss-potuni-vaculi-elymol-betnan
BELA_T18_06	12/2002	66.5866	-163.818	U	0	0	Esic	Es	100	Sdee	Upland Dry Crowberry Shrub	empnig-elymol	Lichen-empnig-Moss-betnan-vacvit-arcalp-leddec
BELA_T18_07	12/2002	66.5864	-163.82	L	3	180	Ob	Fh	30	Hgmss/Sloe	outlier	betnan-vacvit-caraqu	Lichen-Moss-caraqu-salpul-vacvit-vaculi-betnan
BELA_T18_08	12/2002	66.5852	-163.814	L	0	0	Of	N	30	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	caraqu-eriang-carcho-erirus-Moss-carmem-salfus
BELA_T18_09	12/2002	66.5843	-163.814	P	0	0	Wlsi	W	0	W	Lowland Lake		water
BELA_T19_01	11/2002	66.4695	-163.842	L	0	0	Ltnc	N	20	Slobw	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	salpul-betnan-eriang-Moss-caraqu-casele-empnig
BELA_T19_02	11/2002	66.4704	-163.845	L	0	0	Ltnm	N	20	Sloeb	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-caraqu-vaculi-empnig-betnan-vacvit-andpol
BELA_T19_03	11/2002	66.4723	-163.851	L	0	0	Ob	Phh	60	Slobe	outlier	betnan-leddec-loipro	Lichen-Moss-betnan-leddec-vacvit-erivag-rubcha
BELA_T19_04	11/2002	66.4716	-163.86	P	0	0	Ltnc	N	20	Hgmbh	Lacustrine Moist Bluejoint Meadow	calcan-rumarc	Moss-calcan-petfri-valcap-poaarc-arnalp-caraqu
BELA_T19_05	11/2002	66.471	-163.869	L	0	0	Of	Plll	30	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	water-eriang-Moss-caraqu-erirus-andpol-betnan-carm
BELA_T19_06	11/2002	66.4669	-163.876	P	0	0	Ltnm	F	10	Hgwfs	Lacustrine Sedge Marsh	caraqu-calpal	caraqu-eriang-potpal-Moss-salfus-polacu
BELA_T21_01	12/2002	66.4484	-165.246	C	0	0	Mta	N	5	Hgwhsgb	Coastal Brackish Wet Sedge–Grass Meadow	salova-descae	Moss-carram-descae-caldes-caramb-saxexi-pedsud
BELA_T21_02	12/2002	66.4480	-165.248	C	0	0	Welsc	W	0	W	Coastal Water		water
BELA_T21_03	13/2002	66.4491	-165.257	C	2	340	Mba	N	5	Bbg	Coastal Barrens		soil
BELA_T21_04	13/2002	66.4485	-165.256	C	0	0	Mti	Mu	15	Hgwhgb	Coastal Brackish Wet Sedge–Grass Meadow	salova-descae	salova-caldes-arclat-carram-dupfis-Moss-junalb
BELA_T21_05	13/2002	66.448	-165.262	C	0	0	Esac	Es	50	Hgdl	Coastal Dry Dunegrass Meadow	elymol-latmar	litteralone-elymol-arttil-chrbip-descae-Moss-carbi
BELA_T21_06	13/2002	66.4448	-165.26	C	0	0	Mti		5	Hgwswt	outlier	salova-descae	carbig-Moss-salova-descae-dupfis-eriang-carcan
BELA_T21_07	13/2002	66.4425	-165.263	C	0	0	Mti	N	2	Hgwhsgb	Coastal Brackish Wet Sedge–Grass Meadow	carram-pucphr	carram-caldes-descae-stehum-poten
BELA_T21_08	13/2002	66.4413	-165.264	U	1	130	Esic	Es	20	Sdee	Upland Dry Crowberry Shrub	empnig-elymol	empnig-salova-Lichen-latmar-Moss-casele-elymol
BELA_T21_09	13/2002	66.4417	-165.266	U	1	120	Esic	Es	60	Sdee	Upland Dry Crowberry Shrub	empnig-elymol	empnig-Lichen-elymol-latmar-Moss-armmar-chrbip

Appendix 2. Continued.

Site ID	Date	LatDD83	LongDD83	Physiog	Slope	Aspect	Geom Unit	Microtopo	MicroRel	VegClass	Ecotype	Floristic Class	Dominant Plants
BELA_T21_10	13/2002	66.4415	-165.267	P	0	0	Wlsid	W		Hafm	Lacustrine Marestail Marsh	hipvul-potam	water-hipvul-calpal-rumarc-potam
CAKR_T01_01	11/2003	67.1327	-162.905	L	6	140	Ch	Mu	80	Fnwws	Upland Moist Spruce Forest	picgla-salpul	Moss-salpul-carbig-picgla-salric-betnan-petfri
CAKR_T01_02	11/2003	67.1351	-162.908	U	23	150	Ch	Mg	40	Fnows	Upland Moist Spruce Forest	picgla-salpul	Moss-picgla-salgla-arcalp-potfru-salpul-dryint
CAKR_T01_03	11/2003	67.1366	-162.907	A	24	150	Ch	Mg	60	Sddt	Alpine Alkaline Dry Dryas Shrub	dryoct-potuni	dryoct-Moss-Lichen-picgla-potfru-aneric-juncom
CAKR_T01_04	11/2003	67.1381	-162.910	A	15	125	Sc	N	5	Bpv	Alpine Alkaline Dry Barrens	dryint-rholap	soil-dryint-saxopp-Lichen-minarc-oxynig-anepar-art
CAKR_T01_05	11/2003	67.1429	-162.912	L	5	10	Ch	Mu -th	70	Fnows	Upland Moist Spruce Forest	picgla-salpul	Moss-equarv-picgla-petfri-rubcha-salpul-salric
CAKR_T02_01	11/2003	67.1455	-163.033	U	6	200	Ch	Mt	25	Hgmss	Upland Moist Sedge–Dryas Meadow	dryint-equarv	Moss-dryint-salret-carlug-Lichen-equarv-salgla
CAKR_T02_02	11/2003	67.1466	-163.032	U	16	220	Ch	Mg	40	Stoa	Upland Moist Tall Alder Shrub	alncri-salpul-rubarc	alncri-arclat-galbor-merpan-caratr-epiang-equarv
CAKR_T02_03	11/2003	67.1471	-163.031	U	26	200	Ch	Mg	50	Sddt	outlier	dryint-rholap	dryint-rholap-salret-arcrub-potfru-salgla-vaculi
CAKR_T02_04	11/2003	67.1474	-163.026	A	26	200	Ct	N	25	Bpv	Alpine Alkaline Dry Barrens	dryoct-potuni	soil-dryoct-carpet-hedmac-artfur-minarc-phlsib-pot
CAKR_T02_05	11/2003	67.1498	-163.020	A	8	100	Bxw	N	15	Sddt	Alpine Alkaline Dry Dryas Shrub	dryoct-potuni	dryoct-Lichen-hedmac-oxybry-carpet-saxopp-andcha
CAKR_T02_06	11/2003	67.1548	-163.018	U	23	10	Ch	Rm	40	Sddl	Alpine Alkaline Dry Dryas Shrub	dryint-rholap	dryala-Lichen-carsci-castet-hedalp-arcrub-salarc
CAKR_T02_07	11/2003	67.1560	-163.017	U	3	5	Ch	Fh	40	Sddf	Lowland Moist Dryas–Forb Shrub	dryint-equarv	Moss-dryint-equarv-carbig-arcrub-salarc-salret
CAKR_T04_01	16/2003	67.0849	-163.484	C	3	350	Mba	N	5	Hgdl	Coastal Dry Dunegrass Meadow	elymol-latmar	elymol-latmar-festu-poaarc-bromu-arttil-cnicni
CAKR_T04_02	16/2003	67.0856	-163.475	L	0	0	Fdob	Fh	50	Sdee	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-empnig-betnan-vacvit-carrar-rubcha-salova
CAKR_T04_03	16/2003	67.0894	-163.472	C	0	0	Mti	N	10	Hgwhsb	Coastal Brackish Wet Sedge–Grass Meadow	carram-dupfis	carram-cocoff-dupfis-poaarc-stehum-caraqu-salfus
CAKR_T04_04	16/2003	67.0903	-163.473	C	0	0	Mti	N	5	Hgwhsb	Coastal Brackish Wet Sedge–Grass Meadow	carram-dupfis	carram-stehum-cocoff-calhol-cheno-dupfis-chrbip
CAKR_T04_05	16/2003	67.0905	-163.473	C	0	0	Wert	W	0	W	Coastal Water		water
CAKR_T04_06	16/2003	67.0903	-163.477	C	0	0	Wels	W	0	W	Coastal Water		water
CAKR_T04_07	16/2003	67.0937	-163.485	C	0	0	Mti	N	5	Hgwhsgb	Coastal Brackish Wet Sedge–Grass Meadow	carram-dupfis	carram-calhol-dupfis-salova-stehum-cocoff-potege
CAKR_T05_00	16/2003	67.0906	-163.568	C	0	0	Mba	n		Bbg	Coastal Barrens		soil
CAKR_T05_01	16/2003	67.0907	-163.567	C	0	0	Mba	n	5	Hgdl	Coastal Dry Dunegrass Meadow	elymol-latmar	elymol-latmar-arttil-cnicni-fesrub-honpep-mermar
CAKR_T05_02	16/2003	67.0909	-163.567	U	0	0	Mbi	n		Hfd	Outlier	elymol-latmar	Moss-fesrub-latmar-buptri-cascau-conchi-epilat
CAKR_T05_03	16/2003	67.0938	-163.565	U	0	0	Mbi	n	10	Sdee	Upland Dry Crowberry Shrub	empnig-elymol	Lichen-empnig-arcrub-Moss-epilat-elymol-salret
CAKR_T05_04	15/2003	67.0887	-163.532	U	0	0	Mbi	Phl	10	Sdee	outlier	betnan-leddec-loipro	empnig-Lichen-Moss-saxtri-vaculi-betnan-epilat
CAKR_T06_01	14/2003	67.2697	-163.67	L	0	0	Of	N	0	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	caraqu-carcho-Moss-eriang-carmem-erirus-utrmac
CAKR_T06_02	14/2003	67.1834	-163.597	L	0	0	Ob	N	10	Hgwsmb	Lowland Sedge–Moss Fen Meadow	caraqu-salfus-sphag	Moss-caraqu-betnan-salpul-eriang-carrar-erirus
CAKR_T06_03	14/2003	67.1847	-163.596	P	0	0	Of	N	0	Hgwsb	Lowland Sedge Fen Meadow	caraqu-calpal	potpal-caraqu-calpal-eriang-ranpal-calcan-salpul
CAKR_T06_04	14/2003	67.1856	-163.595	P	0	0	Wldit	W		W	Lowland Lake		water
CAKR_T06_05	14/2003	67.1832	-163.614	L	0	0	Ltic	N	0	Slobe	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-betnan-vacvit-leddec-petfri-salpul-vaculi
CAKR_T06_06	14/2003	67.1840	-163.613	P	0	0	Wldit	w	0	Hafm	Lacustrine Marestail Marsh		water-hipvul
CAKR_T06_07	14/2003	67.1865	-163.610	L	0	0	Of	N	0	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	eriang-caraqu-carcho-erirus-utrmac-pedic
CAKR_T06_08	14/2003	67.1877	-163.611	L	0	0	Ob	Mpm	0	Slobe	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-betnan-vacvit-leddec-vaculi-empnig-Lichen
CAKR_T06_09	14/2003	67.1897	-163.620	L	0	0	Ob	Fh	20	Slobb	Lowland Wet Dwarf Birch–Ericaceous Shrub	betnan-vacvit-caraqu	Moss-caraqu-vaculi-betnan-carrar-empnig-erirus
CAKR_T07_01	14/2003	67.2721	-163.614	U	1	330	Ch	N	25	Hgmt	Upland Moist Dwarf Birch–Tussock Shrub	erivag-betnan	Moss-Lichen-leddec-vacvit-carbig-empnig-erivag
CAKR_T07_02	14/2003	67.2721	-163.623	U	2	300	Ch	N	50	Hgmbh	outlier	calcan-rumarc	Moss-calcan-caraqu-petfri-dodfri-equarv-eriang
CAKR_T07_03	14/2003	67.273	-163.628	L	1	300	Ch	D	5	Slcw	Lowland Moist Low and Tall Willow Shrub	salpul-calcan	petfri-salpul-Moss-calcan-equarv-valcap-acodel
CAKR_T07_04	14/2003	67.2749	-163.627	R	0	0	Fmric	N	10	Stcw	Riverine Moist Tall Willow Shrub	salala-astsib	salala-Moss-equarv-salric-petfri-merpan-arttil
CAKR_T07_05	14/2003	67.2728	-163.651	U	5	170	Ch	Ff	25	Sdds	Upland Moist Dryas–Sedge Shrub	dryint-rholap	dryint-Lichen-Moss-rholap-carsci-arcrub-castet
CAKR_T07_06	14/2003	67.273	-163.658	U	3	130	Ch	Fh	40	Hgmsd	Upland Moist Sedge–Dryas Meadow	dryint-carbig-senatr	Moss-dryint-Lichen-arcrub-salarc-salret-caraqu
CAKR_T07_07	14/2003	67.2705	-163.665	A	3	60	Ch	N,Ff	10	Sddt	Alpine Alkaline Dry Dryas Shrub	dryoct-potuni	dryoct-Lichen-anedru-carfra-fesalt-saxopp-carglac
CAKR_T08_01	13/2003	67.3507	-163.721	R	0	0	Wrln	W	0	W	Riverine Water		water
CAKR_T08_02	13/2003	67.3512	-163.723	R	0.5	20	Fmrac	N	3	Bbg	Riverine Barrens	epilat-agrmac	soil-epilat-salala-allsch-arclat-fesrub-wilphy
CAKR_T08_03	13/2003	67.3510	-163.724	R	0.5	10	Fmrac	N	20	Bpv	Riverine Barrens	epilat-agrmac	soil-epilat-salnip-salala-astsib-fesrub-arclat-poa
CAKR_T08_04	13/2003	67.3507	-163.723	R	0	0	Fmoa	N	5	Stcw	Riverine Moist Tall Willow Shrub	salala-astsib	salric-salala-Moss-salgla-caraqu-potfru-salnip
CAKR_T08_05	13/2003	67.3507	-163.724	R	0	0	Fmoi	N	20	Slow	Riverine Moist Low Willow Shrub	salric-fesalt	arcrub-salric-Moss-salret-salpul-salgla-fesalt
CAKR_T08_06	13/2003	67.3499	-163.723	R	0	0	Fmoi	N	20	Slow	Riverine Moist Low Willow Shrub	salric-fesalt	Moss-dryint-salpul-salret-vaculi-arcrub-carbig

Appendix 2. Continued.

Site ID	Date	LatDD83	LongDD83	Physiog	Slope	Aspect	Geom Unit	Microtopo	MicroRel	VegClass	Ecotype	Floristic Class	Dominant Plants
CAKR_T08_07	13/2003	67.3491	-163.724	L	0	0	Fmob	N	25	Slott	Upland Moist Dwarf Birch–Tussock Shrub	betnan-salpul-pyrgra	Moss-betnan-salpul-erivag-rubcha-petfri-carbig
CAKR_T08_08	13/2003	67.3480	-163.724	L	0	0	Fmob	Ms	40	Hgwsb	Lowland Sedge Fen Meadow	caraqu-carcho	carsax-Moss-carcho-caraqu-carrar-eriang-pedsud
CAKR_T08_09	13/2003	67.3493	-163.721	R	0	0	Fmoa	Es?	35	Stow	Riverine Moist Tall Willow Shrub	salala-astsib	galbor-salnip-arcrub-salala-salret-Moss-equarv
CAKR_T08_10	13/2003	67.3507	-163.721	R	0	0	Fmrif	N	5	Slow	outlier	dryint-rholap	Moss-salnip-dryint-luparc-epilat-oxybor-potfru
CAKR_T10_01	13/2003	67.4899	-163.378	A	0	0	Bxw	N	15	Sddt	Alpine Alkaline Dry Dryas Shrub	dryoct-potuni	dryoct-Lichen-carnar-saxopp-hedmac-andcha-artarc
CAKR_T10_02	13/2003	67.4899	-163.382	U	3	200	Ch	M	30	Hgmss	Upland Moist Sedge–Dryas Meadow	dryint-equarv	Moss-dryint-Lichen-equarv-salret-castet-salarc
CAKR_T10_03	13/2003	67.4846	-163.418	L	10	320	Of	Dt	20	Stow	Lowland Moist Low and Tall Willow Shrub	salpul-calcan	Moss-salret-petfri-salric-rubarc-salpul-equarv
CAKR_T10_04	13/2003	67.4841	-163.419	U	6	220	Ch	Mg	40	Hgmss	Upland Moist Sedge–Dryas Meadow	dryint-equarv	Moss-dryint-Lichen-salret-equarv-carbig-arcrub
CAKR_T10_05	13/2003	67.4837	-163.421	U	10		Ch	Mg	35	Sddt	Alpine Alkaline Dry Dryas Shrub	dryint-rholap	Lichen-Moss-dryint-castet-arcrub-salret-vaculi
CAKR_T11_01	11/2003	67.479	-163.733	R	0	0	Wrln	w	0	W	Riverine Water		water
CAKR_T11_02	11/2003	67.4789	-163.733	R	2	20	Fmrac	N	5	Bbg	Riverine Barrens		soil
CAKR_T11_03	11/2003	67.4785	-163.733	R	0	0	Fmrac	N	20	Bpv	Riverine Barrens	epilat-agrmac	soil-epilat-salala-astsib-salhas-Moss-agrop-arclat
CAKR_T11_04	11/2003	67.4776	-163.733	R	0	0	Fmric	N	5	Stow	Riverine Moist Tall Willow Shrub	salala-astsib	salala-Moss-Lichen-artarc-cascau-fesalt-epilat
CAKR_T11_05	11/2003	67.4771	-163.731	R	0	0	Fmric	N	15	Slcbw	Riverine Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-betnan-salgla-salpul-petfri-vaculi-arclat
CAKR_T11_06	11/2003	67.4757	-163.735	R	0	0	Fmric	N	20	Stow	Riverine Moist Tall Willow Shrub	salala-astsib	salala-Moss-galbor-Lichen-potfru-salhas-arcrub
CAKR_T11_07	11/2003	67.4751	-163.730	R	0	0	Fmoi	N	20	Slcbw	Riverine Moist Dwarf Birch–Willow Shrub	salpul-calcan	salpul-Moss-betnan-calcan-salric-equarv-potfru
CAKR_T11_08	11/2003	67.4728	-163.729	R	0	0	Fmoi	Y	10	Slcb	Riverine Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	betnan-Moss-vacvit-calam-Lichen-polbis-pyrgra
CAKR_T12_01	12/2003	67.5951	-163.728	A	0	0	Bxw	N	50	Sddl	Alpine Nonalkaline Dry Dryas Shrub	dryoct-salphl-hiealp	Lichen-dryoct-Moss-dialap-salphl-hiealp-selsel
CAKR_T12_02	12/2003	67.5956	-163.725	A	16	60	Ct	N	2	Hbl	Alpine Nonalkaline Dry Barrens	dryoct-salphl-hiealp	Lichen-Moss-artarc-salphl-anenar-carpod-dialap
CAKR_T12_03	12/2003	67.5937	-163.725	A	14	120	Ch	N	60	Sddl	Alpine Nonalkaline Dry Dryas Shrub	dryoct-salphl-hiealp	Lichen-dryoct-Moss-dialap-salphl-leddec-anenar
CAKR_T12_04	12/2003	67.5923	-163.725	A	6	140	Ch	Mu	50	Sddt	Alpine Nonalkaline Dry Dryas Shrub	dryoct-salphl-hiealp	Lichen-dryoct-Moss-arcrub-salphl-vacvit-selsel
CAKR_T12_05	12/2003	67.5894	-163.724	A	11	140	Ch	N	20	Sdee	outlier	dryoct-salphl-hiealp	Lichen-empnig-artarc-loipro-Moss-fesalt-carpod
CAKR_T12_06	12/2003	67.5887	-163.723	L	4	120	Ch	N	25	Slce	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-vaculi-salpul-leddec-petfri-rubcha-carpod
CAKR_T13_01	13/2003	67.7167	-163.368	U	3	350	Ob	FH	20	Slott	Upland Moist Dwarf Birch–Tussock Shrub	erivag-betnan	Moss-erivag-Lichen-betnan-leddec-rubcha-vacvit
CAKR_T13_02	13/2003	67.7170	-163.375	U	3	310	Ch	FF+FH	25	Slobw	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-salpul-pyrgra	Moss-Lichen-salpul-vaculi-petfri-carbig-empnig
CAKR_T13_03	13/2003	67.7166	-163.391	L	1	250	Ch	N	10	Slow	Lowland Moist Low and Tall Willow Shrub	salpul-calcan	Moss-salpul-petfri-calcan-artarc-rubcha-valcap
CAKR_T13_04	13/2003	67.7155	-163.397	L	5	270	Ch	FS	20	Slow	Lowland Moist Low and Tall Willow Shrub	salric-fesalt	Moss-equarv-salpul-salret-salric-Lichen-petfri
CAKR_T13_05	13/2003	67.7146	-163.402	L	3	290	Ch	N	7	Sddf	Lowland Moist Dryas–Forb Shrub	dryint-carbig-senatr	Moss-dryoct-salret-carbig-Lichen-arclat-artarc
CAKR_T13_06	13/2003	67.7147	-163.403	R	5	360	Wrhm	W		W	Riverine Water		water
CAKR_T14_01	12/2003	67.7512	-163.767	P	0	0	Wlsit	W	0	Hafm	Lacustrine Marestail Marsh	hipvul-potam	hipvul-potpal-Moss-mentri-ranpal-arcful-caraqu
CAKR_T14_02	12/2003	67.7511	-163.769	U	0	0	Ltim	Phl	35	Slott	Upland Moist Dwarf Birch–Tussock Shrub	erivag-betnan	Moss-leddec-betnan-erivag-vaculi-vacvit-Lichen
CAKR_T14_03	12/2003	67.7497	-163.768	L	0	0	Ltim	N	15	Slcbw	Lowland Moist Dwarf Birch–Willow Shrub	betnan-salpul-pyrgra	Moss-salpul-betnan-petfri-calcan-pyrgra-vaculi
CAKR_T14_04	12/2003	67.7473	-163.767	L	0	0	Ob	n	15	Hgwsmb	Lowland Sedge–Moss Fen Meadow	caraqu-salfus-sphag	Moss-eriang-caraqu-erirus-betnan-luzarc2-salfus
CAKR_T14_05	12/2003	67.7450	-163.777	L	0	0	Ltic	Pd	15	Hgwsmb	Lowland Sedge–Moss Fen Meadow	betnan-vacvit-caraqu	Moss-carbig-vaculi-betnan-caraqu-leddec-vacvit
CAKR_T14_06	12/2003	67.7434	-163.774	U			Ltip	M	30	Slobe	Upland Moist Dwarf Birch–Ericaceous Shrub	betnan-salpul-pyrgra	Moss-leddec-betnan-vaculi-vacvit-petfri-arclat
CAKR_T15_01	14/2003	67.2634	-163.758	U	4	160	CH	FH	15	Sddf	Lowland Moist Dryas–Forb Shrub	dryint-equarv	Moss-salret-dryint-equarv-Lichen-petfri-salric
CAKR_T15_02	14/2003	67.2649	-163.766	C	0	0	Wmn	W	0	W	Coastal Water		water
CAKR_T15_03	14/2003	67.2649	-163.766	C	3	270	Mba	N	0	Bbg	Coastal Barrens		soil
CAKR_T15_04	14/2003	67.2649	-163.766	C	5	260	Mba	ND		Bpv	Coastal Barrens	elymol-latmar	soil-elymol-honpep-mermar-latmar-senec
CAKR_T15_05	14/2003	67.265	-163.765	C	3	100	Mba	ND		Hgdl	Coastal Dry Dunegrass Meadow	elymol-latmar	elymol-latmar-senpse-conchi-cnicni-astsea-honpep
CAKR_T15_06	14/2003	67.2655	-163.763	C	0	0	Mti	ND		Hgwhsb	Coastal Brackish Wet Sedge–Grass Meadow	carram-dupfis	carram-potege-salova-caldes-dupfis-stehum-rumarc
CAKR_T15_07	14/2003	67.2656	-163.763	C	0	0	Wels	ND	0	W	Coastal Water		water
CAKR_T15_08	14/2003	67.2639	-163.763	C	0	0	Wels	ND		Habm	Coastal Marestail Marsh		water-hiptet
CAKR_T15_09	14/2003	67.2628	-163.76	R	0	0	Fmoi	FH	15	Hgwst	outlier	calcan-rumarc	eriang-caraqu-Moss-petfri-poaalp2-salova-valcap
CAKR_T15_10	14/2003	67.2634	-163.758	R	0	0	Wrln	W		W	Riverine Water		water

Appendix 3. Data file listing of environmental characteristics intensive ground reference plots in the Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

Site ID	NWIWaterReg	WaterDepth	Saturated<30cm	Drainage	SoilMoisture	MottleDepth	MatrixDepth	HydricSoil	Cryoturb	SurfOrg	CumOrg40(cm)	DomMineral40	DomText40	LoessThick(cm)	ThawDepth	FrostBoil	SitepH	SiteEC	SiteChemistry
BELA_T01_01	Np	100	y	F	A	nd	nd	u	nd			nd	nd	nd		nd	8	130	Alkaline
BELA_T01_02	Nse	-47	n	W	M	nd	50	n	a	0	0	S	S	nd	97	0	7	50	Circumneutral
BELA_T01_03	Nse	-150	n	W	M	nd	nd	n	a	0	0	S	S	nd	112	0	6	50	Circumneutral
BELA_T01_04	Nse	-114	n	W	M	a	a	n	a	0	0	S	S	nd	114	0	6	50	Circumneutral
BELA_T01_05	Nse	-50	n	W	M	12	52	n	a	6	6	L	L	0	52	0	6	60	Circumneutral
BELA_T01_06	Nsa	-26	n	Ps	M	25	a	n	p	6	6	L	L	0	25	0	6	80	Circumneutral
BELA_T01_07	Nsa	-8	y	P	W	25	a	y	a	25	25	O	O	0	25	0	5	50	Acidic
BELA_T02_01	Nsa	0	y	Pv	W	a	a	y	a	25	25	O	O	0	25	0	5	40	Acidic
BELA_T02_02	Nsa		y	W	M	a	a	y	a	5	5	L	L	0	25	0	6	50	Circumneutral
BELA_T02_03	Np	40	y	F	A	nd	nd	u	nd			nd	nd	nd		nd	6	80	Circumneutral
BELA_T02_04	Np	4	y	Pv	W	a	a	y	a	32	32	O	O	0	32	0	6	40	Circumneutral
BELA_T02_05	Nsa	-17	y	Pv	W	a	a	y	a	6	6	L	L	0	26	0	5	60	Acidic
BELA_T02_06	Nsa	-14	y	Ps	W	a	a	y	a	10	10	L	L	0	16	0	5	380	Acidic
BELA_T02_07	Nse	5	y	Pv	W	a	a	y	a	31	31	O	O	0	31	0	5	70	Acidic
BELA_T02_08	Nsa	0	y	Pv	W	a	a	y	a	18	18		L	0	23	0	5	220	Acidic
BELA_T02_09	Nsp	5	y	Pv	W	a	a	y	a	41	41	O	O	0	41	0	6	100	Circumneutral
BELA_T03_02	U		n	W	M	a	a	n	a	3	3	R	R	0		0	7	30	Circumneutral
BELA_T03_04	U		n	Ps	M	12	a	y	a	12	12	L	L	0		0	6	47	Circumneutral
BELA_T04_01	U		n	W	M	nd	nd	n	a	2	2	L	L	0	60	0	6	130	Circumneutral
BELA_T04_02	U		n	W	M	nd	nd	n	p	3	4	L	L	0	95	0	7	120	Circumneutral
BELA_T04_03	U	-16	y	Ps	M	nd	nd	n	a	13	13	L	L	0	36	0	7	40	Circumneutral
BELA_T04_04	U		n	W	M	35	nd	n	p	3	3	L	L	0	50	0	6	50	Circumneutral
BELA_T04_05	Nsa	-15	y	Ps	M	29	29	y	p	2	2	L	L	0	29	0	6	20	Circumneutral
BELA_T04_06	U		n	Ps	M	nd	nd	n	p	7	7	L	L	0	30	0	7	190	Circumneutral
BELA_T04_07	U		n	W	M	nd	nd	n	a	3	3	R	R	0		0	5	70	Acidic
BELA_T04_08	U		n	E	D	nd	nd	n	a	2	2	RE	RE	0		0	8	180	Alkaline
BELA_T05_01	U	-52	n	W	M	a	a	n	p	0	0	S	S	nd	52	15	5	20	Acidic
BELA_T05_02	Nsa	-12	y	Ps	W	a	a	n	p	0	0	R	R	nd	60	2	6	10	Circumneutral
BELA_T05_04	U	-25	n	W	M	a	a	n	a	1	1	R	R	nd	25	0	5	40	Acidic
BELA_T06_01	U		nd	W	M	10	nd	n	a	4	4	L	L	0	60	0	5	10	Acidic
BELA_T06_02	U		nd	Es	M	nd	nd	n	a	3	3	Re	RE	0		0	6	30	Circumneutral
BELA_T06_04	Tr	30	y	F	A	nd	nd	n	a			nd	nd	0		0	7	10	Circumneutral
BELA_T06_05	U		nd	Es	M	nd	nd	n	p	2	2	R	R	0		25	5	20	Acidic
BELA_T06_06	Nsa	-16	y	Ps	W	nd	nd	y	p	27	27	O	O	0	27	0	5	20	Acidic
BELA_T06_07	U		nd	W	M	nd	nd	n	p	3	3	L	L	0	30	15	5	10	Acidic
BELA_T06_08	U		nd	W	M	nd	nd	n	p	4	4	L	L	0		0	5	40	Acidic
BELA_T06_10	U		nd	Es	D	nd	nd	n	p	1	1	R	R	0		0	5	10	Acidic
BELA_T07a_0	U	-20	n	W	M	7	7	n	a	4	3.5	R	R	17		0	7	20	Circumneutral
BELA_T08_01	U	-50	n	E	D	a	a	n	a	0	0	RE	RE	0		0	8	50	Alkaline
BELA_T08_02	U	-35	n	W	M	a	a	n	a	3	3	R	R	30	35	2	7	280	Alkaline
BELA_T08_03	U	-40	n	W	M	a	a	n	a	6	6	R	R	nd	40	10	7	280	Alkaline
BELA_T08_04	U	-30	n	W	M	a	a	n	a	0	0	R	R	nd	30	0	8	100	Alkaline
BELA_T08_05	U	-40	n	W	M	a	a	n	a	4	4	L	L	nd	40	0	7	140	Circumneutral
BELA_T09_02	U		n	W	M	a	a	n	a	0	0	R	R	0		nd	8	120	Alkaline
BELA_T09_03	U		n	W	M	16	a	n	a	16	16	L	L	0		nd	8	110	Alkaline
BELA_T09_04	W		n	W	M	nd	nd	n	a	3	3	R	R	nd		nd	8	150	Alkaline
BELA_T09_05	Nsa	-40	y	W	M	23	nd	y	a	23	23	L	O	nd		nd	7	640	Circumneutral
BELA_T10_01	Np	30	y	F	A	a	a	n	a	0	0	nd	nd	nd		nd	8	210	Alkaline
BELA_T10_02	Ni		n	Es	M	nd	nd	n	a			RE	RE	nd		0	8	50	Alkaline
BELA_T10_03	Ni		n	Es	M	nd	nd	n	a	0	0	RE	RE	0		0	8	90	Alkaline
BELA_T10_04	Nse	-48	y	W	M	28	nd	n	a	2	4	L	L	0	55	0	7	930	Circumneutral
BELA_T10_05	Nsa		nd	Ps	M	nd	nd	n	p	5	17	L	L	0	22	0	7	170	Circumneutral
BELA_T10_06	Nsa	-1	y	Pv	W	nd	nd	n	p	10	28	L	O	0	28	0	7	140	Circumneutral
BELA_T10_07	U	-20	y	Ps	M	nd	nd	n	p	16	16	L	L	0	22	0	5	40	Acidic
BELA_T10_08	Nse		n	Ps	M	25	nd	n	p	4	4	L	L	0	40	0	7	240	Circumneutral
BELA_T11_01	U	-50	n	E	D	20	20	n	a	0	0	RE	RE	0	20	0	8	110	Alkaline
BELA_T11_02	U	-50	n	E	D	30	30	n	a	0	0	RE	RE	0	30	0	8	80	Alkaline
BELA_T11_03	Nsa	-18	y	Ps	M	15	40	y	p	2	2	L	L	0	76	3	7	410	Alkaline
BELA_T11_04	Nsa	-28	y	W	M	10	30	y	a	5	5	L	L	0	74	0	8	200	Alkaline
BELA_T11_05	U	-45	n	W	M	19	54	n	a	7	9	S	S	0	54	0	7	220	Circumneutral
BELA_T11_06	Np	15	y	F	A	nd	nd	u	nd			nd	nd	nd		nd	8	340	Alkaline

Appendix 3. Continued.

Site ID	NWIWaterReg	WaterDepth	Saturated<30cm	Drainage	SoilMoisture	MottleDepth	MatrixDepth	HydricSoil	Cryoturb	SurfOrg	CumOrg40(cm)	DomMineral40	DomText40	LoessThick(cm)	ThawDepth	FrostBoil	SitepH	SiteEC	SiteChemistry
BELA_T11_07	Nsa	-8	y	Ps	M	6	45	y	p	1	1	R	R	10	84	2	8	400	Alkaline
BELA_T11_08	Nsa	-10	y	Ps	M	17	48	y	a	3	7	L	L	0	48	0	8	460	Alkaline
BELA_T11_09	Nsa	-14	y	W	M	17	82	y	p	14	14	L	L	0	82	3	7	320	Circumneutral
BELA_T12_01	U		n	W	M	a	a	y	a	0	0	RE	RE	0	30	0	7	20	Circumneutral
BELA_T12_02	U		n	W	M	a	a	n	a	0	0	RE	RE	0	51	0	7	20	Circumneutral
BELA_T12_03	Nsa	-30	y	Ps	M	a	a	y	a	2	2	R	R	0	50	0	6	50	Circumneutral
BELA_T12_04	Nsa	-1	y	Pv	W	a	a	y	a	5	5	RE	RE	0	16	0	6	40	Circumneutral
BELA_T12_05	Nsa	-8	y	Pv	W	a	a	y	p	22	22	L	O	0	28	0	5	30	Acidic
BELA_T12_06	Nsa	0	y	Pv	W	a	a	n	a	21	21	O	O	0	21	0	5	190	Acidic
BELA_T12_07	Nsa	-8	y	Pv	W	a	a	y	a	18	18	RE	RE	0	20	0	6	40	Circumneutral
BELA_T13_01	Nsa		nd	P	W	nd	nd	n	p	6	10	O	L	0	20	0	4	140	Acidic
BELA_T13_03	Nsa		nd	Ps	M	nd	nd	n	p	13	13	O	O	0	13	0	6	40	Circumneutral
BELA_T13_04	Nsa		nd	W	M	nd	nd	n	p	6	16	L	L	0	25	0	4	30	Acidic
BELA_T13_05	Nsa		nd	W	M	nd	nd	n	p	4	4	L	L	0	26	0	5	30	Acidic
BELA_T13_06	Nsa	-2	y	Pv	W	nd	nd	y	a	25	25	O	O	0	25	0	6	30	Acidic
BELA_T13_07	Nsa	-1	y	P	W	nd	nd	y	a	3	3	L	L	0	25	0	7	60	Circumneutral
BELA_T13_08	Np	40	y	F	A	nd	nd	u	nd			nd	nd	nd		0	7	90	Circumneutral
BELA_T14_01	Tr	50	y	F	A	nd	nd	u	nd			nd	nd	nd		nd	8	140	Alkaline
BELA_T14_02	Ni	-150	n	W	M	nd	nd	n	a	0	0	S	S	0		0	8	20	Alkaline
BELA_T14_03	Nse	2	n	W	M	nd	nd	n	a	0	0	S	S	0	93	0	7	90	Circumneutral
BELA_T14_04	Nse	-200	n	W	M	nd	nd	n	a	1	1	S	S	0	47	0	6	60	Circumneutral
BELA_T14_05	Nse		nd	Ps	M	nd	nd	n	a	5	5	L	L	0	26	0	6	80	Circumneutral
BELA_T14_06	Nsa		nd	Ps	M	nd	nd	n	p	4	8	L	L	nd	25	0	7	200	Circumneutral
BELA_T14_07	Nsa		nd	Ps	M	nd	nd	n	p	5	5	L	L	0	24	0	6	110	Circumneutral
BELA_T14_08	Nsa	-3	y	Pv	W	nd	nd	y	p	27	27	O	O	0	27	0	7	160	Circumneutral
BELA_T14_09	Nsa	-1	y	Pv	W	nd	nd	y	a	25	25	O	O	0	25	0	6	50	Circumneutral
BELA_T14_10	Ni		nd	W	M	nd	nd	n	p	4	8	L	L	0	25	0	6	60	Circumneutral
BELA_T14_11	Nsa	0	y	Pv	W	nd	nd	y	a	28	28	O	O	0	28	0	6	60	Circumneutral
BELA_T14_12	Nsa	0	y	Pv	W	nd	nd	y	a	25	25	O	O	0	25	0	6	50	Circumneutral
BELA_T14_13	Tr	50	y	F	A	nd	nd	n	a			nd	nd	nd	26	nd	7	40	Circumneutral
BELA_T16_01	Nsa	-5	y	Pv	W	a	a	y	a	30	30	O	O	0	30	0	6	60	Circumneutral
BELA_T16_02	Nsp	-3	y	Pv	W	a	a	y	a	23	23	O	O	0	23	0	5	70	Acidic
BELA_T16_03	Np	15	y	F	A	a	a	y	a	35	35	O	O	0	35	0	6	60	Circumneutral
BELA_T16_04	Nsa	-16	y	W	M	a	a	y	a	27	27	L	O	0	27	0	5	60	Acidic
BELA_T16_05	U	-14	n	Ps	M	a	a	n	a	14	14	O	O	0	14	0	5	10	Acidic
BELA_T17_01	Ts	200	y	F	A	nd	nd	u	nd			nd	nd	nd		nd	8	11500	Brackish
BELA_T17_02	Ts	-10	y	Pv	W	2	nd	y	p	0	0	S	S	nd	62	0	7	18790	Saline
BELA_T17_03	Ts	-8	y	Pv	W	a	18	y	a	18	28	S	O	0	90	0	6	29800	Saline
BELA_T17_04	Ti	-42	n	W	M	4	29	y	a	0	4	S	S	0	87	0	6	13480	Brackish
BELA_T17_05	Ti	-16	y	P	W	0	38	y	a	3	37	L	O	0	82	0	6	30700	Saline
BELA_T17_06	Ti	30	y	F	A	nd	nd	u	nd	0	0	nd	nd	0		0	8	12300	Brackish
BELA_T17_07	Ti	-50	y	Ps	M	a	16	y	a	16	26	L	O	0	53	0	7	13600	Brackish
BELA_T17_08	Ti	-40	y	Ps	M	a	37	y	a	31	31	L	O	0		0	7	24200	Saline
BELA_T17_09	Ti	-40	y	Ps	M	a	40	y	a	36	36	L	O	0	45	0	7	22800	Saline
BELA_T18_01	Ts	50	y	F	A	nd	nd	u	nd			nd	nd	nd		nd	7	45300	Saline
BELA_T18_02	Ti	-44	n	W	M	nd	nd	n	a	0	0	S	S	0	110	0	8	4412	Brackish
BELA_T18_03	U	-90	n	E	D	90	90	n	a	0	0	S	S	0	90	0	6	110	Brackish
BELA_T18_04	Nse	-5	y	P	W	nd	nd	y	a	0	0	S	S	0	108	0	7	220	Brackish
BELA_T18_05	U	-78	n	Es	D	78	78	n	a	1	3	S	S	0	78	0	6	80	Circumneutral
BELA_T18_06	U	-81	y	Es	D	81	81	n	a	1	1	S	S	0	81	0	7	20	Circumneutral
BELA_T18_07	Nsa	-15	y	Ps	M	p	p	y	a	20	40	O	O	0	20	0	7	200	Circumneutral
BELA_T18_08	Nsp	12	y	Pv	W	p	p	y	a	60	40	O	O	0	40	0	7	130	Circumneutral
BELA_T18_09	Np	80	y	F	A	nd	nd	u	nd			nd	nd	nd		nd	7	130	Alkaline
BELA_T19_01	Nsa	-7	y	Pv	W	p	p	y	a	27	27	L	O	0	32	0	6	90	Circumneutral
BELA_T19_02	Nsa	-7	y	Pv	W	p	p	y	a	20	31	L	O	0	32	0	6	80	Acidic
BELA_T19_03	Nsa	-15	y	Ps	M	p	p	y	a	40		O	O	0	28	0	4	110	Acidic
BELA_T19_04	Nsa	-3	y	Pv	W	p	p	y	a	9	9	L	L	0	28	0	6	90	Circumneutral
BELA_T19_05	Nsp	8	y	Pv	W	p	p	y	a	28	28	O	O	0	28	0	6	100	Circumneutral
BELA_T19_06	Nsp	12	y	F	A	p	p	y	a	13	15	L	L	0	40	0	6	60	Circumneutral
BELA_T21_01	Nsa	-10	y	Pv	W	a	a	y	a	1		S	S	0	35	0	7	1560	Brackish
BELA_T21_02	Np	50	y	F	A	a	a	n	a			nd	S	nd	100	nd	9	4500	Brackish

Appendix 3. Continued.

Site ID	NWIWaterReg	WaterDepth	Saturated<30cm	Drainage	SoilMoisture	MottleDepth	MatrixDepth	HydricSoil	Cryoturb	SurfOrg	CumOrg40(cm)	DomMineral40	DomText40	LoessThick(cm)	ThawDepth	FrostBoil	SitepH	SiteEC	SiteChemistry
BELA_T21_03	U	-35	n	Es	M	a	a	n	a	0	0	S	S	0	90	0	7	5070	Brackish
BELA_T21_04	Nsa	-1	y	Pv	W	a	a	y	a	1	7	S	S	0	60	0	6	6100	Brackish
BELA_T21_05	U	-50	n	Es	D	a	a	n	a	0	0	S	S	0	50	0	8	20	Brackish
BELA_T21_06	Nsa	0	y	Pv	W	a	a	y	a	18	18	S	S	0	62	0	6	590	Brackish
BELA_T21_07	Nsa	0	y	Pv	W	a	a	y	a	3	6	S	S	0	78	0	7	2000	Brackish
BELA_T21_08	U	-40	n	W	M	a	a	y	a	0	2	S	S	0	83	0	7	150	Circumneutral
BELA_T21_09	U	-50	n	E	D	a	a	n	a	1	1	S	S	0	85	0	6	40	Circumneutral
BELA_T21_10		40	y	F	A	nd	nd	u	nd			nd	nd	nd	40	0	7	160	Circumneutral
CAKR_T01_01	Nsa	-28	y	Ps	M	27	>38	y	p	27	27	L	O	nd	30	0	7	410	Circumneutral
CAKR_T01_02	U	-75	n	W	M	>50	>50	n	a	4	4	L	L	13		0	7	130	Circumneutral
CAKR_T01_03	U	-100	n	Es	D	>50	>50	n	a	2	2	R	R	0		1	8	149	Alkaline
CAKR_T01_04	U	-150	n	E	D	>25	>25	n	a	0	0	RE	RE	0		0	9	120	Alkaline
CAKR_T01_05	Nsa	-8	y	Ps	M	17	>48	y	a	17	18	L	L	7	76	0	7	250	Circumneutral
CAKR_T02_01	Nsa	-30	y	Ps	M	a	a	n	a	16	16	R	R	0	60	0	8	370	Alkaline
CAKR_T02_02	U	-100	n	W	M	a	a	n	a	5	5	R	R	0		0	8	170	Alkaline
CAKR_T02_03	U	-100	n	W	M	20	a	n	a	2	2	R	R	0		0.1	8	170	Alkaline
CAKR_T02_04	U	-150	n	Es	D	a	a	n	a	0	0	RE	RE	0		0	8	160	Alkaline
CAKR_T02_05	U	-150	n	Es	D	a	a	n	a	0	0	RE	RE	0		0	8	80	Alkaline
CAKR_T02_06	U	-150	n	W	M	a	a	n	a	1	1	RE	RE	0		0	8	150	Alkaline
CAKR_T02_07	Nsa	-20	y	Ps	M	20	nd	s	a	9	9	R	R	0	80	0	7	370	Alkaline
CAKR_T04_01	U	-100	n	E	D	a	a	n	a	0	0	S	S	0	125	0	7	160	Brackish
CAKR_T04_02	Nsa	-16	y	P	W	a	a	y	a	24	24	S	O	0	24	0	5	150	Acidic
CAKR_T04_03	Ti	-5	y	Pv	W	a	21	y	a	18	19	L	L	0	75	0	6	8480	Brackish
CAKR_T04_04	Ni	-1	y	Pv	W	25	25	y	a	25	25	L	O	0	125	0	6	17070	Saline
CAKR_T04_05	Np	200	y	F	A	a	a	u	nd			nd	nd	nd		nd	9	10800	Brackish
CAKR_T04_06	Np	200	nd	F	A	nd	nd	u	nd			nd	nd	nd		nd	7	240	Brackish
CAKR_T04_07	Nsa	-16	y	P	W	a	26	y	a	26	26	L	O	0	65	0	6	9000	Brackish
CAKR_T05_00	T	-75	n	E	m	>10	>10	n	a	0	0	S	S	0	150	0			Saline
CAKR_T05_01	Ti	-150	n	E	d	>50	>50	n	a	0	0	S	S	0	125	0	7	60	Brackish
CAKR_T05_02	U	-150	n	E	d	>10	>10	n	a	1	1	R	R	0	150	0	7	40	Circumneutral
CAKR_T05_03	U	-95	n	E	d	>92	>92	n	a	1	1	R	R	3	92	0	5	270	Acidic
CAKR_T05_04	U	-100	n	Es	M	a	a	n	a	1	1	R	R	0		0	6	180	Circumneutral
CAKR_T06_01	Nsp	8	y	Pv	W	p	p	n	a	40	40	O	O	a	49	0	6	100	Circumneutral
CAKR_T06_02	Nsp	4	y	Pv	W	p	p	n	a	40	40	O	O	a	30	0	6	250	Circumneutral
CAKR_T06_03	Nsp	11	y	Pv	W	p	p	u	a	60	60	O	O	a	43	0	6	300	Circumneutral
CAKR_T06_04	P	200	y	F	A	nd	nd	n				nd	nd	a		0	7	310	Circumneutral
CAKR_T06_05	Nsa	-13		W	M	13	24	n	a	13	13	L	L	1m	24	0	5	40	Acidic
CAKR_T06_06	Np	71	y	F	A	nd	nd	u	nd	0	0	L	L	0		0	6	170	Circumneutral
CAKR_T06_07	Nsp	9	y	Pv	W	nd	nd	u	a	60	60	O	O	a	50	0	6	70	Circumneutral
CAKR_T06_08	Nsa	-31	y	W	M	p	p	n	a	23	23	O	O	a	31	0	5	110	Acidic
CAKR_T06_09	Nsa	-8	y	P	W	p	p	y	a	40	40	O	O	0	36	0	5	30	Acidic
CAKR_T07_01	Nsa	-12	30	P	W	a	a	y	a	30	30	O	O	0	30	0.1	4	40	Acidic
CAKR_T07_02	Nsa	-19	y	P	M	15	15	y	a	12	12	L	L	0	30	0	6	240	Circumneutral
CAKR_T07_03	Nsa	-1	y	Pv	W	a	a	y	a	35	35	O	O	0	69	0	6	30	Circumneutral
CAKR_T07_04	Ni	-100	n	W	M	a	a	n	a	3	3	S	S	0	150	0	8	50	Alkaline
CAKR_T07_05	U	-100	n	W	M	a	a	n	a	3	3	R	R	0		15	8	150	Alkaline
CAKR_T07_06	Nsa	-19	y	Pv	W	0	2	y	a	2	2	R	R	0	73	5	8	420	Alkaline
CAKR_T07_07	U	-100	n	W	M	a	a	n	a	0	0	R	R	0		10	8	120	Alkaline
CAKR_T08_01	Np	75	y	F	nd	nd	nd	u	nd			nd	nd	nd		na	8	280	Alkaline
CAKR_T08_02	Nse	-75	n	W	M	a	a	n	a	0	0	R	R	0		0	8	210	Alkaline
CAKR_T08_03	Ni	-75	n	W	M	a	a	n	a	0	0	S	S	0		0	8	100	Alkaline
CAKR_T08_04	Ni	-75	n	W	M	a	a	n	a	2	1.5	S	S	0		0	7	90	Circumneutral
CAKR_T08_05	Ni	-75	n	Ps	M	a	a	n	a	5	5	R	R	0		0	8	90	Alkaline
CAKR_T08_06	U	-75	n	Ps	M	a	a	n	a	4	3.5	R	R	0		0	7	90	Circumneutral
CAKR_T08_07	Nsa	-24	y	P	W	12	a	y	a	5	4.5	L	L	0	28	0	6	90	Circumneutral
CAKR_T08_08	Nsp	10	y	Pv	W	a	a	y	a	29	29	O	O	0	29	0	7	170	Circumneutral
CAKR_T08_09	Ni	-75	n	W	M	a	a	n	a	0	0	S	S	0	125	0	8	10	Alkaline
CAKR_T08_10	U	-75	b	W	M	a	a	n	a	0	0	R	R	0		0	8	10	Alkaline
CAKR_T10_01	U	-150	n	Es	D	a	a	n	a	0	0	Re	RE	0		a	8	150	Alkaline
CAKR_T10_02	U	-50	n	Ps	M	15	3	y	a	3	3	R	R			1	8	240	Alkaline
CAKR_T10_03	Nsa	-13	y	Ps	W	0	0	y	a	50	40	O	O	n	50	0	6	70	Circumneutral

Appendix 3. Continued.

Site ID	NWIWaterReg	WaterDepth	Saturated<30cm	Drainage	SoilMoisture	MottleDepth	MatrixDepth	HydricSoil	Cryoturb	SurfOrg	CumOrg40(cm)	DomMineral40	DomText40	LoessThick(cm)	ThawDepth	FrostBoil	SitepH	SiteEC	SiteChemistry
CAKR_T10_04	Nsa	-12	y	P	W	10	a	y	a	10	10	R	R	a	40	0	8	310	Alkaline
CAKR_T10_05	U	-100	n	W	M	a	a	n	a	3	3	R	R	a		0	7	240	Circumneutral
CAKR_T11_01	Np	100	y	F	A	nd	nd	u	a	0	0	RE	RE	0		0	6	160	Circumneutral
CAKR_T11_02	Nt	-37	n	Es	M	>37	>37	n	a	0	0	RE	RE	0		0	7	150	Circumneutral
CAKR_T11_03	Nt	-100	n	E	D	>30	>30	n	a	0	0	RE	RE	0		0	7	30	Circumneutral
CAKR_T11_04	Nt	-100	n	Es	D	>22	>22	n	a	2	2	RE	RE	0		0	6	20	Circumneutral
CAKR_T11_05	Nt	-75	n	W	M	>20	>55	y	a	3	4	L	L	0		N	6	40	Circumneutral
CAKR_T11_06	Ni	-75	n	ES	D	>28	>28	n	a	0	0	R	R	0		N	6	10	Circumneutral
CAKR_T11_07	Ni	-115	n	W	M	>20	>48	y	a	4	5	L	L	0	125	N	6	30	Circumneutral
CAKR_T11_08	Ni	-75	n	W	M	>35	>35	n	a	3	4	L	L	0		N	6	40	Circumneutral
CAKR_T12_01	U	-100	n	W	M	a	a	n	a	2	2	R	R	0		n	6	10	Circumneutral
CAKR_T12_03	U	-100	n	W	M	a	a	n	a	0.5	0.5	R	R	0		0	6	10	Acidic
CAKR_T12_04	U	-100	n	W	M	a	a	n	a	2	2	R	R	0		a	5	10	Acidic
CAKR_T12_05	U	-100	n	W	M	a	a	n	a	0.5	0.5	R	R	0		0	4	10	Acidic
CAKR_T12_06	Nsa	-40	y	Ps	M	a	a	y	a	1	1	R	R	0		0	6	10	Acidic
CAKR_T13_01	Nsa	-15	y	Ps	M	p	p	y	a	40	40	O	O	0	30	1	6	20	Acidic
CAKR_T13_02	Nsa	-18	y	Ps	M	p	p	y	p	24	24	L	O	0	28	5	6	30	Circumneutral
CAKR_T13_03	Nsa	-31	y	Ps	M	16	>40	y	a	13	13	L	L	0	55	0	5	30	Acidic
CAKR_T13_04	U	-75	n	W	M	>46	>46	n	p	5	6	L	L	0		1	7	200	Circumneutral
CAKR_T13_05	U	-97	n	W	M	>12	>40	y	a	10	10	L	L	0	97	N	6	40	Circumneutral
CAKR_T13_06	Np	20	y	F	A	nd	nd	u	nd			nd	nd	nd		ND	7	240	Circumneutral
CAKR_T14_01	Np	15	y	F	A	nd	nd	u	a	35	35	O	O	0	35	a	6	20	Circumneutral
CAKR_T14_02	Nsa	-12	y	P	W	nd	nd	y	a	24	24	L	O	a	24	0	5	30	Acidic
CAKR_T14_03	Nsa	-17	y	Ps	M	17	a	y	a	15	15	L	L	0	32	0	6	40	Acidic
CAKR_T14_04	Nsa	-14	y	Pv	W	a	a	y	a	30	30	O	O	0	26	0	5	70	Acidic
CAKR_T14_05	Nsa	-13	y	Pv	W	a	a	u	a	32	32	L	O	0	32	n	5	40	Acidic
CAKR_T15_01	Nsa	-10	y	P	W	19	>30	y	a	13	13	L	L	0	30	0	6	130	Circumneutral
CAKR_T15_02	Ts		na	W	nd	nd	nd	u	nd			nd	nd	nd		na	7	46400	Saline
CAKR_T15_03	Tr	-100	n	E	D	a	a	y	a	0	0	S	S	0		0	7		Saline
CAKR_T15_04	Ti	-100	n	E	D	>43	>43	n	a	0	0	S	S	0		0	8	280	Brackish
CAKR_T15_05	Ti	-100	n	E	D	>40	>40	n	a	3	3	R	R	0	125	0	8	140	Brackish
CAKR_T15_06	Nsa	-10	y	PV	W	7	>40	y	a	4	6	L	L	0	40	N	7	7200	Brackish
CAKR_T15_07	Np		y	F	A	nd	nd	y	a			nd	nd	nd		ND	8	3000	Brackish
CAKR_T15_08	Np	10	y	F	A	nd	nd	y	a	5	5	L	L	0	80	0	7	4800	Brackish
CAKR_T15_09	Nsa	-13	y	Ps	W	5	>30	y	nd	4	14	L	L	0	30	0	7	1100	Brackish
CAKR_T15_10	Np	50	y	F	A	nd	nd	u	nd			nd	nd	nd		ND	8	320	Alkaline

Appendix 4. List of vascular plant species found in the Bearing Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

Aspidiaceae (Shield fern)
- *Dryopteris fragrans* (L.) Schott

Aspleniaceae
- *Gymnocarpium dryopteris* (L.) Newm.

Athyriaceae
- *Cystopteris montana* (Lam.) Bernh.

Betulaceae
- *Alnus crispa* (Ait.) Pursh
- *Betula nana* L.

Boraginaceae
- *Eritrichium aretioides* (Cham.) DC.
- *Mertensia maritima* SL
- *Mertensia paniculata* (Ait.) G. Don
- *Myosotis alpestris* F. W. Schmidt

Campanulaceae
- *Campanula lasiocarpa* Cham.
- *Campanula* sp.
- *Campanula uniflora* L
- *Lomatogonium rotatum* (l.) E. Fries

Caprifoliaceae
- *Linnaea borealis* L.

Caryophyllaceae
- *Arenaria longipedunculata* Hult.
- *Cerastium beeringianum* Cham. & Schlecht. var.
- *Honckenya peploides* (L.) Ehrh.
- *Melandrium apetalum* (L.) Fenzl.
- *Melandrium* sp.
- *Minuartia arctica* (Stev.) Aschers. & Graebn.
- *Minuartia macrocarpa* (Pursh) Ostenf.
- *Minuartia rossii* (T. Br.) Graebn.
- *Minuartia* sp.
- *Moehringia lateriflora* (L.) Fenzl
- *Silene acaulis* L.
- *Silene* sp.
- *Stellaria crassifolia* Ehrh.
- *Stellaria edwardsii* R. Br.
- *Stellaria humifusa* Rottb.
- *Stellaria longipes* Goldie
- *Stellaria* sp.
- *Wilhelmsia physodes* (Fisch.) McNeill

Compositae (Asteraceae)
- *Antennaria friesiana* (Trautv.) Ekman
- *Antennaria* sp.
- *Arnica alpina* L.
- *Arnica frigida* C. A. Mey.
- *Arnica lessingii* Greene
- *Arnica* sp.
- *Artemisia arctica* Less. ssp. *arctica*
- *Artemisia furcata* Bieb.
- *Artemisia glomerata* Ledeb.
- *Artemisia senjavinensis* Bess.
- *Artemisia* sp.
- *Artemisia tilesii* Ledeb.
- *Aster sibiricus* L.
- *Aster* sp.
- *Chrysanthemum arcticum* L.
- *Chrysanthemum bipinnatum* L.
- *Chrysanthemum integrifolium* Richards.
- *Crepis nana* Richards.
- *Erigeron humilis* Graham
- *Erigeron hyperboreus* Greene.
- *Erigeron purpuratus* Greene
- *Erigeron* sp.
- *Petasites frigidus* (L.) Franchet
- *Saussurea angustifolia* (Willd.) DC.
- *Saussurea nuda* Ledeb.
- *Senecio atropurpureus* (Ledeb.) Fedtsch.
- *Senecio conterminus* Greenm.
- *Senecio lugens* Richardson
- *Senecio pseudoarnica* Less.
- *Senecio resedifolius* Less.
- *Senecio* sp.
- *Solidago multiradiata* Ait. var. *multiradiata*
- *Taraxacum phymatocarpum* J. Vahl
- *Taraxacum* sp.

Crassulaceae
- *Sedum rosea* (L.) Scop.

Cruciferae (Brassicaceae)
- *Braya humilis* (C. A. Mey.) Robins
- *Cardamine hyperborea* O.E. Schulz
- *Cardamine pratensis*
- *Cardamine* sp.
- *Cochlearia officinalis* L.
- *Cochlearia officinalis* L. ssp. *arctica*
- *Draba cinerea* Adams.
- *Draba fladzinensis* Wulf
- *Draba glabella* Pursh
- *Draba nivalis* Liljebl.
- *Draba* sp.
- *Lesquerella arctica* (Wormsk.) S. Wats.
- *Parrya nudicaulis* (L.) Regel

Cupressaceae
- *Juniperus communis* L.

Cyperaceae
- *Carex amblyorhynca* Krecz.
- *Carex aquatilis* Wahlenb. ssp. *aquatilis*
- *Carex atrofusca* Schkuhr
- *Carex bigelowii* Torr.
- *Carex canescens* L.
- *Carex capillaris* L.
- *Carex capitata* Soland. In L.
- *Carex chordorrhiza* Ehrh.
- *Carex franklinii* Boott
- *Carex glacialis* Mack.
- *Carex glareosa* Wahlenb. ssp. *amphigena* (Fern.) Hulten
- *Carex krausei* Boeck.
- *Carex lachenalii* Schkuhr.
- *Carex lugens* Holm
- *Carex membranacea* Hook.
- *Carex microchaeta* Holm.
- *Carex misandra* R. Br.
- *Carex nardina* E. Fries
- *Carex obtusata* Lilj.
- *Carex petricosa* Dewey
- *Carex podocarpa* C. B. Clarke
- *Carex ramenskii* Kom.
- *Carex rariflora* (Wahlenb.) Smith
- *Carex rotundata* Wahlenb.
- *Carex rupestris* All.
- *Carex saxatilis* L.ssp. *laxa* (Trautv.) Kalela
- *Carex scirpoidea* Michx.
- *Carex* sp.
- *Carex subspathacea* Wormsk.
- *Carex Williamsii* Britt.
- *Eriophorum angustifolium* Honck. ssp. *subarcticum* (V.
- *Eriophorum angustifolium* Honck. ssp. *triste* (T. Fries) Löve
- *Eriophorum brachyanterum* Trautv. & Mey.
- *Eriophorum russeolum* Fries
- *Eriophorum scheuchzeri* Hoppe
- *Eriophorum* sp.

Appendix 4. Continued.

Eriophorum vaginatum L.
Kobresia myosuroides (Vill.) Fiori & Paol.
Kobresia sibirica
Kobresia sp.
Diapensiaceae
Diapensia lapponica L.
Elaegnaceae
Shepherdia canadensis (L.) Nutt.
Empetraceae
Empetrum nigrum L.
Equisetaceae
Equisetum arvense L.
Equisetum scirpoides Michx.
Equisetum variegatum Schleich.
Ericaceae
Andromeda polifolia L.
Arctostaphylos alpina (L.) Spreng.
Arctostaphylos rubra (Rehd. & Wilson) Fern.
Arctostaphylos uva ursi (L.) Sprengel
Cassiope tetragona (L.) D. Don
Chamaedaphne calyculata (L.) Moench
Ledum decumbens (Ait.) Lodd.
Loiseleuria procumbens (L.) Desv.
Oxycoccus microcarpus Turcz. ex Rupr.
Rhododendron camtschaticum Pallas
Rhododendron lapponicum (L.) Wahlenb.
Vaccinium uliginosum L.
Vaccinium vitis idaea L.
Gentianaceae
Gentiana glauca Pallas
Gentiana propinqua Richards. ssp. *propinqua*
Gentiana sp.
Graminae (Poaceae)
Agropyron boreale (Turcz.) Drobov ssp. *alaskanum*
Agropyron macrourum (Turcz.) Drobov
Agropyron sp.
Agropyron violaceum (Hornem.) Lange
Agrostis scabra Willd.
Agrostis sp.
Arctagrostis latifolia (R. Br.) Griseb.
Arctophila fulva (Trin.) Anderss.
Bromopsis pumpellianus Scribn.
Bromus sp.
Calamagrostis canadensis (Michx.) Beauv.
Calamagrostis deschampsioides Trin.
Calamagrostis holmii Lange
Calamagrostis inexpansa Gray
Calamagrostis purpurascens R. Br. subs. *purpurascens*
Calamagrostis sp.
Deschampsia caespitosa (L.) P. Beauv. ssp. *caespitosa*
Dupontia fischeri R.Br.
Elymus arenarius L. ssp. *mollis* (Trin.) Hult.
Festuca altaica Trin.
Festuca baffinensis Polunin
Festuca brachyphylla Schult
Festuca rubra L.
Festuca sp.
Hierchloe alpina (Sw.) Roem. & Schult.
Hierochloe pauciflora R. Br.
Poa alpigena (E. Fries) Lindm.
Poa alpina L.
Poa arctica R. Br.
Poa eminens Presl
Poa glauca M. Vahl.
Poa lanata Scribn. & Merr.
Poa sp.
Puccinellia borealis Swallen
Puccinellia phryganodes (Trin.) Scribner & Marr.
Puccinellia sp.
Trisetum spicatum (L.) Richter
Haloragaceae
Hippuris tetraphylla L.F.
Hippuris vulgaris L.
Myriophyllum spicatum L.
Iridaceae
Iris setosa Pall. ssp. *setosa*
Juncaceae
Juncus albescens SL
Juncus arcticus Willd.
Juncus biglumis L.
Juncus castaneus Smith
Juncus sp.
Juncus triglumis L.
Luzula arctica Blytt.
Luzula arcuata (Wahlenb.) Sw.
Luzula confusa Lindeb.
Luzula multiflora (Retz.) Lej.
Luzula parviflora (Ehrh.) Desv.
Luzula sp.
Luzula tundricola Gorodk.
Juncaginaceae
Triglochin maritimum L.
Triglochin palustris L.
Leguminosae
Astragalus alpinus L.
Astragalus eucosmus Hornem. Subs. *Sealie* (LePage) Hult.
Astragalus umbellatus Bunge
Hedysarum alpinum L.
Hedysarum mackenzii Richards.
Lathyrus maritimus SL
Lupinus arcticus S. Wats.
Oxytropis arctica R. Br.
Oxytropis borealis DC
Oxytropis bryophila (E. Greene) Yurtsev
Oxytropis campestris (L.) DC.
Oxytropis maydelliana Trautv.
Oxytropis Mertensiana Turcz.
Oxytropis nigrescens (Pall.) Fisch.
Oxytropis sp.
Lentibulariaceae
Pinguicula villosa L.
Pinguicula vulgaris L.
Utricularia sp.
Utricularia vulgaris L. ssp. *macrorhiza* (LeConte) Clauson
Liliaceae
Allium schoenoprasum L.
Tofieldia coccinea Richards.
Tofieldia pusilla (Michx.) Pers.
Tofieldia sp.
Veratrum album L. ssp. *oxysepalum* (Turcz.) Hult.
Zygadenus elegans Pursh
Linaceae
Linum perenne L.
Lycopodiaceae
Lycopodium alpinum L. [=*Diphasiastrum alpinum* (L.)
Lycopodium annotinum L.
Lycopodium selago SL
Menyanthaceae
Menyanthes trifoliata L.
Onagraceae
Epilobium angustifolium L.
Epilobium ciliatum Raf. ssp. *glandulosum* (Lehm.) Hoch &
Epilobium latifolium L.
Ophioglossaceae
Botrychium lunaria (L.) Sw.

Appendix 4. Continued.

Orchidaceae
Coeloglossum viride (L.) Hartm. ssp. *bracteatum* (Muhl.)
Lloydia serotina (L.) Rchb.
Papaveraceae
Papaver lapponicum (Tolm.) Nordh.
Papaver macounii Greene
Papaver sp.
Pinaceae
Picea glauca (Moench) Voss
Plumbaginaceae
Armeria maritima (Mill.) Willd. ssp. *arctica* (Cham.) Hult.
Polemoniaceae
Phlox sibirica L. ssp *sibirica*
Polemonium acutiflorum Willd.
Polygonaceae
Polygonum bistorta L. subsp. *plumosum* (Small) Hult.
Polygonum sp.
Polygonum viviparum L.
Rumex arcticus Trautv.
Rumex sp.
Portulacaceae
Claytonia acutifolia ssp. *graminifolia*
Claytonia sarmentosa C. Meyer
Potamogetonaceae
Potamogeton sp.
Primulaceae
Androsace chamaejasme Host ssp *Lehmannia* (Spreng.)
Androsace septentrionalis L.
Dodecatheon frigidum Cham. & Schlecht.
Primula anvilensis S. Kelso
Primula borealis Duby
Pyrolaceae
Pyrola asarifolia Michx.
Pyrola grandiflora Radius
Pyrola minor L.
Ranunculaceae
Aconitum delphinifolium DC.
Anemone Drummondii S. Watts.
Anemone Drummondii S. Watts. (*Anemone multiceps*)
Anemone multifida Poir.
Anemone narcissiflora L.
Anemone parviflora Michx.
Anemone richardsonii Hook.
Anemone sp.
Caltha natans Pall.
Caltha palustris L. ssp. *asarifolia* (DC.) Hult.
Ranunculus hyperboreus Rottb.
Ranunculus pallasii Schlect.
Ranunculus sp.
Thalictrum alpinum L.
Rosaceae
Dryas octopetala L. ssp. *alaskensis* (Pors.) Hult.
Dryas integrifolia Vahl.
Dryas octopetala L. ssp *octopetala*
Geum glaciale Adams
Geum rossii (R. Br.) Ser.
Potentilla biflora Willd.
Potentilla Egedii Wormsk. ssp. *grandis* (Torr. & Gray)
Potentilla fruticosa L.
Potentilla Hookeriana SL
Potentilla palustris (L.) Scop.
Potentilla sp.
Potentilla uniflora Ledeb.
Potentilla villosa Pall.
Rubus arcticus L.
Rubus arcticus L. ssp. *stellatus* (Sm.) Boiv. Emend. Hulten
Rubus chamaemorus L.
Sanguisorba officinalis L.
Spiraea beauverdiana Schneid.
Rubiaceae
Galium boreale L.
Galium sp.
Galium trifidum L.
Salicaceae
Populus balsamifera L.
Salix alaxensis (Anderss.) Cov.
Salix arbusculoides Anderss.
Salix arctica Pall.
Salix barclayi Anderss.
Salix chamissonis Anderss.
Salix fuscescens Anderss.
Salix glauca L.
Salix hastata L.
Salix lanata richardsonii (*Salix richardsonii*)
Salix niphoclada SL
Salix ovalifolia Trautv.
Salix phlebophylla Anderss.
Salix planifolia Pursch. ssp.*pulchra* (Cham.) Argus
Salix reticulata L.
Salix rotundifolia Trautv.
Salix sp.
Saxifragaceae
Chrysosplenium tetrandrum (Lund) T. Fries
Parnassia palustris L.
Saxifraga bronchialis L.
Saxifraga cernua L.
Saxifraga exilis Steph
Saxifraga flagellaris Willd.
Saxifraga hieracifolia Waldst. & Kit.
Saxifraga hirculis L.
Saxifraga oppositifolia L.
Saxifraga punctata L.
Saxifraga sp.
Saxifraga tricuspidata Rottb.
Scrophulariaceae
Castilleja caudata (Pennell) Rebr.
Castilleja elegans Malte
Castilleja hyperborea Pennell
Castilleja sp.
Lagotis glauca Gaertn.
Pedicularis capitata Adams.
Pedicularis kanei Durand subsp. *Kanei*
Pedicularis labradorica Wirsing
Pedicularis langsdorffii Fisch. subsp.*arctica* (R. Br.) Pennell
Pedicularis lapponica L.
Pedicularis parviflora J.E. Sm. Ssp. *Pennellii* (Hult.) Hult.
Pedicularis sp.
Pedicularis sudetica Willd.
Pedicularis verticillata L.
Selaginellaceae
Selaginella selaginoides (L.) Link
Selaginella sibirica (Milde) Hieron.
Umbelliferae (FR=Apiaceae)
Angelica lucida L. (*Angelica lucida* E. Nels.)
Bupleurum triradiatum Adams
Cnidium cnidifolium (Turcz.) Schishchk
Conioselinum chinense L. BSP.
Heracleum lanatum Michx.
Ligusticum scoticum L. ssp. *hultenii* (Fern.) Cald. & Tayl.
Valerianaceae
Valeriana capitata Pall.
Violaceae
Viola epipsila Ledeb. ssp. *repens* (Turcz.) Becker
Viola sp.

Appendix 5. List of some nonvascular plant species found in the Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003.

Mosses and Liverworts

Warnstorfia sarmentosa (Wahlenb.) Hedenaes
Warnstorfia fluitans (Hedw.) Loeske
Tortula norvegica (Web.f.) Wahlenb. Ex Lindb.
Tortella fragilis (Hook. Et Wils. In Drumm.) Limpr.
Tomentypnum nitens (Hedw.) Loeske
Timmia austriaca Hedw.
Thuidium recognitum (Hedw.) Lindb.
Syntrichia norvegica Web.
Splachnum cf. *sphaericum* Hedw. (with immature capsules)
Sphenolobus minutus (Schreb.) Berggr.
Sphagnum warnstorfii Russ.
Sphagnum subsecundum Nees ex Sturm
Sphagnum squarrosum Crome
Sphagnum sp.
Sphagnum rubellum Wils.
Sphagnum perfoliatum L.Savicz
Sphagnum obtusum Warnst.
Sphagnum lindbergii Schimp. Ex Lindb.
Sphagnum lenense H.Lindb. ex Pohle
Sphagnum imbricatum Hornsch. Ex Russ.
Sphagnum girgensohnii Russ.
Sphagnum fuscum (Schimp.) Klinggr.
Sphagnum fimbriatum Wils.
Sphagnum compactum DC. In Lam. Et DC.
Sphagnum cf. *jensnii* H. Lindb.
Sphagnum capillifolium (Ehrh.) Hedw.
Sphagnum balticum (Russ.) Russ. Ex C.Jens.
Sphagnum angustifolium (Russ. Ex Russ.) C.Jens
Scorpidium scorpioides (Hedw.) Limpr.
Schistidium sp. (complex apocarpum)
Sanionia uncinata (Hedw.) Loeske
Rhytidium rugosum (Hedw.) Kindb.
Rhytidiadelphus squarrosus (Hedw.) Warnst.
Rhytidiadelphus sp.
Rhizomnium sp.
Racomitrium sp.
Racomitrium lanuginosum (Hedw.) Brid.
Ptilidium pulcherrimum (G. Web.) Vain.
Ptilidium ciliare (L.) Hampe
Pseudocalliergon turgescens (T.Jens.) Loeske
Polytrichum strictum Brid.
Polytrichum sp.
Polytrichum juniperinum Hedw.
Polytrichum jensenii Hag.
Polytrichum hyperboreum R.Br.
Pohlia sp.
Pohlia nutans (Hedw.) Lindb.
Pohlia cruda (Hedw.) Lindb.
Pleurozium schreberi (Brid.) Mitt.
Plagiothecium denticulatum (Hedw.) B.S.G.
Plagiothecium cavifolium (Brid.) Iwats.
Plagiothecium berggrenianum Frisvoll
Plagiomnium sp.
Plagiomnium ellipticum (Brid.) T.Kop.
Plagiomnium curvatulum (Lind.) Schljakov
Philonotis tomentella Molendo
Paludella squarrosa (Hedw.) Brid.
Mnium thomsonii Schimp.
Mnium sp.
Mnium blyttii B. S.G.
Meesia uliginosa Hedw.
Limprichtia revolvens (Sw.) Loeske
Leptobryum pyriforme (Hedw.) Wils.
Isopterygiopsis pulchella (Hedw.) Iwats.
Hypnum sp.
Hypnum pratense Koch ex Spruce

Mosses and Liverworts continued

Hypnum plicatulum (Lindb.) Jaeg.
Hypnum lindbergii Mitt.
Hypnum holmenii Ando
Hypnum bambergeri Schimp.
Hylocomium splendens (Hedw.) B.S.G.
Eurhynchium pulchellum (Hedw.) Jenn.
Drepanocladus sp.
Drepanocladus aduncus (Hedw.) Warnst. s.l.
Ditrichum flexicaule (Schwaegr.) Hampe
Distichium capillaceum (Hedw.) B.S.G.
Didymodon asperifolius (Mitt.) Crum et al.
Dicranum spadiceum Zett.
Dicranum sp.
Dicranum majus Sm.
Dicranum laevidens Williams
Dicranum groenlandicum Brid.
Dicranum fuscescens Turner.
Dicranum elongatum Schleich. ex Schwaegr.
Dicranum bonjeanii De Not
Dicranum angustum
Dicranum alaevdens Williams
Dicranum acutifolium (Lindb. et H.Arnell) C.Jens.
Ctenidium procerrimum (Mol.) Lindb.
Climacium dendroides (Hedw.) Web. et Mohr.
Cirriphyllum cirrosum (Schwaegr.) Grout
Cinclidium subrotundum Lindb.
Cinclidium latifolium Lindb.
Cinclidium arcticum B.S.G.
Ceratodon purpureus (Hedw.) Brid.
Catoscopium nigritum (Hedw.) Brid.
Campylium stellatum (Hedw.) C.Jens.
Campylium sp.
Campylium polygamum (B.S.G.) C.Jens.
Campylium longicuspis (Lindb. etH.Arnell) Hedenaes
Calliergon stramineum (Brid.) Kindb.
Calliergon giganteum (Schimp.) Kindb.
Bryum sp.
Bryum pseudotriquetrum (Hedw.) Gaertn. et al.
Bryum pallescens Schleich. exSchwaegr. (with capsules)
Bryoerythrophyllum recurvirostrum (Hedw.) Chen
Brachythecium sp.
Brachythecium salebrosum (Web. et Mohr) B.S.G.
Brachythecium rivulare Schimp. in B.S.G.
Brachythecium reflexum (Starke in Web.et Mohr) Schimp.
Brachythecium mildeanum (Schimp.) Schimp. ex Milde
Brachythecium erythrorrhizon Schimp. in B.S.G.
Brachythecium coruscum Hag.
Aulacomnium turgidum (Wahlenb.) Schwaegr.
Aulacomnium sp.
Aulacomnium palustre (Hedw.) Schwaegr.
Aulacomnium acuminatum
Aongstroemia longipes (Somm.) B.S.G.

Lichen

Xanthoria sp.
Vulpicida tilesii (Ach.) J.-E. Mattsson & M. J. Lai
Vulpicida pinastri (Scop.) J.-E. Mattsson & M. J. Lai (on bark)
Umbilicaria torrefacta (Lightf.) Schrader
Umbilicaria sp.
Umbilicaria proboscidea (L.) Schrader
Umbilicaria hyperborea (Ach.) Hoffm.
Umbilicaria caroliniana Tuck.
Thamnolia vermicularis (Sw.) Ach. ex Schaerer
Thamnolia subuliformis (Ehrh.) Culb.
Stereocaulon tomentosum Fr.
Stereocaulon sp.

Appendix 5. Continued.

Lichen continued

Stereocaulon paschale (L.) Hoffm.
Stereocaulon apocalypticum Nyl. (saxicolous)
Stereocaulon alpinum Laurer ex Funck
Sphaerophorus globosus (Hudson) Vainio
Sphaerophorus fragilis (l.) Pers.
Rinodina turfacea (Wahlenb.) Körber
Rhizocarpon umbilicatum (Ramond) Flagey
Rhizocarpon sp.
Rhizocarpon geographicum (L.) DC.
Ramalina almquistii Vainio
Psoroma hypnorum (Vahl) Gray
Pseudephebe pubescens (L.) M. Choisy
Pertusaria subobducens Nyl.
Pertusaria sp.
Pertusaria panyrga (Ach.) A. Massal.
Pertusaria dactylina (Ach.) Nyl.
Peltigera sp.
Peltigera rufescens (Weiss) Humb.
Peltigera neckeri Hepp ex Müll. Arg.
Peltigera malacea (Ach.) Funck
Peltigera leucophlebia (Nyl.) Gyelnik
Peltigera didactyla var. *extenuata* (Nyl. ex Vainio) Goffinet &
Peltigera canina (L.) Willd.
Peltigera aphthosa (L.) Willd.
Parmeliopsis hyperopta (Ach.) Arnold (on bark)
Parmeliopsis ambigua (Wulfen) Nyl. (on bark)
Parmelia sp.
Parmelia omphalodes (L.) Ach.
Ophioparma lapponica (Räsänen) Hafellner & R. W. Rogers
Ochrolechia upsaliensis (L.) A. Massal.
Ochrolechia sp.
Ochrolechia inaequatula (Nyl.) Zahlbr.
Ochrolechia frigida (Sw.) Lynge
Nephroma sp.
Nephroma arcticum (L.) Torss
Melanelia commixta (Nyl.) Thell
Megaspora verrucosa (Ach.) Hafellner & V. Wirth
Masonhalea richardsonii (Hook.) Karnefelt
Lobaria linita (Ach.) Rabenh.
Leptogium gelatinosum (With.) J. R. Laundon
Lecanora sp.
Lecanora epibryon (Ach.) Ach.
Lecanora beringii Nyl.
Icmadophila ericetorum (L.) Zahlbr.
Hypogymnia subobscura (Vainio) Poelt
Hypogymnia physodes (L.) Nyl.
Flavocetraria nivalis (L.) Kärnefelt & Thell

Lichen continued

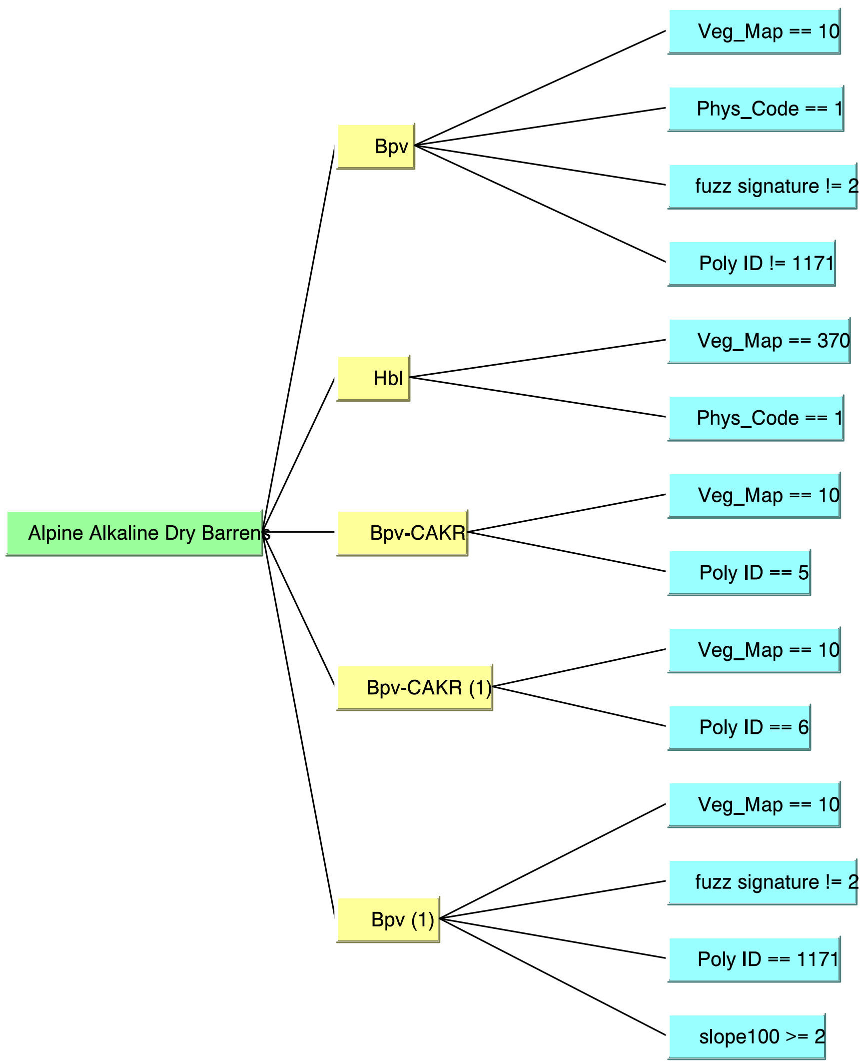
Flavocetraria cucullata (Bellardi) Kärnefelt & Thell
Evernia perfragilis Llano
Dactylina arctica (Richardson) Nyl.
Cladonia uncialis (L.) F. H. Wigg.
Cladonia sulphurina (Michaux) Fr.
Cladonia subfurcata (Nyl.) Arnold
Cladonia squamosa Hoffm.
Cladonia sp.
Cladonia pyxidata (L.) Hoffm.
Cladonia pleurota (Flörke) Schaerer
Cladonia nipponica Asah.
Cladonia macilenta Hoffm.
Cladonia gracilis (L.) Willd.
Cladonia furcata (Hudson) Schrader
Cladonia ecmocyna Leighton
Cladonia cornuta (L.) Hoffm.
Cladonia coccifera (L.) Willd. s. lat.
Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel
Cladonia bellidiflora (Ach.) Schaerer
Cladonia amaurocraea (Flörke) Schaerer
Cladonia alaskana A. Evans
Cladina stygia (Fr.) Ahti
Cladina stellaris (Opiz) Brodo
Cladina sp.
Cladina rangiferina (L.) Nyl.
Cladina mitis (Sandst.) Hustich
Cladina arbuscula (Wallr.) Hale & Culb.
Cetrariella fastigiata (Delise ex Nyl.) Kärnefelt & Thell
Cetrariella delisei (Bory ex Schaerer) Kärnefelt & Thell
Cetraria tilesii Ach.
Cetraria sp.
Cetraria nigricans Nyl.
Cetraria laevigata Rass.
Cetraria kamczatica Savicz
Cetraria islandica subsp. *crispiformis* (Räsänen) Kärnefelt
Cetraria islandica (L.) Ach. subsp. *islandica*
Cetraria islandica (L.) Ach.
Cetraria aculeata (Schreber) Fr.
Caloplaca tiroliensis Zahlbr.
Buellia insignis(Naeg. ex Hepp) Th. Fr.
Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw.
Bryocaulon divergens (Ach.) Kärnefelt
Asahinea chrysantha (Tuck.) Culb. & C. Culb.
Arctoparmelia separata (Th. Fr.) Hale
Alectoria sp.
Alectoria ochroleuca (Hoffm.) A. Massal.
Alectoria nigricans (Ach.) Nyl.

Appendix 6. List of signature vegetation classes with associated ground vegetation classes and showing the number of spectral signatures for each class.

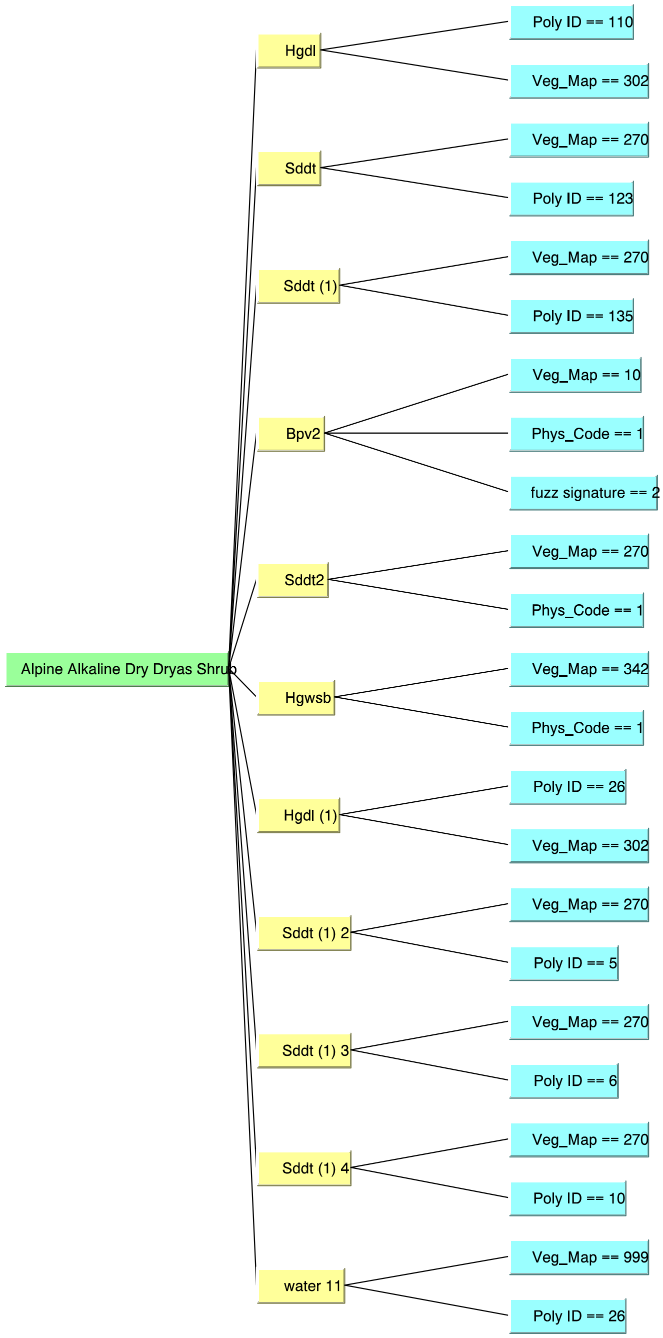
Consolidated Signature Vegetation Class	Gound Vegetation Class	Number of Signatures Used
Partially Vegetated	Barren	20
	Partially Vegetated	37
	Water	1
Open White Spruce	Open White Spruce	5
	White Spruce Woodland	3
Lichen	Lichen	8
Elymus	Elymus	4
Bluejoint Meadow	Bluejoint Meadow	5
	Bluejoint–Herb	1
	Bluejoint–Shrub	2
	Wet Sedge Meadow Tundra	1
Moist Sedge–Dryas Tundra	Moist Sedge–Dryas Tundra	5
	Moist Sedge–Shrub Tundra	12
	Moist Sedge–Willow Tundra	1
	Tussock Tundra	1
	Dryas–Forb Dwarf ShrubTundra	13
	Dryas–Sedge Dwarf ShrubTundra	9
	Bearberry Dwarf Shrub Tundra	1
Halophytic Sedge–Grass Wet Meadow, brackish	Halophytic Grass Wet Meadow, brackish	1
	Halophytic Sedge Wet Meadow, brackish	2
	Halophytic Sedge–Grass Wet Meadow, brackish	3
	Halophytic Sedge–Grass Wet Meadow, saline	2
	Halophytic Sedge Wet Meadow, saline	1
Subartic Lowland Sedge Bog Meadow	Fresh Sedge Marsh	2
	Subartic Lowland Sedge Bog Meadow	8
	Wet Sedge Meadow Tundra	5
	Wet Sedge–Willow Tundra	2
Subartic Lowland Sedge–Moss Bog Meadow	Subartic Lowland Sedge–Moss Bog Meadow	10
	Wet Sedge Meadow Tundra	6
Dryas Dwarf Shrub Tundra	Dryas–Forb Dwarf ShrubTundra	1
	Dryas–Lichen Dwarf Shrub Tundra	10
	Dryas–Sedge Dwarf ShrubTundra	5
	Dryas Dwarf Shrub Tundra	17
	Ericaceous Dwarf Shrub Tundra	6

Appendix 6. Continued.

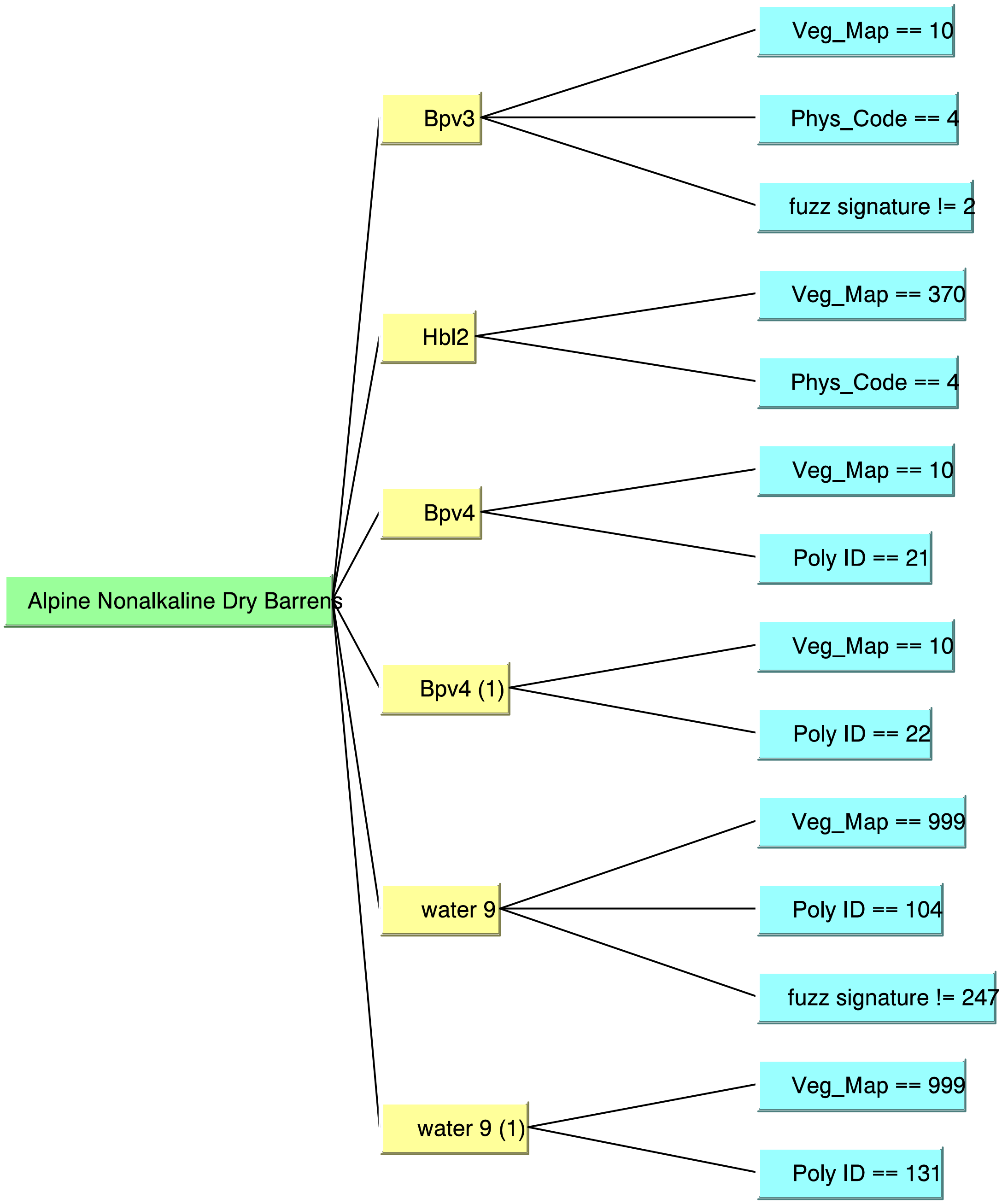
Consolidated Signature Vegetation Class	Gound Vegetation Class	Number of Signatures Used
Crowberry Dwarf Shrub Tundra	Crowberry Dwarf Shrub Tundra	8
Open Low Mesic Shrub Birch–Ericaceous Shrub	Dryas Dwarf Shrub Tundra	1
	Ericaceous Dwarf Shrub Tundra	1
	Closed Low Shrub Birch–Ericaceous Shrub	5
	Open Low Shrub Birch–Ericaceous Shrub Bog	1
	Open Low Mesic Shrub Birch–Ericaceous Shrub	10
	Open Low Ericaceous Shrub Bog	1
Open Low Shrub Birch–Willow	Closed Low Shrub Birch	1
	Closed Low Shrub Birch–Willow	5
	Closed Low Ericaceous Shrub	1
	Open Low Shrub Birch–Willow	12
Open Mixed Low Shrub–Sedge Tussock Tundra	Tussock Tundra	7
	Open Mixed Low Shrub–Sedge Tussock Tundra	31
Open Low Willow	Subartic Lowland Sedge–Moss Bog Meadow	1
	Closed Low Willow	6
	Open Low Willow	12
	Open Tall Alder	1
Closed Tall Alder–Willow	Closed Tall Alder	4
	Closed Tall Alder–Willow	1
	Closed Tall Shrub Birch–Willow	1
Open Tall Willow	Open Balsam Poplar	1
	Closed Tall Willow	2
	Open Tall Alder	1
	Open Tall Alder–Willow	2
	Open Tall Willow	5
Water	Common Marestail	2
	Fresh Grass Marsh	1
	Water	55
Total		389



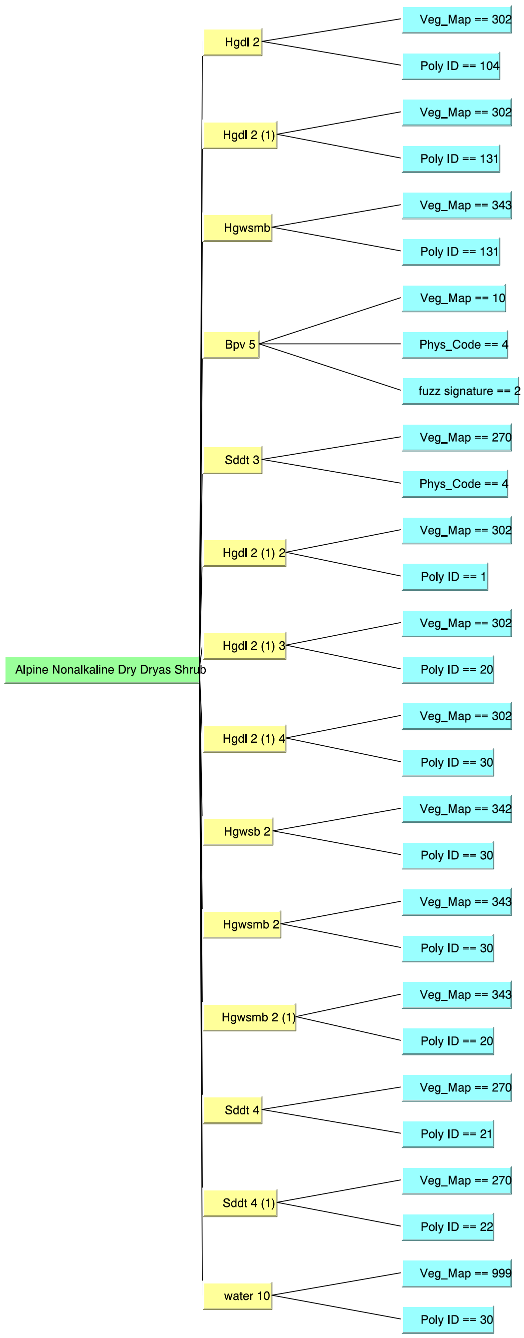
Appendix 7. Example diagrams of rules used to model ecotypes using the ERDAS knowledgebase routine. See Appendix 8 for codes.



Appendix 7. Continued.



Appendix 7. Continued.



Appendix 7. Continued.

Appendix 8. Codes used in ERDAS rule-based classification of ecotypes for Bering Land Bridge National Preserve and Cape Krusenstern National Monument, 2004.

ERDAS Numeric Code		Variable Title	Alpha Code
ERDAS_Park_Code		Park	
	1	BELA	
	2	CAKR	
			Vegetation
ERDAS_Veg_Map_Code		Signature Vegetation Name	Alpha Code
	10	Partially Vegetated	Bpv
	124	Open White Spruce Forest	Fnows
	370	Lichen	Hbl
	302	Elymus Meadow	Hgdl
	311	Bluejoint Meadow	Hgmb
	323	Sedge–Dryas Tundra	Hgmsd
	346	Halophytic Sedge–Grass Wet Meadow	Hgwhsgb
	342	Lowland Sedge Bog Meadow	Hgwsb
	343	Lowland Sedge–Moss Bog Meadow	Hgwsmb
	270	Dryas Dwarf Shrub Tundra	Sddt
	283	Crowberry Dwarf Shrub Tundra	Sdee
	253	Open Low Shrub Birch–Ericaceous Shrub	Slobe
	257	Open Low Shrub Birch–Willow Shrub	Slobw
	252	Open Low Mixed Shrub–Tussock Tundra	Slott
	260	Open Low Willow Shrub	Slow
	224	Closed Tall Alder–Willow Shrub	Stcaw
	231	Open Tall Willow Shrub	Stow
	999	Water	W
	0	unclassified	
ERDAS_Phys_Code		Aggregated Physiography	
	1	Alkaline Alpine and Upland	
	2	Coastal	
	3	Lowland	
	4	Nonalkaline Alpine and Upland	
	5	Riverine	
	6	Upland	
	7	Upland Lava	
	8	Upland-Lowland	

Appendix 9. Cross-walk of 33 ecotypes and 31 plant associations developed from analysis of ground data, and 29 map ecotypes, 17 map vegetation types, 12 map aggregated ecotypes. Map classes were aggregated from ground classes to match spectral characteristics.

Ground Ecotypes	Plant Associations	Map Ecotypes	Map Vegetation Types	Map Aggregated Ecotypes
Alpine Alkaline Dry Barrens	*Dryas integrifolia–Rhododendron lapponicum*	Alpine Alkaline Dry Barrens	Partially Vegetated	Alpine and Upland Dwarf Shrub and Barrens
	Dryas octopetala–Potentilla uniflora	Alpine Alkaline Dry Barrens	Partially Vegetated	Alpine and Upland Dwarf Shrub and Barrens
Alpine Nonalkaline Dry Barrens	*Dryas octopetala–Salix phlebophylla–Hierochloe alpina*	Alpine Nonalkaline Dry Barrens	Partially Vegetated	Alpine and Upland Dwarf Shrub and Barrens
Alpine Alkaline Dry Dryas Shrub	*Dryas integrifolia–Rhododendron lapponicum*	Alpine Alkaline Dry Dryas Shrub	Dryas Dwarf ShrubTundra	Alpine and Upland Dwarf Shrub and Barrens
	Dryas octopetala–Potentilla uniflora	Alpine Alkaline Dry Dryas Shrub	Dryas Dwarf ShrubTundra	Alpine and Upland Dwarf Shrub and Barrens
Alpine Nonalkaline Dry Dryas Shrub	*Dryas octopetala–Salix phlebophylla–Hierochloe alpina*	Alpine Nonalkaline Dry Dryas Shrub	Dryas Dwarf ShrubTundra	Alpine and Upland Dwarf Shrub and Barrens
Upland Dry Lichen	*Betula nana–Ledum decumbens–Loiseleuria procumbens*	Upland Dry Lichen Barrens	Lichen	Alpine and Upland Dwarf Shrub and Barrens
Upland Moist Spruce Forest	*Picea glauca–Salix planifolia pulchra*	Upland Moist Spruce Forest	Open White Spruce Forest	Upland Spruce Forest
Upland Moist Low Willow Shrub	*Salix glauca–Dryas integrifolia*	Upland Moist Low Willow Shrub	Tall and Low Willow Shrub	Upland and Lowland Low Willow Shrub
Upland Dry Crowberry Shrub	*Empetrum nigrum–Elymus arenarius mollis*	Upland Dry Crowberry Shrub	Crowberry Dwarf Shrub Tundra	Upland and Lowland Dwarf Birch–Willow Shrub
Upland Moist Dwarf Birch–Ericaceous Shrub	*Betula nana–Ledum decumbens–Loiseleuria procumbens*	Upland Moist Dwarf Birch–Ericaceous Shrub	Low Shrub Birch–Ericaceous Shrub	Upland and Lowland Dwarf Birch–Willow Shrub
Upland Moist Dwarf Birch–Tussock Shrub	*Betula nana–Eriophorum vaginatum*	Upland Moist Dwarf Birch–Tussock Shrub	Low Mixed Shrub–Tussock Tundra	Upland Dwarf Birch–Tussock Shrub
Upland Moist Sedge–Dryas Meadow	*Dryas integrifolia–Carex bigelowii–Senecio atropurpureus*	Upland Moist Sedge–Dryas Meadow	Sedge–Dryas Tundra	Upland and Lowland Sedge–Dryas Meadow
Lowland Moist Tall Alder–Willow Shrub	*Alnus crispa–Salix planifolia pulchra–Rubus arcticus*	Lowland Moist Tall Alder–Willow Shrub	Tall and Low Willow Shrub	Upland and Lowland Low Willow Shrub
Lowland Moist Low Willow Shrub	*Salix planifolia pulchra–Calamagrostis canadensis*	Lowland Moist Low Willow Shrub	Tall and Low Willow Shrub	Upland and Lowland Low Willow Shrub
Lowland Moist Dwarf Birch–Willow Shrub	*Betula nana–Salix planifolia pulchra–Pyrola grandiflora*	Lowland Moist Dwarf Birch–Willow Shrub	Low Shrub Birch–Willow Shrub	Upland and Lowland Dwarf Birch–Willow Shrub
Lowland Wet Dwarf Birch–Ericaceous Shrub	*Betula nana–Vaccinium vitis-idaea–Carex aquatilis*	Lowland Wet Dwarf Birch–Ericaceous Shrub	Low Shrub Birch–Ericaceous Shrub	Upland and Lowland Dwarf Birch–Willow Shrub
Lowland Moist Sedge–Dryas Meadow	*Dryas integrifolia–Equisetum arvense*	Lowland Moist Sedge–Dryas Meadow	Sedge–Dryas Tundra	Upland and Lowland Sedge–Dryas Meadow
Lowland Sedge–Moss Fen Meadow	*Carex aquatilis–Salix fuscescens–Sphagnum*	Lowland Sedge–Moss Fen Meadow	Lowland Sedge–Moss Bog Meadow	Lowland Sedge Fen Meadow

Appendix 9. Continued.

Lowland Sedge Fen Meadow	*Carex aquatilis–Carex chorddorhiza*	Lowland Sedge Fen Meadow	Lowland Sedge Bog Meadow	Lowland Sedge Fen Meadow
Lacustrine Moist Bluejoint Meadow	*Calamagrostis canadensis–Rumex arcticus*	Lacustrine Moist Bluejoint Meadow	Bluejoint Meadow	Lowland Sedge Fen Meadow
Lacustrine Marestail Marsh	*Arctophila fulva*	Lowland Water	Water	Freshwater
	Hippurus vulgaris–Potamogeton spp.	Lowland Water	Water	Freshwater
	Carex aquatilis–Caltha palustris	Lowland Water	Water	Freshwater
Lowland Water	Water	Lowland Water	Water	Freshwater
Riverine Water	Water	Riverine Water	Water	Freshwater
Riverine Moist Tall Alder–Willow Shrub	*Alnus crispa–Salix barclayi*	Riverine Moist Low and Tall Willow Shrub	Tall and Low Willow Shrub	Riverine Low and Tall Willow Shrub
Riverine Moist Tall Willow Shrub	*Salix alaxensis–Aster sibiricus*	Riverine Moist Low and Tall Willow Shrub	Tall and Low Willow Shrub	Riverine Low and Tall Willow Shrub
Riverine Moist Low Willow Shrub	*Salix lanata richardsonii–Festuca altaica*	Riverine Moist Low and Tall Willow Shrub	Tall and Low Willow Shrub	Riverine Low and Tall Willow Shrub
Riverine Moist Dwarf Birch–Willow Shrub	*Betula nana–Salix planifolia pulchra–Pyrola grandiflora*	Riverine Moist Dwarf Birch–Willow Shrub	Low Shrub Birch–Willow Shrub	Riverine Low and Tall Willow Shrub
Riverine Barrens	*Epilobium latifolium–Agropyron macrourum*	Riverine Barrens	Partially Vegetated	Riverine and Coastal Barrens
Coastal Barrens	*Elymus arenarius mollis–Lathyrus maritimus*	Coastal Barrens	Partially Vegetated	Riverine and Coastal Barrens
	Carex ramenskii–Puccinellia phryganodes	Coastal Barrens	Partially Vegetated	Riverine and Coastal Barrens
Coastal Dry Dunegrass Meadow	*Elymus arenarius mollis–Lathyrus maritimus*	Coastal Dry Dunegrass Meadow	Elymus Meadow	Riverine and Coastal Barrens
Coastal Brackish Wet Sedge–Grass Meadow	*Salix ovalifolia–Deschampsia caespitosa*	Coastal Wet Sedge–Grass Meadow	Halophytic Sedge–Grass Wet Meadow	Coastal Sedge–Grass Meadow
	Carex ramenskii–Dupontia fisheri	Coastal Wet Sedge–Grass Meadow	Halophytic Sedge–Grass Wet Meadow	Coastal Sedge–Grass Meadow
Coastal Saline Wet Sedge–Grass Meadow	*Carex ramenskii–Puccinellia phryganodes*	Coastal Wet Sedge–Grass Meadow	Halophytic Sedge–Grass Wet Meadow	Coastal Sedge–Grass Meadow
Coastal Water	Water	Coastal Water	Water	Coastal Water
Human Modifed Barrens	None	Human Modifed Barrens	Partially Vegetated	Human Modifed Barrens

Appendix 10. Cross-tabulation of consistency between independently derived spectral classes (nodes of hierarchical clustering) and signature vegetation class. Boxes denote central tendencies of nodes associated with vegetation types.

Node	Hbl	Bpv	Hgdl	Sddt	Hgmsd	Slott	Slobe	Slobw	Slow	Stow	Stcaw	Hgmb	Fnows	Sdee	Hgwsmb	Hgwsb	Hgwhsgb	W	Total
8111	2	1																	3
7111	2																		2
8112	4	2					1												7
7122		3																	3
1121		3																	3
8121		2																	2
7112		2																	2
1221		19		1															20
1111		6		1															7
1122		8		1	1														10
8122		3		1															4
6111		4		4															8
6221		1	1	2			1												5
1211		1		4															5
1112		1		6															7
5111				5															5
5112		1		5	2														8
5121				3															3
2212					5		1								1				7
2121					7	5													12
2211					2										1				3
5211				2	6	8													16
2111					1	3													4
2122					1	1													2
2412						8	2		1			1							12
2311						3													3
2322						1			1										2
3113			1		1	1									1				4
3312					2	1	2		1					1	1				8
2321						2	1												3
2411						1	1												2
3322							2	1	2	1				1		1			8
2312			1				1												2
3111						1		2											3
2621					1			2											3
2421						1	1	4				2							8
3122							1	2											3
2612					1			3				2							6
2622								3											3
3211									3										3
2500							1		1										2
4122									2			1							3
4111								1	2	4	2					1			10
4121									2	3	4	1							10
4211									3	1		2							6
7321										2			4						6
7311									1				3						4
5221					1									1					2
6211					2									2	2				6
5212				2	1										5				8
6212				1	5	2	1							1	2	1			13
6121					2		1							1	2	2			8
3321					1		1	1	1					1	1	2	1		9
8211																4	1		5
8221			1													1	2		4
7212																3	3		6
8222																1	1		2
7211																1	1		2
7220													1					2	3
9110																		12	12
9120																		36	36
9220																		7	7
Total	8	58	4	39	42	38	19	19	20	11	6	9	8	8	16	17	9	58	389
% in	100	88	25	62	33	66	42	84	30	36	67	22	88	38	56	35	78	100	65

Appendix 11. Comparison of mapped and ground ecotypes determined at 256 points used to create map signatures. Shaded values indicate the number of correctly mapped points and bolded values indicate the dominant types of misclassification.

Ground Ecotypes	Alpine Alkaline Dry Barrens	Alpine Alkaline Dry Dryas Shrub	Alpine Nonalkaline Dry Barrens	Alpine Nonalkaline Dry Dryas Shrub	Coastal Barrens	Coastal Dry Dunegrass Meadow	Coastal Water	Coastal Wet Sedge-Grass Meadow	Lacustrine Moist Bluejoint Meadow	Lowland Moist Dwarf Birch-Willow Shrub	Lowland Moist Low Willow Shrub	Lowland Moist Sedge-Dryas Meadow	Lowland Moist Tall Alder-Willow Shrub	Lowland Sedge Fen Meadow	Lowland Sedge-Moss Fen Meadow	Lowland Water	Lowland Wet Dwarf Birch-Ericaceous Shrub	Riverine Barrens	Riverine Moist Dwarf Birch-Willow Shrub	Riverine Moist Low and Tall Willow Shrub	Riverine Water	Upland Dry Crowberry Shrub	Upland Dry Lichen Barrens	Upland Moist Dwarf Birch-Ericaceous Shrub	Upland Moist Dwarf Birch-Tussock Shrub	Upland Moist Low Willow Shrub	Upland Moist Sedge-Dryas Meadow	Upland Moist Spruce Forest	Point Total	Fraction Correct
Alpine Alkaline Dry Barrens	16	2																											18	0.89
Alpine Alkaline Dry Dryas Shrub	1	21		1																							**3**		26	0.81
Alpine Nonalkaline Dry Barrens	**5**		2																										7	0.29
Alpine Nonalkaline Dry Dryas Shrub	1	**5**		2																				1					9	0.22
Coastal Barrens					2	1	1																						4	0.50
Coastal Dry Dunegrass Meadow						2						1										1							4	0.50
Coastal Water							3					**2**																	5	0.60
Coastal Wet Sedge-Grass Meadow								9																					9	1.00
Lacustrine Moist Bluejoint Meadow									6		1			1															8	0.75
Lowland Moist Dwarf Birch-Willow										3														**2**					5	0.60
Lowland Moist Low Willow Shrub										1	3		**3**							1				1		**6**			15	0.20
Lowland Moist Sedge-Dryas Meadow																	1										**4**		5	0.00
Lowland Moist Tall Alder-Willow													3													1			4	0.75
Lowland Sedge Fen Meadow		1												10															11	0.91
Lowland Sedge-Moss Fen Meadow															8											1			9	0.89
Lowland Water										1				**3**		3													7	0.43
Lowland Wet Dwarf Birch-Ericaceous															1		4					1		1	1				8	0.50
Riverine Barrens																		2											2	1.00
Riverine Moist Dwarf Birch-Willow																			1										1	1.00
Riverine Moist Low and Tall Willow											1		1					1		5									8	0.63
Riverine Water																					1								1	1.00
Upland Dry Crowberry Shrub							1															4							5	0.80
Upland Dry Lichen Barrens			1																				7						8	0.88
Upland Moist Dwarf Birch-Ericaceous																	**2**							9	1				12	0.75
Upland Moist Dwarf Birch-Tussock																									25				25	1.00
Upland Moist Low Willow Shrub																								**3**		2			5	0.40
Upland Moist Sedge-Dryas Meadow		1										**3**													1		22		27	0.81
Upland Moist Spruce Forest																												8	8	1.00
Point Total	23	30	3	3	2	3	5	9	6	5	5	6	7	14	9	3	7	3	1	6	1	6	7	17	28	10	29	8	256	
Fraction correct	0.70	0.70	0.67	0.67	1.00	0.67	0.60	1.00	1.00	0.60	0.60	0.00	0.43	0.71	0.89	1.00	0.57	0.67	1.00	0.83	1.00	0.67	1.00	0.53	0.89	0.20	0.76	1.00		0.71

Appendix 12. Comparison of mapped and ground vegetation determined at 256 points used to create map signatures. Ground classes were cross walked to correspond to reduced set of mapped classes. Shaded values indicate the number of correctly mapped points and bolded values indicate the dominant types of misclassification.

Ground Vegetation Class	Bluejoint Meadow	Crowberry Dwarf Shrub Tundra	Dryas Dwarf ShrubTundra	Elymus Meadow	Halophytic Sedge-Grass Wet Meadow	Lichen	Low Mixed Shrub-Tussock Tundra	Low Shrub Birch-Ericaceous Shrub	Low Shrub Birch-Willow Shrub	Lowland Sedge Bog Meadow	Lowland Sedge-Moss Bog Meadow	Open White Spruce Forest	Partially Vegetated	Sedge-Dryas Tundra	Tall and Low Willow Shrub	Water	Point Total	Fraction Correct
Bluejoint Meadow	6									1					1		8	0.75
Crowberry Dwarf Shrub Tundra		4														1	5	0.80
Dryas Dwarf ShrubTundra			29					1					2	**3**			35	0.83
Elymus Meadow		1		2										1			4	0.50
Halophytic Sedge-Grass Wet Meadow					9												9	1.00
Lichen						7							1				8	0.88
Low Mixed Shrub-Tussock Tundra							25										25	1.00
Low Shrub Birch-Ericaceous Shrub		1					**2**	16			1						20	0.80
Low Shrub Birch-Willow Shrub								**2**	4								6	0.67
Lowland Sedge Bog Meadow			1							10							11	0.91
Lowland Sedge-Moss Bog Meadow											8				1		9	0.89
Open White Spruce Forest												8					8	1.00
Partially Vegetated			2	1									27			1	31	0.87
Sedge-Dryas Tundra			1				1	1						29			32	0.91
Tall and Low Willow Shrub								**4**	1				1		26		32	0.81
Water									1	**3**				2		7	13	0.54
Point Total	6	6	33	3	9	7	28	24	6	14	9	8	31	35	28	9	256	
Fraction Correct	1.00	0.67	0.88	0.67	1.00	1.00	0.89	0.67	0.67	0.71	0.89	1.00	0.87	0.83	0.93	0.78		0.85

Appendix 13. Comparison of mapped and ground ecotypes after aggregation into 12 classes, determined at 256 points used to create map signatures. Shaded values indicate the number of correctly mapped points and bolded values indicate the dominant types of misclassification..

Aggregated Ground Ecotype	Coastal Water	Alpine and Upland Dwarf Shrub and Barrens	Coastal Sedge-Grass Meadow	Freshwater	Lowland Sedge Fen Meadow	Riverine and Coastal Barrens	Riverine Low and Tall Willow Shrub	Upland and Lowland Dwarf Birch-Willow Shrub	Upland and Lowland Low Willow Shrub	Upland and Lowland Sedge-Dryas Meadow	Upland Dwarf Birch-Tussock Shrub	Upland Spruce Forest	Point Total	Fraction Correct
Coastal Water	3									**2**			5	0.60
Alpine and Upland Dwarf Shrub and Barrens		64						1		**3**			68	0.94
Coastal Sedge-Grass Meadow			9										9	1.00
Freshwater				4	**3**			1					8	0.50
Lowland Sedge Fen Meadow		1			25				2				28	0.89
Riverine and Coastal Barrens	1					7		1		1			10	0.70
Riverine Low and Tall Willow Shrub						1	6		**2**				9	0.67
Upland and Lowland Dwarf Birch-Willow Shrub	1				1			26			2		30	0.87
Upland and Lowland Low Willow Shrub							1	**5**	18				24	0.75
Upland and Lowland Sedge-Dryas Meadow		1						1		29	1		32	0.91
Upland Dwarf Birch-Tussock Shrub											25		25	1.00
Upland Spruce Forest												8	8	1.00
Point Total	5	66	9	4	29	8	7	35	22	35	28	8	256	
Fraction Correct	0.60	0.97	1.00	1.00	0.86	0.88	0.86	0.74	0.82	0.83	0.89	1.00		0.88

Appendix 14. Vegetation cover and frequency for ecotypes described by two plant associations. Data summarized by plant association.

Alpine Alkaline Dry Dryas Shrub

Dryas integrifolia–Rhododendron lapponicum (n = 6)	Cover		Freq
	Mean	SD	%
Total Vascular Cover	73.9	10.9	100
Total Evergreen Shrub Cover	49.2	12.1	100
Cassiope tetragona	5.3	5.2	83
Dryas integrifolia	31.7	18.6	83
Rhododendron lapponicum	1.4	1.8	83
Total Deciduous Shrub Cover	10.5	4.1	100
Salix arctica	4.2	2.3	100
Andromeda polifolia	0.5	0.5	50
Arctostaphylos rubra	3.7	1.5	100
Salix reticulata	1.3	1.9	67
Vaccinium uliginosum	0.7	1.2	50
Total Forb Cover	8.6	3.0	100
Senecio sp.	0.1	0.1	50
Polygonum viviparum	0.3	0.4	100
Equisetum variegatum	0.5	0.8	67
Anemone sp.	0.1	0.1	50
Artemisia furcata	0.1	0.1	50
Astragalus umbellatus	0.1	0.1	67
Chrysanthemum integrifolium	0.1	0.0	83
Hedysarum alpinum	1.0	1.2	67
Lagotis glauca	0.2	0.4	50
Pedicularis capitata	0.3	0.4	100
Saussurea angustifolia	0.5	0.5	50
Saxifraga oppositifolia	1.0	1.1	50
Silene acaulis	0.4	0.5	83
Thalictrum alpinum	0.1	0.1	67
Tofieldia coccinea	0.2	0.4	50
Tofieldia pusilla	0.4	0.5	67
Total Grass Cover	0.3	0.4	67
Arctagrostis latifolia	0.2	0.4	17
Total Sedge Cover	5.3	1.9	100
Eriophorum angustifolium	0.5	0.5	50
Carex bigelowii	0.7	1.0	33
Carex membranacea	0.5	0.5	50
Carex misandra	0.5	0.8	33
Carex scirpoidea	2.3	2.3	100
Total NonVascular Cover	60.1	32.1	100
Total Moss Cover	14.2	9.0	100
Hylocomium splendens	2.5	4.2	33
Rhytidium rugosum	4.0	4.7	67
Tomentypnum nitens	5.5	7.3	67
Total Lichen Cover	45.9	34.5	100
Flavocetraria nivalis	2.8	1.9	83
Thamnolia vermicularis	5.8	5.6	83
Alectoria ochroleuca	1.7	2.0	67
Bryocaulon divergens	0.7	1.2	33
Cetraria islandica cf	5.5	12.0	50
Cetraria tilesii	0.2	0.4	50
Dactylina arctica	0.9	1.2	67
Flavocetraria cucullata	11.0	12.6	100
Masonhalea richardsonii	0.3	0.5	33
Nephroma arcticum	7.0	16.2	50
Ochrolechia frigida	3.0	4.0	50
Total Bare Ground	34.9	23.1	100
Litter alone	28.3	22.9	100
Soil	6.5	5.7	100

Alpine Alkaline Dry Dryas Shrub

Dryas octopetala–Potentilla uniflora (n = 7)	Cover		Freq
	Mean	SD	%
Total Vascular Cover	49.5	19.6	100
Evergreen Tree	0.7	1.9	14
Picea glauca	0.7	1.9	14
Total Evergreen Shrub Cover	39.8	17.0	100
Cassiope tetragona	0.3	0.5	29
Dryas octopetala	39.3	16.4	100
Rhododendron lapponicum	0.0	0.0	29
Total Deciduous Shrub Cover	0.7	1.2	43
Arctostaphylos alpina	0.1	0.4	14
Arctostaphylos rubra	0.1	0.4	14
Salix reticulata	0.3	0.8	29
Total Forb Cover	6.1	1.4	100
Androsace chamaejasme	0.1	0.0	71
Artemisia furcata	0.2	0.4	57
Artemisia senjavinensis	0.2	0.4	29
Castilleja hyperborea	0.0	0.1	43
Erigeron sp.	0.2	0.4	29
Hedysarum mackenzii	0.7	1.1	71
Lesquerella arctica	0.1	0.1	57
Minuartia arctica	0.0	0.1	43
Oxytropis bryophila	0.3	0.8	29
Oxytropis nigrescens	0.2	0.4	43
Phlox sibirica sibirica	0.3	0.8	29
Pinguicula vulgaris	0.0	0.1	43
Potentilla uniflora	0.2	0.4	29
Saxifraga oppositifolia	1.3	0.7	100
Senecio resedifolius	0.0	0.1	43
Silene acaulis	0.0	0.1	43
Total Grass Cover	0.3	0.7	57
Festuca altaica	0.3	0.8	14
Total Sedge Cover	1.9	1.5	100
Carex franklinii	0.3	0.8	14
Carex nardina	0.6	0.8	57
Kobresia sp.	0.1	0.4	14
Total NonVascular Cover	14.1	9.8	100
Total Moss Cover	1.2	2.2	57
Rhytidium rugosum	0.2	0.4	29
Tortella fragilis	0.7	1.9	14
Total Lichen Cover	12.9	10.4	100
Flavocetraria nivalis	1.1	1.3	57
Thamnolia vermicularis	1.8	1.6	100
Cetraria tilesii	0.3	0.5	29
Evernia perfragilis	0.1	0.1	29
Flavocetraria cucullata	1.1	1.3	57
Ochrolechia frigida	2.3	5.6	43
Ochrolechia upsaliensis	0.6	1.5	29
Pertusaria sp.	2.4	3.8	43
Pertusaria subobducens	0.6	1.5	14
Thamnolia subuliformis	0.4	0.9	29
Vulpicida tilesii	0.5	0.8	57
Total Bare Ground	52.9	28.4	100
Litter alone	12.0	13.7	100
Soil	40.9	28.3	100

Appendix 14. Continued.

Lacustrine Marestail Marsh

Hippuris vulgaris–Potamogeton sp (n = 3)	Cover Mean	Cover SD	Freq %
Total Vascular Cover	22.8	21.6	100
Total Forb Cover	22.1	20.5	100
Ranunculus pallasii	0.7	1.2	33
Hippuris vulgaris	13.3	7.6	100
Caltha palustris	0.3	0.6	33
Menyanthes trifoliata	0.7	1.2	33
Potamogeton sp.	0.4	0.6	67
Potentilla palustris	6.7	11.5	33
Total Grass Cover	0.3	0.6	33
Arctophila fulva	0.3	0.6	33
Total Sedge Cover	0.3	0.6	33
Carex aquatilis	0.3	0.6	33
Total NonVascular Cover	5.3	9.2	33
Total Moss Cover	5.3	9.2	33
Limprichtia revolvens	3.3	5.8	33
Scorpidium scorpioides	1.7	2.9	33
Sphagnum cf. jensnii	0.3	0.6	33
Total Bare Ground	91.7	13.5	100
Water	91.3	14.2	100
Litter alone	0.3	0.6	33

Lacustrine Marestail Marsh

Carex aquatilis–Caltha palustris (n = 2)	Cover Mean	Cover SD	Freq %
Total Vascular Cover	42.1	8.4	100
Total Deciduous Shrub Cover	0.5	0.7	50
Salix fuscescens	0.5	0.7	50
Total Forb Cover	16.6	16.2	100
Ranunculus hyperboreus	1.5	2.1	50
Hippuris vulgaris	1.5	2.1	50
Caltha natans	7.5	10.6	50
Caltha palustris	1.5	2.1	50
Myriophyllum spicatum	1.5	2.1	50
Polemonium acutiflorum	0.1	0.1	50
Potamogeton sp.	0.5	0.7	50
Potentilla palustris	2.5	3.5	50
Total Grass Cover	10.0	14.1	50
*Arctophila fulva**	10.0	14.1	50
Total Sedge Cover	15.0	21.2	50
Eriophorum angustifolium	7.5	10.6	50
Carex aquatilis	7.5	10.6	50
Total NonVascular Cover	1.5	2.1	50
Total Moss Cover	1.5	2.1	50
Sphagnum squarrosum	1.5	2.1	50
Total Bare Ground	125.0	35.4	100
Water	80.0	28.3	100
Litter alone	45.0	63.6	50

**Arctophila fulva* typically occurs as a unique plant association, but was included here because of insufficient data to describe it separately.

Coastal Barrens

Elymus arenarius mollis–Lathyrus maritimus (n = 6)	Cover Mean	Cover SD	Freq %
Total Vascular Cover	3.8	6.6	33
Total Deciduous Shrub Cover	0.0	0.1	17
Salix ovalifolia	0.0	0.0	17
Salix planifolia pulchra	0.0	0.0	17
Total Forb Cover	1.6	2.6	33
Stellaria sp.	0.0	0.0	17
Artemisia tilesii	0.0	0.0	17
Honckenya peploides	1.0	1.5	33
Lathyrus maritimus	0.2	0.4	33
Mertensia maritima	0.3	0.8	17
Senecio pseudoarnica	0.0	0.0	17
Total Grass Cover	2.2	4.0	33
Festuca rubra	0.0	0.0	17
Elymus arenarius mollis	2.2	4.0	33
Total NonVascular Cover	0.1	0.2	33
Total Moss Cover	0.1	0.2	33
Ceratodon purpureus	0.0	0.1	17
Bryum pseudotriquetrum	0.0	0.1	17
Dicranum spadiceum	0.0	0.1	17
Leptobryum pyriforme	0.0	0.1	17
Total Bare Ground	98.3	4.1	100
Litter alone	2.7	4.1	50
Soil	95.7	6.5	100

Coastal Barrens

Carex ramenskii–Puccinellia phryganodes (n = 1)	% Cover
Total Vascular Cover	1.4
Total Forb Cover	0.3
Stellaria humifusa	0.1
Chrysanthemum arcticum	0.1
Potentilla egedii	0.1
Total Grass Cover	0.1
Elymus arenarius mollis	0.1
Total Sedge Cover	1.0
Carex subspathacea	1.0
Total NonVascular Cover	0.2
Total Moss Cover	0.2
Sphagnum obtusum	0.2
Total Bare Ground	99.1
Water	1.0
Litter alone	0.1
Soil	98.0

Appendix 14. Continued.

Coastal Brackish Wet Sedge–Grass Meadow

Salix ovalifolia–Deschampsia caespitosa (n = 2)	Cover		Freq
	Mean	SD	%
Total Vascular Cover	53.6	14.3	100
Total Deciduous Shrub Cover	11.0	12.7	100
Salix ovalifolia	11.0	12.7	100
Total Evergreen Shrub Cover	0.6	0.6	100
Empetrum nigrum	0.6	0.6	100
Total Forb Cover	8.5	2.6	100
Sedum rosea	0.1	0.1	50
Androsace chamaejasme	0.1	0.1	50
Pedicularis sudetica	2.0	0.0	100
Rumex arcticus	0.1	0.0	100
Stellaria sp.	0.1	0.1	50
Castilleja elegans	0.5	0.7	50
Chrysanthemum arcticum	1.0	0.0	100
Cochlearia officinalis arctica	1.0	0.0	100
Lathyrus maritimus	0.5	0.7	50
Melandrium apetalum	0.1	0.1	50
Pedicularis langsdorffii arctica	0.5	0.7	50
Potentilla sp.	0.1	0.0	100
Primula borealis	0.1	0.1	50
Saxifraga exilis	2.5	3.5	50
Total Grass Cover	19.1	5.6	100
Dupontia fisheri	2.5	3.5	50
Calamagrostis deschampsioides	7.5	3.5	100
Arctagrostis latifolia	2.5	3.5	50
Deschampsia caespitosa	6.0	5.7	100
Elymus arenarius mollis	0.6	0.6	100
Total Sedge Cover	14.6	0.8	100
Eriophorum angustifolium	1.1	1.3	100
Carex aquatilis	1.0	1.4	50
Carex amblyorhynca	2.5	3.5	50
Carex canescens	1.0	1.4	50
Carex ramenskii	7.5	3.5	100
Juncus albescens	1.5	2.1	50
Total NonVascular Cover	16.0	15.6	100
Total Moss Cover	16.0	15.6	100
Bryum sp.	3.8	1.8	100
Aulacomnium palustre	1.0	1.4	50
Bryum pallescens	2.5	3.5	50
Campylium polygamum	2.5	3.5	50
Campylium sp.	3.8	1.8	100
Leptobryum pyriforme	2.5	3.5	50
Total Bare Ground	49.5	14.8	100
Water	0.5	0.7	50
Litter alone	47.5	17.7	100
Soil	1.5	2.1	50

Coastal Brackish Wet Sedge–Grass Meadow

Carex ramenskii–Dupontia fisheri (n = 5)	Cover		Freq
	Mean	SD	%
Total Vascular Cover	45.9	11.1	100
Total Deciduous Shrub Cover	2.6	4.2	60
Salix ovalifolia	2.4	4.3	40
Salix fuscescens	0.2	0.4	20
Total Forb Cover	8.3	5.8	100
Stellaria humifusa	4.0	3.7	100
Cochlearia officinalis	1.8	2.2	60
Rumex arcticus	0.3	0.4	80
Chrysanthemum bipinnatum	0.0	0.0	20
Polygonum sp.	0.0	0.0	20
Potentilla egedii	2.2	4.4	60
Potentilla sp.	0.0	0.0	20
Total Grass Cover	8.8	5.2	100
Calamagrostis holmii	2.4	4.3	40
Dupontia fisheri	2.0	1.9	80
Calamagrostis deschampsioides	3.0	4.5	40
Poa arctica SL	0.4	0.9	20
Deschampsia caespitosa	1.0	2.2	20
Total Sedge Cover	26.2	4.4	100
Carex aquatilis	0.2	0.4	20
Carex ramenskii	26.0	4.2	100
Total Bare Ground	73.4	21.2	100
Water	0.2	0.4	60
Litter alone	62.0	22.5	100
Soil	11.2	21.7	100

The Department of the Interior protects and manages the nation’s natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior

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