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Ecological Land Survey and Soil Landscapes Map for Lake Clark National Park and Preserve, Alaska, 2011

Natural Resource Technical Report NPS/LACL/NRTR—2013/693








ON THIS PAGE
Top left: Self-portrait of Vegetation Ecologist Aaron Wells in Gladiator Basin, Chigmit Mountains, Lake Clark National Park and Preserve, Alaska.
Middle left: Torre Jorgenson taking a closer look at volcanic glass, upper Kejik River Valley, Lake Clark National Park and Preserve. Photograph by Tracy Christopherson.
Bottom left: GIS and Remote Sensing Specialist Matt Macander sampling vegetation near Slope Mountain, southeastern Lake Clark National Park and Preserve. Photograph by Eric Pullman.
Right: Soil Scientist Tracy Christopherson sampling soils in the upper Necons River valley. Photograph by Aaron Wells.

ON THE COVER
Top left: Neacola Mountains from the Stony River valley. Photograph by Tracy Christopherson.
Bottom left: Turquoise Lake. Photograph by Aaron Wells.
Right: Lake Clark. Photograph by Aaron Wells.

Ecological Land Survey and Soil Landscapes Map for Lake Clark National Park and Preserve, Alaska, 2011

Natural Resource Technical Report NPS/LACL/NRTR—2013/693

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Acronyms

ABR—ABR, Inc. Environmental Research and Services

ACCA—Automated Cloud-Cover Assessment algorithm

ALA—Herbarium at the University of Alaska Fairbanks

ALAG—Alagnak Wild River

ANIA—Aniakchak National Monument and Preserve

AVC—Alaska Vegetation Classification (Viereck et al. 1992)

EC—Electrical conductivity

ELS—Ecological Land Survey

EPA—Environmental Protection Agency

GIS—Geographic Information System

ITU—Integrated Terrain Unit

KATM—Katmai National Park and Preserve

KEFJ—Kenai Fjords National Park

LACL—Lake Clark National Park and Preserve

LEDAPS—Landsat Ecosystem Disturbance Adaptive Processing

NIR—Near Infrared

NMDS—Non-metric Multidimensional Scaling

NPS—National Park Service

NRCS—Natural Resource Conservation Service

PAM—Partitioning Around Medoids

PRISM—Parameter-elevation Regressions on Independent Slopes Model

R—R Project for statistical computing (http://www.r-project.org/)

SWAN—Southwest Alaska Network of National Parks

USGS—United States Geological Survey

Definitions

A-horizon—mineral soil horizon dominated by an accumulation of organic carbon related to high amounts of fine root decomposition. Typically occurs at or near the soil surface where fine roots from forbs and grasses are most abundant.

Andic—unique properties of soils developing in volcanic ejecta (e.g, volcanic ash, pumice, cinders, or lava) and/or volcaniclastic materials (e.g., lahar deposits) characterized by an abundance of volcanic glass; a smeary, almost oily feel when rubbed between two fingers; and a low bulk density (i.e., a given volume of soil feels lighter than it appears). See the page 15 (Diagnostic Soil Characteristics for Mineral Soils: Andic Soil Properties) in the 11th Edition of the Keys to Soil Taxonomy (Soil Survey Staff 2010) for more details.

O-horizon—soil horizon dominated by organic materials and divided into fibric, hemic, and sapric based on degree of of decomposition.

Aluminum-Humus Complexes—soil particles formed from the binding of negatively charged organic particles to positively charged aluminum ions.

Chroma—a soil color characteristic related to the degree of color saturation as per the Munsell® Soil Color Chart. Lower chroma soils colors are often indicative of the loss of soil materials from a portion of the soil profile through translocation. Typically denoted in soil descriptions along with Hue (primary color) and Value (degree of color lightness) as "Hue Value/Chroma"; e.g., 10YR 3/2.

Cryic—soil temperature regime that occurs in cold temperate climates. Soils in the cryic temperature regime have a mean annual soil temperature at 50 cm below the soil surface between 0 and 8° C and do not have permafrost.

Cryoturbation—heaving and displacement of soils and rock fragments due to freeze-thaw processes.

Fibric—organic soil materials that have undergone the least amount of decomposition. The source of the organic material (e.g. deciduous leaves, moss fibers) and often the species from which the organic material was derived remains identifiable. Abbreviated as "Oi" in soil horizon descriptions.

Gelic—a soil temperature regime that occurs in extremely cold; subarctic, arctic, and alpine climates. Soils in the gelic temperature regime have a mean annual soil temperature at 50 cm below the soil surface at or below 0° C and have permafrost.

Hemic—organic soil materials that have undergone intermediate decomposition that is more than fibric soil materials, but less than sapric soil materials. The source of the organic material and the lifeform from which it was derived remains identifiable, however species distinctions can no longer be made. Abbreviated as "Oe" in soil horizon descriptions.

O-horizon—a soil horizon dominated by organic materials and divided into fibric, hemic, and sapric based on degree of decomposition.

Permafrost—soil material that remains below 0° C for two or more consecutive years. Divided into ice-rich (≥50% ice content) and ice-poor (<50% ice content).

Redoximorphic depletions—low-chroma zones from which iron and manganese oxide or a combination of iron and manganese oxide and clay has been removed due to translocation. These zones are indications of the chemical reduction of iron resulting from saturation (Soil Survey Staff 2010).

Sapric—organic soil materials that have undergone the highest amount of decomposition. The source of the organic material, and the lifeform and species from which it was derived is unidentifiable. Abbreviated as "Oa" in soil horizon descriptions.

Translocation—movement of materials (e.g, organic carbon, iron, aluminum) through time from the upper to the lower soil profile via the forces of chemical weathering and gravity.

Udic—soil moisture regime that occurs in humid temperature climates. A udic soil moisture regime is one in which the upper meter of soil remains moist to wet throughout the growing season.

Water Retention—the degree to which soils can retain water within the pore spaces between individual soil particles; measured in terms of the soil water content of a given volume of soil that remains in the soil when a set amount of pressure (i.e., kilopascals) is applied to a soil sample in the laboratory.

How to Use this Ecological Land Survey and Mapping

Overview

An ELS and classification, in conjunction with a landcover map, enables resource managers to more effectively evaluate land resources and develop appropriate management strategies. An ELS is an integrated approach of inventorying and classifying ecological characteristics from the "bottom up" while using environmental and GIS modeling to better differentiate the distribution of ecosystems across space from the "top down." An ELS can be used to efficiently allocate inventory and monitoring efforts, to partition information for analysis of ecological relationships, to develop predictive models, and to improve techniques for assessing and mitigating impacts. This section provides guidance on how to use this ELS and associated mapping products.

Definitions

Definitions of important terminology and mapping concepts are provided below:

- Aggregated Ecotype Code—A numeric code assigned to ecotypes during the process of aggregating up to mapping classes (see below, Map Ecotype, Soil Landscapes, Disturbance Landscapes), and used to cross-walk ecotypes to the combined strata and land cover layer (see GIS Modeling: Aggregated Ecotypes for more details).

- Disturbance Landscapes—Aggregations of ecotypes with similar disturbance pathways. The focus of the disturbance landscape aggregation was on similarities in disturbance regimes across physiography, soil and vegetation classes.

- Ecotype—Conceptually, ecotypes are local-scale ecosystems classified by aggregating the field data for individual ecological components (e.g., soils, geomorphology, vegetation), using a hierarchical approach. Two naming convensions for ecotypes are used in this report, including:

    - Abbreviated ecotype—Shortened ecotype name designed to emphasize primary characteristics of the class and facilitate discussion (e.g., Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra). In this report, including text, tables and figures, abbreviated ecotype names have been used unless specifically stated otherwise.

    - Ecotype long-name—Full ecotype names based on the aggregated ecological components, including ecoregion, physiography, soil chemistry, soil texture, and vegetation; e.g., Alpine Gelic Dry Acidic-Circumacidic Rocky Dwarf Shrub-Lichen Tundra.

- Map Ecotype—Aggregations of ecotypes with similar vegetation for use in mapping. The focus of the map ecotype aggregation was on vegetation type and structure with less emphasis on soils (e.g., Alpine Meadows and Dwarf Shrub). Thus, map ecotype classes represent aggregations of similar or closely associated vegetation types with differing soil textures.

- Plant Associations—also called Floristic Associations. Assemblages of plants with similar composition that are repeatable across space. Plant associations are characterized by one (occasionally two) dominant species and one to several indicator species that occur consistently and are indicative of specific environmental conditions.

- Soil Landscapes—Aggregations of ecotypes with similar soils for use in mapping. The focus of the soil landscape aggregation was on soils with less emphasis on vegetation (e.g., Alpine Ashy-Loamy-Rocky Meadows and Shrublands). Thus, soil landscape classes represent aggregations of similar or closely associated soil types with different vegetation types that are typically associated through a successional sequence

Purpose and Limitations

The purpose of an ELS is to provide field verification data for the classification and description of local-scale (thousands of square meters to tens and hundreds of hectares) ecosystems while simultaneously informing the analysis and mapping of ecosystem components at the landscape-scale (hundred to thousands of hectares to hundreds to thousands of square kilometers). Hence an ELS provides useful products for land managers and scientists at both the local- and landscape-scales. While the products from the two spatial scales may be useful independent of one another, the real power of an ELS lies where the products of the two spatial scales overlap and, depending on the objectives of the end user, the two are often used in conjunction with one another. The process of using this ELS and how the two scales overlap is described in the next section.

This ELS provides a robust classification and mapping products, however these products are not without their limitations. First, while steps were taken during the planning phase to design a balanced, well-stratified sample design, the constraints of weather, a relatively short sampling period, and the overall remote and diverse character of ecosystems in LACL resulted in a low sample size for some vegetation types, soils, and environments. Therefore, the classification of ecotypes should not be considered exhaustive of the possible vegetation and soil types in LACL. Secondly, the short sampling window did not allow us to conduct an accuracy assessment of the maps provided as part of this ELS. Third, the map series produced as part of this ELS provides a landscape scale view of ecosystem components with a minimum pixel size of 30 m. While this scale of mapping is appropriate for large, remote parks like LACL it does limit the usefulness for some applications. Applications for which the mapping series are useful and appropriate include landscape scale analyses of ecological components (e.g., terrain suitability, wildlife habitat), broad-scale management and planning, and development of stratified sampling designs for landscape scale inventory and monitoring studies. Applications for which this ELS mapping is inappropriate include site specific management, planning, analysis, and study design. An Integrated Terrain Unit (ITU) approach (Jorgenson et al. 2003, Wells 2012) to mapping geomorphology, soils, vegetation, and ecotypes is better suited for these finer-scale applications.

Guildlines for Use

Guidelines for two likely scenarios for using this ELS and mapping are provided below. In both scenarios it is assumed that the researcher(s) has basic knowledge of common plant species in LACL, and soil sampling and GIS techniques.

Field Data × Classification and Mapping

In the first scenario land managers and/or researchers are interested in classifying ecotypes and 1) are in the field in LACL collecting data, or 2) are in the office reviewing vegetation and soil field data collected in LACL. If in the field, first locate a relatively homogenous patch of vegetation with a suggested minimum area ranging between 314 m^2 (the area of an ELS plot) to 900 m^2 (the area of one 30×30 m pixel in the ecotype and soil landscapes map) that is obviously associated with a specific landform or slope position. An appropriate sample site should be

located firmly on a landform and not near the boundary between two landforms. Plots should be roughly 314 m^2 in size and circular (10-m radius). On long, narrow landforms, such as in steep, narrow riparian zones, the shape of the plot may be changed to fit on the landform, so long as the area of the plot is approximately the same as above. Next, go to the the Ecotype Key (see Table 5) to determine the ecotype. Once the ecotype has been determined the user is directed to:

- The ecotype descriptions (see Results: Ecotypes and Plant Associations, below) for information regarding general environment, vegetation, and soils;
- Table 6 which provides a cross-walk between ecotypes (abbreviated ecotype name) and ecotype long name, floristic classes, and Viereck et al. (1992) Level IV vegetation Classes included in each ecotype;
- Tables 2, 7, and 18 which provide descriptions of generalized soil texture classes (used in the ecotype names), plant associations, and soil subgroups described in the ecotype descriptions, respectively;
- Tables 21–26 which provide the cross-tabulations of abbreviated ecotypes and soil subgroups used to classify soil landscapes;
- Appendix 8 which provides a cross-walk between abbreviated ecotypes and aggregated ecotype code (used for mapping);
- Appendix 6 which provides a cross-walk between aggregated ecotype codes, abbreviated ecotypes, and map classes in the Map Ecotype (see Figure 19), Soil Landscape (see see Figure 23), and Disturbance Landscape (see Figure 20) maps. Appendices 6 and 8 should be used together to determine the map classes within which each ecotype was aggregated.

The ecotype descriptions, descriptive tables of ecotype components (e.g., floristic associations), and ecotype key provide valuable information for classifying and describing ecotypes in the field, and in the office from field data. Additionally, the Map Ecotype, Soil Landscape, and Disturbance Landscape maps in conjunction with the cross-walks in Appendices 6 and 8 provide the user with the spatial context of each ecotype in LACL as it relates to the above three maps. Lastly, the crosswalks allow the user to see the relationship between a given ecotype classified using the ecotype key and other closely related ecotypes and soils (both spatially and through successional sequences).

Guidelines for using the ecotype classification in conjunction with the map ecotype, soil landscapes, and disturbance landscapes maps are provided below:

A. Use the Ecotype Key (Table 5) to determine the ecotype (e.g., Alpine Gelic Rocky Lichen Tundra);
B. Refer to the ecotype descriptions (see Results: Ecotypes and Floristic Associations, below) for information regarding general environment, vegetation, and soils;
C. Refer to Tables 2, 6, 7, 18, and 21–26 for detailed information regarding the vegetative and soil characteristics of the ecotype;
D. Refer to Appendix 8 and locate the ecotype of interest in the alphabetical list (e.g., 10001);

E. Refer to Appendix 6 to determine the map ecotype (e.g., Alpine Gelic Barrens and Lichen Tundra), soil landscape (e.g., Alpine Gelic Rocky Barrens and Shrublands), and disturbance landscape (e.g., Mass wasting-Avalanche-Wind-scour-Snow drifts) class within which the ecotype was aggregated for mapping. Additionally, Appendix 6 allows the user to see the other ecotypes aggregated with the ecotype of interest into each map class (e.g., Alpine Gelic Rocky Barrens).

Office × Classification and Mapping

In the second scenario, LACL land managers and/or researchers are in the office and are interested in the location of specific park resources (e.g., permafrost), in designing a landscape scale management plan or stratified sample design for inventory and monitoring, or in producing landscape level analyses (e.g,. habitat assessment, landscape sensitivity). In this scenario users are directed to the series of mapping products provided with this ELS to include printed (see Figures 3, 12–16, 18–23, and 24) and digital (ArcGIS geodatabase) versions. The base maps, including Air Temperature (Figure 3), Typical Snow Free Day (Figure 12), Physiography (Figure 13), Generalized Texture (Figure 14), Soil Temperaure (Figure 15), Permafrost (Figure 16), and Landcover (Figure 18) represent useful standalone products or may be used in conjunction with one another. The user is directed to the results section for each base map (see Results: Ecosystem Mapping) for more information regarding these stand alone map products.

The Map Ecotype (Figure 19), Soil Landscape (Figure 23), and Disturance Landscape (Figure 20) maps were developed by spatially overlaying the base layers to create strata and then assigning those strata to aggregations of ecotypes with similar vegetation (termed map ecotypes), similar soils (termed soil landscapes), and similar disturbance pathways (termed disturbance landscapes). Users interested in using these aggregated maps are directed to:

- Tables 18 and 27 which provide descriptions of soil subgroups sampled in LACL and a cross-tabulation of soil subgroups by each soil landscape class, respectively;

- Appendices 6 and 7 which provide the cross-walk between aggregated ecotype codes, abbreviated ecotypes, and map classes in the Map Ecotype (Figure 19), Soil Landscape (Figure 23), and Disturbance Landscape (Figure 20) maps;

- Appendices 9–11 which provide a cross-walk between the map classes in the above 3 maps and aggregated ecotype code. Appendices 6–7 and 9–11 should be used together to determine the map strata and ecotypes that were aggregated to create each map class;

- Additionally, descriptions of soil landscape classes are provided (see Results: Soil Landscapes). Descriptions of map ecotypes are not provided. Instead, the user is directed to the descriptions of individual ecotypes that were aggregated to create each map ecotype class (see below).

Guidelines for using the map ecotype, soil landscape, and disturbance landscape maps in conjunction with the ecotype classification are provided below. For this example we use Map Ecotypes; however the same guidelines apply to the soil and disturbance landscape maps in which case the user would substitute Appendices 10 or 11 (respectively) in place of Appendix 9.

A. Refer to the Map Ecotype map and choose the map class of interest (e.g., Map Ecotype Class “Alpine Gelic Barrens and Lichen Tundra”)

B. Refer to Appendix 9 and locate the map ecotype class of interest in the sorted list (e.g., 10001);

C. Refer to Appendix 6 and use the aggregated ecotype code to determine the ecotypes that were aggregated to create the map ecotype of interest (e.g,. Alpine Gelic Rocky Barrens, Alpine Gelic Rocky Lichen Tundra) and the soil landscapes (SL) and disturbance landscapes (DL) that this map ecotype is associated with (e.g., SL = Alpine Gelic Rocky Barrens and Shrublands, DL = Mass wasting-Avalanche-Wind-scour-Snow drifts);

D. Refer to the ecotype descriptions (see Results: Ecotypes and Plant Associations, below), soil landscape descriptions (see Results: Soil Landscapes), for information regarding general environment, vegetation, and soils of the ecotypes and soil landscapes identified in step C, above;

E. Refer to Appendix 7 and use the aggregated ecotype code to determine the map strata classes (strata = ecoregion physiography, generalized soil textures; e.g., Northern Alpine, ashy-loamy-rocky) and NLCD land cover classes (e.g., Barren Land) assigned to the map ecotype of interest.

Introduction

The Southwest Alaska Network (SWAN) consists of five units of the National Park System (NPS) within Alaska: Katmai National Park and Preserve (KATM), Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), Lake Clark National Park and Preserve (LACL), and Kenai Fjords National Park (KEFJ). Combined, these parks comprise 38,000 km^2 and include a diverse array of climate patterns, geologic features, soils, and ecosystems. To establish baseline information and to provide information on the long-term trends in the conditions of these natural resources, the NPS has developed inventory and monitoring programs for vegetation, terrestrial wildlife, fish, weather, and coastal and glacial processes. These programs help the NPS to detect changes in ecosystem form and function and determine how human activities (e.g., invasive species, land disturbances) or large-scale phenomena (fire, climate change, earthquakes) influence the changes observed. The inventory and monitoring programs also help the NPS focus their efforts to manage and protect park resources for the future. Soils provide fundamental controls on landscape and vegetation dynamics by greatly influencing plant community composition, successional processes, food web dynamics, and a host of other ecosystem functions, and are therefore a key component of the NPS Inventory Program. In support of these objectives, ABR, Inc.—Environmental Research & Services (ABR) worked with the NPS to initiate an Ecological Land Survey (ELS) designed to map the ecosystems and soils in LACL.

The structure and function of natural ecosystems are regulated largely along gradients of energy, moisture, nutrients, and disturbance. These gradients are affected by many ecological components including climate, physiography, geomorphology, soils, hydrology, vegetation, and fauna, which are referred to as state factors (Barnes et al. 1982, ECOMAP 1993, Bailey 1996). We used the state-factor approach (Jenny 1941, Van Cleve et al. 1990, Vitousek 1994, Bailey 1996, Ellert et al. 1997) to evaluate relationships among individual ecological components and to develop a reduced set of ecotypes (Figure 1). An ecological land classification also involves organizing ecological components within a hierarchy of spatial and temporal scales (Wiken 1981, Allen and Starr 1982, Driscoll et al. 1984, O'Neil et al. 1986, Delcourt and Delcourt 1988, Klijn and Udo de Haes 1994, Forman 1995, Bailey 1996). 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). Local-scale features (e.g., geomorphic units, vegetation) are nested within regional-scale components, (e.g., climate and physiography) (Figure 1). 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, topography, 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

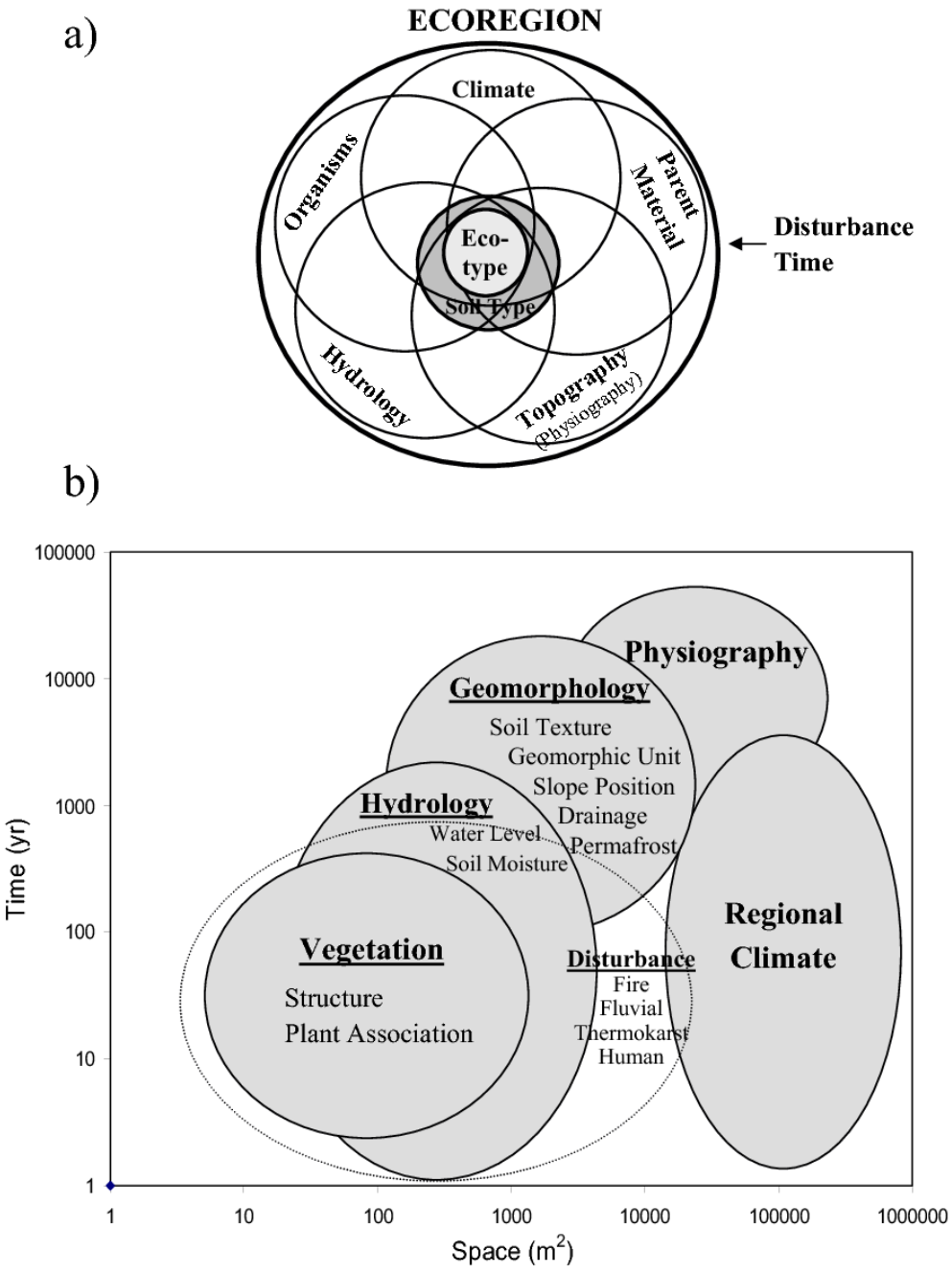


Figure 1. Interaction of interrelated state factors that control the structure and function of ecosystems (a) and the scale at which they operate (b).

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). For example, the Aleutian and Alaska Ranges block warmer, moisture laden air from the coast from reaching northwestern LACL. Thus eastern LACL is characterized by a relatively mild, moist maritime climate, while northwestern LACL is characterized by a colder, more arid climate similar to interior Alaska. The differences in climate resulting from the topographic divide imposed by the mountains combined with the available species pool are expressed in the distinct vegetation assemblages in eastern (coastal rainforest) and western (boreal forest) LACL. In turn, the disturbance regime differs between these two regions of the park, including a more fire dominated disturbance regime in northwestern LACL.

To implement the ecological land classification portion of the overall mapping effort, we used a simplified Integrated Terrain Unit (ITU) approach that incorporates physiography, surface form (primarily slope characteristics), geomorphic unit, and vegetation; these features can readily be mapped or modeled. The ITU approach, along with the landscape relationships developed from the analysis of field survey data, allows for the development of an enhanced set of ecosystem types from existing landcover mapping that essentially differentiates ecosystems at the site level ("ecotypes") of ecological land classification. For instance, superimposing a delineation of areas that are influenced by tidal waters and storm surges (i.e., coastal physiography) over an existing landcover map allows for the delineation of coastal salt marshes where they may have not been mapped in the stand alone landcover map. This integrated approach has several benefits. First, it incorporates the important effects of geomorphic processes on natural disturbance regimes (e.g., flooding, thermokarst) and the flow of energy and material. Second, it preserves the diversity of environmental characteristics. Finally, it uses a systematic approach to classifying landscape features for applied analyses. To demonstrate an application of this approach, as part of this present study we analyzed the relationships among soils and ecotypes and used these relationships to develop maps of soil and disturbance landscapes. The maps can serve as a spatial database with differing ecological components to aid resource managers in evaluating ecological impacts and developing land management strategies appropriate for a diversity of landscape conditions.

This report provides the results of a four-year (2009–2012) ELS study to complete field surveys, compile and analyze data, and map ecosystems and soils of LACL. We compiled existing vegetation, soils, GIS, and remote sensing data from a variety of sources to develop a preliminary spatially-explicit conceptual model of soils in LACL and identify data gaps. We used the resulting model to develop a stratified, gradient-oriented sampling scheme to collect field verification data. We used a pre-existing landcover map in combination with field verification data collected in LACL in 2011, several additional existing GIS data layers, rule-based modeling, and the analysis of geomorphology-soils-vegetation relationships to develop a map of soils in LACL, using the soil landscape approach used by Jorgenson et al. for Wrangell-St. Elias National Park and Preserve (2008a) and the Arctic Network of National Parks (2009).

Specific objectives of this project were to:

1. Conduct field inventories of vegetation, soils and environmental characteristics in LACL,
2. Compile pre-existing field-survey data with data collected by ABR for use in classification and mapping,
3. Input the comprehensive terrain-soil-vegetation data set to classify ecotypes based on analysis of vegetation characteristics and relationships among ecological components,
4. Classify soil types based on field soil profile descriptions and laboratory analysis data,
5. Develop maps using an existing landcover map and rule-based modeling,
6. Initiate the development of a soils Near Infrared (NIR) spectroscopy library for the SWAN parks, and
7. Document survey results for map users.

Study Area Definition

The study area was defined to include all of LACL and some of the surrounding areas (Figure 2). Surrounding areas within a three mile buffer were included if they were also covered by the Lake Clark digital elevation model (DEM; see GIS AND REMOTE SENSING DATA COMPILATION, below). Chisik Island was excluded because it was thought to be substantially different from the adjacent mainland. Additionally, Chisik Island lands are managed by U.S. Fish and Wildlife and a land use permit was not available at the time of field surveys. Therefore, no field data were available for ground verification. Thus defined, the study area includes 19,104 km^2, of which 16,327 km^2 lies within boundaries of LACL.

The raster modeling was performed using cells of 30 m resolution in the Alaska Albers (NAD1983) horizontal coordinate system. The alignment of cells followed a USGS convention such that the center of one 30 m cell was aligned at (0, 0). The bounding box for the study area was defined with an upper left corner coordinate of (-60615, 1284645) and a lower right corner coordinate of (98475, 1091205), resulting in raster dimensions of 5,303 columns and 6,448 rows at 30 m resolution.

Methods

Field Surveys

We conducted field work over two sampling periods in 2011, including August 8–17 and September 12–18. Transect locations were stratified across the landscape using a gradient-directed sampling scheme (Austin and Heyligers 1989) to gather the range of ecological conditions and to provide the spatially-related data needed to interpret ecosystem development. Intensive sampling was conducted along toposequences (transects) stratified within broad ecoclimatic regions and major physiographic units using maps prepared for Lake Clark (Wells et al. 2010). Page Spencer and Amy Miller (NPS, Anchorage, AK) provided ABR with a GIS file that included general locations and descriptions of study areas in LACL within which to focus field data collection efforts during summer 2011. The general study areas identified were determined to be representative of the diverse ecological character of LACL, and were used to aid in determination of transect locations.

Data were collected at 267 plots along 44 transects (toposequences). Along each transect, 5–10 plots (approximately 10-m radius) were typically sampled, each in a distinct vegetation type or spectral signature identifiable on aerial photographs. Sample plot locations were selected intuitively by the field crew leader, choosing homogenous patches of vegetation (~½–¾ ha, minimum area) and avoiding ecotones. Plots were spaced so as to cover the entire length of each transect and to avoid "pseudoreplication" (i.e., sampling the same or very similar vegetation and soils in more than one plot on a transect). Plot locations were pinpricked on aerial photographs/ satellite imagery, and coordinates (including approximate elevations) were obtained with Garmin eTrex Legend HCx Global Positioning System (GPS) receivers (accuracy ±5 m). At each plot, geology, hydrology, soil stratigraphy, soil chemistry and vegetation structure and cover were described or measured (see below). Digital photos were taken at each plot location, including landscape and ground cover view, and photos of the soil pit face. Also, at the end of the day a flyover of each transect was completed (weather permitting) and a photos of each plot was taken from the air.



Figure 2. Sampling locations and study area boundary for the ecological land survey and soil landscapes mapping for Lake Clark National Park and Preserve (LACL), Alaska.

Geologic and surface-form variables recorded included physiography, geomorphic unit, slope, aspect, surface form, and height of microrelief. Hydrologic variables measured included depth of water above or below ground surface, depth to saturated soil, pH, and electrical conductivity (EC). Ground surface variables included percent frost boils and surface fragments. Water-quality measurements (pH and EC) were made using Oakton portable meters that were calibrated daily with standard solutions.

General soils data were collected from shallow soil plugs or pits (40–50 cm deep) at each plot. When frozen ground was encountered at 40 cm or less below the surface, we continued to dig for approximately 10 cm into the frozen ground to confirm the presence of ice structure or other evidence of permafrost. Soil data collected at each plot included depth to lithic contact, depth of surface organic matter, cumulative thickness of all organic horizons, cumulative thickness of loess, depth to upper boundary of coarse fragments (>15% by volume), presence of cryoturbation, presence of effervescence using a dilute acid solution, and depth of thaw. When water was not present, EC and pH were measured from a saturated soil paste. Soil texture was assessed by hand texturing, using a 2 mm mesh sieve to remove coarse fragments. A single simplified texture (i.e., loamy, sandy, ashy, organic) was assigned to characterize the dominant texture in the top 40 cm at each plot for ecotype classification.

A complete soil stratigraphy was described at 63 plots. With the exception of the depth requirements of soil pits, soil descriptions followed standard Natural Resources Conservation Service (NRCS) protocols (USDA NRCS 2007). Soils were classified to the subgroup level using the 11th edition of the Keys to Soil Taxonomy (Soil Survey Staff 2010). Soil pits for full stratigraphic descriptions were dug to at least 50 cm plus the thickness of surface and buried organic layers combined (see below), to a maximum depth of 70 cm. In stratified soils (e.g., floodplains), stratifications were grouped into broader horizons and denoted as such with notes describing the interbedded soil materials. Buried organic horizons ≥1.0 cm thick were designated as unique horizons, while those horizons <1.0 cm were grouped with adjacent mineral soils with descriptive notes included. A rapid soil stratigraphy was completed at 110 plots, and included horizon top and bottom depths, texture, and field horizonation. Color and pH were recorded opportunistically if required for classification to soil subgroup.

Soil specimens were typically collected from plots where full soil stratigraphy was recorded, but were also collected at rapid soil pits when time allowed. Soil specimens from 63 plots were collected for laboratory analysis. Specimens were collected from mineral horizons only. A total of approximately 9 oz (250 grams) sieved (2 mm) moist soil sample was collected from each pit and samples were taken from a maximum of three mineral horizons within the upper 40 cm of mineral soil (i.e., sampling zone). Soil specimens were collected within each horizon from the center ~10 cm for those horizons >10 cm thick, and from the entire horizon for those horizons ≤ 10 cm. If the lower boundary of the lowest horizon within the sampling zone extended below the sampling zone, only that portion of the horizon that was within the sampling zone was sampled. Soils from each horizon were collected in quart size Ziplock™ freezer bags for transportation to the office. The bags were labeled with plot and horizon number, upper and lower horizon boundary depths (cm), and the initials of the collector. All remaining soil samples have been deposited with the Museum Curator at Lake Clark National Park and Preserve in Anchorage, AK.

Vegetation composition and structure data was collected semi-quantitatively for at least ten-twenty dominant vascular and non-vascular plant species (more were often recorded when time allowed), and several categories of non-vascular plants, including percent *Sphagnum* species; percent feathermoss, and percent combined *Cladonia*/*Cladina* species. If total live cover was <10% or >90%, cover of each species or category was visually estimated to the nearest 1%; for total cover 10–90%, individual cover values were estimated to the nearest 5%. Isolated individuals or species with very low cover were assigned a cover value of 0.1%. Total cover of each plant growth form (e.g., tall shrub, dwarf shrub, lichen) was estimated independently of the cover estimates for individual species. Data were cross-checked to ensure that the summed cover values for individual species within a growth form category was similar to the total cover estimated for that growth form. Vegetation structure (e.g., Low Scrub, Broadleaf Forest) and Alaska Vegetation Classification (AVC) Level IV vegetation class (Viereck et al. 1992) were also recorded. Taxonomic nomenclature was based on Viereck & Little (1972) for trees and shrubs, and Hultén (1968) for all other vascular taxa. Voucher specimens were collected for verification of plants that were difficult to identify in the field. Dominant vascular species that could not be identified in the field were identified by Carolyn Parker, University of Alaska Museum of the North Herbarium (ALA), Fairbanks. Nomenclature for bryophytes and lichens followed the National Plants Database (USDA NRCS 2012). 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 Celia Miller, ALA (lichens) and Brian Heitz, Alaska Natural Heritage Program (mosses). Plant species identified are listed in Appendices 1 and 2. All vascular and non-vascular plant specimens have been deposited with the Museum Curator at Lake Clark National Park and Preserve in Anchorage, AK.

Supplementary Datasets

To increase the amount of field data available for the ecological classification, we conducted a feasibility assessment for developing soil maps in the SWAN parks. As part of the feasibility assessment we acquired ecological datasets from over a dozen additional sources (Wells et al. 2010). These data were run through several quality assessment and control routines. Several datasets were excluded after the initial review because they lacked accurate location data, were missing important field data, or were incomplete when obtained. The remaining datasets had vegetation information (Viereck et al. 1992 Level IV) and (at a minimum) general soil classification (dominant soil texture in upper 40 cm of soil profile) for the same site and were further considered for use in this study. These data were imported into the comprehensive database, and variable codes were converted into ABR's coding system. For use in this study, priority was given to (in order of importance): 1) those datasets with adequate soils data for classifying the soils to the subgroup level of soil taxonomy (NRCS 2010), 2) plots with complete plants species composition data, and 3) those datasets with plots that occurred within or near the LACL boundary or within other SWAN parks. Datasets meeting this set of criteria included SWAN coastal monitoring (n=154) and Lake Clark glacial geology (n=13) (Table 1). These supplemental datasets were then combined with the 2011 LACL field verification data collected by ABR and reviewed. Upon review several gaps in important AVC vegetation types and general soil textural classes were evident in the combined dataset, including Dryas Dwarf Shrub Tundra, mixed and broadleaf forests, and upland tall shrub and white spruce woodland with rocky (> 15% rock fragments) soils. Plot data from the Pebble Project wildlife habitat mapping data set (PLP 2011) were reviewed, and those plots with the above vegetation types and soils (n = 185) were included in the final data set for analysis.

Table 1. List of pre-existing field plot data compiled for Lake Clark National Park and Preserve (LACL) and adjacent areas, Alaska, 2011.

Data Set	Source	Location	Description	Soil Data	Vegetation Data	Years of data collection	Usage[1]	# Plots used in analysis
Lake Clark Glacial Geology	ABR	LACL	M.T. Jorgenson assessment of ecosystem development on glacial deposits of late Holocene to middle Pleistocene to map the surficial geology of the Lime Hills Tyonek Quadrangles.	Y	Y	2004	full	13
ABR Habitat plots	ABR/Pebble Limited Partnership	Pebble Project study areas[2]	Site, soils, and vegetation data collected to map wildlife habitats for the Pebble Project Environmental Baseline Document (PLP 2011).	Y	Y	2004–2005	partial	185
Swan Coastal Monitoring	ABR/NPS	KATM, LACL	Data collected by ABR as part of National Park Service (National Park Service) Southwest Alaska Network (SWAN) coastal monitoring program (Jorgenson et al. 2010).	Y	Y	2007–2008	full	154

[1] Full usage applies to datasets with adequate soils data to classify to the subgroup level of Soil Taxonomy, complete vegetation species composition data, and accurate location data. These data were used for ecotype and floristic analyses and for map ecotype, soil landscape, and disturbance landscape mapping. Partial applies to datasets with basic soils data (i.e. general texture) insufficient for subgroup classification, complete vegetation species composition data, and accurate locations. These data were used in the ecotype and floristic analyses to fill in for gaps in several AVC vegetation types (Viereck et al. 1992) and general soil textural classes that were identified in the 2011 LACL field data during preliminary analysis.

[2] See chapter sections 16.1, 16.6, and 41.1 in the Pebble Project Environmental Baseline Document (PLP 2011)

Ecological Classification

We classified ecosystems 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 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 water depth, salinity, and genesis.

Surface forms (macrotopography) were classified according to a system modified from that of Schoeneberger et al. (2002). Microtopography was classified according to the periglacial system of Washburn (1973).

Vegetation was generally classified in the field to AVC Level IV vegetation class (Viereck et al. 1992). Additionally, plant associations were classified and named according to standard methods (Vegetation Subcommittee 2008, Jennings et al. 2009). First, unknown taxa and those taxa identified to the Genus level only were removed for the analysis. Those species occurring at less than 3% cover in a plot were removed from the initial stage of the analysis. Second, vegetation data (species by plot) were clustered in R: a language and environment for statistical computing (R Development Core Team, 2011) using the fixed clustering algorithm Partitioning Around Medoids (PAM) (Kaufman and Rousseeuw 1990) and a Bray/Curtis dissimilarity matrix (Bray and Curtis 1957). Forth, non-metric multidimensional scaling (NMDS) (Shepard 1962a&b, Kruskal 1964a&b) using the same dissimilarity matrix used in the clustering was used to chart the plots in species space to assess their dispersion and identify outliers. Finally, sorted table analyses (Mueller-Dombois and Ellenberg 1974) were used to refine the groups. Species occurring at less than 3% cover were added back into the dataset during the sorted table analyses. After groups were finalized, each plant association was identified by dominant and characteristic species.

Ecotypes

We classified ecotypes using a three-step process: (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 can be interpreted from aerial photographs. We used a nomenclature for ecotypes similar to that used by Jorgenson et al. (2008a, 2009) that describes ecological characteristics (ecoregion, physiography, soil temperature, soil chemistry, soil texture, 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 or vegetation composition), using a hierarchical approach. For the ecotype classification, we combined the northern and southern interior ecoregions into a more general "interior" ecoregion. Geomorphic units were assigned to physiographic settings based on their erosional or depositional processes. Surface forms were aggregated into a reduced set of slope elements (crest, upper slope, lower slope, toe, and flat). For vegetation, we used the structural levels of the AVC (Viereck et al. 1992), because they are readily identifiable on aerial photographs and used a typical species common name (e.g., White Spruce Forest). We grouped soils based on similarities in general textural class (e.g., rocky, ashy, loamy, organic) and then by commonly associated textures (e.g., sandy-rocky, ashy-loamy, loamy-organic). Table 2 provides descriptions of general texture classes used in the classification of ecotypes. We sometimes grouped textural classes because the vegetation associated with them was similar (e.g., ashy-loamy-rocky), and vegetation structures (e.g., open and closed shrub) were often grouped because their species composition and soils were similar. Full ecotype names (referred to in the remainder of this reort as "ecotype long-name") were then based on the aggregated ecological components e.g., Alpine Gelic Dry Acidic-Circumacidic Rocky Dwarf Shrub-Lichen Tundra.

Common relationships among ecosystem components were identified using 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 combined with those having similar characteristics or excluded as atypical (outliers). Finally, ecotype names were abbreviated (referred to in the remainder of this report as "ecotype") to emphasize primary characteristics of the class and facilitate discussion (e.g., Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra). The resulting final ecotypes were used for mapping and to summarize the field data.

Soils

Soil Chemical Analyses and Classification:

Of the total 63 plots where soil samples were collected, soils from 27 plots were designated for chemical analysis of select horizons (Appendix 3). Soil from these 27 plots were air-dried and sieved through a 2 mm USDA standardized sieve for separating the fine earth fraction (i.e., sand, silt and clay). Air-dried and sieved samples were sent to the University of Alaska, Palmer Research Center (Laurie Wilson, Lab Manager). Priority for selection of plots for horizon analysis were given based on secondary diagnostic horizons requiring laboratory data for taxonomic classification, spatial distribution within Lake Clark National Park, and whether or not a full soil characterization had been completed for the plot. Percent Total Carbon (C) and Total Nitrogen (N) were measured using the combustion method of the LECO TruSpec CHN 1000 instrument. Particle Size Analysis was run to determine the total percent of sand, silt and clay within a given horizon (Michaelson et al. 1992). Ammonium oxalate extracts of Iron (Fe), Aluminum (Al) and Silicon (Si) were run on samples to provide data for substantiating andic soil properties for those field sites with an accumulation of volcanic ash and/or other volcanic ejecta. Additionally, percent Organic Carbon, percent Phosphate Retention (New Zealand P Method), and percent Base Saturation were run on selected horizons (Michaelson et al. 1992).

Table 2. Description of twelve generalized soil texture classes used in ecotype classification and mapping, including texture range and predominant soil orders.

Generalized texture class	Texture range (< 2 mm)	Description	Predominant Soil Order(s)
Ashy-loamy	Silt loam to sandy loam	In upper 40 cm, mineral soil in upper 40 cm a mixture of volcanic ash and loamy material from other sources, >15 rock fragments (>2 mm) rare	Andisols and Spodosols
Ashy-loamy-rocky	Silt loam to sandy loam	In upper 40 cm, mineral soil in upper 40 cm a mixture of volcanic ash and loamy material from other sources, >15 rock fragments (>2 mm) common	Andisols, Spodosols, and Inceptisols (andic subgroups)
Bedrock	Silt loam to sand	Rocky soils (>15% rock fragments in upper 40 cm) derived from bedrock or a thin (<40 cm) veneer of colluvium, till, or loess over bedrock derived soils.	Entisols and Inceptisols
Loamy-organic	Silt loam to sandy loam	Soils with moderately thick (10-40 cm) to thick (≥ 40 cm) surficial organics over loamy mineral soil, >15% rock fragments rare	Histosols, Entisols, and histic and folistic subgroups of Inceptisols
Rocky	Silt loam to sand	In upper 40 cm, >15% rock fragments (> 2 mm) very common, includes a variety of mineral soil textures	Entisols and Inceptisols
Sandy-rocky	Sandy	In upper 40 cm, mineral soil sandy, >15% rock fragments (> 2 mm) very common	Entisols and Inceptisols
Organic-rich	Na	Soils with thick (≥ 40 cm) surficial organic horizons	Histosols
Ashy-rocky-organic	Silt loam to sandy loam	In upper 40 cm, mineral soil in upper 40 cm a mixture of volcanic ash and loamy material from other sources, >15 rock fragments (>2 mm) common, and moderately thick (10-40 cm) surficial organics common	Folistic subgroups of Andisols, Spodosols, and Inceptisols
Loamy	Silt loam to sandy loam	In upper 40 cm, mineral textures predominanty loamy, >15% rock fragments rare	Inceptisols
Silty-clayey	Silt loam to silty clay	In upper 40 cm, mineral textures predominanty silty to clayey, >15% rock fragments rare	Entisols and Inceptisols
Silty-sandy-rocky	Silt loam to sand	In upper 40 cm, soils stratified, mineral textures alternating between silty and sandy, >15% rock fragments common	Entisols and Inceptisols
Sandy-rocky-organic	Silt loam to sandy	In upper 40 cm, soils stratified, mineral textures alternating between silty and sandy, >15% rock fragments common, and moderately thick (10-40 cm) surficial organics common	Entisols and Inceptisols
Ashy-loamy-organic	Silt loam to sandy loam	Soils with moderately thick (10-40 cm) to thick (≥ 40 cm) surficial organics over a mixture of volcanic ash and loamy material from other sources, >15% rock fragments rare	Histosols and histic and folistic subgroups of Inceptisols, Andisols, and Spodosols

Soils from 21 of the 27 plots that were selected for chemical analysis of selected soil horizons were also selected for analysis of 1500 kilopascal (kPa) water retention (Appendix 3). The 1500 kPa water retention were run specifically on soil horizons comprised primarily of volcanic ash material. This analysis was performed by Colorado State University, Soil Testing Lab, Fort Collins, CO (Dr. James R. Self). This data was acquired using Water Retention Methods described in Klute (1986). This data is used for classifying soils in Vitric subgroups in the Keys to Soil Taxonomy (Soil Survey Staff 2010). Vitric soils have a 1500 kPa Water Retention of less than 15% on air-dried samples and tend to have coarser, sandier ash grains and/or pumice within the soil profile.

We classified soils to the subgroup level according to NRCS soil taxonomy, 11th Edition (Soil Survey Staff 2010). Soils that classified near the cut-point with another soil class were assigned a alternate subgroup classification. When some of the data needed for the taxonomic keys were missing for a given plot, soil subgroups were assigned using the available field data (e.g., photos, rapid horizonation, colors, textures, field pH, etc.) and by drawing inferences from the soil classifications from plots with full stratigraphic characterizations and soils laboratory data. For instance, Haplocryepts were differentiated from Dystrocryepts based on a cutpoint of 5.5 for the pH reaction, although the actual diagnostic criterion is 50% base saturation from laboratory analyses.

Soils Near Infrared Analysis:

Near Infrared (NIR) spectroscopy has been used across multiple disciplines to assess a variety of materials, including soils. In NIR spectroscopy, the spectral signature of a material is defined by the reflectance or absorbance, as a function of wavelength in the electromagnetic spectrum (Shepherd and Walsh, 2002). Recently, research has demonstrated the ability of NIR spectroscopy to provide rapid and inexpensive prediction of soil chemical and physical properties, including pH, cation exchange capacity (CEC), particle size, organic carbon (OC), total nitrogen and carbon, and extractable phosphorus, among others (Awiti et al. 2008). As part of this project we initiated the development of a soils NIR spectral library for the SWAN parks as described by Shepherd and Walsh (2002). The basic steps involved are: 1) widely sample soils representative of the study area, 2) sample NIR spectra of soils, 3) acquire wet lab data for those same soils (e.g., pH, CEC, particle size, OC, total nitrogen and carbon, extractable phosphorus), 4) build statistical models to calibrate soil attributes with NIR spectra. Once the library has been developed and an acceptable level of accuracy achieved, it can then be used to predict attributes of new soil samples, thereby avoiding the costly and time consuming step of acquiring soil lab data on new samples. Samples from eighteen different soils from LACL were sampled for NIR spectra and soils laboratory data to be used 1) in a pilot study designed to assess the feasibility of using soil NIR data for predicting soil chemical and physical properties and linking those properties to soil taxonomy , and 2) in the future with additional soil samples to develop a soils NIR library for the SWAN parks.

Of the total 63 plots where soil samples were collected, soils from 18 plots were designated for NIR analysis. These 18 soils were air-dried and sieved through a 2 mm USDA standardized sieve for separating the fine earth fraction (i.e., sand, silt and clay). For each plot, a 20 g mixed air-dried sample from the upper 40 cm of mineral soil (i.e., mixing of an even proportion of each horizon in upper 40 cm) was sent in for NIR spectral analysis. For example, if the soil at a plot had two horizons in the upper 40 cm of the profile, a mixed sample of 10 g from each horizon

was sent in for NIR spectral analysis. Spectral analysis of the mixed soil samples were performed at the VisNIR Diffuse Reflectance Spectroscopy Service Center within the Department of Crop and Soil Sciences at Washington State University in Pullman, WA (Dr. David Brown). Replicate scans were performed on each sample to allow for error checking prior to spectral processing. Data were processed to account for gaps between the three spectral detectors used to capture the 350–2500 nm range, replicate scans were averaged, and then the averaged spectra were smoothed by fitting a smoothing spline. Additional details regarding the spectral processing can be found in Brown et al. (2006). See Appendix 4 for the absorbance spectra from the 18 NIR plots.

Soil samples from the 18 NIR plots were additionally targeted for select chemical analyses processed by the University of Alaska, Palmer Research Center. A mixed air-dried sample of 60 g from the upper 40 cm of mineral soil was sent in for chemical analyses. If a site had more than one horizon in the upper 40 cm of mineral soil, an even proportion of each horizon was mixed and sent in for analysis. Percent Total Carbon (C) and Total Nitrogen (N) were obtained by using the combustion method of the LECO TruSpec CHN 1000 instrument (TruSpec Operations Manual, pp.7–3). Particle Size Analysis was run to determine the total percent of sand, silt and clay (Michaelson et al. 1992). Additionally percent Organic Carbon and percent Phosphate Retention (New Zealand P Method) were run on eighteen of the mixed samples using Michaelson et al. (1992). See Appendix 5 for the results of the chemical analyses on the 18 NIR plots.

Soil samples from the 18 NIR plots were also sent to Alaska Beget Consulting (Dr. James Beget), Fairbanks, AK for determining percent volcanic glass content. Volcanic glass content is the percent (by grain count) of glass, glass-coated mineral grains, glass aggregates, and glassy materials in the 0.02 to 2.0 mm fraction (Soil Survey Staff 2010). A mixed air-dried sample of 20 g from the upper 40 cm of mineral soil was sent in for analysis. If a site had more than one horizon in the upper 40 cm of mineral soil, an even proportion of each horizon was mixed and sent in for analysis. Further sample preparation included weighing out a 10 g sub-sample into a small beaker and agitating the mixture for one hour with a dilute 15% solution of NaHexametaphosphate and distilled water. This agitation process brings the clay fraction (<0.02 mm) into suspension. Dr. Beget utilized the procedure described in Step 7.11 on p. 43 of the Soil Survey Laboratory Methods Manual, version 42 (USDA NRCS, 2004). After one hour the very fine soil fraction that was in suspension was decanted from the beaker and the remaining sediment (0.02 to 2.0 mm) was dried in an oven at 50° C.

The tephra (volcanic glass) content of each sample was determined by manufacturing a grain mount thin section and examining the sediment under a petrographic microscope. The percentage of glass in each sample was estimated by identifying the volcanic material using optical mineralogical techniques, including the use of double light polarizing plates. Once the character of the volcanic particles in each sample was determined, Beget used standard petrographic charts published by the American Geologic Institute (AGI) to determine the percentage of volcanic particles present. For some samples, where Beget felt more data was necessary, transects were completed across the grain mount slides identifying 100 particles as to whether they were volcanic or non-volcanic. Additionally, Beget made optical mineralogical observations on each sample. See Appendix 5 for volcanic glass data on the 18 NIR plots.

Non-metric multidimensional scaling (NMDS) (Shepard 1962a,b; Kruskal 1964a,b) was used to separate plots by Near Infrared (NIR) absorbance spectra. Groupings of similar soil absorbance spectra were identified using the fixed clustering algorithm Partitioning Around Medoids (PAM) (Kaufman and Rousseeuw 1990). The soil chemical and physical laboratory data was then summarized by cluster and displayed on the NMDS.

Rock Samples:
Sixteen rock samples were collected across LACL for verification of bedrock geology. Identification of the geologic material was performed by Dr. Rainer Newberry, Department of Geology and Geophysics, University of Alaska, Fairbanks. Samples were cut using lapidary equipment and initially evaluated ocularly for composition and texture. A handheld X-Ray Fluorescence (XRF) Analyzer was utilized for obtaining accurate elemental analysis of each sample. All rock samples have been deposited with the Museum Curator at Lake Clark National Park and Preserve in Anchorage, AK.

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

The contingency table analysis also was used to evaluate how well these general relationships conformed to the data set, and how reliably they could be used to extrapolate trends across the landscape. During development of the relationships, outliers were excluded from the table, based on 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. The outliers may represent 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 apparent.

GIS and Remote Sensing Data Compilation
Overview
Remote sensing and GIS data were compiled for a range of ecological components, including land cover, elevation, ecological subsections, coastal habitats, hydrography, topography, climate, surficial and bedrock geology, wetlands, snow cover, and glaciers (Table 3). The individual components and GIS processing are described below.

These data were analyzed, processed and combined to characterize the major components that partition the landscape and soils, including ecoregion, physiography, generalized soil texture, soil temperature, and vegetation. Combinations of these components were aggregated, using guidance from the field data and soil analytical results, to model the distribution of map ecotypes and soil landscapes.

Table 3. Pre-existing and derived GIS and remote sensing data compiled for the Ecological Land Survey and Soils Landscape mapping for Lake Clark National Park and Preserve, Alaska.

Dataset Description	Type	Path	Origin
GeoEye DEM, 1 arc-second	Single band GRID	Soil_LS_Model\DEM\Raw\mos_lacl	Derived
GeoEye DEM (m), 30-m	Single band GRID	Soil_LS_Model\DEM\GeoEye_DEM_V2012_30m_BI.tif	Derived
GeoEye DEM Slope (Degrees), 30-m	Single band GRID	Soil_LS_Model\DEM\GeoEye_SlopeDeg_Int_V2012_30m_BI.tif	Derived
GeoEye DEM Aspect (Degrees), 30-m	Single band GRID	Soil_LS_Model\DEM\GeoEye_Aspect_V2012_30m_BI.tif	Derived
GeoEye DEM Hillshade, 30-m	Single band GRID	Soil_LS_Model\DEM\GeoEye_HS_V2012_30m_BI.tif	Derived
Historical Glacier Extent, 1950s	Polygon feature class	Soil_LS_Model\Glacier_Extents\Glacier_Extents.gdb\AKALB83\LakeClark_DRGs_working_1950s	Pre-existing
Historical Glacier Extent, 1986–1987	Polygon feature class	Soil_LS_Model\Glacier_Extents\Glacier_Extents.gdb\AKALB83\LACL_GlacierExtent_1986_1987	Pre-existing
Current Glacier Extent, 2007	Polygon feature class	Soil_LS_Model\Glacier_Extents\Glacier_Extents.gdb\AKALB83\GLIMS_glac_merged_final_2007	Derived
Glacier Extent Union, 1950s vs. 2007	Polygon feature class	Soil_LS_Model\Glacier_Extents\Glacier_Extents.gdb\AKALB83\LACL_Glaciers_1950s_2007_Union	Derived
Lake Clark Land Cover	Single band GRID	PDS\Albers\parks\lacl\base\biologic\statewid\lc_lacl	Pre-existing
NLCD2001 Land Cover	Single band TIFF	Soil_LS_Model\Land_Cover\NLCD\AK_NLCD_2001_Subset_Shift_30n_30w.tif	Derived
Ecological Subsection Mapping	Polygon shapefile	PDS\Albers\parks\lacl\base\biologic\statewid\subse_la.shp	Pre-existing
Updated Coastal Subsection Mapping	Polygon feature class	Soil_LS_Model\Physiography\Coastal\Coastal_Physiography.gdb\AKALB83\LACL_subsect_2007_coastal	Pre-existing
NHDArea, LACL	Polygon feature class	Soil_LS_Model\NHD\NHD_LACL.gdb\AKALB_NAD83_Hydrography_LACL_Merge\NHDArea_ClipLACL_Merge	Pre-existing
NHDFlowline, LACL	Polyline feature class	Soil_LS_Model\NHD\NHD_LACL.gdb\AKALB_NAD83_Hydrography_LACL_Merge\NHDFlowline_ClipLACL_Merge	Derived
NHDWaterbody, LACL	Polygon feature class	Soil_LS_Model\NHD\NHD_LACL.gdb\AKALB_NAD83_Hydrography_LACL_Merge\NHDWaterbody_LakePond_ClipLACL_Merge	Derived
WBD (12-Digit) 6th Level Subwatersheds	Polygon feature class	Soil_LS_Model\NHD\NHD_LACL.gdb\HUC12	Derived
Down-scaled PRISM, Monthly Temperature	Single band GRIDs (12)	Soil_LS_Model\PRISM\Downscaled\tmean01_m (01=Jan, 02=Feb, etc.)	Derived

Table 3. Pre-existing and derived GIS and remote sensing data compiled for the Ecological Land Survey and Soils Landscape mapping for Lake Clark National Park and Preserve, Alaska (continued).

Dataset Description	Type	Path	Origin
Down-scaled PRISM, Mean Annual Temperature	Single band GRID	Soil_LS_Model\PRISM\Downscaled\tmean_avg_c	Derived
Surficial Geology		PDS (path unknown)	Pre-existing
IKONOS Mosaic, CIR	Layer file for symbolizing multiple 4-band TIFFs	Soil_LS_Model\IKONOS\LACL IKONOS CIR.lyr	Pre-existing
IKONOS Mosaic, Natural Color	Layer file for symbolizing multiple 4-band TIFFs	Soil_LS_Model\IKONOS\LACL IKONOS NatColor.lyr	Pre-existing
Landsat Imagery (raw data)	Gzipped TIFF files	Soil_LS_Model\Landsat\raw\wrs2\ppp\rrr* (ppp=wrs2 path, rrr=wrs2 row)	Derived
Landsat Imagery (tiles)	Multiband TIFFs	Soil_LS_Model\Landsat\tiles	Derived
csm (tiles, Cloud/Snow/Mask from Landsat)	Single band TIFFs	Soil_LS_Model\Landsat\tiles	Derived
Snow-free Day of Year (sf_doy) Landsat Metric	Single band GRID	Soil_LS_Model\Outputs\Snow\lacl_sf_doy.tif	Derived
Ancillary Landsat Metrics from Snow Regime Analysis (sf_doy_f, n, n_snow, n_snowfree, n_snow_correct, n_snowfree_correct, p_correct)	Single band GRIDs	Soil_LS_Model\Outputs\Snow\ancillary*.tif	Derived
Climatic regions, general	Single band GRID	Soil_LS_Model\Ecoregion\Ecoregion.gdb\LACL_Ecoregion_buff_10mi_Clip_LACL_SA_20120314	Derived
Generalized Soil Texture	Single band GRID	Soil_LS_Model\Outputs\GenTexture\stext_from_phystext_v08_u8.tif	Derived
Modeled 50 cm Soil Temperature	Single band GRID	Soil_LS_Model\Outputs\Soil_Temp\soil_temp_C_50cm_tavg_sfdoy.tif	Derived
Permafrost Occurrence Likelihood	Single band GRID	Soil_LS_Model\Outputs\Soil_Temp\lacl_permafrost_class.tif	Derived
Generalized Physiography	Single band GRID	Soil_LS_Model\Outputs\Physiography\phys_from_meco_v05.tif	Derived
Strata	Single band GRID	Soil_LS_Model\Outputs\Modeling\phystext_v08	Derived
Strata/Landcover	Single band GRID	Soil_LS_Model\Outputs\Modeling\strata_from_phystext_v08_x_NLCD_Agg.tif	Derived

Table 3. Pre-existing and derived GIS and remote sensing data compiled for the Ecological Land Survey and Soils Landscape mapping for Lake Clark National Park and Preserve, Alaska (continued).

Dataset Description	Type	Path	Origin
Aggregated Ecotypes	Single band GRID	Soil_LS_Model\Outputs\Modeling\deco_v05	Derived
Map Ecotypes	Single band GRID	Soil_LS_Model\Outputs\Map_Ecotypes\mapeco_v05	Derived
Soil Landscapes	Single band GRID	Soil_LS_Model\Outputs\Soil_Landscapes\soilland_v05	Derived
Disturbance Landscapes	Single band GRID	Soil_LS_Model\Outputs\Dist_Landscapes\distland_v05	Derived

Naming Conventions

Geographic Information System (GIS) datasets are referred to in italics using a descriptive name: *Current Glacier Extent*. The full filename and path to the GIS file are listed in Table 3. Some GIS files were obtained from the NPS GIS data store, while others are contained in the GIS deliverable package accompanying this report. The field names within GIS datasets are italicized and quoted: *Updated Coastal Subsection Mapping "Physiog"* field. Attributes stored in fields are presented in plain text, and are quoted in the case of text fields: *NHDFlowline,* "*FType*" value of "Streams and Rivers".

Existing GIS Data Sources

Digital Elevation Model (DEM):

Several available DEM data sources were reviewed, including the *National Elevation Dataset* (2 arc-seconds), the *Shuttle Radar Topography Mission DEM* (2 arc-seconds), the *ASTER GDEM* (version 2, 1 arc-second), and the *GeoEye DEM* (1 arc-second) produced as part of the IKONOS base imagery acquisition for Lake Clark National Park and Preserve. Based primarily on visual review of hillshades, the *GeoEye® DEM* was determined to have the highest level of detail while minimizing artifacts.

To maximize the fidelity of the *GeoEye® DEM*, the raw source data were reprocessed. The data required manual edge-masking because consistent edge fill values were not used. A new mosaic in the raw 1 arc-second coordinate system was constructed and the mosaic was then reprojected to the Alaska Albers (NAD1983) coordinate system at 30 m resolution.

Glacier Extent:

Current Glacier Extent data (c. 2007) was obtained from a satellite-derived glacier inventory for Western Alaska (Le Bris et al. 2011). The Current Glacier Extent mapping was based on Landsat 5 Thematic Mapper (TM) imagery from August 26–28, 2007 with some additional coverage in cloudy portions provided by August 20, 2005 imagery. Glaciers were identified primarily using manual thresholding of the band 3 to band 5 ratio. Additional steps included a band 1 (blue) threshold to resolve confusion in shadowed areas, a low pass median filter, and manual edits.

Historical Glacier Extent data was provided by Arendt et al. (2012) based on the Digital Raster Graphic (DRG) representations of USGS 1:63,360 topopraphical maps. The DRGs were compiled based on 1950s aerial photography.

Lake Clark Land Cover:

The *Lake Clark Land Cover* layer was prepared by Pacific Meridian Resources and NPS staff utilizing 1995 Satellite Pour l'Observation de la Terre (SPOT) satellite imagery (Golden and Spencer 1998). The land cover map included 32 classes.

ABR obtained an IKONOS 2004-2010 mosaic for LACL in February 2011 and used the mosaic as a basemap for digitizing riverine and lacustrine physiography, among other purposes. During a quality control/quality assurance review of the riverine and lacustrine physiography, it became apparent that there were nonsystematic offsets in the location of features between the IKONOS imagery and the *Lake Clark Land Cover*. Geolocation discrepancies are substantial when comparing the land cover map to modern IKONOS imagery and other reference data layers.

Although we do not have independent ground control data, we believe that the discrepancies arise from limitations of the land cover map geolocation, as explained below.

When the SPOT images used for the land cover map were initially processed, some terrain correction/orthorectification was performed. However, the quality of the available elevation models was poor and orthorectification models were not well developed at the time. The original report (Golden and Spencer 1998) indicates that the geolocation quality of the original terrain-corrected images was low. During development of the land cover map, the geolocation was refined using three rounds of rubber-sheeting, mainly referencing available digital line graphics depicting hydrologic features such as rivers, streams, and lakes. This process did improve the match of the imagery in some areas (areas which were used for control points), but the rubber-sheeting had unpredictable consequences elsewhere in the study area.

We reviewed 8 Level 5 watersheds to assess the geolocation of the LACL land cover map compared to the IKONOS imagery. In all 8 watersheds there were areas with geolocation differences of 100 m or greater. In numerous cases gravel land cover pixels associated with riverine channels occurred outside the photo-interpreted riverine channel on the imagery. In some cases the entire gravel channel (as shown on the land cover map) appeared outside the photo-interpreted riverine channel (as digitized based on the location of gravel in the IKONOS imagery) suggesting that the geolocation differences were related to more than simply natural changes in river channels through time. Rather, the relatively large and spatially consistent offset between the LACL landcover map and IKONOS imagery is indicative of geo-registration errors associated with the LACL land cover map. Given the many geolocation errors of 50–100 m or more compared to other data layers that would be used for the soils landscape modeling, the *Lake Clark Land Cover* layer was not used for the final soils landscape modeling.

National Land Cover Database 2001:

The Lake Clark soils study area was mapped by USGS as part of the National Land Cover Database 2001 (Homer et al. 2004, *NLCD2001*, Alaska Zone 6). Source imagery for the study area included early season Landsat imagery (6/4/2000 or 6/17/2002), late season Landsat imagery (8/28/1999 or 9/6/1999), and ancillary data including elevation and derivatives. The horizontal resolution of *NLCD2001* is 30 m.

A major difference between the *Lake Clark Land Cover* layer and the *NLCD2001* map is that the land cover classes for *NLCD2001* are much more generalized. For example, the *NLCD2001* has a single "Deciduous Forest" category while the *Lake Clark Land Cover* has Open Birch Forest, Closed Birch Forest, Open *Populus* Forest and Closed *Populus* Forest. The soils landscape modeling approach uses fairly broad land cover categories, as can be seen in the ecotype and soils landscape classifications. For example, interior upland open and closed birch and *Populus* vegetation classes are merged into a single map ecotype (e.g., Interior Upland Broadleaf Forest), and they are generally merged (along with barrens, shrublands, and mixed and needleleaf forests) into soils landscape classes for each general texture class (e.g., Interior Upland Ashy-Loamy Shrublands and Forests, Interior Upland Rocky Barrens, Shrublands, and Forests). The soils landscape approach in this case does not require the fine scale vegetation types from the *Lake Clark Land Cover* layer—in particular, the canopy closure classes are not used. There are two other advantages to using the *NLCD2001* data to provide vegetation classes; it is more current than the Lake Clark Land Cover layer (c. 2001 vs. 1995) and has less cloud cover.

For the current analysis, the *NLCD2001* was clipped to the study area. Several classes with very small areas were merged, and the open water class was split into marine water and other water based on the coastal physiography mapping (described below).

Ecological Subsections:
Ecological Subsection Mapping was originally performed by manual interpretation of Landsat Enhanced Thematic Mapper Plus (ETM+) imagery acquired 6 September 1999 (Spencer 2001). *Updated Coastal Subsections* were recently completed using high resolution IKONOS satellite imagery for much of the Lake Clark study area (Jorgenson et al. 2010). These data covered the entire coastal portion of the study area.

National Hydrography Dataset (NHD):
The *NHD* is managed by the USGS and EPA: "[The NHD] is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs, and wells (USGS 1999). The *NHD* was used to categorize the water land cover class into river and lake types.

Watershed Boundary Dataset (WBD):
The *WBD* (Watershed Boundary Dataset 2011) is a "complete digital hydrologic unit boundary layer to the Subwatershed (12-digit) 6th level for the entire United States." It was produced through a coordinated effort between the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), the United States Geological Survey (USGS), and the Environmental Protection Agency (EPA). These boundaries were used mainly to define the boundaries between the maritime and boreal regions.

Parameter-elevation Regressions on Independent Slopes Model (PRISM) temperatures:
PRISM temperature maps for Alaska at 771-m resolution were obtained from the NPS (Daly 2004). These maps are based on the climatological period 1971–2000 and were produced by the Spatial Climate Analysis Service at Oregon State University. The maps were clipped to an area slightly larger than the study area. *Down-scaled PRISM , Monthly Temperature* grids (January-December) at 30-m resolution were then produced using a moving window regression technique (Zimmerman and Roberts 2000) with a 20 pixel (600 m) window size. For portions of the study area where the algorithm did not produce valid results (mostly adjacent to the coast), the coarse resolution climate values were used. The *Down-scaled PRISM , Mean Annual Temperature* raster was then generated by averaging the *Down-scaled PRISM , Monthly Temperature* grids (Figure 3).

Surficial Geology:
The Digital Surficial Map of Lake Clark National Park and Preserve and Vicinity, Alaska (*Surficial Geology*) was compiled as a component of the Geologic Resources Inventory (GRI) program. The GRI program is funded by the NPS Inventory and Monitoring (I&M) Division and administered by the NPS Geologic Resources Division (GRD). Source geologic maps and data used to complete this GRI digital dataset were provided by the U.S. Geological Survey (Wilson et al. 2009a, 2009b, 2009c, 2009d, 2009e, 2009f, 2009g, 2009h). The surficial geology mapping was used as a source for physiography (primarily upland and lowland) and generalized soil texture.

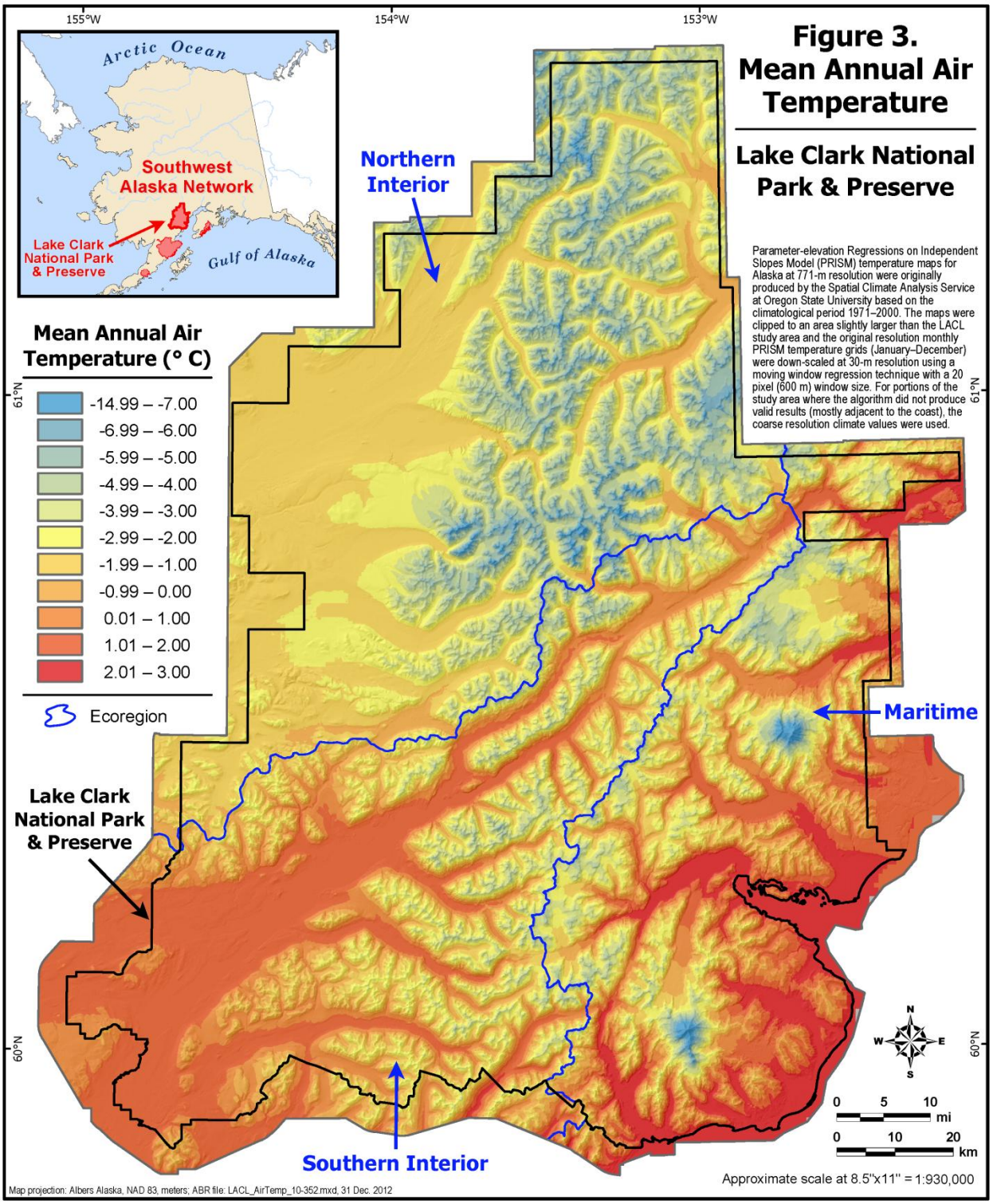


Figure 3. Ecoregions and mean annual air temperature for the Lake Clark National Park and Preserve, Alaska.

Remote Sensing Data Sources

IKONOS Mosaic:

The NPS provided a mosaic based on orthorectified IKONOS-2 and GeoEye-1 imagery acquired in 2004–2010. The horizontal accuracy was rated at 15 m (Circular Error at 90% confidence, CE90). The mosaic was based on pan-sharpened, dynamic-range-adjusted imagery with a pixel size of 1 meter. Four bands (Blue/Green/Red/NIR) were provided. The IKONOS Mosaic was used as the geolocation truth and served as the basemap for several digitizing and other data compilation efforts.

Landsat:

We acquired an extensive collection of Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper+ (ETM+) imagery for LACL, organized into paths and rows based on the World Reference System 2. The path/row combinations that covered any portion of LACL were identified and all of the browse imagery was reviewed. Scenes with substantial cloud-free coverage over the study area (1,077 scenes in total) were ordered and downloaded.

We standardized each scene to top-of-atmosphere reflectance using the Landsat Ecosystem Disturbance Adaptive Processing (LEDAPS, Masek et al. 2006) lndcal algorithm. The LEDAPS lndcsm algorithm was used to calculate a cloud mask using the Automated Cloud-Cover Assessment algorithm (ACCA, Irish et al. 2006). The cloud mask identified each pixel as gap, cloud, or cloud-free based on the ACCA algorithm. Gap values occurred either beyond the edge of the image, or in wedge-shaped gaps caused by the scan-line corrector malfunction on Landsat 7 images acquired after May 2003. Cloud shadows were not detected by lndcsm.

A statewide tiling scheme in the Alaska Albers (NAD 1983) coordinate system was developed to facilitate the creation of time-series stacks from overlapping Landsat paths. The state is divided into non-overlapping square tiles 30 km (1000 × 1000 30-m Landsat pixels) to a side. A GDAL script was used to reproject the standardized Landsat imagery from the default UTM projection to Alaska Albers (NAD 1983) and clip the imagery to the extent of each tile. Adjacent rows from the same acquisition date were mosaicked together as part of the same processing step. The nearest neighbor resampling method was used during reprojection and the 30-m pixel size was maintained. The same procedure was used to reproject and tile the cloud mask.

GIS Modeling

GIS modeling techniques were applied to generate inputs for the ecotype and soil landscape modeling. These included ecoregion, snow regime, physiography, generalized soil texture, soil temperature, and permafrost likelihood maps. The raster modeling was performed carefully, with review and refinement at several different points as data layers were combined, to minimize the effect of mismatch between different input data layers.

EcoRegions

Ecoregions were coded as five digit numbers evenly divisible by 10000, with the region encoded in the first digit. Topographic divides, as defined by the WBD, were the primary reference used to divide the study area into interior and maritime regions based on climate modeling (see SNOW REGIME MODELING, below) and knowledge of the broad-scale climate patterns in LACL. The interior region was subdivided into northern and southern subregions based on a soil

temperature model prepared for LACL (see SOIL TEMPERATURE, below) knowledge of the broad-scale climate patterns in LACL (Figure 3).

Snow Regime Modeling

We acquired and analyzed an extensive time series of Landsat imagery (1985–2010) to characterize patterns of snow persistence on the landscape. Snow persistence is related to snow depth and growing season length, which are important factors in soil and vegetation development. The persistence of snow cover (and the distribution of snow depths) is very heterogeneous within LACL. Therefore, we analyzed the time series of Landsat imagery depicting snowmelt patterns for different years and a variety of dates within years to characterize the snow regime across LACL.

Snow Mapping (Single Date):

The Snowmap algorithm (Hall et al. 1995, 2001) was used to generate a binary map of the presence or absence of snow for all non-fill pixels. Snow is one of the few natural materials that is both highly reflective in the visible wavelengths and absorbed in the middle infrared wavelengths; therefore, satellite snow-mapping algorithms are based on these properties. The Normalized Difference Snow Index (NDSI) tends to be high when snow is present in a remote-sensing pixel and is calculated from the visible and short-wavelength infrared wavelengths as follows:

$$NDSI = (VIS - SWIR) \div (VIS + SWIR)$$

Where:

VIS = Top-of-atmosphere reflectance in a visible wavelength, typically about 0.55 micrometer (μm). Landsat TM and ETM+ band 2.

SWIR = Top-of-atmosphere reflectance in a short-wavelength infrared, typically about 1.64 μm. Landsat TM and ETM+ band 5.

The Snowmap algorithm (Hall et al., 2001) classifies pixels as snow if the following conditions are met: NDSI is greater than 0.4, visible reflectance (Landsat TM and ETM+ band 3) is greater than 0.10, and near-infrared (NIR, about 0.85 μm; Landsat TM and ETM+ band 4) reflectance is greater than 0.11.

The Snowmap algorithm identified each pixel as snow or snow-free. The cloud mask and Snowmap data were then combined so that the cloud-free areas were classified as snow or snow-free. The end result was a cloud/snow map for each tile and each date with four categories: gap (255), cloud (9), snow (1), and snow-free (0).

Snow Mapping (Typical Snow-Free Date):

The set of cloud/snow maps was filtered to select all dates between March 1 and August 31. Dates before March 1 often had extensive terrain shadows, which were not reliably mapped correctly. Dates after August 31 also had increasing terrain shadows, and were more likely to have recent snow, complicating the detection of the snow melt date. The resulting set of cloud/snow maps (*csm*) for each tile was stacked into a virtual dataset (VRT) using GDAL. The Julian date (day of year, *doy*) for each layer in the stack was tracked. For analysis, both gaps and

clouds were treated as unknown; the relevant response variable was the binary snow presence (1) or absence (0).

To identify the day of year value that best separated the snow-covered from the snow-free season, we analyzed the *csm* stack and *doy* vector in R using a binary classification tree (rpart), which was constrained to one split. Logistic regression is an alternative statistical technique that could be used; however, the classification tree was selected because it is less influenced by outliers. For each pixel, the split value (Julian date) that provided the best split, and the direction of the split (left or right) were extracted. The split value was stored as a floating point number in the *sf_doy_f* raster layer. Other values extracted included *n* (the count of cloud-free observations), *n_snow* (the count of cloud-free observations with snow), *n_snowfree* (the count of cloud-free observations with no snow), *n_snow_correct* (the count of cloud-free observations with snow that are correctly classified by the split value in *sf_doy_f*), and *n_snowfree_correct* (the count of cloud-free observations that are snow-free that are correctly classified by the split value in *sf_doy_f*).

The *sf_doy_f* output raster is coded with the Julian date that the pixel typically becomes snow-free. For performance and visualization reasons, the raster was stored as an 8-bit unsigned integer *sf_doy*, with values 0–255. Because a date filter was used in the analysis (March 1–August 31), valid values returned by the classification tree algorithm were between Julian dates 60–244. Values outside this range were special cases, and were filled using an alternative approach.

The special cases occurred either when there was no split, or when the split was reversed (i.e., from snow-free to snow-covered). The no split condition was common and was usually associated with situations where the pixel was nearly always snow-covered or nearly always snow-free. In these cases, the classification tree determined that the optimal split was no split, i.e., leaving all the data in one class.

Splits from snow-free to snow-covered were rare, and occurred mostly in areas with deep terrain shadows. The visible and near-infrared reflectance tests in Snowmap are intended to prevent false detection of snow over open water and other dark objects; however, these two tests may result in misclassification of shadowed snow as snow-free. These false snow-free detections tended to occur early in the time series when the sun angle was lower and shadows were more extensive. The time window used for our analysis was restricted to April 1–August 31, partly to avoid the real transition that occurs in the fall when snow returns.

To fill the values for the special cases, the proportion of snow (*p_snow*) was calculated by dividing *n* by *n_snow*. The *p_snow* value was used to fill in the *sf_doy* values for the no split and reverse split cases as follows: if $p\_snow \leq 0.25$, the condition was defined as "Usually snow-free" and the value was set to 1. If $p\_snow \geq 0.75$ the condition was defined as "Usually snow-covered" and the value was set to 254. If $0.25 < p\_snow < 0.75$, the condition was defined as "no pattern" and the value was set to 0. The value 255 was reserved for No Data, i.e., pixels that occur within the extent of the raster but are outside the study area.

Physiography

Physiography characterizes the dominant tectonic and geomorphic process controlling the landscape. For the GIS modeling, physiography was constructed by combining several sources of data. The sequence of assigning physiography generally followed the order described below, so that once a grid cell had been assigned a physiography class it was not overwritten by subsequent layers.

Glaciers and Snow Fields (9100):

Active glaciers, snow fields, and persistently late-lying snow drifts were combined in a glacier/snow field physiography class (9100). Included in this class were current era glaciers (from the c. 2007 glacial extent mapping), the "Perennial Ice/Snow" land cover class from NLCD2001, and pixels with a snowmelt date of 16 August or later, based on the snow regime analysis. In general these three sources of information were in agreement; for the modeling, any one of the three conditions was sufficient.

Glacial (9200):

Recently deglaciated areas were identified by overlaying the 1950s glacier extent on the c. 2007 glacier extent. Areas that were glaciated in the 1950s but that were not glaciated in 2007 were set to the glacial physiography type (9200). In addition some of the surficial geology classes were defined as glacial.

Riverine (3300/3400/3500/3600/3700/3800/3900):

Riverine physiography corridors were digitized based on the IKONOS mosaic. In areas outside the extent of the IKONOS coverage, Landsat imagery was used. Riverine polygons were classified as glacial, non-glacial, or coastal (tidally influenced) for use in mapping ecotypes and soil and disturbance landscapes (see below). In addition, each riverine polygon was classified to a particular riverine class, including alluvial fans, braided, delta, headwater, meander, riverine lake, and steep constricted.

Coastal (4300/4400):

The *Updated Coastal Subsections* (Jorgenson et al. 2010) mapped the coastal physiography zone for most of the study area. The coastal riverine class from the current study was also included as a coastal physiography type. For the current study, the coastal zone was further split to divide marine water from brackish water.

Volcanic (8100/8200):

A volcanic physiography zone was digitized on the IKONOS basemap based on review of field data and photo-interpretation. The volcanic zone was further divided for use in disturbance landscape mapping into Volcanic Alpine, Volcanic Upland, Volcanic Lowland, Volcanic Coastal, and Volcanic Riverine based on a spatial overlay of the volcanic physiography layer over the physiography model for the non-volcanic classes (see below). Volcanic physiography is defined as those areas directly and immediately (within minutes to several hours) impacted by volcanic eruptions and that has experienced volcanic eruptions semi-regularly (~60–100 year intervals or less) over the past several centuries. The volcanic physiography class was limited to the area directly surrounding (within ~10–15 miles) Mount Redoubt, which has a record of regular eruptions within the last century and earlier. These include most recently, observations recorded in 1902, 1966, 1989, and 2009, with possible activity noted in 1881 and 1933 (Till et al.

1994, AVO 2012a). Despite Mount Illiamna being an active volcano there have been no documented historical eruptions. Reports of eruptions in the 1860's and 1870's are inconclusive, and do not clearly show eruptive activity or emission of volcanic ash (Miller et al. 1998). Therefore, the area surrounding it was not considered volcanic physiography for the purposes of this study.

Lacustrine (7200):
Lacustrine physiography generally occurs either in lakes, along lake margins, or in recently drained lake basins (< 50 years). Lacustrine physiography was mapped based on photo-interpretation of the IKONOS mosaic.

Subalpine and Alpine (1000/1100/2000):
The southern and northern interior ecoregions generally included both subalpine and alpine physiography zones, while only alpine physiography occurred within the maritime ecoregion. The presence of subalpine or alpine physiography was primarily determined by elevation based on local thresholds. Three sets of break points were established based on photo-interpretation of the IKONOS mosaic and review of the field data:

- Upland/Subalpine breaks: A point located at the upper edge of the upland zone and lower edge of the subalpine zone; determined using the photo-interpretation cues showing transitions from open and closed forests to woodland (10–24% tree cover) or dwarf tree (height < 3 m) communities or tall shrub dominated communities in conjunction with increasing elevation.

- Subalpine/Alpine break: A point located at the upper edge of the subalpine zone and the lower edge of the alpine zone; determined using the photo-interpretation cues showing transitions from tall shrub or low shrub dominated communities to dwarf shrub dominated communities in conjunction with increasing elevation.

- Upland/Alpine break: A point located at the lower edge of the alpine zone in an area that lacked a subalpine zone (generally, but not always, in the maritime region); determined using the photo-interpretation cues showing transitions from forested and low and tall shrub communities to dwarf shrub dominated communities in conjunction with increasing elevation.

After these breakpoints were established, an inverse distance weighted (IDW) interpolation was used to generate a surface for each transition (upland/subalpine, subalpine/alpine, and upland/alpine). The default IDW parameters were used (power=2, variable search radius, 12 points). Then, the smoothed transition surfaces were compared to the DEM. For the boreal region, elevations above the upland/subalpine threshold but below the subalpine/alpine threshold were assigned to subalpine physiography; and elevations above the subalpine/alpine threshold were assigned to alpine physiography. For the coastal region, all elevations above the upland/alpine threshold were assigned to alpine physiography.

This approach allowed photo-interpretation of physiography transitions to guide the delineation of subalpine and alpine physiographic zones, but avoided the more time-consuming task of

digitizing the actual breaks. A total of 4,281 break points were identified, including 2659 Subalpine/Alpine breaks, 1004 Upland/Alpine breaks, and 618 Upland/Subalpine breaks.

Surficial Geology for Physiography Gaps:
Surficial geology classes based on the *Surficial Geology "GLG_SYM"* codes were used to derive physiography for the remaining areas after glacier/snow, glacial, coastal, volcanic, lacustrine, subalpine, and alpine physiographies were defined. Most of the remaining areas were assigned to either upland or lowland based on the surficial geology unit descriptions along with review of field data. The physiographic units for some surficial geology types were ambiguous; these were resolved by reviewing summary slope statistics for each polygon and by manual review. Several alluvium types (Qal=Alluvium, Qao=Older alluvium, Qat=Terrace deposits) that occurred outside riverine corridors and below the subalpine or alpine break had variable physiographies (depending on the surrounding types). These polygons were reviewed and were either assigned to a physiographic class manually, or else were lumped into the adjacent physiographic type with the longest shared border.

Waterbodies
Waterbodies were identified as the "Open Water" type in the *NLCD2001*. Water outside the coastal and riverine physiography zones was assigned to a lake class. Water within the riverine physiography zones was assigned to either a lake or river class, based on proximity to stream/river or lake sources in the NHD. Stream/river sources were defined by the *NHDFlowline* with the value "StreamRiver" and the *NHDArea* "*FType*" with the values "StreamRiver" or "Area of Complex Channels". Lake sources were defined by the *NHDWaterbody* "*FType*" value of "LakePond".

The two sources (riverine and lake) were merged into a single grid at 30-m resolution. The nearest source was then defined for each pixel in the study area based on the Euclidean distance. Finally, the water pixels from the *NLCD 2001* map were assigned to the riverine or lake water class based on the nearest source. In this way, water pixels that occurred over an NHD feature were assigned to the overlapping type and water pixels that did not overlap an NHD feature or the marine water class were assigned to the class they were closest to. This accounted for small misalignments between the NHD and the land cover map and also allowed all water pixels to be assigned to one of the two classes.

Coastal water was assigned to a marine water class or a brackish water class based on a dividing line digitized within the coastal physiography zone. Coastal land (4400) and coastal/tidal riverine water were assigned to the brackish water class while the remaining coastal water was assigned to the marine water class.

Bedrock Chemistry
Based on analysis of field data, bedrock chemistry was generally limited to acidic and circumacidic ranges and was not a primary driver of soil variability. Therefore a bedrock chemistry layer was not incorporated into the ecotype and soils landscape models.

Generalized Texture

The Surficial Geology "GLG_SYM" codes were aggregated into generalized soil texture categories based primarily on a lookup table (Table 4). The lookup table textures were determined based on review of field data and map descriptions. Several surficial geology types required special treatment. Areas coded as "nm=Not mapped" or "Qus=Surficial deposits, undivided" were manually reviewed and were assigned to specific surficial geology codes and textures. Several alluvium types (Qal=Alluvium, Qao=Older alluvium, Qat=Terrace deposits) had variable textures based largely on the surrounding types. Where these occurred within Riverine physiography, the texture was set to "sandy-rocky-organic". Outside the riverine corridors, the occurrence of these types was reviewed manually and where appropriate, the soil texture was set manually (splitting large polygons if necessary). The remainder of the alluvium polygons were mostly narrow strips. These were filled based on the nearest surrounding non-alluvium texture.

To account for offsets between the surficial geology water layer and the land cover water layer, water surficial geology polygons were filled based on the nearest non-water surficial geology polygon; the land cover water layer was later superimposed on the surficial geology-derived texture map.

The results of the generalized texture mapping were reviewed against the field plots and the IKONOS imagery. In many cases manual edits were made to override the preliminary texture assignments that were based on automated methods. For instance, based on our field data, it was apparent that some of the areas classified as bedrock in the *Surficial Geology* layer were in fact overlain by up to several meters of volcanic ash. Many of these areas could be identified by physiography (e.g., lowlands), landscape position, slope (e.g., flat and low angle), or vegetation community. The final result was a *Generalized Soil Texture* raster. Generalized soil texture classes are described in Table 2.

Soil Temperature

The relationship between air temperature, snow cover, and soil temperature (at 50 cm depth) was assessed using data from Alaska SNOTEL sites. Sites where all three parameters (air and soil temperature and snow depth) were measured for at least 336 days during an individual water year (October 1 through September 30) were included in the analysis. A linear regression was developed to predict the soil temperature based on air temperature and the number of days with snow cover after December 31. The days with snow cover after December 31 was highly correlated with the total number of days with snow cover and was directly comparable to the snow persistence metric derived from the Landsat time-series analysis. *Modeled 50 cm Soil Temperature* for the study area was then modeled based on downscaled PRISM air temperature data and the snow persistence data derived from the Landsat time-series analysis.

Permafrost

The ecoregions (northern and southern interior), physiography types (lowland, lacustrine, subalpine, alpine), slope gradients (< 8°), and general texture classes (generally finer and organic) where permafrost occurrence was most likely were identified based on field data and literature review (Jorgenson et al. 2008b). The modeled soil temperatures were reviewed in conjunction with the field data and permafrost occurrence likelihood categories were developed for susceptible types. The *Permafrost Occurrence Likelihood* outputs are a useful stand-alone

Table 4. Cross-walk between surficial geology map classes (Wilson 2009a-h) and generalized soil texture classes, Lake Clark National Park and Preserve, 2011.

GLG_SYM	GLG_Name	Generalized Texture
bu	Undifferentiated bedrock	rocky
g	Glaciers and permanent icefields	rocky
nm	Not mapped	na
Qac	Abandoned channel deposits and landforms	loamy-organic
Qad	Andesite and dacite domes	rocky
Qaf	Alluvial fan deposits	rocky
Qal	Alluvium	rocky-organic
Qao	Older alluvium	rocky-organic
Qat	Terrace deposits	rocky-organic
Qat2	Older terrace deposits	ashy-loamy-rocky
Qav	Volcanic avalanche deposits	rocky
Qbd	Beach deposits	rocky
Qca	Ash-rich colluvium	ashy-loamy-rocky
Qcd	Colluvial deposits, undivided	ashy-loamy-rocky
Qcf	Colluvial-alluvial fan deposits	rocky
Qdf	Debris flow and mudflow deposits	rocky
Qdf1	Debris flow deposits of North Fork, Crescent River	ashy-loamy-rocky
Qdf2	Older debris flow deposits of North Fork, Crescent River	ashy-loamy-rocky
Qdl	Deltaic deposits	rocky
Qdr	Drift River mudflows	rocky
Qek	Esker and related ice-contact deposits	rocky
Qes	Estuarine deposits	silty-clayey
Qew	Glacial deposits of probable Early Wisconsin age	ashy-loamy-rocky
Qewo	Outwash deposits of probable Early Wisconsin age	ashy-loamy-rocky
Qgl	Glaciolacustrine deposits	loamy-organic
Qglf	Glaciolacustrine fan deposits	ashy-loamy-rocky
Qhv	Volcanic rocks	rocky
Qiu	Older glacial deposits	ashy-loamy-rocky
Qld	Lacustrine deposits	organic
Qls	Landslide deposits	ashy-loamy-rocky
Qmg	Ground moraine of Mak Hill or Knik age	ashy-loamy-rocky
Qnd	Moraines of Neoglacial and modern glaciers	rocky
Qno	Outwash deposits	ashy-loamy-rocky
Qpd	Pyroclastic deposits	ashy-loamy-rocky
Qrg	Active and recently active rock glacier deposits	rocky
Qsb	Glacially scoured bedrock	rocky
Qsf	Solifluction deposits	ashy-loamy-rocky
Qsg	Superglacial drift	rocky
Qsw	Swamp deposits	organic
Qtc	Talus cone deposits	rocky
Qtf	Modern tidal flat and estuarine deposits	silty-clayey
QTgu	Glacial deposits, undivided	ashy-loamy-rocky
QTv	Old volcanic rocks, undivided	rocky
Qus	Surficial deposits, undivided	na
Qvr	Undivided volcanic rocks and deposits	ashy-loamy-rocky
Qwg	Undifferentiated glacial deposits of Late Wisconsin age	ashy-loamy-rocky
Qwg1	Latest Wisconsin moraine, Iliuk or late Farewell II	ashy-loamy-rocky
Qwg2	Late Wisconsin moraine, Newhalen or Farewell II	ashy-loamy-rocky
Qwg3	Earlier late Wisconsin moraine, Iliamna and older Farewell II	ashy-loamy-rocky
Qwg4	Oldest Late Wisconsin moraine, Kvichak or earliest Farewell II	ashy-loamy-rocky
Qwgo	Outwash and ice-contact deposits of Late Wisconsin age	ashy-loamy-rocky
water	Water	water

product. For the purpose of mapping ecotypes and soil landscapes two criteria were set, 1) in the northern interior ecoregion the areas with a "highly likely" permafrost probability class were treated as a frozen ground ecotype and soil landscape class, and 2) in the southern interior ecoregion the areas with a "highly likely" and "likely" permafrost likelihood class were treated as a frozen ground ecotype and soil landscape class.

Generalized Physiography

An aggregated Generalized Physiography layer was produced from the more detailed Physiography layer via a lookup table for use in the raster modeling.

Strata

Generalized Physiography and Generalized Soil Texture were combined in a preliminary Generalized Physiography and Soil Texture raster. The preliminary results were reviewed and unlikely combinations were flagged for review. In most cases these combinations were due to minor mismatch between the physiography layer and the surficial geology linework, and were addressed by recoding the generalized soil texture based on the neighboring texture types within the same physiography class.

After the issues due to mismatches between generalized physiography and soil texture were addressed, the results from the permafrost model were overlaid. The highly probable permafrost types were recoded as a frozen class with the appropriate Generalized Physiography. The final Strata layer contained the final Generalized Physiography and Generalized Soil Texture information, including a "Frozen" modifier.

Aggregated Ecotypes

Ecotypes were aggregated for mapping based on similarity in vegetation structure and general soil texture (e.g., Alpine Gelic Rocky Barrens and Alpine Gelic Rocky Lichen Tundra). A review of the NLCD land cover classes by physiography revealed that for several common ecotypes (e.g., Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow) an equivalent land cover class would not be available. In these cases, the ecotypes without an equivalent land cover class were aggregated with a closely associated ecotype for mapping (e.g., Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow and Interior Subalpine Ashy-Loamy Alder-Willow Shrub). While aggregation was important to reduce the total number of ecotype classes mapped, the ecotype aggregation also emphasized maintaining distinctions between ecotypes with differences in soils, vegetation, or disturbance regime important for mapping and use and management (e.g., Interior Lowland Frozen Loamy-Organic Black Spruce Forest versus Interior Lowland Ashy-Loamy-Organic Black Spruce Forest). Ecotypes were given an aggregated ecotype code which was used to cross-walk to the combined strata and land cover layer (see COMBINED STRATA AND LAND COVER, below). Appendix 6 provides a cross-walk between aggregated ecotype codes and ecotype classes.

Combined Strata and Land Cover

For the reasons explained above, the primary vegetation data layer used for the modeling of ecotypes and soil landscapes was based on the NLCD2001 (with several classes with very small area combined, and the open water class split into marine and other water). The final Strata layer was combined with the Aggregated NLCD2001 layer through a raster combination operation.

The combinations of strata (generalized physiography + generalized soil texture) and land cover classes (strata × land cover) were reviewed and each combination was assigned to an aggregated ecotype. The assignment was based on expert knowledge and review of the field data and map outputs. A cross-walk (Appendix 7) was then developed between the strata-landcover combinations and the aggregated ecotype codes.

Map Ecotypes and Soil Landscapes

The ecotypes were aggregated into map ecotype and soil landscape classes for use in mapping (Appendix 6). The focus of the map ecotype aggregation was on vegetation type and structure with less emphasis on soils (e.g., Alpine Meadows and Dwarf Shrub), while the focus of the soil landscape aggregation was on soils with less emphasis on vegetation. Therefore, map ecotype classes represent aggregations of similar or closely associated vegetation types with differing soil textures and soil landscape classes represent aggregations of similar or closely associated soil types with different vegetation types that are typically associated through a successional sequence. When the aggregation process was complete, the map ecotype and soil landscape maps were then derived from the combined strata-land cover layer based on the lookup table in Appendix 7 with the aggregated ecotype code as the primary key.

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

We did not use the standard NRCS term “soil association” because that term has a specific concept of widely differing soils being associated with each other along toposequences and repeated across the landscape. In addition, “soil associations” are recognized in soil mapping to be large polygon-based map units with aggregated soil types. In this study, the map is based on a 30-m pixel size and the term “soil landscape” refers to closely related soil types on a portion of the landscape at a broad scale.

Disturbance Landscapes

Additionally, the aggregated ecotypes were further aggregated into preliminary disturbance landscape classes for use in mapping (Appendix 6). The focus of the disturbance landscape aggregation was on similarities in disturbance regime across physiography, soil, and vegetation classes. A preliminary disturbance landscape map was then derived from the combined strata-land cover layer based on the lookup table in Appendix 7 with the aggregated ecotype code as the primary key. Next, the volcanic physiography layer (which identified areas that would be most strongly impacted by a volcanic eruption) was overlaid on the preliminary disturbance landscape map. The final disturbance landscape classes incorporated a volcanic disturbance modifier (either “Lahars and Flash Floods” or “Thick Ash-fall and Volcanic Ejecta”) with the preliminary disturbance class. This approach accounted for both the volcanic and non-volcanic disturbance factors within areas of volcanic physiography.

Disturbance regime-landscape associations, or disturbance landscapes, were developed to characterize and map broad-scale relationships among soil type, physiography, vegetation, and commonly associated factors of landscape change, including ecosystem processes and natural agents of disturbance. The resulting associations were named after the suite of processes and disturbance agents identified for each aggregated ecotype.

Results

Ecotypes and Plant Associations

Descriptions of 91 ecotypes defined by general distribution, landscape features, plant associations, dominant soil textures and chemistry, and hydrologic characteristics are presented for LACL in the ecotypes section. A key to the ecotypes is provided in Table 5. Most ecotypes were associated with one or two plant associations. However, twenty ecotypes had three or more plants associations, and twenty-seven plant associations described more than one ecotype (Table 6). This overlap resulted from communities that were floristically comparable but had different site factors (e.g., communities on rocky versus ashy-loamy soils), or from communities that were immediately adjacent in a successional sequence (e.g., Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub and Riverine Silty-Sandy-Rocky Poplar Forest). There were 70 plant associations (Table 7). In many cases ecotypes were specific to an ecoregion (i.e., interior or maritime). However, there were some cases when ecotypes were not assigned to an ecoregion, including all alpine and glacial ecotypes, 7 riverine, 3 lowland, and 3 upland ecotypes. Alpine ecotypes were classified based on soil temperature, including those with gelic (colder, northern interior) and cryic (warmer, southern interior and maritime) soil temperature regimes. The glacial, and several riverine, lowland, and upland ecotypes were not assigned to specific ecoregions due to low sample size in one or both ecoregions. These ecotypes are applicable across ecoregions, and vegetation and soil characteristics of these ecotypes unique to each ecoregion are explained in the descriptions of the ecotypes (see below). We did not map two ecotypes that were uncommon and an additional six ecotypes were mapped that were not based on plot data (Appendix 6).

Ecotypes

Alpine
Glacial
Subalpine
Upland
Lowland
Lacustrine
Riverine
Coastal

Alpine Ashy-Loamy Dwarf Shrub Hummocks
This ecotype occurs in glacial cirques and alpine valleys on gentle slopes at elevations between approximately 750 and 1000 m above sea level (a.s.l.) in the southern interior and maritime ecoregions. Tightly grouped mineral cored hummocks are conspicuous and unique to this ecotype. Soils are typically ashy with few to no coarse fragments. Soils form in ash-laden loess and are well-drained to moderately well-drained, moist, acidic, and feature a thin (3-4 cm) surficial organic horizon. Soil cryoturbation is common. However, it is hypothesized that frost-action is not the primary driver of hummock formation. Rather the hummocks may be related to a complex interaction of wind deposited ash, snow drifting, stabilization by vegetation, and erosion of the inter-hummock surfaces by melt water. Soil subgroups in this ecotype include Andic Haplocryods, Spodic Haplocryands, and Vitriandic Humicryepts. Vegetation is predominantly *Cassiope stelleriana-Luetkea pectinata*.





Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra
This ecotype occurs on gentle to moderately steep alpine slopes on colluvial fans and in ash-laden loess deposits between approximately 600 to 1400 m a.s.l. Soils are typically ash-rich and rocky, deep, moist, acidic, and well-drained. Soil subgroups include Typic Haplocryands and Typic Vitricryands. Vegetation is predominantly *Cassiope stelleriana-Luetkea pectinata*.





Alpine Rocky Dwarf Shrub Late-Lying Snowbanks

This ecotype occurs on gentle slopes in cirques, glacial valleys, and on alpine slopes and ridges between 600 to 1000 m a.s.l. This ecotype is associated with snow drifts that form in concavities on the leeward side of gentle rises and in nivation hollows where wind-driven snow accumulates forming a late-snowban k environment. Snow melts off later in the summer (early to mid-July) than in other alpine areas resulting in a shorter growing season. In the winter, a deep snow pack insulates the soil thus moderating the soil temperatures relative to more exposed alpine areas. Hence, soils in this ecotype have been classified in the Cryic temperature regime in all alpine areas of LACL. Solifluction processes predominate in these environments where melt water and freeze-thaw activity cause soil to slowly creep downhill. Soils are typically a mixture of sandy-rocky till or colluvium and volcanic ash. Organic material at the surface is very thin to absent. Soil subgroups in this ecotype include Typic Cryorthents and Andic Haplocryepts. Vascular plants in this ecotype are typically somewhat sparse (25-40% cover), while non-vascular plants tend to predominate, at times approximating a cryptobiotic crust. Vegetation in this ecotype is *Salix rotundifolia-Carex microchaeta.*





Alpine Rocky Lichen Tundra
This ecotype occurs on gentle to moderate slopes on alpine ridges and mountain slopes and in glacial cirques between 600 and 900 m a.s.l. Soil parent materials include till with a thin mantle of ash-laden loess and talus. Soils are rocky, dry to moist, well- to excessively-drained, and acidic to circum-acidic. Soil subgroups include Typic Cryorthents and Andic Haplocryepts. Vegetation is *Cladina arbuscula - Cladina stellaris* and *Umbilicaria* sp.*-Rhizocarpon geographicum-Hierochloe alpina*.





Alpine Ashy-Loamy-Rocky Moist Sedge Meadow

This ecotype occurs on gentle slopes on alpine ridges, plateaus, and cirques between 900 and 1000 m a.s.l. Parent materials in the two plots sampled in this ecotype include rocky co-alluvium with a thin mantle of volcanic ash on an old alluvial fan and pumiceous volcanic pyroclastic deposits on a ridgetop near Mount Redoubt. Soils are rocky, moist, acidic, and well-drained. Surface organics are typically thin and may be completely absent in areas where volcanic ash and pumice deposition regularly bury the soil surface resulting in a series of thin buried organic-rich horizons near the soil surface. Soil subgroups include Andic Haplocryepts and Vitrandic Cryorthents. Vegetation is *Carex microchaeta-Luzula* sp.





Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks

The soils and vegetation of this ecotype are similar to Alpine Ashy-Loamy Dwarf Ericaceous Hummocks with the exception that this ecotype occurs in the northern interior ecoregion. Soils in alpine areas of this ecoregion occur in a gelic (MAST ≤ 0°C) soil temperature regime, thus the soils are colder than in other alpine areas of LACL and permafrost may be present at some sites. One plot was sampled in the upper Kejik River valley in mineral-cored hummocks formed from ash-laden loess. Soils are ashy, well-drained, moist, acidic Turbic Vitrigelands. Vegetation is *Vaccinium uliginosum-Carex microchaeta* and *Salix reticulata-Carex podocarpa*.





Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra

The soils and vegetation of this ecotype are similar to Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra with the exception that this ecotype occurs in the northern interior ecoregion. Soils in alpine areas of this ecoregion occur in a gelic (MAST ≤ 0°C) soil temperature regime, thus the soils are colder than in other alpine areas of LACL and permafrost may be present at some sites. This ecotype occurred on alpine plateaus, mountainsides, lateral moraines, and drumlins on gentle to moderately steep slopes between 600 and 1400 m a.s.l. Soils form in ash-laden loess, hillside colluvium, and till, are rocky and often ash-rich, acidic to circum-acidic, moist, and well- to excessively drained. Cryoturbation is common. Soil subgroups include Humic Vitrigelands, Andic Haplogelods, Andic Humigelepts, Andic Umbriturbels, Turbic Haplogelods, and Typic Haplogelods. Vegetation includes *Empetrum nigrum-Cladina* sp., *Vaccinium uliginosum-Carex microchaeta*, *Betula nana-Ledum decumbens-Cladina* sp., and *Cassiope stelleriana-Luetkea pectinata*.





Alpine Gelic Rocky Lichen Tundra
The soils and vegetation of this ecotype are similar to Alpine Ashy-Loamy-Rocky Lichen Tundra with the exception that this ecotype occurs in the northern interior ecoregion. Soils in alpine areas of this ecoregion occur in a gelic (MAST ≤ 0°C) soil temperature regime, thus the soils are colder than in other alpine areas of LACL and permafrost may be present at some sites. This ecotype occurs on rocky outcrops on ridges, boulder fields on mountains slopes, and older moraines between 900 and 1700 m a.s.l. on moderately steep to steep slopes. Soils form from mafic and igneous bedrock, colluvium, and till. Soils are rocky with an occasional ash-rich mantel, dry to moist, acidic to circum-acidic and somewhat excessively to excessively drained. Surface organic horizons, when they do occur, are typically thin (< 3 cm) and cryoturbation is common. Soil subgroups include Typic Gelorthents, Typic Humigelepts, and Turbic Haplogelepts. Vegetation includes *Umbilicaria* sp.-*Rhizocarpon geographicum-Hierochloe alpina,* and *Cladina arbuscula - Cladina stellaris*.





Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow

This ecotype occurs on gentle to moderate slopes on mountains sides and plateaus between 900 and 1400 m a.s.l. Soils form from colluvium, till, and ash-laden loess. Cryoturbation is common and periglacial frost-related features, including sorted ground and mineral cored hummocks are often associated with this ecotype. Surface organic horizons are typically thin (< 3 cm). Soils are moist, rocky-ashy, well- to moderately well-drained, and acidic to circum-acidic. Soil subgroups include Andic Humigelepts, Oxyaquic Humigelepts, and Andic Haplogelepts. Vegetation includes *Carex microchaeta-Luzula* sp. and *Carex bigelowii-Dryas integrifolia*.





Alpine Gelic Rocky Barrens
The soils and vegetation of this ecotype are similar to Alpine Rocky Barrens with the exception that this ecotype occurs in the northern interior ecoregion. Soils in alpine areas of this ecoregion occur in a gelic (MAST ≤ 0°C) soil temperature regime, thus the soils are colder than in other alpine areas of LACL and permafrost may be present at some sites. This ecotype occurs on alpine ridges and rocky mountain slopes and passes between 1100 and 1900 m a.s.l. Soils form in talus and mafic bedrock. The soil surface is rocky with little to no organic material. Cryoturbation is absent. Soils were dry, rocky, excessively well drained, and circum-acidic. Soil subgroups include Typic Gelorthents. Vegetation was *Dryas integrifolia-Oxytropis nigrescens.*





Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra

The soils and vegetation of this ecotype are similar to Alpine Rocky Dwarf Shrub-Lichen Tundra with the exception that occurs in the northern interior ecoregion. Soils in alpine areas of this ecoregion occur in a gelic (MAST ≤ 0°C) soil temperature regime, thus the soils are colder than in other alpine areas of LACL and permafrost may be present at some sites. This ecotype occurs on mountain slopes, summits and shoulders between 700 and 1000 m a.s.l. Soils form from till and bedrock. Soils are rocky with a loamy matrix, moist, acidic, and well- to somewhat excessively drained. Soil subgroups include Typic Gelorthents, Typic Humigelepts, and Turbic Dystrogelepts. Vegetation is *Dryas integrifolia-Oxytropis nigrescens* and *Dryas integrifolia-Cladina* sp.





Alpine Gelic Rocky Dwarf Willow Tundra
The soils and vegetation of this ecotype are similar to Alpine Ashy-Loamy-Rocky Moist Sedge Meadow with the exception that this ecotype occurs in the northern interior ecoregion. Soils in alpine areas of this ecoregion occur in a gelic (MAST ≤ 0°C) soil temperature regime, thus the soils are colder than in other alpine areas of LACL and permafrost may be present at some sites. This ecotype occurs along the flanks of alpine valleys and plateaus between 900 and 1400 m a.s.l. Soils form in sandy-gravelly co-alluvium on an inactive alluvial fan and in loamy-rocky solifluction deposits. Soils are rocky, moist, acidic to circum-acidic, and well- to excessively drained. Surficial organic horizons are thin (< 3 cm). Soil subgroups include Typic Gelorthents and Typic Humigelepts. Vegetation includes *Salix rotundifolia-Carex microchaeta* and *Salix reticulata-Carex podocarpa*.





Alpine Lake
This ecotype represents alpine lakes that are typically formed in kettles and small glacially scoured depressions. Lake water is oligotrophic, cold, and ranged from acidic to nearly neutral, and electrical conductivity was low (< 100 µS).



Alpine Loamy-Organic Wet Sedge Meadow
This ecotype was sampled at approximately 1000 m a.s.l. on the Telequana Highlands, an alpine plateau directly south of Telequana Lake. It is likely that this ecotype occurs elsewhere in alpine areas of LACL. Soils and vegetation in this ecotype were diverse as it encompasses a wide range of wet alpine tundra. This ecotype occurred in an organic-fen and in a complex of frost-sorted mineral soil cored mounds and flooded, rocky depressions. Soils range from ashy-rocky to peaty, and were wet, acidic to circum-acidic, and somewhat poorly- to poorly-drained. Water depths range from -31 to +3 cm. In an organic-fen (n=1), soils were Typic Haplosaprists with 41 cm of highly decomposed organic material directly over bedrock. Soils in the frost-sorted complex (n=1) were Aquandic Gelaquepts. Vegetation is *Carex aquatilis-Salix fuscescens* and *Carex bigelowii-Dryas integrifolia*.





Alpine Rocky Barrens
This ecotype occurs on alpine ridges, steep gullies, and rock outcrops and cliff-faces on mountain sides between 600 and 1000 m a.s.l. Slope ranges between nearly flat on ridges to nearly vertical on cliffs and rock outcrops. Soils form from igneous and mafic bedrock and colluvium. Soils were dry to moist, extremely rocky, acidic to circum-acidic, well- to excessively drained, and often shallow (< 50 cm) to bedrock. Soil subgroups include Lithic Cryorthents and Lithic Haplocryolls on ridges, rock outcrops and cliffs. In a steep erosion gully on the southwest flanks of Mount Redoubt soils were Vitrandic Dystrocryepts with abundant pumice fragments. Vegetation includes *Umbilicaria* sp.-*Rhizocarpon geographicum-Hierochloe alpina*.



Alpine Rocky Dwarf Shrub-Lichen Tundra
This ecotype occurs on steep mountain slopes and on ridgelines and summits between 550 and 900 m a.s.l. Soils are rocky, moist, well- to excessively drained, and acidic. Soil subgroups include Vitrandic Humicryepts. Vegetation is *Dryas integrifolia-Cladina* sp. and *Dryas integrifolia-Oxytropis nigrescens.*



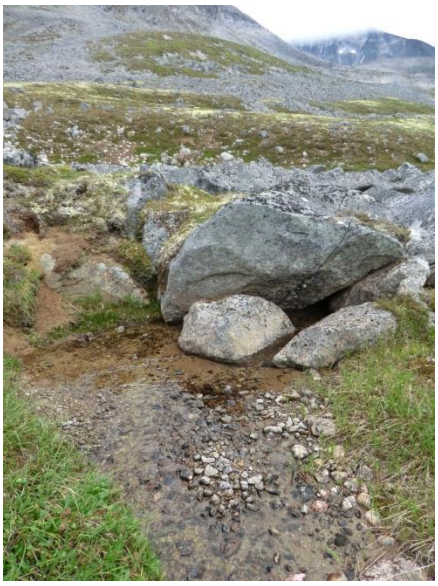


Alpine Rocky Dwarf Willow Tundra
This ecotype occurs on moderately steep slopes on alpine ridges, mountain slopes, and avalanche paths between 600 and 800 m a.s.l. Soils form in rocky ash-rich colluvium and in rocky-loamy avalanche deposits, and are well-drained to excessively drained, moist, and acidic. Soil subgroups include Typic Cryorthents on avalanche deposits and Thaptic Haplocryands on ash-rich colluvium. Vegetation is *Salix rotundifolia-Carex microchaeta*.





Alpine Spring
This ecotype represents small alpine springs in glacial cirques and high mountain valleys that are fed by sub-surface water from snow and glacier melt. One spring was sampled in Little Gladiator Basin at approximately 900 m a.s.l. near where the spring water emerged above ground from the base of a steep slope. Spring water was oligotrophic, nearly neutral, and EC was low (< 100 µS).



Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow
This ecotype occurs in the maritime ecoregion on moderately steep slopes on alpine ridges and mountain-sides between 500 and 700 m a.s.l. in the maritime ecoregion. Soils in this ecotype form in colluvium and volcanic pyroclastic deposits. Soils are moist, rocky and often ash-rich, well-drained, and acidic. Surficial organic horizons range from 5–11 cm thick. Soil subgroups are Spodic Vitricryands and Typic Haplocryolls. Vegetation is *Calamagrostis canadensis-Angelica lucida*.





Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra

This ecotype occurs in the maritime ecoregion on moderately steep slopes on alpine ridges and mountain-sides between 600 and 900 m a.s.l. in the maritime ecoregion. This ecotype occurs on rocky mixed sandstone and siltstone colluvium, pumiceous volcanic pyroclastic deposits, and in thick ash-laden loess. Soils are ash-rich and rocky, moist, well-drained, and acidic to circum-acidic. Surface organics are typically thin and may be completely absent in areas where volcanic ash and pumice deposition regularly bury the soil surface resulting in a series of thin buried organic-rich horizons near the soil surface. Soils forming in ash-laden loess and pyroclastic deposits include Typic Haplocryands and Thaptic Vitricryands, respectively. Soils forming in colluvium includeTypic Haplocryolls. Vegetation is *Vaccinium uliginosum-Carex microchaeta*.





Glacier

This ecotype includes present day glaciers and ice fields. Soils are often non-existent and glacier ice with a thin veneer (< 0.5 m) of rocky rubble is common. Crevasses, seracs, and moulins are common features in this ecotype. Hundreds of glaciers occur in LACL, the majority of them unnamed. Examples of some of the more prominent glaciers include Red, Tuxedni, and Double Glaciers in the maritime ecoregion.



Glacial Sandy-Rocky Barrens

Soils in this ecotype are young deposits of unconsolidated material comprised of mixed mineralogy with little to no soil development. Soils typically form on convex or undulating, complex surfaces at elevations ranging from 800 to 1100 m a.s.l. These soils exist on younger, recently deglaciated (since ~1950) landforms such as lateral and end moraines and ice-cored moraines. Soil subgroups in alpine and subalpine areas are Typic Gelorthents. Soil subgroups in the maritime zone are Typic Cryorthents. These soils are often very rocky, with a coarse fragment content (> 2 mm) ranging from 35 to 90 %. Soils are typically circum-acidic and have a high soil water permeability causing them to be excessively drained. Vegetation is *Umbilicaria* sp.*-Rhizocarpon geographicum-Hierochloe alpina.*





Glacial Sandy-Rocky Alder Shrub
Soils in this ecotype are similar to soils in the Glacial Sandy-Rocky Barrens ecotype but have had more time since deglaciation for vegetation succession to progress. This ecotype occurs on lateral, end, and ice-cored moraines. The soils are typically very rocky with a coarse fragment (> 2 mm) content ranging from 35 to 90%. Soils are acidic and may have a thin accumulation of organic matter at the surface. Soils are dry to moist with high soil permeability and are well to moderately well drained. Soils in this ecotype are weakly to moderately well-developed and may include Typic Cryorthents and Typic Gelorthents. Vegetation is *Alnus crispa-Dryopteris dilatata*.





Interior Subalpine Ashy-Loamy Alder-Willow Shrub

This ecotype occurs between approximately 700 and 1100 m a.s.l. on steep (10 to 30°) subalpine slopes often featuring southerly aspects. Solifluction lobes when present have croyturbated soils with thicker organic and humus-rich soil at the lobe front and thinner organic mats with less developed soils in the inter-lobe margins. Surface organic horizons are typically moderately thick (5–14 cm) and overlie an ash-rich mantle (upwards of 40 cm thick) over colluvium. The depth to >15% rock fragments ranges from 25 to 50 cm below the soil surface. Soils are acidic, moist and well-drained. The typical soil subgroups are Andic Haplogelods, Andic Humigelepts, Turbic Humigelepts, and Typic Vitrigelands. Vegetation is *Alnus crispa-Dryopteris dilatata* and *Salix* sp.-*Calamagrostis canadensis.*





Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow

This ecotype occurs on all aspects on flat to steep (0 to 30°) lower backslopes, footslopes, and toeslopes of mountains within elevations ranging from 500 to 800 m a.s.l. Soils in subalpine environments in the northern interior ecoregion were classified in a gelic temperature regime while subalpine soils in the southern interior ecoregion were classified in a cryic temperature regime. Soils in both ecoregions may be cryoturbated due to frost sorting of rock fragments and/or solifluction movement. However, permafrost is lacking. Soil surface organic mats are thin (<10 cm) and overlie ash-rich loess over rocky colluvium. The depth to rock fragments ranges from 5 to 50 cm below the soil surface. Soils range from acidic to circum-acidic, are moist, and well-drained. Typical soil subgroups include Andic Haplocryods, Andic Haplogelods, and Turbic Vitrigelands. Vegetation is *Calamagrostis canadensis-Angelica lucida.*





Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub

This ecotype occurs on all aspects on gentle to moderately steep (3 to 10°) subalpine slopes at elevations ranging from 550 to 800 m a.s.l. On warmer south-facing slopes, this ecotype can extend higher in elevation to upwards of 1000 m. Smaller, less pronounced mineral cored hummocks are characteristic of this ecotype. The organic mat thickness on hummocks will vary slightly between convex mound centers (thinner) and intermound areas (thicker). Surface organic horizons are typically moderately thick (5–14 cm) and overlie an ash-rich loess cap over gravelly colluvium. Soils are typically cryoturbated. However, it is unclear if permafrost exists within 200 cm of the soil surface. These soils often have a darker, humus-rich epipedon with an acidic soil pH. Soils are moist, well-drained, and the depth to coarse fragments ranges from 15 to 60 cm below the soil surface. The typical soil subgroups are Humic Vitrigelands, Turbic Vitrigelands, and Typic Vitrigelands. Vegetation is *Betula nana-Ledum decumbens-Cladina* sp. and *Betula glandulosa-Ledum decumbens-Cladina* sp.





Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub

This ecotype occurs on flat to gently sloping (1 to 3°) planar and concave surfaces at elevations ranging from 400 to 700 m a.s.l. Soils are typically acidic to circum-acidic, moist, and well-drained, forming small mineral cored hummocks. Soils often feature a thin (<5 cm) organic horizon overlying an ash-rich loess mantle (<30 cm thick) over rocky glacial deposits. Soils in subalpine environments in the northern interior ecoregion were classified in a gelic temperature regime while subalpine soils in the southern interior ecoregion were classified in a cryic temperature regime. Soils in both ecoregions may be cryoturbated due to frost sorting of rock fragments and/or hummock development, but lack permafrost. Soil surface organic mats are thin (<10 cm) and overlay ash-rich loess overlaying rocky colluvium. The typical soil subgroups are Andic Haplocryods, Andic Haplogelods, and Typic Vitrigelands. Vegetation is *Empetrum nigrum*-*Cladina* sp.





Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland

This ecotype occurs between approximately 400 and 700 m a.s.l. on steep (10 to 25°) subalpine mountains slopes and valleys where deep, ash-laden loess blankets till and colluvium. Soils are typically ashy and rocky, acidic, moist, and well-drained. Soils often feature a thick (20–40 cm) moist organic horizon at the surface over weathered volcanic ash. Snow drifting at these sites is likely the primary driver of the open woodland canopy and the development of the thick surficial organic horizons. Soils in subalpine environments in the northern interior ecoregion were classified in a gelic temperature regime while subalpine soils in the southern interior ecoregion were classified in a cryic temperature regime. The typical soil subgroups are Folistic Haplocryands and Typic Vitrigelands. Vegetation is *Picea glauca-Vaccinium uliginosum-Sphagnum* sp.





Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub
This ecotype was observed on flat complex surfaces where palsas form in ice-rich peat mounds. One site was described at approximately 600 m a.s.l. in an acidic peat bog near Snipe Lake. Small collapse scar bogs were common in the area. Soils were thick frozen organic deposits (> 40 cm) overlying finer textured mineral soil at depth. Soils were acidic, moist, and poorly-drained. The soil subgroup was Sphagnic Fibristels. Vegetation is *Betula nana-Ledum decumbens-Sphagnum* sp.





Interior Subalpine Organic-rich Alder Tall Shrub

This ecotype occurs on all aspects of mountain slopes at elevations ranging from 300 to 700 m a.s.l. Slopes tend to be moderately steep to steep (8 to 25°) with a convex slope shape. Soils are typically acidic, moist, and well-drained. The formation of thick, non-saturated organic mats (>15cm) is characteristic of these soils and barring disturbance, they can accumulate to thicknesses greater than 40cm forming organic soils. Ash and loess tend not to accumulate at these sites due to steeper convex slopes and a tighter vegetative canopy. The thick organic mat insulates the mineral soil and seasonal frost was encountered at depth. No cryoturbation was evident and permafrost is thought not to be present within 200cm of the mineral soil surface. Typically the organic mat directly overlies rocky colluvium. This ecotype occurs on stable landscape positions and is considered to be climax vegetation for the Interior Subalpine Rocky Alder-Willow Shrub ecotype. Soils in subalpine environments in the northern interior ecoregion were classified in a gelic temperature regime while subalpine soils in the southern interior ecoregion were classified in a cryic temperature regime. The typical soil subgroups are Folistic Dystrocrypets, Typic Dystrogelepts, and Typic Udifolists. Vegetation is *Alnus crispa-Dryopteris dilatata.*





Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog

This ecotype occurs on flat concave surfaces in fluvial deposits within glacially scoured valleys at elevations ranging from 500 to 700 m a.s.l. Soils typically feature a thick organic mat (>20cm) overlying loamy mineral soil. The soil organic mats are primarily comprised of fibers from graminoids and woody plant species. These soils are typically circum-acidic and have saturated soil conditions with water at or near the surface. Soils are wet and range from being somewhat poorly drained to very poorly drained. Typical subgroups include Histic Gelaquepts, Fluvaquentic Gelaquepts, Fluvaquentic Cryofibrists, Terric Cryofibrists and Terric Haplofibrists. Vegetation is *Carex aquatilis-Salix fuscescens-Sphagnum* sp.

(No photos.)

Interior Subalpine Rocky Alder-Willow Shrub

This ecotype occurs on all aspects of lower backslopes of mountains and hills at elevations ranging from 300 to 700 m a.s.l. Slopes tend to be moderately steep to steep (8 to 25°) with a convex slope shape. Soils are typically acidic, moist, and well-drained. This ecotype occurs on disturbed sites such as newly formed colluvial and alluvial fan deposits and avalanche debris piles. Surface organic mat thickness ranges from 0 to 14cm depending upon time since last disturbance. Subsurface soils include sandy and rocky colluvium. An ashy mantle is typically absent from the soil profile, due to slope steepness and wind scouring on convex slopes. This ecotype is considered an earlier seral stage for the Interior Subalpine Organic-rich Alder Tall Shrub ecotype. Soils in subalpine environments in the northern interior ecoregion were classified in a gelic temperature regime while subalpine soils in the southern interior ecoregion were classified in a cryic temperature regime. The typical soil subgroups are Andic Humicryepts, Fluventic Dystrogelepts, Fluventic Haplogelepts , and Typic Cryofluvents . Vegetation is *Salix alaxensis-Angelica lucida* and *Alnus crispa-Dryopteris dilatata.*





Interior Subalpine Rocky Balsam Poplar Forest

This ecotype was observed on gentle to moderately steep subalpine slopes (3 to 10°) on co-alluvial deposits throughout the northern and southern interior ecoregions. However, only one site was described at approximately 700 m a.s.l on a gently sloping inactive alluvial fan in the upper Kejik River valley. The soils featured 10 cm of organic material over a thin layer of ash-rich loess overlying gravelly co-alluvium. Soils were moist, circum-acidic, and well-drained. The soil subgroup was Fluventic Haplogelepts and vegetation was *Populus balsamerifera-Salix alaxensis*.





Interior Upland Ashy-Loamy Mixed Forest
This ecotype occurs in the interior ecoregion on gentle to moderately steep lower mountains slopes, outwash plains, and older moraines between 100 and 600 m a.s.l. Mineral-cored hummocks and tree mounds (downed logs with root balls) are common micro-topographic features. Soils form in ash-rich loess over outwash, till, or loamy colluvium. Soils are typically ash-rich, acidic, moist, and well- to moderately well-drained. Surficial organic horizons are moderately thick, ranging from 5–10 cm in thickness. Soil subgroups include Spodic Haplocryands, Spodic Vitricryands, Folistic Haplocryands, and Andic Haplocryods. Vegetation includes *Betula papyrifera* var. *kenaica-Alnus sinuata-Dryopteris dilatata, Picea glauca-Betula papyrifera* var. *kenaica, Picea glauca-Populus tremuloides-Cornus canadensis,* and *Picea mariana-Populus tremuloides-Vaccinium vitis-idaea*.





Interior Upland Rocky Mixed Forest
This ecotype occurs in the southern interior ecoregion on moderately steep bedrock-controlled mountain slopes, older moraines, and alluvial fans between approximately 100 and 500 m a.s.l. Mineral-cored hummocks, tree mounds (downed logs with root balls), and soil-covered boulders are common micro-topographic features. Soils are formed in sandy-rocky alluvium, till, and colluvium, and are acidic, moist, and well-drained. Soil subgroups were not classified for this ecotype. However, it is likely that soils within this ecotype fall within the Entisols and Inceptisols soil orders. Vegetation is *Picea glauca-Betula papyrifera* var. *kenaica* and *Picea glauca-Populus trichocarpa-Viburnum edule*.

(No photos.)

Interior Upland Rocky Alder Shrub
This ecotype occurs in the interior ecoregion on bedrock-controlled mountain slopes, avalanche paths, and old alluvial fans on moderately steep to steep slopes between 100 and 500 m a.s.l. Soils are rocky with a loamy or ashy matrix, moist, and well- to moderately well-drained. Vegetation is *Alnus sinuata-Dryopteris dilatata*.

(No photos.)

Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub

This ecotype occurs in the interior ecoregion on flat to gently sloping uplands, including older moraines, outwash plains, and old alluvial terraces between 100 and 500 m a.s.l. Soils are formed in ash-laden loess over rocky till, outwash, or alluvium. Soils are moist, acidic, and well drained. Soil subgroups include Typic Haplocryands, Spodic Haplocryands, and Spodic Vitricryands. Vegetation is *Betula glandulosa-Ledum decumbens-Cladina* sp., *Betula glandulosa-Ledum decumbens-Sphagnum* sp., and *Betula nana-Ledum decumbens-Cladina* sp.





Interior Upland Ashy-Loamy Black Spruce Forest

This ecotype occurs in the interior ecoregion on flat to moderately sloping uplands, including older moraines, outwash plains, inactive sand dunes, and old alluvial terraces between 100 and 400 m a.s.l. on northerly and easterly aspects. Soils form from thick ash-laden loess over rocky till, colluvium, alluvium, and eolian sands interbedded with volcanic ash. Soils are moist, acidic to circum-acidic, and well- to excessively drained. Surface organic horizons are typically moderately thick (7–16 cm). Soil subgroups include Folistic Haplocryods, Andic Humicryods, Spodic Haplocryands, Typic Haplocryods, and Folistic Vitricryands. Vegetation is *Picea mariana-Ledum decumbens-Cladina arbuscula* and *Picea mariana-Ledum decumbens-Sphagnum* sp.





Interior Upland Rocky White Spruce Woodland

This ecotype occurs in the southern interior ecoregion on moderately steep bedrock-controlled mountain slopes, older moraines, outwash, and glacio-fluvial deposits between approximately 100 and 600 m a.s.l. Mineral-cored hummocks, tree mounds (downed logs with root balls), and soil-covered boulders are common micro-topographic features. Soils are formed in sandy-rocky alluvium, till, and colluvium, and are acidic, moist, and well-drained. Soils subgroups include Typic Cryorthents. Vegetation is *Picea glauca-Alnus* sp., *Picea glauca-Betula nana-Sterocaulon* sp., and *Picea glauca-Ledum decumbens.*

(No photos.)

Interior Upland Rocky Birch-Ericaceous Low Shrub

This ecotype occurs in the southern interior ecoregion on moderately steep bedrock-controlled mountain slopes, older moraines, outwash plains, and alluvial fan deposits between approximately 100 and 600 m a.s.l. Soils are formed from rocky alluvium, till, and glacial outwash, and are acidic, moist, and well- to excessively drained. Soil subgroups were not classified for this ecotype. However, it is likely that soils within this ecotype fall within the Entisols and Inceptisols soil orders. Vegetation is *Betula nana-Ledum decumbens-Cladina* sp. and *Betula glandulosa-Ledum decumbens-Cladina* sp.

(No photos.)

Upland Ashy-Loamy Birch-Poplar Forest
This ecotype occurs in the interior ecoregion on gentle to moderately steep lower mountains slopes, outwash plains, and older moraines between 100 and 300 m a.s.l. Mineral-cored hummocks, tree mounds (downed logs with root balls), and rocky mounds are common micro-topographic features. Soils are formed from ash-rich loess over outwash and till and loamy-rocky colluvium. Soils are typically ash-rich and rocky, acidic, moist, and well- to moderately well-drained. Vegetation is *Betula papyrifera* var. *kenaica-Alnus sinuata-Dryopteris dilatata, Betula papyrifera* var. *kenaica-Ledum decumbens, Populus balsamifera-Alnus* sp., *Populus balsamifera-Viburnum edule,* and *Populus trichocarpa-Viburnum edule*.

(No photos.)

Upland Rocky Birch-Poplar Forest

This ecotype occurs on hill and mountain slopes, as well as inactive and abandoned alluvial deposits such as alluvial fans, terraces or overbank deposits. On slopes, this ecotype is most commonly found on convex slope with a slope range of 10 to >30°. Hillslope soils have a thin organic mat (<5 cm) overlying sandy and gravelly colluvium and are typically moderately developed Inceptisols. Soils forming on alluvial deposits will have a thin organic mat (<5 cm) overylying sandy and gravelly riverine or slope alluvium deposits. Soils forming on alluvial deposits range from being poorly developed Entisols to moderately developed Inceptisols. Soils are moist and range from well to somewhat excessively well-drained. Soils are circum-acidic with an EC less than 50 µS/cm. Typical soil subgroups include Fluventic Haplocryepts, Typic Haplocryepts, and Typic Cryofluvents. Vegetation is *Betula papyrifera* var. *kenaica-Alnus sinuata-Dryopteris dilatata, Betula papyrifera* var. *kenaica-Ledum decumbens, Populus balsamifera-Alnus* sp., and *Populus trichocarpa-Oplopanax horridus*.

(No photos.)

Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow
This ecotype occurs on gentle to moderately steep (3–28°) mountain slopes in the martime ecoregion between 300 and 500 m a.s.l. This ecotype is commonly associated with recent volcanic ash or volcanic pyroclastic deposits, including the flanks of Mount Redoubt, and is one of the first vegetation communities to establish on fresh ash. Soils are moist, ash-rich and often pumiceous, and acidic. Surface organic horizons are thin (1–3 cm) or completely absent. Typical soil subgroups include Typic Haplocryands and Thaptic Haplocryands. Vegetation is *Calamagrostis canadensis-Angelica lucida*.





Maritime Upland Ashy-Loamy Mixed Low Shrub

This ecotype occurs in the maritime ecoregion on either steep slopes (15–35°) that are less stable or on flat areas that have experienced a recent disturbance such as wind throw. This ecotype is expected to occur on all aspects at elevations ranging from 30–300 m a.s.l. Soils form in thick deposits of ash-rich loess. Soils may have a thick, non-saturated organic mat at the surface (>15 cm) and podzolization (translocation of aluminum and/or iron) will be evident in the soil subsurface. Soils are well-drained and loamy with rocky colluvium at 75–150 cm below the soil surface. Soils are acidic and have an EC less than 100 µS/cm. Typical soil subgroups include Spodic Haplocryands and Folistic Haplocryands. Vegetation is *Rubus spectabilis-Oplopanax horridus* and *Vaccinium ovalifolium-Oplopanax horridus.*





Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest

This ecotype occurs in the maritime ecoregion on moderately steep and steep slopes (10–30°), on all aspects, and at elevations ranging from 30–300 m a.s.l. Soils form in thick ash deposits or loamy loess overlying hillslope colluvium or till at depth (>40 cm). Soils are acidic and have an EC less than 100 µS/cm. Soils are moist and range from moderately well to well-drained. Soils are well-developed Andisols or Spodosols and the development of a spodic horizon (accumulation of translocated aluminum and/or iron) is a diagnosic soil characteristic. Surface organic mat thickness is expected to range from 5–20 cm. Typical soil subgroups include Folistic Haplocryands, Typic Haplocryands, Spodic Haplocryands, Andic Haplocryods, Folistic Haplocryods, and Typic Haplocryods. Vegetation is *Picea* × *lutzii*-*Oplopanax horridus*.





Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub

This ecotype occurs in the maritime ecoregion on gentle to moderately steep mountain slopes and shoulders, alluvial fans, old alluvial terraces, and older moraines between 75 and 700 m a.s.l. Soils formin ash-laden loess, volcanic pyroclastic deposits, and ash-rich colluvium. Soils are typically ashy and pumiceous, moist, highly acidic, and well-drained. Surface organic horizons were typically moderately deep (7-12 cm). This ecotype experiences volcanic ash deposition regularly enough that organic horizons buried by ash were common in the upper soil profile, especially in the direct vicinity of Mount Redoubt. Soil subgroups were Spodic Haplocryands, Alic Haplocryands, Typic Vitricryands, and Andic Haplocryods. Vegetation is *Alnus crispa-Dryopteris dilatata, Alnus crispa-Epilobium latifolium, Alnus sinuata-Dryopteris dilatata,* and *Salix* sp.-*Calamagrostis canadensis*.





Upland Ashy-Loamy-Rocky White Spruce Woodland

This ecotype occurs in the interior and maritime ecoregions on gentle to moderately steep mountain slopes, moraines, and outwash deposits between 100–500 m a.s.l. Soils are formed from ash-laden loess, hillside colluvium and till mantled with volcanic ash, and in the vicinity of Mount Redoubt, volcanic pyroclastic deposits. Soils are predominantly loam to silt loam in texture, acidic, moist, and moderately well- to well-drained. Surface organics are typically moderately thick (6–10 cm) and may range up to 20–23 cm thick at some sites. Soil subgroups include Folistic Haplocryands, Folistic Haplocryods, Andic Haplocryods, Vitrandic Haplocryands, Typic Haplocryods, and Spodic Haplocryands. Vegetation includes *Picea glauca-Ledum decumbens, Picea glauca-Betula nana-Sterocaulon* sp., and *Picea glauca-Alnus* sp.





Maritime Upland Rocky Alder Shrub
This ecotype occurs in the maritime ecoregion on very steep slopes (>30°) at elevations ranging from 400 to 700 m a.s.l. This ecotype occurs primarily on convex backslopes of mountains and hills where rocky colluvium overlies bedrock. Soils range from poorly developed Entisols that are shallow or moderately deep to bedrock (25 to 100cm) to weakly developed Inceptisols. Despite the steep slopes, surface organic matter can accumulate to depths exceeding 15cm. Ash and loess may be mixed with rocky hillslope colluvium in the upper portion of the epipedon. Soils are moist, acidic and well drained. Typical soil subgroups include Typic Cryorthents, Folistic Dystrocryept and Typic Haplocryepts. Vegetation is *Alnus crispa-Dryopteris dilatata.*





Maritime Upland Sandy-Rocky Alder-Willow Shrub

This ecotype occurs in the maritime ecoregion on abandoned marine beach ridges and co-alluvial fans on gentle to moderately steep slopes (2–20°) between 0 and 500 m a.s.l. Soils are sandy marine sediments or hillslope alluvium with depths to >15% rock fragments ranging from 5–90 cm below the soil surface. Soils are moist, acidic to circum-acidic, and are well to somewhat excessively drained. Surface organic horizons are typically thin or absent and buried organic horizons may be present. The buried organics are related to fluvial (co-alluvial fans), eolian (abandoned beach ridges), or volcanic events (both). However, ash deposition is never thick enough for these soils to be considered Andisols (> 36 cm). Areas with a total thickness of ash that is 18 cm or more within 75 cm of the mineral soil surface were classified into an ashy subgroup such as Andic or Vitrandic. Soil EC is typically less than 100 µS/cm. Typical soil subgroups include Typic Cryofluvents, Mollic Cryofluvents, Vitrandic Cryofluvents and Vitrandic Cryopassaments. Vegetation includes *Alnus sinuata-Dryopteris dilatata, Salix* sp.-*Calamagrostis canadensis,* and *Alnus crispa-Epilobium latifolium.*





Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest

This ecotype occurs in the maritime ecoregion on flat abandoned marine beaches and inactive coastal dunes at elevations ranging from 0–15 m a.s.l. Soils are moderately developed Inceptisols with a surface organic mat ranging from 3–14 cm thick. Soils range from being circum-acidic to acidic and have an EC < 50 µS/cm. Soils are moist and sandy and may have buried organic horizons reflecting historical flooding events. Soils are well to excessively well-drained and depth to >15% rock fragments ranges between 30–75 cm below the soil surface. Relic redoximorphic features associated with past water table fluctuations, such as iron concentrations within the soil matrix, are common. Typical soil subgroups include Fluventic Dystrocryepts, Mollic Cryofluvents, and Typic Cryorthents. Vegetation includes *Picea* × *lutzii-Leymus mollis-Lathyrus maritimus* and *Picea* × *lutzii-Oplopanax horridus.*





Interior Lowland Ashy-Loamy-Organic Black Spruce Forest

This ecotype occurs in flat to gently sloping (5–8°) broad glacial valley floors in thick ash-laden loess deposits overlying till and glaciofluvial deposits between 100 and 400 m a.s.l. Mineral cored hummocks are common micro-topographic features in this ecotype. Soils are typically ash-rich and rocky, moist, well-drained, and acidic. Surface organic horizons are typically moderately thick (12–23 cm). Soil subgroups in this ecotype include Andic Haplocryods, Folistic Vitricryands, Spodic Haplocryands, Spodic Vitricryands, and Typic Vitricryands. Vegetation is *Picea mariana-Ledum decumbens-Cladina arbuscula*.





Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub
This ecotype occurs in flat areas in broad glacial valleys at elevations between 50 and 600 m a.s.l. Small mineral-cored hummocks are common micro-topographic features. Soils are weathered by alluvial processes that have washed away surface loess deposits causing a thinner, ash-rich loess mantle to be present (<50 cm). The depth to gravelly glacio-fluvial deposits is shallow (<25 cm) to moderately deep (<50 cm). Soils in this ecotype are typically moist to wet and some-what poorly to poorly drained. These soils lack permafrost, but cryoturbation is common. Soils range from being acidic to circum-acidic and have an electrical conductivity less than 100 µS/cm. Soil subgroups in this ecotype include Aquic Haplocryepts, Typic Dystrogelepts, Aquic Humicryods, and Spodic Haplocryands. Vegetation is *Betula glandulosa-Ledum decumbens-Cladina* sp.





Interior Lowland Ashy-Loamy-Rocky Mixed Forest
This ecotype occurs in flat areas, concavities, and other areas of gentle slope on abandoned floodplains, footslopes and toeslopes. Soils form from ashy-laden loess and fine-textured alluvium. Soils are acidic, moist to wet, poorly to moderately well drained, and are occasionally rocky. Vegetation is *Betula papyrifera* var. *kenaica-Alnus sinuata-Dryopteris dilatata, Picea glauca-Betula papyrifera* var. *kenaica*, and *Picea glauca-Populus trichocarpa-Viburnum edule*.

(No photos.)

Interior Lowland Frozen Loamy-Organic Black Spruce Forest

This ecotype occurs in flat areas in broad glacial valleys at elevations between 50 and 400 m a.s.l. This ecotype occurs in a zone of sporadic ice-rich permafrost in the early to middle stages of degradation. Thermokarst features, including collapse scar bogs and drunken forest, are common throughout these areas. These soils have thick organic mats (>40 cm) that are primarily comprised of *Sphagnum* fibers. Despite being frozen, these soils typically lack cryoturbation within the pedon. These soils form in thaw-sensitive permafrost. Disturbance to the organic mat from fire is projected to result in significant and rapid thaw settlement. These soils are moist, moderately well drained and acidic. Soil subgroups include Sphagnic Fibristels, Terric Fibristels, Typic Folistels and Typic Haploturbels. Vegetation is *Picea mariana-Ledum decumbens-Sphagnum* sp. and *Picea mariana-Ledum decumbens-Cladina arbuscula.*





Interior Lowland Frozen Organic-Rich Dwarf Spruce Forest

This ecotype was observed on flat to gently sloping toeslopes and footslopes in lowlands area with sporadic permafrost. One plot was sampled in this ecotype at approximately 150 m a.s.l near Henmore Lake. The soils were comprised of thick organic deposits (>40 cm) consisting primarily of *Sphagnum* fibers. A seasonal frost layer occurred between 35–50 cm, and permafrost was assumed to occur within 200 cm of the soil surface. The frozen soils and saturated acidic active layer result in *Picea mariana* having a stunted growth form. The soil subgroup was Fluvaquentic Hemistels. Vegetation was *Picea mariana-Ledum decumbens-Sphagnum* sp.





Interior Lowland Frozen Organic-Rich Sedge-Shrub Bog

This ecotype was observed on flat or concave landforms in thick organic deposits in lowland areas with sporadic permafrost. The thick organic cap insulates the subsurface soil and supports the formation and persistence of permafrost. Ice lenses may form over time and be expressed on the landscape as subtle low-centered polygons. One plot was sampled in this ecotype in a bog at the southern end of Pickerel Lakes. Soils were acidic and very poorly drained. The soil subgroup was Sphagnic Fibristels. Vegetation was *Betula nana-Ledum decumbens-Sphagnum* sp.





Interior Lowland Organic-Rich Birch-Ericaceous Shrub

This ecotype occurs in broad, flat valleys along headwater streams, adjacent to lake margins, or within concave basins or depressions. This ecotype occurs between 50 to 500 m a.s.l. Peat mounds are common micro-topographic features with an organic mat thickness ranging from 15 to 50cm. A thick organic mat (>20cm) typically overlies loamy mineral soil. Soils range from poorly to very poorly drained and range from acidic to circum-acidic. Soil subgroups include Histic Cryaquepts, Sphagnic Cryofibrists, Typic Cryohemists, Terric Cryohemists, and Terric Cryosaprists. Vegetation is *Betula nana-Ledum decumbens-Sphagnum* sp., *Myrica gale-Salix pulchra-Calamagrostis canadensis*, *Betula glandulosa-Ledum decumbens-Sphagnum* sp., and *Andromeda polifolia-Drosera rotundifolia-Sphagnum.*





Interior Lowland Organic-Rich Wet Sedge Meadow

This ecotype occurs in valley bottoms on abandoned floodplains or in organic fens between 200 to 500 m a.s.l. Soils will likely have a thick organic mat (>20 cm) overlying mineral soil that may be stratified at depth on abandoned floodplains as the result of historic flood events. Organic mats are primarily comprised of fibers from graminoids and woody plant species. These soils are circum-acidic, saturated and are either very poorly drained or flooded with water at the surface during some time during the normal growing season. Soil subgroups include Histic Cryaquepts, Fluvaquentic Cryofibrists, and Terric Cryofibrists. Vegetation is *Carex limosa-Salix fuscescens* and *Carex aquatilis-Salix fuscescens.*





Lowland Acidic Ashy-Loamy Birch-Poplar Forest
This ecotype occurs in flat areas, concavities, and areas of gentle slope on valley floors, abandoned floodplains, footslopes, and toeslopes. Soils are typically formed from ashy-laden loess and fine-textured alluvium. Soils are acidic, moist to wet, poorly to moderately well drained, and occasionally rocky. Vegetation is *Populus trichocarpa-Viburnum edule, Populus trichocarpa-Alnus sinuata, Populus balsamifera-Salix alaxensis*, and *Betula papyrifera* var. *kenaica-Ledum decumbens*.

(No photos.)

Lowland Lake
This ecotype includes freshwater lakes in all physiographic areas within the survey boundary. These lakes vary in size from the 42 mile long Lake Clark to small kettle lakes. Water pH is typically circum-neutral with an electrical conductivity of less than 50 µS/cm.



Lowland Organic-Rich Sedge-Shrub Bog
This ecotype occurs in basins and other concavities on valley floors between 0 to 500 m a.s.l. Soils in this ecotype are differentiated from lacustrine ecotypes by the primary parent material, including glacial drift in lowlands and lake deposits in recently drained lakes. Soils typically have thick surficial organic mats (> 40cm) comprised primarily of *Sphagnum* fibers. Soils are acidic and very poorly drained with water at or near the surface. Soil subgroups include Sphagnic Cryofibrists, Fluvaquentic Cryofibrists, Terric Cryofibrists, Typic Cryofibrists and Histic Cryaquepts. Vegetation is *Carex aquatilis-Salix fuscescens-Sphagnum* sp., *Carex limosa-Salix fuscescens-Sphagnum* sp., and *Andromeda polifolia-Drosera rotundifolia-Sphagnum* sp.





Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub
This ecotype most commonly occurs on abandoned tidal flats or abandoned overbank deposits along tidal rivers. These sites are no longer flooded by the tide and receive inputs of nutrients and water primarily from fresh water sources. Once the flooding disturbance from tidal fluctuations has ceased, organic materials accumulate over time to the extent that deep organic soils often develop (>40 cm). Soils are primarily circum-acidic and are typically fresh or slightly brackish with an EC < 1,000 µS/cm. The water table is generally within 10 cm of the soil surface. However, ponded water is variable, depending largely on the amount of precipitation in a given year. These soils are saturated, anaerobic, and have poor to very poor soil drainage. A typical soil profile will have an organic mat overlying a thin ash-rich loess mantle (<10 cm) over loamy marine sediments. Course fragments (>2 mm) may be present at depth, typically exceeding 1 meter. Typical soil subgroups include Typic Cryaquents, Histic Cryaquepts, Terric Cryofibrists, and Aquandic Cryaquents. Vegetation is *Myrica gale-Salix fuscescens-Carex lyngbyaei* and *Myrica gale-Salix pulchra-Calamagrostis canadensis*





Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest
This ecotype occurs on marine terraces in flat to gently sloping (<5°) areas. Thin organic mats (<15 cm) overlie ash-rich loess over loamy marine sediments with coarse fragments at depths greater than 50 cm. Soils are circum-acidic with an EC less than 100 µS/cm and are moderately well drained. Typical soil subgroups include Aquic Haplocryepts and Aquandic Haplocryepts. Vegetation is *Picea* × *lutzii-Oplopanax horridus* and *Picea* × *lutzii-Leymus mollis-Lathyrus maritimus.*





Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow

This ecotype occurs on abandoned tidal flats, bogs and inactive alluvial fan deposits. Soils tend to be slightly more acidic than the Organic-rich Sweetgale-Willow-Ericaceous shrub ecotype on account of a higher prevalence of *Sphagnum* sp. and other mosses. Thick organic mats (>20 cm) are characteristic and given sufficient time without disturbance organic soils may develop once the organic mat exceeds 40 cm in thickness. The water table is characteristically above or just below the soil surface for the duration of the growing season. Soils range from acidic to circum-acidic and are very poorly drained with saturated soil conditions. These soils are not brackish and typically have an EC less than 500 µS/cm. Typical soil subgroups include Histic Cryaquepts, Fluvaquentic Cryaquepts, Fluvaquentic Cryofibrists, Sphagnic Cryofibrists, and Terric Cryofibrists. Vegetation is *Calamagrostis canadensis-Carex* sp.





Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow

This ecotype occurs on lacustrine sediments below 700 m a.s.l. in recently drained basins in ash-laden loess over lacustrine deposits. Soils are typically ashy and loamy and sometimes rocky, acidic, moist, and well-drained. The organic horizon is often thin (6 cm). A water table may be present within 50 cm of the soil surface. Micro-topographic features are not always present, but may include mounds and sorted and non-sorted stripes and circles. Thaw depths were often difficult to determine, however it was assumed that permafrost was not present within a depth of 100 cm. Vegetation is characteristic of secondary succession for drained lake basins. Soil subgroups in clude Andic Humicryepts. Vegetation is *Calamagrostis canadensis-Carex* sp.





Interior Lacustrine Ashy-Loamy-Rocky Low Shrub

This ecotype occurs on lacustrine sediments below 700 m a.s.l. in recently drained basins and drained and abandoned beaver pond complexes. Soils are typically circum-acidic, moist, and somewhat poorly-drained. These soils have anaerobic soil conditions and are saturated in one or more horizons within 100 cm of the mineral soil surface. Surface organic horizons range from 10 to 15 cm thick and overlie ash-rich loess over loamy-gravelly mineral soil. Drained basins may have remnant mounds related to frost sorting when the former lake bottom was under water. Thaw depths were often difficult to determine, however it was assumed that permafrost was not present in the sub-soil within a depth of 100 cm. The typical soil subgroups include Aquic Haplocryods and Aquic Haplocryepts. Vegetation is characteristic of a climax plant community for drained lake basins. Vegetation is *Salix* sp.-*Calamagrostis canadensis.*





Interior Lacustrine Loamy-Rocky Barrens
This ecotype occurs on lacustrine sediments below 700 m a.s.l. in recently drained basins. Soils are typically loamy and rocky with little to no organic matter at the surface. Depth to water table is moderately deep (<50 cm) where saturated, anaerobic soil conditions persist. Soils are young and poorly developed and may express signs of cryoturbation within the soil profile. Sorted and non-sorted circles may be evident in the recently exposed lake bottoms. Thaw depths are often difficult to determine, however it was assumed that permafrost was not present in the sub-soil within a depth of 100 cm. Soils are circum-acidic and range from moderately well- to well-drained. Typic Cryaquents is the typical soil subgroup. Vegetation is characteristic of primary plant succession in recently drained lake basins. The floristic class is *Juncus arcticus-Equisetum* sp.





Interior Lacustrine Organic-Rich Sedge Marsh

This ecotype occurs on lacustrine sediments below 700 m a.s.l. in thermokarst lakes and ponds, or along lowland lake margins. Soils are typically peaty, acidic, and aquatic. These organic soils are well developed with an organic mat that can range in thickness from 40 to 130 cm. Soils that have formed in thermokarst lakes and ponds will likely have a horizon of water separating organic material at the soil surface, derived from post-thermokarst vegetation, from those at the lake bottom, derived from pre-thermokarst vegetation. Typical soil subgroups for thermokarst lakes and ponds include Hydric Cryofibrists. Typical soil subgroups for lowland lakes include Terric Cryohemists. Vegetation is *Carex limosa-Menyanthes trifoliata* and *Carex utriculata-Eriophorum angustifolium.*





Interior Lacustrine Organic-Rich Sedge-Shrub Bog

This ecotype occurs in flat to concave areas on lacustrine sediments below 700 m a.s.l. in drained basins or thermokarst depressions. This ecotype has been colonized primarily by *Sphagnum* sp. fibers which form thick organic mats (>40 cm) and undergo slow decomposition rates. Depth to the water table is often above the soil surface. Soils are typically acidic, very poorly drained, and tend to be nutrient poor. Typical soil subgroups include Fluvaquentic Haplofibrists, Sphagnic Cryofibrists, and Typic Cryofibrists. Vegetation is *Carex aquatilis-Salix fuscescens-Sphagnum* sp., *Andromeda polifolia-Drosera rotundifolia-Sphagnum* sp., and *Carex limosa-Salix fuscescens.*





Interior Lacustrine Organic-Rich Wet Sedge Meadow

This ecotype occurs in lacustrine sediments below 700 m a.s.l. in basins. Common macro-topographic features include lake margins, drained basins and beaver pond complexes. Soils typically have a thick organic mat (>20 cm) overlying loamy mineral soil. The soil organic mats are primarily comprised of fibers from graminoids and less commonly, woody plant species. These soils are typically circum-acidic and have saturated soil conditions with water at or near the surface. Typical soil subgroups include Fluvaquentic Cryohemists, Histic Cryaquepts, Histic Gelaquepts, and Terric Cryofibrists. Vegetation is *Calamagrostis canadensis-Carex* sp. and *Carex saxatilis-Carex aquatilis*.

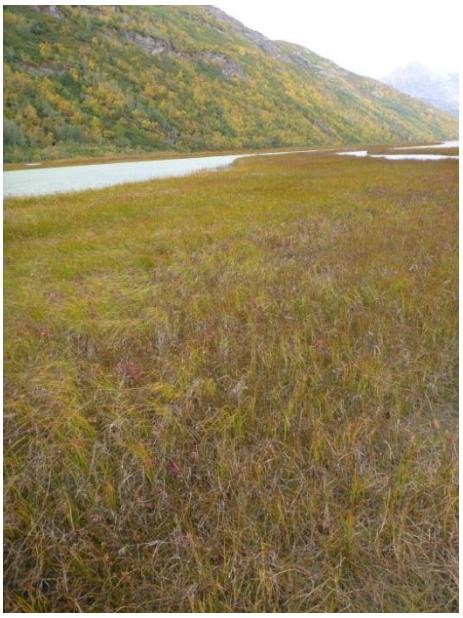




Maritime Lacustrine Marestail Marsh
This ecotype occurs in lacustrine sediments below 200 m a.s.l. in brackish shallow lakes. These organic soils are permanently flooded. The source of herbaceous organic material is related to the turnover of roots in the upper soil profile. Soils are acidic and brackish. Typical soil subgroups include Fibric Haplowassists where vegetation has colonized to the surface and thick organic deposits have accumulated. Typic Haplowassents occur in areas with little to no vegetation at the surface and thin surficial organic deposits, often near the lake center. Vegetation is *Hippuris vulgaris-Sparganium angustifolium.*



Interior Riverine Sandy Forb Meadow
This ecotype occurs on active overbank deposits of braided rivers on flat to gentle slopes (0 to 5°). One plot was sampled at an approximate elevation of 400 m a.s.l. in a levee-riverine lake complex along the Neacola River (see Figure 7). These levees and riverine lakes form a complex pattern unique in LACL to the Neacola River. Soils are circum-acidic, wet and have an EC less than 200 µS/cm. Soils are expected to be poorly developed Entisols or weakly developed Inceptisols with buried organic horizons and/or stratified sediments related to alluvial flooding events. Soils form in a saturated, anaerobic environment and are poorly drained. A thin organic mat may be present at the surface (<5 cm) which overlies stratified sandy and loamy alluvial sediments with a thick, dense root mat. Typical soil subgroups include Fluvaquentic Cryaquepts and Typic Cryaquents. Vegetation is Wet Forb Meadow characterized by *Equisetum variegatum, Potentilla pulchella, Calliergon stramineum*, and *Sanionia uncinata*.







Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub

This ecotype occurs across the subalpine and boreal zones on active meander overbank deposits and, less commonly, on inactive overbank deposits of headwater streams. This ecotype is encountered on flat interfluves at elevations ranging from 20 to 900 m a.s.l. The vegetation succession is associated with a low floodplain seral phase. Surface organic matter may accumulate between flooding events to an average maximum of 5 cm. Thin buried organic horizons and stratified sandy and rocky alluvial sediments are common diagnostic features in the soil pedon. Soils are forming in a saturated, anaerobic soil environment with the depth to water table ranging from 20 to 80 cm below the soil surface. Soils are circum-acidic and range from moderately well to poorly drained. Typical soil subgroups include Typic Gelaquents and Fluvaquentic Cryaquepts. Vegetation is *Alnus sinuata-Salix alaxensis, Myrica gale-Salix pulchra-Calamagrostis canadensis, Populus balsamifera-Alnus* sp., *Salix alaxensis-Alnus tenuifolia, Salix alaxensis-Angelica lucida,* and *Salix* sp.-*Calamagrostis canadensis.*





Interior Riverine Silty-Sandy-Rocky White Spruce Forest

This ecotype occurs on inactive floodplains along braided and meandering rivers in the interior ecoregion. Soils are typically composed of interbedded silts, sands, and thin organic deposits along low gradient rivers, and gravelly to very gravelly and cobbly sands along steeper, more powerful rivers. Soils are moist to wet, circum-acidic, and moderately well to poorly drained. Soil subgroups include Typic Cryaquents and Oxyaquic Cryofluvents. These sites are regularly flooded during breakup and may experience damage from ice-scour. Vegetation is *Picea glauca-Alnus* sp.





Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub

This ecotype occurs on flat to gentle slopes (0 to 3°) of alluvial fans and active and inactive overbank deposits of braided rivers and headwater streams. This ecotype is encountered on all aspects at elevations ranging from 5 to 600 m a.s.l. Site hydrology is variable and soils often form in saturated, anerobic soil conditions with the depth to water table less than 50 cm from the soil surface. At some locations, site hydrology may include a fluctuating water table with the average depth to water greater than 50 cm and expressed morphologically as redoximorphic features associated with both oxidation and reduction. Surface organic horizons range in thickness from 0 to 10 cm. Buried organic horizons and stratified sandy and rocky alluvial sediments are common diagnostic features in the pedon. Soils range from acidic to circum-acidic and have an EC ranging from 10 to 500 µS/cm. Soils are moist or wet and range from moderately well to very poorly drained. Typical soil subgroups include Oxyaquic Cryofluvents, Fluvaquentic Cryaquepts, and Typic Cryaquents. Vegetation is *Picea* × *lutzii-Alnus crispa, Alnus crispa-Dryopteris dilatata, Alnus crispa-Epilobium latifolium,* and *Salix* sp.-*Calamagrostis canadensis.*





Maritime Riverine Silty-Sandy-Rocky Spruce Forest

This ecotype was observed on inactive overbank deposits along river corridors and on inactive alluvial fans on flat to gentle slopes (< 3°) in the maritime ecoregion. One site was sampled at approximately 25 m a.s.l. on the Red River fan. Soils were moist, acidic, and poorly drained and surface organic were 9 cm thick. Soils were stratified gravelly to very gravelly silts and sands. Soils were Aeric Cryaquepts. Vegetation was *Picea* × *lutzii-Vaccinium ovalifolium.*





Riverine Ashy-Loamy-Organic Wet Sedge Meadow

This ecotype occurs on inactive floodplains and on broad, flat alluvial fan deposits along braided and meandering rivers in the interior and maritime ecoregions. Soil texture is silt-loam with moderately thick to thick surficial organic horizons and several thin buried organic horizons resulting from regular flooding and sedimentation. Soils are typically wet, circum-acidic to neutral, and very poorly drained. Soil subgroups include Typic Cryaquents, Fluvaquentic Cryaquepts, and Histic Cryaquepts. Floristic associations include *Carex saxatilis-Carex aquatilis* and *Carex utriculata-Eriophorum angustifolium*. In the maritime ecoregion, vegetation may also include *Carex lyngbyaei-Cicuta mackenzieana* and *Calamagrostis canadensis-Carex lyngbyaei*.





Riverine Glacial River Water
This ecotype represents glacial rivers throughout LACL. Glacial rivers are those that receive the greater percentage of their waters directly from melting glaciers and are characterized by being heavily laden with glacial silt. These rivers are silty, circum-acidic to neutral, with low EC (avg. ~90 µS/cm). Examples include Stony River, Currant Creek, Redoubt Creek, and Necons River.



Riverine Lake Water
This ecotype represents riverine lakes and ponds. Riverine lakes are those lakes that occur in the floodplain of a river and are regularly or semi-regularly flooded by the adjacent river. Vegetation is typically sedge marsh along the lake margins. Beavers often create riverine ponds, and beaver dams and associated ponds are common along floodplains especially in the interior ecoregion.



Riverine Non-Glacial River Water
This ecotype represents glacial rivers through LACL. Non-glacial rivers include small headwater streams and large rivers that receive the majority of their water from non-glacial sources and are characterized by being clear and predominantly silt-free. These rivers are typically circum-acidic to neutral with low EC (avg. ~70 µS/cm). Many of the largest of these rivers flow out of large lowland lakes in the northern interior. Examples of non-glacial rivers include the Kejik, Mulchatna, and Chilikadrotna Rivers.



Riverine Silty-Sandy-Rocky Barrens
This ecotype occurs on active floodplains and sand and cobble bars in the interior and maritime ecoregions. Soil textures range from sandy and very to extremely gravelly/cobbly. Soils are dry to moist, moderately well-drained to somewhat poorly drained, and circum-acidic. Surficial and buried organic horizons are absent. These sites are flooded annually to semi-annually and experience active erosion and sedimentation processes. Soil subgroups include Oxyaquic Cryorthents, Oxyaquic Cryofluvents, and Typic Cryaquents. Plant associations include *Alnus crispa-Epilobium latifolium*, *Epilobium latifolium* , *Juncus arcticus-Equisetum* sp.





Riverine Silty-Sandy-Rocky Mixed Forest
This ecotype occurs on active overbank deposits along river corridors between 20 to 200 m a.s.l. The vegetation succession is associated with a mid-floodplain seral phase. Surface organic matter may accumulate between flooding events to an average of 10 to 15 cm thick. Thin buried organic horizons and stratified silt and sand over gravelly to very gravelly alluvial sediments are common diagnostic features in the pedon. Soils form primarily in an aerobic environment with the depth to the water table fluctuating between 40 to 100 cm below the soil surface throughout the growing seasons. Soil subgroups were not classified for this ecotype. However, it is likely that soils within this ecotype fall within oxyaquic subgroups of Fluvents and Cryepts soil suborders. Vegetation is *Picea glauca-Betula papyrifera* var. *kenaica, Picea glauca-Populus balsamifera-Viburnum edule,* and *Picea glauca-Populus trichocarpa-Viburnum edule.*





Riverine Silty-Sandy-Rocky Poplar Forest
This ecotype occurs on active flood plains and cobble bars along braided and meandering rivers and broad, low-gradient alluvial fans. Soils are coarse-textured, including very to extremely gravelly and cobbly sands. Soils are moist, acidic to circum-acidic, and well- to moderately well-drained. Surficial organics are thin (3-8 cm) to completely absent, and thin buried horizons occur infrequently. Soil subgroups include Oxyaquic Cryofluvents and Oxyaquic Dystrocryepts. Vegetation includes *Populus balsamifera-Alnus* sp., *Populus balsamifera-Viburnum edule, Populus trichocarpa-Alnus sinuata, Populus trichocarpa-Oplopanax horridus,* and *Populus trichocarpa-Viburnum edule.*





Maritime Coastal Loamy Saline Wet Sedge Meadow

This ecotype occurs primarily on active tidal flats, but may also be present on younger inactive tidal flats. This ecotype occurs adjacent to tidal guts resulting in fluctuations in the water table with the tide. The depth to the water table can range from 10 cm above the soil surface to 50 cm below the soil surface. Soils have an average EC of 14,280 µS/cm but may ranges as low as 2,300 µS/cm and as high as 54,200 µS/cm. Soils are typically saline, circum-acidic, wet and range from moderately well drained to very poorly drained. Soils are poorly developed and are forming in saturated, anaerobic soil conditions. Soils typically lack a surface organic horizon, but accumulations of up to 10 cm of organic material were occasionally observed in the field. Soil textures are loamy marine sediments with a depth to >15% rock fragments ranging from 20 to 70 cm below the soil surface. Typical soil subgroups include Aquic Cryofluvents, Aquic Cryorthents, Typic Cryaquents, and Typic Cryaquepts. Vegetation is *Carex ramenskii-Triglochin maritimum.*





Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow

This ecotype is prevalent on active and inactive tidal flats ranging in elevation from 0 to 75 m. This ecotype may occur in channels, swales, tidal guts and along smooth, flat lake margins. Soils are generally poorly developed Entisols with little to no organic mat. However, in areas where organic mats have accumulated greater than 20 cm, these soils are recognized as weakly developed Inceptisols. Soils are forming in saturated, anaerobic soil conditions that range in permeability from moderately well drained to very poorly drained. Soils are circum-acidic loamy marine sediments overlying rocky marine sediments at depths ranging from 40 to 130 cm below the soil surface. Soils are typically slightly brackish to strongly brackish with an average EC of 3,844 µS/cm. Typical soil subgroups include Aquic Cryofluvents, Aquic Cryorthents, Histic Cryaquepts, Typic Cryaquents and Vitrandic Cryofluvents. Vegetation is broadly defined and includes *Carex glareosa-Carex lyngbyaei-Potentilla egedii*, *Carex ramenskii-Triglochin maritimum*, *Leymus mollis-Plantago maritima*, *Carex lyngbyaei-Cicuta virosa*, and *Calamagrostis canadensis-Carex* sp.





Maritime Coastal Saline Marestail Ponds and Marshes

This ecotype occurs in brackish shallow lakes in close proximity to the ocean. Soils have an EC ranging from 800 to 35,000 µS/cm. These marshes are hydrologically connected to the tide and remain flooded with saturated soil conditions persisting and aquatic vegetation present year round. At times these marshes may be cut off from the regular tide cycle. Without the regular influx of tidal water these marshes may begin to dry out. Salt content of the water and soils will increase as the water evaporates. Eventually, the tidal regime may return or storm surges will carry sea water into the marshes changing them to brackish conditions. Soils may contain an accumulation of hydrogen sulfides just beneath an iron-oxide rich zone (0–3 cm) at the soil surface. Volcanic ash deposits from historical eruptions, or subsequently blown or washed in from surrounding surfaces, can accumulate to form moderately thick horizons (>10 cm) below the water surface. These saline soils are poorly developed, circum-acidic, and very poorly drained. Soils are very deep loamy marine sediments with rock fragments at depths greater than 1 m. Soil subgroups include Fibric Haplowassists and Typic Cryaquents. Vegetation is *Hippuris tetraphylla-Potamogeton* sp.



Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow

This ecotype occurs on all aspects of both active and inactive marine beaches, and active beach ridges and dunes on flat to low slopes ranging from 0 to 10°. Soils range from circum-acidic to acidic and have lower EC than adjacent tidal flats, ranging from 20 to 300 µS/cm. Soils may be weakly developed Entisols or moderately developed Inceptisols that typically have several thin (≤ 10 cm) buried organic horizons with depth. These buried horizons are related to fluvial and/or eolian events and in some instances ashy horizons may accumulate. However, ash thickness is not sufficient for these soils to be considered Andisols (>36 cm). Areas with a total thickness of ash that is 18 cm or thicker within 75 cm of the mineral soil surface were classified into ash-rich subgroups such as Andic or Vitrandic. Soils in this ecotype typically have little to no organic material accumulating at the surface (<10 cm). Soils are sandy marine or eolian sediments overlying gravelly marine sediments with the depth to >15% rock fragments ranging from 5–90 cm below the soil surface. Soils range from somewhat excessively to excessively drained. The soils are dry to moist and the water table is usually below 1 m. A fluctuating water table is likely present in the upper meter of the soil early in the growing season. Typical soil subgroups include Oxyaquic Cryorthents, Typic Cryorthents, Mollic Cryofluvents, Typic Cryofluvents, Typic Cryopsamments, Oxyaquic Cryopsamments and Vitrandic Haplocryepts. Vegetation is *Leymus mollis-Lathyrus maritimus.*





Maritime Coastal Sandy-Rocky Saline Barrens

This ecotype occurs on active marine beaches and tidal flats on flat to gentle slopes ranging from 0 to 10°. Soils that are below high tide line are flooded regularly. However, the duration of flooding is dependent on the height above mean tide line. This gradient of flooding frequency and duration is reflected in many soil characteristics along this sequence. Very thin buried organic horizons are present at high tide line but are lacking at low tide line. EC values are lower near the high tide line (125 µS/cm) and higher near the low tide line (34,100 µS/cm). Soils lack a surface organic horizon and are sandy and gravelly marine sediments that are well- to excessively drained. Soils with a fluctuating water table and redoximorphic features associated with oxidation were classified in an Oxyaquic subgroup, which is consistent throughout the survey. Typical subgroups include Typic Cryaquents and Oxyaquic Cryothents. Vegetation is *Honckenya peploides-Stellaria humifusa.*



Maritime Coastal Silty-Clayey Saline Barrens

This ecotype occurs on active tidal flats on flat to gently sloping areas (0–3°) along the coast where finer sediments from glacially fed rivers and streams flow out to the sea. Soils lack any surface organic material and are typically finer textured throughout, with the depth to rock fragments ranging from 10–75 cm below the soil surface. Soils are somewhat poorly to very poorly drained, have low permeability, and are forming in a saturated, anaerobic environment. Soils are typically saline with an EC ranging from 2,000–35,000 µS/cm depending on position along the tidal gradient (i.e., typically higher EC near low tide line). The typical soil subgroup for this ecotype is Typic Craquents. Vegetation is *Puccinellia phryganodes-Triglochin maritimum.*



Tidal River

This ecotype represents tidal rivers along the Cook Inlet coast in the maritime ecoregion. Tidal rivers are those freshwater rivers that experience periodic influx of salt water due to tidal influence. The water in these rivers ranges from fresh (EC < 800 µS/cm) and slightly brackish (~800-2,000 µS/cm) to strongly brackish (~12,000-18,000 µS/cm) depending on the level of tides, the distance upstream from the ocean, and the flow rate of fresh water from upstream. All of these factors influence the mixing of fresh and salt water in these rivers. Examples of tidal rivers include the extreme lower portions of several large rivers as the empty into Cook Inlet, including Glacier Creek, Middle Glacier Creek, Johnson River, and Tuxedni River, and numerous smaller creeks that meander through tidal flats and meadows, including Silver Salmon Creek and Shelter Creek.



Nearshore Water

This ecotype includes the estuarine waters of Cook Inlet. The water ranges from strongly brackish to saline (~16,500–27,000 µS/cm) and pH is typically circum-alkaline to alkaline (~7.5–8.2).



Table 5. Ecotype Key for Lake Clark National Park and Preserve.

The Ecotype Key provides the end user of this Ecological Land Survey with an organized means by which to identify ecotypes in the field. While not technically a dichotomous key, the ecotype key is very similar, leading the user through a series of logical conditions that include both vegetation composition and environment, including physiography, soil parent material, landform, and elevation. The criteria used in the key were chosen for ease of identification in the field. Understanding of basic soil properties, including general soil texture (e.g. loamy vs. sandy) and electrical conductivity (for coastal ecotypes); and access to a shallow (40 cm) soil pit or plug are useful in some cases for identifying ecotypes using this key. However, technical soil properties, including epipedon, diagnostic subsurface horizons, particle size, and soil depth were purposefully excluded from the Ecological Type Key as these are often difficult to determine in the field, requiring extra time to excavate a full (1 m) soil pit, and specialized equipment and skills for proper data collection and description. When determining an ecotype using the Ecotype Key, it is recommended that the reader compare the description (vegetation, soils, general environment) of the ecotype at the terminal node to what is observed in the field before finalizing their selection. Refer to the section entitled "How to use this Ecological Land Survey and Mapping" for more information on how to use this Ecotype Key.

1a.Glacier, ice cap, or permanent snow field…… Glacier

1b. Not a glacier, ice cap, or permanent snow field…… 2

2a. Permanent **waterbody** (standing water persistent throughout year and typically >10 cm deep)…… 3

3a. Waterbody with < 10% cover of emergent vegetation…… 4

4a. Waterbody occurs near the coast and is the ocean or is affected by tidal fluctuations and/or periodic storm surges…… .. 5

5a. Waterbody is an ocean…… Nearshore Water

5b. Waterbody is a river near its confluence with the ocean that experiences tidal fluctuations…… Tidal River

5c. Waterbody is an estuarine lake or pond…… Maritime Coastal Saline Marestail Ponds and Marshes

4b. Waterbody occurs inland and is not affected by the ocean…… 6

6a. Waterbody is characterized by flowing water…… 7

7a. Water flows perennially…… 8

8a. Waterbody is a river or stream that receives the greater percentage of its water directly from glaciers and water is typically very silty …… Riverine Glacial River Water

8b. Waterbody is a river or stream that receives the greater percentage of its water from non-glacial sources or indirectly from glacial sources (i.e. emerges from large lake) and water is typically free of silt …… Riverine Non-glacial River Water

7b. Water flow is intermittent, waterbody is a small seep or spring emerging directly from the ground, and is located in the alpine (above treeline)…… Alpine Spring

6b. Waterbody is a lake or pond…… 9

9a. Lake developed in an abandoned river channel on a floodplain and is periodically flooded by the river…… Riverine Lake Water

9b. Lake did not develop in an abandoned river channel on a floodpain or is not periodically flooded by a river…… 10

10a. Lake is at low elevations in valley bottoms and flatlands……Lowland Lake

10b. Lake is at high elevations in the mountains (above treeline)……Alpine Lake

3b. Waterbody with ≥ 10% cover of emergent vegetation…… 11

11a. Waterbody is a shallow pond or small lake occurring in the maritime ecoregion……12

12a. Waterbody is located near the coast and is affected by the ocean, water is brackish (EC 2, 000-18,000 µS/cm) to saline (EC > 18,000 µS/cm) and *Hippuris tetraphylla* is the dominant species …… Maritime Coastal Saline Marestail Ponds and Marshes

12b. Waterbody islocated inland from the coast, water is fresh (EC < 800 µS/cm) to slightly brackish (EC 800-2,000 µS/cm) and *Hippuris vulgaris* is the dominant species……Maritime Lacustrine Marestail Marsh

11b. Waterbody occurs in the northern or southern ecoregion along a lake or pond margin and the dominant species are sedges, typically *Carex limosa* and/or *Carex utriculata*……Interior Lacustrine Organic-Rich Sedge Marsh

2b. Not a permanent waterbody…… 13

13a. Site is proximal to the **ocean**, electrical conductivity (EC) is > 800 µs/cm, and is affected by ocean processes including tidal fluctuations, storm surges, and/or wind-borne salt water…… 14

14a. Vegetation cover <30% …… 15

15a. Site occurs on sandy to gravelly active marine beaches and soil is moist to wet …… Maritime Coastal Sandy-Rocky Saline Barrens

15b. Site occurs on silty to clayey active tidal flats and soil is moist to wet, *Puccinellia phryganodes* and/or *Triglochin maritimum* commonly occur at low abundance……Maritime Coastal Silty-Clayey Saline Barrens

14b. Vegetation cover ≥30%…… 16

16a.Sites on active beach ridges and sand dunes, soils are sandy to gravelly and the dominant species are *Leymus mollis* (syn: *Elymus arenarius* ssp. *mollis*) and *Lathyrus maritimus*…… Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow

16b. Sites on active and inactive tidal flats, soils are silty to clayey and occasionally organic-rich (20-40 cm surface organics)……18

17a. Water chemistry is brackish (800-18,000 µs/cm) and *Carex glareosa, Carex lyngbyaei*, and/or *Leymus mollis* are the dominant species with *Potentilla egedii* and/or *Plantago maritima* as common associates …… Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow

17b. Sites are wet, water chemistry is strongly brackish (~12,000-18,000 µS/cm) to saline (800-18,000 µs/cm), and the dominant species is *Carex ramenskii*……Maritime Coastal Silty-Clayey Saline Barrens

13b. Site occurs **inland**, electrical conductivity is < 800 µs/cm, and is not affected by the ocean…… 18

18a. **Barren** or partially vegetated where total vascular plant cover <30%…… 19

19a. Site is on an active floodplain…… Riverine Silty-Sandy-Rocky Barrens

19b. Site is on other terrain…… 20

20a. Site located in the northern or southern interior ecoregion in a drained lake basin or margin of a waterbody ……Interior Lacustrine Loamy-Rocky Barrens

22b. Site not adjacent to a waterbody nor in a lake basin…… 23

Table 5. Ecotype Key for Lake Clark National Park and Preserve (continued).

23a. Site occurs in presently or recently (app. post 1950) deglaciated areas
…… Glacial Sandy-Rocky Barrens
23b. Site occurs elsewhere…… 24
24a. Site is in the northern interior ecoregion and is in the mountains at higher elevations than the vegetated zone
……..25
25a. Soil surface and rock faces are dominated by lichens, namely *Cladina arbuscula*, *Cladina stellaris*, *Umbilicaria* sp.-and/or *Rhizocarpon geographicum*
…… Alpine Gelic Rocky Lichen Tundra
25b. Soil surface dominated by rocks and bare soil……..Alpine Gelic Rocky Barrens

24b. Site is in the southern interior and maritime ecoregions and is in the mountains at higher elevations than the vegetated zone
……..25
26a. Soil surface and rock faces are dominated by lichens, namely *Cladina arbuscula*, *Cladina stellaris*, *Umbilicaria* sp.-and/or *Rhizocarpon geographicum*……..Alpine Rocky Lichen Tundra
26b. Soil surface dominated by rocks and bare soil…….…… Alpine Rocky Barrens
18b. Vegetation cover (vascular species only) ≥ 30% …… 27
27a. **Tree canopy is < 10% cover**…… 28
28a. **Shrub cover is < 25%** and vegetation is primarily graminoid-dominated…… 29
29a. Cover of forbs, namely *Equisetum variegatum* is > cover of sedges and site occurring on riverine levees along the Neacola River
…… Interior Riverine Sandy Forb Meadow
29b. Cover of grasses, particularly bluejoint, *Calamagrostis canadensis*, is > cover of sedges…… 30
30a.Sites occurring in the northern or southern interior ecoregions…… 31
31a. Soils are moist to wet and site occurs in lake basin
…….. Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow
31b. Soils are moist and site occurs in the subalpine…… Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow
30b. Sites occurring in the maritime ecoregion……32
32a. Soils are moist and site occurs in the alpine (above treeline)
…….. Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow
32b. Soils are moist and site occurs in uplands……Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow
29c Cover of sedges is equal to or greater than cover of grasses…….. 33
33a.Site occurs on a floodplain, soils are wet and organic-rich (20-40 cm surface organics)
……..Riverine Ashy-Loamy-Organic Wet Sedge Meadow
33b.Site occurs in alpine areas (above tree line)…… 34
34a. Soils are wet and loamy to organic-rich…… Alpine Loamy-Organic Wet Sedge Meadow
34b. Site occurs in northern interior ecoregion, soils are moist and ashy to loamy and sometimes rocky
…….Alpine Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow
34c. Site occurs in the southern interior or maritime ecoregion, soils are moist and ashy to loamy and sometimes rocky
…….Alpine Ashy-Loamy-Rocky Moist Sedge Meadow
33c.Site occurs elsewhere…… 35
35a. Site is in northern or southern interior ecoregion…… 36
36a. Site is located in a lake basin…… 37

37b. Site is located in a lake basin and soils are wet and organic-rich (>40 cm), *Sphagnum* spp. Is typically dominant and *Andromeda polifolia*, *Drosera rotundifolia*, and/or *Salix fuscescens* are often present
…….. Interior Lacustrine Organic-Rich Sedge-Shrub Bog
37b. Site is located in a lake basin and soils are wet and loamy to organic-rich (20-40 cm), *Sphagnum* spp. is absent or restricted to microsites *Andromeda polifolia*, *Drosera rotundifolia*, and *Salix fuscescens* are typically absent……..Interior Lacustrine Loamy-Organic Wet Sedge Meadow
36b Site is not located in a lake basin…… 38
38a. Site is located in a subalpine environment and soils are wet and organic-rich
…… Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog
38b. Soils are wet and peaty to organic-rich, elevation
lower…… 39
39a. Site is dominated by *Sphagnum* spp. and *Andromeda polifolia* and *Drosera rotundifolia*, are often present…… Lowland Organic-Rich Sedge-Shrub Bog
39b. *Sphagnum* spp. is absent or restricted to microsites *and Andromeda polifolia* and *Drosera rotundifolia*, are typically absent…… Interior Lowland Organic-Rich Wet Sedge Meadow
35a. Site is located in lowland areas in the maritime ecoregion…… 40
40a. Soils are wet and peaty, site is dominated by *Sphagnum* spp. and *Andromeda polifolia* and *Drosera rotundifolia*, are often present……Lowland Organic-Rich Sedge-Shrub Bog
40b. Soils are wet, loamy to organic, and vegetation is dominated *Carex lyngbyaei* and *Calamagrostis canadensis*
…… Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow
28b. **Shrub cover is >25%**…… 37
37a. **Shrub height < 0.20 m**…… 38
38a. .Site is in alpine areas in the northern interior ecoregion …….. 39

Table 5. Ecotype Key for Lake Clark National Park and Preserve (continued).

39a. Mineral soil-cored hummocks occur tightly clustered dominating the site, soils are ashy to loamy and coarse fragments if present occur below 40 cm…… Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks

39b. Mineral soil-cored hummocks are absent or rare ……. 40

40a. Site occurs in a late snowbank environment (snow melts later than ~July 1) ……Alpine Rocky Dwarf Shrub Late-Lying Snowbanks

40b. Site occurs elsewhere …….. 41

41a. Soils dry and rocky, vascular cover sparse (30-45%), characterized by *Dryas integrifolia, Oxytropis nigrescens*, and *Cladina* sp …….. Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra

41b. Soils moist to dry and rocky, vascular cover sparse, dwarf *Salix* spp. combined cover greater than any other single dwarf shrub species…….. Alpine Gelic Rocky Dwarf Willow Tundra

41c. Soils moist, ashy to loamy and occasionally rocky, vegetation cover more dense (45-65%), characterized by dwarf ericaceous shrubs, including *Empetrum nigrum, Betula nana, Ledum decumbens*, and *Cassiope stelleriana* and *Cladina* spp…… Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra

38b. .Site is in alpine areas in the maritime ecoregion …….. 42

43a. Site occurs in the maritime ecoregion, soils are moist, ashy to loamy and occasionally rocky, and vegetation is dominated by dwarf *Vaccinium uliginosum* and *Carex microchaeta* ……. Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra

38c. .Site is in alpine areas in either the southern interior or maritime ecoregion …….. 43

43a. Mineral soil-cored hummocks occur tightly clustered dominating the site, soils are ashy to loamy and coarse fragments if present occur below 40 cm, vegetation dominated by *Cassiope stelleriana* and *Luetkea pectinata* ……. Alpine Ashy-Loamy Dwarf Shrub Hummocks

43b. Mineral soil-cored hummocks are absent or rare ……. 44

44a. Site occurs in a late snowbank environment (snow melts later than ~July 1) ……Alpine Rocky Dwarf Shrub Late-Lying Snowbanks

44b. Site occurs elsewhere …….. 45

45a. Soils dry and rocky, vegetation sparse (30-45%), characterized by *Dryas integrifolia, Oxytropis nigrescens*, and *Cladina* sp …….. Alpine Rocky Dwarf Shrub-Lichen Tundra

45b. Soils moist to dry and rocky, vegetation cover more dense, dwarf *Salix* spp. combined cover greater than any other single dwarf shrub species…….. Alpine Rocky Dwarf Willow Tundra

45c. Soils moist, ashy to loamy and occasionally rocky, vegetation cover more dense (45-65%), characterized by dwarf ericaceous shrubs, including *Cassiope stelleriana* and *Empetrum nigrum*. ……Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra

38d. .Site is in subalpine areas in the northern or southern interior ecoregion, soils are moist, ashy to loamy and sometimes rocky, vegetation is dominated by the dwarf shrub *Empetrum nigrum* …….. Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub

37b. Shrub height > 0.20m……. 46

46a. **Shrub height < 1.5 m**……. 47

38a. .Site is in the maritime ecoregion …….. 48

48a. Site is in a lowland environment, soils are wet and ashy to loamy and organic-rich, *Myrica gale* and/or *Salix fuscescens* are the dominant shrubs and *Carex lyngbyaei* and/or *Calamagrostis canadensis* either singly or collectively dominate the herbaceous layer ……Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub

48b. Site is in a recently disturbed area (wind throw, landslide) in an upland environment, soils are moist and ashy to loamy, and *Rubus spectabilis* and *Vaccinium ovalifolium* are the dominant shrubs …… Maritime Upland Ashy-Loamy Mixed Low Shrub

38b. .Site is in the northern or southern interior ecoregion …….. 49

49a. Site is located in a recently drained lake basin…….. 50

50a. Soils are moist to wet, ashy to loamy and sometimes rocky, *Salix* spp. and *Calamagrostis canadensis* dominate the shrub and herbaceous layers, respectively…….. Interior Lacustrine Ashy-Loamy-Rocky Low Shrub

50b. Vegetation or soils not as above,……..Undefined

49b. Site located elsewhere…… 51

51a. Site is located in a subalpine environment and is dominated by *Alnus crispa* and/or Salix spp.……52

52a. Site located on a geomorphic surface or slope position characterized by erosion (e.g. active alluvial fan, steep slope), soils dry to moist and rocky…….. Interior Subalpine Rocky Alder-Willow Shrub

52b. Site located on a geomorphic surface or slope position (e.g. abandonded alluvial fan,gentle slope, characterized by deposition , soils moist and ashy to loamy …….. Interior Subalpine Ashy-Loamy Alder-Willow Shrub

49c. Site is located in a subalpine, upland, or lowland environment and is dominated by *Betula glandulosa* or *Betula nana* with an understory of dwarf ericaceous shrubs…… 53

53a. Site located in subalpine environment…….. 54

54a. Soils moist to wet, organic-rich, and permanently frozen …….. Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub

54b. Soils moist, ashy to loamy and often rocky …….. Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub

53b. Site located in upland environment…….. 55

Table 5. Ecotype Key for Lake Clark National Park and Preserve (continued).

55a. Site located on a geomorphic surface or slope position characterized by erosion (e.g. active alluvial fan, steep slope), soils moist and rocky

……..Interior Upland Rocky Birch-Ericaceous Low Shrub

55b. Site located on a geomorphic surface or slope position (e.g. abandonded alluvial fan,gentle slope, characterized by deposition , soils moist and ashy to loamy

……. Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub

53c. Site located in lowland environment

…….. 56

56a. Site located on gentle slope or slightly convex geomorphic surface, soils ashy to loamy and sometimes rocky……..Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub

56b. Site located on a flat or concave geomorphic surface or depression, soils wet and loamy-ashy and organic-rich

……..Interior Lowland Organic-Rich Birch-Ericaceous Shrub

49d. Site is located in a lowland environment and is dominated by *Salix fuscescens* and *Sphagnum* spp. and *Andromeda polifolia* and/or *Drosera rotundifolia* are often present, soils wet and peaty

…… Lowland Organic-Rich Sedge-Shrub Bog

46b. **Shrub height ≥ 1.5 m**…….. 57

58a. Site is on an active floodplain, vegetation is dominated by *Alnus tenuifolia* or *A. sinuata* and/or *Salix* spp.

……59

59a. Site is located in Maritime ecoregion……Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub

59b. Site is located in the northern or southern interior ecoregion

……Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub

58b. Site is located elsewhere……. 60

60a. Site is located in presently glaciated or recently (post 1950) deglaciated areas, soils sandy and rocky, vegetation is dominated by *Alnus crispa*

……Glacial Sandy-Rocky Alder Shrub

60b. Site is located on mountains sides in subalpine environments in the northern or southern interior ecoregions and vegetation dominated by *Alnus crispa* and/or *Salix* spp……61

61a.Soil dry to moist and rocky…… Interior Subalpine Rocky Alder-Willow Shrub

61b.Soil moist and organic-rich…… Interior Subalpine Organic-rich Alder Tall Shrub

61c.Soil moist and ashy to loamy…… Interior Subalpine Ashy-Loamy Alder-Willow Shrub

60c. Site is located upland environments ……62

62a.Site is located in the northern or southern interior ecoregion, soils are dry to moist and rocky

…… Interior Upland Rocky Alder Shrub

62b.Site is located in the maritime ecoregion……63

63a. Sites on inactive and abandoned beach ridges and sand dunes near the coast, soil moist, and sandy to rocky

…… Maritime Upland Sandy-Rocky Alder-Willow Shrub

63b. Sites on steep mountain sides and cliffs, soil dry to moist, and rocky

…… Maritime Upland Rocky Alder Shrub

63c. Sites on gentle to moderately steep hillsides and mountains, soils moist and ashy to loamy and sometimes rocky

…… Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub

27b. **Tree canopy is ≥10%** cover…….. 64

64a. **Dwarf needleleaf** trees comprise >75% of total tree cover……... 65

65a. Site occurs in lowland areas and *Picea mariana* is the dominant tree species, soils are moist to wet, organic-rich and **frozen**

…… Interior Lowland Frozen Loamy-Organic Black Spruce Forest

65b. Vegetation and soils not as above …… Undefined

64b. **Needleleaf** trees comprise >75% of total tree cover……... 66

66a. *Picea mariana* is the dominant tree species……... 67

67a. Site occurs in lowlands and soils are loamy to organic rich and **frozen**

…… Interior Lowland Frozen Loamy-Organic Black Spruce Forest

67b. Site occurs in lowland areas soils are unfrozen, wet, loamy-ashy and organic-rich or peaty……Interior Lowland Ashy-Loamy-Organic Black Spruce Forest

67c. Site occurs in upland areas and *Picea mariana* is the dominant tree species, soils are unfrozen, moist, and ashy to loamy…… Interior Upland Ashy-Loamy Black Spruce Forest

66b. *Picea glauca* is the dominant tree……69

69a. Site occurs on a floodplain……70

70a. Site occurs in the northern or southern interior ecoregion

……Interior Riverine Silty-Sandy-Rocky White Spruce Forest

70b. Site occurs in the maritime ecoregion

…… Maritime Riverine Silty-Sandy-Rocky Spruce Forest

69b. Site occurs on subalpine slopes in the northern or southern in terior ecoregion

……Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland

69c. Site occurs on upland hillslopes and mountains sides

……71

Table 5. Ecotype Key for Lake Clark National Park and Preserve (continued).

71a. Site occurs in the northern or southern interior ecoregion and soils are rocky
……Interior Upland Rocky White Spruce Woodland
71b. Site occurs in any ecoregion, soils are ashy to loamy and sometime rocky
……Upland Ashy-Loamy-Rocky White Spruce Woodland

66c. *Picea sitchensis* or *P. × lutzii* is the dominant tree……72

72a. Site occurs on a floodplain……Maritime Riverine Silty-Sandy-Rocky Spruce Forest
72b. Site occurs in a lowland environment, soils are moist to wet and ashy to loamy
……Maritime Riverine Silty-Sandy-Rocky Spruce Forest
72c. Site occurs in an upland environment……73

73a. Site occurs on an inactive or abandoned beach ridge or sand dune near the coast, soils moist and sandy to rocky
……Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest
73b. Site occurs on hillslope and mountains sides, soils ashy to loamy
……Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest

64c. Needleleaf trees comprise <75% of total tree cover…… 74

74a. **Deciduous tree** species comprise >75% of total tree cover……75

65a. Site occurs on a floodplain and the dominant tree is *Populus* spp (either *P. balsamifera* or *P. trichocarpa*)
…….. Riverine Silty-Sandy-Rocky Poplar Forest
65b. Site occurs on subalpine mountain slopes in the northern or southern interior ecoregion and the dominant species is *P. balsamifera* and soils are rocky
…….. Interior Subalpine Rocky Balsam Poplar Forest
65c. Site occurs in lowland environments and the dominant species is *Betula papyrifera var. kenaica* and/or *Populus* spp (either *P. balsamifera* or *P. trichocarpa*) and soils are moist to wet and ashy to loamy
……Lowland Acidic Ashy-Loamy Birch-Poplar Forest
65d. Site occurs in upland environments and the dominant species is *Betula papyrifera var. kenaica* and/or *Populus* spp (either *P. balsamifera* or *P. trichocarpa*) ……76

76a. Soils dry to moist and rocky……Upland Rocky Birch-Poplar Forest
76b. Soils moist and ashy to loamy……Lowland Acidic Ashy-Loamy Birch-Poplar Forest

74b. Deciduous tree species comprise < 75% total tree cover…….. 77

77a. Site occurs on a floodplain and *Picea glauca* and *Betula papyrifera var. kenaica* or *Populus* spp (either *P. balsamifera* or *P. trichocarpa*) are co-dominant……. Riverine Silty-Sandy-Rocky Mixed Forest
77b. Site occurs in the northern or southern interior ecoregion……78

78a. Site occurs in a lowland environment, soils are moist to wet, ashy to loamy and sometimes rocky, *Picea glauca* and *Betula papyrifera var. kenaica* or *Populus* spp (either *P. balsamifera* or *P. trichocarpa*)
…… Interior Lowland Ashy-Loamy-Rocky Mixed Forest
78a. Site occurs in an upland environment ……79

79a. Site occurs in an upland environment ……80

80a. Soils dry to moist and rocky……Interior Upland Rocky Mixed Forest
80b. Soils moist and ashy to loamy……Interior Upland Ashy-Loamy Mixed Forest

1. Lifeform and species cover cutpoints represent approximate guidelines and classification should also rely on dominant indicator species and landscape position.

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska.

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Moist Acidic-Circumacidic Ashy-Loamy Dwarf Shrub Hummocks	*Cassiope stelleriana-Luetkea pectinata*	Cassiope Dwarf Shrub Tundra
Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Moist Acidic-Circumacidic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	*Cassiope stelleriana-Luetkea pectinata*	Cassiope Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub Tundra
Alpine Ashy-Loamy-Rocky Moist Sedge Meadow	Alpine Moist Acidic-Circumacidic Ashy-Loamy-Rocky Sedge Meadow	*Carex microchaeta-Luzula* sp.	Moist Sedge Meadow Tundra
Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Moist Acidic-Circumacidic Ashy-Loamy Dwarf Shrub Hummocks	*Salix reticulata-Carex podocarpa*	Bluejoint Meadow
		Vaccinium uliginosum-Carex microchaeta	Ericaceous Dwarf Shrub Tundra
Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Gelic Moist Acidic-Circumacidic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	*Betula nana-Ledum decumbens-Cladina* sp.	Crowberry Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub–Lichen Tundra
		Cassiope stelleriana-Luetkea pectinata	Cassiope Dwarf Shrub Tundra
		Empetrum nigrum-Cladina sp.	Crowberry Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub Tundra
			Ericaceous Dwarf Shrub–Lichen Tundra
		Vaccinium uliginosum-Carex microchaeta	Ericaceous Dwarf Shrub–Lichen Tundra
Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Alpine Gelic Moist Acidic-Circumacidic Ashy-Loamy-Rocky Sedge Meadow	*Carex bigelowii-Dryas integrifolia*	Moist Sedge Meadow Tundra
			Moist Sedge–Shrub Tundra
		Carex microchaeta-Luzula sp.	Moist Sedge Meadow Tundra
Alpine Gelic Rocky Barrens	Alpine Gelic Dry Acidic-Circumacidic Rocky Barrens	*Dryas integrifolia-Oxytropis nigrescens*	Partially Vegetated
Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Dry Acidic-Circumacidic Rocky Dwarf Shrub-Lichen Tundra	*Dryas integrifolia-Oxytropis nigrescens*	Dryas-Lichen Dwarf Shrub Tundra

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Alpine Gelic Rocky Dwarf Willow Tundra	Alpine Gelic Moist Acidic-Circumacidic Rocky Dwarf Willow Tundra	*Salix reticulata-Carex podocarpa*	Willow Dwarf Shrub Tundra
		Salix rotundifolia-Carex microchaeta	Willow Dwarf Shrub Tundra
Alpine Gelic Rocky Lichen Tundra	Alpine Gelic Dry Acidic-Circumacidic Rocky Lichen Tundra	*Cladina arbuscula - Cladina stellaris*	Foliose and Fruticose Lichen
			Lichen
		Umbilicaria sp.-*Rhizocarpon geographicum-Hierochloe alpina*	Crustose Lichen
			Foliose and Fruticose Lichen
			Lichen
Alpine Loamy-Organic Wet Sedge Meadow	Alpine Wet Acidic Loamy-Organic Sedge Meadow	*Carex aquatilis-Salix fuscescens*	Wet Sedge Meadow Tundra
		Carex bigelowii-Dryas integrifolia	Wet Sedge Meadow Tundra
Alpine Rocky Barrens	Alpine Dry Acidic-Circumacidic Rocky Barrens	*Umbilicaria* sp.-*Rhizocarpon geographicum-Hierochloe alpina*	Barren
Alpine Rocky Dwarf Shrub Late-Lying Snowbanks	Alpine Moist Acidic-Circumacidic Rocky Dwarf Shrub Late-Lying Snowbanks	*Salix rotundifolia-Carex microchaeta*	Willow Dwarf Shrub Tundra
Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Dry Acidic-Circumacidic Rocky Dwarf Shrub-Lichen Tundra	*Dryas integrifolia-Cladina* sp.	Dryas-Lichen Dwarf Shrub Tundra
		Dryas integrifolia-Oxytropis nigrescens	Dryas Dwarf Shrub Tundra
Alpine Rocky Dwarf Willow Tundra	Alpine Moist Acidic-Circumacidic Rocky Dwarf Willow Tundra	*Salix rotundifolia-Carex microchaeta*	Willow Dwarf Shrub Tundra
Alpine Rocky Lichen Tundra	Alpine Dry Acidic-Circumacidic Rocky Lichen Tundra	*Cladina arbuscula - Cladina stellaris*	Foliose and Fruticose Lichen
		Umbilicaria sp.-*Rhizocarpon geographicum-Hierochloe alpina*	Foliose and Fruticose Lichen
Glacial Sandy-Rocky Alder Shrub	Glacial Moist Acidic Sandy-Rocky Alder Shrub	*Alnus crispa-Dryopteris dilatata*	Open Tall Alder
Glacial Sandy-Rocky Barrens	Glacial Dry Acidic-Circumacidic Sandy-Rocky Barrens	*Umbilicaria* sp.-*Rhizocarpon geographicum-Hierochloe alpina*	Partially Vegetated
Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Interior Lacustrine Moist Circumacidic Ashy-Loamy-Rocky Bluejoint Meadow	*Calamagrostis canadensis-Carex* sp.	Bluejoint Meadow
			Moist Graminoid Meadow
Interior Lacustrine Ashy-Loamy-Rocky Low Shrub	Interior Lacustrine Moist Circumacidic Ashy-Loamy-Rocky Low Shrub	*Salix* sp.-*Calamagrostis canadensis*	Open Low Willow
Interior Lacustrine Loamy-Organic Wet	Interior Lacustrine Acidic-Circumacidic Loamy-	*Calamagrostis canadensis-Carex*	Wet Sedge Meadow Tundra

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Sedge Meadow	Organic Wet Sedge Meadow	sp.	
			Wet Sedge–Grass Meadow Tundra
		Carex saxatilis-Carex aquatilis	Wet Sedge–Grass Meadow Tundra
Interior Lacustrine Loamy-Rocky Barrens	Interior Lacustrine Wet Circumacidic Loamy-Rocky Barrens	*Juncus arcticus-Equisetum* sp.	Wet Bryophyte
Interior Lacustrine Organic-rich Sedge Marsh	Interior Lacustrine Acidic Organic-rich Sedge Marsh	*Carex limosa-Menyanthes trifoliata*	Fresh Sedge Marsh
		Carex utriculata-Eriophorum angustifolium	Fresh Sedge Marsh
Interior Lacustrine Organic-rich Sedge-Shrub Bog	Interior Lacustrine Wet Acidic Organic-rich Sedge-Shrub Bog	*Andromeda polifolia-Drosera rotundifolia-Sphagnum*	Subarctic Lowland Sedge-Moss Bog Meadow
		Carex aquatilis-Salix fuscescens-Sphagnum sp.	Subarctic Lowland Sedge Bog Meadow
			Subarctic Lowland Sedge-Moss Bog Meadow
		Carex limosa-Salix fuscescens	Subarctic Lowland Sedge Bog Meadow
Interior Lowland Ashy-Loamy-Organic Black Spruce Forest	Interior Lowland Moist Acidic Ashy-Loamy-Organic Black Spruce Forest	*Picea mariana-Ledum decumbens-Cladina arbuscula*	Black Spruce Woodland
			Open Black Spruce Forest
Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Moist Acidic Ashy-Loamy-Rocky Birch-Ericaceous Shrub	*Betula glandulosa-Ledum decumbens-Cladina* sp.	Open Low Mesic Shrub Birch-Ericaceous Shrub
			Open Low Shrub Birch-Ericaceous Shrub Bog
Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Moist Acidic Ashy-Loamy-Rocky Mixed Forest	*Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata*	Open Spruce–Paper Birch
		Picea glauca-Betula papyrifera var. kenaica	Closed Spruce–Paper Birch
			Open Paper Birch–Balsam Poplar–Spruce
			Open Spruce-Balsam Poplar Forest
			Open Spruce–Paper Birch
		Picea glauca-Populus trichocarpa-Viburnum edule	Open Paper Birch–Balsam Poplar–Spruce
Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Frozen Acidic Loamy-Organic Black Spruce Forest	*Picea mariana-Ledum decumbens-Cladina arbuscula*	Open Black Spruce Forest

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
		Picea mariana-Ledum decumbens-Sphagnum sp.	Black Spruce Woodland
			Open Black Spruce Forest
Interior Lowland Frozen Organic-Rich Dwarf Spruce Forest	Interior Lowland Frozen Acidic Organic-Rich Dwarf Spruce Forest	*Picea mariana-Ledum decumbens-Sphagnum* sp.	Dwarf Black Spruce Woodland
Interior Lowland Frozen Organic-Rich Sedge-Shrub Bog	Interior Lowland Frozen Acidic Organic-Rich Sedge-Shrub Bog	*Betula nana-Ledum decumbens-Sphagnum* sp.	Subarctic Lowland Sedge-Moss Bog Meadow
Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Wet Acidic Organic-Rich Birch-Ericaceous Shrub	*Andromeda polifolia-Drosera rotundifolia-Sphagnum*	Open Low Ericaceous Shrub Bog
		Betula glandulosa-Ledum decumbens-Sphagnum sp.	Open Low Mesic Shrub Birch-Ericaceous Shrub
		Betula nana-Ledum decumbens-Sphagnum sp.	Open Low Ericaceous Shrub Bog
			Open Low Mesic Shrub Birch-Ericaceous Shrub
			Open Low Shrub Birch-Willow
		Myrica gale-Salix pulchra-Calamagrostis canadensis	Closed Low Shrub Birch–Ericaceous Shrub
			Open Low Shrub Birch-Willow
Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lowland Wet Acidic-Circumacidic Organic-Rich Wet Sedge Meadow	*Carex aquatilis-Salix fuscescens*	Subarctic Lowland Sedge Wet Meadow
			Subarctic Lowland Sedge-Shrub Wet Meadow
		Carex limosa-Salix fuscescens	Subarctic Lowland Sedge-Moss Bog Meadow
			Wet Sedge Meadow Tundra
Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Interior Riverine Moist Acidic-Circumacidic Sandy-Rocky-Organic Alder-Willow Shrub	*Alnus sinuata-Salix alaxensis*	Closed Tall Alder
			Closed Tall Alder-Willow
			Open Tall Alder-Willow
		Myrica gale-Salix pulchra-Calamagrostis canadensis	Open Low Willow
		Populus balsamifera-Alnus sp.	Open Tall Alder
		Salix alaxensis-Alnus tenuifolia	Closed Tall Alder-Willow
			Open Tall Alder-Willow
		Salix alaxensis-Angelica lucida	Open Low Willow

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
			Open Tall Willow
		Salix sp.-*Calamagrostis canadensis*	Closed Low Willow
			Closed Tall Willow
			Open Low Willow
			Open Tall Willow
Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Interior Riverine Moist Circumacidic Silty-Sandy-Rocky White Spruce Forest	*Picea glauca-Alnus* sp.	Open White Spruce Forest
			White Spruce Woodland
Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Moist Acidic Ashy-Loamy-Rocky Alder-Willow Shrub	*Alnus crispa-Dryopteris dilatata*	Closed Tall Alder
		Salix sp.-*Calamagrostis canadensis*	Closed Low Willow
			Open Low Willow–Graminoid Shrub Bog
Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Interior Subalpine Moist Acidic-Circumacidic Ashy-Loamy-Rocky Bluejoint-Forb Meadow	*Calamagrostis canadensis-Angelica lucida*	Bluejoint Meadow
			Bluejoint-Herb
			Fireweed
			Mixed Herbs
Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Moist Acidic Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	*Betula glandulosa-Ledum decumbens-Cladina* sp.	Open Low Mesic Shrub Birch-Ericaceous Shrub
		Betula nana-Ledum decumbens-Cladina sp.	Closed Low Shrub Birch–Ericaceous Shrub
			Open Low Mesic Shrub Birch-Ericaceous Shrub
Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Interior Subalpine Moist Acidic Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	*Empetrum nigrum-Cladina* sp.	Crowberry Dwarf Shrub Tundra
Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Moist Acidic Ashy-Rocky-Organic White Spruce Woodland	*Picea glauca-Vaccinium uliginosum-Sphagnum* sp.	White Spruce Woodland
Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub	Interior Subalpine Frozen Acidic Organic-Rich Birch-Ericaceous Low Shrub	*Betula nana-Ledum decumbens-Sphagnum* sp.	Open Low Mesic Shrub Birch-Ericaceous Shrub
Interior Subalpine Organic-rich Alder Tall Shrub	Interior Subalpine Moist Acidic Organic-rich Alder Tall Shrub	*Alnus crispa-Dryopteris dilatata*	Closed Tall Alder
			Closed Tall Alder-Willow

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Interior Subalpine Wet Acidic Organic-Rich Sedge-Shrub Meadow and Bog	*Carex aquatilis-Salix fuscescens-Sphagnum* sp.	Wet Sedge–Willow Tundra
Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Moist Acidic Rocky Alder-Willow Shrub	*Alnus crispa-Dryopteris dilatata*	Closed Tall Alder
		Salix alaxensis-Angelica lucida	Closed Low Willow
			Open Tall Willow
Interior Subalpine Rocky Balsam Poplar Forest	Interior Subalpine Moist Circumacidic Rocky Balsam Poplar Forest	*Populus balsamifera-Salix alaxensis*	Open Balsam Poplar Forest
Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Moist Acidic Ashy-Loamy Birch-Ericaceous Low Shrub	*Betula glandulosa-Ledum decumbens-Cladina* sp.	Open Low Mesic Shrub Birch-Ericaceous Shrub
		Betula glandulosa-Ledum decumbens-Sphagnum sp.	Open Low Shrub Birch-Willow
		Betula nana-Ledum decumbens-Cladina sp.	Closed Low Shrub Birch–Ericaceous Shrub
			Open Low Mesic Shrub Birch-Ericaceous Shrub
Interior Upland Ashy-Loamy Black Spruce Forest	Interior Upland Moist Acidic Ashy-Loamy Black Spruce Forest	*Picea mariana-Ledum decumbens-Cladina arbuscula*	Black Spruce Woodland
			Open Black Spruce Forest
		Picea mariana-Ledum decumbens-Sphagnum sp.	Open Black Spruce Forest
Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Moist Acidic Ashy-Loamy Mixed Forest	*Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata*	Open Spruce–Paper Birch
		Picea glauca-Betula papyrifera var. kenaica	Open Spruce-Balsam Poplar Forest
			Open Spruce–Paper Birch
			Spruce–Paper Birch Woodland
		Picea glauca-Populus tremuloides-Cornus canadensis	Open Quaking Aspen Forest
			Open Quaking Aspen–Spruce
			Spruce–Aspen Woodland
		Picea mariana-Populus tremuloides-Vaccinium vitis-	Open Quaking Aspen Forest
Interior Upland Rocky Alder Shrub	Interior Upland Moist Acidic Rocky Alder Shrub	*Alnus sinuata-Dryopteris dilatata*	Closed Tall Alder-Willow
			Open Tall Alder

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Moist Acidic Rocky Birch-Ericaceous Low Shrub	*Betula glandulosa-Ledum decumbens-Cladina* sp.	Open Low Mesic Shrub Birch-Ericaceous Shrub
		Betula nana-Ledum decumbens-Cladina sp.	Open Low Mesic Shrub Birch-Ericaceous Shrub
			Open Low Shrub Birch-Willow
Interior Upland Rocky Mixed Forest	Interior Upland Moist Acidic Rocky Mixed Forest	*Picea glauca-Betula papyrifera var. kenaica*	Open Spruce–Paper Birch
			Spruce–Paper Birch Woodland
		Picea glauca-Populus trichocarpa-Viburnum edule	Open Spruce-Balsam Poplar Forest
Interior Upland Rocky White Spruce Woodland	Interior Upland Moist Acidic Rocky White Spruce Woodland	*Picea glauca-Alnus* sp.	White Spruce Woodland
		Picea glauca-Betula nana-Sterocaulon sp.	White Spruce Woodland
		Picea glauca-Ledum decumbens	White Spruce Woodland
Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Lowland Moist Acidic Ashy-Loamy Birch-Poplar Forest	*Betula papyrifera var. kenaica-Ledum decumbens*	Open Paper Birch
		Populus balsamifera-Salix alaxensis	Open Balsam Poplar Forest
		Populus trichocarpa-Alnus sinuata	Open Black Cottonwood Forest
		Populus trichocarpa-Viburnum edule	Open Balsam Poplar Forest
			Open Black Cottonwood Forest
			Open Paper Birch–Balsam Poplar
Lowland Organic-Rich Sedge-Shrub Bog	Lowland Wet Acidic Organic-Rich Sedge-Shrub Bog	*Andromeda polifolia-Drosera rotundifolia-Sphagnum*	Subarctic Lowland Sedge-Moss Bog Meadow
		Carex aquatilis-Salix fuscescens-Sphagnum sp.	Subarctic Lowland Sedge-Shrub Wet Meadow
		Carex limosa-Salix fuscescens-Sphagnum sp.	Subarctic Lowland Sedge-Moss Bog Meadow
Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Alpine Moist Acidic-Circumacidic Ashy-Loamy-Rocky Bluejoint-Forb Meadow	*Calamagrostis canadensis-Angelica lucida*	Bluejoint-Herb
			Ferns
			Fireweed
Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Maritime Alpine Moist Acidic-Circumacidic Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	*Vaccinium uliginosum-Carex microchaeta*	Vaccinium Dwarf Shrub Tundra

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Maritime Coastal Loamy Saline Wet Sedge Meadow	Maritime Coastal Loamy Saline Wet Sedge Meadow	*Carex ramenskii-Triglochin maritimum*	Halophytic Sedge Wet Meadow
			Halophytic Sedge Wet Meadow, brackish
			Halophytic Sedge Wet Meadow, saline
Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	*Calamagrostis canadensis-Carex* sp.	Halophytic Sedge Wet Meadow, brackish
		Carex glareosa-Carex lyngbyaei-Potentilla egedii	Bluejoint-Herb
			Halophytic Grass Wet Meadow, brackish
			Halophytic Sedge Wet Meadow, brackish
		Carex lyngbyaei-Cicuta mackenzieana	Halophytic Grass Wet Meadow, brackish
			Halophytic Sedge Wet Meadow
			Halophytic Sedge Wet Meadow, brackish
		Carex ramenskii-Triglochin maritimum	Halophytic Grass Wet Meadow, brackish
			Halophytic Sedge Wet Meadow, brackish
			Halophytic Sedge–Grass Wet Meadow, brackish
		Leymus mollis-Plantago maritima	Halophytic Grass Wet Meadow, brackish
Maritime Coastal Saline Marestail Ponds and Marshes	Maritime Coastal Saline Marestail Ponds and Marshes	*Hippuris tetraphylla- Potamogeton* sp.	Four-leaf Marestail
Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow	Maritime Coastal Sandy-Rocky Moist Circumacidic Beachgrass-Forb Meadow	*Leymus mollis-Lathyrus maritimus*	Bluejoint-Herb
			Elymus
			Mixed Herbs
Maritime Coastal Sandy-Rocky Saline Barrens	Maritime Coastal Sandy-Rocky Saline Barrens	*Honckenya peploides-Stellaria humifusa*	Barren
			Partially Vegetated
Maritime Coastal Silty-Clayey Saline	Maritime Coastal Silty-Clayey Saline Barrens	*Puccinellia phryganodes-Triglochin*	Halophytic Grass Wet Meadow,

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Barrens		*maritimum*	saline
			Halophytic Sedge–Grass Wet Meadow, saline
			Partially Vegetated
Maritime Lacustrine Marestail Marsh	Maritime Lacustrine Acidic-Circumacidic Marestail Marsh	*Hippuris vulgaris-Sparganium angustifolium*	Common Marestail
Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Lowland Moist Ashy-Loamy Acidic Sitka-Lutz Spruce Forest	*Picea* × *lutzii-Leymus mollis-Lathyrus maritimus*	Open Sitka Spruce Forest
		Picea × *lutzii-Oplopanax horridus*	Lutz Spruce Woodland
Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub	Maritime Lowland Wet Acidic Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub	*Myrica gale-Salix fuscescens-Carex lyngbyaei*	Open Low Sweetgale-Graminoid Bog
			Open Low Willow
		Myrica gale-Salix pulchra-Calamagrostis canadensis	Open Low Sweetgale–Graminoid Shrub Meadow (slightly brackish)
			Open Low Willow
			Open Tall Willow
Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Wet Acidic Organic-Rich Sedge-Grass Meadow	*Calamagrostis canadensis-Carex* sp.	Bluejoint Meadow
			Halophytic Sedge Wet Meadow, brackish
			Subarctic Lowland Graminoid–Herb Wet Meadow
			Subarctic Lowland Sedge-Moss Bog Meadow
Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Maritime Riverine Moist Acidic-Circumacidic Sandy-Rocky-Organic Alder-Willow Shrub	*Alnus crispa-Dryopteris dilatata*	Closed Tall Alder
			Open Tall Alder
		Alnus crispa-Epilobium latifolium	Open Tall Alder-Willow
		Picea × *lutzii-Alnus crispa*	Open Tall Alder
		Salix sp.-*Calamagrostis canadensis*	Open Low Willow–Graminoid Shrub Bog
Maritime Riverine Silty-Sandy-Rocky Spruce Forest	Maritime Riverine Moist Circumacidic Silty-Sandy-Rocky Spruce Forest	*Picea* × *lutzii-Vaccinium ovalifolium*	Open Lutz Spruce
Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Moist Acidic-Circumacidic Ashy-Loamy Mixed Low Shrub	*Rubus spectabilis-Oplopanax horridus*	Closed Low Salmonberry
		Vaccinium ovalifolium-Oplopanax horridus	Open Low Vaccinium Shrub

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Moist Acidic Ashy-Loamy Sitka-Lutz Spruce Forest	*Picea* × *lutzii-Oplopanax horridus*	Open Lutz Spruce
			Open White Spruce Forest
			White Spruce Woodland
Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Moist Acidic Ashy-Loamy-Rocky Alder-Willow Shrub	*Alnus crispa-Dryopteris dilatata*	Closed Tall Alder
			Open Low Alder
			Open Tall Alder
		Salix sp.-*Calamagrostis canadensis*	Closed Low Willow
			Open Low Willow
			Open Tall Willow
Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Moist Acidic-Circumacidic Ashy-Loamy-Rocky Bluejoint-Forb Meadow	*Calamagrostis canadensis-Angelica lucida*	Bluejoint-Herb
			Mixed Herbs
			Moist Graminoid Meadow
Maritime Upland Rocky Alder Shrub	Maritime Upland Moist Acidic Rocky Alder Shrub	*Alnus crispa-Dryopteris dilatata*	Closed Tall Alder
			Open Tall Alder
Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Moist Acidic Sandy-Rocky Alder-Willow Shrub	*Alnus crispa-Dryopteris dilatata*	Open Tall Alder
		Alnus crispa-Epilobium latifolium	Open Low Alder–Willow
		Alnus sinuata-Dryopteris dilatata	Closed Tall Alder
		Salix sp.-*Calamagrostis canadensis*	Open Tall Willow
Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Maritime Upland Moist Acidic Sandy-Rocky Sitka-Lutz Spruce Forest	*Picea* × *lutzii-Leymus mollis-Lathyrus maritimus*	Elymus
			Mixed Herbs
		Picea × *lutzii-Oplopanax horridus*	Open Lutz Spruce
			Open White Spruce Forest
Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Wet Circumacidic Ashy-Loamy-Organic Wet Sedge Meadow	*Calamagrostis canadensis-Carex* sp.	Wet Graminoid Meadow
		Carex lyngbyaei-Cicuta mackenzieana	Fresh Sedge Marsh
		Carex saxatilis-Carex aquatilis	Wet Sedge Meadow Tundra
		Carex utriculata-Eriophorum	Wet Sedge Meadow Tundra

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
		angustifolium	
Riverine Lake Water	Riverine Circumneutral Lake Water	*Carex saxatilis-Carex aquatilis*	Fresh Water
Riverine Silty-Sandy-Rocky Barrens	Riverine Moist Acidic-Circumacidic Silty-Sandy-Rocky Barrens	*Alnus crispa-Epilobium latifolium*	Partially Vegetated
		Epilobium latifolium	Fireweed
			Partially Vegetated
		Juncus arcticus-Equisetum sp.	Wet Bryophyte
Riverine Silty-Sandy-Rocky Mixed Forest	Riverine Moist Circumacidic Silty-Sandy-Rocky Mixed Forest	*Picea glauca-Betula papyrifera var. kenaica*	Open Spruce–Paper Birch
			Spruce–Paper Birch Woodland
		Picea glauca-Populus balsamifera-Viburnum edule	Closed White Spruce–Paper Birch–Balsam Poplar
			Open Paper Birch–Balsam Poplar–Spruce
			Open Spruce-Balsam Poplar Forest
		Picea glauca-Populus trichocarpa-Viburnum edule	Open Paper Birch–Balsam Poplar–Spruce
			Open Spruce-Balsam Poplar Forest
			Open Spruce–Paper Birch
Riverine Silty-Sandy-Rocky Poplar Forest	Riverine Moist Acidic-Circumacidic Silty-Sandy-Rocky Poplar Forest	*Populus balsamifera-Alnus* sp.	Balsam Poplar Woodland
			Open Balsam Poplar Forest
		Populus balsamifera-Viburnum edule	Balsam Poplar Woodland
		Populus trichocarpa-Alnus sinuata	Open Balsam Poplar Forest
		Populus trichocarpa-Oplopanax horridus	Open Black Cottonwood Forest
		Populus trichocarpa-Viburnum edule	Open Balsam Poplar Forest
Upland Ashy-Loamy Birch-Poplar Forest	Upland Moist Circumacidic Ashy-Loamy Birch-Poplar Forest	*Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata*	Open Paper Birch
		Betula papyrifera var. kenaica-Ledum decumbens	Closed Paper Birch
			Open Paper Birch
		Populus balsamifera-Alnus sp.	Open Balsam Poplar Forest
		Populus balsamifera-Viburnum	Balsam Poplar Woodland

Table 6. Crosswalk of abbreviated ecotypes with full ecotype names, floristic class, and Viereck level IV vegetation types in Lake Clark National Park and Preserve, Alaska (continued).

Abbreviated Ecotype	Ecotype (long name)	Floristic Class	VegetationType (Level IV)
		edule	
			Open Balsam Poplar Forest
		Populus trichocarpa-Viburnum edule	Open Balsam Poplar Forest
Upland Ashy-Loamy-Rocky White Spruce Woodland	Upland Moist Acidic Ashy-Loamy-Rocky White Spruce Woodland	*Picea glauca-Alnus* sp.	White Spruce Woodland
		Picea glauca-Betula nana-Sterocaulon sp.	White Spruce Woodland
		Picea glauca-Ledum decumbens	Open Spruce–Paper Birch
			White Spruce Woodland
Upland Rocky Birch-Poplar Forest	Upland Moist Acidic-Circumacidic Rocky Birch-Poplar Forest	*Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata*	Open Paper Birch
		Betula papyrifera var. kenaica-Ledum decumbens	Open Paper Birch
		Populus balsamifera-Alnus sp.	Balsam Poplar Woodland
		Populus trichocarpa-Oplopanax horridus	Open Black Cottonwood Forest

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011.

Floristic Class	Description
Alnus crispa-Dryopteris dilatata	*Alnus crispa* forms an open to closed tall shrub canopy with an understory dominated by the fern *Dryopteris dilatata americana*. Other common species include *Calamagrostis canadensis*, *Gymnocarpium dryopteris*, *Rubus spectabilis*, *Epilobium angustifolium*, *Oplopanax horridus*, *Veratrum viride eschscholtzii*, *Ribes glandulosum*, *Polytrichum juniperinum*, *Athyrium filix-femina cyclosorum*, and *Streptopus amplexifolius*.
Alnus crispa-Epilobium latifolium	*Alnus crispa* forms an open tall shrub canopy and may share dominance with *Salix sitchensis* or *Salix planifolia* pulchra. The understory is sparse but always includes scattered *Epilobium latifolium*. Other understory species that may occur at low abundance include *Dryopteris dilatata americana*, *Epilobium angustifolium*, and *Equisetum arvense*.
Alnus sinuata-Dryopteris dilatata	*Alnus sinuata* forms an open to closed tall shrub canopy and may share dominance with *Salix planifolia pulchra* or *Oplopanax horridus*. The understory is dominated by the fern *Dryopteris dilatata americana*. Other common species include *Calamagrostis canadensis*, *Rubus arcticus*, *Epilobium angustifolium*, *Thelypteris phegopteris*, *Spiraea beauverdiana*, *Senecio triangularis*, *Veratrum viride eschscholtzii*, and *Angelica lucida*.
Alnus sinuata-Salix alaxensis	*Alnus sinuata* and *Salix alaxensis* together form an open to closed tall shrub canopy. The understory is typically sparse and rocky as this plant association is common on active floodplains and cobble bars. Characteristic understory species include *Calamagrostis canadensis*, *Artemisia tilesii*, *Climacium dendroides*, *Gymnocarpium dryopteris*, and *Epilobium latifolium*. This plant association is seral to *Populus balsamifera* or *P. trichocarpa*, the seedlings and saplings of which often occur at low abundance in the understory.
Andromeda polifolia-Drosera rotundifolia-Sphagnum	Thick *Sphagnum*, including *S. squarrosum*, *S. lindbergii*, *S. lenense*, and *S. papillosum*, predominates in this plant association with *Andromeda polifolia* and *Drosera rotundifolia* or *D. angelica* occurring consistently at relatively low abundance. Common associated species speak further to the boggy environment at these sites, including *Ledum decumbens*, *Oxycoccus microcarpus*, *Rubus chamaemorus*, *Eriophorum vaginatum*, *Vaccinium uliginosum*, *Myrica gale*, *Drosera anglica*, and *Chamaedaphne calyculata*. Standing water is common.
Betula glandulosa-Ledum decumbens-Cladina sp.	*Betula glandulosa* and *Ledum decumbens* together create an open low shrub canopy. Fruticose and foliose lichen occurring at moderately high abundance and *Sphagnum* sp. either absent or at very low abundance and limited to wetter microsites are indicative of this plant association. *Cladina arbuscula* and *Cladina stellaris* are the most common lichens, others may include *Cladina stygia*, *Cladonia uncialis*, *Cladonia gracilis turbinata*, *Stereocaulon* sp., and *Flavocetraria cucullata*. Other common species include *Vaccinium vitis-idaea*, *Empetrum nigrum*, *Spiraea beauverdiana*, *Salix glauca*, and *Calamagrostis canadensis*. Bare soil and rocks at the surface are common.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Betula glandulosa-Ledum decumbens-Sphagnum sp.	*Betula glandulosa* and *Ledum decumbens* together create an open low shrub canopy, occasionally sharing the shrub canopy with *Salix fuscescens*. *Sphagnum* sp. occurring at moderately high abundance and fruticose and foliose lichen absent or at very low abundance and limited to drier microsites are indicative of this plant association. Other common species include *Carex bigelowii*, *Vaccinium vitis-idaea*, *Carex canescens*, *Carex saxatilis*, and *Rubus chamaemorus.*
Betula nana-Ledum decumbens-Cladina sp.	*Betula nana* and *Ledum decumbens* together create an open low shrub canopy. At higher elevations and more exposed sites this plant association may approximate a dwarf shrub (<20 cm) stand. Fruticose and foliose lichen occurring at moderately high abundance and Sphagnum sp. either absent or at very low abundance and limited to wetter microsites are indicative of this plant association. *Cladina arbuscula*, *Cladina stellaris*, and *Cladina rangiferina*, and *Stereocaulon* sp.are the most common lichens, others may include *Cladina stygia*, Cladonia *uncialis*, *Thamnolia vermicularis*, and *Flavocetraria cucullata*. Other characteristic species include *Empetrum nigrum*, *Ledum decumbens*, *Vaccinium vitis-idaea*, *Hierochloe alpina*, *Loiseleuria procumbens*, *Salix glauca*, *Salix arctica*, and *Arctostaphylos alpina*.
Betula nana-Ledum decumbens-Sphagnum sp.	*Betula glandulosa* and *Ledum decumbens* together create an open low shrub canopy, occasionally sharing the shrub canopy with *Salix fuscescens*, *Salix planifolia pulchra*, or *Myrica gale*. *Sphagnum* sp. occurring at moderately high abundance and fruticose and foliose lichen absent or at very low abundance and limited to drier microsites are indicative of this plant association. *Sphagnum angustifolium* is the most common, other may include S*. fimbriatum*, *S. fuscum*, *S. girgensohnii*, *S. lenense*, *S. magellanicum*, *S. papillosum*, *S. rubellum*, and *S. squarrosum*. Other characteristic species include *Rubus chamaemorus*, *Carex aquatilis aquatilis*, *Carex bigelowii*, and *Andromeda polifolia*.
Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata	*Betula papyrifera* var. *kenaica* creates an open forest in which *Alnus sinuata* forms an loose tall shrub canopy. *Dryopteris dilatata americana* dominates the understory. Other common species include *Rubus pedatus*, *Trientalis europaea arctica*, *Calamagrostis canadensis*, *Gymnocarpium dryopteris*, *Spiraea beauverdiana*, and *Streptopus amplexifolius*. *Picea glauca* seedlings and saplings commonly occur in the understory.
Betula papyrifera var. kenaica-Ledum decumbens	*Betula papyrifera* var. *kenaica* creates an open forest in which *Ledum decumbens*, *Empetrum nigrum*, *Vaccinium vitis-idaea* form a dense low and dwarf shrub layer. Other common species include *Cornus suecica*, *Salix scouleriana*, *Calamagrostis Canadensis*, *Vaccinium uliginosum*, *Linnaea borealis*, *Trientalis europaea arctica*, *Spiraea beauverdiana*,, *Epilobium angustifolium*, *Pleurozium schreberi*, and *Gymnocarpium dryopteris*. *Alnus sinuata* forms a loose tall shrub canopy. *Dryopteris dilatata americana* and *Alnus sinuata* are typically absent but may occasionally occur at low abundance.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Calamagrostis canadensis-Angelica lucida	*Calamagrostis canadensis* dominates a forb-rich moist meadow characterized by *Sanguisorba stipulata Geranium erianthum*, *Epilobium angustifolium*, *Angelica lucida*, *Rubus arcticus*, *Veratrum viride eschscholtzii*, *Senecio triangularis*, *Achillea borealis*, *Aconitum delphinifolium*, *Thelypteris phegopteris*, and *Heracleum lanatum*. *Athyrium filix-femina cyclosorum* and *Fritillaria camschatcensis* may occur in this plant association in the maritime ecoregion. Sedges may co-dominate with *C. canadensis* at some sites, including *Carex sitchensis*, *C. mackenziei*, and *C. macrochaeta*.
Calamagrostis canadensis-Carex sp.	*Calamagrostis canadensis* and *Carex* sp. co-dominate these often species poor wet meadows. In the interior ecoregion the dominant sedges are typically *Carex aquatilis*, *Carex canescens*, or *Carex saxatilis*. In the maritime ecoregion near the coast the dominant sedge is *C. lyngbyaei*. *Potentilla palustris* is a forb commonly associated with this ecotype.
Carex aquatilis-Salix fuscescens	*Carex aquatilis* dominates these stands with *Salix fuscescens* occurring consistently at low abundance. *Salix richardsonii* or *S. pulchra* are also often present at low abundance. Other common species include *Potentilla palustris*, *Carex rariflora*, *Carex canescens*, *Eriophorum angustifolium*, *Limprichtia revolvens*, and *Trichophorum caespitosum*. *Sphagnum* sp. often occurs, but at very low abundance.
Carex aquatilis-Salix fuscescens-Sphagnum sp.	*Carex aquatilis* dominates these stands with *Salix fuscescens* occurring consistently at low abundance. *Chamaedaphne calyculata*, *Andromeda polifolia*, and *Oxycoccus microcarpus* are indicative of this plant association, as is the dominance by a variety of *Sphagnum* species, including *S. fuscum*, *S. girgensohnii*, *S. riparium*, *S. squarrosum*, and *S. teres*. *Potentilla palustris* and *Eriophorum angustifolium* are other species commonly occurring in this floristic class.
Carex bigelowii-Dryas integrifolia	*Carex bigelowii* dominate these moist alpine meadows accompanied by *Dryas integrifolia* and a variety of other dwarf shrubs, most notably *Empetrum nigrum*, *Diapensia lapponica*, *Cassiope tetragona*, *Loiseleuria procumbens*, *Salix reticulata*, and *Vaccinium uliginosum*. Common forbs and graminoids include *Sedum rosea integrifolium*, *Festuca altaica*, *Artemisia arctica*, *Hierochloe alpina*, *Sanguisorba stipulate*, *Pedicularis verticillata*, *Equisetum arvense*, *Carex podocarpa*, *Arnica lessingii*, *Senecio atropurpureus*, *Polygonum viviparum*, and *Deschampsia caespitosa*. This floristic class was sampled solely in the Telequana Highlands, a broad alpine plateau in the northern interior ecoregion. However, it is possible that it occurs elsewhere in alpine areas of LACL.
Carex glareosa-Carex lyngbyaei-Potentilla egedii	*Carex glareosa* and *Carex lyngbyaei* dominate these coastal wet meadows. *Potentilla egedii*, *Festuca rubra Poa eminens*, *Triglochin maritimum*, *Calamagrostis deschampsioides*, and *Chrysanthemum arcticum* are consistent floristic associates and often co-dominate with the sedges. *Carex ramenskii* may occur but at low abundance.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Carex limosa-Menyanthes trifoliata	This floristic class is associated with marshes, lake margins and beaver ponds. These sites are permanently flooded. *Carex limosa* and *Menyanthes trifoliata* are often the only species present at these sites.
Carex limosa-Salix fuscescens	*Carex limosa* dominates these stands with *Salix fuscescens* occurring consistently at low abundance. Other common species include *Calamagrostis canadensis*, *Eriophorum scheuchzeri*, *Carex canescens*, *Carex chordorrhiza*, *Epilobium palustre*, *Calliergon stramineum*, and *Utricularia vulgaris macrorhiza*. *Sphagnum* sp. often occurs, but at very low abundance.
Carex limosa-Salix fuscescens-Sphagnum sp.	*Carex limosa* dominates these stands with *Salix fuscescens* occurring consistently at low abundance. *Salix planifolia pulchra* or *Salix brachycarpa niphoclada* are also often present at low abundance. *Oxycoccus microcarpus* is indicative of this plant association, as is the dominance by a variety of *Sphagnum* species, including *Sphagnum girgensohnii* and *S. fimbriatum*. *Eriophorum russeolum* and *Carex pluriflora* are other species commonly occurring in this floristic class.
Carex lyngbyaei- Cicuta mackenzieana	*Carex lyngbyaei* forms a dense sward with scattered *Cicuta mackenzieana* in these wet coastal slightly brackish to brackish meadows. *Leymus mollis* may share dominance at some sites. The dense sedge canopy often precludes other species from reaching appreciable abundance, and these sites are often somewhat species poor. Common associated species include *Galium trifidum trifidum*, *Epilobium palustre*, *Potentilla egedii*, *Poa eminens*, *Potentilla palustris*, *Calamagrostis deschampsioides*, *Triglochin maritimum*, and *Lathyrus palustris*.
Carex microchaeta-Luzula sp.	*Carex microchaeta* and *Luzula wahlenbergii wahlenbergii* or *Luzula arcuata* dominate these moist alpine meadows. Dwarf shrubs, including *Salix arctica*, *Vaccinium uliginosum*, *Salix phlebophylla*, *Empetrum nigrum*, and *Cassiope tetragona* occur regularly at low abundance. Other common species include *Carex dioica gynocrates*, *Hierochloe alpina*, and *Luetkea pectinata*.
Carex ramenskii-Triglochin maritimum	*Carex ramenskii* and *Triglochin maritimum* dominate these wet brackish to saline wet coastal meadows. *Potentilla egedii*, *Plantago maritima*, and *Carex glareosa* share dominance. Other common species include *Calamagrostis deschampsioides*, *Stellaria humifusa*, *Chrysanthemum arcticum*, *Festuca rubra*, and *Puccinellia phryganodes*, *Puccinellia nutkaensis.*
Carex saxatilis-Carex aquatilis	*Carex saxatilis*, *Carex aquatilis aquatilis*, and/or *Carex canescens* co-occur at low abundance in wet meadow and marsh environments. Standing water is common throughout the growing season. These stands are typically species poor. Common associated species include *Equisetum fluviatile* and *Eriophorum angustifolium*.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Carex utriculata-Eriophorum angustifolium	*Carex utriculata* and *Eriophorum angustifolium* form a near monoculture in these wet meadows. A variety of species occur in this floristic class. However, species richness and abundance at any given site is typically limited due to the perennially wet soils and dense sedge roots. Commonly associated species may include *Potentilla palustris*, *Carex limosa*, *Carex canescens*, *Hippuris vulgaris*, *Menyanthes trifoliata*, *Scorpidium scorpioides*, *Cicuta mackenzieana*, *Epilobium palustre*,and *Equisetum fluviatile*.
Cassiope stelleriana-Luetkea pectinata	*Cassiope stelleriana* and *Luetkea pectinata* co-dominate in these species rich dwarf shrub stands on more sheltered slope positions and snow beds. Commonly associated species include *Lycopodium alpinum*, *Luetkea pectinata*, *Salix arctica*, *Cladina arbuscula*, *Cladonia bellidiflora*, *Empetrum nigrum*, *Carex podocarpa*, *Phyllodoce aleutica*, and *Artemisia arctica.*
Cladina arbuscula - Cladina stellaris	*Cladina arbuscula* and/or *Cladina stellaris* typically dominate this lichen tundra floristic class. *Cladina mitis* or *Cladina stygia* may co-dominate. Other common lichens include *Thamnolia vermicularis* and *Racomitrium lanuginosum*. Vascular plants occur sporadically and at low abundance, including *Diapensia lapponica*, *Salix rotundifolia*, *Vaccinium vitis-idaea*, *Carex microchaeta*, and *Sedum rosea integrifolium*.
Dryas integrifolia-Cladina sp.	*Drya integrifolia* dominates the dwarf shrub layer at some sites. More commonly *Dryas* co-occurs at low abundance with several dwarf shrub species, including *Salix arctica*, *Ledum decumbens*, *Diapensia lapponica*, *Vaccinium uliginosum*, *Dryas integrifolia*, and *Empetrum nigrum*. Typically, no single dwarf shrub dominates at these rocky, exposed alpine tundra sites. However, when combined, dwarf shrubs compose 25-35 percent cover, making this floristic class borderline lichen tundra. Commonly associated lichen species include *Cladina arbuscula*, *Cladina stellaris*, and *Thamnolia vermicularis*.
Dryas integrifolia-Oxytropis nigrescens	*Dryas integrifolia* is the dominant shrub occurring at 5 to 15% cover and is often accompanied by lesser amounts of *Salix phlebophylla*, *Empetrum nigrum*, *Diapensia lapponica*, and/or *Ledum decumbens*. *Oxytropis nigrescens* and *Thamnolia vermicularis* are always present typically at low abundance. Other associated species include *Pedicularis capitata*, *Artemisia arctica arctica*, *Arnica lessingii*, *Hierochloe alpina*, and *Antennaria monocephala*.
Empetrum nigrum-Cladina sp.	*Empetrum nigrum* forms a open dwarf shrub canopy often accompanied by *Vaccinium uliginosum*, *Ledum decumbens*, *Cladina arbuscula*, and *Vaccinium vitis-idaea*. Forbs and graminoids are typically sparse, while fruticose lichens are common and abundant, including *Cladina stellaris*, *Cladina arbuscula*, *Stereocaulon* sp., and *Thamnolia vermicularis*. Other characteristic species include *Loiseleuria procumbens*, *Hylocomium splendens*, *Peltigera aphthosa*,. *Betula glandulosa*, *Carex podocarpa*, *Betula nana*, and *Diapensia lapponica*
Epilobium latifolium	*Epilobium latifolium* occurs loosely clumped across these rocky river bars. Scattered seedlings of *Salix sitchensis*, *Alnus crispa*, *Salix alaxensis*, and/or *Populus trichocarpa* (maritime) commonly co-occur.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Hippuris tetraphylla- Potamogeton sp.	*Hippuris tetraphylla* and *Potamogeton filiformis* or *P. pectinatus* dominate these often species poor brackish to saline coastal marshes. Standing water is common. Associated species include *Eleocharis palustris*, *Triglochin maritimum*, and *Carex ramenskii*.
Hippuris vulgaris-Sparganium angustifolium	*Hippuris vulgaris* and *Sparganium angustifolium* dominates these fresh water marshes. Standing water is common. Other common species include *Potamogeton sp.*, *Myriophyllum sp.*, and *Carex lyngbyaei* (maritime).
Honckenya peploides-Stellaria humifusa	*Honckenya peploides* and *Stellaria humifusa* occur consistently at low abundance and are typically scattered across these sandy coastal beaches and inactive tidal flats. Exposed beach sand is common and abundant at the soil surface. Other associated species occurring at low abundance include *Senecio pseudoarnica*, *Leymus mollis*, *Lathyrus maritimus maritimus*, *Potentilla egedii*, and *Festuca rubra*.
Juncus arcticus-Equisetum sp.	*Juncus arcticus* and *Equisetum arvense* or *E. pratense* occur at low abundance on these wet, rocky, partially vegetated river bars, active alluvial fans, and recently drained lake bottoms. Associated species are widely variable but may include *Carex aquatilis aquatilis*, *Deschampsia caespitosa*, *Ranunculus reptans*, *Carex saxatilis*, *Calamagrostis Canadensis*, *Juncus castaneus castaneus*, and *Alopecurus aequalis*.
Leymus mollis-Lathyrus maritimus	*Leymus mollis* and *Lathyrus maritimus* maritimus dominate these dry to moist species rich graminoid-forb meadow on sandy-gravelly inactive coastal beaches and sand dunes. Commonly associated forbs include *Achillea millefolium*, *Angelica lucida*, *Ligusticum scoticum*, *Trientalis europaea*, *Senecio pseudoarnica*, *Moehringia lateriflora*, *Rhinanthus minor borealis*, *Fritillaria camschatcensis*, *Stellaria crassifolia*, and *Lupinus nootkatensis*. Common graminoids include *Festuca rubra*, *Carex gmelinii*, *Calamagrostis canadensis*, and *Carex macrocephala*.
Leymus mollis-Plantago maritima	*Leymus mollis* dominantes these wet tidal flats with *Plantago maritima* occurring consistently at somewhat lower abundance. Associated species include *Potentilla egedii*, *Festuca rubra*, *Puccinellia phryganodes*, *Triglochin maritimum*, *Poa eminens*, *Puccinellia nutkaensis*, and *Chrysanthemum arcticum*.
Myrica gale-Salix fuscescens-Carex lyngbyaei	*Myrica gale* and *Salix fuscescens* co-dominate these lowland wet shrublands near the coast. *Carex lyngbyaei* consistently dominates the understory. Common associated species include *Potentilla palustris*, *Calamagrostis canadensis*, *Carex pluriflora*, *Trientalis europaea*, *Betula nana*, and *Carex canescens*.
Myrica gale-Salix pulchra-Calamagrostis canadensis	*Myrica gale* and *Salix pulchra* co-dominate these lowland and riverine wet shrublands. *Calamagrostis canadensis* consistently dominates the understory. Other characteristic species include *Potentilla palustris*, *Equisetum fluviatile*, *Carex utriculata*, *Potentilla fruticosa*, *Equisetum arvense*, *Betula nana*, *Rubus arcticus*, and *Calliergon cordifolium*.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Picea × *lutzii-Alnus crispa*	*Picea* × *lutzii* or *Picea sitchensis* dominates these active and inactive floodplains in the maritime ecoregion. *Alnus crispa* dominates the understory, and in early successional stages of this floristic class, may co-occur with *Picea* × *lutzii* saplings to forms a nearly impenetrable tall shrub stand. Forbs and graminoids are characteristically sparse, particularly in early successional stands. Associated species include *Pyrola secunda*, *Rubus arcticus*, *Salix barrattiana*, *Ribes glandulosum*, *Rubus spectabilis*, *Athyrium filix-femina cyclosorum*, and *Oplopanax horridus*.
Picea × *lutzii-Leymus mollis-Lathyrus maritimus*	*Picea* × *lutzii or Picea sitchensis* saplings dominate these inactive beach ridges in the maritime ecoregion. The understory composition is similar to the *Leymus mollis-Lathyrus maritimus* floristic class. However, *Leymus mollis* occurs at much lower abundance presumably due to shading of the understory by *Picea* × *lutzii* saplings. Common associated species include *Angelica lucida*, *Festuca rubra*, *Achillea millefolium*, *Lupinus nootkatensis*, *Lathyrus maritimus maritimus*, and *Trientalis europaea*. These stands are early successional stages of the *Picea* × *lutzii-Oplopanax horridus* and *Picea* × *lutzii-Vaccinium ovalifolium* floristic classes.
Picea × *lutzii-Oplopanax horridus*	*Picea* × *lutzii* or *Picea sitchensis* dominate these maritime forests. *Oplopanax horridus* forms a formidable low to tall shrub layer and may be joined by *Alnus sinuata*, *Menziesia ferruginea*, *Rubus spectabilis*, *Alnus crispa*, and *Viburnum edule*. Common associated understory species include *Gymnocarpium dryopteris*, *Dryopteris dilatata americana*, *Rubus pedatus*, *Trientalis europaea arctica*, *Athyrium filix-femina cyclosorum*, *Lycopodium annotinum*, and *Brachythecium nelsonii*.
Picea × *lutzii-Vaccinium ovalifolium*	*Picea* × *lutzii* or *Picea sitchensis* dominate these maritime forests. *Vaccinium ovalifolium* dominates the low shrub layer and may be joined by *Menziesia ferruginea* and *Sorbus scopulina*. Typical species may include *Dryopteris dilatata americana*, *Rubus pedatus*, *Lycopodium annotinum*, *Pyrola secunda*, *Cornus Canadensis*, *Gymnocarpium dryopteris*, and *Trientalis europaea arctica*. *Oxycoccus microcarpus* and *Sphagnum* sp. may occur in wetter versions of this floristic class.
Picea glauca-Alnus sp.	*Picea glauca* creates a woodland or open forest aspect accompanied in the tall shrub layer by *Alnus* sp., including *Alnus tenuifolia* in riverine environments and *A. sinuata* or *A. crispa* in uplands. In uplands, *Salix barrattiana* and *Salix scouleriana* may also be present in the tall shrub layer. Associated understory species include *Calamagrostis canadensis*, *Vaccinium vitis-idaea*, *Spiraea beauverdiana*, *Empetrum nigrum*, *Vaccinium uliginosum*, *Linnaea borealis*, *Lycopodium annotinum*, *Cornus canadensis*, *Streptopus amplexifolius*, *Rubus pedatus*, and *Trientalis europaea arctica*. Common mosses include *Hylocomium splendens*, *Ptilium crista-castrensis*, and *Pleurozium schreberi*. *Ranunculus lapponicus* and/or *Carex saxatilis* may occur in wet microsites in riverine environments.
Picea glauca-Betula nana-Sterocaulon sp.	*Betula nana*, *Betula glandulosa*, and *Ledum decumbens* form an open low shrub layer in a *Picea glauca* woodland. The dwarf shrubs *Empetrum nigrum* and *Vaccinium vitis-idaea* round out the shrub layer. Herbaceous plants are typically sparse, rather lichens dominate understory. *Stereocaulon* sp., *Cladina stellaris*, *Flavocetraria cucullata*, *Cladina rangiferina* are the most common lichens associated with this floristic class. Herbaceous species may include *Anemone narcissiflora*, *Campanula lasiocarpa*, *Carex macrochaeta*, *Festuca altaica*, *Hierochloe alpina*. The understory is typically open and rocks are often exposed at the soil surface.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Picea glauca-Betula papyrifera var. kenaica	*Picea glauca* and *Betula papyrifera* var. *kenaica* combined to create the open mixed forest canopy of this broadly defined type. A variety of shrub species occur in the understory, the most common includes the dwarf shrub *Vaccinium vitis-idaea* and the low shrubs *Spiraea beauverdiana*, *Viburnum edule*, and *Vaccinium uliginosum*. Others may include *Ledum decumbens*, *Betula glandulosa*, *Alnus sinuata*, *Salix planifolia pulchra*, and *Menziesia ferruginea*. Associates herbaceous species include *Calamagrostis Canadensis*, *Trientalis europaea arctica*, *Gymnocarpium dryopteris*, *Dryopteris dilatata Americana*, *Epilobium angustifolium*, *Lycopodium annotinum*, *Equisetum sylvaticum*, and *Linnaea borealis*. Feathermosses often dominate the forest floor, including *Hylocomium splendens*, *Ptilium crista-castrensis*, *Pleurozium schreberi*.
Picea glauca-Ledum decumbens	*Picea glauca* forms a woodpland canopy beneath which *Ledum decumbens* heads up a thick, diverse low and dwarf shrub layer, including *Vaccinium vitis-idaea*, *Empetrum nigrum*, *Vaccinium uliginosum*, *Betula nana*, *Ledum decumbens*. The tall shrubs Salix *glauca* and *Salix bebbiana* also commonly occur in these woodlands Fruticose lichens are common but are not dominant as in the *Picea glauca-Betula nana-Sterocaulon* sp. and are limited to drier microsites and *Stereocaulon* species are rarely if ever present. *Andromeda polifolia*, *Rubus chamaemorus*, and *Sphagnum* sp. may occur in wetter microsites and wetter versions of this type.
Picea glauca-Populus balsamifera-Viburnum edule	*Picea glauca* and *Populus balsamifera* co-dominate these mixed riverine forests. *Viburnum edule* always occurs in the low shrub layer and may be accompanied by *Ribes triste*, *Rosa acicularis*, *Ribes laxiflorum*, and *Alnus sinuata*. Common understory species include *Gymnocarpium dryopteris*, *Dryopteris dilatata Americana*, *Trientalis europaea arctica*, *Epilobium angustifolium*, *Calamagrostis Canadensis*, *Sanguisorba stipulata*, *Equisetum pretense*, *Thalictrum sparsiflorum*.
Picea glauca-Populus tremuloides-Cornus canadensis	*Picea glauca* and *Populus tremuloides* co-dominate these mixed upland and subalpine forests. Beneath the open forest canopy *Vaccinium uliginosum*, *Vaccinium vitis-idaea*, *Salix bebbiana*, and *Betula glandulosa* form the low and dwarf shrub layer. Common associated forbs and grasses include *Festuca altaica*, *Cornus suecica*, *Sanguisorba stipulata*, *Cornus Canadensis*, and *Lycopodium annotinum*. *Peltigera aphthosa*, *Ptilium crista-castrensis*, *Hylocomium splendens* are non-vascular species commonly associated with this floristic class.
Picea glauca-Populus trichocarpa-Viburnum edule	*Picea glauca* and *Populus trichocarpa* co-dominate these mixed forested stands. *Viburnum edule* always occurs in the low shrub layer and may be accompanied by *Ribes triste*, *Ribes laxiflorum*, *Alnus sinuata*, *Salix barclayi* and *Salix alaxensis*. Commonly associated understory species include *Calamagrostis Canadensis*, *Pyrola asarifolia*, *Epilobium angustifolium*, *Gymnocarpium dryopteris*, *Equisetum arvense*, *Pyrola secunda*, *Streptopus amplexifolius*, *Aconitum delphinifolium*, and *Dryopteris dilatata americana*. This floristic class occurs primarily in the maritime ecoregion, but alsooccur occastionally in the southeastern southern interior ecoregion.
Picea glauca-Vaccinium uliginosum-Sphagnum sp.	*Picea glauca* forms a woodland canopy beneath which *Vaccinium uliginosum* creates an open dwarf to low shrub community. *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, *Betula nana*, and *Ledum decumbens* often occur but at low abundance. *Sphagnum* species occur in peat mounds on the forest floor, while feathermosses, including *Hylocomium splendens* and *Ptilium crista-castrensis* dominate elsewhere in the otherwise sparse understory.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Picea mariana-Ledum decumbens-Cladina arbuscula	*Picea mariana* creates a woodland or open forest aspect with dense low shrub layer composed primarily of *Ledum decumbens* and also often including *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, and *Betula glandulosa*. Herbarceous species are sparse in these stands. Fruiticose lichens instead predominate, including most commonly *Cladina arbuscula*, *Nephroma arcticum*, *Cladina stellaris*, *Flavocetraria cucullata*, and *Cladina rangiferina*.
Picea mariana-Ledum decumbens-Sphagnum sp.	*Picea mariana* forms a woodland aspect in these wet, boggy lowlands. *Ledum decumbens*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, and *Betula nana* are the typical shrub species similar to the *Picea mariana-Ledum decumbens-Cladina arbuscula* floristic class. However, *Sphagnum* species predominate on the forest floor, including *Sphagnum angustifolium*, *S. fuscum*, *S. girgensohnii*, *S. lindbergii*, *S. russowii*. Other common associated species include *Carex bigelowii*, *Oxycoccus microcarpus*, *Chamaedaphne calyculata*, *Andromeda polifolia*, and *Drosera rotundifolia.*
Picea mariana-Populus tremuloides-Vaccinium vitis-	*Populus tremuloides* and *Picea mariana* co-dominate in these mixed upland forests. *Betula glandulosa*, *Vaccinium vitis-idaea* and *V. uliginosum* are predominate shrub species in this floristic class. *Geocaulon lividum* and *Epilobium angustifolium* occur scattered throughout the sparse understory. Common lichens include *Cladina arbuscula*, *Stereocaulon* sp., and *Peltigera aphthosa*. This floristic class is likely a fire related mid-successional stage of *Picea mariana-Ledum decumbens-Cladina arbuscula*.
Populus balsamerifera-Salix alaxensis	*Populus balsamifera* creates an open broadleaf forest on these rocky river cobble bars and active alluvial fans. *Salix alaxensis* always occurs in the tall shrub layer and may be accompanied by *Salix glauca*, *Salix arbusculoides*, and *Salix lanata richardsonii*. Common herbaceous species include *Lupinus arcticus*, *Polemonium acutiflorum*, *Heracleum lanatum*, *Aconitum delphinifolium*, *Equisetum* sp., *Erigeron peregrinus*, *Pyrola grandiflora*, *Galium boreale*, *Geranium erianthum*, *Linnaea borealis*, and *Bromus pumpellianus*. *Populus balsamifera* saplings may dominate in early seral stand of this floristic class.
Populus balsamifera-Alnus sp.	*Populus balsamifera* creates a woodland or open forest aspect accompanied in the tall shrub layer by *Alnus* sp., including *Alnus tenuifolia* in riverine environments and *A. sinuata* or *A. crispa* typically in uplands. *Viburnum edule*, *Ribes triste*, *Salix scouleriana*, *Oplopanax horridus* , *Salix alaxensis* (riverine) commonly co-occur in the tall shrub layer but at appreciably lower abundance. Common associated understory species include *Calamagrostis canadensis*, *Gymnocarpium dryopteris*, *Equisetum arvense*, *Pyrola secunda*, and *Dryopteris dilatata americana*.
Populus balsamifera-Viburnum edule	*Populus balsamifera* creates a woodland or open forest aspect with *Viburnum edule* dominating the shrub layer. Other shrubs may include *Salix barclayi*, *Salix lanata richardsonii*, and *Oplopanax horridus*. Associated herbaceous species include *Calamagrostis Canadensis*, *Gymnocarpium dryopteris*, *Sanguisorba stipulata*, *Streptopus amplexifolius*, *Pyrola asarifolia*, *Athyrium filix-femina cyclosorum* (Maritime), *Aconitum delphinifolium*, *Equisetum pretense*, and *Heracleum lanatum.*

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Populus trichocarpa-Alnus sinuata	This floristic class is dominated by *Populus trichocarpa* with a thick tall shrub layer of *Alnus sinuata*. These riverine maritime forests are characterized by *Trientalis europaea arctica*, *Gymnocarpium dryopteris*, *Calamagrostis Canadensis*, *Pyrola asarifolia*, *Equisetum sylvaticum*, *Equisetum arvense. Galium boreale*, *Rubus arcticus*, and *Thalictrum sparsiflorum*. *Climacium dendroides* is a commonly associated moss.
Populus trichocarpa-Oplopanax horridus	*Populus trichocarpa* forms an open broadleaf canopy below which *Oplopanax horridus* and *Alnus crispa* create a nearly impenetrable tall shrub layer. Closely associated species include *Athyrium filix-femina cyclosorum*, *Galium triflorum*, *Pyrola asarifolia*, *Dryopteris dilatata americana*, *Calamagrostis canadensis*, *Pyrola secunda*, *Equisetum arvense*, and *Streptopus amplexifolius*.
Populus trichocarpa-Viburnum edule	This floristic class is dominated by *Populus trichocarpa* with a diverse shrub layer of in which *Viburnum edule* is typically present but not necessarily dominant. Often no single shrub species is dominant in these stands. Commonly associated shrubs include *Ribes glandulosum*, *Ribes triste*, *Rubus spectabilis*, *Salix alaxensis*, *Salix barclayi*, and *Salix planifolia pulchra*. A suite of mesic forbs characterizes the understory, including *Athyrium filix-femina cyclosorum*, *Streptopus amplexifolius*, *Heracleum lanatum*, *Aconitum delphinifolium*, *Geranium erianthum*, *Thalictrum sparsiflorum*, *Viola epipsila repens*, and *Veratrum viride eschscholtzii*.
Puccinellia phryganodes-Triglochin maritimum	*Puccinellia phryganodes* and/or *Puccinellia nutkaensis* dominate these brackish to saline wet tidal flats. *Plantago maritime* co-dominates with the grasses. Associated species include *Stellaria humifusa* and *Triglochin maritimum*.
Rubus spectabilis-Oplopanax horridus	These dense shrublands commonly occur in forest gaps created by windthrown spruce and landslides in upland and lowland maritime forests. Dominated by *Rubus spectabilis* and *Oplopanax horridus* these stands are quite thick and the understory is heavily shaded, lending to a depauperate herbaceous layer. Associated species may include *Rubus pedatus*, *Dryopteris dilatata americana*, *Galium triflorum*, *Pyrola secunda*, and *Gymnocarpium dryopteris*.
Salix alaxensis-Alnus tenuifolia	This riverine tall shrub type is dominated by *Salix alaxensis* and *Alnus tenuifolia*. Characteristic understory species include *Trientalis europaea arctica*, *Calamagrostis Canadensis*, *Viola epipsila repens*, *Equisetum arvense*, *Polemonium acutiflorum*, and *Thalictrum sparsiflorum*. *Potentilla palustris* may occur in wetter microsites.
Salix alaxensis-Angelica lucida	This tall shrub type occurs on active and inactive co-alluvial fans in uplands and subalpine environments. *Salix alaxensis* consistently occurs and is often co-dominate with other *Salix* species, including *S. commutate*, *S. glauca*, *S. myrtillifolia*, and *S. planifolia pulchra*. A forb-rich understory consistently featuring *Angelica lucida* is characteristic of this floristic class. Closely associated species include *Geranium erianthum*, *Aconitum delphinifolium*, *Pyrola asarifolia*, *Sanguisorba stipulata*, *Pyrola secunda*, *Lupinus arcticus*, *Solidago multiradiata*, *Gymnocarpium dryopteris*, *Heracleum lanatum*, *Erigeron peregrinus*, *Dodecatheon frigidum*, *Artemisia tilesii*, and *Veratrum viride eschscholtzii*.

Table 7. Plant association descriptions, Lake Clark National Park and Preserve (LACL), southwest Alaska, 2011 (continued).

Floristic Class	Description
Salix reticulata-Carex podocarpa	*Salix reticulata* dominates a loose dwarf shrub layer that may include *Dryas integrifolia*, *Empetrum nigrum*, *Ledum decumbens*, *Loiseleuria procumbens*, *Salix rotundifolia*, *Vaccinium uliginosum*, and *Vaccinium vitis-idaea*. Sedges and grasses, including *Carex podocarpa*, *Festuca altaica*, *Hierochloe alpina*, *Trisetum spicatum spicatum* dominate the herbaceous layer in these alpine meadows. Other closely associated species include *Lycopodium alpinum*, *Artemisia arctica*, and *Solidago multiradiata*.
Salix rotundifolia-Carex microchaeta	*Salix rotundifolia* is the dominate dwarf shrub and often co-dominates with *Salix arctica*, *Salix phlebophylla*, and/*or Salix polaris*. While dwarf willows tend to dominate in this floristic class, their overall cover is typically low (10-20%). Other dwarf shrubs may also occur, including *Empetrum nigrum*, *Dryas integrifolia*, *Diapensia lapponica*, and *Cassiope stelleriana*. *Carex microchaeta* consistently occurs at low abundance. Other associated species include *Artemisia arctica*, *Epilobium latifolium*, *Claytonia sarmentosa*, *Luetkea pectinata*, *Oxyria digyna*, *Boykinia richardsonii*. Fruiticose lichens occur consistently but at low abundance. Common lichens include *Stereocaulon* sp., *Cladina arbuscula*, *Cladina mitis*, and *Cladina stellaris*.
Salix sp.*-Calamagrostis canadensis*	This floristic class broadly defined and encompasses a number of different *Salix* species that form low to tall shrub canopies with understories dominated by *Calamagrostis canadensis*. *Salix* species include *S. barclayi*, *S. barrattiana*, *S. commutate*, *S. fuscescens*, *S. glauca*, *S. lanata richardsonii*, and *S. planifolia pulchra*. Common associated species include *Epilobium angustifolium*, *Sanguisorba stipulata*, *Rubus arcticus*, *Aconitum delphinifolium*, *Pyrola asarifolia*, *Galium boreale*, *Equisetum arvense*, and *Geranium erianthum*. *Potentilla palustris* and *Carex aquatilis aquatilis* may occur in wetter microsites.
Umbilicaria sp.*-Rhizocarpon geographicum-Hierochloe alpina*	This floristic class occurs on rocky alpine barrens and is dominated by crustose lichens predominately *Umbilicaria hyperborea*, *Umbilicaria proboscidea*, and *Rhizocarpon geographicum*. Other common lichens include *Flavocetraria cucullata*, *Cladina stellaris*, *Stereocaulon* sp., *Thamnolia vermicularis*, and *Alectoria ochroleuca*. Vascular plants typically occur at very low abundance or are completely absent. Associated vascular plants include *Salix phlebophylla*, *Salix arctica*, *Dryas integrifolia*, *Hierochloe alpina*, and *Saxifraga oppositifolia*.
Vaccinium ovalifolium-Oplopanax horridus	These dense shrublands commonly occur in forest gaps created by windthrown spruce and landslides in upland and lowland maritime forests. *Vaccinium ovalifolium* dominates the overstory with lesser amounts of *Oplopanax horridus*, *Menziesia ferruginea*, and *Rubus spectabilis*. *Dryopteris dilatata americana*, *Rubus pedatus*, and *Trientalis europaea arctica* are characteristic understory species.
Vaccinium uliginosum-Carex microchaeta	*Vaccinium uliginosum* and *Empetrum nigrum* co-dominate the dwarf shrub layer while *Carex microchaeta* occurs consistently at low to moderate abundance. *Ledum decumbens*, *Diapensia lapponica*, *Arctostaphylos alpine*, *Salix reticulata*, and *Cassiope stelleriana* are other closely associated dwarf shrubs. Common associated herbaceous species include *Festuca altaica*, *Calamagrostis canadensis*, *Sanguisorba stipulata*, *Erigeron peregrinus*, *Lupinus nootkatensis*, *Ledum decumbens*, *Sedum rosea integrifolium*, and *Artemisia arctica*. Fruiticose lichens are typically sparse. However, *Cladina arbuscula* consistently occurs at low abundance.

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 landscape-soil-vegetation relationships that were used as the basis for classifying and mapping ecotypes (Figures 4–7). Vegetation classes follow the AVC (Viereck et al. 1992). Four toposequences representing distinct ecosystems within the study area are described below and summarize ecological relationships in maritime alpine-upland-glacial, northern interior alpine, and southern interior upland-lowland environments, and in a riverine environment unique in LACL to the Neacola River in the northern interior ecoregion.

On an alpine-upland-glacial toposequence in the martime ecoregion the bedrock geology was non-calcareous sedimentary rocks, including siltstone and sandstone (Figure 4). Small limestone outcrops were observed in the area but were not representative of the area as a whole. Geomorphology was dominated by hillslope colluvium, till and glacial ice, and ash-laden loess. Soils varied from rocky, organic carbon-rich, circum-acidic on mountain slopes; to acidic and sandy-rocky on recent ice-cored moraines and alpine summits; to fine, ash-rich, and acidic on ash-laden loess deposits. Vegetation ranged from ice, barrens, and Closed Tall Alder on ice-cored moraines; to barrens and Vaccinium and Cassiope Dwarf Shrub Tundra on alpine mountain slopes and summits; to Bluejoint-Herb Meadow and Open Tall Alder on upland mountain slopes.

On an alpine transect in the Telaquana Highlands in the northern interior ecoregion bedrock was granitic (Figure 5). The geomorphology was dominated by an older till sheet reworked extensively by periglacial processes, including frost-sorting and gelifluction; thin ash-laden loess deposits, narrow headwater floodplains; and thin (< 1 m) organic deposits over bedrock. Ice-rich permafrost may underlie large portions of this area. Soils varied from wet, ash-rich, and rocky in areas of sorted ground including complexes of hummocks and flooded sorted stone nets and non-flooded stone circles and nets, to moist and acidic and ashy to loamy on headwater floodplains and gelifluction lobes, and organic deposits in fens. Vegetation ranged from Wet Sedge Meadow Tundra in fens and sorted ground complexes to Moist Sedge Meadow Tundra, Moist Sedge-Shrub Tundra, and Dwarf Willow Shrub Tundra on sorted stone circles and nets, headwater floodplains, and gelifluction deposits.

On an upland-lowland toposequence in the southern interior ecoregion near Henmore Lake the geomorphology is characterized by glaciofluvial deposits, thick organic deposits, frozen glacio-lacustrine deposits, and headwater floodplains (Figure 6). Soils varied from moist, acidic, and ash-rich and rocky on upper slope positions on hills formed from glaciofluvial deposits; to wet, acidic, organic-deposits in bogs and headwater floodplains; to ice-rich permafrost in thick organic accumulations over glaciolacustrine deposits on toeslopes and valley bottoms. Vegetation ranged from Open Black Spruce Forest on hillsides and frozen valley bottoms, to

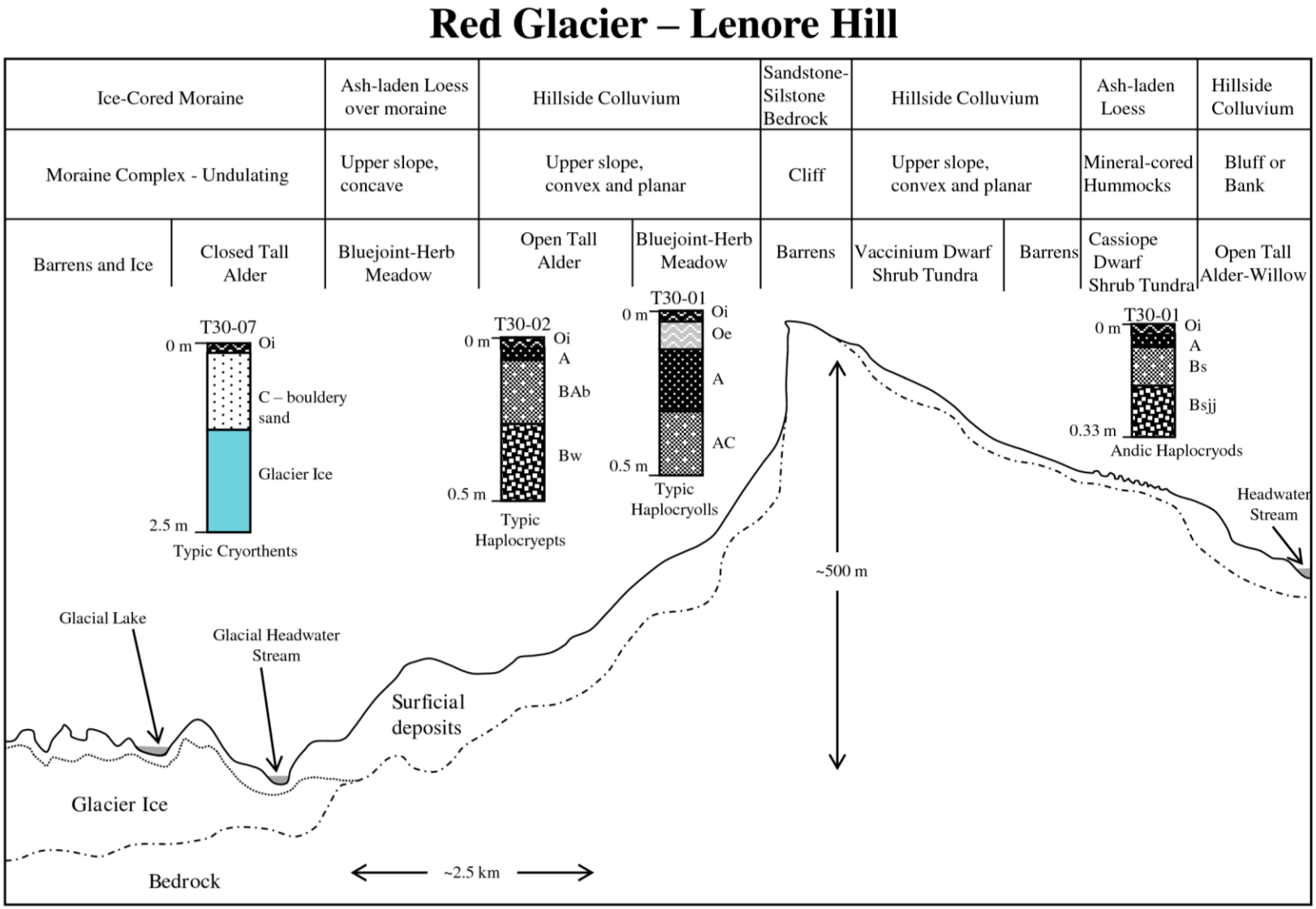


Figure 4. A generalized toposequence illustrating relationships among topography, geology, geomorphology, permafrost, soils, and vegetation; Red Glacier to Lenore Hill.

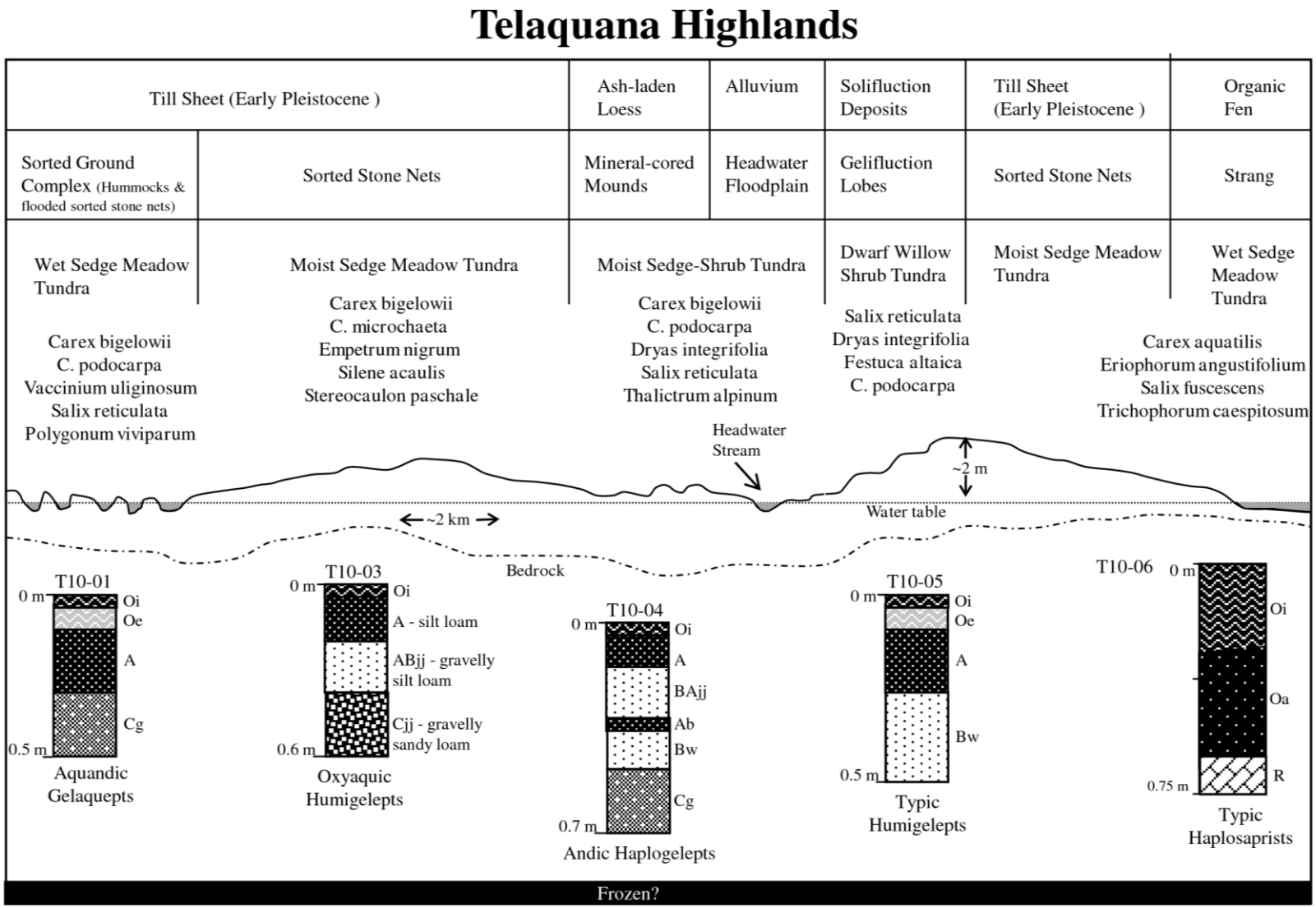


Figure 5. A generalized toposequence illustrating relationships among topography, geology, geomorphology, permafrost, soils, and vegetation; Telequana Highlands.

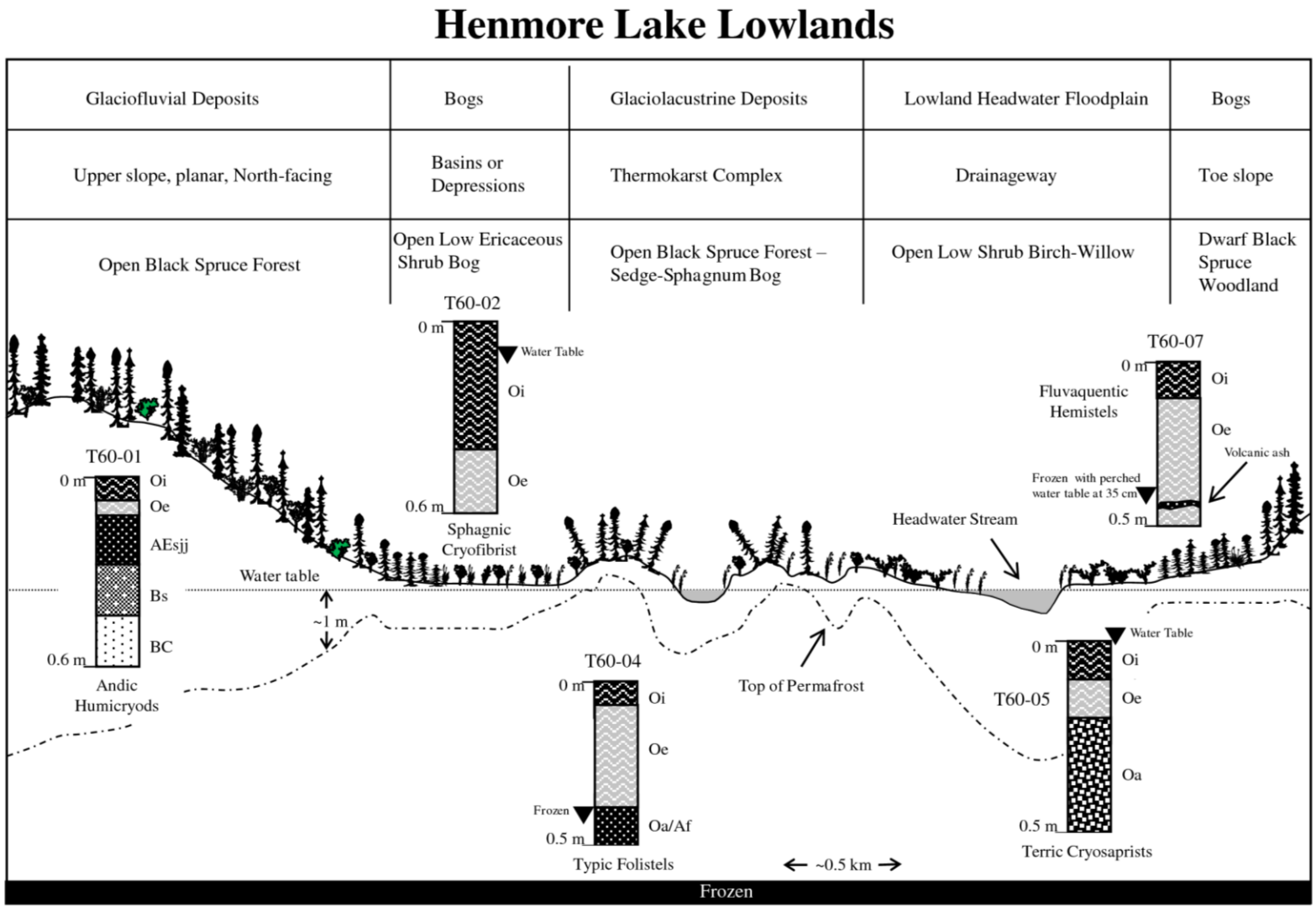


Figure 6. A generalized toposequence illustrating relationships among topography, geology, geomorphology, permafrost, soils, and vegetation; Henmore Lake lowlands.

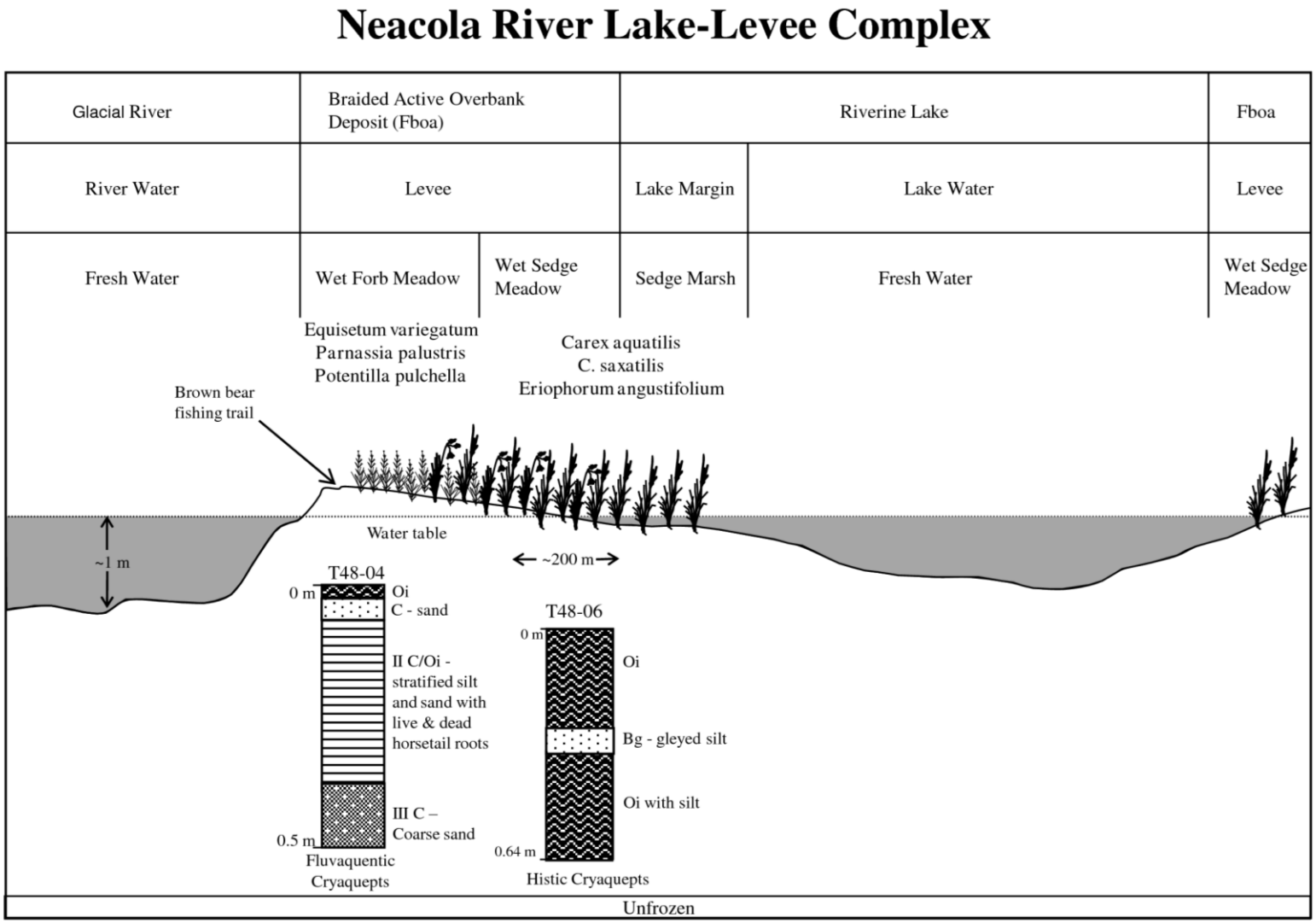


Figure 7. A generalized toposequence illustrating relationships among topography, geology, geomorphology, permafrost, soils, and vegetation; Neacola River Lake-Levee pond complex.

Open Low Ericaceous Shrub Bog and Dwarf Black Spruce Forest in bogs and on toeslopes, to Open Low Shrub Birch-Willow in headwater floodplains.

On a riverine toposequence in a levee-lake complex along the Neacola River geomorphology is dominated by active riverine overbank flooding and levee dynamics (Figure 7). Soils range from sandy-silty on upper levee positions to organic-rich on lower levee positions and along margins of riverine lakes. Vegetation varies from Wet Forb Meadow on sandier soils to Wet Sedge Meadow and Sedge Marsh on organic soils. The exact mechanism behind landform formation in these environments is in question. These landforms may be a relic of the Little Ice Age (LIA) resulting from the lowering of the Neacola River during the LIA. The lower water levels would have exposed river bottom sediments that were subsequently colonized by horsetails, thus stabilizing the soils. As the climate began to warm and the water level of the Neacola River rose, natural levee formation processes began to dominate, thus reinforcing this landform pattern. Many of these levees are breached, allowing river water to enter into the adjacent lakes. Over time the breaches become sediment filled and the lakes become isolated from the direct influx of river water. Beavers may also play a role in helping to re-inforce this pattern of levee-pond development in the Neacola River (P. Spencer, pers. comm.). It is likely that these lakes represent important salmon rearing areas. A brown bear fishing trail and predated salmon were observed along the margin of the one levee sampled in this ecotype.

Hierarchical Organization of Ecological Components

We developed hierarchical relationships among ecological components by successively grouping data from the 619 intensive plots by physiography, soil texture, geomorphology, slope position, surface form, drainage, soil chemistry, vegetation structure, and floristic class. Frequently, geomorphic units with similar textures or genesis were grouped (e.g., loamy and organic were grouped for some lowlands) to reduce the number of classes. Ecotypes then were derived from these tabular associations to differentiate sets of associated characteristics.

Analyzing the toposequences and cross-tabulation of the plot data revealed consistent associations among soil texture, geomorphic units that denote depositional environments, slope position, surface forms related to hydrology, and vegetation structure (Appendix 12). 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, subalpine, upland, lowland, lacustrine, riverine, and coastal areas (see section on Factors Affecting Landscape Evolution). Identifying the changing patterns in geomorphic units and vegetation, along with analysis of changes in soil properties, helps identify processes (e.g., acidification, sedimentation) that affect the changing patterns. Second, the hierarchical relationships developed “from the ground up” were used to determine the rules for modeling and restricting the distribution of map classes “from the top down” (see Methods, GIS Modeling). Third, knowing the ecological relationships, we could recode the strata × land cover classes (Appendices 6 and 7) and derive ecological characteristics, such as an ecotype

map, soil landscape map, or disturbance regime map (see Results, Classification and Description of Soil Landscapes).

The contingency table analysis also can be used to evaluate how well these general relationships conform to the data set, and how reliably they can be used to extrapolate trends across the landscape. During development of the relationships, approximately 12% of the observations (71 plots) 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 12%) of sites that do not conform to the overall relationships among factors. These sites may be: (1) transitional (ecotones); (2) sites where vegetation and soils have been affected by historical factors (e.g., changes in water levels, disturbances) in ways that are not readily explainable based on current environmental conditions; 3) vegetation and soil types that are prevalent on the landscape but were inadequately sampled; or (4) rare and thus not mappable.

Environmental Characteristics

Single-factor Comparisons by Ecotype:

Six environmental parameters (pH, electrical conductivity, surface organic-horizon thickness, depth to groundwater, rock depth, and elevation) were charted for comparison among ecotypes (Figure 8). We excluded ecotypes with insufficient data.

The thickness of the surface organic horizon showed large differences among sites (Figure 8). Ecotypes where surface organic accumulations were absent ranged from areas with severe climate and soil conditions, such as Alpine Rocky Barrens and Alpine Gelic Rocky Barrens; to areas with frequent sediment deposition, such as Riverine Silty-Sandy-Rocky Barrens; and areas that have had little time for vegetation and soil development including Interior Lacustrine Loamy-Rocky Barrens and Glacial Sandy-Rocky Barrens Barrens. The thickest surface organic accumulations were found in bogs and fens, including Interior Lacustrine Organic-rich Sedge Marsh, Interior Lacustrine Organic-rich Sedge-Shrub Bog, and Lowland Organic-rich Sedge-Shrub Bog, indicating long-term paludification and reduced frequency or absence of sedimentation events; and environments characterized by permafrost, including Interior Lowland Frozen Loamy-Organic Black Spruce Forest.

Depth to > 15% rocks was shallowest on exposed slope positions (e.g., Alpine Gelic Rocky Barrens) and active alluvial fans and rocky hillsides (e.g., Interior Subalpine Rocky Alder-Willow Shrub), and deepest in organic-rich lowland and lacustrine environments and coastal areas with fine-grained deposits (e.g., Interior Lacustrine Organic-rich Sedge Marsh, Maritime Coastal Loamy Saline Wet Sedge Meadow). Ecotypes with rock depths ≥ 1.5 m represent an estimated minimum depth.

Depth to water above (+) or below (–) the surface also varied widely among ecotypes, but relatively little within ecotypes. Mean water depths were above the soil surface for 14 ecotypes, and were highest for Lowland Lake and riverine water ecotypes, including Riverine Glacial

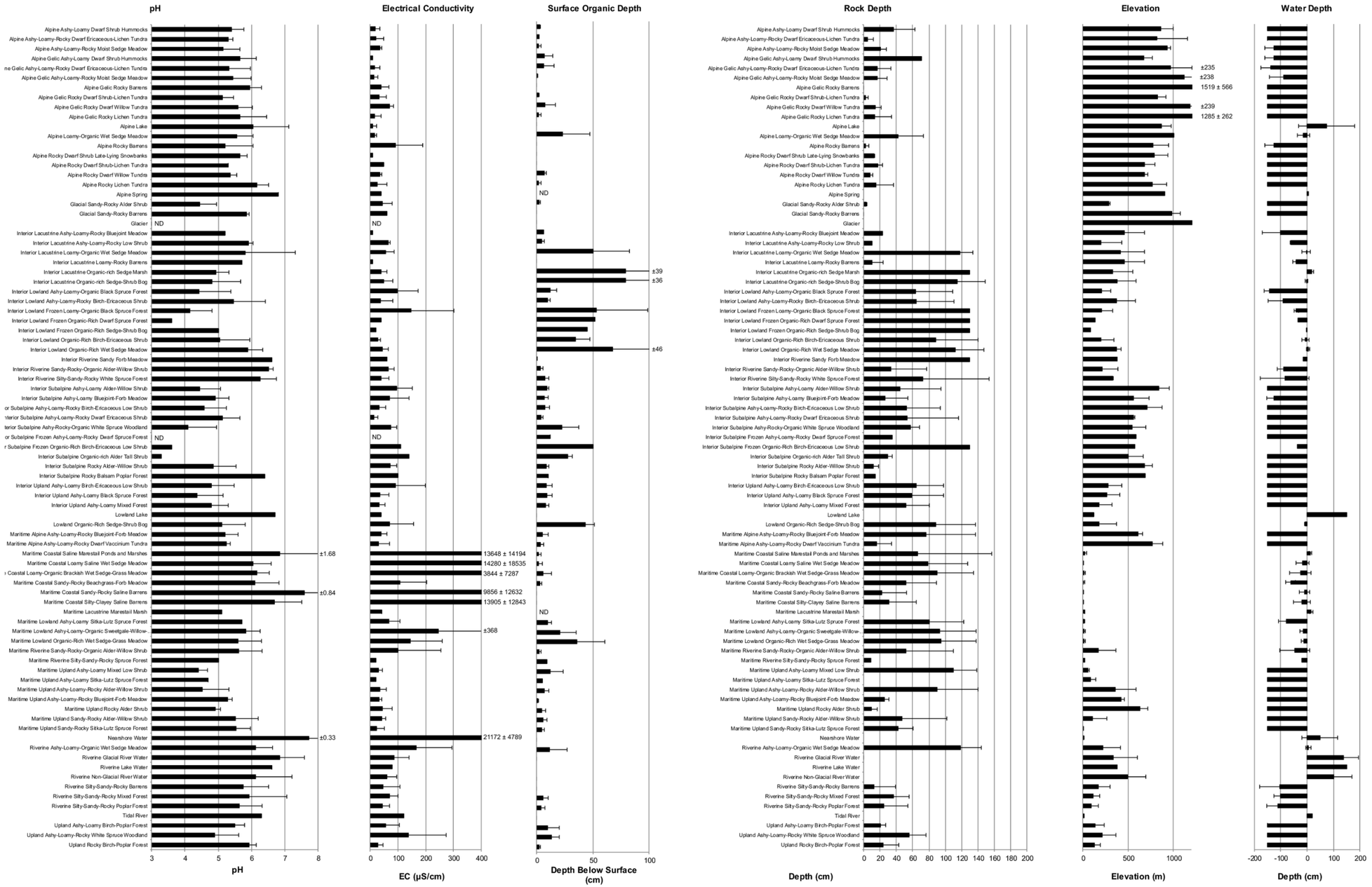


Figure 8. Mean (± SD) site pH, site electrical conductivity, surface organic depth, rock depth, water depth, and elevation in Lake Clark National Park, Alaska. ND indicates no data. For water depth and rock depth measurements ≥ 150 cm indicate minimum depth, not true depth.

River Water, Riverine Non-glacial River Water, Riverine Lake Water, and Tidal River. Ecotypes with the deepest water tables were found in alpine, subalpine, and uplands areas with ashy and rocky soils, including Alpine Ashy-Loamy-Rocky Dwarf Ericaceous Lichen Tundra, Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub, and Maritime Upland Rocky Alder Shrub. Values ≥ 1 m represent minimum, estimated depths.

Overall, soil pH in LACL was typically acidic (≤ 5.5) to circum-acidic (~5.5–6.5). However, soil pH values ranged widely, from 3.2–9.0 among physiography and ecotype. Ecotypes with the lowest (most acidic) pH values occurred in Subalpine and Upland Alder, spruce, and birch-ericaceous dominated ecotypes (e.g., Interior Subalpine Organic-rich Alder Tall Shrub, Interior Upland Ashy-Loamy Black Spruce Forest) and in lowland and lacustrine bog ecotypes characterized by abundant *Sphagnum* (e.g., Interior Lacustrine Organic-rich Sedge-Shrub Bog). Nitrogen fixation from Alder and organic acids from spruce, ericaeous, and *Sphagnum* lower the pH in these ecotypes. The forested ecotypes also occur in older, more stable environments in which much of the soil cations have been leached from the soil over long time periods. Ecotypes with the highest pH occurred in coastal and riverine environments with frequent influx of fresh sediments (e.g., Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub), waterbody ecotypes (e.g., Alpine Spring) and in recently exposed till deposits in which insufficient time has passed for cation leaching or the accumulation of organic acids (e.g., Glacial Sandy-Rocky Barrens).

Electrical conductivity (EC) measurements indicated that ecotypes in northern and southern interior ecoregions, and alpine, upland, riverine, and most lowland maritime ecotypes were non-saline. However, a few lowland maritime ecotypes were slightly brackish (800–2000 µS/cm; e.g., Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow). Brackish (800–18,000 µS/cm) to saline (>18,000 µS/cm) ecotypes were limited to coastal environments in the maritime ecoregion (e.g., Maritime Coastal Loamy Saline Wet Sedge Meadow, Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow). EC values were low (<200 µS/cm) in nearly all other ecotypes. Variability was low within non-saline ecotypes and high within brackish and saline ecotypes.

Overall, elevation values in the dataset ranged from sea level along the Cook Inlet coast to nearly 2000 meters in the mountains. Elevation ranged broadly between ecotypes occurring in different physiography classes, and less so between ecotypes within each physiography.

Vegetation Composition

Species Summary:

There were 91 ecotypes, consisting of 93 AVC vegetation classes at the plot level and 71 plant associations (Table 6). The AVC vegetation classes included 3 barrens or partially, 26 forested (including 2 dwarf classes), 4 moss or lichen, 6 forb, 23 graminoid, 8 dwarf shrub (≤ 0.20 m), 15 low shrub (0.20–1.5 m), 6 tall shrub (≥ 1.5 m), and 2 water vegetation structure classes. We recorded 366 vascular and 133 non-vascular species, excluding subspecies (Appendices 1 and 2). However, due to our sampling methods (in some instances excluding trace taxa) and analysis (use of data from outside LACL) this should be considered an approximate minimum number of species in LACL as a comprehensive floristic survey was beyond the scope of this project.

Ordination of Vegetation:

In addition to the single-factor comparisons, non-metric multidimensional scaling (NMDS) (Shepard 1962a,b; Kruskal 1964a,b) was used to separate 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. Because of the large number of species, ecotypes, and differing environmental gradients, the ordinations were completed separately for each physiographic grouping (Figures 9–11). Within each physiographic grouping, species occurring at less than 3% cover were removed, prior to analysis. Each physiographic ordination was computed using a Bray/Curtis dissimilarity matrix calculated from the abundance data for each physiographic group (Bray and Curtis 1957). The combined effects of physiography and various environmental variables were assessed by superimposing the ecotype class for each plot on the ordination. On the ordinations, the central cluster of each ecotype was circled and outliers were occasionally excluded to better differentiate highly central tendencies. The ordinations reveal which ecotypes had very similar species composition, those with distinct species assemblages, and the diversity of species composition within ecotypes.

Alpine and glacial ecotypes had few very distinct classes and many classes had substantial overlap among ecotypes (Figure 9). Glacial Sandy-Rocky Alder Shrub, Alpine Gelic Rocky Lichen Tundra, Alpine Ashy-Loamy Dwarf Shrub Hummocks, Alpine Rocky Dwarf Shrub-Lichen Tundra, Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow, and Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra had the most distinct vegetation assemblages. Significant overlap occurred between Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra, Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra, Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow, and Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks.

Subalpine ecotypes had fairly distinct separation in species assemblages (Figure 9). The overlap that did occur between ecotypes was related to ecotypes with distinct soils but with similar vegetation (e.g., Interior Subalpine Ashy-Loamy Alder-Willow Shrub and Interior Subalpine Rocky Alder-Willow Shrub).

Coastal ecotypes had distinct separation in species assemblages (Figure 10). There was little overlap among any of the ecotypes. Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow was the most floristically diverse ecotype and overlapped slightly with Maritime Coastal Loamy Saline Wet Sedge Meadow. Axes one and two revealed a gradient from saline, silty-clayey barrens and sedge meadows in the upper right corner, to sandy beach grass-forb meadows on the far left, to brackish loamy-organic sedge and grass meadows spanning across Axis 1 in the center of the ordination. The broad central grouping corresponds with the ecotype Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow, which includes plots ranging from strongly brackish (upper end of axis 2) to slightly brackish (lower end of axis 2).

Lowland and lacustrine ecotypes had good distinction in species assemblages (Figure 10). Some overlap occurred between Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow and Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub, and Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub and Interior Lowland Ashy-Loamy-Organic Black Spruce Forest. Axes one and two revealed a gradient from moist, ashy-loamy-

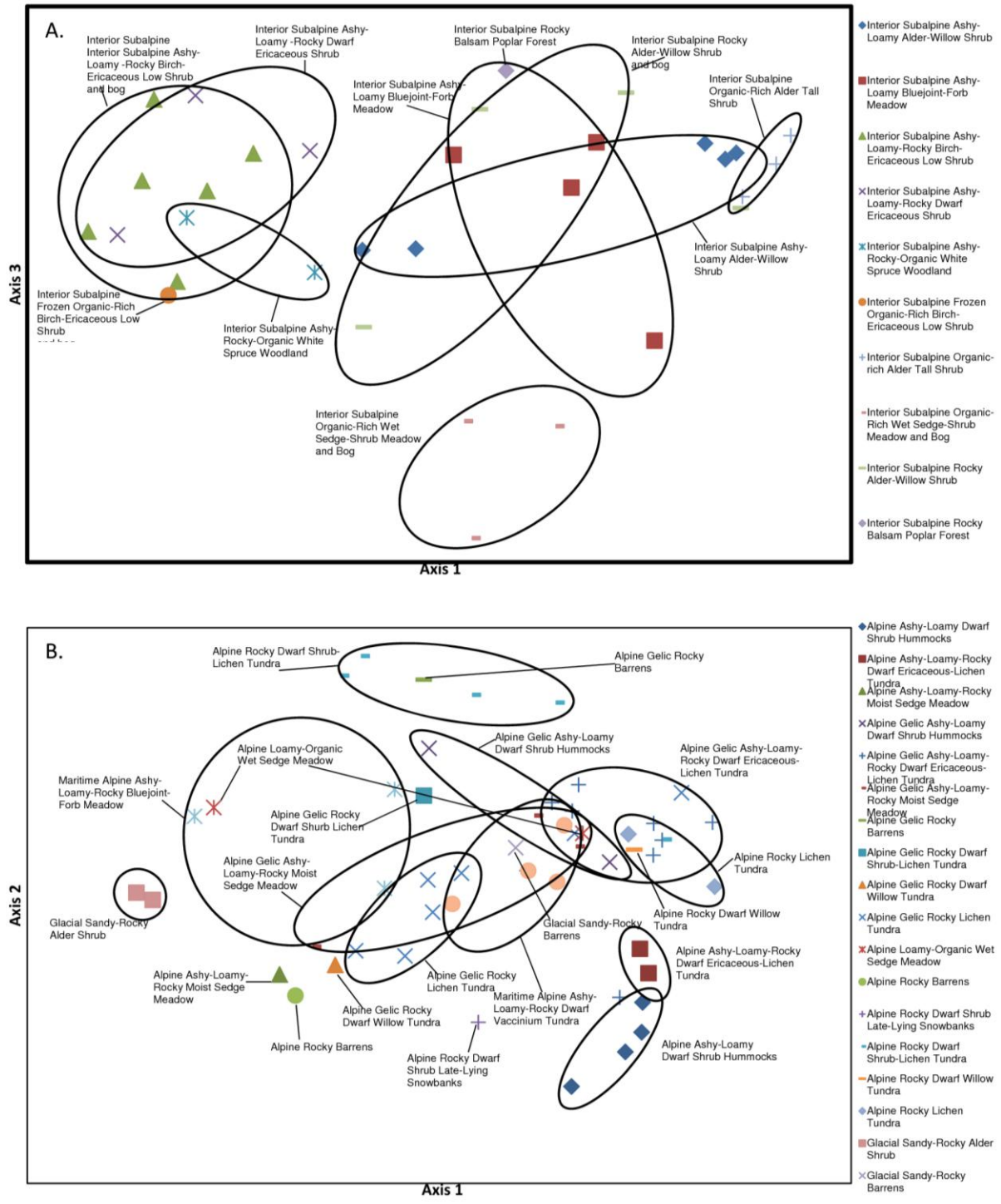


Figure 9. Non-metric multidimensional scaling of species composition for subalpine (A) and alpine/glacial (B) ecotypes in Lake Clark National Park and Preserve, Alaska.

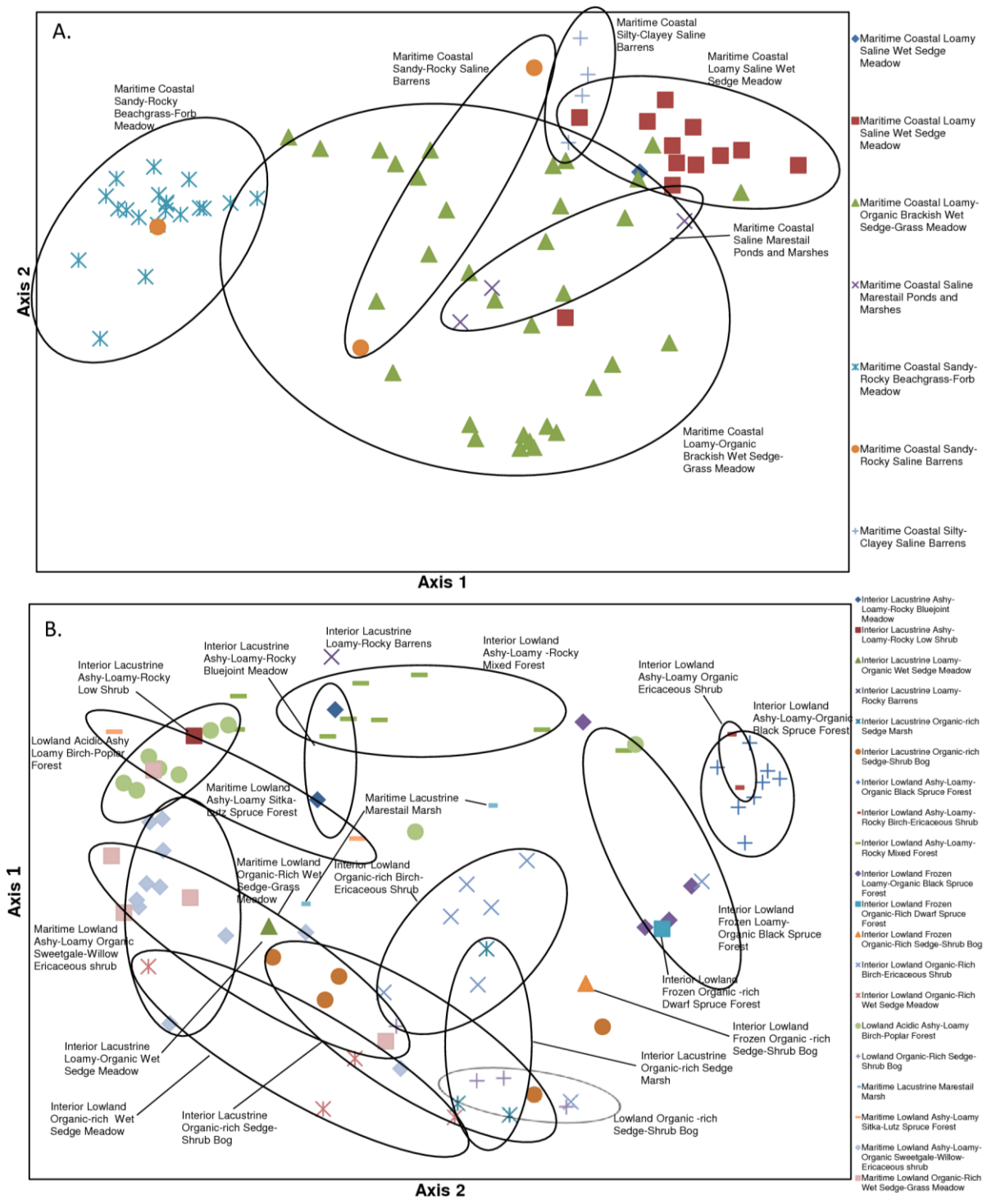


Figure 10. Non-metric multidimensional scaling of species composition for coastal (A) and lowland-lacustrine (B) ecotypes in Lake Clark National Park and Preserve, Alaska.

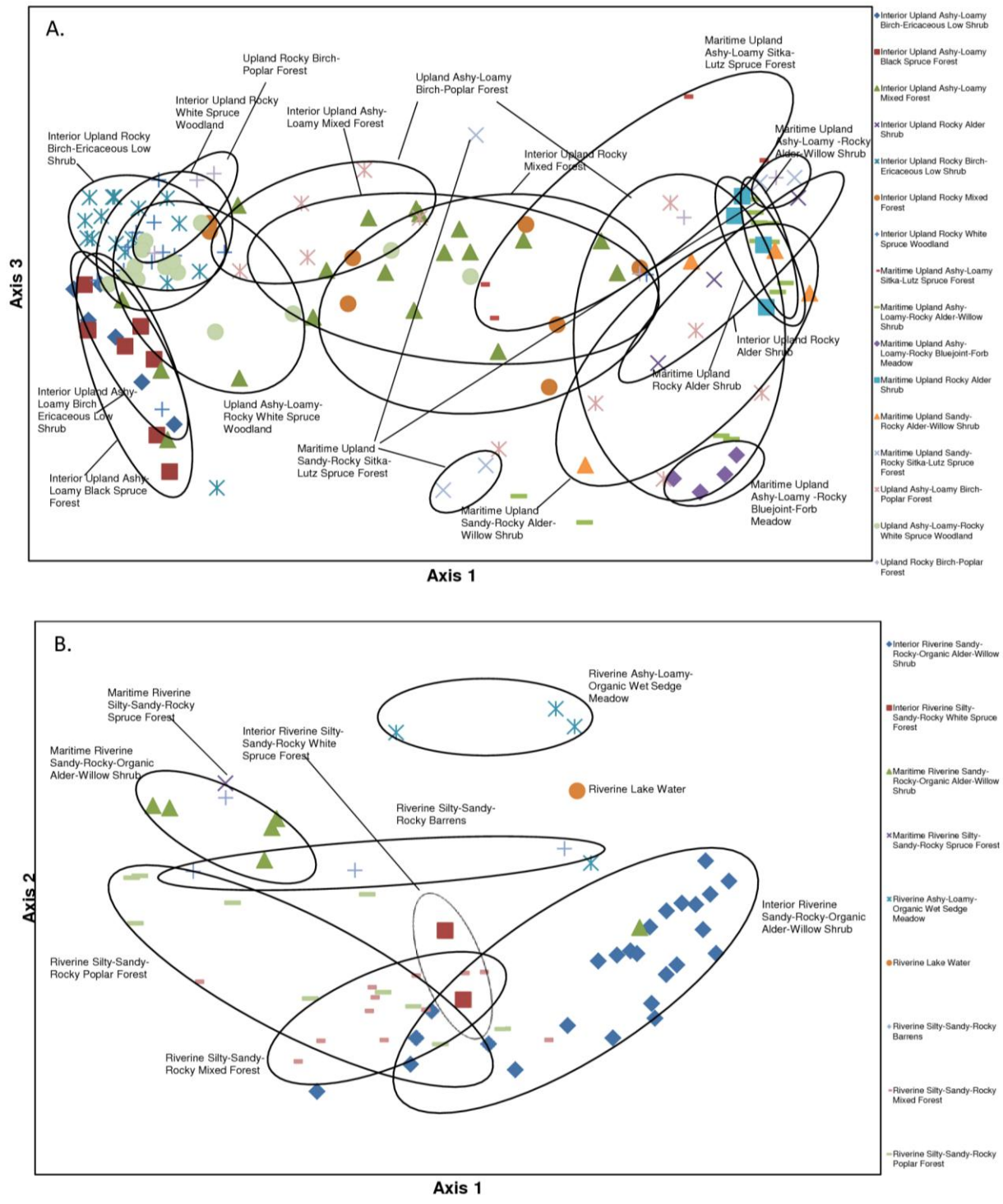


Figure 11. Non-metric multidimensional scaling of species composition for upland (A) and riverine (B) ecotypes in Lake Clark National Park and Preserve, Alaska.

organic black spruce forests in the upper right to broadleaf forests in the upper left with mixed forests occurring in the upper center. Wet, organic rich meadows, bogs, and marshes occur in the lower center of the ordination implying a moister, organic content gradient along axis 2.

Upland ecotypes had few very distinct classes and many classes had substantial overlap among ecotypes (Figure 11). However, much of the overlap was related to ecotypes with distinct soils but with similar vegetation (e.g., Interior Upland Rocky White Spruce Woodland and Interior Upland Ash-Loamy-Rocky White Spruce Woodland). An exception to this trend is the strong overlap between Interior Upland Ashy-Loamy Black Spruce Forest and Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub. This is likely related to the high abundance of *Ledum decumbens* and *Betula nana* in the understory component, and relatively low abundance of *Picea mariana* in the ecotype Interior Upland Ashy-Loamy Black Spruce Forest. A few ecotypes did show distinct groupings, including Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow and Interior Upland Rocky Birch-Ericaceous Low Shrub.

Riverine ecotypes had good distinction between species assemblages (Figure 11). Some overlap occurred between Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub and Riverine Silty-Sandy-Rocky Popular Forest. Axes one and two revealed a gradient from wet sedge meadows in the upper center of the ordination, to interior alder-willow and mixed forests in the lower right, to maritime alder-willow and barrens in the center left of the ordination. Riverine Silty-Sandy-Rocky Poplar Forest occurs as two distinct groupings corresponding to those *Populus trichocarpa* dominated stands with strongly maritime species assemblages (center, left) and *P. balsamifera* stands (bottom, center) with a mixture of interior and maritime species assemblages.

Sorted Tables:
Sorted vegetation tables (Tables 8–12) were constructed to provide a more direct means of comparing similarities and differences in floristic composition of closely associated ecotypes (horizontal order) and for evaluating the association of species along environmental gradients (vertical order). Plots that were identified as outliers in the floristic analysis were excluded from calculations and the tables include 1) only those ecotypes with more than one plot (after outliers were removed), and 2) only those species that occurred at relatively high frequency in an ecotype ($\geq$ 40% of the plots). These tables associate common species within an ecotype. Similarities and differences in species composition on the sorted tables are consistent with the NMDS results.

Ecosystem Mapping

Two sets of map products were developed by the mapping effort for LACL: 1) a series of GIS modeling products that were the base layers for the ecosystem mapping and that in many cases represent useful stand-alone products, and 2) a series of ecosystem maps, including ecotype, soil landscape, and disturbance landscape. The first set of map products and the ecotype and disturbance landscape maps are described below, while the soil landscape map is described in a later section.

Table 8. Mean plant cover by alpine, glacial, and subalpine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5%.

	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Organic-Rich Alder Tall Shrub	Glacial Sandy-Rocky Alder Shrub	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Rocky Lichen Tundra	Alpine Rocky Lichen Tundra	Alpine Gelic Rocky Dwarf Willow Tundra
Differential Taxa																						
Potentilla palustris	**6.7**			0																		
Eriophorum russeolum	0.7																					
Carex aquatilis aquatilis	**15.7**	10																				
Salix fuscescens	**15**	3.5									0.2	**1**				0.1						
Eriophorum angustifolium	**3.3**	**6**																				
Carex rariflora	**2**	1.5																				
Andromeda polifolia	0	0.5									0.2											
Carex bigelowii		7.5	**12**	0.2							0.3					0.6						
Arctagrostis latifolia		1	1	0.5																		
Polygonum bistorta		0.5	0.7													0.1		0				
Senecio atropurpureus		0.5	0.7													0.1						
Valeriana sitchensis		0.5	0.7																			
Pedicularis verticillata		0.5	0.3											0								
Luzula multiflora		0	0.4																			
Polygonum viviparum		0	0.3																		0	
Trichophorum caespitosum		2.5																				
Anemone parviflora		0.5																				
Senecio lugens		0.5																				
Solidago multiradiata var. multiradiata		0.5																				
Polytrichum sexangulare			3.3																			
Racomitrium sudeticum			3.3																			
Carex dioica gynocrates			1.7																	0.7		
Lagotis glauca glauca			0.3																0			
Thalictrum alpinum			0.3																			
Vahlodea atropurpurea				1.2											0.2			0				
Carex macrochaeta				1																		
Rubus arcticus stellatus				0.8																		
Senecio triangularis				0.5																		
Epilobium angustifolium				**28**	**9.3**	**3.4**	**2**		1.5		0.7	1	0.8									
Gymnocarpium dryopteris				21.2	1.7	3	**4**	0.7														

Table 8. Mean plant cover by alpine, glacial, and subalpine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Organic-Rich Alder Tall Shrub	Glacial Sandy-Rocky Alder Shrub	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Rocky Lichen Tundra	Alpine Rocky Lichen Tundra	Alpine Gelic Rocky Dwarf Willow Tundra
Sanguisorba stipulata		0	0.3	3.8	**6.3**	**5.2**	3.5				0.2	1	0.8	**1.5**			1				
Geranium erianthum				**3.8**	**2.7**	1.2	**2.8**														
Heracleum lanatum				0.5	3.3	1	5														
Angelica lucida				**3.2**	**1**		**1**							0.5							
Veratrum viride eschscholtzii				0.2	1.7		0.5	1								0					
Trientalis europaea arctica				0.5		**2**	0.2				0.2										
Pyrola grandiflora				0.2		0.6	0.2														
Artemisia tilesii					**2.3**	0.6	0.5						0.8								
Athyrium filix-femina cyclosorum				0.8	5				2.5												
Sanionia uncinata				0.8		0.8				0.2											
Valeriana capitata				0		0															
Rosa acicularis				1.2			0.5														
Poa arctica				1			0.8														
Polemonium acutiflorum				0.2			0.2														
Pyrola asarifolia					1.7		1.8														
Thelypteris phegopteris					**11**																
Vaccinium ovalifolium					4												0.5				
Salix barclayi					2.7																
Lycopodium selago		0.3			2.7		0.5									0.2		0	0		
Danthonia intermedia					1.3																
Actaea rubra					0.7																
Achillea millefolium					0.3																
Arnica amplexicaulis					0.3																
Salix lanata richardsonii						2															
Viburnum edule						1															
Petasites frigidus						0.6															
Rhytidiadelphus squarrosus						0.6															
Plagiothecium laetum						0.2															

Table 8. Mean plant cover by alpine, glacial, and subalpine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Organic-Rich Alder Tall Shrub	Glacial Sandy-Rocky Alder Shrub	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Rocky Lichen Tundra	Alpine Rocky Lichen Tundra	Alpine Gelic Rocky Dwarf Willow Tundra
Salix glauca						4	5				3.8			0.5		0.6					
Linnaea borealis						**2.4**	4							0.5							
Equisetum pratense						0.6	0.2														
Pyrola secunda						0	0.8														
Streptopus amplexifolius						0.4	0.2														
Anemone richardsonii						0.2	0.2														
Climacium dendroides				0		0.2	0.2														
Alnus crispa						**49**	20.5	**73.3**	**62.5**	1.5			1.2								
Dryopteris dilatata americana			0	0.5		1	8.8	**47.3**	**6**												
Ribes triste						0.4	1.8	1.7													
Brachythecium starkei						0.2	6		0.8												
Salix barrattiana						12		5				0		2.5							
Ribes glandulosum							1.8		0.5												
Salix alaxensis				0			**13.5**														
Salix myrtillifolia							11.2														
Salix commutata							5														
Shepherdia canadensis							1.2														
Lupinus arcticus							0.8														
Equisetum arvense	1	0.3	0.5			0.6		5		0.5				0.5							
Trientalis europaea								3.3													
Viola epipsila repens								3.3													
Betula papyrifera								1.7													
Sorbus scopulina								1.7													
Oplopanax horridus									5												
Sambucus racemosa									**2**												
Aruncus sylvester									1												
Brachythecium nelsonii									1												
Epilobium ciliatum									0.5												
Rubus spectabilis									0.5												
Carex gmelinii									0.5												
Picea glauca		**0.4**								**12.5**	0	1				0.1		0			
Sphagnum girgensohnii										7.5											

Table 8. Mean plant cover by alpine, glacial, and subalpine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Organic-Rich Alder Tall Shrub	Glacial Sandy-Rocky Alder Shrub	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Rocky Lichen Tundra	Alpine Rocky Lichen Tundra	Alpine Gelic Rocky Dwarf Willow Tundra
Populus tremuloides										1											
Betula nana	0.3			0		0.2				**10**	**15**	3.3		**4**		6.1					
Betula glandulosa			0							7.5	12.3	**1.7**				0.1			0.2		
Peltigera aphthosa										1	**1.3**	**0.8**				0.3					
Peltigera malacea										0.5	0.2	0.7									
Cornus canadensis										**6**	0.8										
Cladina arbuscula		1.5								2.5	**3.2**	**1.7**	1.8	**2.5**	**1.8**	**5.9**	3.5	2	4.4		
Vaccinium uliginosum	1	2.5	**1.3**		0.3	1	0.5			**37**	**10.2**	**8.7**	**21.2**	**10.5**	0.2	**6.9**		**1.2**	0.4	2.5	
Cladina stellaris			2.3								**1.5**	**1.7**		0.5		3.9		2	1.4	**25**	
Flavocetraria cucullata											1	**1.3**		0.5		0.3		**1.2**	1	7.5	
Trisetum spicatum spicatum											0.2	1.7		2.5				0	0.1	0	0.1
Arctostaphylos alpina			0							1.5	2.5		3.8			0.3		0.2	0.1		
Thamnolia vermicularis											0.2		0.2			**2.8**		**0.6**	1.7	2.5	
Lycopodium alpinum					**2.3**									**1.5**	**6.8**	0.4	1.5				1
Nephroma arcticum											0.3	0.3			0.2	1					
Cetraria cf. islandica											0.3					0.3	1.5	0.2			
Cladina rangiferina											0.5			1		0.3					
Spiraea beauverdiana			0	0.8		0.6					2.7					0					
Rhytidium rugosum											1.3										
Rubus chamaemorus											0.8										
Polytrichum strictum											0.7										
Sphagnum rubellum											0.5										
Carex laeviculmis											0.3										
Cladonia uncialis											0.2										
Salix sitchensis												2.7									
Salix arbusculoides												1									
Picea mariana												**0.7**				0.2					
Stereocaulon paschale			1									5									
Lupinus nootkatensis				0.5									2	0.5							
Salix ovalifolia													2								
Erigeron peregrinus	0						0.2						0.8	0	0						
Timmia austriaca													0.8								

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	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Organic-Rich Alder Tall Shrub	Glacial Sandy-Rocky Alder Shrub	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Rocky Lichen Tundra	Alpine Rocky Lichen Tundra	Alpine Gelic Rocky Dwarf Willow Tundra
Brachythecium albicans													0.5								
Cassiope stelleriana													0		**48.8**	2.2	**27.5**				
Luetkea pectinata													0.2		**16.8**	3.3	**17.5**				
Phyllodoce aleutica					0.3										0.5	0.3	1.5				
Cladonia bellidiflora															**3**		1				
Salix arctica			0										0.5		**1.5**	0.3	**4**	**1.8**	0.4	**5.5**	0.2
Racomitrium lanuginosum														1		0.1			2.9		0.5
Salix rotundifolia			0.3												2.5	0.8			1.7		**8**
Cladina mitis		5											0.5		**2.8**					15	
Arctostaphylos rubra													0.5			0.3		1.6			
Dryas octopetala														1.5		2.3		**8.6**			
Pedicularis capitata														0		0.1		**0.1**			
Cladina stygia															1.2			1		5	
Campanula lasiocarpa																0.1		**0.1**			0
Solidago multiradiata		0.3				0.2								**5**							1.5
Potentilla fruticosa						0.2								4.5		0.1					
Ptilidium ciliare					0.3					0.5	0.5			**3.5**							
Dicranum acutifolium															7.5						
Carex mackenziei															1						
Cetrariella fastigiata															1						
Rhytidiopsis robusta															0.8						
Cladonia gracilis															0.8						
Racomitrium canescens																1.1					
Aulacomnium turgidum																0.7					
Carex lugens																0.6					
Alectoria nigricans																0.6					
Ochrolechia frigida																0.6					
Astragalus umbellatus																0.1					
Cassiope mertensiana																0.1					
Tofieldia pusilla																0.1					
Salix phlebophylla		0.3														0.6		0.8	0.4		
Oxytropis nigrescens																0		**0.3**			

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	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Organic-Rich Alder Tall Shrub	Glacial Sandy-Rocky Alder Shrub	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Rocky Lichen Tundra	Alpine Rocky Lichen Tundra	Alpine Gelic Rocky Dwarf Willow Tundra
Anemone narcissiflora				0												0.1		**0.1**				
Cassiope tetragona			**0.7**													2.2			1			
Alectoria ochroleuca																0.3			0.6			
Artemisia borealis																0.2			0.3			
Umbilicaria proboscidea																			6.1	5		
Potentilla uniflora																			0.1	0.5		
Cladonia ecmocyna																	2					
Carex nesophila																		**1.2**				
Salix polaris																		0.6				0
Arnica lessingii		0.5	0.3															**0.6**				
Antennaria monocephala																		**0.4**				
Minuartia macrocarpa																		**0.4**				
Artemisia arctica arctica																		**0.4**				
Hierochloe pauciflora																		0.4				
Sphaerophorus globosus																		0.2				
Artemisia globularia																		**0.1**				
Rhizocarpon geographicum																0.1			5.9			
Umbilicaria hyperborea																			4.3			
Polytrichum piliferum																			0.9			
Solorina crocea																			0.3			
Dactylina arctica																			0.1			
Saxifraga oppositifolia																			0	1.5	0	
Dryopteris fragrans																				1.5		
Saxifraga bronchialis																		0		1		
Minuartia arctica																		0		0.5		
Saxifraga hirculus																				0.5		
Tomentypnum nitens																					15	
Aulacomnium palustre	0.2									1.5											5	
Saxifraga punctata																					2	
Oxyria digyna																					1.5	
Claytonia sarmentosa																					1	
Festuca rubra																					1	

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Carex lachenalii																						1
Common Taxa																						
Empetrum nigrum	0.3	2.5	**10**		**4**	0.6	1.2			2.5	**11.3**	**23.3**	**11.2**	**22.5**	2.5	**19.9**	**12.5**	**3.6**	1.4	2.5	5
Vaccinium vitis-idaea		1	1.7	0.8		0.4				**4**	**2.7**	**2**	**1.2**	1		**2.3**	1	**0.6**	1.1	0.5	1
Festuca altaica		0.5	**2**	1.2	3.3		0.2				**2.8**	4	1.5	**6**	0	0.6	1.5		0.3		7.5
Salix planifolia pulchra	**1.4**	1	1	0		8	7.5				0.5	1		0.5		0.6		0.4			0.5
Sedum rosea integrifolium	**0.4**	0	**0.7**	0			**1.1**							0.5	0	0.3		0	0.3	0.5	0.5
Calamagrostis canadensis	**4**			**20**	**18**	**16**	**12.5**	**2.3**	**2.5**	1.5	1.3	**3.3**	2.2	**10.5**							
Carex podocarpa		1	1		1.3						1.2	**4.4**		5	0.2		**3**	0.6	0.6	0.5	3
Ledum decumbens			0.3			0.6				**2.5**	**10.5**	**4.3**	0.5	**2.5**		**4.2**		**1.4**	0.6		0.5
Loiseleuria procumbens			1								0.3	0.3	0.2	0.5	0.8	2.2		**2.4**	1.6	1	1
Polytrichum juniperinum			0.8	1.3	**1.6**			**0.8**			2.7	**0.8**	0.8	1	0	0.4			0.6		
Pleurozium schreberi	10	5	0.8			0.2			3	**6.3**	0.3			2.5		0.8					**17.5**
Artemisia arctica	1	**0.7**											0	**2.5**	0.3	0.7		0.4	0.3	1.5	1.5
Carex microchaeta		**5.7**										1.7	**7**	2.5		3.3	0	0.4	0.9	0.5	**4**
Hierochloe alpina	0	**1.3**									0.7			**8**		1		**0.2**	0.2	0	0.5
Hylocomium splendens			0.8			1	2.5		22.5	3.3	**0.8**			2		1.1		0.2			
Epilobium latifolium				5	0.2	0.5		0.5					1.2		0	0				0.5	1
Aconitum delphinifolium	1	1.7	1		0.2	0.5									0						0.5
Salix reticulata	0	2.3											3.8	**7.5**		1.3		0.8			7.5
Diapensia lapponica		0.3											0.2			1.1	1	**0.8**	1.1	1	
Rubus arcticus			0.5	**3.3**	**1.8**	0.5						**1**	1	0.5							
Gentiana propinqua	0	0				0								0	0.5						0
Dryas integrifolia	1.5	**4**														0.6		1.4	2.9		7.5
Lycopodium annotinum					**2.2**	1.2					0.5			0.5	0.2		1				
Achillea borealis			0.5	**2**		0.2								0.5			0				
Flavocetraria nivalis	0	0.3									0.3					2					
Luzula arcuata		3.3															1.5	0	0.1		
Accidental Taxa																					
Deschampsia caespitosa	1	0																			1.5
Lycopodium clavatum		0.3									0								0.3		
Ptilium crista-castrensis									1	0.3						0.2					

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	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Organic-Rich Alder Tall Shrub	Glacial Sandy-Rocky Alder Shrub	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Rocky Lichen Tundra	Alpine Rocky Lichen Tundra	Alpine Gelic Rocky Dwarf Willow Tundra
Lobaria linita												0.2			0.2	0.5					
Luzula wahlenbergii piperi		0														0.1					
Silene acaulis			0													0					
Phleum commutatum var. americanum					1								0.5								
Galium triflorum					0.3									0.5							
Rubus pedatus							0.8			1.5											
Rhytidiadelphus triquetrus							0.2					0.7									
Dicranum fuscescens											0.2					0.2					
Pedicularis sudetica	0																				
Leptarrhena pyrofolia		0																			
Juncus castaneus castaneus		0																			
Epilobium palustre			0																		
Fritillaria camschatcensis			0																		
Alopecurus alpinus			0																		
Cardamine umbellata			0																		
Galium boreale						0															
Botrychium lunaria						0															
Pedicularis labradorica											0										
Ditrichum flexicaule											0										
Sphagnum russowii											0										
Dicranum scoparium															0						
Cetraria laevigata																0					
Campanula rotundifolia																0					
Antennaria friesiana																	0				
Juncus drummondii																	0				
Artemisia frigida																		0			
Androsace chamaejasme																		0			
Gentiana algida																		0			
Lloydia serotina																		0			
Potentilla hyparctica																		0			

Table 8. Mean plant cover by alpine, glacial, and subalpine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

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Primula cuneifolia																			0			
Ranunculus occidentalis																			0			
Tofieldia coccinea																			0			
Festuca brachyphylla																			0			
Geum rossii																				0		
Festuca brevissima																				0		
Bare Soil	0.3	2.5	**26**	0.2		**1.2**	0.2		**4**		0.7	**5.3**	**22.5**		1.2	**6.6**	**7.5**	**25.6**	**40.4**	**11**	**11.5**
Sample Size	3	2	3	4	3	5	4	3	2	2	6	3	4	2	4	9	2	5	7	2	2

Table 9**.** Mean plant cover by coastal ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5%.

	Maritime Coastal Saline Marestail Marsh	Maritime Coastal Loamy Saline Wet Sedge Meadow	Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow	Maritime Coastal Silty-Clayey Saline Barrens	Maritime Coastal Sandy-Rocky Saline Barrens
Differential Taxa						
Hippuris tetraphylla	32		0			
Potamogeton pectinatus	10.7					
Eleocharis palustris	1		0.1			
Carex ramenskii	2.3	71.2	9.1		0.5	
Stellaria humifusa		7.4	0.7		0.5	1
Atriplex gmelini		0.3				
Puccinellia hultenii		0.2				
Potentilla egedii		11.4	12.3	0.3	0	6.3
Poa eminens		3.8	8.1	2.6		
Triglochin palustris		2.3	1.4			
Potentilla anserina		0.4	0.3			
Hordeum brachyantherum		0.2	0.2	0		
Carex lyngbyaei		0	59.9			0.3
Carex glareosa		1.3	15.7	0		
Calamagrostis deschampsioides		0.8	7			
Salix fuscescens			3.1			
Myrica gale			2.1			
Cicuta mackenzieana			1.9			
Carex pluriflora			1.7			
Eleocharis kamtschatica			1			
Deschampsia beringensis			0.9			0
Epilobium palustre			0.7			
Lathyrus palustris			0.6			
Potentilla palustris			0.3			
Carex aquatilis aquatilis			0.3			
Agrostis scabra			0.2			
Polygonum viviparum			0.1			
Potamogeton praelongus			0.1			
Rumex fenestratus			0.1			
Saussurea nuda			0.1			
Puccinellia grandis			0.1			

Table 9. Mean plant cover by coastal ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5%.

	Maritime Coastal Saline Marestail Marsh	Maritime Coastal Loamy Saline Wet Sedge Meadow	Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow	Maritime Coastal Silty-Clayey Saline Barrens	Maritime Coastal Sandy-Rocky Saline Barrens
Leymus mollis		0.4	16.5	45.5	0	2.7
Festuca rubra			7.4	21.1		0
Stellaria crassifolia			1.2	3.8		
Chrysanthemum arcticum		0	2.9	1		0
Carex mackenziei	0		1.4	1.8		
Galium trifidum trifidum			1	0.4		
Stellaria crispa			0.1	0		
Lathyrus maritimus maritimus			1.4	54.2		2.7
Achillea millefolium			0	26.8		
Angelica lucida			0.1	17.6		
Carex gmelinii			0	9.8		
Ligusticum scoticum			0.7	5.3		
Calamagrostis canadensis			1	6.1		
Sanionia uncinata				4.7		
Moehringia lateriflora			0.1	4.1		
Pleurozium schreberi				4		
Trientalis europaea			0.2	3.9		
Carex macrocephala				3.8		
Rhinanthus minor borealis			0.1	3.5		
Lupinus nootkatensis				3.4		
Senecio pseudoarnica				2.9		0.1
Epilobium angustifolium				1.9		0
Poa arctica				1.7		
Iris setosa				0.8		
Geranium erianthum				0.7		
Conioselinum chinense			0	0.6		
Rhytidiadelphus triquetrus				0.4		
Carex macrochaeta				0.3		
Fritillaria camschatcensis			0	0.3		
Solidago multiradiata var. multiradiata				0.2		

Table 9. Mean plant cover by coastal ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5%.

	Maritime Coastal Saline Marestail Marsh	Maritime Coastal Loamy Saline Wet Sedge Meadow	Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow	Maritime Coastal Silty-Clayey Saline Barrens	Maritime Coastal Sandy-Rocky Saline Barrens
Poa pratensis				0.2		
Ptilium crista-castrensis				0.2		
Picea sitchensis				0.1		
Hylocomium splendens				0.1		
Puccinellia phryganodes		5.3	0.6		35	
Puccinellia nutkaensis		2.7	0.1		18.8	0.7
Honckenya peploides				0.7	0	21.4
Common Taxa						
Triglochin maritimum	1.7	16.7	5.7		5.5	
Plantago maritima		15.2	4.5		23.8	4
Accidental Taxa						
Chenopodium glaucum			0		0	0
Mertensia maritima				0		0
Empetrum nigrum			0			
Equisetum arvense			0			
Juncus arcticus			0			
Rubus arcticus				0		
Thelypteris phegopteris				0		
Bare Soil	6	15.7	1.7	1.6	48.2	72.7
Sample Size	3	12	33	20	4	3

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5%.

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Differential Taxa																
Hippuris vulgaris	**45**	0.3		0		1										
Sparganium angustifolium	**44**															
Scorpidium scorpioides		20														
Carex utriculata		**11.7**						1	2.5							
Menyanthes trifoliata		**3.7**														
Cicuta mackenzieana	0	0.3						0								
Potentilla palustris		1.7	0.2	2.6	**5.8**	**2.7**		**2.2**	**9.5**			0		0.9		
Carex canescens		0.3		1.4	2.5	3.3	0.5	0	5.1							
Salix fuscescens			5	3.4	**4**		2.5	7.4	**33.2**					0.6	0.2	
Carex aquatilis aquatilis			9.5	**15**	20.2	20	1	0.4						2.1		
Epilobium palustre	0			0.6	0.2	0.3		0.6	1.2							
Carex limosa	**1.7**	2.5		7	2.2											
Eriophorum angustifolium	1.7	0.5		4	0.2											
Sphagnum lindbergii			22.5													
Sphagnum fimbriatum			7.5													
Carex pauciflora			6.2													
Eriophorum russeolum			3.8						0							
Sphagnum flexuosum			2.5													
Salix brachycarpa niphoclada			0.8													
Salix arbusculoides			0.2													
Sphagnum girgensohnii			3.8	6.4										3.1	11.2	
Sphagnum fuscum				6.4	0.8									6.2	6.2	
Sphagnum teres			7.5	4	1.8									4.4		

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Chamaedaphne calyculata		0.3	2.5		0.8									1.6	0.5	
Oxycoccus microcarpus			0.8	2										0.2	0.2	
Sphagnum papillosum			15	6										1.5		
Andromeda polifolia			**1.8**		1.5									1.6		
Sphagnum magellanicum			1.2		0.2									0.2		
Sphagnum lenense				8										10		
Eriophorum scheuchzeri				**6.8**	1											
Sphagnum riparium				6.2										0.6		
Kobresia sibirica				5												
Sphagnum aongstroemii				4												
Limprichtia revolvens				2.2	0.8											
Calliergon stramineum			0.8	1.4												
Warnstorfia fluitans				1.2												
Carex livida				1												
Eriophorum vaginatum				1										0.4		
Drosera anglica				0.2												
Drepanocladus aduncus					7.5											
Carex chordorrhiza					2											
Carex rariflora					1.2		0.5									
Carex rotundata					1											
Bryum pseudotriquetrum					0.8											

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Sarmenthypnum sarmentosum					0.2											
Carex rostrata						15										
Poa arctica						10						0				
Sanionia uncinata						**8.3**	2.5		0.1							
Luzula multiflora						1.7	0									
Ranunculus gmelini				0		0.3										
Polytrichum commune						6.7	7.5									
Carex saxatilis						3.3	1									
Agrostis geminata							7.5									
Polytrichum piliferum							2.5								1	
Stereocaulon paschale							2.5									
Festuca altaica							1									
Carex brunnescens							1									
Juncus filiformis							0.5									
Cetraria cf. islandica							0.5									
Sphagnum squarrosum				5	0.5			**19.6**	4.7					2.5		
Hierochloe odorata								1.2								
Potentilla pulchella								1								
Carex sitchensis								0.8								
Stellaria crassifolia								0.4								
Epilobium ciliatum								0.2								
Rhinanthus minor borealis								0.2								
Rumex fenestratus								0.2								
Carex lyngbyaei	8							**25.6**	**13.5**							
Carex pluriflora			0.5					**6.8**	11.6							
Calamagrostis deschampsioides								5.4	0.8							

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Salix barrattiana								1	0.3							
Galium trifidum trifidum								0.4	0.2							
Poa eminens								0.2	0.1							
Picea sitchensis								0.8	4.7	5	0					
Festuca rubra								1	1	5						
Trientalis europaea								0.2	0.9	1.5						
Myrica gale	9.5		1.2						**49**			0.2		7.4		
Equisetum fluviatile					0.8	2		1.6	9.7					0.9		
Calliergon cordifolium						0.3			4.1							
Angelica genuflexa									1.7							
Polemonium acutiflorum								0	0.8		0	0				
Salix commutata									0.5							
Ligusticum scoticum									0.5							
Carex glareosa									0.5							
Lathyrus palustris									0.4							
Potentilla egedii									0.3							
Campylium stellatum									0.3							
Deschampsia beringensis									0.1							
Juncus arcticus									0.1							
Drepanocladus revolvens									0.1							
Alnus crispa		0								25						
Angelica lucida									0	10	0.1					
Achillea millefolium								0.4	1.2	10	0					
Oplopanax horridus										7.5	1					
Picea \xd7 lutzii								0.2		6	0.1					
Lathyrus maritimus maritimus									0	5						
Leymus mollis										5						

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Fritillaria camschatcensis									0.2	2.5						
Iris setosa									0.3	2.5						
Lupinus nootkatensis										2.5						
Circaea alpina										2						
Brachythecium nelsonii										2						
Agrostis gigantea										1						
Viburnum edule										1	**8.5**	8.1				
Epilobium angustifolium							0.5			1.5	**7.3**	**3**	1			0
Dryopteris dilatata americana										2.5	1.8	**5.6**				
Athyrium filix-femina cyclosorum										2.5	4.6	0.3				
Thelypteris phegopteris										0	3	0.6				
Heracleum lanatum					0.2					0.5	0.8	0.2				
Pyrola asarifolia										0	0.6	0.5				
Rubus spectabilis										1	0.4					
Galium triflorum										0	0.2					
Populus trichocarpa											**19.7**	2.2				
Salix alaxensis											2.2					
Ledum groenlandicum											1.1	0.1				
Solidago multiradiata var. multiradiata											0.6					
Veratrum viride eschscholtzii											0.3					
Equisetum pratense											0.2					

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Rubus arcticus stellatus											0.2					
Climacium dendroides											0.1					
Betula papyrifera var. kenaica									1.4		10.4	**25**				
Gymnocarpium dryopteris										0.5	**11.9**	**13.7**				
Alnus sinuata											5.6	3.3				
Salix scouleriana											3.3	1				
Populus balsamifera											2.2	2.2				
Salix lanata richardsonii					0.8						0.9	1.1				
Ribes triste											0.6	1.1				
Cornus suecica											0.7	0.6				
Salix barclayi									0		1.1	0.2				
Trientalis europaea arctica						1					**0.3**	**0.9**				
Streptopus amplexifolius											**0.4**	0.6				
Sanguisorba stipulata											0.3	0.4				
Geranium erianthum											0.2	0.4				
Ribes laxiflorum											0	0.5				
Aconitum delphinifolium											**0.4**	0				
Thalictrum sparsiflorum											0	0.3				
Galium boreale											0.1	0				
Pyrola secunda											0.1	0				
Carex macrochaeta											0	0.1				
Moehringia lateriflora											0	0				

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Viola epipsila repens											0	0				
Ledum decumbens				0.6							3.3	6.2	**35**	**12.4**	**22.8**	**35.8**
Betula glandulosa											0.3	0.9	**22.5**	2.5	1.5	**5.6**
Empetrum nigrum			0.8	0.4							3.3	6.8	**3.5**	0.2	**2.8**	0.1
Pleurozium schreberi							5				1.9	5		1.6	**15.8**	**8.2**
Spiraea beauverdiana				0.2							0.7	**7**	1	0.2	1.5	
Peltigera aphthosa							0				0	0.2	1		1	1.1
Vaccinium vitis-idaea												**7.7**	**11.5**	2.2	**5.2**	**6**
Cladina stellaris												0.1	7.5	0.6		**9.5**
Picea glauca											2.7	**18.6**		0		
Rubus pedatus										0	0.6	9.3				
Betula papyrifera var. humilis												3.9				
Lycopodium annotinum											0	2.3				
Sorbus scopulina												1.3				
Menziesia ferruginea												1.1				
Ptilium crista-castrensis												1				
Linnaea borealis											0.1	**0.9**				
Valeriana capitata												0.2				
Cladina stygia		0.4											7.5	0.6		
Salix glauca												0.6	**5**	0.2		0.1
Flavocetraria cucullata		0.4											5			0.6
Lycopodium clavatum													2.5			
Cladonia gracilis turbinata													1.5			

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Arctostaphylos rubra											0.1	0.2	1			
Cladina arbuscula							0.5						**6**	0.6	1	**27.8**
Polytrichum juniperinum				0.8									2.5	0.2	0.5	0.6
Ptilidium ciliare														4.4	2.5	1.9
Carex bigelowii														2.1	0.5	0.1
Sphagnum angustifolium														4.8	11.2	
Potentilla fruticosa														1.6		
Carex membranacea														1.2		
Eriophorum brachyantherum														1.2		
Sphagnum rubellum														1.2		
Parnassia palustris														0.1		
Betula hybrids														0.6		
Sphagnum warnstorfii														3.2		
Tomentypnum nitens														0.5		
Sphagnum russowii		2													10.5	
Rubus chamaemorus		0.8			0.4									1.2	**7.5**	
Equisetum sylvaticum											1.3	2.1			6.2	
Ceratodon purpureus															0.2	
Peltigera malacea															0.2	
Peltigera polydactylon															0.2	
Picea mariana		0.2											2.5	1.1	**25.8**	**26.2**
Nephroma arcticum															0.5	**2.5**

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Cladina rangiferina												0.2				12.5
Salix bebbiana																**1.3**
Betula papyrifera																0.6
Peltigera leucophlebia																0.6
Geocaulon lividum																0.1
Common Taxa																
Calamagrostis canadensis			1	**7**	1.5	**16.7**	**25**	**28.8**	**40.5**	7.5	**16.1**	**8.7**	0.5	**4.8**	1	
Vaccinium uliginosum			0.2	0.8	0.5	**1.3**	**4**				3.9	6.2	2.5	**11.3**	**5.2**	**5.6**
Betula nana			1.8	1.2	**2.2**	**2**	1.5		2.5			0.9		**13.2**	**9.5**	1.2
Salix planifolia pulchra			0.5		3.8	0.7		0	7.3		2.2	1.1		6.2		
Aulacomnium palustre				0.4		10	12.5		0.3					0.5		1.9
Equisetum arvense						**1.7**			1.5		1.2	2.7		0.6	6.2	
Rubus arcticus							1.5	0.4	1		0	0.2		0.1		
Hylocomium splendens								3				9.4		1.1	2.5	0.6
Accidental Taxa																
Salix planifolia planifolia						1	2.5							0.6		0.6
Drosera rotundifolia				0.2					0.1					0.1		
Polygonum viviparum							0		0.2							
Conioselinum chinense									2.7	2.5						
Viola langsdorffii									0.5		0.2					
Cornus canadensis												0.3				0.1
Utricularia vulgaris macrorhiza					0											
Pedicularis labradorica							0									
Cicuta douglasii								0								

Table 10. Mean plant cover by Lowland and Lacustrine ecotypes within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Lacustrine Marestail Marsh	Interior Lacustrine Organic-Rich Sedge Marsh	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lacustrine Organic-Rich Sedge-Shrub Bog	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous Shrub	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest
Chrysosplenium tetrandrum										0						
Stellaria crispa										0						
Tellima grandiflora										0						
Rubus idaeus											0					
Artemisia tilesii											0					
Ranunculus lapponicus											0					
Alopecurus alpinus											0					
Carex loliacea											0					
Salix arctica												0				
Adoxa moschatellina												0				
Goodyera repens var. ophioides												0				
Rumex arcticus												0				
Carex spectabilis												0				
Peltigera canina												0				
Agrostis scabra																0
Epilobium latifolium																0
Abietinella abietina																0
Ditrichum flexicaule																0
Polytrichum strictum																0
Bare Soil				1			1		0.3	1.5			1	0.4	2.5	0.5
Sample Size	2	3	4	5	4	3	2	5	11	2	9	9	2	8	4	8

Table 11. Mean plant cover by Riverine ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5%.

	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Silty-Sandy-Rocky Mixed Forest	Riverine Silty-Sandy-Rocky Poplar Forest	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Riverine Silty-Sandy-Rocky Barrens
Differential Taxa							
Meesia uliginosa	12.5						
Carex lyngbyaei	7.5			0			
Carex utriculata	6.2			0			
Carex saxatilis	3.8					0.5	
Equisetum fluviatile	3.2						
Carex aquatilis aquatilis	2.5			0.2			0.2
Eriophorum angustifolium	1.5						
Salix lasiandra	0.8						
Campylium stellatum	0.8						
Deschampsia beringensis	0.5						
Rhinanthus minor borealis	0.2						
Polytrichum commune	0.2						
Gymnocarpium dryopteris		**23.9**	**11.9**	1.1	1		
Betula papyrifera var. kenaica		**16.7**	0.3	1.5			
Viburnum edule		**14.4**	**3**	0.2			
Dryopteris dilatata americana		**6.3**	3.3	0	1		0
Spiraea beauverdiana		3.2		0.4		0	0
Rubus pedatus		2.8					
Feather mosses		1.7					
Cornus suecica		1.5					
Betula papyrifera var. humilis		1.2					
Betula glandulosa		0.7		0.2			
Salix bebbiana		0.3					
Ledum groenlandicum		0.2					
Populus balsamifera		9.6	9.7	1.4	0.5		
Ribes triste		**2.5**	2.4				
Rosa acicularis		0.4	1				
Ribes glandulosum		0.8	0.5		0.3		
Alnus sinuata		7.8	12.2	9.9			
Epilobium angustifolium		**1**	**2.9**	1.5	0.4		0.2
Trientalis europaea arctica		**1.3**	1	0.7		0	

Table 11. Mean plant cover by Riverine ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Silty-Sandy-Rocky Mixed Forest	Riverine Silty-Sandy-Rocky Poplar Forest	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Riverine Silty-Sandy-Rocky Barrens
Ribes laxiflorum		0.9	0.2	0.1			
Equisetum sylvaticum		0.7	1.7	0.3			
Vaccinium uliginosum		0.3	0.1	1.2		0.5	
Heracleum lanatum		0.7	0.1	0.3			
Streptopus amplexifolius		0.1	0.1	0			
Sanguisorba stipulata		0.3	0.2	0.8			
Aconitum delphinifolium		0	0.2	0.2			
Thalictrum sparsiflorum		0	0	0			
Populus trichocarpa		9.6	**26**	1.3			1
Pyrola asarifolia		0.8	**6.2**	0.1	1.7		
Oplopanax horridus			4.1		0.2		
Dryas integrifolia			4				
Athyrium filix-femina cyclosorum		0	2.2	0.1	0.3		
Sorbus sitchensis			2				
Salix scouleriana			0.8				
Galium triflorum			0.3	0			
Veratrum viride eschscholtzii			0.1				
Salix planifolia pulchra		0.4		**17.2**	0.3	1.5	
Salix alaxensis	0.3	0.4	0.6	**14.1**			0.2
Salix lanata richardsonii				6			
Racomitrium canescens				1.4			
Salix fuscescens				1.1			
Myrica gale		0		1			
Angelica lucida				1			
Viola epipsila repens				0.9			
Potentilla fruticosa				0.8			
Galium boreale		0	0	0.8			
Polemonium acutiflorum		0	0	0.7			
Artemisia tilesii			0.2	0.7		0	
Betula nana				0.4			
Achillea borealis				0.4			

Table 11. Mean plant cover by Riverine ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Silty-Sandy-Rocky Mixed Forest	Riverine Silty-Sandy-Rocky Poplar Forest	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Riverine Silty-Sandy-Rocky Barrens
Arctagrostis latifolia				0.4			
Valeriana capitata				0.2			
Achillea millefolium				0.1			
Andromeda polifolia				0.1			
Ledum decumbens				0.1			
Angelica genuflexa				0.1			
Bidens cernua				0.1			
Equisetum variegatum				0.1			
Mertensia paniculata				0.1			
Petasites frigidus				0.1			
Rubus chamaemorus				0.1			
Viola langsdorffii				0.1			
Festuca rubra				0.1			
Poa alpina				0.1			
Poa arctica				0.1		0	
Alnus crispa		1.2	20		**33.7**		**2**
Picea \xd7 lutzii			0.7		10.8		0
Salix sitchensis					5		**0.8**
Carex rostrata					3.3		
Salix commutata	0.5			0.2	3.3		1
Aulacomnium palustre					3.3		
Potentilla palustris		0		0.8	2	0.5	
Helodium blandowii					1.7		
Rhizomnium pseudopunctatum					1.7		
Racomitrium microcarpon					1.3		
Salix barrattiana					0.8		
Rubus arcticus stellatus		0.2			0.7		
Pyrola minor					0.5		
Rubus spectabilis			0.1		0.5		
Brachythecium salebrosum					0.3		
Pogonatum urnigerum					0.3		
Agrostis scabra				0	0.2		

Table 11. Mean plant cover by Riverine ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Silty-Sandy-Rocky Mixed Forest	Riverine Silty-Sandy-Rocky Poplar Forest	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Riverine Silty-Sandy-Rocky Barrens
Epilobium ciliatum					0.2		
Brachythecium starkei					0.2		
Dicranella schreberiana					0.2		
Racomitrium varium					0.2		
Picea glauca		**14.2**	1.2	0.7		**32.5**	
Pleurozium schreberi		2.5	0	0.8		**27.5**	
Alnus tenuifolia		2.5	5.5	2.4		**22.5**	
Rosa woodsii						**4**	
Linnaea borealis		0				**1.1**	
Climacium dendroides		0	0.1	0.2	0.5	**1**	
Cornus canadensis		0.2	0.2	0		**0.6**	
Pyrola secunda secunda				0		0.5	
Ranunculus lapponicus				0		0.5	
Moehringia lateriflora		0	0	0		0.5	
Rhytidiadelphus triquetrus						0.5	
Aongstroemia longipes							11.2
Epilobium latifolium		0		0.6	0.8		**4.5**
Racomitrium elongatum							3
Juncus arcticus				0			2
Racomitrium ericoides							1
Juncus castaneus castaneus				0			0.2
Polytrichum juniperinum							0.2
Common Taxa							
Calamagrostis canadensis	7.5	**12.6**	**10.9**	**14.8**	**6**	**6.5**	0
Equisetum pratense	3	2.2	2.1				1.2
Equisetum arvense		5.6	**1.9**	**5**	1	7.5	0.3
Hylocomium splendens		4.8	3.3	0.1	**5.8**	**6**	
Rubus arcticus		0.1	0	1.2	0.5	0.5	
Pyrola secunda		0.3	1.1	0	1		
Ptilium crista-castrensis		1.3	0			**1.6**	
Salix barclayi		0.8		8.9	7.8		
Vaccinium vitis-idaea		1		0		1.5	

Table 11. Mean plant cover by Riverine ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Silty-Sandy-Rocky Mixed Forest	Riverine Silty-Sandy-Rocky Poplar Forest	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Riverine Silty-Sandy-Rocky Barrens
Empetrum nigrum		0.4		0.2		0.5	
Accidental Taxa							
Geranium erianthum		0.2		0.2			
Cardamine umbellata		0		0			
Rumex arcticus		0		0			
Peltigera aphthosa		0		0			
Pyrola grandiflora		0.4			0.5		
Salix arbusculoides			0.3	0.1			
Anemone richardsonii			0	0			
Boschniakia rossica			0	0			
Heuchera glabra			0	0			
Spiranthes romanzoffiana	0						
Delphinium glaucum		0					
Platanthera hyperborea			0				
Dicranum fuscescens			0				
Eurhynchium pulchellum			0				
Plagiomnium cuspidatum			0				
Sanionia uncinata			0				
Oxycoccus microcarpus				0			
Arctostaphylos alpina				0			
Anemone parviflora				0			
Artemisia arctica				0			
Cardamine purpurea				0			
Dodecatheon frigidum				0			
Epilobium anagallidifolium				0			
Epilobium glandulosum				0			
Epilobium hornemannii				0			
Epilobium palustre				0			
Lupinus arcticus				0			
Lupinus nootkatensis				0			
Oxytropis campestris				0			
Parnassia palustris				0			

Table 11. Mean plant cover by Riverine ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Silty-Sandy-Rocky Mixed Forest	Riverine Silty-Sandy-Rocky Poplar Forest	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Riverine Silty-Sandy-Rocky Barrens
Sedum rosea integrifolium				0			
Senecio lugens				0			
Solidago lepida				0			
Solidago multiradiata				0			
Solidago multiradiata var. multiradiata				0			
Stellaria calycantha				0			
Stellaria monantha				0			
Thalictrum alpinum				0			
Agrostis geminata				0			
Festuca altaica				0			
Festuca brachyphylla				0			
Poa alpigena				0			
Poa glauca				0			
Trisetum spicatum spicatum				0			
Carex bigelowii				0			
Eriophorum russeolum				0			
Juncus alpinus				0			
Juncus filiformis				0			
Luzula arcuata				0			
Luzula parviflora				0			
Luzula wahlenbergii piperi				0			
Thamnolia vermicularis				0			
Sphagnum warnstorfii					0		
Peltigera venosa					0		
Polytrichum jensenii							0
Bare Soil	2.5		8.7	5.5	2.5		**64.5**
Sample size	4	12	10	25	6	2	4

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5%.

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Differential Taxa																	
Carex sitchensis	8.5																
Carex mackenziei	6.2				1.2												
Sanguisorba stipulata	**5.2**		0.8		0.8	1.7			0.5		0.4	0.2					
Epilobium latifolium	5		0.3	0.8					0.5					0.1	0.6		
Carex macrochaeta	5		0				0		0.2		0		0.1				
Rubus arcticus	**4.2**		0.8	4		**0.7**		0	0.1		0.1	0.2	0				
Veratrum viride eschscholtzii	**4**	0	1		0.8	**1**					0	0		0			
Senecio triangularis	**4**		0.1			**0.1**											
Luzula parviflora	2.5																
Carex macloviana	1.2																
Cratoneuron filicinum	0.8																
Lupinus arcticus	0.5																
Rubus spectabilis	1	**26.5**	0.8	2.5	**8.5**		0.2	0.2	0	0.2				0.1			
Vaccinium ovalifolium		20						0.2	0.3		0.4	0.1		0.1			
Vaccinium caespitosum			0.4								0						
Pyrola grandiflora			0.2			0											
Achillea borealis			0.2														
Brachythecium calcareum			0.1														
Salix barclayi			19.2	11.5					4.6		0.2	2.5	0.4				
Salix planifolia pulchra			5.8	18	0.8	**28.7**			0.2	0.2	0.6	0.6	0.3	0.3		1	
Aconitum delphinifolium	0.2		0.2		0	**0.4**			0		0.1	0					
Dryopteris dilatata americana		**6.5**	**23.8**	24	**12.5**	**15**	18	**10.2**	7.6	15	6.6	8	0.4	1.2			
Alnus crispa	0.5		**41.2**	20	**68.8**			9	1.4	7.5			2.9				0.1
Sambucus racemosa			1.7	1	1.2			0.8	0	0.3		0.2					
Brachythecium nelsonii		2.5	0.2		1.2		6.2	0.4									
Alnus sinuata				25.2		**38.3**	**17.5**	0.2	1.6	0.8	4.7	4.4	1.8	3.5		0.4	
Myrica gale				6													
Salix sitchensis				1.2						0.8							

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Polemonium acutiflorum				0.2							0	0					
Epilobium ciliatum					0.8												
Saxifraga punctata nelsoniana					0.8												
Brachythecium reflexum					0.8												
Tellima grandiflora					0.5												
Circaea alpina					0.2												
Heuchera glabra					0.2		0				0						
Petasites hyperboreus					0.2												
Agrostis scabra					0.2												
Hylocomiastrum pyrenaicum					0.2												
Rubus arcticus stellatus						0.7					0.3						
Carex spectabilis						0.7											
Arctagrostis latifolia							0.8				0					0.2	
Picea \xd7 lutzii		8.5					13.8	16					0				
Rhytidiadelphus loreus							0.8	1									
Lathyrus maritimus maritimus								14.2									
Achillea millefolium			0.4	4.2				13.8	0		0.1						
Picea sitchensis				0			1.2	10.6									
Sanionia uncinata				0.2				8.8									
Angelica lucida	1		0.2	0.5		0		7.6	0		0.1						
Calamagrostis deschampsioides								3.6									
Moehringia lateriflora								3.2									
Leymus mollis				1				2.8									
Carex pluriflora								2.4									
Festuca rubra				0.2				1.8									
Stellaria humifusa								0.4									
Poa arctica						0		0.4									
Carex gmelinii								0.4									

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Polytrichastrum alpinum								0.4									
Carex glareosa								0.2									
Populus balsamifera									11.8	3.5	0.5						
Equisetum pratense									2.7								
Urtica lyallii									1.4								
Geum macrophyllum macrophyllum									0.6								
Rubus idaeus									0.5			0					
Matteuccia struthiopteris									0.5								
Pyrola minor									0.2								
Conioselinum chinense									0.1								
Galium trifidum trifidum									0.1								
Betula papyrifera var. kenaica				2.8				0.2	26.8	28.3	18.6	28.2	4	2.2		0.1	
Equisetum arvense						1			0.1	0.2	2.6	2				0.2	0.1
Linnaea borealis						0			0.4	0.2	0.4	0.9	0.4				
Sorbus scopulina		0						0.2	0.1	0.2	0.3	0.1		0			
Populus trichocarpa									2.3	5.8		2.8					
Viburnum edule			0.4					0.6	5.5		1.3	2.2					
Equisetum sylvaticum			0.1						2.3		0.5	0.9		0			
Thelypteris phegopteris		0		0		0	0		0.1	0.5	0.5						
Salix lanata richardsonii									0.6		0.5			0.2			
Ledum decumbens									9.4	30	3	13.1	30.6	18.6	28.3	18.8	19.1
Empetrum nigrum									8.2	3.3	5.9	10.6	16.7	21.2	4	12.4	5.1
Vaccinium vitis-idaea							0		7.3	13.3	7.6	9.8	9.1	7.5	8.7	4.1	5.4
Vaccinium uliginosum	0		0.1	0.2	0.2	1		4	3.5	5	5.5	5.5	12.6	10.2	10.3	10.7	9
Betula nana						0			5.7	0.8	1.3	4.5	9.1	10.4	12.1	17	2.4
Picea glauca							14.5		2.5	1.2	13.5	12.6	14.4	10.8	3.7	1.4	1.4
Betula glandulosa									3.1	1.7	3.6	0.5	5.9	5.6	9.3	0.8	4
Spiraea beauverdiana			0			1	1.5		3.1	0.3	2.8	1.1	1.3	0.2	1.1	1.2	0.3
Salix glauca										0.8	0.5	0.1	3.1	1.8	1	2.8	1.4

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Salix scouleriana									3.4	0.5	0.7	1.4	1.1	0.5	0.7		0.1
Cornus suecica						0	0.3		2.6	0.8	1.2	0.8	0.3	0.3		0.4	
Aulacomnium acuminatum										1.7							
Brachythecium starkei			0							0.7							
Salix reticulata										0.2							
Menziesia ferruginea		3	0.2				0.8	0	0.5	0.2	10.1	0.6					
Populus tremuloides											8			0.1	0.6		0.2
Betula papyrifera var. humilis											0.8			0			
Thuidium recognitum											0.2						
Sorbus sitchensis											0.1						
Salix bebbiana										0	0.5	1.6	1.6	0.6			0.4
Ptilium crista-castrensis				0.5		0		1	0.3		4	2	1.4				
Cornus canadensis											1.7	1.2	0.3				0.4
Rosa acicularis											0.3	0.2	0.4				
Geocaulon lividum											0.5		0.7		0.4		
Peltigera aphthosa											0.5	0.5	0.4	0	0.3	0	0.3
Thamnolia vermicularis											0.1	0.2	0	0.1		0.7	0.3
Festuca altaica			0.3								0.2		0.2	0.2	0.4	0	0
Cladina stellaris												1.9	5.4	9.5	3.1	5.4	7.3
Ptilidium ciliare							0.2				0.2		0	0.1		0.1	2.1
Salix alaxensis												0.2					
Betula papyrifera													1.8				0.3
Betula occidentalis													0.4			0	
Salix barrattiana													0.3				
Sphagnum (green)													1.1				
Cladina rangiferina			0.2									0.1	6.6	1.8	6.4	2.5	
Arctostaphylos alpina									0.4		0.5		1.1	3.5	1.1	0.8	
Ledum groenlandicum											0.2		2.1	3.5		0.9	
Carex nesophila											0		0	0.3		1.3	
Hierochloe alpina													0	0.2		0.4	
Andromeda polifolia											0		0	0.2		0.3	
Carex bigelowii													0		0.4	1.1	

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Cetraria cf. islandica												0.6		1.8		2.6	
Flavocetraria cucullata													0.4	0.8	0.7	0.9	1.9
Cladina arbuscula											0.5		2.9	1.2	12.6		14.4
Flavocetraria nivalis														0.4		1	0.4
Racomitrium lanuginosum														0.4			
Rhytidium rugosum														0.4			
Thamnolia subuliformis														0.2			
Salix fuscescens															5		
Polytrichum strictum											0.1				0.7		0.3
Cladina mitis															0.3		
Pedicularis labradorica															0.1		
Carex canescens															0.1		
Carex saxatilis															0.1		
Salix arctica			0											0		2.4	
Loiseleuria procumbens														0.4		2.1	
Carex microchaeta																0.7	
Diapensia lapponica																0.4	
Salix phlebophylla														0.2		0.4	
Dryas octopetala																0.3	
Salix rotundifolia																0.3	
Oxytropis maydelliana																0.1	
Salix arbusculoides						0										0.1	
Sphaerophorus globosus																0.1	
Picea mariana											0.5			0.3	1.3		20.7
Stereocaulon paschale															0.6		5.1
Cladina stygia															0.7	0.2	5
Nephroma arcticum												0.2	0.1		0.7		3.4
Sphagnum girgensohnii																	2.9
Peltigera malacea																	0.3

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Abietinella abietina																	0.1
Racomitrium canescens																	0.1
Common Taxa																	
Calamagrostis canadensis	17.2		8.2	9	5.5	8	0.2	1.4	5.4	1	4.2	9.6	1.3	0.5	0.4	0.4	0.1
Epilobium angustifolium	12.5		1.3	18.2	0.8	1.2		0.2	3.4	0.5	1.2	4.4	0.3	0.8		0.1	0.1
Hylocomium splendens		16.5	5.5	0.8			11.2	4	5		13.4	9.4	3.6		1.4	2.2	6.9
Pleurozium schreberi		2		2.5			1.2	10	3	0.8	6.9	4.4	3.8	0.4	0.7	0.1	5.7
Streptopus amplexifolius	0.3		0.6		0.5	0.3		0.2	0.3	0	0.2	0.5	0.4	0			
Athyrium filix-femina cyclosorum	9.5		7.6	10.2	0.8		21.2	0.6	10.5	0.8	0.1						
Geranium erianthum	0.5		0.4		0			2.4	0.1	0.2	0.1	0					
Polytrichum juniperinum	1		1.5		0.5				0.2		0.4		0.4		4.4		1.1
Pyrola asarifolia	0.5		1.2			0.3			0.5	0.8	0.1	0.1					
Gymnocarpium dryopteris		3.5	2.7	1.2			7.2	1.6	5.9	0.7	7.2	7.1	0.9	0.8			
Trientalis europaea arctica		1.5	0			0.1	0.3	0	0.7	0.2	0.5	0.9	0.2	0			
Pyrola secunda		1		0	0.2	0	1	0	0.2	0.7	0.1	0	0.1				
Lycopodium annotinum		0.5			0.2	0.7	0.6	0.2	0.3		2.4	0.6	0.6	0.1			0.6
Oplopanax horridus		12.5	0.5	6.2	0.5	13.3	12.5	8.8	4.1	8.3		0.1					
Rubus pedatus		5.5				1	0.8	1.2	2.7	0	6.3	3.4	0.1	1.9			
Galium triflorum		0.5	0.1				0.2			0.3		0					
Heracleum lanatum			0.2		0.3	0.7			0.8		0.3	0.6					
Rubus chamaemorus			0.4						0.2		0.1		0.2			0.2	0.3
Lupinus nootkatensis			0.2	0.2					0.2				0.1	0.5			
Ribes glandulosum			0.2					0.2	0.2		0.2	0.5					
Ribes laxiflorum				1.2		0			0.2		0.6	0.1		0			
Arctostaphylos rubra					1.2					0.7				0.4	0.3	0.4	0.6
Accidental Taxa																	
Boschniakia rossica			0			0			0		0						
Climacium dendroides						0			0		0	0					

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Ribes triste							1.2			0.5	0.5	0.8					
Oxycoccus microcarpus										0		0				0	0.1
Artemisia arctica arctica						0					0					0.1	
Iris setosa						0			0.1		0.1						
Peltigera canina							0						0			0.1	
Goodyera repens var. ophioides									0		0	0					
Cladonia uncialis										0.3					0.4		0.9
Polytrichum piliferum											0.1				0.3		0.4
Aulacomnium palustre											0.3					0.1	0.3
Brachythecium salebrosum	0.2		0.4														
Trientalis europaea				1.2				2									
Sedum rosea integrifolium					0	0											
Viola langsdorffii						0					0						
Aulacomnium turgidum							0.2						0.2				
Thalictrum sparsiflorum											0	0					
Valeriana capitata											0	0					
Cladonia squamosa											0.1					0	
Peltigera rufescens											0.2						0.1
Dactylina arctica													0.1			0	
Anemone narcissiflora														0		0	
Campanula lasiocarpa														0		0	
Fritillaria camschatcensis		0															
Rhytidiadelphus triquetrus		0															
Phleum commutatum var. americanum					0												
Luzula multiflora					0												
Plagiomnium insigne					0												

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Erigeron peregrinus						0											
Ranunculus occidentalis						0											
Sanguisorba officinalis						0											
Solidago multiradiata var. multiradiata						0											
Woodsia glabella							0										
Polytrichum commune							0										
Sphagnum sect cuspidata							0										
Epilobium adenocaulon									0								
Mertensia paniculata									0								
Eriophorum angustifolium								0									
Galium boreale										0							
Listera cordata										0							
Moneses uniflora										0							
Rumex arcticus										0							
Lycopodium complanatum												0					
Artemisia tilesii												0					
Euphrasia disjuncta																0	
Minuartia arctica																0	
Minuartia obtusiloba																0	
Oxytropis campestris																0	
Oxytropis nigrescens																0	
Pedicularis langsdorffii arctica																0	
Polygonum bistorta																0	
Polygonum viviparum																0	
Anemone parviflora																0	
Arnica lessingii																0	
Tofieldia pusilla																0	
Agrostis geminata																0	

Table 12. Mean plant cover by Upland ecotype within the Lake Clark National Park. Boxes indicated species that are dominant and differential; bold indicates species with frequency >60%; and zeros have trace values <0.5% (continued).

	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Rocky Alder Shrub	Interior Upland Rocky Alder Shrub	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Upland Ashy-Loamy Birch-Poplar Forest	Upland Rocky Birch-Poplar Forest	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Rocky Mixed Forest	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Rocky White Spruce Woodland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Ashy-Loamy Black Spruce Forest
Festuca brachyphylla																0	
Luzula arcuata																0	
Stereocaulon symphycheilum																	0
Bare Soil	2.5		83.7	6.2	2	333			0.1	0.3		0.1	0.1	0.8	2.6	0.9	1.6
Sample size	4	2	12	4	4	3	4	5	11	6	19	8	14	13	7	16	7

GIS Modeling

Snow Regime Modeling

Snow Mapping (Typical Snow-Free Date):

The study area was covered by forty-six 30-km tiles, containing a combined total of 46 million pixels. The classification-tree output was solved for nearly 81% of the area (Table 13). For the remainder, 0.1% was solved with a reverse split (snow-free to snow) and 18.9% had no split. The proportion of snow (p_snow) was used to fill values for these cases. Of these cases, 11.1% had p_snow values ≤ 25% and were assigned to the "usually snow-free" category; 7.9% had p_snow values ≥ 0.75 and were assigned to the "usually snow-covered" category; and 0.04% had intermediate p_snow values and were assigned to the "no pattern" category.

Table 13. Summary of snow-free date algorithm results by method.

Method	Count (pixels)	Percentage of Area
Classification Tree (snow to snow-free)	37239484	80.96%
Alternate Method	8760516	19.04%
Classification Tree (snow-free to snow)	51297	0.11%
No split	8709219	18.93%
Alternate Results	8760516	19.04%
Usually snow-free (p_snow <= 0.25)	5118312	11.13%
Usually snow-covered (p_snow >= 0.75)	3624889	7.88%
No pattern (0.25 < p_snow < 0.75)	17315	0.04%
Total	46000000	100.00%

The typical snow-free day of year (Figure 12) was produced by combining the results from the classification tree (where a snow to snow-free split was provided) and the alternate p_snow method (for all other cases). Water, derived from the National Land Cover Dataset 2001 (Homer et al. 2004) is displayed over the map for clarity. The snow-free date was calculated for water (dry, snow-covered ice would be mapped as snow). The ice-off date would be a more useful metric for lakes, however, the snow mapping algorithm does not distinguish snow-free ice from open water. The results from our algorithm were not intended to be interpreted over water and therefore were excluded from the maps and tables in this report. Visual photographic interpretation is usually applied to map lake ice extent. The Landsat time series images could provide useful information to supplement ongoing efforts that track lake ice cover using coarser MODIS time series.

The total number of cloud-free Landsat observations used to determine the snow-free date (Figure 12) ranged from 19 to 237 (mean = 142.4, standard deviation = 30.4). The overlap pattern of the Landsat swaths (Figure 1) resulted in two strips with higher sample sizes than the remainder of the study area: one along Cook Inlet, and a second one towards the western edge of the LACL.

Figure 12. Typical Snow-free Day of Year

Lake Clark National Park & Preserve

155°W 154°W 153°W

61°N 60°N

Typical Snow-free Day of Year

- No Pattern
- Usually or Always Snow-free
- March 1–10
- March 11–20
- March 21–31
- April 1–10
- April 11–20
- April 21–30
- May 1–10
- May 11–20
- May 21–31
- June 1–10
- June 11–20
- June 21–30
- July 1–15
- July 16–31
- August 1–15
- August 16–31
- Usually or Always Snow
- Water

N W E S

0 5 10 15 20 mi

0 10 20 30 km

Approximate scale at 11"x17": 1:650,000

Landsat imagery acquired March 1–August 31, 1985–2010 was classified to cloud, snow, or snow-free. For each pixel, the Julian date and snow status for all non-cloudy observations was analyzed using a binary classification tree. The day of year separating the snow from the snow-free season was returned. In the case of pixels where the classification tree did not return a split, or where the split was from snow-free to snow, the proportion of snow-covered observations was used to assign the pixel to the usually/always snow-free, usually/always snow-covered, or no pattern category.

Map projection: Albers Alaska, NAD 83, meters;
ABR file: LACL_TypSnowFreeDay_10-352.mxd,
14 December 2012

Lake Clark National Park & Preserve

Landsat imagery acquired March 1–August 31, 1985–2010 was classified to cloud, snow, or snow-free. The count of non-cloudy observations used for the typical snow-free date calculation is presented here.

Count of Cloud-free Landsat Observations, March 1–August 31, 1985–2010

- 19–20
- 21–40
- 41–60
- 61–80
- 81–100
- 101–120
- 121–140
- 141–160
- 161–180
- 181–200
- 201–220
- 221–240
- 241–237

0 20 40 60 km

Percentage of Landsat Observations with Snow Status Correctly Classified, March 1–August 31, 1985–2010

- 52–75%
- 76–80%
- 81–85%
- 86–90%
- 90–95%
- 95–97%
- 97–99%
- >99%
- No Pattern

The percentage of observations with the correct snow state (snow-covered or snow-free) was calculated for each pixel, based on Landsat TM and ETM+ data from March 1–August 31, 1985–2010. For pixels where a snow-free day of year was assigned, the sum of snow-covered observations before the snow-free day of year and snow-free obserations after the snow-free day of year was divided by the total number of observations. For the pixels classified by the alternate method as "usually or always snow-free" the count of snow-free observations was divided by the total number of observations. For "usually or always snow-covered" pixels, the count of snow-covered observations was divided by the total number of observations. Areas with low values for correct classification do not have a strong seasonal pattern where a snow-covered period is followed by a snow-free period. They may have high variability of snow presence/absence during winter due to wind and melt events. Low values may also indicate problems in the snow mapping algorithm, due to terrain shadows, closed canopies, or sensor saturation.

Figure 12. Typical snow-free day of year, count of cloud-free Landsat observations, and percentage of Landsat observations with snow status correctly classified, March 1 – August 31, 1985–2010. Lake Clark National Park and Preserve, Alaska.

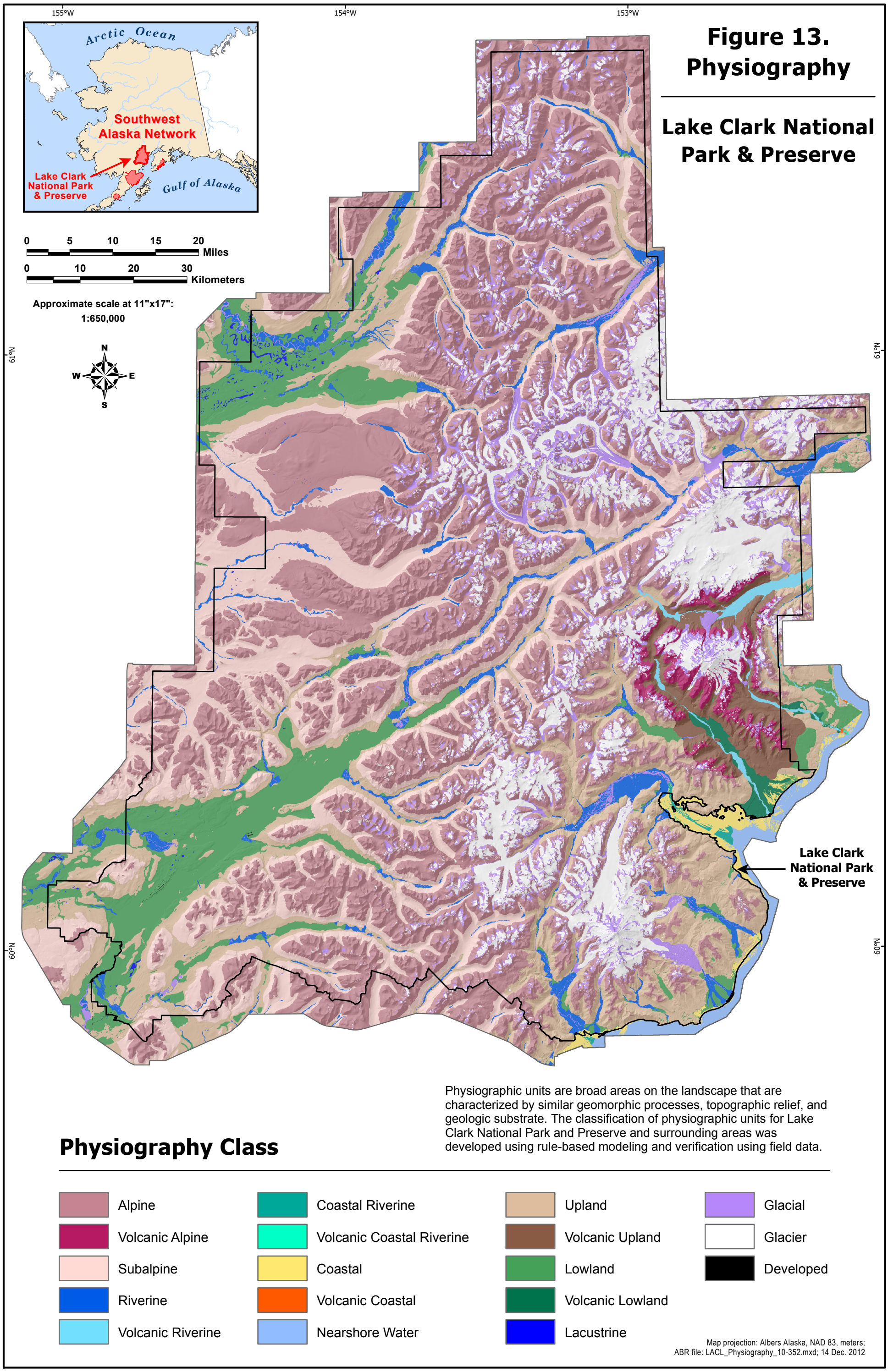


Figure 13. Physiography map for Lake Clark National Park and Preserve, Alaska.

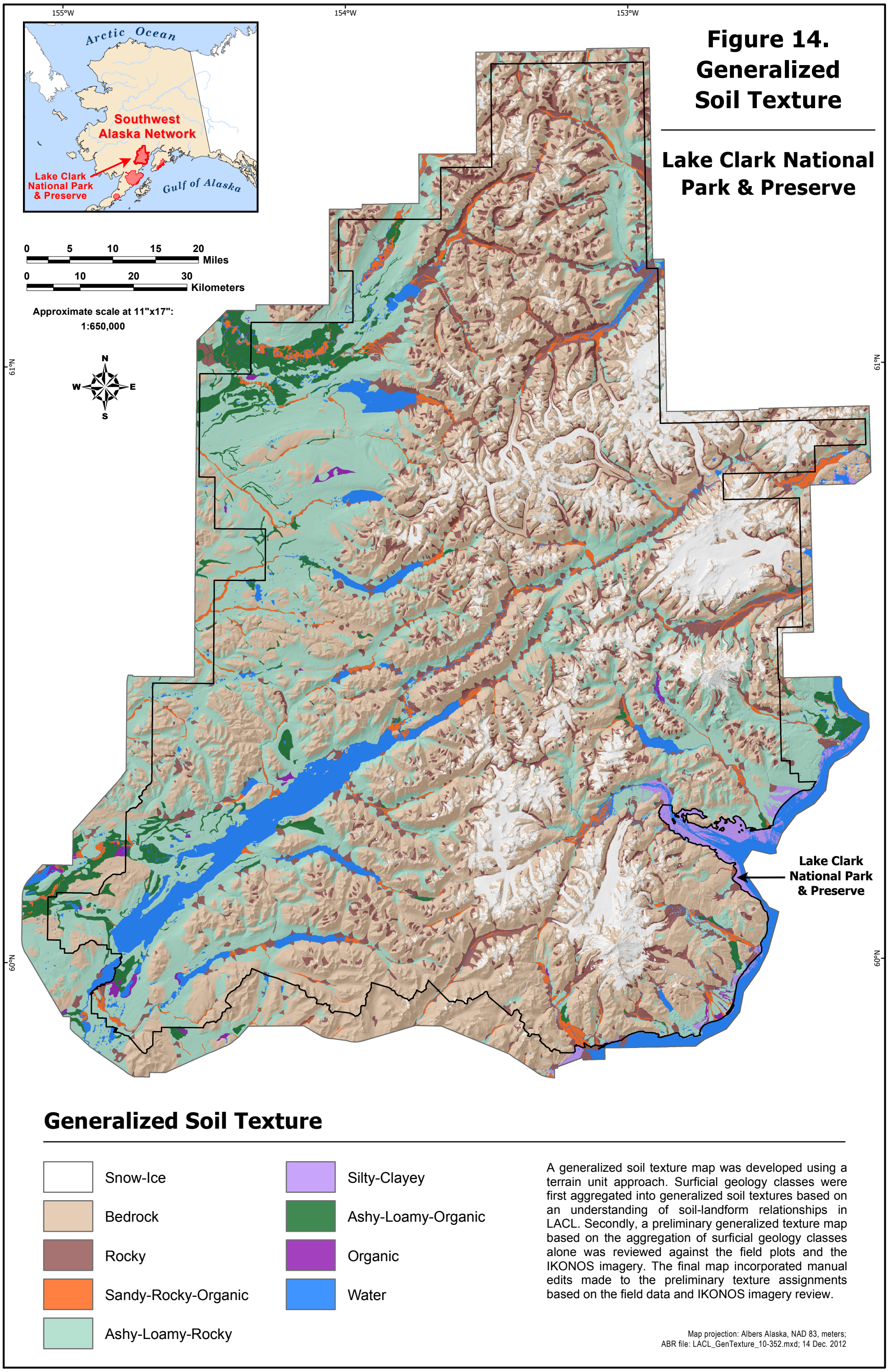


Figure 14. Generalized soil texture map for Lake Clark National Park and Preserve, Alaska.

The proportion of observations that were correctly classified is a useful diagnostic (Figure 12). Correct classification was calculated as the number of snow observations before the snow-free date plus the number of snow-free observations on or after the snow-free, divided by the total number of cloud-free observations. For summarizing, the correct classification rate was converted to a percentage and was rounded to the nearest 1%. The correct classification rate was 90% or higher for 84.3% of the land portion of the study area, and was 75–89% for 15.6% of the area. The correct classification rate was less than 75% (ranging from 52–74%) for only 0.1% of the land portion of the study area. Note that the 0.04% of the study area that was categorized as "no pattern" was not included in this summary.

Correct classification rates were highest for areas with permanent snow. Rates were lower at low elevations, for example, along the coast and near Lake Clark. These areas often experienced winter thaw events and snow was sometimes absent during mid winter. Rates of correct classification were also relatively low for wind-exposed sites in the mountains, which were sometimes, but not always, scoured free of snow. Generally, the correct classification rate was low for areas where the snow regime was characterized by alternating periods of snow and snow-free conditions within a single winter.

Physiography

Eleven aggregated physiography classes were mapped, the most common of which were Alpine (35.0% of area), Upland (17.3%), Subalpine (16.8%), Glacier (10.8%), and Lowland (8.5%) (Figure 13, Table 14). The least common (<1%) included Coastal, Lacustrine, and Developed.

Generalized Texture

Nine generalized soil textures were mapped, the most common of which were bedrock (44.3%), ashy-loamy-rocky (25.7%), snow-ice (10.5%), and rocky (8.8%) (Figure 14, Table 14). The least common (<1%) included organic and silty-clayey. Table 2 provides definitions of generalized soil texture classes.

Soil Temperature

Soil temperature regime (STR) is a soil taxonomy concept that groups soils into classes within the soil taxonomic hierarchy based on long-term (20–30 years) mean annual soil temperature (at 50 cm depth) cutpoints (Soil Survey Staff 2010). In many soil surveys, including the present study, long-term soil temperature data are unavailable at broad spatial scales for making data driven decisions regarding STR. Therefore, we used freely available soil temperature data (at 50 cm) from Alaska SNOTEL sites to develop a statistical relationship between air and soil temperature and snow depth and persistence. We used this relationship to develop a model of mean annual soil temperature at 50 cm depth across LACL using the down-scaled PRISM mean air temperature map (Figure 3) and snow regime map (Figure 12) as a means of assessing the broad scale soil temperature patterns in the park. Modeled soil mean annual soil temperature at 50 cm for the LACL study area is presented in Figure 15. The results of the soil temperature modeling were used to 1) establish soil temperature regime (Soil Survey Staff 2010) rules for soil classification, and 2) as a parameter in the LACL permafrost model.

Table 14. Areas (km^2) of physiography, generalized soil texture, and National Land Cover Database (NLCD) land cover classes, Lake Clark National Park and Preserve, Alaska.

Physiography	Area (km^2)	%
Alpine	6506.1	34.1%
Volcanic Alpine	183.2	1.0%
Coastal	142.0	0.7%
Coastal Riverine	16.1	0.1%
Volcanic Coastal	1.3	<0.1
Volcanic Coastal Riverine	0.6	<0.1
Lowland	1555.8	8.1%
Volcanic Lowland	66.7	0.3%
Riverine	554.5	2.9%
Volcanic Riverine	63.9	0.3%
Upland	2956.3	15.5%
Volcanic Upland	344.7	1.8%
Developed	2.2	<0.1
Glacial	1215.4	6.4%
Glacier	2067.0	10.8%
Lacustrine	22.9	0.1%
Nearshore Water	199.0	1.0%
Subalpine	3206.2	16.8%
Grand total	19103.8	100.0%

Aggregated Physiography Totals

Alpine	6689.3	35.0%
Coastal	159.9	0.8%
Lowland	1622.5	8.5%
Riverine	618.5	3.2%
Upland	3301.0	17.3%

Generalized Texture Class	Area (km^2)	%
snow-ice	2011.0	10.5%
bedrock	8471.9	44.3%
rocky	1686.2	8.8%
sandy-rocky-organic	395.5	2.1%
ashy-loamy-rocky	4909.8	25.7%
silty-clayey	135.8	0.7%
ashy-loamy-organic	495.3	2.6%
organic	44.1	0.2%
water	954.3	5.0%
Grand total	19103.8	100.0%

NLCD Land Cover Class	Area (km^2)	%
Open Water	755.4	4.0%
Perennial Ice/Snow	2011.0	10.5%
Marine Water	199.9	1.0%
Developed	2.1	0.0%
Barren Land	6539.1	34.2%
Deciduous Forest	399.0	2.1%
Evergreen Forest	2225.7	11.7%
Mixed Forest	508.4	2.7%
Dwarf Shrub	1966.6	10.3%
Shrub/Scrub	4380.7	22.9%
Graminoid/Herbaceous	2.4	<0.1
Woody Wetlands	79.2	0.4%
Emergent Herbaceous Wetlands	34.2	0.2%
Grand Total	19103.8	100.0%

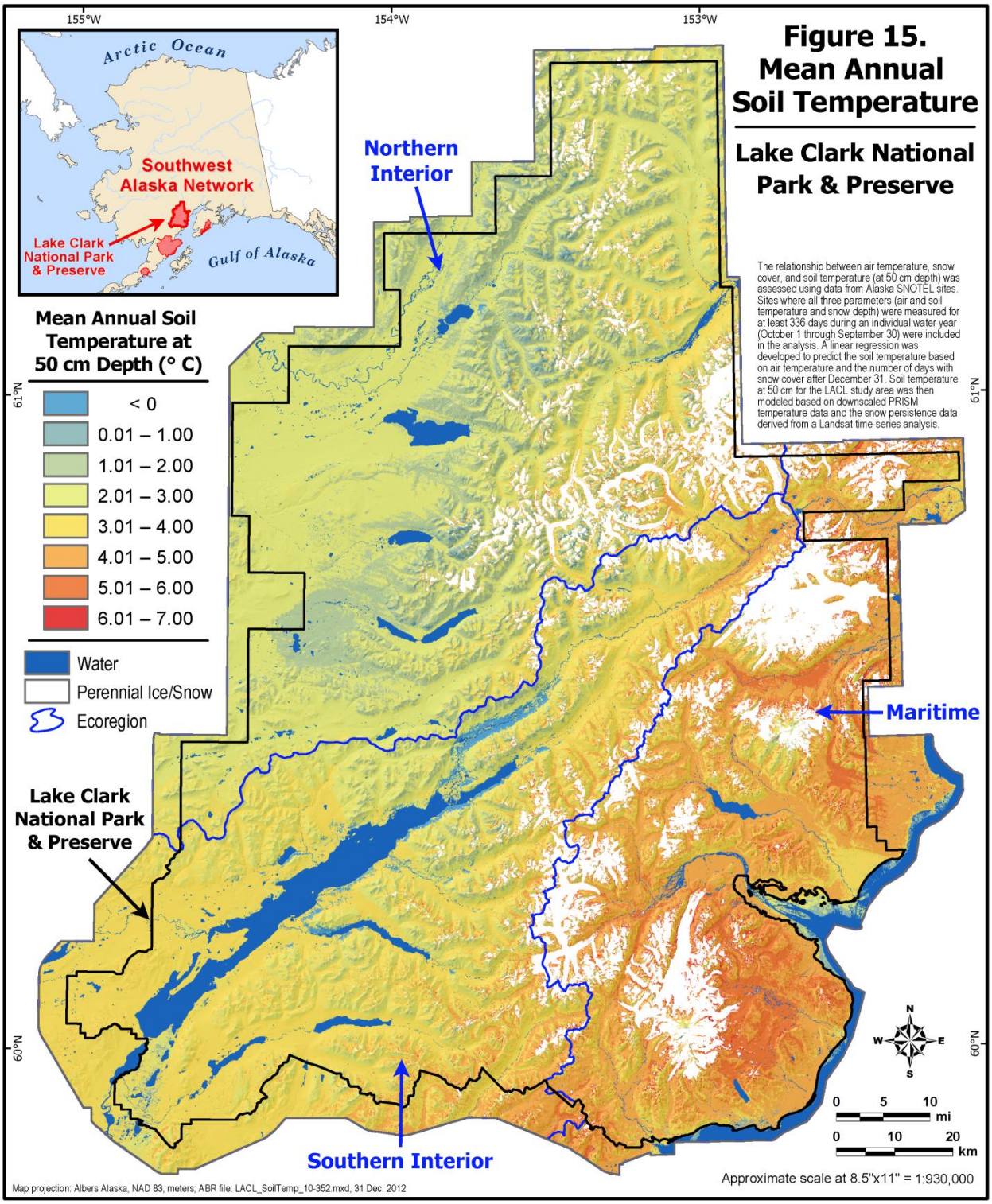


Figure 15. Map of mean annual soil temperature (°C) at 50 cm for Lake Clark National Park and Preserve, Alaska.

Soil temperatures were predicted to be warmest in the martime and southern interior ecoregions, while colder soil temperatures were predicted in the northern interior ecoregion. Predicted soil temperatures also generally followed an elevation gradient. Colder soil temperatures were predicted at higher elevations, with two exceptions where the reverse pattern was true, including 1) areas along the Tlikakila River and northeast margin of Lake Clark where snow persistence was predicted to be "Usually or Always Snow-free" (Figure 12), and 2) areas in the maritime ecoregion with a predicted snow persistence date of approximately June 11–20 or later. In the first case, the snow pack is predicted to be shallow to absent and the soils are exposed to extremes of air temperature without the buffering effect of a winter snow pack. Thus soils in these areas are predicted to be colder than soils at equivalent elevations with a more persistent snow pack. The second case includes broad areas in the maritime ecoregion including alpine cirques and middle to upper reaches of river valleys in the martime ecoregion. While the longer persistence of snow in these areas is likely the result of a consistently deep winter snow pack, which would serve to insulate the soils and buffer them from extremes in air temperature, it is likely that the soil temperature model overcompensated for the influence of snow on soil temperatures in these areas. The result is an overestimate of soil temperatures in maritime areas with a predicted snow persistence date of approximately June 11–20 or later.

Lastly, for the purpose of assigning soil temperature regimes for soil classication, soils in the northern interior alpine and subalpine were classified as gelic soil temperature regime (MAST $\leq 0°C$ for all soils). Southern interior subalpine and alpine, and maritime alpine were classified as cryic (MAST $0 > 8°C$ in soils with no surface organic horizon, and MAST $0 > 15°C$ for soil with a surface organic horizon). Soils in the remaining physiography classes in all ecoregions were assigned to the cryic soil temperature regime, with the exception of those soils with permafrost in the upper 2 meters, which were assigned a gelic soil temperature regime and classified in the Gelisols soil order.

Permafrost

A map of the likelihood of permafrost occurrence in LACL and field plot locations at which permafrost was encountered are presented in Figure 16. Permafrost is defined as soil materials that remain at or below 0°C for two or more successive years (Soil Survey Staff 2010). However, we distinguish here between ice-rich and ice-poor permafrost. The permafrost map shows the areas in LACL that were predicted to be most likely to have *ice-rich* permafrost (≥50% ice by volume, Williams and Smith 1991) within 2 meters of the soil surface based on soil texture, soil temperature (see above), physiography, and slope. Alpine soils in the northern interior ecoregion were assigned a gelic soil temperature regime and are considered to have a high likelihood of having ice-poor permafrost (and sporadic occurrences of ice-rich permafrost as per the permafrost model) in the upper 2 meters of the soil profile. The permafrost map for LACL was developed to aid in future broad-scale planning and monitoring efforts in LACL. General areas in LACL where ice-rich permafrost was predicted to be highly likely and likely include the upper Chilikadrotna River drainage, the lower Stony River valley, the lower Chulitna River, the southern end of Lake Clark near Sixmile and Pickerel Lakes, and the Tommy Creek drainage located immediately north of Tanalian Mountain.

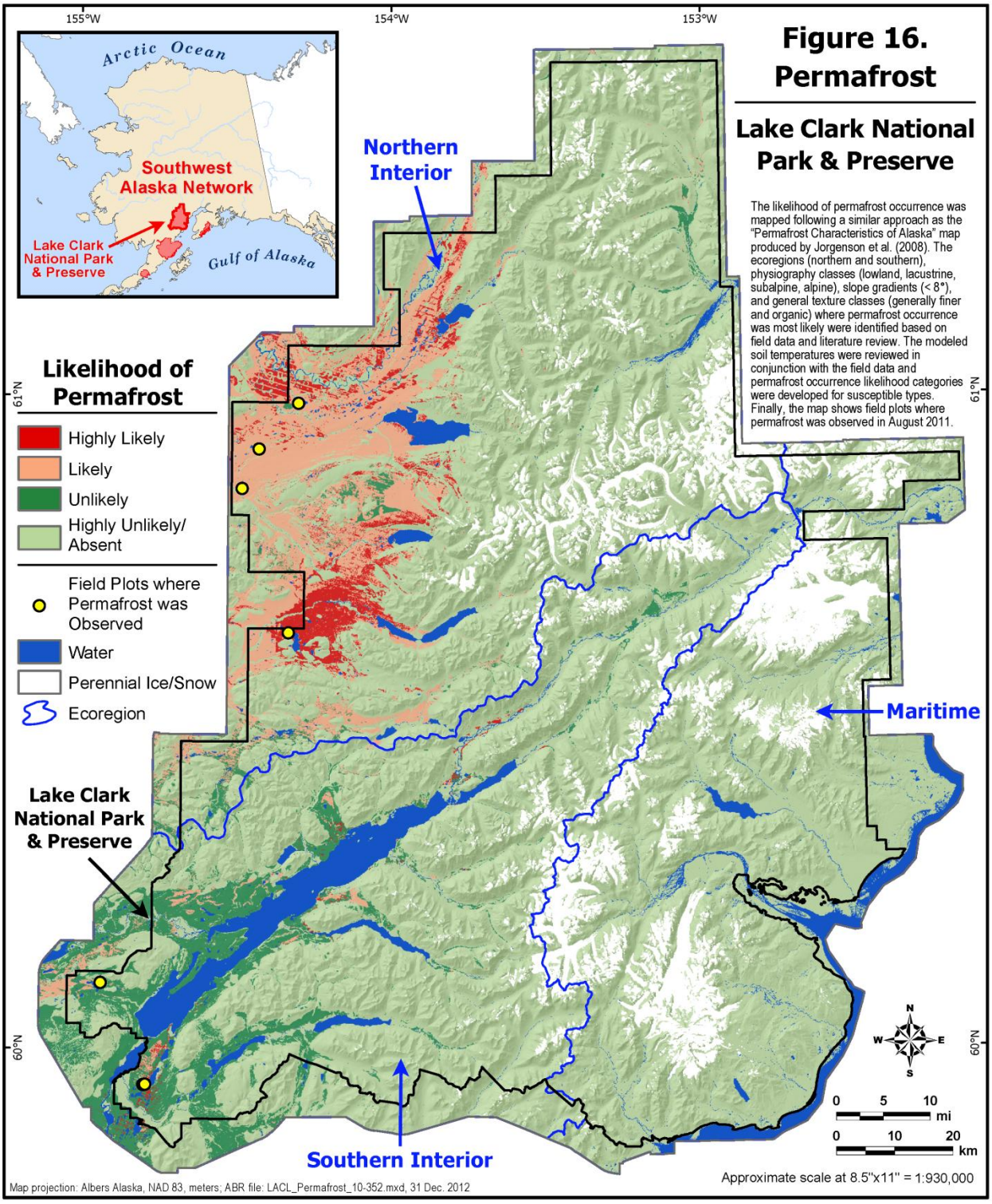


Figure 16. Permafrost map with likelihood of occurrence and field plots where permafrost was observed in August 2011, Lake Clark National Park and Preserve, Alaska.

The permafrost model was verified by field plots in two ways. First, the plot data where permafrost was encountered were used to determine preliminary soil temperature breaks for permafrost likelihood classes. Second, the field plots were used to identify satellite image signatures representative of permafrost landscapes and a GIS analyst was then tasked with locating similar signatures in broad areas of LACL where plot data were unavailable. Upon completion, the additional permafrost areas in conjunction with the soil temperature map were used to refine the soil temperature breaks for the permafrost likelihood classes.

The permafrost model rules are presented as a decision tree diagram in Figure 17. The permafrost model included northern and southern interior ecoregions; lowland, lacustrine, subalpine, and alpine physiography; lower slope gradients (< 8°); fine-textured and organic-rich soils, and colder soil temperatures. Soil temperature breaks were developed as described

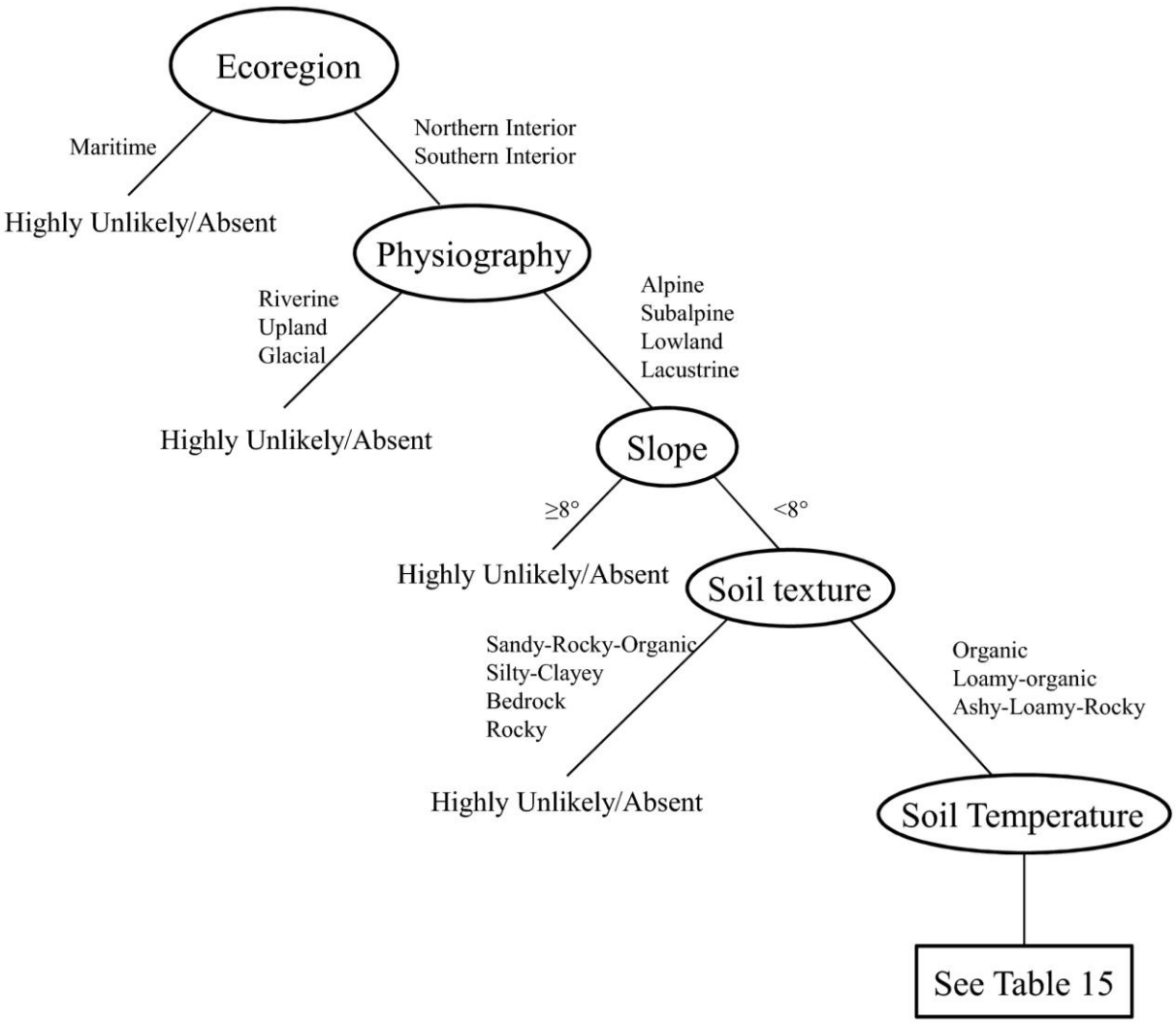


Figure 17. Decision tree diagram of rules used for developing a permafrost model for Lake Clark National Park and Preserve, Alaska.

above (Table 15). However, two points are worthy of discussion. First, the soil temperature model represents predicted soil temperatures at a depth of 50 cm, while the permafrost map represents areas with varying likelihoods of ice-rich permafrost (with a temperature ≤ 0°C) within a depth of 2 m. Therefore, in the permafrost model the predicted temperatures at 50 cm were used as a proxy for deeper (1–2 m) soil temperatures, and the assumption was made that soil temperature at depths greater than 50 cm were colder. Second, the soil temperature model predicted very few areas with soil temperatures at 50 cm of less than 0°C, including areas where permafrost was encountered in the field at a depth of less than 50 cm. This is likely related to the soil temperature model failing to capture micro-climatic factors important in the distribution of permafrost in LACL, namely cold air inversions in which denser, colder air drains downslope and pools in low-lying areas.

Table 15. Soil temperature breaks by generalized texture for assigning permafrost likelihood classes in a permafrost model for Lake Clark National Park and Preserve, Alaska.

Generalized texture	Permafrost Likelihood Class	Minimum Soil Temp (°C)	Maximum Soil Temp(°C)
Organic	highly likely	na	na
	likely	na	<2.0
	unlikely	2.00	3.50
	highly unlikely/absent	>3.5	na
Loamy-organic	highly likely	na	<2.25
	likely	2.25	3.36
	unlikely	3.36	4.00
	highly unlikely/absent	>4.00	na
Ashy-loamy-rocky	highly likely	na	<2.0
	likely	2.00	2.75
	unlikely	2.75	3.75
	highly unlikely/absent	>3.75	na

Land Cover

Thirteen NLCD land cover classes occurred in the study area, the most common of which were Barren Land (34.2%), Shrub/Scrub (22.9%), Evergreen Forest (11.7%), Perennial Ice/Snow (10.5%), and Dwarf Shrub (10.3%) (Figure 18, Table 14). The least common classes (<1%), included Woody Wetlands, Emergent Herbaceous Wetland, Graminoid/Herbaceous, and Developed.

Map Ecotypes

Fifty-four ecotypes were mapped, the most common of which were Alpine Barrens and Lichen Tundra (12.3% of area), Alpine Gelic Barrens and Lichen Tundra (12.3%), Glaciers and Permanent Snow Fields (10.8%), Interior Subalpine Low-Tall Shrub and Graminoid Meadow (9.5%), and Maritime Upland Shrub and Graminoid Meadow (6.6%) (Figure 19, Table 16). The least common (all < 0.1%) were Alpine Lakes and Springs, Alpine Wet Sedge Meadow, Interior Upland Barrens, Developed Land, Glaical Lake, Maritime Coastal Brackish Ponds and Marshes, Maritime Lowland Broadleaf Forest, Maritime Lowland Wet Sedge Meadow and Bog, and Interior Subalpine Wet Sedge-Shrub Meadow and Bog, Riverine Lake, Riverine Wet Sedge-Forb Meadow..

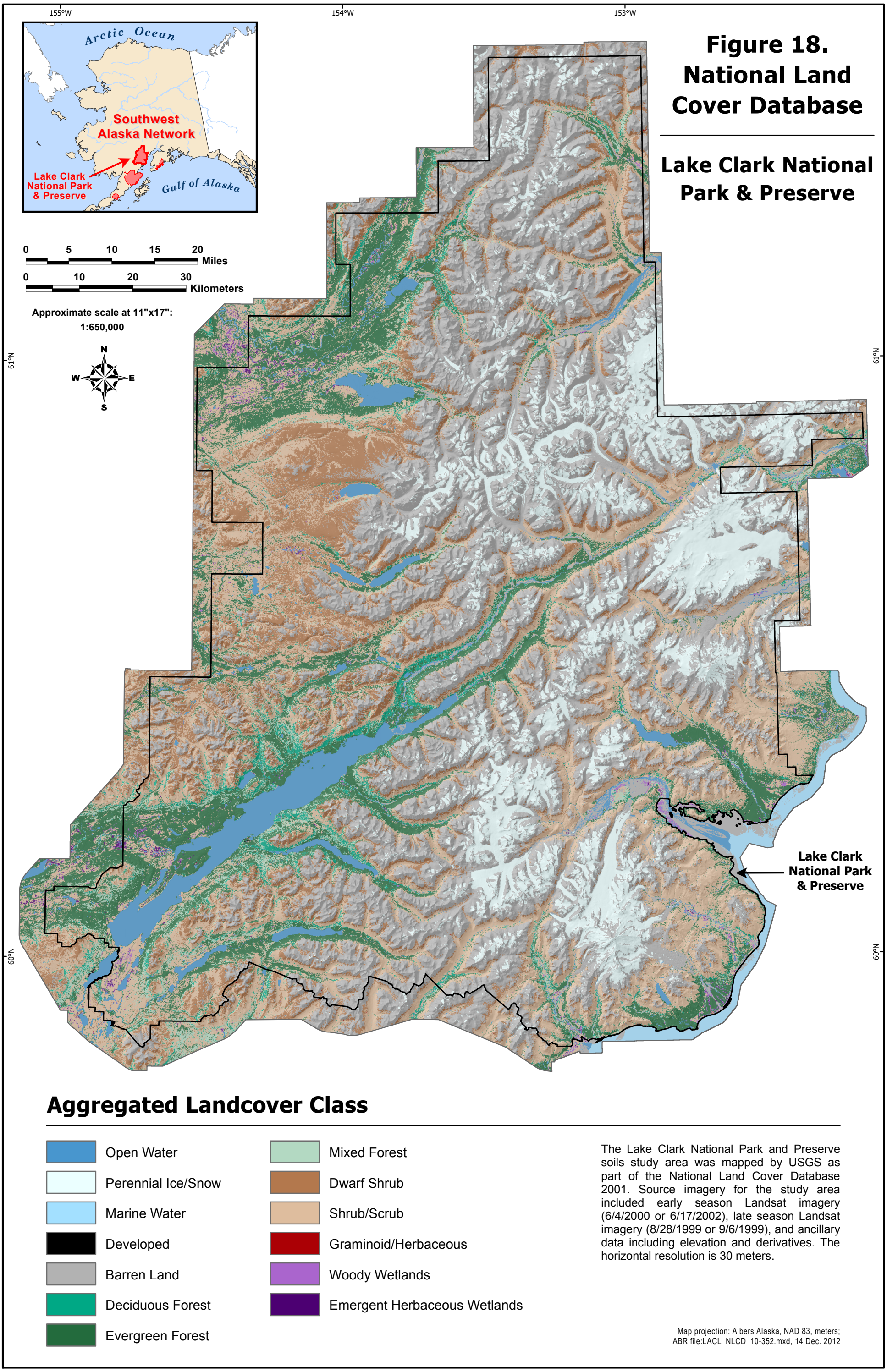


Figure 18. National Land Cover Database

Lake Clark National Park & Preserve

Figure 18. National Land Cover Database (NLCD) land cover map for Lake Clark National Park and Preserve, Alaska.

Figure 19.
Map Ecotypes

Lake Clark National Park & Preserve



155°W 154°W 153°W

N 19

N 60

0 5 10 15 20 Miles

0 10 20 30 Kilometers

Approximate scale at 11"x17": 1:650,000

N W E S

The classification of local-scale ecosystems (ecotypes) combines ecoregion (e.g. interior, maritime), physiography (e.g., riverine, coastal), topography (DEM), geology and vegetation from an existing land cover map (National Land Cover Database). These layers are used to model ecotypes in a way that best partitions geomorphic, hydrologic, pedologic, and vegetative characteristics.

Map projection: Albers Alaska, NAD 83, meters;
ABR file: LACL_Ecotype_10-352.mxd, 14 Dec. 2012

Lake Clark National Park & Preserve

Map Ecotype Class

- Alpine Gelic Barrens and Lichen Tundra
- Alpine Gelic Meadows and Dwarf Shrub
- Alpine Barrens and Lichen Tundra
- Alpine Meadows and Dwarf Shrub
- Alpine Dwarf Shrub Late-Lying Snowbanks
- Alpine Wet Sedge Meadow
- Glacial Barrens
- Glacial Alder Shrub
- Interior Subalpine Barrens
- Interior Subalpine Dwarf Ericaceous Shrub
- Interior Subalpine Low-Tall Shrub and Graminoid Meadow
- Interior Subalpine Balsam Poplar Forest
- Interior Subalpine White Spruce Woodland
- Interior Subalpine Frozen Birch-Ericaceous Low Shrub
- Interior Subalpine Wet Sedge-Shrub Meadow and Bog
- Interior Upland Barrens
- Interior Upland Low and Tall Shrub
- Interior Upland Mixed-Spruce Forest
- Interior Upland Broadleaf Forest
- Maritime Upland Barrens
- Maritime Upland Shrub and Graminoid Meadow
- Maritime Upland Spruce Forest
- Maritime Upland Broadleaf Forest
- Interior Lowland Mixed-Spruce Forest
- Interior Lowland Broadleaf Forest
- Interior Lowland Birch-Ericaceous Shrub
- Interior Lowland Wet Sedge Meadow and Bog
- Interior Lowland Frozen Spruce Forest
- Interior Lowland Frozen Sedge-Shrub Bog
- Maritime Lowland Sitka-Lutz Spruce Forest
- Maritime Lowland Broadleaf Forest
- Maritime Lowland Sweetgale-Willow-Ericaceous shrub
- Maritime Lowland Wet Sedge Meadow and Bog
- Interior Lacustrine Low Shrub-Bluejoint Meadow
- Interior Lacustrine Wet Sedge Meadow, Bogs, and Fens
- Riverine Barrens
- Riverine Alder-Willow Shrub
- Interior Riverine Mixed-Spruce Forest
- Maritime Riverine Mixed-Spruce Forest
- Riverine Poplar Forest
- Riverine Wet Sedge-Forb Meadow
- Maritime Coastal Saline Barrens
- Maritime Coastal Meadows
- Maritime Coastal Brackish Ponds and Marshes
- Alpine Lakes and Springs
- Subalpine Lake
- Glacial Lake
- Lowland Lake
- Riverine Lake
- Glacial and Non-Glacial River Water
- Tidal River
- Nearshore Water
- Glaciers and Permanent Snow Fields
- Developed Land

Figure19. Map ecotypes for Lake Clark National Park and Preserve, Alaska.

Table 16. Area of map ecotypes in Lake Clark National Park and Preserve, Alaska.

Map Ecotype	Area (km^2)	%
Alpine Barrens and Lichen Tundra	2353.3	12.3%
Alpine Dwarf Shrub Late-Lying Snowbanks	31.3	0.2%
Alpine Gelic Barrens and Lichen Tundra	2340.7	12.3%
Alpine Gelic Meadows and Dwarf Shrub	1224.2	6.4%
Alpine Lakes and Springs	4.3	<0.1
Alpine Meadows and Dwarf Shrub	729.4	3.8%
Alpine Wet Sedge Meadow	6.1	<0.1
Developed Land	2.1	<0.1
Glacial Alder Shrub	22.3	0.1%
Glacial and Non-Glacial River Water	104.9	0.5%
Glacial Barrens	1081.2	5.7%
Glacial Lake	7.1	<0.1
Glaciers and Permanent Snow Fields	2067.0	10.8%
Interior Lacustrine Low Shrub-Bluejoint Meadow	11.6	0.1%
Interior Lacustrine Wet Sedge Meadow, Bogs, and Fens	11.2	0.1%
Interior Lowland Birch-Ericaceous Shrub	267.1	1.4%
Interior Lowland Broadleaf Forest	12.4	0.1%
Interior Lowland Frozen Sedge-Shrub Bog	89.7	0.5%
Interior Lowland Frozen Spruce Forest	64.4	0.3%
Interior Lowland Mixed-Spruce Forest	438.2	2.3%
Interior Lowland Wet Sedge Meadow and Bog	13.3	0.1%
Interior Riverine Mixed-Spruce Forest	148.5	0.8%
Interior Subalpine Balsam Poplar Forest	191.3	1.0%
Interior Subalpine Barrens	232.0	1.2%
Interior Subalpine Dwarf Ericaceous Shrub	438.3	2.3%
Interior Subalpine Frozen Birch-Ericaceous Low Shrub	71.2	0.4%
Interior Subalpine Low-Tall Shrub and Graminoid Meadow	1808.7	9.5%
Interior Subalpine Wet Sedge-Shrub Meadow and Bog	1.0	<0.1
Interior Subalpine White Spruce Woodland	408.0	2.2%
Interior Upland Barrens	3.8	<0.1
Interior Upland Broadleaf Forest	107.4	0.6%
Interior Upland Low and Tall Shrub	399.3	2.1%
Interior Upland Mixed-Spruce Forest	1034.6	5.4%
Lowland Lake	551.0	2.9%
Maritime Coastal Brackish Ponds and Marshes	7.3	<0.1
Maritime Coastal Meadows	40.1	0.2%
Maritime Coastal Saline Barrens	95.9	0.5%
Maritime Lowland Broadleaf Forest	6.5	<0.1
Maritime Lowland Sitka-Lutz Spruce Forest	108.8	0.6%
Maritime Lowland Sweetgale-Willow-Ericaceous shrub	69.4	0.4%
Maritime Lowland Wet Sedge Meadow and Bog	1.7	<0.1
Maritime Riverine Mixed-Spruce Forest	62.9	0.3%
Maritime Upland Barrens	188.7	1.0%
Maritime Upland Broadleaf Forest	44.2	0.2%
Maritime Upland Shrub and Graminoid Meadow	1262.7	6.6%
Maritime Upland Spruce Forest	260.2	1.4%
Nearshore Water	199.0	1.0%
Riverine Alder-Willow Shrub	176.3	0.9%
Riverine Barrens	190.0	1.0%

Table 16. Area of map ecotypes in Lake Clark National Park and Preserve, Alaska (continued).

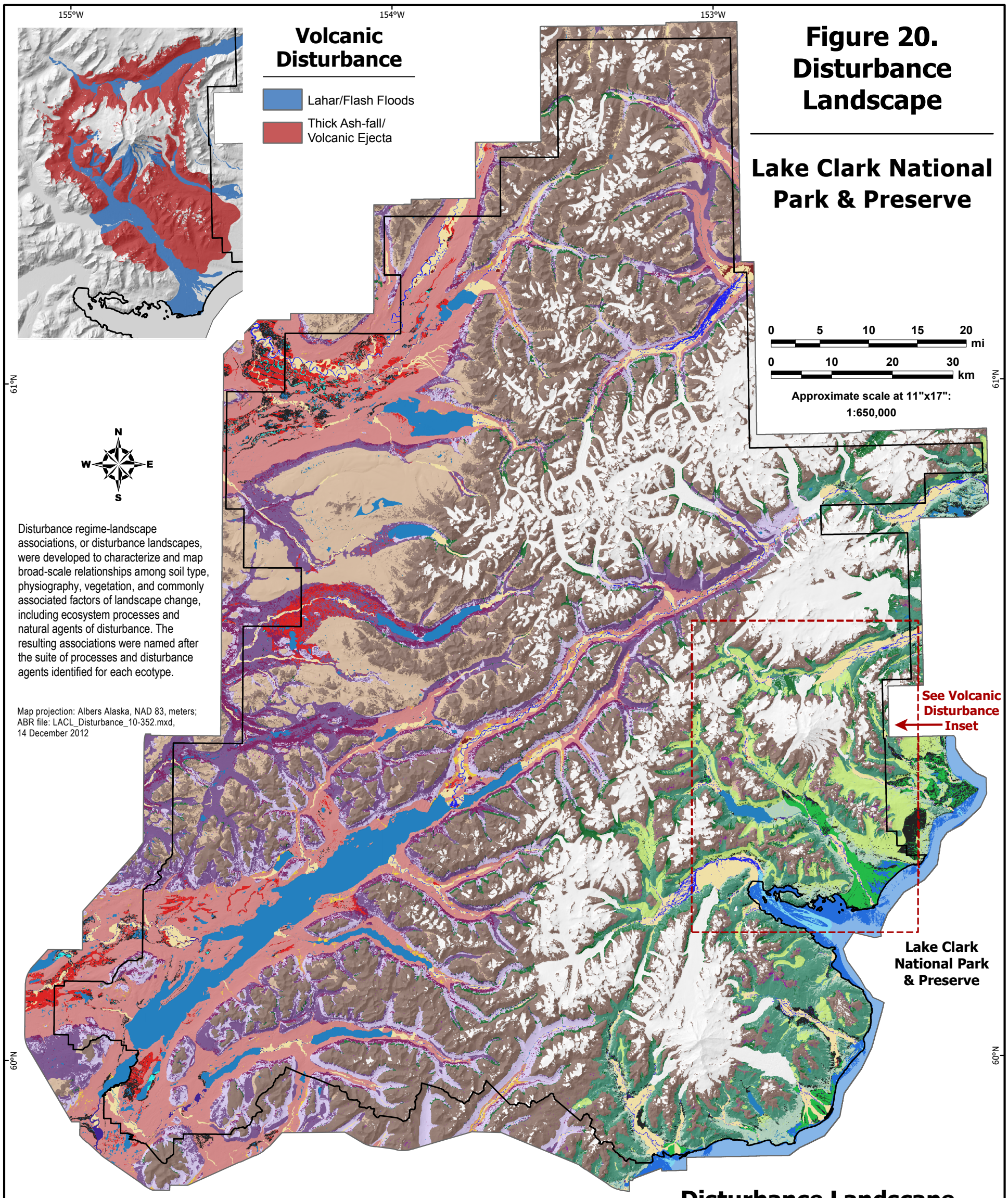
Map Ecotype	Area (km^2)	%
Riverine Lake	8.9	<0.1
Riverine Poplar Forest	25.9	0.1%
Riverine Wet Sedge-Forb Meadow	6.0	<0.1
Subalpine Lake	55.7	0.3%
Tidal River	16.7	0.1%
Grand Total	19103.8	100.0%

Disturbance Landscapes

Twenty-five non-volcanic disturbance landscape classes were mapped across the study area, the most common of which were Mass wasting/Avalanche/Wind-scour/Snow Drifts (27.9% of area), Surges/Ablation/Mass Movement (16.6%), Fire/Spruce Beetle (11.1%), Avalanche/Snow Drifts (7.1%), and Cryoturbation (6.9%) (Figure 20, Table 17). The least common (<0.1%) included Flooding/Sedimentation/ Tapping/Paludification. In addition to the non-volcanic disturbance landscapes, two volcanic disturbance landscape classes were mapped within areas of volcanic physiography, including Lahar/Flash Floods and Thick Ash-fall/Volcanic Ejecta (Figure 19, inset). These two classes account for 1.0% (198 km^2) and 2.5% (474 km^2) of the study area, respectively. Disturbance regime-landscape associations, or disturbance landscapes, were developed to characterize and map broad-scale relationships among soil type, physiography, vegetation, and commonly associated factors of landscape change, including ecosystem processes and natural agents of disturbance. The disturbance landscape concept is relatively new, and it is suggested that an expert panel be assembled to refine the disturbance landscape classification and mapping.

Figure 20. Disturbance Landscape

Lake Clark National Park & Preserve



Disturbance regime-landscape associations, or disturbance landscapes, were developed to characterize and map broad-scale relationships among soil type, physiography, vegetation, and commonly associated factors of landscape change, including ecosystem processes and natural agents of disturbance. The resulting associations were named after the suite of processes and disturbance agents identified for each ecotype.

Map projection: Albers Alaska, NAD 83, meters;
ABR file: LACL_Disturbance_10-352.mxd,
14 December 2012

Figure 20. Disturbance landscape map of Lake Clark National Park and Preserve, Alaska.

Table 17. Area of disturbance landscape classes, Lake Clark National Park and Preserve, Alaska.

Disturbance Landscape	Area (km^2)	%
Avalanche/Mass Wasting/Erosion/Flash Floods	1078.4	5.6%
Avalanche/Snow Drifts	1359.9	7.1%
Avalanche/Snow Drifts/Fire/Spruce Beetle/Wind Throw	408.1	2.1%
Catastrophic Drainage/Drying/Paludification	631.5	3.3%
Cryoturbation	1312.9	6.9%
Erosion/Flash Floods	41.2	0.2%
Fire/Spruce Beetle	2116.1	11.1%
Flooding	24.8	0.1%
Flooding/Glacial Outburst Floods	86.6	0.5%
Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle	609.6	3.2%
Flooding/Sedimentation/Tapping/Paludification	8.9	<0.1
Lake Formation	11.2	0.1%
Landslide/Avalanche/Flash Floods/Tidal Waves	878.1	4.6%
Landslides/Snow Drifts	384.6	2.0%
Mass wasting/Avalanche/Wind-scour/Snow Drifts	5334.7	27.9%
Negligible	230.8	1.2%
Rockfall/Avalanche	424.5	2.2%
Snow Drifts/Cryoturbation	31.3	0.2%
Spruce Beetle/Flooding	108.8	0.6%
Spruce Beetle/Wind Throw	260.2	1.4%
Surges/Ablation/Mass Movement	3177.5	16.6%
Thermokarst/Fire/Spruce Beetle	225.2	1.2%
Tides and Storms/Ice Flows	199	1.0%
Tides and Tidal Waves/Storm Surges and Erosion/Glacial Rebound	136	0.7%
Tides and Tidal Waves/Storm Surges/Flooding	23.9	0.1%
Avalanche/Mass Wasting/Erosion/Flash Floods	1078.4	5.6%
Grand Total	19103.8	100.0%

Soil Landscapes

Summary of Soil Characteristics

Soil Classification

Of the total 619 plots included in the ecotype analysis, sufficient soils data for use in soil subgroup classification existed for 353 plots. Soils from eight orders of soil taxonomy were encountered during field sampling, including Alfisols, Andisols, Entisols, Gelisols, Histosols, Inceptisols, Mollisols, and Spodosols (Table 18). Entisols included 19 observed subgroups and comprised 38% of observations. Entisols are undeveloped soils having little to no horizon development or translocation and accumulation of materials lower in the soil profile. Surface organic (O -horizons) and A-horizons if present are typically thin (< 5 cm). Entisols are soils that have not had sufficient time for soil development to occur often due to their location in a dynamic environment (e.g., floodplain, alluvial fan) or sometimes due to intensive land use management practices. Entisols occurred most often in rocky alpine, subalpine, and upland environments and loamy to rocky riverine and coastal environments. Inceptisols accounted for 23% of observations and included 32 observed subgroups. Inceptisols are soils that are moderately developed and include soils that do not meet the requirements for other soil orders. Inceptisols are characterized by distinct horizon development and mild weathering and translocation of materials to lower in the soil profile but do not meet the requirement for any other soil order. Inceptisols occurred across all physiographies but were most common in wet meadows and shrublands in coastal and lowland environments and in rocky, loamy to ashy soils in alpine environments. Andisols accounted for 20% of observations and included 14 observed subgroups. Andisols are soils developing in volcanic ejecta (e.g, volcanic ash, pumice, cinders, or lava) and/or volcaniclastic materials (e.g., lahar deposits). Andisols are characterized by an abundance of volcanic glass and a low bulk density (i.e., a given volume of soil feels lighter than it appears). Andisols occurred most commonly on older, stable geomorphic surfaces in upland and subalpine alder and willow shrublands and Spruce woodlands and mixed forests. Spodosols accounted for 5% of observations, and included 8 observed subgroups. Spodosols are soils that have thick accumulations of translocated humus and aluminum and/or iron in the mineral subsurface. Spodosols occurred most commonly in upland and lowland *Picea glauca* and *P. mariana* forests and in alpine dwarf ericaceous shrub tundra. Mollisols accounted for 1% of observations, and included 2 subgroups. Mollisols are soils that have a high pH (≥ 5.5) and thick (>18 cm) accumulations of dark organic-carbon rich soil material (related to abundant fine root turn-over) at, or near, the soil surface. Mollisols were strongly correlated with maritime alpine and upland environments with siltstone and shale parent material. Histosols (thick peats) accounted for 10% of observations, and included 13 subgroups. Histosols occurred primarily in lowland and lacustrine bogs and fens. Gelisols accounted for ~3% of observations, and included 6 soil subgroups. Gelisols are soils with permafrost (soil materials < 0° C for ≥ 2 years) within 2 meters of the soil surface. Gelisols were most common in concave, flat, and gently sloping lowland and subalpine environments in fine-textured soils with thick surficial organics. Alfisols (well-developed, clay-rich soils) accounted for <1% of observations, and included one soil subgroup. Alfisols are soils that typically develop in cool, humid climate with thick accumulations of translocated clay. The single plot sampled in this soil order was located in the maritime ecoregion on an abandoned alluvial. Soils were formed from mixed shale and siltstone alluvium. While it is highly unlikely that Alfisols are common across the entirety of LACL, it is possible that Alfisols are more common in maritime areas with sandstone and siltstone parent

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011. Soil classes are ordered hierarchically from soil order (broadest grouping of soil taxonomy, far left), through suborder (center left), great group (center right), and soil subgroup (finest grouping of soil taxonomy, far right). In many cases descriptions have been generalized for readability. For official criteria for each soil subgroup, please refer to Soil Survey Staff (1999, 2010).

Soil Taxonomic Class: **Order** **Suborder** **Great Group** **Subgroup**	**Description**
Alfisols	Soils that typically develop in cool, humid climates with thick accumulations of translocated clay. Clay accumulation in the subsurface is a diagnostic characteristic for this soil order.
Cryalfs	Alfisols that occur in a cryic soil temperature regime.
Haplocryalfs	Cryalfs that do not meet the taxonomic requirements for any other great groups.
Andic Haplocryalfs	Haplocryalfs forming in weathered volcanic eject or volcaniclastic materials and do not meet the requirement for Andisols.
Andisols	Soils developing in volcanic ejecta (volcanic ash, pumice, cinders, or lava) and/or volcaniclastic materials (lahar deposits). Andisols are characterized by an abundance of volcanic glass and a low bulk density (i.e. a given volume of soil feels lighter than it appears). The volcanic glass weathers into its constituent minerals aluminum and silica which often bind with organic matter (humus) in the soil to form stable organic complexes. These complexes can persist in the soil for significant time periods (>50 years).
Cryands	Andisols that have formed in a cryic soil temperature regime.
Vitricyrands	Cryands that have low water retention due to an abundance of coarser textured volcanic ejecta and/or high volcanic glass content and/or pumice rock fragments.
Folistic Vitricryands	Vitricryands that have a thick (15-40 cm) organic surface horizon that is not saturated for more than 30 days (cumulative) in normal years.
Spodic Vitricryands	Vitricryands that have thick accumulations of translocated organic matter and Aluminum (Al), or organic matter, Al, and Iron (Fe) lower in the soil profile.
Thaptic Vitricryands	Vitricryands have a buried A- or O-horizon that is ≥10cm thick. The material above the buried organic rich horizon is typically comprised of tephra-rich, loess deposits.
Typic Vitricryands	Vitricyrands that are typical for this great group.
Haplocryands	Cryands that do not meet the taxonomic requirements for any other great groups. These ash derived soils are typically finer in texture than Vitricryands.
Alic Haplocryands	Haplocryands that are typically very acidic (pH <5.0) due to high concentrations of aluminum-humus complexes.
Folistic Haplocryands	Haplocryands that have a thick organic surface horizon (15-40 cm) thick that is not saturated for more than 30 days (cumulative) in normal years.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Spodic Haplocryands	Haplocryands that have thick accumulations of translocated organic matter and Aluminum (Al), or organic matter, Al, and Iron (Fe).
Thaptic Haplocryands	Haplocryands have a buried A or O horizon that is ≥10cm thick. The material above the buried organic rich horizon is typically comprised of tephra-rich, loess deposits.
Typic Haplocryands	Haplocryands that are typical for this great group.
Vitric Haplocryands	Haplocryands that have coarser textured volcanic ejecta deposits and/or higher concentrations of unweathered volcanic glass, but do not meet the requirements for Vitricryands.
Gelands	Andisols that have formed in a gelic soil temperature regime.
Vitrigelands	All Gelands are considered Vitrigelands.
Humic Vitrigelands	Vitrigelands that have a thick dark organic carbon-rich surface horizon and characteristically have a higher soil pH (>5.5).
Turbic Vitrigelands	Vitrigelands that show evidence of cryoturbation (frost churning) and/or ice segregation in the seasonal frost/thaw layer.
Typic Vitrigelands	Vitrigelands that are typical for this great group.
Entisols	Undeveloped soils having little to no horizon development or translocation and accumulation of materials lower in the soil profile. Surface organic (O - horizons) and A-horizons if present are typically thin (< 5 cm). Entisols are soils that have not had sufficient time for soil development to occur often due to their location in a dynamic environment (e.g. floodplain, alluvial fan) or sometimes due to intensive land use management practices.
Aquents	Entisols that are saturated with water and have reducing, anaerobic soil conditions within the soil profile throughout the growing season.
Cryaquents	Aquents that occur in a cryic soil temperature regime.
Aquandic Cryaquents	Cryaquents that have thick (≥ 18 cm) deposits of coarse unweathered volcanic ejecta such as pumice or coarse volcanic cinders, or an abundance (5% of soil volume) volcanic glass and accumulations of aluminum and iron in the soil subsurface.
Typic Cryaquents	Cryaquents that are typical for this great group.
Gelaquents	Aquents that occur in a gelic soil temperature regime.
Typic Gelaquents	Gelaquents that are typical of this great group.
Fluvents	Entisols that have buried soil horizon(s) with an appreciation of organic carbon typically resulting from periodic flooding events.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Cryofluvents	Fluvents that have formed in a cryic soil temperature regime.
Aquic Cryofluvents	Cryofluvents that have within 50 cm of the soil surface redox depletions or a reduced matrix resulting from saturated anaerobic soil conditions throughout the growing season.
Mollic Cryofluvents	Cryofluvents that have high concentrations of organic carbon (dark brown in color) within the upper soil profile.
Oxyaquic Cryofluvents	Cryofluvents that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
Typic Cryofluvents	Cryofluvents that are typical for this great group.
Vitrandic Cryofluvents	Cryofluvents that have thick (≥ 18 cm) deposits of coarse, unweathered volcanic ejecta such as pumice or coarse volcanic cinders, or an abundance (5% of soil volume) volcanic glass and accumulations of aluminum and iron in the soil subsurface.
Orthents	Entisols that do not meet the taxonomic requirements for any other suborder of Entisols.
Cryorthents	Orthents that occur in a cryic soil temperature regime.
Aquic Cryorthents	Cryorthents that have within 50 cm of the soil surface redox depletions or a reduced matrix resulting from saturated anaerobic soil conditions throughout the growing season.
Lithic Cryorthents	Cryorthents that have bedrock within 50cm of the mineral soil surface.
Oxyaquic Cryorthents	Cryorthents that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
Typic Cryorthents	Cryorthents that are typical for this great group.
Vitrandic Cryorthents	Cryorthents that have thick (≥ 18 cm) deposits of coarse unweathered volcanic ejecta such as pumice or coarse volcanic cinders, or an abundance (5% of soil volume) volcanic glass and accumulations of aluminum and iron in the soil subsurface.
Gelorthents	Orthents that occur in a gelic soil temperature regime.
Typic Gelorthents	Gelorthents that are typical for this great group.
Psamments	Entisols that are sandy (soil texture class of loamy fine sand or sand) and have low abundance (<35%) of coarse fragments (>2 mm).
Cryopsamments	Psamments that occur in a cryic soil temperature regime.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: **Order** **Suborder** **Great Group** **Subgroup**	**Description**
Oxyaquic Cryopsamments	Cryopsamments that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
Spodic Cryopsamments	Cryopsamments that have a horizon 5 cm or more thick that has an appreciation of Iron and/or Aluminum in the subsurface.
Typic Cryopsamments	Cryopsamments that are typical for this great group.
Vitrandic Cryopsamments	Cryopsamments that have thick (≥ 18 cm) deposits of coarse unweathered volcanic ejecta such as pumice or coarse volcanic cinders, or an abundance (5% of soil volume) volcanic glass and accumulations of aluminum and iron in the soil subsurface.
Wassents	Entisols that are aquatic in nature and are perpetually saturated with water at the soil surface for more than 21 hours of each day in all years.
Haplowassents	Wassents that are considered typical for this suborder.
Typic Haplowassents	Haplowassents that are considered typical for this great group.
Gelisols	Soils that have permafrost within 100cm of the soil surface or within 200cm of the soil surface if the soil profile has been cryoturbated (showing signs of frost heaving). Permafrost is defined as a thermal condition in which soil material remains below 0° C for two or more years in succession. Cryoturbation is the mixing of soil material, or the sorting of rock fragments, due to annual freezing and thawing cycles.
Histels	Gelisols that have organic soil material at the surface that is greater than 40cm thick and are saturated throughout the growing season.
Fibristels	Histels that are comprised of fibric soil materials more than any other kind of organic soil material within the upper 50 cm of the soil profile.
Sphagnic Fibristels	Fibristels that have three-fourths or more of the fibric soil materials derived from *Sphagnum* within the upper 50 cm of the soil profile.
Terric Fibristels	Fibristels that have a layer of mineral soil 30 cm or more thick within 100 cm of the soil surface.
Hemistels	Histels that are comprised of hemic soil materials more than any other kind of organic soil material within the upper 50 cm of the mineral soil surface. .
Fluvaquentic Hemistels	Hemistels that have one or more thin (≤ 5 cm) buried mineral soil layers within the upper 100 cm of organic soil material. The buried mineral soils are typically derived from flooding events or volcanic ash.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Folistels	Histels that are saturated with water for less than 30 cumulative days during normal years.
Typic Folistels	Folistels that are considered typical for this great group.
Turbels	Gelisols that have one or more soil horizons showing cryoturbation (frost heaving) in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and oriented rock fragments.
Umbriturbels	Turbels that have a thick accumumlation of organic carbon in the upper soil profile and characteristically have low soil pH (<5.5).
Andic Umbriturbels	Umbriturbels forming in weathered volcanic eject or volcaniclastic materials and that do not meet the requirement for Andisols.
Haploturbels	All Turbels that do not fit into any other great group are considered Haploturbels.
Aquic Haploturbels	Haploturbels that have in one or more horizon within 100 cm of the soil surface redox depletions or a reduced matrix resulting from prolonged saturated anaerobic soil conditions.
Typic Haploturbels	Haploturbels that are considered typical for this great group.
Histosols	Soils that are saturated throughout the growing season and are comprised primarily of thick accumulations (typically >40 cm) of organic matter.
Fibrists	Histosols that are comprised of fibric soil materials more than any other kind of organic soil materials within a general depth of 0 to 120 cm.
Cryofibrists	Fibrists that have formed in a cryic soil temperature regime.
Fluvaquentic Cryofibrists	Cryofibrists that have one or more thin (≤ 5 cm) buried mineral soil layers within the upper 100 cm of organic soil material. The buried mineral soils are typically derived from flooding events or volcanic ash.
Hydric Cryofibrists	Cryofibrists that have a layer of water within a depth of 0 to 160 cm (e.g. floating organic mat).
Sphagnic Cryofibrists	Cryofibrists that have three-fourths or more of the fibric soil materials composed of *Sphagnum* within the depth of 0 to 60cm.
Terric Cryofibrists	Cryofibrists that have a layer of mineral soil 30 cm or more thick that has its upper boundary within 60 to 160 cm.
Typic Cryofibrists	Cryofibrists that are considered typical for this great group.
Haplofibrists	Fibrists that have not formed in a gelic soil temperature regime and are not comprised primarily of *Sphagnum* fibers.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Fluvaquentic Haplofibrists	Haplofibrists that have one or more thin (≤ 5 cm) buried mineral soil layers within the upper 100 cm of organic soil material. The buried mineral soils are typically derived from flooding events or volcanic ash.
Typic Haplofibrists	Haplofibrists that are considered typical for this great group.
Folists	Histosols that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).
Udifolists	Folists that have formed in a udic soil moisture regime.
Typic Udifolists	Udifolists that are considered typical for this great group.
Hemists	Histosols that are comprised of hemic soil materials more than any other kind of organic soil material within a general depth of 0 to 120 cm.
Cryohemists	Hemists that have formed in a cryic soil temperature regime.
Fluvaquentic Cryohemists	Cryohemists that have one or more thin (≤ 5 cm) buried mineral soil layers within the upper 100 cm of organic soil material. The buried mineral soils are typically derived from flooding events or volcanic ash.
Terric Cryohemists	Cryohemists that have a layer of mineral soil 30cm or more thick that has its upper boundary within 60 to 160 cm.
Typic Cryohemists	Cryohemists that are considered typical for this great group.
Saprists	Histisols that have more thickness of sapric soil materials than any other kind of organic soil material within a general depth of 0 to 120 cm.
Cryosaprists	Saprists that have formed in a cryic soil temperature regime.
Terric Cryosaprists	Saprists that have a layer of mineral soil 30 cm or more thick that has its upper boundary within 60 to 160 cm.
Haplosaprists	All Saprists that do not fit into any other great group are considered Haplosaprists.
Typic Haplosaprists	Saprists that are considered typical for this great group.
Wassists	Histosols that are aquatic in nature and are perpetually saturated with water at the soil surface for more than 21 hours of each day in all years.
Haplowassists	Wassists that are strongly brackish to saline (EC > 20,000 µS/m) and lack accumulations of hydrogen sulfide (H^2S).
Fibric Haplowassists	Haplowassists that are comprised of fibric soil materials more than any other kind of organic soil materials within a general depth of 0 to 120 cm.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Inceptisols	Soils that are moderately developed and include soils that do not meet the requirements for other soil orders. Inceptisols are characterized by distinct horizon development and mild weathering and translocation of materials to lower in the soil profile. Inceptisols also include soils with moderately thick (20-40 cm) surficial organic deposits that do not meet the requirements for Histosols.
Aquepts	Inceptisols that are saturated with water and have reducing, anaerobic soil conditions within the soil profile throughout the growing season.
Cryaquepts	Aquepts that occur in a cryic soil temperature regime.
Aeric Cryaquepts	Cryaquepts that have a higher soil chroma that is representative of either deeper ground water or a shorter period of saturation than the Typic subgroup.
Aquandic Cryaquepts	Cryaquepts that have thick (≥ 18 cm) deposits of coarse weathered volcanic ejecta such as pumice or coarse volcanic cinders, and/or more than 35% by volume coarse volcanic cinders, pumice, or pumice-like fragments.
Fluvaquentic Cryaquepts	Cryaquepts that have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Histic Cryaquepts	Cryaquepts that have organic soil materials at the surface that are 21-40 cm thick and remain saturated with water for 30 days or more cumulative in a normal year and do not meet the requirements for Histosols.
Typic Cryaquepts	Cryaquepts that are considered typical for this great group.
Gelaquepts	Aquepts that have formed in a gelic soil temperature regime.
Aquandic Gelaquepts	Gelaquepts that have thick (≥ 18 cm) deposits of coarse weathered volcanic ejecta such as pumice or coarse volcanic cinders, and/or more than 35% by volume coarse volcanic cinders, pumice, or pumice-like fragments.
Fluvaquentic Gelaquepts	Gelaquepts that have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Histic Gelaquepts	Gelaquepts that have organic soil materials at the surface that are 21-40cm thick and remain saturated with water for 30 days or more cumulative in a normal year and do not meet the requirements for Histosols.
Cryepts	Inceptisols that occur in a cryic soil temperature regime.
Humicryepts	Cryepts that have thick (>18 cm) accumulations of dark organic-carbon rich soil material at, or near, the soil surface and do not meet the requirements for Mollisols.
Andic Humicryepts	Humicryepts forming in weathered volcanic eject or volcaniclastic materials and do not meet the requirement for Andisols.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Fluvaquentic Humicryepts	Humicryepts that are 1) located on a landform with a slope of less than 25%, 2) have redoximorphic depletions resulting from anaerobic soil conditions, and 3) have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Fluventic Humicryepts	Humicryepts have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Typic Humicryepts	Humicryepts that are considered typical for this great group.
Dystrocryepts	Cryepts that typically have a lower soil pH (<5.5 and do not have thick (>18 cm) accumulations of dark organic-carbon rich soil material at, or near, the soil surface.
Fluventic Dystrocryepts	Dystrocrypets that have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Folistic Dystrocryepts	Dystrocryepts that have a thick organic surface horizon (15-40 cm) and are not saturated for more than 30 days cumulative in normal years.
Oxyaquic Dystrocryepts	Dystrocryepts that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
Vitrandic Dystrocryepts	Dystrocryepts that have 18 cm or more of either coarse volcanic ejecta such as pumice or coarse volcanic cinders, or that have 5 percent or more volcanic glass and an appreciation of aluminum and iron in the soil subsurface.
Haplocryepts	Cryepts that predominantly have higher pH values (>5.5) and do not have thick (>18 cm) accumulations of dark organic-carbon rich soil material at, or near, the soil surface.
Andic Haplocryepts	Haplocryepts forming in weathered volcanic eject or volcaniclastic materials and do not meet the requirement for Andisols.
Aquandic Haplocryepts	Haplocryepts that have an saturated anaerobic soil environment and redoximorphic depletions within 75 cm of the mineral soil surface and are forming in weathered volcanic eject or volcaniclastic materials. However, these soils do not meet the requirement for Andisols.
Aquic Haplocryepts	Haplocryepts that have within 50 cm of the soil surface redoximorphic depletions resulting from saturated anaerobic soil conditions for extended periods during the growing season.
Fluvaquentic Haplocryepts	Haplocryepts that have in one or more horizons within 75 cm of the mineral soil surface redoximorphic depletions (the result of saturated, anaerobic conditions throughout the growing season) and that have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Fluventic Haplocryepts	Haplocryepts that have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Typic Haplocryepts	Haplocryepts that are considered typical for this great group.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Vitrandic Haplocryepts	Haplocryepts that have 18 cm or more of either coarse volcanic ejecta such as pumice or coarse volcanic cinders, or that have 5 percent or more volcanic glass and an appreciation of aluminum and iron in the soil subsurface.
Vitrandic Humicryepts	Humicryepts that have 18 cm or more of either coarse volcanic ejecta such as pumice or coarse volcanic cinders, or that have 5 percent or more volcanic glass and an appreciation of aluminum and iron in the soil subsurface
Gelepts	Inceptisols that occur in a gelic soil temperature regime.
Humigelepts	Gelepts that have thick (>18 cm) accumulations of dark organic-carbon rich soil material at, or near, the soil surface and do not meet the requirements for Mollisols.
Andic Humigelepts	Humigelepts that have a total thickness of 18cm or more of soil with andic soil properties within 75 cm of the mineral soil surface. Andic soil properties commonly form during the weathering of tephra or other parent materials containing significant volcanic glass content.
Oxyaquic Humigelepts	Humigelepts that do not remain saturated, but experience periods of saturation within 100 cm of the mineral soil surface in normal years for 20 or more consecutive days, or 30 or more cumulative days.
Turbic Humigelepts	Humigelepts that have one or more soil horizons showing cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and/or oriented rock fragments within 200 cm of the mineral soil surface.
Typic Humigelepts	Gelepts that are considered typical for this great group.
Dystrogelepts	Gelepts that have a lower pH (<5.5) and do not have thick (>18 cm) accumulations of dark organic-carbon rich soil material at, or near, the soil surface.
Fluventic Dystrogelepts	Dystrogelepts that have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Turbic Dystrogelepts	Dystrogelepts that have been cryoturbated (frost heaving) as expressed in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and/or oriented rock fragments within 200 cm of the mineral soil surface.
Typic Dystrogelepts	Dystrogelepts that are considered typical for this great group.
Haplogelepts	Gelepts that have a higher (pH ≥5.5) and do not have thick (>18 cm) accumulations of dark organic-carbon rich soil material at, or near, the soil surface.
Andic Haplogelepts	Gelepts forming in weathered volcanic eject or volcaniclastic materials and do not meet the requirement for Andisols.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: Order / Suborder / Great Group / Subgroup	Description
Fluventic Haplogelepts	Haplogelepts that have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Turbic Haplogelepts	Haplogelepts that have been cryoturbated (frost heaving) as expressed in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and/or oriented rock fragments within 200 cm of the mineral soil surface.
Mollisols	Soils that have a higher pH (≥ 5.5) and thick (>18 cm) accumulations of dark organic-carbon rich soil material (related to abundant fine root turn over) at, or near, the soil surface and do not meet the requirements for Andisols.
Cryolls	Mollisols that have formed in a cryic soil temperature regime.
Haplocryolls	Mollisols that do not classify into any other great group of Cryolls.
Lithic Haplocryolls	Haplocryolls that have bedrock within 50 cm of the mineral soil surface.
Typic Haplocryolls	Haplocryolls that are considered typical for this great group.
Spodosols	Soils that have thick accumulations of translocated humus and aluminum and/or iron in the mineral subsurface.
Cryods	Spodosols that occur in a cryic soil temperature regime.
Haplocryods	Spodosols that do not have cemented horizons and do not have 6% organic carbon or more throughout a layer 10 cm or more thick within the spodic horizon.
Andic Haplocryods	Haplocryods forming in weathered volcanic eject or volcaniclastic materials.
Aquic Haplocryods	Haplocryods that have within 75cm of the soil surface redoximorphic depletions resulting from saturated anaerobic soil conditions throughout the growing season.
Folistic Haplocryods	Haplocryods that have a thick organic surface (15-40 cm), and are not saturated for more than 30 days (cumulative) in normal years.
Typic Haplocryods	Haplocryods that are considered typical for this great group.
Humicryods	Cryods that have significant accumulations (> 6%) of organic carbon within the horizon of translocated aluminum and/or iron.
Andic Humicryods	Humicryods forming in weathered volcanic eject or volcaniclastic materials.

Table 18. Description of soil subgroups found in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Taxonomic Class: **Order** **Suborder** **Great Group** **Subgroup**	**Description**
Aquic Humicryods	Humicryods that have within 75 cm of the soil surface redoximorphic depletions resulting from saturated anaerobic soil conditions that persist throughout the growing season.
Gelods	Spodosols that have formed in a gelic soil temperature regime.
Haplogelods	Gelods that do not have 6.0 percent or more organic carbon in the spodic horizon.
Andic Haplogelods	Haplogelods forming in weathered volcanic eject or volcaniclastic materials.
Turbic Haplogelods	Haplogelods show evidence of cryoturbation (frost churning) and/or ice segregation in the active layer (seasonal thaw layer) and/or the upper part of the permafrost.
Typic Haplogelods	Haplogelods that are considered typical for this great group.

material and are simply under represented in the dataset. Overall across the entire dataset, ninety-five soil subgroups were identified during field sampling, although 55 soil subgroups were rare (< 3 observations). Table 19 displays the number of total field plots and most common soil subgroups sampled within eight physiography classes.

Single-factor Comparisons by Subgroup

The soil classification was effective at partitioning the variability of numerous soil properties because the classification is based largely on soil temperature and moisture, thaw depth, depth to water table, volcanic ash content as inferred from thickness of ash-laden loess, organic thickness and base saturation as inferred from pH (Figure 21). For example soils in colder alpine and subalpine climates were associated with Gelic suborders of Entisols, Inceptisols, Spodosols, and Andisols, and those soils with measurable thaw depths were associated with Gelisols. Andisols and Andic subgroups of Spodosols were associated with soils having greater loess thicknesses. Rock depths <20 cm and surface fragments greater than 50% were commonly associated with the great groups Cryorthents and Gelorthents (within the Entisol order) and Lithic subgroups all soil orders (e.g., Lithic Haplocryolls). Water depths within 30 cm of the surface were associated with the great groups Cryohemists and Cryofibrists (Histosols), Cryaquepts and Gelaquepts (Inceptisols), and Cryaquents and Cryaquepts (Entisols). Surface organic thicknesses greater than 40 cm were associated with Cryofibrists, Cryohemists, and Cryosaprists (Histosols), while those between 15 and 40 cm were associated with Histic (e.g., Histic Cryaquepts) and Folistic (e.g., Folistic Haplocryands) subgroups of Inceptisols, Spodosols, and Andisols. Soil pH values <5.5 were associated with the Dystrocryepts and Dystrogelpts great groups of the Inceptisol order.

The addition of Turbic subclasses to Gelic suborders allowed for differentiation between those soils with cryoturbation from those without. However, the lack of Turbic subgroups for Cryic soil suborders failed to separate those Cryic soils with cryoturbation from those without. This was an issue particularly in alpine soils in the maritime and southern interior ecoregions where cryoturbation is common, but soil temperature regime was classified as Cryic. The classification lumps all Gelands (Andisols with a gelic temperature regime) into the Vitrigelands great group. However, lab data revealed that several Gelands did not have vitric soil properties (1500 kPa water retention < 15%). The lack of differentiation among Gelands did not allow for distinction between Gelands with and without vitric properties, and suggests that the inclusion of a Haplogelands great group in soil taxonomy may be warranted.

Ordination of Soils NIR Spectra

In addition to single-factor comparisons of soils, non-metric multidimensional scaling (NMDS) (Shepard 1962a,b; Kruskal 1964a,b) was used to separate plots by Near Infrared (NIR) absorbance spectra. The absorbance spectra were clustered using the fixed clustering algorithm Partitioning Around Medoids (PAM) (Kaufman and Rousseeuw 1990). Soil physical and chemical data was summarized by the clusters, and the clusters were displayed on the NMDS for interpretation and discussion purposes. NMDS and clustering were based on a Bray/Curtis dissimilarity matrix (Bray and Curtis 1957).

The three cluster solution provided the best balance between the number of clusters, metrics of cluster integrity (ratio of between to within cluster similarity), and interpretability (Figure 22). Overall, there was good separation between the clusters in n-dimensional ordination space.

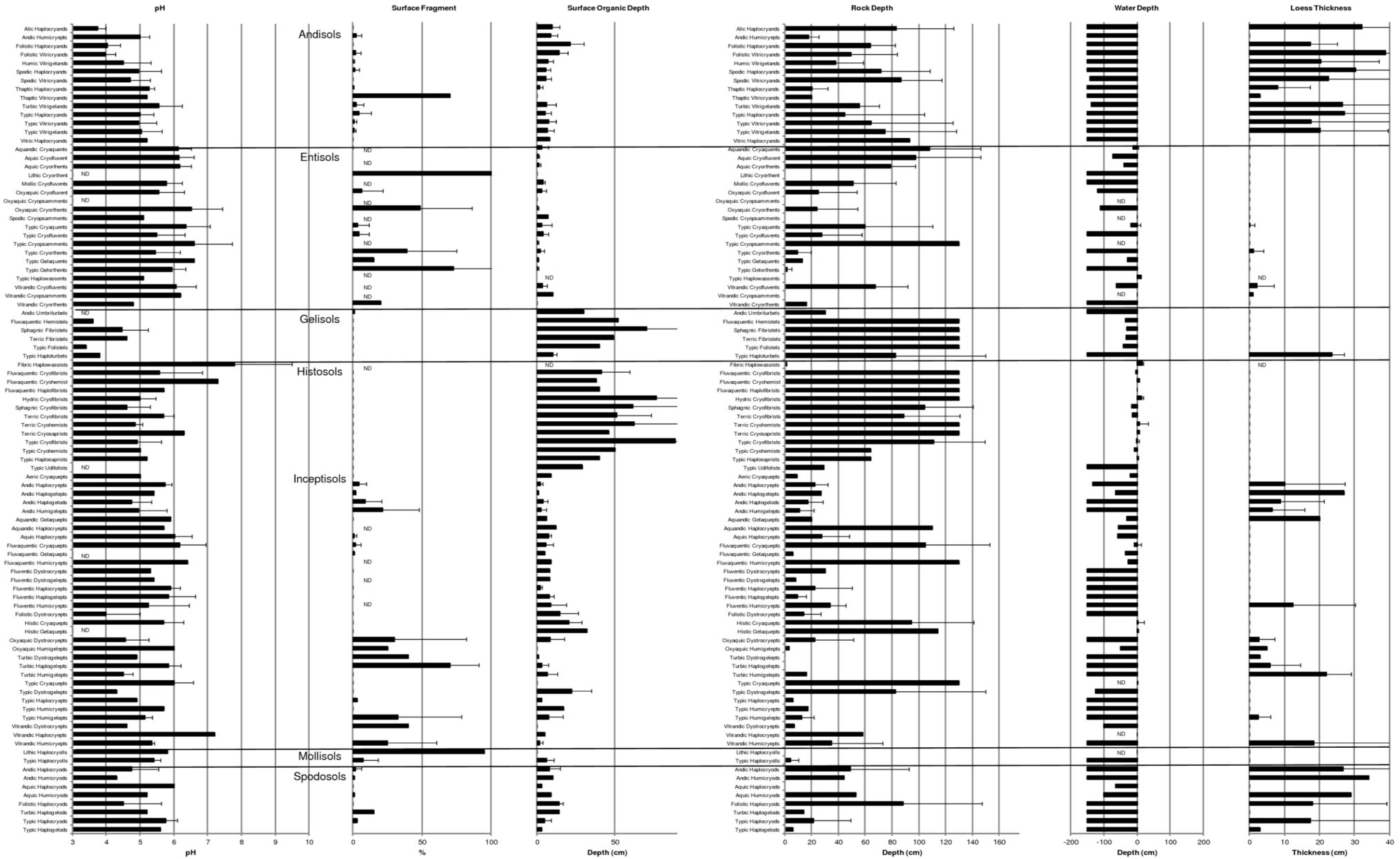


Figure 21. Mean (± SD) pH, surface fragmens, surface organic depth, rock depth, water depth, and loess thickness for soil subgroups in Lake Clark National Park and Preserve, Alaska.

Table 19. Total number of field plots and common soil subgroups sampled within eight physiography classes, Lake Clark National Park and Preserve, Alaska, 2011.

Physiography	Total number of soil subgroups	Total number of plots sampled	Common soil subgroups	% of total by physiography
Alpine	32	56	Typic Gelorthents	11
			Andic Humigelepts	7
			Typic Cryorthents	5
			Andic Haplocryepts	5
			Turbic Vitrigelands	5
				33
Glacial	2	4	Typic Cryorthents	75
			Typic Gelorthents	25
				100
Subalpine	18	31	Typic Vitrigelands	23
			Humic Vitrigelands	13
			Andic Haplogelods	10
			Fluventic Haplogelepts	6
			Andic Haplocryods	6
				58
Upland	26	63	Spodic Haplocryands	27
			Spodic Vitricryands	5
			Typic Cryorthents	5
			Andic Haplocryods	5
			Thaptic Haplocryands	5
				47
Lowland	27	53	Histic Cryaquepts	17
			Terric Cryofibrists	**11**
			Sphagnic Cryofibrists	8
			Andic Haplocryods	6
			Fluvaquentic Cryofibrists	6
				48
Lacustrine	15	19	Typic Cryofibrists	16
			Hydric Cryofibrists	16
			Terric Cryohemists	5
			Aquic Haplocryepts	5
			Andic Humicryepts	5
				47
Riverine	10	36	Oxyaquic Cryofluvents	31
			Typic Cryaquents	19
			Fluvaquentic Cryaquepts	17
			Oxyaquic Cryorthents	14
			Histic Cryaquepts	6
				87
Coastal	18	91	Typic Cryaquents	42
			Aquic Cryofluvents	3
			Histic Cryaquepts	2
				47

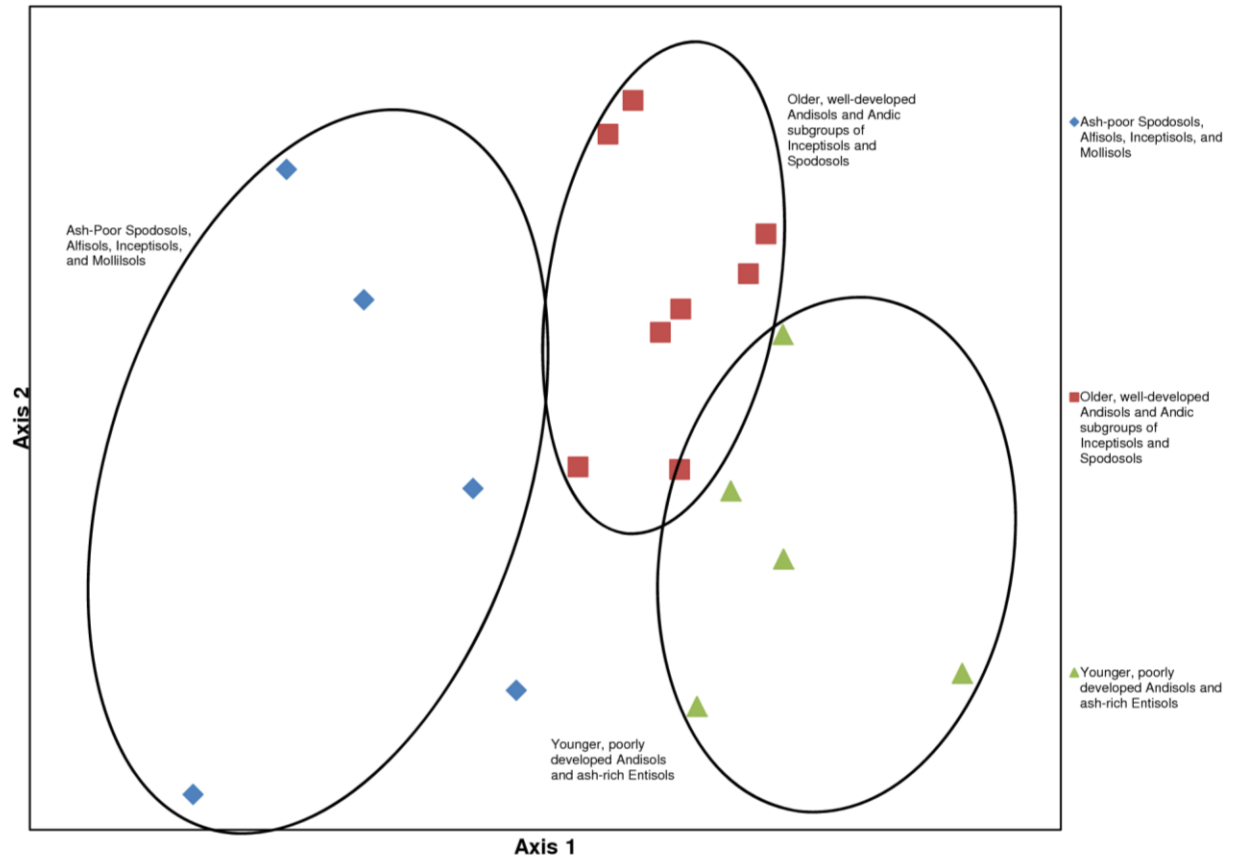


Figure 22. Non-metric multidimensional scaling of Near Infrared (NIR) soil absorbance spectra for soil groups in Lake Clark National Park and Preserve, Alaska.

Soils in cluster 1 had the lowest average percent organic carbon, volcanic glass content, silt, and percent phosphate retention; and the highest average percent sand (Table 20). Soils in this cluster corresponded to volcanic ash-poor Spodosols, Alfisols, Mollisols, and Inceptisols. Soils in cluster 2 had the highest average % organic carbon and phosphate retention, and moderate average percent sand and volcanic glass content. Soils in this cluster corresponded to older, well-developed Andisols and Andic subgroups of Inceptisols and Spodosols. Soils in cluster 3 corresponded to younger, poorly developed Andisols and ash-rich Entisols. Soil in this cluster had low average percent organic carbon and moderate percent sand, high average percent phosphate retention, and the highest average volcanic glass content. Ordination and clustering of the NIR absorbance spectra grouped soils with similar physical and chemical properties, which corresponded well with soil classifications. For instance, older, well-developed Andisols and other soils with andic properties tend to have large accumulations of soil organic carbon and extremely high phosphorus retention capacity (Nanzyo 2002, Ugolini and Dahlgren 2002). These older soils are also more weathered, and a larger proportion of volcanic glass is broken down into constituent elements. Younger Andisols and Entisols with recent volcanic ash deposition would have lower accumulations of organic carbon, and the highest volcanic glass content as insufficient time has

Table 20. Chemical and physical laboratory data for soil samples from 18 plots collected as part of a soils Near Infrared Spectroscopy pilot study summarized by soil NIR absorbance spectra cluster, Lake Clark National Park and Preserve, Alaska, 2011.

Analysis	Ash-poor Spodosols, Alfisols, Inceptisols, and Mollisols Mean (SD)	Older, well-developed Andisols and Andic subgroups of Inceptisols and Spodosols Mean (SD)	Younger, poorly developed Andisols and ash-rich Entisols Mean (SD)
Mean % Organic Carbon	2.90% (1.30%)	7.60% (3.50%)	4.10% (1.70%)
Mean Total Nitrogen	0.2 (0.1)	0.4 (0.2)	0.2 (0.1)
Mean % Sand	71.20% (5.00%)	57.90% (10.20%)	56.40% (10.30%)
Mean % Silt	23.60% (5.30%)	37.90% (11.70%)	39.20% (10.50%)
Mean % Clay	5.20% (3.00%)	4.30% (2.00%)	4.40% (0.90%)
Mean % Phosphate Retention	57.20% (19.50%)	88.50% (8.10%)	84.20% (20.90%)
Mean % volcanic glass	9.00% (9.60%)	36.30% (16.40%)	63.00% (31.90%)
Soil Subgroups[a]	Humic Vitrigelands, Typic Humigelepts, Andic Haplocryalfs, Typic Haplocryolls, Folistic Haplocryods	Alic Haplocryands, Spodic Haplocryands [2], Typic Vitrigelands [2], Andic Humicryepts, Andic Humigelepts, Andic Humicryods	Thaptic Haplocryands, Typic Haplocryands, Spodic Haplocryands, Typic Vitricryands, Vitrandic Cryorthents

[a]Sample size of one for soil subgroups unless otherwise noted in brackets.

passed for weathering and transformation. The ash-poor Spodosols, Alfisols, Mollisols, and Inceptisols are clustered together due to a combination of the small sample size and the very different chemical and physical properties of these soils relative to Andisols and Andic subgroups. The results of the NIR spectral analysis suggest that NIR spectroscopy of soils may be used effectively to predict soil chemical and physical properties and to link those properties to soil taxonomy. However, the full benefits of soil NIR spectroscopy are realized through the development of a soil NIR spectral library (Shepherd and Walsh 2002), of which this study component represents the early stages. We foresee two potential applications for the spectral library. First, the spectra could be linked to landscape-scale variables in a GIS to develop maps of soil spectral properties in the study area similar to Viscarra Rossel and Chen (2011). Secondly, the soil spectral library could serve as a baseline for assessing and monitoring soil conditions in SWAN parks into the future. For instance, NIR spectroscopy has been used as a rapid, inexpensive method for measuring soil carbon (McCarty et al. 2002) and NIR soil spectral properties have recently been mapped at broad spatial scales. Hence, the potential exists for the soil spectral library to serve as a baseline for mapping and monitoring soil carbon at the landscape scale.

Classification and Description of Soil Landscapes

Alpine Ashy-Loamy-Rocky Meadows and Shrublands

This soil landscape encompasses five ecotypes, including Alpine Ashy-Loamy Dwarf Shrub Hummocks, Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra, Alpine Ashy-Loamy-Rocky Moist Sedge Meadow, Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow, and Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra. It is found in mountainous areas above treeline in the southern interior and maritime ecoregions, and characterizes alpine environments where an ash-rich loess mantle overlays rocky colluvium or till. The soils and vegetation of this soil landscape are similar to Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands. However, the soil landscape occurs in the southern interior and maritime ecoregions where the soils are assumed to be warmer. Common soil types include Spodic Haplocryands, Spodic Vitricryands, Typic Haplocryands, Andic Haplocryepts and Vitrandic Humicryepts. Mollisols may exist in this soil landscape but are to the southeastern maritime ecoregion in areas of sandstone and siltstone parent material.

Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands

This soil landscape encompasses three ecotypes, including Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks, Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra, Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow. The soils and vegetation of this soil landscape are similar to Alpine Ashy-Loamy-Rocky Meadows and Shrublands with soil forming in an ash-rich loess mantle overlays rocky colluvium or till. However, this soil landscape occurs in mountainous areas in the northern interior ecoregion where the soils are assumed to be colder. Soils were classified in the gelic soil temperature regime and the presence of discontinuous ice-poor permafrost is likely. Soils tend to be circum-acidic to acidic and well drained Inceptisols with andic soil properties, Andisols, Spodosols, and Gelisols. Common soil types include Andic Humigelepts, Andic Haplogelepts, Humic Vitrigelands, Turbic Vitrigelands, Andic Haplogelods and Andic Umbriturbels.

Alpine Gelic Rocky Barrens and Shrublands

This soil landscape encompasses four ecotypes, including Alpine Gelic Rocky Barrens, Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra, Alpine Gelic Rocky Dwarf Willow Tundra, Alpine Gelic Rocky Lichen Tundra. The soils and vegetation are similar to the Alpine Rocky Barrens and Shrublands soil landscape. However, this soil landscape occurs in mountainous areas in the northern interior ecoregion where the soils are assumed to be colder. Soils were classified in the gelic soil temperature regime and the presence of discontinuous ice-poor permafrost is likely. Soils are typically rocky with little to no volcanic ash, acidic to circum-acidic Entisols or weakly developed Inceptisols. Soils may be shallow to bedrock (<50cm). Common soil subgroups include Typic Gelorthents, Turbic Dystrogelepts, Turbic Haplogelepts, and Turbic Humigelepts.

Alpine Loamy-Organic Wet Sedge Meadows

This soil landscape encompasses one soil landscape and occurs in all ecoregions. It occurs in alpine wet meadows and fens. Soils are wet and often feature thick surficial organic horizons. Soils are Histosols and saturated, organic-rich Entisols and Inceptisols.

Alpine Rocky Barrens and Shrublands

This soil landscape encompasses five ecotypes, including Alpine Rocky Barrens, Alpine Rocky Dwarf Shrub Late-Lying Snowbanks, Alpine Rocky Dwarf Shrub-Lichen Tundra, Alpine Rocky

Dwarf Willow Tundra, Alpine Rocky Lichen Tundra. The soil and vegetation of this soil landscape are similar to the Alpine Gelic Rocky Barrens and Shrubland except soils in this landscape are forming in a cryic soil temperature regime in mountainous areas in the southern interior and maritime ecoregions. Soils are typically acidic to circum-acidic Entisols or weakly developed Inceptisols. Soils may have thin accumulations of ash within the soil profile but are predominately rocky. If present, the organic surface horizon is thin (<5cm) and overlays a mixed loamy and rocky subsurface that is well to somewhat excessively well drained. Soils may be shallow to bedrock (<50cm). Common soil subgroups include Typic Cryorthents, Lithic Cryorthents, Vitrandic Dystrocryepts, Vitrandic Cryorthents., and Vitrandic Humicryepts.

Developed Land
This soil landscape occurs in locations that have been permanently modified by anthropogenic activities. Examples of these areas include the town of Port Alsworth, private inholdings and remote airstrips, and the Crescent River oil facilities.

Glacial Sandy-Rocky Barrens and Shrublands
This soil landscape encompasses two ecotypes, including Glacial Sandy-Rocky Alder Shrub and Glacial Sandy-Rocky Barrens. This soil landscape occurs in recently deglaciated areas (≤ ~60 years ago) in the upper portion of mountain valleys and may include ice-cored moraines. Soils are rocky and sandy, acidic to circum-acidic with little soil development. Early successional vegetation, including barrens and *Alnus crispa* shrublands, predominates. Soil subgroups include Typic Cryorthents (southern interior and maritime) and Typic Gelorthents (northern interior).

Glaciers and Permanent Snow Fields
This soil landscape encompasses one ecotype, including Glacier. This soil landscape occurs in presently glaciated areas and those alpine areas with permanent snow fields. Hundreds of glaciers occur in LACL, the majority of them unnamed. Examples of some of the more prominent glaciers include Red, Tuxedni, and Double Glaciers in the maritime ecoregion.

Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands
This soil landscape encompasses three ecotypes, including Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow, Interior Lacustrine Ashy-Loamy-Rocky Low Shrub, and Interior Lacustrine Loamy-Rocky Barrens. This soil landscape occurs in recently drained lakes and along lake margins in the northern and southern ecoregions. Soil are typically moist to wet, loamy to rocky and sometimes ashy, and acidic to circum-acidic. The ecotypes in this soil landscape represent a successional sequence from barrens on the youngest drained lakes to wet *Calamagrostis* and *Carex* meadows to *Salix*-dominated shrublands in the oldest drained lakes. Soils start out as rocky Entisols with little to no surficial organics, and sometimes feature frost-sorted rocky nets. Overtime ash-laden loess accumulates in these drained basins lending to the development of ashy-loamy Inceptisols that often feature thin accumulations of organic material at the surface. Soil subgroups commonly associated with this soil landscape include Typic Cryaquents in more recently drained lakes, and Andic Humicryepts, Aquic Haplocryods, and Aquic Haplocryepts in older drained lakes.

Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens
This soil landscape encompasses three ecotypes, including Interior Lacustrine Loamy-Organic Wet Sedge Meadow, Interior Lacustrine Organic-rich Sedge Marsh, and Interior Lacustrine

Organic-rich Sedge-Shrub Bog. This soil landscape occurs in the interior ecoregions in recent thaw lakes formed by thermokarst and along the margins of lowland, subalpine, and alpine lakes. Soils are wet and organic-rich and often permanently flooded. Vegetation includes sedge and willow dominated wet meadows and fens, and *Sphagnum* dominated bogs. Soils are Histosols and organic-rich Inceptisols, including Hydric Cryofibrists, Fluvaquentic Haplofibrists, Shagnic Cryofibrists, Fluvaquentic Cryohemists, Typic Cryofibrists, Histic Cryaquepts, Histic Gelaquepts, and Terric Cryofibrists.

Interior Lowland Ashy-Loamy-Organic Shrublands and Forests
This soil landscape encompasses four ecotypes, including Interior Lowland Ashy-Loamy-Organic Black Spruce Forest, Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub, Interior Lowland Ashy-Loamy-Rocky Mixed Forest, Lowland Acidic Ashy-Loamy Birch-Poplar Forest. Vegetation includes *Picea mariana* forests, mixed forest with *Picea glauca, Populus balsamifera*, and *Betula papyrifera* var. *kenaica*, and shrublands dominated by *Betula glandulosa* and *Ledum decumbens*. This soil landscape occurs in lowland areas in the interior ecoregions in flat to gently sloping (5-8 degrees), broad glacial valley floors in thick ash-laden loess deposits overlying till and glaciofluvial deposits, and on toeslopes along hills and mountains. Soils are typically ash-rich and rocky, moist to wet, well-drained, and acidic. Forested soils commonly feature a moderately thick (12-13 cm) Surface organic horizon. Soils are commonly ash-rich Spodosols, and Andisols with spodic properties, including Andic Haplocryods, Folistic Vitricryands, Spodic Haplocryands, Spodic Vitricryands, Aquic Haplocryepts, Typic Dystrogelepts, Aquic Humicryods, and Typic Vitricryands.

Interior Lowland Frozen Loamy-Organic Bogs and Forests
This soil landscape encompasses three ecotypes, including Interior Lowland Frozen Loamy-Organic Black Spruce Forest, Interior Lowland Frozen Organic-Rich Dwarf Spruce Forest, and Interior Lowland Frozen Organic-Rich Sedge-Shrub Bog. This soil landscape occurs in lowlands in areas of discontinuous ice-rich permafrost. This includes areas in the lower Stony River valley, near Six Mile Lake and Pickerel Lakes at the southern end of Lake Clark, and in the Chulitna River drainage in southwestern LACL. Soils are frozen within one meter of the soil surface, wet, and organic-rich. Vegetation sedge-shrub bog *Betula nana, Ledum decumbens, and Sphagnum* sp and *Picea mariana* forests and dwarf woodlands. Soils subgroups commonly associated with this soil landscape include Sphagnic Fibristels, Terric Fibristels, Typic Folistels, and Typic Haploturbels.

Interior Lowland Organic-Rich Wet Meadows and Shrublands
This soil landscape encompasses three ecotypes, including Interior Lowland Organic-Rich Birch-Ericaceous Shrub, Interior Lowland Organic-Rich Wet Sedge Meadow, and Lowland Organic-Rich Sedge-Shrub Bog. This soil landscape occurs on abandoned floodplains, kettle basins, and in bogs and fens in lowland environments in interior ecoregions. The vegetation and soils in this soil landscape are similar to those of the Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens soil landscape. However, the later is uniquely associated with wetlands forming in drained and thermokarst lakes and along lake margins. Vegetation includes birch-ericaceous and willow shrublands dominated by *Betula nana, Ledum decumbens, Betula glandulosa*, and *Myrica gale, Salix pulchra, and Salix fuscescens,* and wet meadows, fens, and bogs dominated by *Sphagnum* sp., *Andromeda polifolia, Carex limosa,* and *Carex aquatilis.* Soils are wet with thick organic deposits and include Histosols and organic-rich Inceptisols. Commonly associated

soil subgroups include Sphagnic Cryofibrists, Fluvaquentic Cryofibrists, Terric Cryofibrists, Typic Cryofibrists Histic Cryaquepts, and Typic Cryohemists.

Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands
This soil landscape encompasses three ecotypes, including Interior Subalpine Ashy-Loamy Alder-Willow Shrub, Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow, Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub, and Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub. This soil landscape occurs in subalpine areas in the interior ecoregions on mountain slopes and broad valleys in areas with thick accumulations of ash-laden loess. Vegetation includes *Alnus crispa, Betula nana, and Betula glandulosa* low and tall shrublands, *Empetrum nigrum* dwarf shrublands, and *Calamagrostis* meadows. Soils are typically moist, acidic, and ashy to loamy with occasional rocks in the upper mantle, and include Andisols and ash-rich Inceptisols and Spodosols. Common soil subgroups include Typic Vitrigelands, Turbic Humigelepts, Humic Vitrigelands, Andic Haplocryods, and Andic Haplogelods.

Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands
This soil landscape encompasses two ecotypes, including Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland and Interior Subalpine Organic-rich Alder Tall Shrub. This soil landscape occurs in subalpine areas in the interior ecoregions on mountain slopes and broad valleys in areas with thick accumulations of surficial organic material over ashy or rocky mineral soils. Vegetation is *Picea glauca* woodlands and forests and *Alnus crispa* shrublands. Soils are typically moist, acidic, organic-rich and ashy to loamy and sometimes rocky. Common soil subgroups associated with this soil landscape include Folistic Haplocryands, Folistic Dystrocryepts, and Typic Udifolists.

Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands and Forests
This soil landscape encompasses two ecotypes, including Interior Subalpine Frozen Ashy-Loamy-Rocky Dwarf Spruce Forest and Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub. This soil landscape occurs in subalpine in areas of discontinuous ice-rich permafrost. Vegetation is dwarf Picea mariana forests and woodlands and ericaceous shrublands dominated by *Betula nana, Ledum decumbens,* and *Sphagnum* sp. Soils are frozen within one meter of the soils surface and typically ashy to loamy, organic-rich, and occasionally rocky. Soil subgroups include Typic Haploturbels and Sphagnic Fibristels.

Interior Subalpine Organic-Rich Wet Meadow and Bogs
This soil landscape encompasses one ecotype, including Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog. This soil landscape occurs in subalpine wet meadows, bogs, and fens. Commonly associated species include *Carex aquatilis, Salix fuscescens, and Sphagnum* sp. Soils are wet and organic rich Inceptisols and Histosols.

Interior Subalpine Rocky Barrens, Shrublands, and Forests
This soil landscape encompasses two ecotypes, including Interior Subalpine Rocky Alder-Willow Shrub and Interior Subalpine Rocky Balsam Poplar Forest. This soil landscape occurs in subalpine in steep, rocky, unstable environments, including active alluvial fans, recent colluviums, and avalanche paths and debris piles. Vegetation is *Populus balsamifera* forests and woodlands and *Alnus crispa* and *Salix alaxensis* low and tall shrublands. Soils are moist, rocky

Inceptisols and Entisols, occasionally rocky, ash-rich Inceptisols. Common soil subgroups include Typic Cryofluvents, Fluventic Haplogelepts, Andic Humicryepts, and Fluventic Dystrogelepts.

Interior Upland Ashy-Loamy Shrublands and Forests
This soil landscape encompasses five ecotypes, including Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub, Interior Upland Ashy-Loamy Black Spruce Forest, Interior Upland Ashy-Loamy Mixed Forest, Upland Ashy-Loamy Birch-Poplar Forest, and Upland Ashy-Loamy-Rocky White Spruce Woodland. This soil landscape occurs in interior upland environments on older, more stable landforms and slope positions with thick accumulations of ash-laden loess. Vegetation includes a broad suite of forested types, including conifer forests dominated by *Picea glauca* and *P. mariana* and mixed forests dominated by *P. glauca* or *P. mariana* and *Populus balsamifera*, *Betula papyrifera* var. *kenaica,* or *Populus tremuloides*. *Betula glandulosa and B. nana* shrublands also occur in this soil landscape. Soils are moist, acidic, loamy to ashy Spodosols and Andisols with spodic properties. Moderately thick surficial organics are common in forests in this soil landscape. Commonly associated soil subgroups include Spodic Haplocryands, Folistic Vitricryands, Spodic Vitricryands, Spodic Haplocryands , Folistic Haplocryods, Folistic Haplocryands, and Andic Haplocryods.

Interior Upland Rocky Barrens, Shrublands, and Forests
This soil landscape encompasses five ecotypes, including Interior Upland Rocky Alder Shrub, Interior Upland Rocky Birch-Ericaceous Low Shrub, Interior Upland Rocky Mixed Forest, Interior Upland Rocky White Spruce Woodland, and Upland Rocky Birch-Poplar Forest. This soil landscape occurs on steep rocky outcrops and mountains slope, active alluvial fans, avalanche paths and debris piles, and rocky glacial drift. Vegetation is similar to the Interior Upland Ashy-Loamy Shrublands and Forests soil landscape and includes a diverse group of forested and shrubland vegetation. Forests vegetation includes *Picea glauca, Populus balsamifera*, and *Betula papyrifera* var. *kenaica* forests and mixed forest with combinations of the above. Shrublands include *Betula glandulosa, B. nana, and Alnus crispa*. Soils are dry to moist, rocky and minimally developed with little to no volcanic ash. Common soil subgroups include Fluventic Haplocryepts, Typic Cryofluvents, and Typic Cryorthents.

Lake Water
This soil landscape encompasses four ecotypes, including Alpine Lake, Alpine Spring, Glacial lakes, Subalpine Lake, Lowland Lake, and Riverine Lake. Fresh lake water is the common theme in this soil landscape. Alpine spring water is also included in this soil landscape. Alpine lakes are commonly small, kettle lakes and ponds, Turquoise Lake, Snipe Lake, and Summit Lake (near Lake Clark Pass) are examples of subalpine lakes, Lake Clark and Telequana Lake are example of lowlands lakes. Riverine lakes are typically small and linked hydrologically to their associated rivers. Larger riverine lakes are common along the Tazimina River downstream of Lower Tazimina Lake in southern LACL.

Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes
This soil landscape encompasses five ecotypes, including Maritime Coastal Brackish Ponds, Maritime Coastal Loamy Saline Wet Sedge Meadow, Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow, Maritime Coastal Saline Marestail Marsh, and Maritime Coastal Silty-Clayey Saline Barrens. This soil landscape occurs in salt marshes along Cook Inlet.

The vegetation includes a variety of salt tolerant sedges, grasses, and forbs including *Carex ramenskii*, *Carex glareosa*, *Carex lyngbyaei*, *Puccinellia phryganodes, Potentilla egedii*, *Triglochin maritimum*, *Leymus mollis*, and *Plantago maritima*. Soils are wet to moist, slightly brackish to brackish, and fine-textured, including clay-rich silts and loams and thick organic deposits in coastal ponds. Commonly associated soils include Typic Craquents, Typic Cryaquents, Histic Cryaquepts, Aquic Cryofluvent, and Fibric Haplowassists.

Maritime Coastal Sandy-gravelly Barrens and Meadows
This soil landscape encompasses two ecotypes, including Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow and Maritime Coastal Sandy-Rocky Saline Barrens. This soil landscape occurs on sandy and gravelly beaches, tidal flats, active sand dunes and beach ridges along Cook Inlet. Vegeation includes *Leymus mollis*, *Lathyrus maritimus, Honckenya peploides*, and *Stellaria humifusa*. Soils are sandy and gravelly, dry to moist and occasionally wet (tidal flats) Entisols. Common soil subgroups include Typic Cryofluvents,Oxyaquic Cryorthents, Typic Cryopsamments , Mollic Cryofluvents, and Typic Cryaquents.

Maritime Lowland Ashy-Loamy Forests
This soil landscape encompasses two ecotypes, including Lowland Acidic Ashy-Loamy Birch-Poplar Forest and Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest. This soil landscape occurs in lowland areas in the maritime ecoregion. Vegetation include *Picea sitchensis, Picea× lutzii, Populus balsamifera, Populus trichocarpa,* and *Betula papyrifera* var. *kenaica*. Soils are wet, ashy to loamy and acidic Inceptisols. Common subgroups include Aquic Haplocryepts and Aquandic Haplocryepts.

Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands
This soil landscape encompasses three ecotypes, including Lowland Organic-Rich Sedge-Shrub Bog, Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub, and Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow. This soil landscape occurs in wetlands in the maritime ecoregion. Vegetation is a diverse combination of shrublands, meadows, and bogs. Characteristic species in shrublands and meadows include *Myrica gale, Salix fuscescens, Salix pulchra, Calamagrostis canadensis, and Carex lyngbyaei*. Bog species include *Salix fuscescens, Carex aquatilis, Carex limosa, Andromeda polifolia, Drosera rotundifolia, and Sphagnum* sp. Soils are wet, acidic, ashy to loamy and organic-rich Entisols and Inceptisols and thick organic deposits (Histosols). Commonly associated soil subgroups include Terric Cryofibrists, Typic Cryaquents, Histic Cryaquepts, Sphagnic Cryofibrists, and Fluvaquentic Cryaquepts.

Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests
This soil landscape encompasses six ecotypes, including Maritime Upland Ashy-Loamy Mixed Low Shrub, Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest, Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub, Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow, Upland Ashy-Loamy Birch-Poplar Forest, Upland Rocky Birch-Poplar Forest, and Upland Ashy-Loamy-Rocky White Spruce Woodland. This soil landscape occurs in maritime uplands on gentle to moderately steep slopes with thick accumulations of volcanic ash. Vegetation is a combination of graminoid meadows characterized by *Calamagrostis canadensis, Epilobium angustifolium, and Angelica lucida*; shrublands characterized by *Alnus crispa, Rubus spectabilis, Oplopanax horridus, Vaccinium ovalifolium, and Salix* sp., and forests dominated by

Picea × lutzii, Picea glauca, and Populus balsamifera. Soils are moist, acidic, ashy and occasionally rocky Andisols. Commonly associated subgroups include Spodic Haplocryands, Alic Haplocryands, and Thaptic Haplocryands.

Maritime Upland Rocky Barrens, Shrublands, and Forests
This soil landscape encompasses three ecotypes, including Maritime Upland Rocky Alder Shrub, Maritime Upland Sandy-Rocky Alder-Willow Shrub, and Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest. This soil landscape occurs on steep, rocky mountain slopes, active alluvial and co-alluvial fans, and abandoned beach ridges in the maritime ecoregion. Vegetation includes *Alnus crispa* and *Salix* sp. shrublands and *Picea × lutzii* conifer forests. Soils are rocky and ash-rich on mountain slopes and rocky with sands on beach ridges and alluvial and co-alluvial fans. Soil orders include Entisols and Inceptisols. Common associated subgroups include Typic Haplocryepts, Typic Haplocryands, Vitrandic Cryofluvents, Typic Cryofluvents, Vitrandic Cryopsamments, and Fluventic Haplocryepts.

Nearshore Water
This soil landscape encompasses one ecotype, Nearshore Water, and represents the estuarine waters of Cook Inlet.

Riverine Glacial River Water
This soil landscape encompasses one ecotype, Riverine Glacial River Water, and represents glacial rivers in LACL. Glacial rivers are those that receive the greater percentage of their waters directly from melting glaciers and are characterized by being heavily laden with glacial silt. Examples include Stony River, Currant Creek, Redoubt Creek, and Necons River.

Riverine Non-Glacial River Water
This soil landscape encompasses one ecotype, Riverine Non-Glacial River Water, and represents non-glacial rivers in LACL. Non-glacial rivers include small headwater streams and large rivers that receive the majority of their water from non-glacial sources and are characterized by being clear and predominantly silt-free. Examples include the Mulchatna and Chilikadrotna Rivers.

Riverine Sandy-Rocky-Organic Meadows and Shrublands
This soil landscape encompasses four ecotypes, including Interior Riverine Sandy Forb Meadow, Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub, Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub, and Riverine Ashy-Loamy-Organic Wet Sedge Meadow. This soil landscape encompasses shrublands and meadows that occur on active and inactive floodplains and terraces and abandoned channels in river corridors in both maritime and interior ecoregions. Vegetation includes *Alnus* sp. and *Salix* sp. shrublands and graminoid and forb dominated wet meadows and marshes. Soils moist to wet and range from sandy and rocky Entisols on younger fluvial surfaces to organic-rich Inceptisols on older fluvial surfaces in wet meadows, abandoned channels, and riverine marshes. Commonly associated Oxyaquic Cryofluvent, Typic Cryaquents, Fluvaquentic Cryaquepts, and Histic Cryaquepts.

Riverine Silty-Sandy-Rocky Barrens and Forests
This soil landscape encompasses five ecotypes, including Interior Riverine Silty-Sandy-Rocky White Spruce Forest, Maritime Riverine Silty-Sandy-Rocky Spruce Forest, Riverine Silty-Sandy-Rocky Barrens, Riverine Silty-Sandy-Rocky Mixed Forest, and Riverine Silty-Sandy-

Figure 23.
Soil Landscapes

Lake Clark National Park & Preserve



155°W 154°W 153°W

N 19

N 09

0 5 10 15 20 Miles

0 10 20 30 Kilometers

Approximate scale at 11"x17": 1:650,000

N W E S

Soil Landscapes are aggregations of similar ecotypes with similar soils. They partition the region into landscapes with similar geomorphic processes, soil characteristics, hydrologic regimes, and vegetation with similar composition that are related through successional sequences.

Map projection: Albers Alaska, NAD 83, meters;
ABR file: LACL_SoilLandscape_10-352.mxd,
17 December 2012

Lake Clark National Park & Preserve

Soil Landscapes

- Alpine Gelic Rocky Barrens and Shrublands
- Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands
- Alpine Rocky Barrens and Shrublands
- Alpine Ashy-Loamy-Rocky Meadows and Shrublands
- Alpine Loamy-Organic Wet Sedge Meadows
- Glacial Sandy-Rocky Barrens and Shrublands
- Interior Subalpine Rocky Barrens, Shrublands, and Forests
- Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands
- Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands
- Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands
- Interior Subalpine Organic-Rich Wet Meadow and Bogs
- Interior Upland Rocky Barrens, Shrublands, and Forests
- Interior Upland Ashy-Loamy Shrublands and Forests
- Maritime Upland Rocky Barrens, Shrublands, and Forests
- Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests
- Interior Lowland Ashy-Loamy-Organic Shrublands and Forests
- Interior Lowland Organic-Rich Wet Meadows and Shrublands
- Interior Lowland Frozen Loamy-Organic Bogs and Forests
- Maritime Lowland Ashy-Loamy Forests
- Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands
- Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands
- Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens
- Riverine Silty-Sandy-Rocky Barrens and Forests
- Riverine Sandy-Rocky-Organic Meadows and Shrublands
- Maritime Coastal Sandy-gravelly Barrens and Meadows
- Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes
- Lake Water
- Riverine Glacial River Water
- Riverine Non-Glacial River Water
- Tidal River
- Nearshore Water
- Glaciers and Permanent Snow Fields
- Developed Land

Figure 23. Soil landscapes map for Lake Clark National Park and Preserve, Alaska.

Rocky Poplar Forest. This soil landscape occurs on active and inactive floodplains and terraces along river corridors The ecotypes in this soil landscape represent a successional sequence from barrens to *Populus* sp. on active fluvial surfaces to mixed forests and *Picea* forests on inactive fluvial surfaces. Soils are typically moist and range from sandy to rocky in early successional stages on active fluvial surface to interbedded silts and sands with occasional buried organic horizons in later successional stages on inactive fluvial surfaces. Commonly associated soil subgroups include Oxyaquic Cryofluvents, Oxyaquic Cryorthents, and Fluvaquentic Cryaquepts.

Tidal River
This soil landscape encompasses one ecotype, Tidal River, and represents tidal rivers in the Maritime ecoregion. Tidal rivers are those portions of rivers that are influenced by salt water during high tide events. Examples of tidal rivers include the extreme lower portion of several large rivers as the empty into Cook Inlet, including Glacier Creek, Middle Glacier Creek, Johnson River, and Tuxedni River, and numerous smaller careeks that meander through tidal flats and meadows, including Silver Salmon Creek and Shelter Creek.

Soil Landscapes Mapping

The map of soil landscapes was developed by aggregating and recoding the ecotypes (based on aggregated ecotype code) into a reduced set of 33 closely related soil subgroups and ecotypes (Figure 23, Tables 21–27). The soil landscapes are named by their ecoregion, physiography, generalized texture, and dominant vegetation structure. The most common soil landscape classes included Alpine Rocky Barrens and Shrublands (15.8%), Alpine Gelic Rocky Barrens and Shrublands (15.5%), Glaciers and Permanent Snow Fields (10.8%), Interior Subalpine Rocky Barrens, Shrublands, and Forests (6.9%), and Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands (6.5%) (Figure 23, Table 28). The least common (all <0.1%) soil landscape classes were Alpine Loamy-Organic Wet Sedge Meadows, Developed Land, and Interior Subalpine Organic-Rich Wet Meadow and Bogs.

Table 21. Alpine and Glacial soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes.

Abbreviated Ecotype	Typic Cryorthents	Lithic Cryorthent	Lithic Haplocryolls	Vitrandic Dystrocryepts	Thaptic Haplocryands	Andic Haplocryepts	Vitrandic Humicryepts	Vitrandic Cryorthents	Thaptic Vitricryands	Typic Vitricryands	Typic Haplocryands	Spodic Haplocryands	Spodic Vitricryands	Andic Haplocryods	Typic Haplocryolls	Typic Gelorthents	Typic Humigelepts	Turbic Dystrogelepts	Turbic Haplogelepts	Turbic Humigelepts	Andic Haplogelepts	Andic Humigelepts	Andic Umbriturbels	Turbic Vitrigelands	Turbic Haplogelods	Andic Haplogelods	Humic Vitrigelands	Typic Haplogelods	Gelaquepts	Oxyaquic Humigelepts	Aquandic Gelaquepts	Typic Haplosaprists	Water	Glacier Ice	Not determined	Grand Total
Glacial Sandy-Rocky	1															1																				2
Glacial Sandy-Rocky Alder Shrub	2																																			2
Alpine Rocky Barrens		1	1	1																																3
Alpine Rocky Lichen Tundra	1					1																														2
Alpine Rocky Dwarf Shrub Late-Lying Snowbanks	1					1																														2
Alpine Rocky Dwarf Shrub-Lichen Tundra							1																												4	5
Alpine Rocky Dwarf Willow Tundra	1				1																															2
Alpine Ashy-Loamy Dwarf Ericaceous Hummocks							1					2		1																						4
Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra										1	1																									2
Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra									1		1				2																					4
Alpine Ashy-Loamy-Rocky Moist Sedge Meadow						1		1																												2
Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow													2		1																					3
Alpine Gelic Rocky Barrens																2																				2
Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra																1	1	1																		3
Alpine Gelic Rocky Dwarf Willow Tundra																1	1																			2
Alpine Gelic Rocky Lichen Tundra																2			2	1				1		1										7
Alpine Gelic Ashy-Loamy Dwarf Ericaceous Hummocks																								2												1
Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra																						3	1		1	1	2	1	1							10
Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow																					1	1									1					3
Alpine Loamy-Organic Wet Sedge Meadow																																1	1			2
Alpine Lake																																		2		2
Alpine Spring																																		1		1
Glacier																																			1	1
Grand Total	6	1	1	1	1	3	2	1	1	1	2	2	2	1	3	7	2	1	2	1	1	4	1	2	1	2	2	1	1	1	1	1	3	1	4	6

Table 22. Coastal soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes.

Abbreviated Ecotype	Soil Subgroup	Mollic Cryofluvents	Typic Cryopsamments	Oxyaquic Cryopsamments	Typic Cryofluvents	Typic Cryorthents	Vitrandic Haplocryepts	Fluventic Humicryepts	Oxyaquic Cryorthents	Typic Cryaquents	Vitrandic Cryofluvents	Aquandic Cryaquents	Typic Cryaquepts	Fluvaquentic Cryaquepts	Histic Cryaquepts	Oxyaquic Cryofluvent	Aquic Cryofluvent	Aquic Cryorthents	Fibric Haplowassists	Water	Not determined	Grand Total
Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow		2	3	1	7	1	1	1	3		1											20
Maritime Coastal Sandy-Rocky Saline Barrens									1	10												11
Maritime Coastal Silty-Clayey Saline Barrens										5											2	7
Maritime Coastal Loamy Saline Wet Sedge Meadow										8			1				2	1				12
Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow										14	4	1	1	1	8	1	7	3			1	41
Maritime Coastal Saline Marestail Ponds and Marshes										1									2	1		4
Tidal River																				1		1
Nearshore Water																				4		4
Grand Total		2	3	1	7	1	1	1	4	38	5	1	2	1	8	1	9	4	2	6	3	100

Table 23. Lowland and Lacustrine soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes. Dashed lines indicate ecotypes that were generalized across ecoregions.

Abbreviated Ecotype	Typic Cryaquents	Oxyaquic Dystrocryepts	Aquandic Cryaquents	Fluvaquentic Humicryepts	Fluvaquentic Cryaquepts	Andic Humicryepts	Aquic Haplocryods	Aquandic Haplocryepts	Aquic Haplocryepts	Aquic Humicryods	Typic Vitricryands	Spodic Haplocryands	Folistic Vitricryands	Spodic Vitricryands	Typic Dystrogelepts	Andic Haplocryods	Typic Haploturbels	Terric Fibristels	Fluvaquentic Hemistels	Sphagnic Fibristels	Typic Folistels	Terric Cryosaprists	Typic Cryohemists	Fluvaquentic Cryofibrists	Sphagnic Cryofibrists	Terric Cryohemists	Typic Cryofibrists	Histic Cryaquepts	Terric Cryofibrists	Hydric Cryofibrists	Fluvaquentic Haplofibrists	Fluvaquentic Cryohemist	Histic Gelaquepts	Fibric Haplowassists	Typic Haplowassents	Water	Not determined	Grand Total
Interior Lacustrine Loamy-Rocky Barrens[1]	1																																			1	2
Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow						1																														1	2
Interior Lacustrine Ashy-Loamy-Rocky Low Shrub							1		1																												2
Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest								1	1																												2
Lowland Acidic Ashy-Loamy Birch-Poplar Forest																																				13	13
Interior Lowland Ashy-Loamy-Organic Black Spruce Forest											1	1	2	1		3																					8
Interior Lowland Ashy-Loamy-Rocky Mixed Forest																																				10	10
Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub									1	1		1			1																							4
Interior Lowland Frozen Loamy-Organic Black Spruce Forest																	1	1		1	1																	4
Interior Lowland Frozen Organic-Rich Dwarf Spruce Forest																			1																			1

Table 23. Lowland and Lacustrine soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes. Dashed lines indicate ecotypes that were generalized across ecoregions (continued).

Abbreviated Ecotype / Soil Subgroup	Typic Cryaquents	Oxyaquic Dystrocryepts	Aquandic Cryaquents	Fluvaquentic Humicryepts	Fluvaquentic Cryaquepts	Andic Humicryepts	Aquic Haplocryods	Aquandic Haplocryepts	Aquic Haplocryepts	Aquic Humicryods	Typic Vitricryands	Spodic Haplocryands	Folistic Vitricryands	Spodic Vitricryands	Typic Dystrogelepts	Andic Haplocryods	Typic Haploturbels	Terric Fibristels	Fluvaquentic Hemistels	Sphagnic Fibristels	Typic Folistels	Terric Cryosaprists	Typic Cryohemists	Fluvaquentic Cryofibrists	Sphagnic Cryofibrists	Terric Cryohemists	Typic Cryofibrists	Histic Cryaquepts	Terric Cryofibrists	Hydric Cryofibrists	Fluvaquentic Haplofibrists	Fluvaquentic Cryohemist	Histic Gelaquepts	Fibric Haplowassists	Typic Haplowassents	Water	Not determined	Grand Total
Interior Lowland Frozen Organic-Rich Sedge-Shrub Bog																				1																	1
Interior Lowland Organic-Rich Birch-Ericaceous Shrub		1																				1	1		2	1		3									9
Interior Lowland Organic-Rich Wet Sedge Meadow																								1				1	1								3
Lowland Organic-Rich Sedge-Shrub Bog																								1	1		1	1	1								5
Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub	3		1	1																								3	3								11
Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow					1																			1	1			1	1								5
Interior Lacustrine Loamy-Organic Wet Sedge Meadow																												1	1			1	1				4
Interior Lacustrine Organic-rich Sedge Marsh																										1				3							4
Interior Lacustrine Organic-rich Sedge-Shrub Bog																									1		3				1						5
Maritime Lacustrine Marestail Marsh[1]																																		1	1		2
Lowland Lake																																				1	1
Grand Total	4	1	1	1	1	1	1	1	3	1	1	2	2	1	1	3	1	1	1	2	1	1	1	3	5	2	4	10	7	3	1	1	1	1	1	25	98

1 Not mapped.

Table 24. Riverine soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes.

Abbreviated Ecotype	Soil Subgroup	Oxyaquic Cryorthents	Oxyaquic Cryofluvent	Typic Cryofluvents	Aeric Cryaquepts	Oxyaquic Dystrocryepts	Fluvaquentic Cryaquepts	Typic Cryaquents	Typic Gelaquents	Aquandic Cryaquents	Histic Cryaquepts	Water	Not determined	Grand Total
Riverine Silty-Sandy-Rocky Barrens		4	1					1						6
Riverine Silty-Sandy-Rocky Poplar Forest		1	4			1							4	10
Riverine Silty-Sandy-Rocky Mixed Forest			1	1			1						13	16
Maritime Riverine Silty-Sandy-Rocky Spruce Forest					1									1
Interior Riverine Silty-Sandy-Rocky White Spruce Forest			1					1						2
Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub							1		1				26	28
Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub			4				2	3		1				10
Interior Riverine Sandy Forb Meadow							1							1
Riverine Ashy-Loamy-Organic Wet Sedge Meadow							1	2			2			5
Riverine Glacial River Water												7		7
Riverine Lake Water												1		1
Riverine Non-Glacial River Water												4		4
Grand Total		5	11	1	1	1	6	7	1	1	2	12	43	91

Table 25. Subalpine soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes.

Abbreviated Ecotype / Soil Subgroup	Typic Cryofluvents	Andic Humicryepts	Fluventic Dystrogelepts	Fluventic Haplogelepts	Turbic Humigelepts	Andic Humigelepts	Humic Vitrigelands	Turbic Vitrigelands	Andic Haplocryods	Andic Haplogelods	Typic Vitrigelands	Typic Dystrogelepts	Folistic Dystrocryepts	Folistic Haplocryands	Typic Udifolists	Sphagnic Fibristels	Sphagnic Cryofibrists	Not determined	Grand Total
Interior Subalpine Rocky Alder-Willow Shrub	1	1	1	1															4
Interior Subalpine Rocky Balsam Poplar Forest				1															1
Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub									1	1	1								3
Interior Subalpine Ashy-Loamy Alder-Willow Shrub					1	1				1	3								6
Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub							4	1			2								7
Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow									1	1								2	4
Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland											1			1					2
Interior Subalpine Organic-rich Alder Tall Shrub												1	1		1				3
Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub																1			1
Interior Subalpine Organic-Rich Wet Sedge Meadow																	1	2	3
Grand Total	1	1	1	2	1	1	4	2	2	3	7	1	1	1	1	1	1	4	36

Table 26. Upland soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes. Dashed lines indicate ecotypes that were generalized across ecoregions.

Abbreviated Ecotype / Soil Subgroup	Vitrandic Cryopsamments	Vitrandic Cryofluvents	Mollic Cryofluvents	Spodic Cryopsamments	Fluventic Dystrocryepts	Fluventic Haplocryepts	Typic Cryofluvents	Typic Cryorthents	Typic Haplocryepts	Folistic Dystrocryepts	Alic Haplocryands	Typic Vitricryands	Thaptic Haplocryands	Spodic Haplocryands	Typic Haplocryands	Folistic Vitricryands	Spodic Vitricryands	Folistic Haplocryands	Vitric Haplocryands	Andic Haplocryods	Typic Haplocryods	Andic Humicryods	Folistic Haplocryods	Typic Humicryepts	Fluventic Humicryepts	Not determined	Grand Total
Maritime Upland Sandy-Rocky Alder-Willow Shrub	1	1	1	1			1																			2	7
Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest			1		1			1													1					1	5
Maritime Upland Rocky Alder Shrub								1	1	1					1												4
Upland Rocky Birch-Poplar Forest						2	1																			7	10
Interior Upland Rocky Alder Shrub																										5	5
Interior Upland Rocky Birch-Ericaceous Low Shrub																										1 7	1 7
Interior Upland Rocky Mixed Forest																										9	9
Interior Upland Rocky White Spruce Woodland								1																		1 6	1 7
Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest														1												2	3
Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub											3	1		6						1						1	12
Maritime Upland Ashy-Loamy Mixed Low Shrub														1				1									2
Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow													3		1												4
Upland Ashy-Loamy-Rocky White Spruce Woodland														1				1	1	1	1		1			1 1	1 17
Upland Ashy-Loamy Birch-Poplar Forest														1										1		1 1	1 13
Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub														3	1	1	1								1		7

Table 26. Upland soil landscapes identified by cross-tabulation of similar soil subgroups with closely associated ecotypes. Dashed lines indicate ecotypes that were generalized across ecoregions (continued).

Abbreviated Ecotype	Soil Subgroup: Vitrandic Cryopsamments	Vitrandic Cryofluvents	Mollic Cryofluvents	Spodic Cryopsamments	Fluventic Dystrocryepts	Fluventic Haplocryepts	Typic Cryofluvents	Typic Cryorthents	Typic Haplocryepts	Folistic Dystrocryepts	Alic Haplocryands	Typic Vitricryands	Thaptic Haplocryands	Spodic Haplocryands	Typic Haplocryands	Folistic Vitricryands	Spodic Vitricryands	Folistic Haplocryands	Vitric Haplocryands	Andic Haplocryods	Typic Haplocryods	Andic Humicryods	Folistic Haplocryods	Typic Humicryepts	Fluventic Humicryepts	Not determined	Grand Total
Interior Upland Ashy-Loamy-Rocky Aspen Forest																	1	1									2
Interior Upland Ashy-Loamy Mixed Forest														2			1			1						1	1 5
Interior Upland Ashy-Loamy Black Spruce Forest														2		2					1	1	1				7
Grand Total	1	1	2	1	1	2	2	3	1	1	3	1	3	17	3	3	3	3	1	3	3	1	2	1	1	9 7	16 0

Table 27. Crosswalk of soil subgroups and their equivalent soil landscape in Lake Clark National Park and Preserve, Alaska.

Soil Subgroup	Alpine Rocky Barrens and Shrublands	Glacial Sandy-Rocky Barrens and Shrublands	Alpine Gelic Rocky Barrens and Shrublands	Maritime Upland Rocky Barrens, Shrublands, and Forests	Interior Subalpine Rocky Barrens, Shrublands, and Forests	Interior Upland Rocky Barrens, Shrublands, and Forests / Maritime Upland Rocky Barrens, Shrublands, and Forests	Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	Interior Upland Ashy-Loamy Shrublands and Forests / Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests / Maritime Lowland Ashy-Loamy Forests	Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands and Forests	Interior Lowland Frozen Loamy-Organic Bogs and Forests	Riverine Silty-Sandy-Rocky Barrens and Forests	Maritime Coastal Sandy-gravelly Barrens and Meadows	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Alpine Loamy-Organic Wet Sedge Meadows	Interior Subalpine Organic-Rich Wet Meadow and Bogs	Maritime Lowland Ashy-Loamy Forests	Interior Lowland Organic-Rich Wet Meadows and Shrublands / Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	Riverine Glacial River	Riverine Non-Glacial River	Tidal River	Nearshore Water	Lake Water	Glaciers and Permanent Snow Fields	Grand Total
Lithic Cryorthent	1																														1
Lithic Haplocryolls	1																														1
Typic Cryorthents	3	3		2		1												1													10
Typic Gelorthents		1	6																												7
Typic Humigelepts			2																												2
Turbic Dystrogelepts			1																												1
Turbic Haplogelepts			2																												2
Typic Dystrogelepts										1		1																			2
Typic Haplocryepts				1																											1
Vitrandic				1																											1
Spodic Cryopsamments				1																											1
Typic Cryopsamments																		3													3
Typic Cryofluvents				1	1	1										1		7													11
Mollic Cryofluvents				2														2													4
Fluventic Dystrocryepts				1																											1
Fluventic Dystrogelepts					1																										1
Fluventic Haplogelepts					2																										2
Fluventic Haplocryepts						2																									2
Fluventic Humicryepts											1							1													2
Typic Humicryepts											1																				1
Andic Humicryepts					1								1																		2
Vitrandic Cryorthents									1																						1
Vitrandic Dystrocryepts	1																														1
Vitrandic Humicryepts	1								1																						2
Vitrandic Haplocryepts																		1													1
Turbic Haplogelods							1																								1

Table 27. Crosswalk of soil subgroups and their equivalent soil landscape in Lake Clark National Park and Preserve, Alaska (continued).

Soil Subgroup	Alpine Rocky Barrens and Shrublands	Glacial Sandy-Rocky Barrens and Shrublands	Alpine Gelic Rocky Barrens and Shrublands	Maritime Upland Rocky Barrens, Shrublands, and Forests	Interior Subalpine Rocky Barrens, Shrublands, and Forests	Interior Upland Rocky Barrens, Shrublands, and Forests / Maritime Upland Rocky Barrens, Shrublands, and Forests	Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	Interior Upland Ashy-Loamy Shrublands and Forests / Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests / Maritime Lowland Ashy-Loamy Forests	Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands and Forests	Interior Lowland Frozen Loamy-Organic Bogs and Forests	Riverine Silty-Sandy-Rocky Barrens and Forests	Maritime Coastal Sandy-gravelly Barrens and Meadows	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Alpine Loamy-Organic Wet Sedge Meadows	Interior Subalpine Organic-Rich Wet Meadow and Bogs	Maritime Lowland Ashy-Loamy Forests	Interior Lowland Organic-Rich Wet Meadows and Shrublands / Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	Riverine Glacial River	Riverine Non-Glacial River	Tidal River	Nearshore Water	Lake Water	Glaciers and Permanent Snow Fields	Grand Total
Andic Haplogelepts							1																								1
Typic Haplogelods							1																								1
Andic Umbriturbels							1																								1
Andic Haplogelods			1				1	3																							5
Turbic Vitrigelands			1				2	1																							4
Humic Vitrigelands							2	4																							6
Andic Humigelepts							4	1																							5
Turbic Humigelepts			1					1																							2
Typic Vitrigelands								6		1																					7
Thaptic Vitricryands									1																						1
Typic Haplocryolls									3																						3
Andic Haplocryepts	2								1																						3
Typic Haplocryands				1					2		2																				5
Spodic Vitricryands									2		3	1																			6
Spodic Haplocryands									2		17	2																			21
Andic Haplocryods								2	1		3	3																			9
Typic Vitricryands									1			1																			3
Thaptic Haplocryands	1																														4
Alic Haplocryands																															3
Vitric Haplocryands											1																				1
Typic Haplocryods											2																				2
Andic Humicryods																															1
Folistic Vitricryands												2																			5
Folistic Haplocryands										1	3																				4

Table 27. Crosswalk of soil subgroups and their equivalent soil landscape in Lake Clark National Park and Preserve, Alaska (continued).

Soil Subgroup	Alpine Rocky Barrens and Shrublands	Glacial Sandy-Rocky Barrens and Shrublands	Alpine Gelic Rocky Barrens and Shrublands	Maritime Upland Rocky Barrens, Shrublands, and Forests	Interior Subalpine Rocky Barrens, Shrublands, and Forests	Interior Upland Rocky Barrens, Shrublands, and Forests / Maritime Upland Rocky Barrens, Shrublands, and Forests	Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	Interior Upland Ashy-Loamy Shrublands and Forests / Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests / Maritime Lowland Ashy-Loamy Forests	Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands and Forests	Interior Lowland Frozen Loamy-Organic Bogs and Forests	Riverine Silty-Sandy-Rocky Barrens and Forests	Maritime Coastal Sandy-gravelly Barrens and Meadows	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Alpine Loamy-Organic Wet Sedge Meadows	Interior Subalpine Organic-Rich Wet Meadow and Bogs	Maritime Lowland Ashy-Loamy Forests	Interior Lowland Organic-Rich Wet Meadows and Shrublands / Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	Riverine Glacial River	Riverine Non-Glacial River	Tidal River	Nearshore Water	Lake Water	Glaciers and Permanent Snow Fields	Grand Total
Folistic Haplocryods											2																				**2**
Folistic Dystrocryepts				1						1																					**2**
Typic Udifolists										1																					**1**
Fluvaquentic Hemistels																1															**1**
Typic Folistels																1															**1**
Terric Fibristels																1															**1**
Sphagnic Fibristels															1	2															**3**
Typic Haploturbels															1	1															**2**
Oxyaquic Dystrocryepts				1													**1**											**1**				**3**
Oxyaquic Humigelepts							1																										**1**
Oxyaquic																		**1**														**1**
Oxyaquic Cryorthents																	**5**	**4**														**9**
Oxyaquic Cryofluvent																	**7**		**1**	**4**												**12**
Typic Cryaquents														1			**2**	**10**	**28**	**5**				**3**								**49**
Vitrandic Cryofluvents				1														**1**	**4**													**6**
Aquic Cryofluvent																			**9**													**9**
Aquic Cryorthents																			**4**													**4**
Typic Cryaquepts																			**2**													**2**
Fluvaquentic Cryaquepts																	**1**		**1**	**5**				**1**								**8**
Fluvaquentic Gelaquepts							1																									**1**
Aeric Cryaquepts																	**1**															**1**
Typic Gelaquents																				**1**												**1**
Aquic Haplocryepts												1	1										1									**3**
Aquic Haplocryods													1																			**1**
Aquic Humicryods												1																				**1**
Histic Gelaquepts																									1							**1**

Table 27. Crosswalk of soil subgroups and their equivalent soil landscape in Lake Clark National Park and Preserve, Alaska (continued).

Soil Subgroup	Alpine Rocky Barrens and Shrublands	Glacial Sandy-Rocky Barrens and Shrublands	Alpine Gelic Rocky Barrens and Shrublands	Maritime Upland Rocky Barrens, Shrublands, and Forests	Interior Subalpine Rocky Barrens, Shrublands, and Forests	Interior Upland Rocky Barrens, Shrublands, and Forests / Maritime Upland Rocky Barrens, Shrublands, and Forests	Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	Interior Upland Ashy-Loamy Shrublands and Forests / Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests / Maritime Lowland Ashy-Loamy Forests	Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands and Forests	Interior Lowland Frozen Loamy-Organic Bogs and Forests	Riverine Silty-Sandy-Rocky Barrens and Forests	Maritime Coastal Sandy-gravelly Barrens and Meadows	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Alpine Loamy-Organic Wet Sedge Meadows	Interior Subalpine Organic-Rich Wet Meadow and Bogs	Maritime Lowland Ashy-Loamy Forests	Interior Lowland Organic-Rich Wet Meadows and Shrublands / Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	Riverine Glacial River	Riverine Non-Glacial River	Tidal River	Nearshore Water	Lake Water	Glaciers and Permanent Snow Fields	Grand Total
Fluvaquentic																								1								1
Aquandic Gelaquepts																				1												1
Typic Haplosaprists																				1												1
Aquandic Haplocryepts																							1									1
Aquandic Cryaquents																			1		1			1								3
Terric Cryosaprists																								1								1
Typic Cryohemists																								1								1
Histic Cryaquepts																			8	2				9	1							20
Fluvaquentic Cryofibrists																								3								3
Terric Cryofibrists																								5	1							7
Terric Cryohemists																								1	1							2
Typic Cryofibrists																								1	3							4
Sphagnic Cryofibrists																						1		4	1							6
Fluvaquentic Cryohemist																									1							1
Fluvaquentic																									1							1
Hydric Cryofibrists																									3							3
Fibric Haplowassists																			2													2
Water																			1							7	4	1	4	5		22
Glacier Ice																															1	1
Not determined	4			3		53		2			40	23	2				17		3	26		2										17
Grand Total	14	4	1	1	5	57	15	20	15	5	86	35	6	2	6	35	31	64	44	2	3	2	33	13	7	4	1	4	5	1	54

Table 28. Area of soil landscape classes, Lake Clark National Park and Preserve, Alaska.

Soil Landscape	Area (km^2)	%
Alpine Ashy-Loamy-Rocky Meadows and Shrublands	88.7	0.5%
Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	600.9	3.1%
Alpine Gelic Rocky Barrens and Shrublands	2963.9	15.5%
Alpine Loamy-Organic Wet Sedge Meadows	6.1	<0.1
Alpine Rocky Barrens and Shrublands	3025.4	15.8%
Developed Land	2.1	<0.1
Glacial Sandy-Rocky Barrens and Shrublands	1103.4	5.8%
Glaciers and Permanent Snow Fields	2067.0	10.8%
Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	11.6	0.1%
Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	11.2	0.1%
Interior Lowland Ashy-Loamy-Organic Shrublands and Forests	616.0	3.2%
Interior Lowland Frozen Loamy-Organic Bogs and Forests	154.1	0.8%
Interior Lowland Organic-Rich Wet Meadows and Shrublands	115.0	0.6%
Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	518.1	2.7%
Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	1249.9	6.5%
Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands	71.2	0.4%
Interior Subalpine Organic-Rich Wet Meadow and Bogs	1.0	<0.1
Interior Subalpine Rocky Barrens, Shrublands, and Forests	1310.3	6.9%
Interior Upland Ashy-Loamy Shrublands and Forests	1091.1	5.7%
Interior Upland Rocky Barrens, Shrublands, and Forests	454.0	2.4%
Lake Water	627.0	3.3%
Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	122.5	0.6%
Maritime Coastal Sandy-gravelly Barrens and Meadows	20.7	0.1%
Maritime Lowland Ashy-Loamy Forests	115.3	0.6%
Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	71.1	0.4%
Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	529.6	2.8%
Maritime Upland Rocky Barrens, Shrublands, and Forests	1226.3	6.4%
Nearshore Water	199.0	1.0%
Riverine Glacial River Water	86.6	0.5%
Riverine Non-Glacial River Water	18.3	0.1%
Riverine Sandy-Rocky-Organic Meadows and Shrublands	182.2	1.0%
Riverine Silty-Sandy-Rocky Barrens and Forests	427.4	2.2%
Tidal River	16.7	0.1%
Grand Total	19103.8	100.0%

Factors Affecting Landscape Evolution and Ecosystem Development

The structure and function of ecosystems are regulated largely along gradients of energy, moisture, nutrients, and disturbance. These gradients are affected by climate, tectonic effects on physiography, and parent material as controlled by bedrock geology and geomorphology (Swanson et al. 1988, ECOMAP 1993, Bailey 1996). Thus, these large-scale ecosystem components can be viewed as state factors that affect ecological organization (Jenny 1941, Van Cleve et al. 1990, Vitousek 1994, Bailey 1996). Information on how these landscape components have affected ecosystem patterns and processes in LACL were synthesized from our results and relevant literature.

Climate

The climate of Lake Clark National Park is influenced by large topographical variations between the coast along Cook Inlet, the central mountain ranges, and the interior west, and the proximity of several large waterbodies. A mild maritime climate dominates in the east, while the Aleutian and Alaska Ranges represent a major topographic divide that forces moist coastal air upwards where it is cooled and falls as precipitation mostly in the form of snow. Western portions of the park lie in a rainshadow of the central mountains and are dominated by a colder, drier, continental climate with sporadic permafrost. Due to the large variations in the park it is best to divide the park into several ecoclimatic regions to assess climate: maritime region, mountainous region, and southern and northern interior regions.

The maritime region in the eastern portion of LACL features cool, damp summers and relatively warm winters with high amounts of precipitation (Figure 24). Temperature fluctuations are moderated by the presence of ocean waters in Cook Inlet which typically do not freeze solid in winter. Average annual total precipitation is 56.6 inches and average total snowfall is 142.4 inches. Average annual maximum and minimum temperatures are 45.6 F and 30.6 F, respectively. July tends to be the warmest month with average highs of 67.5 F and January tends to be the coldest with average lows of 12.8 F (Big River Lake station data from WRCC 2012).

In the mountainous regions of LACL, climate stations are scarce and climate varies greatly depending on elevation, latitude/longitude, and slope and aspect. One weather station in the mountainous region of LACL provides a glimpse at the climate in the mountainous region. However, the record is short, only three years of data are available and the weather station is equipped to measure liquid precipitation only. Therefore, snowfall data is not available. Average annual maximum and minimum temperatures are 29.6 F and 20.5 F, respectively (C. Lindsay pers. comm.). June and July tend to be the warmest months with high temperaturs around 50 F and low temperatures around 40 F, while January is the coldest month with highs around 30 F and lows around -15 F (Chigmit station data from WRCC 2012).

The southern interior region has relatively cold winters and warm summers and receives less precipitation than the other regions, around 15 inches annually. Climate in the southern interior ecoregion is strongly influenced by the Bering Sea to the west which typically freezes solid by mid- to late-winter lending to lower precipitation, colder temperatures, and larger annual temperature fluctuations than the maritime region. Total snowfall is approximately 79 inches.

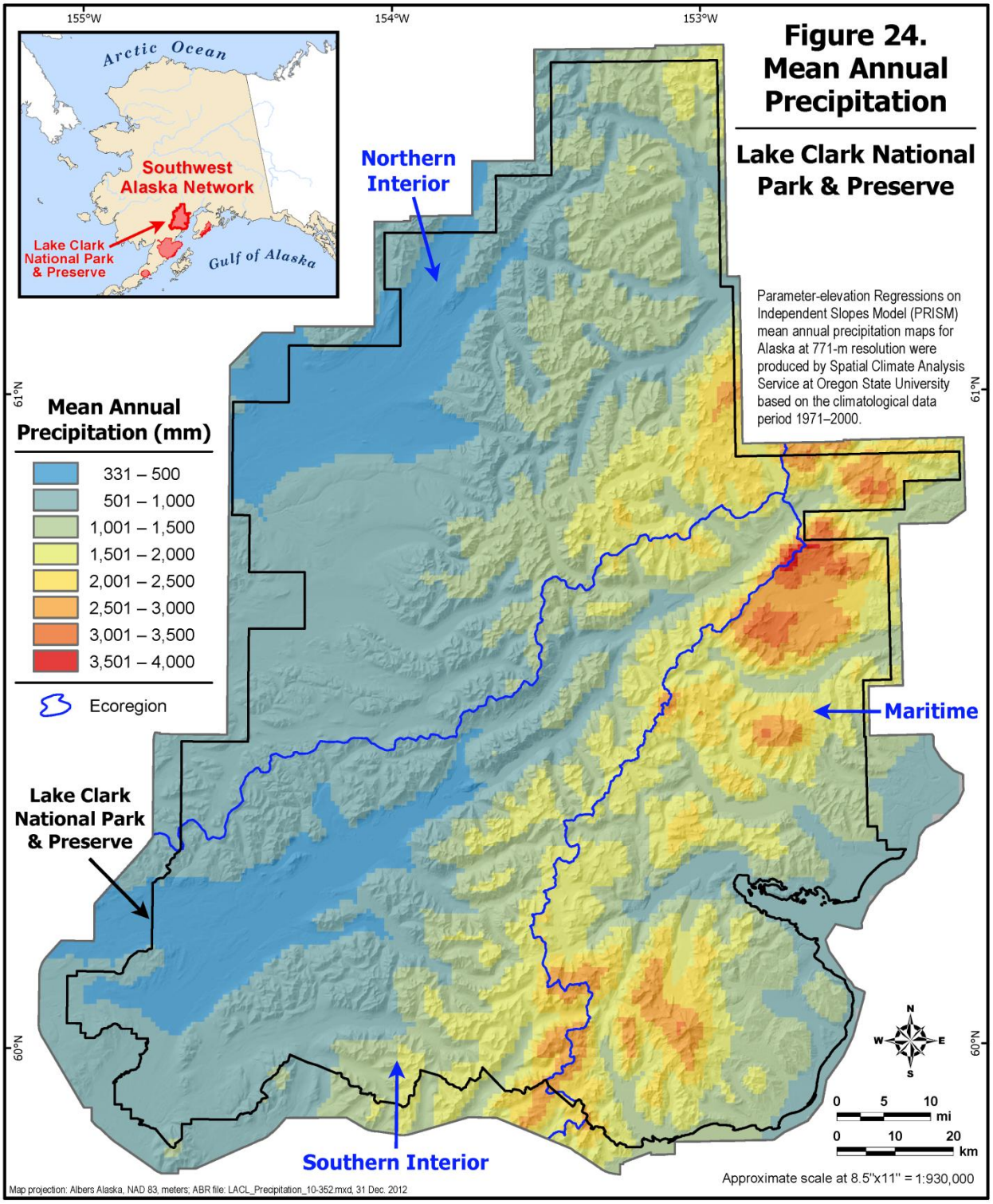


Figure 24. Ecoregions and Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation map and mean annual precipitation for the Lake Clark National Park and Preserve, Alaska study area.

Average annual maximum and minimum temperatures are 44.3 F and 25.7, respectively. July tends to be the warmest month with average highs of 67.5 F and January tends to be the coldest with average lows of 5.4 F (Port Alsworth station data from WRCC 2012).

The northern interior region has a continental climate with cold winters and warm summers. Annual precipitation is around 10 to 24 inches. Total snowfall is approximately 90 to 100 inches. Average annual maximum and minimum temperatures are 36 to 50 F and 16 to 23 F, respectively. July tends to be the warmest month with average highs of 60 to 70 F and December and January tend to be the coldest with average lows of -22 to 0 F. (McGrath, Sparrevohn, and Snipe Lake station data from WRCC 2012).

At the landscape scale, the influence of climate on soil development is strongly related to topography and distance from the moderating influence of the ocean. Elevation ranges broadly across LACL and also changes rapidly over relatively short distances lending from the steep mountainous terrain. For example, in eastern LACL, elevation ranges from sea level along Cook Inlet to the 3108 meter summit of Mount Redoubt over a distance of approximately 25-30 km. This dramatic topographic relief results in steep climatic gradients as elevation typically has an inverse relationship with temperature and direct relationship with precipitation at the landscape scale. At higher elevations in alpine environments soils are colder than at lower elevations and soil development occurs more slowly due to reduced microbial decomposition and rate of physical and chemical weathering processes. Alpine areas often have colder, less developed soils, including Entisols and Inceptisols, while soils in lower elevations in LACL have stronger soil development, including Spodosols (soils with high concentrations of weathered aluminum) and Spodic subgroups of Andisols. The steep mountains also create a rain shadow effect in the southern and northern interior ecoregions and isolate these areas from the moderating influence of the ocean. Hence, the interior ecoregions are drier and have more dramatic temperature fluctuations throughout the year.

Aspect influences climate at the local-scale depending on slope orientation (Barry and Van Wie 1974). Northerly slopes tend to experience lower solar radiation input, and thus lower evapo-transpiration, cooler temperatures, fewer frost-free days, and higher available soil water throughout the growing season. Southerly slopes experience higher radiation inputs, and thus higher evapo-transpiration, warmer temperatures, more frost-free days, and lower available soil water throughout the growing season. The influence of aspect on local climate is manifested in the variability in alpine treeline observed across LACL. On colder north-facing slopes, treeline tends to be lower in elevation, while treeline on warmer southerly slopes tends to be higher.

Micro- and macro-topography can also drive climate patterns at the local-scale, particularly in montane environments where aspect and the direction of the prevailing winds play a role in the movement and deposition of the winter snow pack (Johnson and Billings 1962). Exposed slope positions, receiving the full force of wind and cold, are areas of net snow loss during the winter months. These areas thus have lower available water and are colder throughout the growing season. Soils tend to be rocky and poorly developed and the vegetation is barrens and lichen-rich dwarf shrub communities. Protected slope positions are areas of net snow accumulation. These areas have higher available water throughout the growing season and the snow acts as insulator thus buffering the soils and vegetation from extreme winter cold. Soils in these areas tend to be finer in texture and better developed and the vegetation cover of vascular plants is more

continuous. The duration of snow cover is directly influenced by the direction of the prevailing winds and slope aspect. Windward slopes accumulate little to no snow and typically melt-off early, while leeward slopes accumulate deep snow drifts, melting off later in the season, or not at all. Southerly slopes receive higher levels of radiation and melt-off earlier than more sheltered north-facing slopes. Cold-air inversions whereby colder, denser air masses sink below warmer air and settle in topographic depression are another local-scale climate phenomenon common in the northern and southern interior ecoregions. Low-lying areas in interior LACL may be upwards of 10 to 15°C colder than adjacent higher elevation areas. Areas of sporadic and discontinuous permafrost in LACL are often associated with these cold air sinks.

Tectonic Setting and Physiography

The jagged peaks, massive ice caps and glaciers, broad glacial valleys, brilliant turquoise lakes, and sinuous glacial rivers of Lake Clark National Park and Preserve (LACL) form an awe-inspiring landscape. Located in the northern Alaska Peninsula, LACL is situated at the southwest extent of the Alaska Range and northern extent of the Aleutian Range (NPS GRI 2010). One of the more prominent geologic features within LACL is the Alaska-Aleutian Range batholith (Reed and Lanphere 1973), which forms the underlying geologic and physiographic framework of the landscape, and provides broad-scale controls on climate. In the central portion of LACL the batholith consists primarily of granite, granodiorite, and quartz-diorite. In the western, far northern, and eastern portions of LACL volcanic rocks, including andesite, basalt, and ash-flow tuff, and meta-sedimentary rocks have intruded into the batholith. The Lake Clark Fault traverses the Alaska-Aleutian Range batholith, forming a rift where the Tlikakila River flows from Lake Clark Pass southwest into Lake Clark. To the east of the Lake Clark fault, the batholith has been penetrated by volcanoes, including Mounts Redoubt and Iliamna, which dominate the geologic landscape and reflect the tectonically active nature of this region. The Bruin Bay fault traverses the southeastern extreme of LACL where a series of Jurassic sedimentary formations, primarily interbedded sandstone and shale with sporadic exposures of limestone, occur to the east of the fault (Wilson et al. 2009a-h). Glaciers and ice sheets dominated the landscape of LACL throughout the Quaternary Period, with the exception of a few isolated areas that likely were ice free during the late Quaternary. These include the Telequana Highlands and the upper Kontrahibuana and Tazimina valleys (Spencer, 2001). Hence, broad till sheets, outwash plains, and extensive moraines occur in LACL, particularly in the northern and southern ecoregions where several broad valleys were shaped by historic glaciers and subsequently reworked by rivers creating uplands, lowlands, and lacustrine and riverine complexes. In the mountains themselves more recent glaciations and modern day glaciers have created and continue to create narrow, steep-sided glacial valleys. Today glaciers and ice caps continue to dominate many of the highest-elevation areas within the Alaska and Aleutian ranges.

Volcanism

The eastern portion of LACL is within the “Ring of Fire” (Gaul, K. 2007) a zone of active subduction that extends along the eastern Aleutian Arc north to Cook Inlet. More than 40 historically and present day active volcanoes exist within the Aleutian Arc. The location of LACL in the Aleutian arc has important implications for soil development, specifically the predominance of volcanic ash in the upper soil mantle.

Redoubt Volcano and Iliamna Volcano are the two highest peaks and the only active volcanoes within the boundaries of LACL. Redoubt Volcano is located near the northeast end of the

Aleutian volcanic arc, in central-eastern LACL approximately 95 km east-northeast of Port Alsworth. It is is a steep-sided, 10,197 ft (3,108 m) high, stratovolcano, composed of intercalated pyroclastic deposits and lava flows, and rests on Mesozoic granitic rocks of the Alaska-Aleutian Range batholith (Till et al, 1994). It is moderately glaciated with a 1.8-km wide, ice-filled summit crater breached on the north side by the northward-flowing Drift Glacier, which spreads into the upper Drift River Valley. Eruptive activity of Redoubt Volcano was recorded in 1902, 1966, 1989, and 2009, and possible activity was noted in 1881 and 1933 (AVO, 2012a).

Following a six month period of precursory seismicity, the 2009 eruption began on March 22. The eruption was characterized by nineteen powerful ash explosions with plumes reaching heights between 17,000 and 62,000 feet (5.2 and 18.9 km, respectively) above sea level. The 2009 eruption shared many similarities with those of 1966 and 1989. In each of these eruptions the eruptive phase lasted several months; consisted of many ash producing explosions; produced andesitic lava and tephra; removed significant amounts of ice from the summit crater and Drift glacier; generated lahars that inundated the Drift River valley; and terminated with the extrusion of a lava dome in the summit crater (Schaefer et al. 2012). Many of the 2009 eruptions resulted in ash falls up to hundreds of miles away, including some that affected Anchorage, and the ash clouds forced airlines to re-route numerous flights. The 2009 lahars not only inundated the Drift River Valley and its downstream coastal fan, but also reached Cook Inlet, where they caused significant damage to the levees of the Drift River Oil Terminal (Carlile and Nelson, 2009). At present Redoubt volcano is in a non-eruptive background state (AVO, 2012b).

Many volcanoclastic deposits can be found in the valleys near Redoubt Volcano. The oldest and largest deposit, known as the Harriet Point debris avalanche, is dated from more than 10,500 yr B.P. This avalanche travelled more than 30 kilometers down the Redoubt Creek valley to Cook Inlet (Beget and Nye, 1994). Approximately 3600 yr B.P., two lahars travelled 30 kilometers down the Crescent River valley (Riehle et al. 1981). Smaller eruptions between 3600-1800 yr B.P. caused additional lahars and floods that affected the upper region of the Crescent River Valley. Between 1000-300 yr B.P., another large lahar, which was initiated by a debris fall from the edifice of Redoubt Volcano, travelled more than 30 kilometers down the Drift River valley.

Iliamna Volcano is an active stratovolcano with an elevation of 10016 ft (3053 m). It is located in the southeastern portion LACL, approximately 70 km east-southeast of Port Alsworth. Iliamna is a broad, deeply dissected and highly altered, roughly cone-shaped mountain, mostly covered by continuous snow and ice and with numerous glaciers crowning the summit area (Waythomas and Miller, 1999). The volcano is composed of interbedded andesite lava flows and pyroclastic rocks, while the underlying geology consists of Jurassic granitic rocks of the Alaska-Aleutian Range batholiths. These are placed next to older, Lower Jurassic lava flows and pyroclastic rocks by the Bruin Bay fault, which lies several kilometers east of the summit (Detterman and Hartsock, 1966). There have been no documented historical eruptions of Iliamna Volcano. Reports of eruptions in the 1860's and 1870's are inconclusive, and do not clearly show eruptive activity or emission of volcanic ash (Miller et al. 1998). Nonetheless, Iliamna Volcano currently has all the characteristics of an active volcano. Steam and gases are emitted from a promiment zone of fumaroles neara the summit, and small, shallow earthquakes occur occasionally beneath the volcano (Waythomas and Miller, 1999).

Although Mount Spurr is not formally within the boundaries of LACL, it is near enough to influence soil development in the park. Mount Spurr is a Quaternary stratovolcano located near the northeastern boundary of LACL, 170 km northeast of Port Alsworth. It rises 11070 ft (3374 m) above sea level, making it both the highest and the most historically active volcano in the area (Miller et al. 1998). Recent eruptions of Mount Spurr have occurred in 1953, 1965, and 1992. Non-eruptive activity was recorded in 2004 (AVO 2012c).

Glaciations

The Quaternary Period (~2.5 Ma–present*) is characterized by a series of broad-scale climatic warming and cooling events, corresponding to interglacial and glacial oscillations. The Marine Isotope Record (MIR) provides a continuous account of the Quaternary glacial and climatic history in a series of deep ocean sediment cores (Walker, 2005). The MIR relies on the ratio of two oxygen isotopes, Oxygen-16 and -18, composing the marine microfossils found in the ocean floor sediments. The ratio of the heavier Oxygen-18 to the lighter Oxygen-16 depends on the amount of water frozen as glacial ice at a given point in time, and is used to reconstruct historic climatic and glacial sequences (Dansgaard and Tauber, 1969). The MIR has been classified into a series of stages, referred to as Marine Isotope Stages, reflecting the global glacial and interglacial intervals during the Quaternary Period. The MIR indicates that worldwide in the past 800 Ka there have been at least seven or eight major glaciations advances. During the earliest of these glacial advances, extensive ice sheets covered a large portion of the northern half of the North American continent, including the northern Alaska Peninsula and Cook Inlet. At this time glacier ice covered all of LACL and extended out into adjacent Bristol Bay to the southwest and Cook Inlet to the east. Glacial deposits on the Alaska Peninsula from these earliest glaciations are likely from the pre- to early Illinoian glacial episodes (greater than ~200 Ka). These earliest deposits are difficult if not impossible to find on shore as they have been obliterated by subsequent glaciations. Exposures of these early glacial deposits are preserved only along the Bristol Bay coast near the village of Naknek (Detterman, 1986). The next youngest glacial deposits, likely from the late Illinoian (~ 200–150 Ka), termed Johnston Hill Drift, are presently only somewhat more extensive, occurring in a narrow band along Bristol Bay, only a few kilometers wide. At this time, LACL remained entirely covered in glacial ice. One exception may be the Telequana Highlands, a broad alpine plateau in northwestern LACL, which has likely been deglaciated for a significant time period as evidenced by the extensive periglacial features observed in this area. ‘Mak Hill’ glacial deposits from the early Wisconsin glacial episode (~100–50 Ka) are slightly more extensive and occur throughout the lowlands adjacent to Bristol Bay. During the Mak Hill advance, large glacial lakes formed behind end moraines which acted as natural dams. Historic glacial lakes occupied the valleys corresponding to present day Becharof, Naknek, and Iliamna Lakes to the south of LACL. Glacial deposits of Mak Hill age may be exposed in the extreme western portion of LACL, near the Mulchatna River. However, much of LACL was still buried in glacial ice during this time. Drift of the Brooks Lake advance (middle to late Wisconsin, ~50–10 Ka) covers most of the lowland areas of the Alaskan Peninsula. The glaciers of the Brook Lake advance destroyed the Mak Hill glacial dams resulting in the lakes draining and the deposition of outwash and glacio-fluvial materials in downstream areas. Also during this time much of the glacial deposits presently exposed in LACL were deposited and the large glacial lakes, including Lake Clark, Twin Lake, Turqoiuse Lake, and Telequana Lake were formed from melting glaciers and impoundment by glacial deposits.

* Ma = Millions of years Ago, Ka = Thousands of years ago. All dates and correlation with MIS are approximate.

Neoglacial advances have occurred periodically during recent times (~10 Ka to present). These glacial events have been limited to middle and upper mountain valleys in LACL, the most recent of which termed the "Little Ice Age" (LIA) began approximately 500 years ago and may have ended as recently 150 years ago (Dahms, 2002).

The relatively recent retreat of glaciers from broad areas of LACL has strong implications for soil and plant community development. Older glacial deposits in the park that have been ice-free and stable for upwards of 10,000-12,000 years show the most soil development and later successional plant community development, while contemporary deposits from the LIA to the present show little to no soil development and early vegetation succession. The pattern of deposition across the landscape, as influences macro-topography, also influences soil development and plant community patterns. In areas with a high degree of spatial heterogeneity in macro-topography, including undulating ground moraines, glacial outwash plains, and esker complexes soils and vegetation can vary dramatically across short distances. On upper, exposed slope positions wind and water have removed finer soil materials and soils tend to be dry, rocky and poorly developed, while directly adjacent lower slope positions have deep accumulation of fine soil materials and tend to be moist to wet and more strongly developed. Vegetation development parallels the soil patterns with open dwarf and low shrub communities with understories dominated by lichens on upper slope positions, and mesic shrub and graminoid dominated communities in lower slope positions.

Coastal Processes

The southeast boundary of LACL encompasses 82 km (130 mi) of coastline in western lower Cook Inlet (Cusick and Bennett 2005). The coastal salt marshes along the LACL coast are some of the most productive ecosystems in the park. Cook Inlet, a dynamic, high-energy estuarine environment, receives fresh water from numerous glacial rivers, and salt water from the Gulf of Alaska. The rivers carry with them tons of glacial sands and silts, and at times volcanic ash, which becomes the substrate by which salt marshes and beaches are formed and maintained along the LACL coast. Tides are perhaps the most conspicuous of coast processes influencing soils and vegetation. Two approximately 12 hours tidal cycles (one low and one high tide) occur during each 24 hours period and range in average height in Cook Inlet between about 5.5 m in Kachemak Bay to 8.8 m at Anchorage. Slight changes in elevation in tidal marshes, on the order of several centimeters to one meter, can have disproportionate affects on vegetation composition and soils. Salt marsh species are adapted to specific hydro-periods and salt tolerances and thus occur in distinct zones along an elevation gradient from mean sea level and the high tide line. Soils in lower elevations in salt marshes are flooded longer for longer periods, sometimes permanently, resulting in the development of anaerobic soil conditions the production of abundant hydrogen sulfide making these soils strongly acidic (Jorgenson et al. 2010). Vegetation in these lower salt marshes is commonly barrens or *Triglochin maritimum* or *Carex ramenskii*. In upper tidal flats, the duration of flooding by salt water is shorter and soils are typically better drained. The continual action of waves creates gravelly beach ridges that are often positioned between the ocean and the tidal marshes thus protecting them from storm surges. The beach ridges become covered in eolian sands forming dunes over time. The beach ridges and dunes occur at elevations well above high tide and storm surges and are not directly influenced by tide water or storm surges. The gravelly-sandy soils are well drained and include Typic Cryopsamments on dunes and Typic Cryorthents on beach ridges. Early vegetation succession begins with *Leymus mollis*. Beach ridges and dunes may eventually become disjunct from the

active wave front (i.e., abandoned) resulting from a combination of processes, including glacial rebound and beach accretion. Vegetation succession parallels beach ridge and dune abandonment shifting from grassland to alder or willow shrublands and eventually to *Picea* × *lutzii* or *P. sitchensis* forests. Tidal rivers carry salt water into the upper reaches of salt marshes and provide pathways for nutrients and travel corridors for biota. Salmon return each year to spawn in the upper freshwater reaches of the tidal rivers. Salmon carcasses provide marine-derived nutrients to adjacent floodplains thus increasing nutrient availability in these environments (Naiman et al. 2002). These coastal marshes and tidal rivers are important for brown bears that frequent these tidal marshes to graze on sedges, dig clams, and fish for salmon.

Geomorphology and Soils

At the landscape scale (hundred to thousands of hectares to hundreds to thousands of square kilometers) the soil formation in LACL is strongly influenced by parent material, namely thick deposits of volcanic ash and loess (wind-blown silts and very fine sands). This is related to the location of LACL at the northern end of the Aleutian Arc with its numerous historically and present day active volcanoes, the direction of historic and present day prevailing winds, and periodic glacial and inter-glacial oscillations over the last several hundred thousand years. Throughout the late Quaternary Period, volcanic ash has been deposited in LACL and adjacent lands episodically. Ash deposition during periods of high eolian activity at glacial maxima led to a mixing by wind of volcanic ash and loess, particularly in broad glacial valleys, including the Stony River and Lake Clark valleys, and the redistribution of this ash-laden loess over substantial portions of the park with thicknesses ranging from 1cm to over 1 m thick in some areas. Due to the strong influence of volcanic ash in the soils and the cool, humid climate, LACL and adjacent lands are included in very small area of the world (~1% of global ice-free land area) where the Andisols soil order (soils derived from weathered volcanic ash) is recognized (Takahashi and Shoji 2002). The vast majority of Lake Clark soils have parent material comprised of some thickness of volcanic ash. Soil cores of glacio-lacustrine sediments at Skilak Lake on the Kenai Peninsula, show evidence of ash falls for the Cook Inlet area to be every 10–35 years in the 20th century, and at least once every 50-100 years in the past 500 years (Beget et al. 1994).

Andisols have unique chemical and physical properties, termed andic properties (Brady and Weil, 2008). These include: 1) a high proportion of volcanic glass or iron- and aluminum-rich minerals with weak crystalline structure making them easily weathered into their constituent elements; 2) low-bulk density (high ratio of pore space to soil particles) lending to a light, fluffy texture, high water holding capacity, and erosion resistance; 3) accumulation of soil organic matter (Ugolini and Dahlgren, 2002); 4) the development of strong acidity and aluminum toxicity with increased weathering intensity; and 5) extremely high phosphorus retention capacity which can lead to severe phosphorus limitations over time (Nanzyo, 2002). Organic matter accumulates in these soils in several ways, including burial of surface organic horizons by subsequent ash deposits, the development of Aluminum-humus (Al-humus) complexes (the binding of negatively charged organic particles to positively charged aluminum), and aluminum toxicity to micro-organisms (Ugolini and Dahlgren, 2002). Due to the high carbon retention of Andisols they play an important role in regional carbon cycles, representing a primary source and sink for carbon. Aluminum toxicity, phosphorus limitations, and strongly acid nature can limit the type and composition of vegetation communities occurring on Andisols. Many of the Andisols in LACL have multiple buried organic horizons and older horizons of ash from periodic

ash deposition each featuring differing stages of weathering and soil development. Phosphorus limitation in Andisols with periodic ash deposition, such as those in LACL, may be ameliorated as the phosphorus content of fresh ash is typically higher than equivalent non-volcanic soils (Nanzyo, 2002).

At local scales (thousands of square meters to tens and hundreds of hectares) the thickness and physical properties of ash-laden loess is widely variable depending on topographic position, namely slope and aspect, time since last disturbance event, source material, and distance from source. Landscape positions that are stable (flat and lower slopes, concavities) and those on the leeward side of prevailing winds are subject to the thickest accumulations of volcanic ash, a pattern related to the nature of volcanic ash deposition. During an eruption, airborne ash will be carried in the direction of the prevailing winds at the time. When the original ash fall occurs it will typically deposit a homogenous layer on the landscape ranging from 2 to 50 cm thick (Pers. Comm. J. Beget). The forces of wind and water quickly erode and redistribute the fine, unconsolidated ash from steeper, upper slope positions to lower slope positions and areas of sediment accumulation (Pers. Comm J. Beget). For instance, soils on alluvial fans may have thick deposits of reworked ash from different aged eruptions and likely from different source volcanoes. Soils across a river valley tend to differ significantly in ash thickness related to age of a given landform in relation to the timing of regional volcanic activity and flooding frequency. Older river terraces typically have thick accumulations of ash deposited from adjacent side slopes and ancient rivers that were inundated with ashy material shortly after historic eruptive events. While younger terraces and active floodplains typically have thin ash mantles or are completely devoid of ash, a pattern related to the ash deposition pre-dating more recent flooding and erosion (Pers. Comm. J. Beget). Coarse-textured Andisols tend to be located within close proximity to the source of ash, where the coarsest and heaviest ash particles will fall from the ash cloud first following an eruption. For instance, the soils in the area around Mount Redoubt are characterized by coarse-textured volcanic glass grains. Coarse-textured Andisols were also associated in two large valleys in the interior ecoregions, including the Lake Clark and Stony River valleys. In the case of interior coarse-textured Andisols, distance from source may be related to historic sources of ash-laden loess dominated by non-volcanic very fine sands. While fine-textured Andisols tend to have high water holding, coarse-textured Andisols (Vitrands suborders and Vitric subgroups of Taxonomy) have very low water holding capacity. The low water holding capacity reduces the ability of these soils to buffer against flooding following snow-melt or large rain events, and flash floods are commonly associated with areas characterized by these soils.

Geologically speaking the Lake Clark region is a relatively young landscape given that ice covered much of the park until relatively recently (5,000–10,000 years ago). Dynamic landform development processes continue to shape and alter the landscape today. Glaciers carve into bedrock and aid in the transport of materials downstream. Braided rivers carry glacial sediments and continually move across the floodplain, abandoning some channels while forming new ones as the sediment loads and water discharge levels fluctuate rapidly and frequently (Tockner et al., 2006). The dynamic process of intermittent or regular flooding along all streams and river corridors within the park impacts the age, parent material, and texture of the soil in these environments. Volcanic activity continues to alter the landscape of LACL depositing fresh ash and resetting soil formation processes to earlier phases. For instance, as recently as 2009, fresh deposits of tephra from Mount Redoubt were added to the landscape.

Soils that have developed on older geomorphic surfaces, in more stable locations, with minimal site disturbance, express the greatest degree of physical and chemical soil development. Examples include older moraines and outwash plains, abandoned alluvial fans and terraces, footslope and toeslopes. These older soils classify taxonomically into the soil order of Spodosols or Spodic subgroups of Andisols and Inceptisols, depending upon the thickness and degree of weathering of pyroclastic materials within the soil pedon. The vast majority of soils in these older, more stable environments have experienced some degree of podzolization within the soil profile. Podzolization is the process by which organic acids contribute to the weathering of aluminum, and occassionally iron, where it can be translocated and precipitate out lower in the soil profile (Lundstrom, et al., 2000). Soil microbes play a notable role in the podzolization process by increasing the decomposition rates of organic material and the production of organic acids necessary for spodic horizon development in Spodosols and Andisols. These organic acids can also be produced from plants, such as alder and spruce. Biological factors such as plants and microorganisms work in tandem and impact soil fertility and nutrient availability as vegetation provides the addition of litter to the soil where soil microorganisms and fauna break it down into humus (Ping et al., 2006). Climate also plays a role in podzolization. For instance, soils forming in the temperate maritime climate experience faster rates of podzolization related to warmer temperatures and higher rates of precipitation.

The greater proportion of Inceptisols (moderately well-developed soils) and Entisols (minimally developed soils), exist on the youngest and most active geomorphic units within the park. These include LIA and contemporary moraines, steep upper back slopes, talus and boulder fields, gravel and cobble bars, active tidal flats and marine beaches, and active alluvial and co-alluvial fans. A presumably recent phenomenon of draining lakes (particularly in the northern interior) have resulted in Entisols forming in lake bottoms that are currently in a state of primary and secondary plant succession.

Soils on upland slope locations tend to form Entisols and Inceptisols in rocky igneous colluvium in alpine, subalpine and boreal environments. In the maritime region of the Park, where temperatures and precipitation are higher, folistic organic epipedons are common on colluviual slopes with alder vegetation cover. Stable, often gentler sloped, mountain and hill slope locations in all physiographic regions feature soils with a higher degree of soil development, often with diagnostic spodic subsurface horizons, which classify as Spodosols. Colluviual soils forming on the upper backslopes of less extensive areas of sedimentary uplifts in the maritime region are unique in that they feature the only Mollisols sampled in the LACL. Lower backslope locations did not classify as Mollisols despite the similar parent material. This is because organic-carbon poor ash and loess begin to accumulate on lower backslopes lowering the base saturation and brightening the soil color so that they no longer interpret as Mollisols.

Wet organic soils (Histosols) are soils dominated by organic material, including thick (>40 cm) accumulations of litter and mosses fibers. Organic soils are found in lacustrine environments, riverine backwaters, and peat bogs and fens in lowland areas. Moist organic-rich soils (Folist soil suborder, Folistic subgroups) are often found in upland and subalpine areas that have a combination of stability for significant periods and cool, moist climate allowing for the accumulation of organic material at the soil surface. Vegetation at these sites includes spruce woodlands and tall alder and willow shrublands.

Ice-rich permafrost (soils with MAST < 0°C with ice structure) occurs sporadically in the northern and southern interior ecoregions. It is associated with flat to gently sloping lowland and subalpine areas with fine-textured and organic-rich soils, such as those associated with glacio-lacustrine deposits, loess, and silt-rich alluvium. Thick (>20 cm) surficial organic mats comprised primarily of *Sphagnum* fibers are commonly associated with permafrost, and these thick mats insulate the frozen ground from warming. Coarse-textured, gravelly and rubbly colluvium and glacial deposits do not promote permafrost formation as these soils are typically well-drained. Ice-poor permafrost (soils with MAST < 0°C lacking ice structure) in alpine areas in the colder northern interior is assumed to be prevalent. Ice-poor permafrost is assumed to be sporadic or absent in alpine areas in the southern interior and maritime ecoregions. Rapid disturbances, such as wildfire, as well as gradual disturbances, such as those associated with a warming climate, will both greatly impact the presence of permafrost in Lake Clark over time. Observations of thermokarst in these isolated areas of permafrost suggest that thermal degradation is actively occurring.

Summary and Conclusions

This report presents the results of an ecological land survey (ELS) the objective of which was to inventory and classify ecosystems in Lake Clark National Park and Preserve (LACL). By analyzing the dynamic processes associated with coastal, riverine, lowland, upland, and subalpine and alpine environments, and the abundance and distribution of their diverse ecological resources, this study contributes to ecosystem management in national parklands in Alaska.

Through field surveys at 267 plots during 2011, and an additional 352 plots from existing datasets, we collected information on the geomorphic, topographic, hydrologic, pedologic, and vegetative characteristics of ecosystems across a wide range of environmental gradients in LACL. Individual ecological components (e.g., geomorphic unit, AVC vegetation type) were determined using standard classification schemes for Alaska, but modified when necessary to differentiate unique characteristics of the study area (e.g., ash-laden loess, ash-rich colluvium). We developed 70 plant associations through multivariate classification techniques. We used the hierarchical relationships among ecological components to develop 91 ecotypes (local-scale ecosystems) that best partition the variation in ecological characteristics across a wide range of aquatic and terrestrial environments.

Soils described at 353 plots were classified into 95 soil types (subgroup level). The most commonly observed types were Typic Gelorthents (11% of the 353 observations), Andic Humigelepts (7%), Typic Cryorthents (5%), Andic Haplocryepts (5%), and Turbic Vitrigelands (5%). The classification was effective at partitioning the variability of numerous soil properties, including organic-layer thickness, depth to rocks, surface fragments, depth to water, loess thickness, and pH. Soil-landscape associations, or soil landscapes, were developed by cross-tabulating soil types with the ecotypes assigned for each plot. The cross-tabulation revealed that 5–7 closely related soil types usually were associated with 3–4 ecotypes. These groupings were used to identify 33 soil landscape classes with broad application for resource management.

Multiple environmental site factors contributed to the distribution of ecotypes and their associated plant species. Mean surface organic-horizon thickness, an indicator of land surface age, anaerobic soil conditions and disturbance, ranged from 0 cm in alpine, glacial, coastal and riverine barrens to > 40–50 cm in Interior Lacustrine Organic-rich Sedge Marsh, Interior Lacustrine Organic-rich Sedge-Shrub Bog, and Lowland Organic-rich Sedge-Shrub Bog. Mean depth to rock, an indicator of the type of surficial deposit and drainage, ranged from 0 cm in alpine barrens and Interior Subalpine Rocky Alder-Willow Shrub to >100 cm in numerous ecotypes that occurred on thick, ash-laden loess surficial deposits. Ice-rich permafrost is absent across much of the LACL study area, including the maritime ecoregion, and alpine, steep subalpine, upland, and riverine environments in the interior ecoregions. In other areas, particularly lowlands and broad, flat, subalpine valleys, ice-rich permafrost was sometimes present at 40–130 cm depth. Mean water depth (negative when below ground) for terrestrial ecotypes ranged from >2 m below the soil surface in many alpine, subalpine and upland ecotypes to -20 to +20 cm in many lowland, lacustrine, and coastal ecotypes. Mean pH, which affects nutrient availability and ion exchange, ranged from < 4.0 in Interior Subalpine Organic-rich Alder Tall Shrub and Interior Lowland Ashy-Loamy-Organic Black Spruce Forest to >7.0 in Riverine Glacial River Water and

Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow. Mean electrical conductivity (EC), important for osmotic regulation in plants, ranged from 10 µS/cm in several alpine, subalpine, and upland ecotypes to 54,200 µS/cm in Maritime Coastal Loamy Saline Wet Sedge Meadow.

Ecotype distribution was greatly affected by numerous landscape-level factors. Climatic gradients in temperature and precipitation resulted in strong differences among ecotypes distributed across the maritime and interior climatic domains. Large, regular tidal fluctuations along the coast have resulted in the occurrence of salt-affected ecotypes along the coast. Soil pH and nutrient status are strongly affected by the degree of volcanic ash influence in the soils. Geomorphic environments associated with sediment erosion and deposition create a wide range of soil conditions and disturbance regimes. Areas underlain by permafrost have impeded subsurface drainage, and the varying volumes of ground ice affect the magnitude of permafrost degradation. Fires modify the dynamics of some ecosystems, particularly in interior areas primarily vegetated by black spruce.

Two sets of map products were developed by the mapping effort for LACL. The first is a series of existing and derived GIS products that were used as the base layers for ecosystem mapping and that, in many cases, represent useful stand-alone products. These include ecoregion, snow regime, physiography, generalized texture, soil temperature, permafrost, and NLCD land cover. The second map set includes a series of ecosystem maps developed using GIS modeling with the first map set as inputs layers. The input maps were combined spatially to produce a strata layer in which each pixel represented a unique combination of each underlying base layer. Ecotypes classified using field data were aggregated for mapping to create aggregated ecotypes. The aggregation was based on similarity in vegetation structure and general soil texture. The aggregated ecotype classes were further aggregated into map ecotype, soil landscape, and disturbance landscape classes. A cross-walk was then developed by assigning an aggregated ecotype to each unique strata class. The cross-walk was then used to recode the strata map to develop the second map set, including map ecotype, soil landscapes, and disturbance landscapes maps. The most common map ecotypes were Alpine Barrens and Lichen Tundra, Alpine Gelic Barrens and Lichen Tundra, Glaciers and Permanent Snow Fields, Interior Subalpine Low-Tall Shrub and Graminoid Meadow, and Maritime Upland Shrub and Graminoid Meadow. The most common disturbance landscapes included Mass wasting/Avalanche/Wind-scour/Snow Drifts, Surges/Ablation/Mass Movement, Fire/Spruce Beetle, Avalanche/Snow Drifts, and Cryoturbation. Lastly, the most common soil landscapes were Alpine Rocky Barrens and Shrublands, Alpine Gelic Rocky Barrens and Shrublands, Glaciers and Permanent Snow Fields, Interior Subalpine Rocky Barrens, Shrublands, and Forests, and Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands.

The ecological land survey approach to understanding landscape processes and their influence on ecosystem functions provides three main benefits. First, landscapes are analyzed as ecological systems with functionally related parts, recognizing the importance of geomorphic and hydrologic processes to disturbance regimes, the flow of energy and material, and ecosystem development. This hierarchical approach, which incorporates numerous ecological components into ecotypes with co-varying properties, allows users to partition the variability of a wide range of ecological characteristics. Second, the analysis of vegetation distribution across the landscape is facilitated by developing a spectral database that integrates spectral and field vegetation

information for use in satellite image processing. Finally, the linkage of landcover maps to climatic, physiographic, and topographic variables to develop ecosystem maps improves our ability to predict the response of ecosystems to human impacts and facilitates the production of thematic maps for resource management applications and analyses.

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Appendix 1. List of vascular species found in the Lake Clark National Park and Preserve, Alaska, 2011.

Adoxaceae
- Adoxa moschatellina L.

Araliaceae
- Oplopanax horridus (Smith) Miquel

Aspidiaceae
- Dryopteris dilatata (Hoffm.) A.Gray ssp. americana (Fisch.) Hult.
- Dryopteris fragrans (L.) Schott
- Gymnocarpium dryopteris (L.) Newm.
- Matteuccia struthiopteris (L.) Tod.

Athyriaceae
- Athyrium filix-femina (L.) Roth
- Cystopteris fragilis (L.) Bernh.
- Woodsia glabella R. Br.

Betulaceae
- Alnus crispa (Ait.) Pursh
- Alnus sinuata (Regel) Rydb.
- Alnus tenuifolia Nutt.
- Betula glandulosa Michx.
- Betula hybrids
- Betula nana L.
- Betula occidentalis Hooker
- Betula papyrifera Marsh.
- Betula papyrifera Marsh. var humilis (Reg.) Fern. & Raup
- Betula papyrifera Marsh. var kenaica (W.H. Evans) Henry

Boraginaceae
- Mertensia maritima (L.) S.F. Gray ssp. maritima
- Mertensia paniculata (Ait.) G. Don

Campanulaceae
- Campanula lasiocarpa Cham.
- Campanula rotundifolia L.

Caprifoliaceae
- Linnaea borealis L.
- Sambucus racemosa L
- Viburnum edule (Michx.) Raf.

Caryophyllaceae
- Cerastium beeringianum Cham. & Schlecht.
- Honckenya peploides (L.) Ehrh.
- Minuartia arctica (Stev.) Aschers. & Graebn
- Minuartia macrocarpa (Pursh) Ostenf.
- Minuartia obtusiloba (Rydb.) House
- Moehringia lateriflora (L.) Fenzl
- Silene acaulis L.
- Stellaria borealis Bigelow
- Stellaria calycantha (Ledeb.) Bong.
- Stellaria crassifolia Ehrh.
- Stellaria crispa Cham. & Schlecht.
- Stellaria humifusa Rottb.
- Stellaria monantha Hult.

Chenopodiaceae
- Atriplex gmelini C.A. Meyer
- Chenopodium glaucum

Compositae (Asteraceae)
- Achillea borealis Bong
- Achillea millefolium L.
- Antennaria friesiana (Trautv.) Ekman
- Antennaria monocephala DC.
- Arnica amplexicaulis Nutt.
- Arnica frigida C.A. Mey.
- Arnica lessingii Greene
- Artemisia arctica Less.
- Artemisia arctica Less. ssp. arctica
- Artemisia borealis Pall.
- Artemisia frigida Willd.
- Artemisia globularia Bess.
- Artemisia tilesii Ledeb.
- Bidens cernua L.
- Chrysanthemum arcticum L.
- Erigeron peregrinus (Pursh) Greene
- Petasites frigidus (L.) Franchet
- Petasites hyperboreus Rydb.
- Saussurea nuda Ledeb.
- Senecio atropurpureus (Ledeb.) Fedtsch.
- Senecio lugens Richardson
- Senecio pseudoarnica Less.
- Senecio triangularis Hook.
- Solidago lepida DC.
- Solidago multiradiata Ait.
- Solidago multiradiata Ait. var. multiradiata

Cornaceae
- Cornus canadensis L.
- Cornus suecica L.

Crassulaceae
- Sedum rosea (L.) Scop. ssp. integrifolium (Raf.) Hult.

Cruciferae (Brassicaceae)
- Cardamine purpurea Cham. & Schlecht
- Cardamine umbellata Greene

Cupressaceae
- Juniperus communis L.

Cyperaceae
- Carex aquatilis Wahlenb. ssp. aquatilis
- Carex bigelowii Torr.
- Carex brunnescens (Pers.) Poir.
- Carex canescens L.
- Carex chordorrhiza Ehrh.
- Carex dioica ssp. gynocrates (Wormsk.) Hult.
- Carex glareosa Wahlenb. ssp. glareosa
- Carex gmelinii Hook. & Arn.
- Carex lachenalii Schkuhr.
- Carex laeviculmis Meinsh.
- Carex limosa L.
- Carex livida (Wahlenb.) Willd.
- Carex loliacea L.
- Carex lugens Holm
- Carex lyngbyaei Hornem.
- Carex mackenziei V. Krecz.

Appendix 1. List of vascular species found in the Lake Clark National Park and Preserve, Alaska, 2011 (continued).

- Carex macloviana Urv.
- Carex macrocephala Willd.
- Carex macrochaeta C.A. Mey.
- Carex membranacea Hook.
- Carex mertensii Prescott
- Carex microchaeta Holm.
- Carex nesophila Holm.
- Carex pauciflora Lightf.
- Carex pluriflora Hult.
- Carex podocarpa C. B. Clarke
- Carex ramenskii Kom.
- Carex rariflora (Wahlenb.) Smith
- Carex rostrata Stokes
- Carex rotundata Wahlenb.
- Carex saxatilis L.ssp. laxa (Trautv.) Kalela
- Carex sitchensis Prescott
- Carex spectabilis Dewey
- Carex utriculata F. Boott
- Eleocharis kamtschatica (C.A. Meyer) V. Komarov
- Eleocharis palustris (L.) Roem. & Schult.
- Eriophorum angustifolium Honck. ssp. subarcticum (V. Vassiljev) Hult.
- Eriophorum brachyantherum Trautv. & Mey.
- Eriophorum russeolum Fries
- Eriophorum scheuchzeri Hoppe
- Eriophorum vaginatum L.
- Kobresia sibirica Turcz.
- Trichophorum caespitosum (L.) Hartm.

Diapensiaceae

- Diapensia lapponica L.

Droseraceae

- Drosera anglica Huds.
- Drosera rotundifolia L.

Elaegnaceae

- Shepherdia canadensis (L.) Nutt.

Empetraceae

- Empetrum nigrum L.

Equisetaceae

- Equisetum arvense L.
- Equisetum fluviatile L. ampl. Ehrh.
- Equisetum pratense L.
- Equisetum scirpoides Michx.
- Equisetum sylvaticum L.
- Equisetum variegatum Schleich.

Ericaceae

- Andromeda polifolia L.
- Arctostaphylos alpina (L.) Spreng.
- Arctostaphylos rubra (Rehd. & Wilson) Fern.
- Arctostaphylos uva-ursi (L.) Sprengel
- Cassiope mertensiana (Bong.) D. Don
- Cassiope stelleriana(Pall.) DC.
- Cassiope tetragona (L.) D. Don
- Chamaedaphne calyculata (L.) Moench
- Ledum decumbens (Ait.) Lodd.
- Ledum groenlandicum Oeder
- Loiseleuria procumbens (L.) Desv.
- Menziesia ferruginea Sm.
- Oxycoccus microcarpus Turcz. ex Rupr.
- Phyllodoce aleutica (Spreng.) A. A. Heller
- Phyllodoce empetriformis (Sm.) D. Don
- Vaccinium caespitosum Michx.
- Vaccinium ovalifolium Sm.
- Vaccinium uliginosum L.
- Vaccinium vitis-idaea L.

Gentianaceae

- Gentiana algida Pallas
- Gentiana glauca Pallas
- Gentiana propinqua Richards. ssp. propinqua

Geraniaceae

- Geranium erianthum DC.

Graminae (Poaceae)

- Agrostis alaskana Hult.
- Agrostis geminata Trin.
- Agrostis gigantea Roth
- Agrostis scabra Willd.
- Alopecuris aequalis Sobol.
- Alopecuris alpinus Sm. ssp. alpinus
- Arctagrostis latifolia (R. Br.) Griseb.
- Bromus pumpellianus SL
- Calamagrostis canadensis (Michx.) Beauv.
- Calamagrostis deschampsioides Trin.
- Danthonia intermedia Vasey
- Deschampsia beringensis Hultén
- Deschampsia caespitosa (L.) P. Beauv.
- Elymus arenarius L. ssp. mollis (Trin.) Hult.
- Festuca altaica Trin.
- Festuca brachyphylla Schult.
- Festuca brevissima Yurtsev
- Festuca rubra L.
- Hierchloe alpina (Sw.) Roem. & Schult.
- Hierochloe odorata (L.) P. Beauv.
- Hierochloe pauciflora R. Br.
- Hordeum brachyantherum Nevski
- Phleum commutatum Gaudin var. americanum (Fourn.) Hult.
- Poa alpigena (E. Fries) Lindm.
- Poa alpina L.
- Poa arctica R. Br.
- Poa eminens Presl
- Poa glauca M. Vahl.
- Poa pratensis L.
- Puccinellia grandis Swallen
- Puccinellia hultenii Swallen
- Puccinellia nutkaensis (Presl) Fern. & Weath.
- Puccinellia phryganodes (Trin.) Scribner & Marr.
- Trisetum spicatum (L.) Richter ssp. spicatum
- Unknown grass
- Vahlodea atropurpurea (Wahlenb.) E. Fries

Haloragaceae

- Hippuris tetraphylla L.F.
- Hippuris vulgaris L.

Iridaceae

- Iris setosa Pall. ssp. setosa

Juncaceae

- Juncus alpinus Villers
- Juncus arcticus Willd.

Appendix 1. List of vascular species found in the Lake Clark National Park and Preserve, Alaska, 2011 (continued).

- Juncus castaneus Sm. ssp. castaneus
- Juncus drummondii E. M
- Juncus filiformis L.
- Juncus mertensianus Bong.
- Luzula arcuata (Wahlenb.) Sw.
- Luzula multiflora (Retz.) Lej.
- Luzula parviflora (Ehrh.) Desv.
- Luzula wahlenbergii Rupr. ssp. piperi (Cov.) Hult.
- Luzula wahlenbergii Rupr. ssp. wahlenbergii

Juncaginaceae
- Triglochin maritimum L.
- Triglochin palustris L.

Leguminosae (Fabaceae)
- Astragalus umbellatus Bunge
- Lathyrus maritimus L. ssp. maritimus
- Lathyrus palustris L. ssp. pilosus (Cham.) Hult.
- Lupinus arcticus S. Wats.
- Lupinus nootkatensis Donn
- Oxytropis campestris (L.) DC.
- Oxytropis maydelliana Trautv.
- Oxytropis nigrescens (Pall.) Fisch.

Lentibulariaceae
- Utricularia vulgaris L. ssp. macrorhiza (LeConte) Clauson

Liliaceae
- Fritillaria camschatcensis (L.) Ker-Gawl.
- Streptopus amplexifolius (L.) DC.
- Tofieldia coccinea Richards.
- Tofieldia pusilla (Michx.) Pers.
- Veratrum viride Ait. ssp. Eschscholtzii (Gray) Love & Love

Lycopodiaceae
- Lycopodium alpinum L.
- Lycopodium annotinum L.
- Lycopodium clavatum L.
- Lycopodium complanatum L.
- Lycopodium selago L.

Menyanthaceae
- Menyanthes trifoliata L.

Myricaeae
- Myrica gale L.

Onagraceae
- Circaea alpina L.
- Epilobium adenocaulon Haussk.
- Epilobium anagallidifolium Lam.
- Epilobium angustifolium L.
- Epilobium ciliatum Raf.
- Epilobium glandulosum Lehm.
- Epilobium hornemannii Reichb. ssp. hornemannii
- Epilobium latifolium L.
- Epilobium palustre L.

Ophioglossaceae
- Botrychium lunaria (L.) Sw.

Orchidaceae
- Goodyera repens (L.) R. Br. var. ophioides Fern.
- Listera cordata (L.) R. Br.
- Lloydia serotina (L.) Rchb.
- Platanthera dilatata Pursh
- Platanthera hyperborea (L.) Lindl.
- Platanthera saccata (Greene) Hult.
- Spiranthes romanzoffiana Cham.

Orobanchaceae
- Boschniakia rossica (Cham & Schldl.) B. Fedtsch.

Papaveraceae
- Papaver alboroseum Hult.

Pinaceae
- Picea × lutzii
- Picea glauca (Moench) Voss
- Picea mariana (Mill.) Britt., Sterns & Pogg
- Picea sitchensis (Bong.) Carr.

Plantaginaceae
- Plantago maritima L. ssp. juncoides (Lam.) Hult.

Polemoniaceae
- Polemonium acutiflorum Willd.
- Polemonium boreale Adams

Polygonaceae
- Oxyria digyna (L.) Hill
- Polygonum bistorta L. ssp. plumosum (Small) Hult.
- Polygonum viviparum L.
- Rumex arcticus Trautv.
- Rumex fenestratus Greene

Portulacaceae
- Claytonia sarmentosa C. Meyer

Potamogetonaceae
- Potamogeton filiformis Pers.
- Potamogeton pectinatus L.
- Potamogeton praelongus Wulf.

Primulaceae
- Androsace chamaejasme Host ssp. lehmannia (Spreng.) Hult.
- Dodecatheon frigidum Cham. & Schlecht.
- Primula cuneifolia Ledeb. ssp. saxifragifolia (Lehm.) Smith & Forrest
- Trientalis europaea L.
- Trientalis europaea L. ssp. arctica (Fisch.) Hult.

Pyrolaceae
- Moneses uniflora (L.) Gray
- Pyrola asarifolia Michx.
- Pyrola grandiflora Radius
- Pyrola minor L.
- Pyrola secunda L.
- Pyrola secunda L. ssp. secunda

Ranunculaceae
- Aconitum delphinifolium DC.
- Actaea rubra (Ait.) Willd.
- Anemone narcissiflora L.
- Anemone parviflora Michx.
- Anemone richardsonii Hook.
- Delphinium glaucum S. Wats.
- Ranunculus eschscholtzii Schlecht.
- Ranunculus gmelini DC. ssp. gmelini
- Ranunculus lapponicus L.
- Ranunculus occidentalis Nutt.
- Ranunculus reptans L.

Appendix 1. List of vascular species found in the Lake Clark National Park and Preserve, Alaska, 2011 (continued).

- Thalictrum alpinum L.
- Thalictrum sparsiflorum Turcz.

Rosaceae

- Aruncus sylvester Kostel.
- Dryas integrifolia Vahl.
- Dryas octopetala L.
- Geum macrophyllum Willd. ssp. macrophyllum
- Geum rossii (R. Br.) Ser.
- Luetkea pectinata (Pursh) Ktze.
- Potentilla anserina L.
- Potentilla egedii Wormsk. ssp. grandis (Torr. & Gray) Hult.
- Potentilla fruticosa L.
- Potentilla hyparctica Malte
- Potentilla palustris (L.) Scop.
- Potentilla pulchella R. Br.
- Potentilla uniflora Ledeb.
- Rosa acicularis Lindl.
- Rosa woodsii Lindl.
- Rubus arcticus L.
- Rubus arcticus L. ssp. stellatus (Sm.) Boiv. Emend. Hulten
- Rubus chamaemorus L.
- Rubus idaeus L.
- Rubus pedatus Sm.
- Rubus spectabilis Pursh
- Sanguisorba officinalis L.
- Sanguisorba stipulata Raf.
- Sibbaldia procumbens L.
- Sorbus scopulina Greene
- Sorbus sitchensis Roem.
- Spiraea beauverdiana Schneid.

Rubiaceae

- Galium boreale L.
- Galium trifidum L. ssp. trifidum
- Galium triflorum Michx.

Salicaceae

- Populus balsamifera L.
- Populus balsamifera L. ssp. trichocarpa (Torr. & Gray) Brayshaw
- Populus tremuloides Michx.
- Salix alaxensis (Anderss.) Cov.
- Salix arbusculoides Anderss.
- Salix arctica Pall.
- Salix barclayi Anderss.
- Salix barrattiana Hook.
- Salix bebbiana Sarg.
- Salix brachycarpa Nutt. ssp. niphoclada (Rydb.) Argus
- Salix commutata Bebb
- Salix fuscescens Anderss.
- Salix glauca L.
- Salix lanata L. ssp. richardsonii (Hook.) Skvort.
- Salix lasiandra Benth.
- Salix monticola Bebb
- Salix myrtillifolia Anderss.
- Salix ovalifolia Trautv.
- Salix phlebophylla Anderss.
- Salix planififolia Pursh
- Salix planifolia Pursch. ssp.pulchra (Cham.) Argus
- Salix polaris Wahlenb. ssp. pseudopolaris (Flod.) Hult.
- Salix reticulata L.
- Salix rotundifolia Trautv.
- Salix scouleriana Barratt
- Salix sitchensis Sanson

Santalaceae

- Geocaulon lividum (Richards.) Fern.

Saxifragaceae

- Boykinia richardsonii (Hook.) Gray
- Chrysosplenium tetrandrum (Lund) T. Fries
- Heuchera glabra Willd.
- Leptarrhena pyrolifolia (D. Don) R. Br. ex Ser.
- Parnassia palustris L.
- Ribes glandulosum Grauer
- Ribes laxiflorum Pursh
- Ribes triste Pall.
- Saxifraga bronchialis L.
- Saxifraga hirculis L.
- Saxifraga oppositifolia L.
- Saxifraga punctata L.
- Saxifraga punctata L. ssp. nelsoniana (D. Don) Hult.
- Tellima grandiflora (Pursh) Dougl.

Scrophulariaceae

- Euphrasia disjuncta Fern & Wieg.
- Lagotis glauca Gaertn. ssp. glauca
- Pedicularis capitata Adams.
- Pedicularis labradorica Wirsing
- Pedicularis langsdorffii Fisch. ssp.arctica (R. Br.) Pennell
- Pedicularis sudetica Willd.
- Pedicularis verticillata L.
- Rhinanthus minor L.

Sparganiaceae

- Sparganium angustifolium Michx.

Thelypteridaceae

- Thelypteris phegopteris (L.) Slosson

Umbelliferae (Apiaceae)

- Angelica genuflexa Nutt.
- Angelica lucida L.
- Cicuta douglasii (DC.) Coult. & Rose
- Cicuta mackenzieana Raup
- Conioselinum chinense L. BSP.
- Heracleum lanatum Michx.
- Ligusticum scoticum L. ssp. hultenii (Fern.) Cald. & Tayl.

Urticaceae

- Urtica lyallii S. Wats.

Valerianaceae

- Valeriana capitata Pall.
- Valeriana sitchensis Bong.

Violaceae

- Viola epipsila Ledeb. ssp. repens (Turcz.) Becker
- Viola langsdorffii Fisch.

Appendix 2. List of non-vascular species found in the Lake Clark National Park and Preserve, Alaska, 2011.

Lichen

- Alectoria nigricans (Ach.) Nyl.
- Alectoria ochroleuca (Hoffm.) A. Massal.
- Allantoparmelia alpicola
- Bryoria nitidula (Th. Fr.) Brodo & D. Hawksw.
- Cetraria aculeata (Schreber) Fr.
- Cetraria islandica (L.) Ach.
- Cetraria laevigata Rass.
- Cetraria nigricans Nyl.
- Cetrariella fastigiata (Delise ex Nyl.) Kärnefelt & Thell
- Cladina arbuscula (Wallr.) Hale & Culb.
- Cladina mitis (Sandst.) Hustich
- Cladina rangiferina (L.) Nyl.
- Cladina stellaris (Opiz) Brodo
- Cladina stygia (Fr.) Ahti
- Cladonia bellidiflora (Ach.) Schaerer
- Cladonia ecmocyna Leighton
- Cladonia gracilis (L.) Willd.
- Cladonia gracilis (L.) Willd. ssp. turbinata (Ach.) Ahti
- Cladonia squamosa Hoffm.
- Cladonia uncialis (L.) F. H. Wigg.
- Dactylina arctica (Richardson) Nyl.
- Flavocetraria cucullata (Bellardi) Kärnefelt & Thell
- Flavocetraria nivalis (L.) Kärnefelt & Thell
- Lobaria linita (Ach.) Rabenh.
- Melanelia stygia (L.) Essl.
- Nephroma arcticum (L.) Torss.
- Ochrolechia frigida (Sw.) Lynge
- Peltigera aphthosa (L.) Willd.
- Peltigera canina (L.) Willd.
- Peltigera leucophlebia (Nyl.) Gyelnik
- Peltigera malacea (Ach.) Funck
- Peltigera polydactylon (Neck.) Hoffm.
- Peltigera rufescens (Weiss) Humb.
- Peltigera venosa (L.) Hoffm.
- Rhizocarpon geographicum (L.) DC.
- Solorina crocea (L.) Ach.
- Sphaerophorus globosus (Hudson) Vainio
- Stereocaulon paschale (L.) Hoffm.
- Stereocaulon rivulorum H. Magn.
- Stereocaulon symphycheilum
- Stereocaulon tomentosum Fr.
- Thamnolia subuliformis (Ehrh.) Culb.
- Thamnolia vermicularis (Sw.) Ach. ex Schaerer
- Umbilicaria hyperborea (Ach.) Hoffm.
- Umbilicaria proboscidea (L.) Schrader

Moss

- Sphagnum papillosum Lindb.
- Abietinella abietina (Hedw.) Fleisch.
- Amphidium mougeotii (Bruch & Schimp.) Schimp.
- Aongstroemia longipes (Somm.) B.S.G.
- Aulacomnium acuminatum (Lindb. & Arnell) Kindb.
- Aulacomnium palustre (Hedw.) Schwaegr.
- Aulacomnium turgidum (Wahlenb.) Schwaegr.
- Brachythecium albicans(Hedw.) B.S.G.
- Brachythecium calcareum Kindb.
- Brachythecium nelsonii Grout
- Brachythecium reflexum (Starke in Web.et Mohr) Schimp.
- Brachythecium salebrosum (Web. et Mohr) B.S.G.
- Brachythecium starkei (Brid.) Schimp.
- Bryum pseudotriquetrum (Hedw.) Gaertn. et al.
- Calliergon cordifolium (Hedw.) Kindb.
- Calliergon stramineum (Brid.) Kindb.
- Campylium stellatum (Hedw.) C.Jens.
- Ceratodon purpureus (Hedw.) Brid.
- Climacium dendroides (Hedw.) Web. et Mohr.
- Cratoneuron filicinum (Hedw.) Spruce
- Dicranella schreberiana (Hedw.) Hilf. Ex H.A. Crum & L.E. Anderson
- Dicranum acutifolium (Lindb. et H.Arnell) C. Jens.
- Dicranum brevifolium (Lindb.) Lindb.
- Dicranum fuscescens Turner.
- Dicranum scoparium Hedw.
- Ditrichum flexicaule (Schwaegr.) Hampe
- Drepanocladus aduncus (Hedw.) Warnst. s.l.
- Drepanocladus revolvens (Sw.) Warnst.
- Drepanocladus sendtneri (Schimp. ex C.Muell.) Warnst.
- Eurhynchium pulchellum (Hedw.) Jenn.
- Grimmia affinis Hoppe & Hornsch. ex Hornsch.
- Helodium blandowii (Web. & Mohr) Warnst.
- Hylocomiastrum pyrenaicum (Spruce) Fleisch.
- Hylocomium splendens (Hedw.) B.S.G.
- Leptobryum pyriforme (Hedw.) Wils.
- Limprichtia revolvens (Sw.) Loeske
- Meesia uliginosa Hedw.
- Paludella squarrosa (Hedw.) Brid.
- Plagiomnium cuspidatum (Hedw.) T. Kop.
- Plagiomnium insigne (Mitt.) T. Kop.
- Plagiothecium laetum Schimp.
- Pleurozium schreberi (Brid.) Mitt.
- Pogonatum urnigerum (Hedw.) P. Beauv.
- Polytrichastrum alpinum (Hedw.) G.L.Sm.
- Polytrichum commune Hedw.
- Polytrichum jensenii Hag.
- Polytrichum juniperinum Hedw.
- Polytrichum piliferum Hedw.
- Polytrichum sexangulare Brid.
- Polytrichum strictum Brid.
- Pseudoleskeella nervosa
- Ptilidium ciliare (L.) Hampe
- Ptilium crista-castrensis (Hedw.) De Not.
- Racomitrium canescens (Hedw.) Brid.
- Racomitrium elongatum Ehrh. ex Frisv.
- Racomitrium ericoides (Web. ex Brid.) Brid.
- Racomitrium lanuginosum (Hedw.) Brid.
- Racomitrium microcarpon (Hedw.) Brid.
- Racomitrium sudeticum (Funck) Bruch & Schimp.
- Racomitrium varium (Mitt.) A. Jaeger

Appendix 2. List of non-vascular species found in the Lake Clark National Park and Preserve, Alaska, 2011.

Rhizomnium pseudopunctatum (Bruch & Schimp.) T. Kop.
Rhytidiadelphus loreus (Hedw.) Warnst.
Rhytidiadelphus squarrosus (Hedw.) Warnst.
Rhytidiadelphus triquetrus (Hedw.) Warnst.
Rhytidiopsis robusta (Hook.) Broth.
Rhytidium rugosum (Hedw.) Kindb.
Sanionia uncinata (Hedw.) Loeske
Sarmenthypnum sarmentosum (Wahlenb.) Tuom. & T. Kop.
Scorpidium scorpioides (Hedw.) Limpr.
Sphagnum angustifolium (Russ. ex Russ.) C.Jens
Sphagnum aongstroemii C.Hartm.
Sphagnum fimbriatum Wils.
Sphagnum fuscum (Schimp.) Klinggr.
Sphagnum girgensohnii Russ.
Sphagnum lenense H.Lindb. ex Pohle
Sphagnum lindbergii Schimp. ex Lindb.
Sphagnum magellanicum Brid.
Sphagnum riparium Ångstr.
Sphagnum rubellum Wils.
Sphagnum russowii Warnst.
Sphagnum sect cuspidata
Sphagnum squarrosum Crome
Sphagnum teres (Schimp.) Ångstr. in Hartm.
Sphagnum warnstorfii Russ.
Thuidium recognitum (Hedw.) Lindb.
Timmia austriaca Hedw.
Tomentypnum nitens (Hedw.) Loeske
Warnstorfia fluitans (Hedw.) Loeske

)hagnaceae

Sphagnum flexuosum Dozy & Molk.

Appendix 3. Chemical and physical laboratory data for 71 soil horizons across 27 plots, Lake Clark National Park and Preserve, Alaska, 2011.

		100 C Oven Dry										Air Dry	
Unique_ID	Depth (cm)	% C	% N	% Sand	% Silt	% Clay	% OC[1]	% Fe	% Al	% Si	% BS[2]	% P Rent[3]	15 Bar % H_2O
LACL_T01_01_2011	16-19	7.89	0.25	NA	NA	NA	7.89	0.95	0.38	0.02	NA	62.10	17.0
LACL_T01_01_2011	19-39	5.46	0.12	NA	NA	NA	5.45	1.66	2.26	0.91	NA	97.88	20.5
LACL_T09_01_2011	0-11	2.81	0.17	29.20	60.40	10.40	2.80	0.79	0.64	0.24	35.43	53.29	14.9
LACL_T09_01_2011	19-39	1.77	0.13	53.20	34.40	12.40	1.77	0.84	1.22	0.47	6.60	80.36	11.2
LACL_T14_03_2011	35-45	17.77	0.74	50.21	41.22	8.57	17.77	1.86	1.69	0.29	2.94	97.88	31.0
LACL_T14_03_2011	70-75	NA	NA	53.20	36.40	10.40	NA	NA	NA	NA	NA	NA	
LACL_T17_01_2011	2-7	8.23	0.34	NA	NA	NA	8.23	NA	NA	NA	22.99	NA	
LACL_T17_01_2011	7-17	3.21	0.15	NA	NA	NA	3.20	NA	NA	NA	4.88	NA	
LACL_T17_03_2011	0-6	7.37	0.38	NA	NA	NA	7.37	NA	NA	NA	45.57	NA	
LACL_T17_03_2011	6-22	4.85	0.27	NA	NA	NA	4.84	NA	NA	NA	31.84	NA	
LACL_T23_02_2011	20-50	4.27	0.28	NA	NA	NA	4.26	1.03	1.76	0.56	NA	96.28	20.9
LACL_T23_02_2011	3-20	5.85	0.37	NA	NA	NA	5.84	1.17	1.98	0.66	NA	97.56	24.7
LACL_T23_03_2011	16-31	7.34	0.39	NA	NA	NA	7.33	1.13	1.30	0.33	NA	96.07	22.6
LACL_T23_03_2011	31-50	4.55	0.29	NA	NA	NA	4.55	1.13	2.57	1.06	NA	98.20	22.1
LACL_T23_03_2011	4-16	7.76	0.39	NA	NA	NA	7.75	1.06	1.77	0.41	NA	98.94	24.7
LACL_T23_09_2011	12-27	5.16	0.30	NA	NA	NA	5.16	NA	NA	NA	54.49	NA	
LACL_T30_01_2011	11-33	5.15	0.46	NA	NA	NA	5.15	NA	NA	NA	63.68	NA	
LACL_T30_01_2011	33-54	4.40	0.38	NA	NA	NA	4.40	NA	NA	NA	56.42	NA	
LACL_T30_06_2011	17-30	5.28	0.30	NA	NA	NA	5.28	1.47	1.43	0.44	NA	92.14	19.6
LACL_T31_01_2011	20-41	3.75	0.21	NA	NA	NA	3.74	NA	NA	NA	100.00	NA	19.0
LACL_T31_01_2011	41-52	2.17	0.11	NA	NA	NA	2.17	0.82	1.44	0.60	NA	88.11	22.8
LACL_T31_01_2011	5-20	4.69	0.28	NA	NA	NA	4.69	NA	NA	NA	44.16	NA	
LACL_T31_03_2011	12-23	NA	NA	69.20	18.40	12.40	NA	NA	NA	NA	NA	NA	
LACL_T31_03_2011	23-52	NA	NA	63.20	18.40	18.40	NA	NA	NA	NA	NA	NA	
LACL_T32_02_2011	18-34	12.90	0.59	NA	NA	NA	12.89	1.59	2.09	0.13	NA	99.58	34.1
LACL_T32_02_2011	34-40	13.57	0.60	NA	NA	NA	13.56	1.75	3.70	0.58	NA	99.04	30.5
LACL_T32_02_2011	7-15	19.25	0.98	NA	NA	NA	19.24	1.09	0.77	<.01	NA	95.54	13.2
LACL_T33_08_2011	12-25	12.94	0.79	NA	NA	NA	12.93	0.83	0.83	0.02	NA	90.98	34.2

Appendix 3. Chemical and physical laboratory data for 71 soil horizons across 27 plots, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

		100 C Oven Dry										Air Dry	
Unique_ID	Depth (cm)	% C	% N	% Sand	% Silt	% Clay	% OC[1]	% Fe	% Al	% Si	% BS[2]	% P Rent[3]	15 Bar % H_2O
LACL_T33_08_2011	25-30	8.41	0.47	NA	NA	NA	8.39	0.82	0.88	0.04	NA	93.42	25.8
LACL_T33_08_2011	30-33	25.71	1.30	NA	NA	NA	25.70	1.90	1.72	0.04	NA	98.94	
LACL_T33_08_2011	33-46	2.34	0.14	NA	NA	NA	2.33	1.42	0.68	0.10	NA	70.49	13.3
LACL_T33_08_2011	46-49	4.80	0.24	NA	NA	NA	4.79	1.52	1.30	0.12	NA	84.82	14.6
LACL_T35_01_2011	27-48	5.12	0.43	NA	NA	NA	5.11	1.17	1.65	0.45	6.11	95.65	18.0
LACL_T35_01_2011	48-57	3.25	0.27	NA	NA	NA	3.25	1.11	2.23	0.79	NA	12.63	
LACL_T35_01_2011	7-14	4.14	0.31	NA	NA	NA	4.14	1.20	0.84	0.16	NA	96.07	15.4
LACL_T35_05_2011	1-5	0.33	0.03	NA	NA	NA	0.33	1.14	0.10	0.03	27.53	95.65	4.5
LACL_T35_05_2011	27-32	4.81	0.27	NA	NA	NA	4.81	1.43	1.06	0.13	NA	99.47	15.9
LACL_T35_05_2011	32-54	13.60	0.75	NA	NA	NA	13.58	1.11	2.01	0.19	1.61	81.42	26.9
LACL_T36_02_2011	11-32	1.17	0.10	NA	NA	NA	1.16	1.54	1.10	0.56	NA	63.91	8.1
LACL_T41_06_2011	10-15	3.03	0.18	NA	NA	NA	3.03	1.26	1.56	0.62	NA	90.55	13.2
LACL_T41_06_2011	25-29	3.21	0.23	NA	NA	NA	3.22	1.35	1.60	0.59	NA	90.66	14.0
LACL_T41_06_2011	45-50												8.2
LACL_T42_01_2011	10.5-21	8.88	0.34	NA	NA	NA	8.88	0.93	1.47	0.23	8.23	97.88	18.9
LACL_T48_01_2011	10-29	5.18	0.38	NA	NA	NA	5.17	0.90	1.05	0.39	22.81	73.46	18.7
LACL_T48_01_2011	29-37	10.89	0.65	NA	NA	NA	10.88	0.94	1.03	0.24	33.04	84.08	32.0
LACL_T48_01_2011	7-10	7.93	0.52	NA	NA	NA	7.93	0.83	1.00	0.34	30.48	77.07	22.3
LACL_T48_03_2011	11-26	5.87	0.40	NA	NA	NA	5.85	0.84	1.07	0.33	17.04	90.02	19.5
LACL_T48_03_2011	26-30	2.90	0.23	NA	NA	NA	2.89	0.82	1.04	0.41	5.82	75.05	13.0
LACL_T48_03_2011	30-37	5.70	0.35	NA	NA	NA	5.70	0.99	1.42	0.51	3.50	89.81	17.2
LACL_T48_03_2011	37-47	5.64	0.36	NA	NA	NA	5.63	0.92	1.43	0.48	5.01	88.75	16.1
LACL_T60_01_2011	10-12	11.59	0.41	NA	NA	NA	11.59	0.77	0.99	0.04	2.29	94.06	26.1
LACL_T60_01_2011	12-29	11.55	0.41	NA	NA	NA	11.53	1.09	1.90	0.19	2.01	99.36	21.1
LACL_T60_01_2011	29-44	3.19	0.14	NA	NA	NA	3.18	1.28	2.12	0.79	NA	96.18	14.7
LACL_T67_01_2011	0-2	0.11	0.03	NA	NA	NA	0.11	1.30	0.09	0.02	NA	20.59	4.6

Appendix 3. Chemical and physical laboratory data for 71 soil horizons across 27 plots, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

		100 C Oven Dry										Air Dry	
Unique_ID	Depth (cm)	% C	% N	% Sand	% Silt	% Clay	% OC[1]	% Fe	% Al	% Si	% BS[2]	% P Rent[3]	15 Bar % H_2O
LACL_T67_01_2011	14-17	2.94	0.17	NA	NA	NA	2.94	1.10	0.63	0.17	NA	68.58	11.5
LACL_T67_01_2011	17-21	2.50	0.17	NA	NA	NA	2.47	0.96	0.80	0.24	NA	70.49	
LACL_T67_01_2011	21-40	0.27	0.02	NA	NA	NA	0.27	0.99	0.26	0.08	NA	24.95	8.0
LACL_T67_01_2011	40-52	0.56	0.04	NA	NA	NA	0.56	1.01	0.35	0.12	NA	31.63	4.0
LACL_T67_01_2011	52-62	1.12	0.09	NA	NA	NA	1.12	1.06	0.67	0.30	17.86	52.65	5.7
LACL_T67_01_2011	5-9	1.94	0.15	NA	NA	NA	1.94	1.16	0.43	0.08	NA	43.95	9.2
LACL_T68_07_2011	18-33	14.64	0.49	NA	NA	NA	14.63	0.94	1.08	0.08	3.46	96.18	26.9
LACL_T68_07_2011	33-53	3.53	0.15	NA	NA	NA	3.52	0.69	1.22	0.40	NA	81.00	9.9
LACL_T68_07_2011	8-18	9.38	0.37	NA	NA	NA	9.38	1.06	1.32	0.23	2.10	96.07	23.9
LACL_T71_07_2011	18-22	3.03	0.13	NA	NA	NA	3.01	1.72	2.44	1.22	NA	97.13	15.3
LACL_T71_07_2011	60-65												6.9
LACL_T71_07_2011	8-13	5.67	0.27	NA	NA	NA	5.65	1.14	1.70	0.54	NA	94.06	19.5
LACL_T72_01_2011	23-28	5.81	0.25	NA	NA	NA	5.79	0.97	1.47	0.43	NA	95.01	16.7
LACL_T72_01_2011	28-40	2.27	0.09	NA	NA	NA	2.25	0.90	1.85	0.90	NA	89.70	10.7
LACL_T72_01_2011	40-54	2.30	0.11	NA	NA	NA	2.30	0.75	1.46	0.84	NA	78.77	10.3
LACL_T90_02_2011	10-20	2.32	0.26	61.20	24.40	14.40	2.32	NA	NA	NA	NA	NA	
LACL_T90_02_2011	80-90	1.14	0.16	34.58	27.50	37.92	1.14	NA	NA	NA	NA	NA	

[1] Percent Organic Carbon

[2] Percent Base Saturation

[3] Percent Phosphate Retention (New Zealand)

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011.

	LACL_T01_01_2011	LACL_T10_05_2011	LACL_T17_01_2011	LACL_T17_03_2011	LACL_T23_02_2011	LACL_T23_03_2011	LACL_T23_09_2011	LACL_T30_01_2011	LACL_T31_01_2011
AB350	2.7782	3.1210	2.6798	2.7843	2.7484	2.8344	2.7970	3.1777	2.5844
AB360	2.7618	3.1198	2.7571	2.8252	2.7724	2.8696	2.8901	3.2156	2.5824
AB370	2.7247	3.0919	2.7655	2.8315	2.7500	2.8592	2.9093	3.2038	2.5584
AB380	2.6557	3.0535	2.7209	2.7948	2.7042	2.8041	2.8712	3.1666	2.4951
AB390	2.5736	2.9907	2.6577	2.7332	2.6333	2.7459	2.8245	3.1202	2.4068
AB400	2.4951	2.9260	2.5948	2.6730	2.5551	2.6890	2.7620	3.1004	2.3274
AB410	2.4177	2.8782	2.5377	2.6251	2.4833	2.6163	2.7037	3.0656	2.2613
AB420	2.3427	2.8124	2.4963	2.5711	2.4125	2.5501	2.6481	3.0209	2.1942
AB430	2.2553	2.7469	2.4385	2.5254	2.3401	2.4912	2.5799	2.9718	2.1350
AB440	2.1750	2.6851	2.3880	2.4857	2.2710	2.4373	2.5164	2.9214	2.0775
AB450	2.1076	2.6344	2.3479	2.4542	2.2186	2.3962	2.4647	2.8776	2.0326
AB460	2.0565	2.5901	2.3129	2.4311	2.1734	2.3576	2.4199	2.8439	1.9973
AB470	2.0134	2.5535	2.2838	2.4061	2.1338	2.3210	2.3841	2.8116	1.9651
AB480	1.9714	2.5094	2.2469	2.3712	2.0877	2.2814	2.3425	2.7821	1.9294
AB490	1.9207	2.4534	2.1963	2.3171	2.0260	2.2237	2.2901	2.7376	1.8800
AB500	1.8650	2.3900	2.1336	2.2537	1.9556	2.1567	2.2275	2.6851	1.8256
AB510	1.8071	2.3226	2.0690	2.1884	1.8824	2.0878	2.1617	2.6267	1.7695
AB520	1.7487	2.2596	2.0077	2.1265	1.8110	2.0206	2.0965	2.5664	1.7161
AB530	1.6930	2.1984	1.9509	2.0697	1.7446	1.9569	2.0353	2.5067	1.6684
AB540	1.6414	2.1445	1.9002	2.0216	1.6865	1.9012	1.9788	2.4510	1.6258
AB550	1.5932	2.1000	1.8600	1.9854	1.6378	1.8551	1.9315	2.4031	1.5917
AB560	1.5483	2.0571	1.8217	1.9504	1.5923	1.8109	1.8881	2.3570	1.5593
AB570	1.5066	2.0113	1.7831	1.9105	1.5465	1.7639	1.8451	2.3095	1.5244
AB580	1.4694	1.9709	1.7509	1.8763	1.5069	1.7218	1.8045	2.2667	1.4928
AB590	1.4361	1.9417	1.7302	1.8571	1.4797	1.6928	1.7737	2.2322	1.4716
AB600	1.4066	1.9212	1.7152	1.8443	1.4586	1.6712	1.7501	2.2048	1.4567
AB610	1.3790	1.8863	1.6872	1.8100	1.4251	1.6348	1.7185	2.1682	1.4298
AB620	1.3536	1.8360	1.6493	1.7554	1.3814	1.5836	1.6773	2.1211	1.3895
AB630	1.3294	1.7804	1.6070	1.6927	1.3326	1.5246	1.6296	2.0690	1.3437
AB640	1.3069	1.7197	1.5611	1.6215	1.2795	1.4582	1.5747	2.0096	1.2930
AB650	1.2834	1.6587	1.5141	1.5481	1.2260	1.3879	1.5152	1.9453	1.2408
AB660	1.2610	1.6011	1.4697	1.4773	1.1756	1.3191	1.4556	1.8800	1.1911
AB670	1.2403	1.5505	1.4304	1.4135	1.1314	1.2558	1.3989	1.8180	1.1465
AB680	1.2208	1.5046	1.3950	1.3549	1.0914	1.1969	1.3456	1.7584	1.1061
AB690	1.2025	1.4632	1.3630	1.3018	1.0559	1.1426	1.2955	1.7021	1.0697

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T01_01_2011	LACL_T10_05_2011	LACL_T17_01_2011	LACL_T17_03_2011	LACL_T23_02_2011	LACL_T23_03_2011	LACL_T23_09_2011	LACL_T30_01_2011	LACL_T31_01_2011
AB700	1.1851	1.4260	1.3343	1.2535	1.0245	1.0935	1.2498	1.6491	1.0370
AB710	1.1689	1.3927	1.3084	1.2101	0.9969	1.0495	1.2074	1.6000	1.0079
AB720	1.1541	1.3630	1.2848	1.1714	0.9727	1.0104	1.1688	1.5547	0.9819
AB730	1.1401	1.3361	1.2632	1.1366	0.9517	0.9758	1.1336	1.5130	0.9586
AB740	1.1276	1.3120	1.2434	1.1055	0.9334	0.9454	1.1014	1.4744	0.9380
AB750	1.1162	1.2903	1.2251	1.0777	0.9178	0.9189	1.0719	1.4389	0.9197
AB760	1.1055	1.2708	1.2084	1.0528	0.9043	0.8957	1.0448	1.4062	0.9032
AB770	1.0965	1.2535	1.1938	1.0311	0.8935	0.8762	1.0202	1.3770	0.8892
AB780	1.0882	1.2382	1.1810	1.0119	0.8844	0.8594	0.9979	1.3508	0.8770
AB790	1.0808	1.2249	1.1700	0.9952	0.8773	0.8454	0.9784	1.3276	0.8666
AB800	1.0742	1.2138	1.1610	0.9807	0.8717	0.8338	0.9616	1.3074	0.8578
AB810	1.0689	1.2049	1.1545	0.9686	0.8681	0.8246	0.9481	1.2904	0.8508
AB820	1.0639	1.1972	1.1494	0.9582	0.8655	0.8170	0.9371	1.2761	0.8451
AB830	1.0599	1.1915	1.1461	0.9496	0.8644	0.8114	0.9287	1.2643	0.8409
AB840	1.0561	1.1871	1.1439	0.9427	0.8641	0.8072	0.9226	1.2543	0.8381
AB850	1.0527	1.1835	1.1424	0.9368	0.8647	0.8042	0.9180	1.2457	0.8359
AB860	1.0499	1.1811	1.1418	0.9322	0.8659	0.8022	0.9149	1.2386	0.8346
AB870	1.0470	1.1791	1.1410	0.9282	0.8675	0.8009	0.9128	1.2322	0.8336
AB880	1.0441	1.1773	1.1403	0.9247	0.8690	0.8000	0.9113	1.2262	0.8327
AB890	1.0418	1.1763	1.1397	0.9221	0.8710	0.8001	0.9101	1.2211	0.8327
AB900	1.0394	1.1749	1.1386	0.9192	0.8726	0.7999	0.9090	1.2160	0.8325
AB910	1.0370	1.1737	1.1372	0.9164	0.8740	0.7997	0.9077	1.2108	0.8321
AB920	1.0342	1.1720	1.1347	0.9133	0.8745	0.7992	0.9063	1.2054	0.8312
AB930	1.0312	1.1696	1.1314	0.9098	0.8743	0.7982	0.9043	1.2002	0.8302
AB940	1.0286	1.1675	1.1280	0.9063	0.8738	0.7969	0.9022	1.1948	0.8290
AB950	1.0257	1.1654	1.1243	0.9025	0.8727	0.7952	0.8995	1.1900	0.8277
AB960	1.0226	1.1627	1.1199	0.8984	0.8708	0.7929	0.8962	1.1852	0.8259
AB970	1.0193	1.1596	1.1153	0.8935	0.8679	0.7899	0.8919	1.1804	0.8233
AB980	1.0162	1.1565	1.1106	0.8887	0.8645	0.7864	0.8876	1.1752	0.8209
AB990	1.0127	1.1526	1.1050	0.8837	0.8603	0.7822	0.8820	1.1703	0.8179
AB1000	1.0109	1.1514	1.1016	0.8808	0.8565	0.7794	0.8772	1.1663	0.8167
AB1010	1.0101	1.1511	1.0979	0.8794	0.8524	0.7773	0.8721	1.1639	0.8171
AB1020	1.0065	1.1471	1.0940	0.8750	0.8487	0.7732	0.8645	1.1599	0.8143
AB1030	1.0031	1.1424	1.0888	0.8699	0.8436	0.7688	0.8572	1.1551	0.8108

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T01_01_2011	LACL_T10_05_2011	LACL_T17_01_2011	LACL_T17_03_2011	LACL_T23_02_2011	LACL_T23_03_2011	LACL_T23_09_2011	LACL_T30_01_2011	LACL_T31_01_2011
AB1040	0.9996	1.1385	1.0850	0.8659	0.8394	0.7649	0.8499	1.1511	0.8079
AB1050	0.9960	1.1348	1.0806	0.8615	0.8352	0.7607	0.8427	1.1468	0.8049
AB1060	0.9931	1.1304	1.0769	0.8578	0.8308	0.7569	0.8358	1.1424	0.8014
AB1070	0.9902	1.1263	1.0738	0.8543	0.8267	0.7532	0.8287	1.1382	0.7981
AB1080	0.9870	1.1225	1.0702	0.8506	0.8229	0.7496	0.8218	1.1339	0.7948
AB1090	0.9842	1.1186	1.0663	0.8471	0.8194	0.7463	0.8151	1.1291	0.7916
AB1100	0.9814	1.1149	1.0625	0.8438	0.8158	0.7433	0.8087	1.1249	0.7885
AB1110	0.9788	1.1109	1.0586	0.8405	0.8124	0.7406	0.8029	1.1200	0.7854
AB1120	0.9762	1.1074	1.0553	0.8371	0.8093	0.7379	0.7972	1.1156	0.7825
AB1130	0.9739	1.1038	1.0514	0.8342	0.8063	0.7354	0.7916	1.1112	0.7800
AB1140	0.9718	1.1010	1.0478	0.8317	0.8038	0.7336	0.7868	1.1076	0.7781
AB1150	0.9703	1.0986	1.0447	0.8294	0.8018	0.7322	0.7821	1.1047	0.7765
AB1160	0.9685	1.0959	1.0412	0.8272	0.7997	0.7308	0.7773	1.1009	0.7746
AB1170	0.9669	1.0931	1.0373	0.8244	0.7973	0.7289	0.7724	1.0970	0.7722
AB1180	0.9654	1.0902	1.0335	0.8219	0.7949	0.7273	0.7674	1.0925	0.7698
AB1190	0.9636	1.0873	1.0292	0.8189	0.7922	0.7252	0.7621	1.0879	0.7671
AB1200	0.9619	1.0839	1.0249	0.8159	0.7893	0.7230	0.7566	1.0834	0.7641
AB1210	0.9603	1.0809	1.0201	0.8131	0.7865	0.7208	0.7515	1.0784	0.7615
AB1220	0.9583	1.0776	1.0157	0.8097	0.7835	0.7184	0.7460	1.0737	0.7585
AB1230	0.9572	1.0747	1.0110	0.8069	0.7810	0.7164	0.7407	1.0693	0.7561
AB1240	0.9553	1.0716	1.0064	0.8038	0.7782	0.7141	0.7354	1.0649	0.7531
AB1250	0.9538	1.0683	1.0017	0.8009	0.7754	0.7118	0.7300	1.0604	0.7506
AB1260	0.9521	1.0652	0.9969	0.7980	0.7726	0.7094	0.7251	1.0564	0.7478
AB1270	0.9506	1.0624	0.9925	0.7951	0.7699	0.7073	0.7203	1.0522	0.7450
AB1280	0.9494	1.0597	0.9883	0.7925	0.7675	0.7052	0.7156	1.0487	0.7425
AB1290	0.9484	1.0574	0.9843	0.7900	0.7654	0.7036	0.7112	1.0454	0.7406
AB1300	0.9477	1.0552	0.9807	0.7879	0.7630	0.7022	0.7066	1.0424	0.7386
AB1310	0.9465	1.0528	0.9767	0.7856	0.7609	0.7005	0.7025	1.0396	0.7367
AB1320	0.9459	1.0509	0.9732	0.7835	0.7593	0.6994	0.6986	1.0376	0.7353
AB1330	0.9453	1.0488	0.9697	0.7817	0.7577	0.6981	0.6950	1.0359	0.7337
AB1340	0.9447	1.0476	0.9668	0.7802	0.7568	0.6976	0.6920	1.0350	0.7327
AB1350	0.9446	1.0468	0.9645	0.7795	0.7565	0.6976	0.6895	1.0348	0.7326
AB1360	0.9449	1.0465	0.9626	0.7793	0.7568	0.6986	0.6872	1.0348	0.7332
AB1370	0.9466	1.0477	0.9614	0.7806	0.7590	0.7009	0.6872	1.0352	0.7349
AB1380	0.9495	1.0523	0.9632	0.7834	0.7637	0.7052	0.6900	1.0404	0.7396

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T01_01_2011	LACL_T10_05_2011	LACL_T17_01_2011	LACL_T17_03_2011	LACL_T23_02_2011	LACL_T23_03_2011	LACL_T23_09_2011	LACL_T30_01_2011	LACL_T31_01_2011
AB1390	0.9530	1.0585	0.9699	0.7885	0.7692	0.7109	0.7007	1.0542	0.7472
AB1400	0.9602	1.0677	0.9808	0.7971	0.7798	0.7211	0.7146	1.0784	0.7611
AB1410	0.9669	1.0771	0.9878	0.8053	0.7901	0.7317	0.7220	1.1026	0.7747
AB1420	0.9692	1.0790	0.9875	0.8095	0.7955	0.7379	0.7242	1.1131	0.7804
AB1430	0.9699	1.0769	0.9856	0.8111	0.7971	0.7402	0.7223	1.1122	0.7792
AB1440	0.9693	1.0745	0.9834	0.8107	0.7961	0.7395	0.7195	1.1076	0.7752
AB1450	0.9684	1.0717	0.9802	0.8090	0.7944	0.7381	0.7161	1.1029	0.7711
AB1460	0.9676	1.0695	0.9769	0.8073	0.7927	0.7367	0.7127	1.0989	0.7680
AB1470	0.9661	1.0664	0.9731	0.8045	0.7901	0.7344	0.7087	1.0940	0.7649
AB1480	0.9639	1.0629	0.9680	0.8006	0.7861	0.7305	0.7036	1.0859	0.7597
AB1490	0.9613	1.0591	0.9632	0.7965	0.7819	0.7265	0.6984	1.0777	0.7540
AB1500	0.9586	1.0549	0.9584	0.7920	0.7775	0.7223	0.6933	1.0703	0.7489
AB1510	0.9568	1.0521	0.9546	0.7887	0.7740	0.7194	0.6885	1.0636	0.7450
AB1520	0.9548	1.0487	0.9506	0.7850	0.7703	0.7159	0.6842	1.0574	0.7406
AB1530	0.9533	1.0460	0.9474	0.7819	0.7675	0.7134	0.6805	1.0523	0.7374
AB1540	0.9518	1.0438	0.9443	0.7794	0.7649	0.7112	0.6773	1.0481	0.7347
AB1550	0.9508	1.0419	0.9419	0.7774	0.7632	0.7098	0.6743	1.0445	0.7327
AB1560	0.9499	1.0402	0.9391	0.7752	0.7614	0.7083	0.6720	1.0411	0.7308
AB1570	0.9494	1.0384	0.9368	0.7734	0.7599	0.7074	0.6696	1.0383	0.7290
AB1580	0.9482	1.0367	0.9338	0.7710	0.7583	0.7059	0.6675	1.0351	0.7270
AB1590	0.9477	1.0353	0.9318	0.7700	0.7576	0.7053	0.6655	1.0329	0.7261
AB1600	0.9476	1.0341	0.9296	0.7684	0.7567	0.7048	0.6636	1.0302	0.7248
AB1610	0.9470	1.0325	0.9270	0.7664	0.7555	0.7038	0.6622	1.0275	0.7230
AB1620	0.9469	1.0318	0.9252	0.7655	0.7553	0.7037	0.6610	1.0260	0.7224
AB1630	0.9467	1.0307	0.9231	0.7642	0.7546	0.7031	0.6598	1.0243	0.7216
AB1640	0.9467	1.0298	0.9217	0.7631	0.7544	0.7031	0.6589	1.0228	0.7210
AB1650	0.9468	1.0291	0.9205	0.7627	0.7547	0.7036	0.6586	1.0224	0.7205
AB1660	0.9473	1.0289	0.9194	0.7622	0.7552	0.7040	0.6588	1.0220	0.7203
AB1670	0.9482	1.0291	0.9193	0.7626	0.7562	0.7053	0.6588	1.0226	0.7207
AB1680	0.9488	1.0295	0.9189	0.7630	0.7572	0.7066	0.6594	1.0233	0.7213
AB1690	0.9498	1.0305	0.9192	0.7638	0.7587	0.7084	0.6604	1.0246	0.7219
AB1700	0.9504	1.0305	0.9191	0.7642	0.7597	0.7099	0.6609	1.0252	0.7224
AB1710	0.9517	1.0310	0.9198	0.7654	0.7615	0.7118	0.6621	1.0270	0.7234
AB1720	0.9536	1.0330	0.9217	0.7676	0.7643	0.7148	0.6640	1.0305	0.7259
AB1730	0.9553	1.0343	0.9229	0.7697	0.7664	0.7175	0.6657	1.0334	0.7278

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T01_01_2011	LACL_T10_05_2011	LACL_T17_01_2011	LACL_T17_03_2011	LACL_T23_02_2011	LACL_T23_03_2011	LACL_T23_09_2011	LACL_T30_01_2011	LACL_T31_01_2011
AB1740	0.9558	1.0349	0.9225	0.7695	0.7677	0.7184	0.6661	1.0341	0.7286
AB1750	0.9564	1.0350	0.9224	0.7697	0.7690	0.7196	0.6670	1.0355	0.7298
AB1760	0.9578	1.0360	0.9232	0.7704	0.7708	0.7214	0.6682	1.0372	0.7313
AB1770	0.9584	1.0367	0.9235	0.7709	0.7719	0.7227	0.6690	1.0387	0.7325
AB1780	0.9583	1.0366	0.9228	0.7707	0.7726	0.7232	0.6694	1.0396	0.7327
AB1790	0.9586	1.0365	0.9226	0.7707	0.7732	0.7238	0.6696	1.0402	0.7333
AB1800	0.9618	1.0413	0.9244	0.7732	0.7754	0.7265	0.6728	1.0406	0.7373
AB1810	0.9662	1.0470	0.9273	0.7761	0.7781	0.7297	0.6755	1.0409	0.7423
AB1820	0.9666	1.0470	0.9268	0.7763	0.7786	0.7306	0.6751	1.0421	0.7435
AB1830	0.9662	1.0456	0.9264	0.7759	0.7784	0.7306	0.6739	1.0423	0.7439
AB1840	0.9671	1.0458	0.9260	0.7762	0.7790	0.7313	0.6742	1.0432	0.7447
AB1850	0.9674	1.0454	0.9257	0.7757	0.7795	0.7318	0.6751	1.0456	0.7463
AB1860	0.9689	1.0475	0.9273	0.7779	0.7826	0.7347	0.6786	1.0526	0.7504
AB1870	0.9753	1.0545	0.9356	0.7862	0.7923	0.7442	0.6871	1.0721	0.7622
AB1880	0.9861	1.0673	0.9489	0.8001	0.8093	0.7595	0.7064	1.1088	0.7836
AB1890	1.0097	1.0982	0.9814	0.8348	0.8505	0.7982	0.7460	1.1840	0.8334
AB1900	1.0468	1.1496	1.0354	0.8913	0.9159	0.8606	0.8094	1.2959	0.9112
AB1910	1.0772	1.1942	1.0781	0.9356	0.9635	0.9059	0.8638	1.3851	0.9683
AB1920	1.0914	1.2145	1.0969	0.9561	0.9820	0.9237	0.8894	1.4137	0.9837
AB1930	1.0930	1.2158	1.0982	0.9597	0.9830	0.9247	0.8936	1.4070	0.9747
AB1940	1.0887	1.2079	1.0907	0.9524	0.9751	0.9163	0.8857	1.3864	0.9583
AB1950	1.0814	1.1956	1.0788	0.9399	0.9624	0.9041	0.8724	1.3630	0.9403
AB1960	1.0721	1.1817	1.0646	0.9254	0.9472	0.8890	0.8573	1.3369	0.9231
AB1970	1.0608	1.1667	1.0500	0.9093	0.9318	0.8740	0.8425	1.3101	0.9058
AB1980	1.0515	1.1534	1.0368	0.8953	0.9169	0.8598	0.8265	1.2862	0.8894
AB1990	1.0416	1.1404	1.0241	0.8805	0.9018	0.8454	0.8112	1.2614	0.8732
AB2000	1.0318	1.1270	1.0111	0.8667	0.8867	0.8315	0.7962	1.2371	0.8570
AB2010	1.0229	1.1159	0.9989	0.8546	0.8738	0.8190	0.7821	1.2164	0.8421
AB2020	1.0142	1.1069	0.9890	0.8443	0.8626	0.8091	0.7711	1.1990	0.8298
AB2030	1.0064	1.0998	0.9796	0.8353	0.8525	0.7996	0.7624	1.1852	0.8189
AB2040	1.0006	1.0956	0.9738	0.8303	0.8458	0.7933	0.7550	1.1761	0.8124
AB2050	0.9954	1.0920	0.9690	0.8258	0.8403	0.7880	0.7494	1.1686	0.8058
AB2060	0.9903	1.0875	0.9648	0.8213	0.8347	0.7828	0.7443	1.1614	0.7997
AB2070	0.9877	1.0841	0.9594	0.8169	0.8293	0.7784	0.7389	1.1529	0.7943
AB2080	0.9836	1.0810	0.9556	0.8129	0.8236	0.7739	0.7349	1.1471	0.7894

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T01_01_2011	LACL_T10_05_2011	LACL_T17_01_2011	LACL_T17_03_2011	LACL_T23_02_2011	LACL_T23_03_2011	LACL_T23_09_2011	LACL_T30_01_2011	LACL_T31_01_2011
AB2090	0.9802	1.0768	0.9526	0.8084	0.8188	0.7686	0.7306	1.1408	0.7845
AB2100	0.9769	1.0724	0.9484	0.8039	0.8133	0.7641	0.7271	1.1356	0.7804
AB2110	0.9723	1.0691	0.9437	0.7993	0.8088	0.7588	0.7229	1.1305	0.7751
AB2120	0.9675	1.0643	0.9388	0.7933	0.8030	0.7529	0.7187	1.1230	0.7692
AB2130	0.9641	1.0606	0.9331	0.7885	0.7981	0.7482	0.7160	1.1179	0.7649
AB2140	0.9640	1.0614	0.9333	0.7884	0.7993	0.7478	0.7166	1.1176	0.7654
AB2150	0.9674	1.0658	0.9360	0.7909	0.8016	0.7511	0.7218	1.1198	0.7685
AB2160	0.9751	1.0748	0.9441	0.7979	0.8102	0.7584	0.7296	1.1280	0.7756
AB2170	0.9854	1.0847	0.9544	0.8065	0.8207	0.7682	0.7405	1.1367	0.7856
AB2180	0.9953	1.0935	0.9653	0.8149	0.8318	0.7780	0.7511	1.1455	0.7962
AB2190	1.0047	1.1042	0.9770	0.8225	0.8423	0.7874	0.7615	1.1557	0.8065
AB2200	1.0101	1.1126	0.9836	0.8278	0.8479	0.7920	0.7670	1.1643	0.8134
AB2210	1.0118	1.1135	0.9868	0.8283	0.8489	0.7939	0.7691	1.1720	0.8169
AB2220	1.0099	1.1052	0.9865	0.8278	0.8476	0.7931	0.7685	1.1699	0.8170
AB2230	1.0107	1.1038	0.9890	0.8280	0.8464	0.7925	0.7697	1.1705	0.8154
AB2240	1.0129	1.1073	0.9984	0.8331	0.8487	0.7941	0.7749	1.1777	0.8181
AB2250	1.0157	1.1133	1.0120	0.8400	0.8513	0.7978	0.7843	1.1876	0.8223
AB2260	1.0206	1.1187	1.0172	0.8455	0.8558	0.8022	0.7928	1.1972	0.8259
AB2270	1.0256	1.1227	1.0194	0.8509	0.8607	0.8078	0.7995	1.2080	0.8305
AB2280	1.0287	1.1283	1.0216	0.8544	0.8635	0.8106	0.8092	1.2161	0.8340
AB2290	1.0335	1.1343	1.0307	0.8609	0.8682	0.8146	0.8223	1.2277	0.8400
AB2300	1.0396	1.1420	1.0403	0.8691	0.8738	0.8210	0.8345	1.2377	0.8467
AB2310	1.0427	1.1467	1.0500	0.8749	0.8785	0.8245	0.8404	1.2471	0.8522
AB2320	1.0384	1.1453	1.0492	0.8714	0.8746	0.8188	0.8390	1.2479	0.8498
AB2330	1.0357	1.1438	1.0519	0.8700	0.8734	0.8176	0.8369	1.2531	0.8495
AB2340	1.0376	1.1445	1.0549	0.8708	0.8748	0.8193	0.8344	1.2605	0.8526
AB2350	1.0401	1.1448	1.0575	0.8748	0.8776	0.8225	0.8351	1.2675	0.8557
AB2360	1.0398	1.1424	1.0515	0.8716	0.8771	0.8222	0.8333	1.2679	0.8572
AB2370	1.0390	1.1399	1.0444	0.8703	0.8802	0.8244	0.8368	1.2748	0.8615
AB2380	1.0434	1.1456	1.0444	0.8744	0.8880	0.8297	0.8447	1.2817	0.8692
AB2390	1.0487	1.1509	1.0475	0.8794	0.8934	0.8374	0.8533	1.2934	0.8793
AB2400	1.0518	1.1540	1.0507	0.8851	0.9021	0.8440	0.8600	1.3062	0.8891
AB2410	1.0584	1.1605	1.0569	0.8941	0.9122	0.8541	0.8678	1.3211	0.9002
AB2420	1.0642	1.1710	1.0664	0.9048	0.9240	0.8644	0.8775	1.3384	0.9125
AB2430	1.0739	1.1821	1.0808	0.9194	0.9384	0.8782	0.8898	1.3601	0.9292

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T01_01_2011	LACL_T10_05_2011	LACL_T17_01_2011	LACL_T17_03_2011	LACL_T23_02_2011	LACL_T23_03_2011	LACL_T23_09_2011	LACL_T30_01_2011	LACL_T31_01_2011
AB2440	*1.0836*	*1.1955*	*1.0967*	*0.9354*	*0.9560*	*0.8947*	*0.9035*	*1.3845*	*0.9453*
AB2450	1.0937	1.2113	1.1106	0.9480	0.9711	0.9100	0.9186	1.4077	0.9626
AB2460	1.1003	1.2224	1.1273	0.9619	0.9847	0.9228	0.9347	1.4265	0.9776
AB2470	1.1097	1.2342	1.1414	0.9797	0.9972	0.9381	0.9468	1.4484	0.9932
AB2480	1.1192	1.2478	1.1520	0.9921	1.0126	0.9481	0.9560	1.4656	1.0090
AB2490	1.1261	1.2650	1.1685	1.0038	1.0238	0.9559	0.9672	1.4854	1.0195
AB2500	1.1332	1.2713	1.1892	1.0078	1.0289	0.9654	0.9681	1.4895	1.0303

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T31_03_2011	LACL_T33_08_2011	LACL_T35_05_2011	LACL_T48_01_2011	LACL_T48_03_2011	LACL_T60_01_2011	LACL_T67_01_2011	LACL_T68_07_2011	LACL_T72_01_2011
AB350	2.4167	2.9810	2.7544	3.0291	2.7226	2.8046	2.4282	2.9557	2.3401
AB360	2.3880	2.9780	2.7631	2.9985	2.7524	2.8822	2.4375	2.9611	2.3860
AB370	2.3589	2.9627	2.7458	2.9895	2.7330	2.9204	2.4182	2.9352	2.3720
AB380	2.3294	2.9422	2.7004	2.9555	2.6670	2.8867	2.3630	2.8898	2.3063
AB390	2.2913	2.9047	2.6390	2.9063	2.5915	2.8309	2.2861	2.8291	2.2112
AB400	2.2604	2.8734	2.5884	2.8747	2.5250	2.7718	2.2115	2.7614	2.1276
AB410	2.2370	2.8282	2.5375	2.8275	2.4642	2.7044	2.1517	2.7042	2.0462
AB420	2.2081	2.7852	2.4804	2.7876	2.4028	2.6367	2.0912	2.6463	1.9708
AB430	2.1754	2.7381	2.4213	2.7476	2.3341	2.5728	2.0317	2.5853	1.8914
AB440	2.1440	2.6955	2.3666	2.7119	2.2782	2.5131	1.9762	2.5297	1.8161
AB450	2.1169	2.6542	2.3244	2.6878	2.2298	2.4554	1.9304	2.4841	1.7548
AB460	2.0950	2.6147	2.2833	2.6654	2.1899	2.4109	1.8920	2.4438	1.7037
AB470	2.0780	2.5783	2.2488	2.6424	2.1527	2.3647	1.8574	2.4010	1.6611
AB480	2.0623	2.5414	2.2185	2.6165	2.1154	2.3197	1.8261	2.3562	1.6189
AB490	2.0400	2.5006	2.1780	2.5724	2.0692	2.2687	1.7851	2.3025	1.5713
AB500	2.0161	2.4608	2.1335	2.5219	2.0161	2.2132	1.7390	2.2466	1.5203
AB510	1.9915	2.4163	2.0829	2.4660	1.9588	2.1562	1.6875	2.1835	1.4675
AB520	1.9678	2.3700	2.0319	2.4125	1.9019	2.0999	1.6363	2.1225	1.4162
AB530	1.9433	2.3235	1.9831	2.3605	1.8476	2.0457	1.5884	2.0635	1.3682
AB540	1.9161	2.2766	1.9365	2.3131	1.7967	1.9928	1.5440	2.0082	1.3238
AB550	1.8819	2.2312	1.8939	2.2754	1.7501	1.9434	1.5049	1.9582	1.2823
AB560	1.8394	2.1854	1.8535	2.2390	1.7064	1.8953	1.4674	1.9109	1.2430
AB570	1.7893	2.1379	1.8125	2.1980	1.6637	1.8477	1.4298	1.8631	1.2055
AB580	1.7402	2.0911	1.7734	2.1612	1.6251	1.8020	1.3955	1.8195	1.1714
AB590	1.6979	2.0477	1.7391	2.1379	1.5937	1.7604	1.3674	1.7823	1.1408
AB600	1.6641	2.0097	1.7125	2.1235	1.5690	1.7230	1.3441	1.7506	1.1132
AB610	1.6366	1.9679	1.6836	2.0913	1.5421	1.6828	1.3170	1.7134	1.0860
AB620	1.6130	1.9216	1.6472	2.0410	1.5092	1.6410	1.2850	1.6715	1.0588
AB630	1.5922	1.8711	1.6058	1.9810	1.4724	1.5978	1.2520	1.6257	1.0329
AB640	1.5722	1.8133	1.5570	1.9114	1.4312	1.5511	1.2167	1.5737	1.0072
AB650	1.5513	1.7500	1.5019	1.8351	1.3839	1.5021	1.1810	1.5163	0.9806
AB660	1.5302	1.6838	1.4441	1.7572	1.3343	1.4528	1.1473	1.4570	0.9549
AB670	1.5095	1.6180	1.3871	1.6837	1.2859	1.4060	1.1166	1.3992	0.9313
AB680	1.4887	1.5519	1.3306	1.6128	1.2386	1.3615	1.0883	1.3426	0.9092
AB690	1.4675	1.4867	1.2765	1.5457	1.1933	1.3191	1.0622	1.2882	0.8885

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T31_03_2011	LACL_T33_08_2011	LACL_T35_05_2011	LACL_T48_01_2011	LACL_T48_03_2011	LACL_T60_01_2011	LACL_T67_01_2011	LACL_T68_07_2011	LACL_T72_01_2011
AB700	1.4459	1.4235	1.2263	1.4830	1.1511	1.2795	1.0387	1.2367	0.8692
AB710	1.4243	1.3635	1.1802	1.4250	1.1124	1.2427	1.0176	1.1888	0.8517
AB720	1.4032	1.3073	1.1387	1.3720	1.0775	1.2088	0.9990	1.1448	0.8360
AB730	1.3828	1.2550	1.1014	1.3235	1.0462	1.1779	0.9824	1.1047	0.8217
AB740	1.3637	1.2064	1.0679	1.2790	1.0183	1.1496	0.9680	1.0677	0.8086
AB750	1.3464	1.1617	1.0380	1.2384	0.9937	1.1237	0.9556	1.0340	0.7972
AB760	1.3313	1.1205	1.0115	1.2013	0.9719	1.1002	0.9449	1.0035	0.7869
AB770	1.3189	1.0835	0.9886	1.1683	0.9534	1.0791	0.9364	0.9761	0.7784
AB780	1.3090	1.0499	0.9686	1.1383	0.9375	1.0598	0.9293	0.9514	0.7709
AB790	1.3015	1.0197	0.9513	1.1117	0.9241	1.0427	0.9235	0.9294	0.7647
AB800	1.2959	0.9925	0.9366	1.0879	0.9127	1.0270	0.9192	0.9099	0.7595
AB810	1.2927	0.9690	0.9245	1.0673	0.9040	1.0132	0.9162	0.8930	0.7557
AB820	1.2908	0.9480	0.9142	1.0491	0.8969	1.0008	0.9140	0.8780	0.7522
AB830	1.2903	0.9302	0.9062	1.0334	0.8918	0.9896	0.9133	0.8655	0.7500
AB840	1.2901	0.9146	0.8997	1.0199	0.8881	0.9797	0.9133	0.8547	0.7487
AB850	1.2902	0.9011	0.8947	1.0080	0.8856	0.9708	0.9140	0.8453	0.7477
AB860	1.2904	0.8897	0.8911	0.9977	0.8841	0.9627	0.9156	0.8371	0.7473
AB870	1.2901	0.8799	0.8880	0.9886	0.8831	0.9553	0.9174	0.8299	0.7473
AB880	1.2890	0.8713	0.8856	0.9803	0.8827	0.9486	0.9194	0.8235	0.7473
AB890	1.2881	0.8644	0.8843	0.9733	0.8829	0.9421	0.9221	0.8180	0.7481
AB900	1.2864	0.8581	0.8831	0.9669	0.8830	0.9363	0.9244	0.8128	0.7486
AB910	1.2843	0.8523	0.8820	0.9607	0.8832	0.9304	0.9263	0.8080	0.7490
AB920	1.2817	0.8466	0.8807	0.9545	0.8827	0.9250	0.9276	0.8032	0.7493
AB930	1.2783	0.8411	0.8791	0.9485	0.8820	0.9196	0.9279	0.7983	0.7491
AB940	1.2755	0.8357	0.8773	0.9428	0.8810	0.9145	0.9279	0.7935	0.7488
AB950	1.2730	0.8302	0.8755	0.9370	0.8795	0.9092	0.9271	0.7888	0.7481
AB960	1.2709	0.8243	0.8727	0.9311	0.8773	0.9040	0.9251	0.7839	0.7472
AB970	1.2693	0.8179	0.8694	0.9247	0.8747	0.8991	0.9222	0.7784	0.7450
AB980	1.2686	0.8112	0.8659	0.9184	0.8715	0.8938	0.9185	0.7731	0.7432
AB990	1.2678	0.8042	0.8613	0.9117	0.8675	0.8886	0.9145	0.7673	0.7407
AB1000	1.2710	0.7966	0.8591	0.9055	0.8659	0.8850	0.9120	0.7624	0.7388
AB1010	1.2769	0.7894	0.8573	0.8999	0.8655	0.8831	0.9101	0.7574	0.7374
AB1020	1.2802	0.7831	0.8536	0.8941	0.8617	0.8779	0.9064	0.7524	0.7352
AB1030	1.2831	0.7768	0.8497	0.8880	0.8576	0.8729	0.9017	0.7467	0.7323
AB1040	1.2867	0.7711	0.8463	0.8821	0.8541	0.8681	0.8979	0.7422	0.7299

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T31_03_2011	LACL_T33_08_2011	LACL_T35_05_2011	LACL_T48_01_2011	LACL_T48_03_2011	LACL_T60_01_2011	LACL_T67_01_2011	LACL_T68_07_2011	LACL_T72_01_2011
AB1050	1.2906	0.7658	0.8429	0.8762	0.8501	0.8633	0.8944	0.7376	0.7267
AB1060	1.2939	0.7607	0.8398	0.8708	0.8469	0.8594	0.8911	0.7333	0.7241
AB1070	1.2989	0.7563	0.8369	0.8654	0.8433	0.8553	0.8882	0.7291	0.7214
AB1080	1.3022	0.7524	0.8345	0.8602	0.8404	0.8515	0.8851	0.7251	0.7191
AB1090	1.3061	0.7485	0.8324	0.8557	0.8374	0.8472	0.8822	0.7214	0.7169
AB1100	1.3100	0.7455	0.8298	0.8510	0.8344	0.8436	0.8798	0.7174	0.7146
AB1110	1.3133	0.7426	0.8280	0.8464	0.8318	0.8398	0.8773	0.7139	0.7125
AB1120	1.3165	0.7403	0.8262	0.8420	0.8293	0.8366	0.8753	0.7106	0.7107
AB1130	1.3202	0.7381	0.8249	0.8381	0.8273	0.8331	0.8733	0.7075	0.7091
AB1140	1.3240	0.7369	0.8247	0.8352	0.8259	0.8304	0.8722	0.7049	0.7078
AB1150	1.3274	0.7365	0.8245	0.8322	0.8246	0.8284	0.8712	0.7028	0.7067
AB1160	1.3305	0.7361	0.8246	0.8294	0.8238	0.8262	0.8703	0.7007	0.7057
AB1170	1.3336	0.7346	0.8240	0.8262	0.8220	0.8238	0.8689	0.6982	0.7040
AB1180	1.3366	0.7334	0.8233	0.8227	0.8205	0.8215	0.8679	0.6955	0.7025
AB1190	1.3390	0.7317	0.8223	0.8190	0.8184	0.8189	0.8666	0.6923	0.7007
AB1200	1.3412	0.7299	0.8213	0.8152	0.8163	0.8163	0.8650	0.6893	0.6988
AB1210	1.3434	0.7280	0.8201	0.8115	0.8143	0.8140	0.8637	0.6862	0.6969
AB1220	1.3454	0.7257	0.8186	0.8073	0.8121	0.8114	0.8620	0.6827	0.6948
AB1230	1.3477	0.7240	0.8177	0.8033	0.8101	0.8088	0.8610	0.6791	0.6930
AB1240	1.3498	0.7219	0.8167	0.7993	0.8079	0.8063	0.8596	0.6756	0.6909
AB1250	1.3519	0.7201	0.8157	0.7955	0.8058	0.8039	0.8582	0.6721	0.6891
AB1260	1.3538	0.7182	0.8148	0.7920	0.8038	0.8017	0.8567	0.6688	0.6869
AB1270	1.3557	0.7164	0.8138	0.7883	0.8018	0.7993	0.8551	0.6658	0.6848
AB1280	1.3579	0.7152	0.8135	0.7849	0.8000	0.7971	0.8538	0.6633	0.6832
AB1290	1.3598	0.7141	0.8129	0.7821	0.7985	0.7953	0.8529	0.6609	0.6815
AB1300	1.3617	0.7133	0.8129	0.7793	0.7972	0.7932	0.8518	0.6586	0.6801
AB1310	1.3635	0.7125	0.8127	0.7767	0.7957	0.7915	0.8506	0.6567	0.6785
AB1320	1.3656	0.7124	0.8130	0.7748	0.7947	0.7903	0.8498	0.6553	0.6775
AB1330	1.3670	0.7127	0.8136	0.7732	0.7935	0.7890	0.8487	0.6539	0.6762
AB1340	1.3688	0.7139	0.8148	0.7725	0.7930	0.7881	0.8481	0.6535	0.6755
AB1350	1.3714	0.7158	0.8169	0.7726	0.7935	0.7877	0.8482	0.6540	0.6757
AB1360	1.3738	0.7176	0.8197	0.7732	0.7943	0.7871	0.8488	0.6554	0.6768
AB1370	1.3761	0.7193	0.8228	0.7738	0.7958	0.7884	0.8491	0.6567	0.6788
AB1380	1.3788	0.7249	0.8292	0.7784	0.7999	0.7914	0.8512	0.6622	0.6829
AB1390	1.3825	0.7354	0.8401	0.7882	0.8058	0.7974	0.8539	0.6727	0.6883

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T31_03_2011	LACL_T33_08_2011	LACL_T35_05_2011	LACL_T48_01_2011	LACL_T48_03_2011	LACL_T60_01_2011	LACL_T67_01_2011	LACL_T68_07_2011	LACL_T72_01_2011
AB1400	1.3883	0.7550	0.8572	0.8061	0.8168	0.8084	0.8591	0.6905	0.6971
AB1410	1.3937	0.7767	0.8746	0.8249	0.8276	0.8208	0.8633	0.7082	0.7047
AB1420	1.3971	0.7922	0.8865	0.8360	0.8336	0.8285	0.8637	0.7193	0.7067
AB1430	1.3984	0.7995	0.8922	0.8406	0.8353	0.8317	0.8628	0.7246	0.7051
AB1440	1.3979	0.8009	0.8937	0.8410	0.8346	0.8318	0.8613	0.7256	0.7021
AB1450	1.3967	0.7998	0.8934	0.8389	0.8332	0.8309	0.8598	0.7245	0.6996
AB1460	1.3957	0.7988	0.8928	0.8362	0.8320	0.8295	0.8589	0.7224	0.6979
AB1470	1.3957	0.7962	0.8909	0.8317	0.8295	0.8270	0.8576	0.7189	0.6957
AB1480	1.3946	0.7907	0.8863	0.8245	0.8255	0.8226	0.8555	0.7123	0.6918
AB1490	1.3934	0.7846	0.8812	0.8168	0.8211	0.8174	0.8535	0.7053	0.6877
AB1500	1.3920	0.7786	0.8757	0.8092	0.8164	0.8125	0.8512	0.6981	0.6838
AB1510	1.3916	0.7737	0.8717	0.8028	0.8131	0.8086	0.8498	0.6923	0.6810
AB1520	1.3912	0.7690	0.8676	0.7965	0.8096	0.8046	0.8481	0.6867	0.6778
AB1530	1.3910	0.7652	0.8644	0.7914	0.8066	0.8011	0.8469	0.6821	0.6751
AB1540	1.3906	0.7624	0.8620	0.7870	0.8042	0.7984	0.8460	0.6784	0.6731
AB1550	1.3903	0.7602	0.8602	0.7832	0.8024	0.7958	0.8453	0.6753	0.6715
AB1560	1.3900	0.7583	0.8582	0.7797	0.8005	0.7938	0.8447	0.6723	0.6698
AB1570	1.3896	0.7569	0.8571	0.7768	0.7992	0.7919	0.8445	0.6698	0.6687
AB1580	1.3892	0.7553	0.8558	0.7736	0.7974	0.7903	0.8436	0.6673	0.6673
AB1590	1.3891	0.7545	0.8550	0.7713	0.7965	0.7888	0.8436	0.6656	0.6666
AB1600	1.3886	0.7540	0.8545	0.7687	0.7957	0.7873	0.8434	0.6638	0.6658
AB1610	1.3873	0.7531	0.8539	0.7659	0.7943	0.7863	0.8428	0.6617	0.6648
AB1620	1.3873	0.7533	0.8539	0.7643	0.7939	0.7855	0.8430	0.6608	0.6646
AB1630	1.3859	0.7534	0.8540	0.7623	0.7935	0.7847	0.8427	0.6598	0.6638
AB1640	1.3853	0.7545	0.8548	0.7612	0.7933	0.7843	0.8428	0.6596	0.6635
AB1650	1.3843	0.7567	0.8562	0.7605	0.7932	0.7845	0.8430	0.6596	0.6633
AB1660	1.3835	0.7589	0.8577	0.7605	0.7933	0.7847	0.8431	0.6600	0.6630
AB1670	1.3829	0.7613	0.8593	0.7611	0.7938	0.7846	0.8436	0.6609	0.6634
AB1680	1.3811	0.7638	0.8610	0.7620	0.7947	0.7852	0.8439	0.6625	0.6640
AB1690	1.3802	0.7666	0.8630	0.7633	0.7958	0.7864	0.8448	0.6646	0.6647
AB1700	1.3790	0.7692	0.8648	0.7648	0.7965	0.7876	0.8451	0.6667	0.6649
AB1710	1.3780	0.7729	0.8672	0.7671	0.7980	0.7893	0.8456	0.6703	0.6660
AB1720	1.3778	0.7777	0.8711	0.7712	0.8006	0.7913	0.8474	0.6749	0.6679
AB1730	1.3774	0.7817	0.8740	0.7742	0.8028	0.7934	0.8488	0.6785	0.6694
AB1740	1.3771	0.7833	0.8761	0.7735	0.8035	0.7936	0.8497	0.6778	0.6697

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T31_03_2011	LACL_T33_08_2011	LACL_T35_05_2011	LACL_T48_01_2011	LACL_T48_03_2011	LACL_T60_01_2011	LACL_T67_01_2011	LACL_T68_07_2011	LACL_T72_01_2011
AB1750	1.3773	0.7856	0.8785	0.7743	0.8044	0.7946	0.8509	0.6789	0.6706
AB1760	1.3770	0.7882	0.8809	0.7760	0.8057	0.7961	0.8521	0.6811	0.6719
AB1770	1.3763	0.7902	0.8832	0.7769	0.8069	0.7969	0.8530	0.6823	0.6728
AB1780	1.3755	0.7919	0.8848	0.7765	0.8070	0.7970	0.8532	0.6825	0.6726
AB1790	1.3745	0.7929	0.8858	0.7764	0.8076	0.7972	0.8537	0.6827	0.6729
AB1800	1.3756	0.7936	0.8872	0.7763	0.8095	0.8020	0.8540	0.6817	0.6724
AB1810	1.3772	0.7949	0.8890	0.7753	0.8120	0.8063	0.8547	0.6798	0.6720
AB1820	1.3780	0.7967	0.8914	0.7768	0.8142	0.8053	0.8576	0.6822	0.6745
AB1830	1.3775	0.7980	0.8929	0.7772	0.8149	0.8042	0.8589	0.6833	0.6755
AB1840	1.3768	0.8001	0.8948	0.7776	0.8162	0.8036	0.8602	0.6851	0.6766
AB1850	1.3752	0.8026	0.8971	0.7795	0.8168	0.8050	0.8599	0.6869	0.6771
AB1860	1.3757	0.8093	0.9030	0.7850	0.8197	0.8086	0.8607	0.6927	0.6803
AB1870	1.3786	0.8260	0.9180	0.8018	0.8310	0.8177	0.8657	0.7088	0.6892
AB1880	1.3809	0.8550	0.9421	0.8328	0.8486	0.8394	0.8721	0.7370	0.7035
AB1890	1.3921	0.9170	0.9930	0.8993	0.8906	0.8830	0.8925	0.7943	0.7413
AB1900	1.4127	1.0087	1.0677	0.9950	0.9561	0.9480	0.9282	0.8783	0.8013
AB1910	1.4386	1.0813	1.1259	1.0675	1.0035	1.0006	0.9487	0.9454	0.8360
AB1920	1.4557	1.1144	1.1545	1.1009	1.0232	1.0260	0.9513	0.9792	0.8425
AB1930	1.4508	1.1186	1.1601	1.1052	1.0242	1.0312	0.9466	0.9858	0.8360
AB1940	1.4342	1.1071	1.1529	1.0931	1.0158	1.0241	0.9393	0.9769	0.8259
AB1950	1.4208	1.0875	1.1390	1.0716	1.0023	1.0110	0.9318	0.9596	0.8136
AB1960	1.4119	1.0649	1.1218	1.0469	0.9866	0.9948	0.9235	0.9381	0.8013
AB1970	1.4005	1.0423	1.1037	1.0215	0.9700	0.9780	0.9148	0.9155	0.7877
AB1980	1.3912	1.0214	1.0870	0.9972	0.9545	0.9596	0.9074	0.8950	0.7763
AB1990	1.3824	1.0008	1.0696	0.9728	0.9392	0.9425	0.8995	0.8742	0.7642
AB2000	1.3729	0.9801	1.0524	0.9503	0.9239	0.9255	0.8916	0.8546	0.7516
AB2010	1.3640	0.9625	1.0367	0.9308	0.9097	0.9111	0.8843	0.8359	0.7397
AB2020	1.3552	0.9476	1.0232	0.9147	0.8973	0.8977	0.8784	0.8211	0.7290
AB2030	1.3461	0.9356	1.0113	0.9012	0.8870	0.8863	0.8722	0.8076	0.7187
AB2040	1.3396	0.9279	1.0019	0.8936	0.8794	0.8766	0.8685	0.7980	0.7113
AB2050	1.3339	0.9211	0.9946	0.8863	0.8728	0.8692	0.8656	0.7900	0.7048
AB2060	1.3277	0.9147	0.9875	0.8782	0.8664	0.8620	0.8622	0.7823	0.6991
AB2070	1.3241	0.9080	0.9811	0.8718	0.8603	0.8555	0.8593	0.7759	0.6940
AB2080	1.3190	0.9021	0.9752	0.8656	0.8549	0.8494	0.8572	0.7695	0.6893
AB2090	1.3146	0.8966	0.9697	0.8592	0.8494	0.8435	0.8533	0.7634	0.6843

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T31_03_2011	LACL_T33_08_2011	LACL_T35_05_2011	LACL_T48_01_2011	LACL_T48_03_2011	LACL_T60_01_2011	LACL_T67_01_2011	LACL_T68_07_2011	LACL_T72_01_2011
AB2100	1.3090	0.8916	0.9640	0.8527	0.8440	0.8378	0.8493	0.7573	0.6798
AB2110	1.3047	0.8863	0.9583	0.8467	0.8382	0.8312	0.8454	0.7504	0.6753
AB2120	1.2986	0.8803	0.9527	0.8396	0.8317	0.8248	0.8404	0.7440	0.6699
AB2130	1.2931	0.8770	0.9488	0.8342	0.8273	0.8204	0.8357	0.7384	0.6657
AB2140	1.2895	0.8763	0.9491	0.8328	0.8260	0.8188	0.8352	0.7366	0.6661
AB2150	1.2907	0.8783	0.9517	0.8348	0.8287	0.8207	0.8380	0.7382	0.6703
AB2160	1.2962	0.8836	0.9594	0.8405	0.8353	0.8258	0.8453	0.7437	0.6785
AB2170	1.3029	0.8899	0.9671	0.8481	0.8435	0.8345	0.8549	0.7513	0.6905
AB2180	1.3097	0.8960	0.9753	0.8547	0.8524	0.8435	0.8624	0.7588	0.7025
AB2190	1.3161	0.9020	0.9821	0.8623	0.8607	0.8507	0.8703	0.7660	0.7141
AB2200	1.3204	0.9040	0.9855	0.8650	0.8656	0.8547	0.8751	0.7702	0.7225
AB2210	1.3248	0.9049	0.9868	0.8673	0.8680	0.8562	0.8772	0.7717	0.7264
AB2220	1.3264	0.9048	0.9865	0.8663	0.8674	0.8560	0.8760	0.7715	0.7270
AB2230	1.3270	0.9073	0.9872	0.8671	0.8676	0.8559	0.8748	0.7718	0.7258
AB2240	1.3273	0.9123	0.9906	0.8729	0.8690	0.8577	0.8753	0.7755	0.7260
AB2250	1.3270	0.9212	0.9948	0.8825	0.8727	0.8627	0.8760	0.7839	0.7265
AB2260	1.3238	0.9310	1.0002	0.8932	0.8773	0.8676	0.8765	0.7919	0.7275
AB2270	1.3204	0.9399	1.0063	0.9020	0.8818	0.8719	0.8781	0.8008	0.7291
AB2280	1.3174	0.9453	1.0101	0.9088	0.8843	0.8768	0.8768	0.8088	0.7301
AB2290	1.3180	0.9524	1.0154	0.9176	0.8892	0.8829	0.8776	0.8196	0.7345
AB2300	1.3181	0.9596	1.0208	0.9272	0.8936	0.8893	0.8788	0.8318	0.7395
AB2310	1.3183	0.9635	1.0250	0.9365	0.8994	0.8942	0.8791	0.8434	0.7424
AB2320	1.3180	0.9596	1.0222	0.9302	0.8943	0.8902	0.8745	0.8347	0.7356
AB2330	1.3209	0.9585	1.0233	0.9280	0.8906	0.8885	0.8716	0.8321	0.7326
AB2340	1.3209	0.9614	1.0252	0.9318	0.8919	0.8915	0.8687	0.8376	0.7332
AB2350	1.3195	0.9669	1.0292	0.9381	0.8947	0.8965	0.8666	0.8448	0.7362
AB2360	1.3165	0.9666	1.0325	0.9382	0.8944	0.8965	0.8650	0.8430	0.7360
AB2370	1.3129	0.9706	1.0364	0.9411	0.8958	0.8999	0.8656	0.8478	0.7398
AB2380	1.3112	0.9785	1.0448	0.9502	0.9032	0.9065	0.8675	0.8574	0.7473
AB2390	1.3112	0.9866	1.0517	0.9608	0.9107	0.9155	0.8702	0.8669	0.7567
AB2400	1.3147	0.9959	1.0605	0.9705	0.9175	0.9240	0.8735	0.8768	0.7635
AB2410	1.3186	1.0092	1.0717	0.9834	0.9268	0.9327	0.8791	0.8868	0.7729
AB2420	1.3238	1.0236	1.0852	1.0006	0.9369	0.9445	0.8838	0.9000	0.7837
AB2430	1.3283	1.0406	1.1005	1.0175	0.9486	0.9573	0.8914	0.9166	0.7944
AB2440	1.3354	1.0636	1.1176	1.0422	0.9661	0.9729	0.9020	0.9331	0.8076

Appendix 4. Near infrared absorbance spectra data for 18 soils in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

	LACL_T31_03_2011	LACL_T33_08_2011	LACL_T35_05_2011	LACL_T48_01_2011	LACL_T48_03_2011	LACL_T60_01_2011	LACL_T67_01_2011	LACL_T68_07_2011	LACL_T72_01_2011
AB2450	1.3430	1.0830	1.1341	1.0610	0.9797	0.9887	0.9100	0.9513	0.8206
AB2460	1.3450	1.1028	1.1504	1.0806	0.9928	1.0028	0.9193	0.9690	0.8308
AB2470	1.3546	1.1200	1.1667	1.1021	1.0052	1.0177	0.9283	0.9851	0.8433
AB2480	1.3532	1.1368	1.1801	1.1218	1.0182	1.0320	0.9367	1.0026	0.8538
AB2490	1.3569	1.1513	1.1955	1.1344	1.0232	1.0412	0.9382	1.0088	0.8640
AB2500	1.3469	1.1506	1.2124	1.1543	1.0309	1.0583	0.9407	1.0193	0.8701

Appendix 5. Chemical and physical laboratory data for soil samples from 18 plots collected as part of a soils Near Infrared Spectroscopy pilot study, Lake Clark National Park and Preserve, Alaska, 2011.

	100 C Oven Dry						Air Dry		
Unique_ID	Total C	% N	% Sand	% Silt	% Clay	% OC[1]	% P Rent[2]	% VG[3]	Notes
LACL_T01_01_2011	3.27	0.04	78.4	17.6	4.0	3.26	69.96	5.0	large rounded detrital mineral grains, with very minor volcanic ash, rare large very weathered pumice, rare small glass shards
LACL_T10_05_2011	3.43	0.28	66.4	31.6	2.0	3.43	62.00	<1	Could not find any volcanic ash
LACL_T17_01_2011	2.93	0.13	74.4	21.6	4.0	2.93	59.87	25.0	large rounded detrital mineral grains, very minor volcanic ash, rare large very weathered pumice, rare small glass shards
LACL_T17_03_2011	4.24	0.21	72.4	21.6	6.0	4.24	78.81	60.0	very altered volcanic glass
LACL_T23_02_2011	4.84	0.31	46.4	49.6	4.0	4.84	96.52	60.0	volcanic glass, some plagioclase, amphibole
LACL_T23_03_2011	6.14	0.32	44.4	51.6	4.0	6.13	97.87	70.0	large glass shards with plagioclase inclusions,
LACL_T23_09_2011	4.13	0.24	54.4	39.6	6.0	4.12	80.16	40.0	minor diatoms
LACL_T30_01_2011	4.12	0.31	68.4	25.6	6.0	4.12	70.96	10.0	many large oxidized minerals, minor diatoms
LACL_T31_01_2011	4.34	0.26	66.4	29.6	4.0	4.34	90.47	85.0	beautiful glass shards
LACL_T31_03_2011	0.58	<.01	68.4	21.6	10.0	0.58	23.43	5.0	clear, well-sorted glass shards, very fine-grained 10-100 microns
LACL_T33_08_2011	13.48	0.72	66.4	27.6	6.0	13.47	94.28	45.0	very altered, weathered glass, 100-200 microns, many small 10-30 microns, plagioclase, quartz, amphibole, mica
LACL_T35_05_2011	5.72	0.27	66.4	27.6	6.0	5.71	95.40	30.0	mica, clay, amphible, slightly rounded grains, detrital, mostly 200-300 microns, mixed with large plagioclase 400-500 microns
LACL_T48_01_2011	8.48	0.56	56.4	41.6	2.0	8.48	79.60	25.0	beautiful large glass shards, clear, 200-250 microns, with minor diatoms, also plagioclase, clay, amphibole, quartz, mica
LACL_T48_03_2011	4.91	0.29	50.4	45.6	4.0	4.90	86.55	40.0	abundant mica
LACL_T60_01_2011	8.68	0.31	40.4	57.6	2.0	8.66	97.87	5.0	large mineral grains
LACL_T67_01_2011	1.59	0.06	64.4	31.6	4.0	1.59	47.42	10.0	much plagioclase present
LACL_T68_07_2011	11.25	0.40	56.4	41.6	2.0	11.24	94.96	45.0	very altered, weathered glass, 100-200 microns, many small 10-30 microns, plagioclase, quartz, amphibole, mica
LACL_T72_01_2011	3.42	0.10	60.4	33.6	6.0	3.41	88.57	90.0	very abundant clear, platey glass shards, fresh appearing, angular, well-sorted, some 200-300 microns, most ca. 100 microns, also plagioclase, mica

[1] Percent Organic Carbon

[2] Percent Phosphate Retention (New Zealand)

[3] Percent Volcanic Glass Content

Appendix 6. Cross/walk between aggregated ecotype code and abbreviated ecotype, map ecotype, soil landscape, and disturbance landscape, Lake Clark National Park and Preserve, Alaska, 2011.

Aggregated Ecotype Code	Abbreviated Ecotype	Map Ecotype	Soil Landscape	Disturbance Landscape
NA	Interior Lacustrine Loamy-Rocky Barrens	not mapped / uncommon	not mapped / uncommon	not mapped / uncommon
NA	Maritime Lacustrine Marestail Marsh	not mapped / uncommon	not mapped / uncommon	not mapped / uncommon
50001	NA – no plot data	Interior Upland Barrens	Interior Upland Rocky Barrens, Shrublands, and Forests	Rockfall/Avalanche
51001	NA – no plot data	Maritime Upland Barrens	Maritime Upland Rocky Barrens, Shrublands, and Forests	Rockfall/Avalanche
40001	NA – no plot data	Interior Subalpine Barrens	Interior Subalpine Rocky Barrens, Shrublands, and Forests	Rockfall/Avalanche
120000	NA – no plot data	Developed Land	Developed Land	Negligible
140000	NA – no plot data	Glacial Lake	Lake Water	Surges/Ablation/Mass movement
190000	NA – no plot data	Subalpine Lake	Lake Water	Catastrophic drainage/Drying/Paludification
NA	NA	Volcanic physiography only	Volcanic physiography only	Lahars and Flash Floods (Volcanic Lahar)
NA	NA	Volcanic physiography only	Volcanic physiography only	Thick Ash/fall and Volcanic Ejecta (All other Volcanic)
10001	Alpine Gelic Rocky Barrens	Alpine Gelic Barrens and Lichen Tundra	Alpine Gelic Rocky Barrens and Shrublands	Mass wasting/Avalanche/Wind-scour/Snow Drifts
	Alpine Gelic Rocky Lichen Tundra	Alpine Gelic Barrens and Lichen Tundra	Alpine Gelic Rocky Barrens and Shrublands	Mass wasting/Avalanche/Wind-scour/Snow Drifts
10002	Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra	Alpine Gelic Meadows and Dwarf Shrub	Alpine Gelic Rocky Barrens and Shrublands	Cryoturbation
	Alpine Gelic Rocky Dwarf Willow Tundra	Alpine Gelic Meadows and Dwarf Shrub	Alpine Gelic Rocky Barrens and Shrublands	Cryoturbation
10003	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Alpine Gelic Meadows and Dwarf Shrub	Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Gelic Meadows and Dwarf Shrub	Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Alpine Gelic Meadows and Dwarf Shrub	Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
11001	Alpine Rocky Barrens	Alpine Barrens and Lichen Tundra	Alpine Rocky Barrens and Shrublands	Mass wasting/Avalanche/Wind-scour/Snow Drifts
	Alpine Rocky Lichen Tundra	Alpine Barrens and Lichen Tundra	Alpine Rocky Barrens and Shrublands	Mass wasting/Avalanche/Wind-scour/Snow Drifts
11002	Alpine Rocky Dwarf Shrub-Lichen Tundra	Alpine Meadows and Dwarf Shrub	Alpine Rocky Barrens and Shrublands	Mass wasting/Avalanche/Wind-scour/Snow Drifts
	Alpine Rocky Dwarf Willow Tundra	Alpine Meadows and Dwarf Shrub	Alpine Rocky Barrens and Shrublands	Mass wasting/Avalanche/Wind-scour/Snow Drifts

Appendix 6. Cross/walk between aggregated ecotype code and abbreviated ecotype, map ecotype, soil landscape, and disturbance landscape, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Abbreviated Ecotype	Map Ecotype	Soil Landscape	Disturbance Landscape
11003	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Alpine Meadows and Dwarf Shrub	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Alpine Meadows and Dwarf Shrub	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
	Alpine Ashy-Loamy-Rocky Moist Sedge Meadow	Alpine Meadows and Dwarf Shrub	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Alpine Meadows and Dwarf Shrub	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Alpine Meadows and Dwarf Shrub	Alpine Ashy-Loamy-Rocky Meadows and Shrublands	Cryoturbation
11004	Alpine Loamy-Organic Wet Sedge Meadow	Alpine Wet Sedge Meadow	Alpine Loamy-Organic Wet Sedge Meadows	Catastrophic drainage/Drying/Paludification
11005	Alpine Rocky Dwarf Shrub Late-Lying Snowbanks	Alpine Dwarf Shrub Late-Lying Snowbanks	Alpine Rocky Barrens and Shrublands	Snow Drifts/Cryoturbation
12019	Alpine Lake	Alpine Lakes and Springs	Lake Water	Catastrophic drainage/Drying/Paludification
	Alpine Spring	Alpine Lakes and Springs	Lake Water	Catastrophic drainage/Drying/Paludification
30001	Glacial Sandy-Rocky Barrens	Glacial Barrens	Glacial Sandy-Rocky Barrens and Shrublands	Surges/Ablation/Mass movement
30002	Glacial Sandy-Rocky Alder Shrub	Glacial Alder Shrub	Glacial Sandy-Rocky Barrens and Shrublands	Surges/Ablation/Mass movement
30003	Glacier	Glaciers and Permanent Snow Fields	Glaciers and Permanent Snow Fields	Surges/Ablation/Mass movement
40002	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Interior Subalpine Dwarf Ericaceous Shrub	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Avalanche/Snow Drifts
40003	Interior Subalpine Rocky Alder-Willow Shrub	Interior Subalpine Low-Tall Shrub and Graminoid Meadow	Interior Subalpine Rocky Barrens, Shrublands, and Forests	Avalanche/Mass wasting/Erosion/Flash Floods
40004	Interior Subalpine Rocky Balsam Poplar Forest	Interior Subalpine Balsam Poplar Forest	Interior Subalpine Rocky Barrens, Shrublands, and Forests	Avalanche/Mass wasting/Erosion/Flash Floods
40005	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Interior Subalpine Low-Tall Shrub and Graminoid Meadow	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Avalanche/Snow Drifts
	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Interior Subalpine Low-Tall Shrub and Graminoid Meadow	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Avalanche/Snow Drifts
	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Interior Subalpine Low-Tall Shrub and Graminoid Meadow	Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	Avalanche/Snow Drifts
40006	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Interior Subalpine White Spruce Woodland	Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	Avalanche/Snow Drifts/Fire/Spruce Beetle/Wind throw

Appendix 6. Cross/walk between aggregated ecotype code and abbreviated ecotype, map ecotype, soil landscape, and disturbance landscape, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Abbreviated Ecotype	Map Ecotype	Soil Landscape	Disturbance Landscape
40008	Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub	Interior Subalpine Frozen Birch-Ericaceous Low Shrub	Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands	Thermokarst/Fire/Spruce Beetle
40009	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	Interior Subalpine Wet Sedge-Shrub Meadow and Bog	Interior Subalpine Organic-Rich Wet Meadow and Bogs	Catastrophic drainage/Drying/Paludification
40010	Interior Subalpine Organic-rich Alder Tall Shrub	Interior Subalpine Low-Tall Shrub and Graminoid Meadow	Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	Avalanche/Snow Drifts
50002	Interior Upland Rocky Alder Shrub	Interior Upland Low and Tall Shrub	Interior Upland Rocky Barrens, Shrublands, and Forests	Fire/Spruce Beetle
	Interior Upland Rocky Birch-Ericaceous Low Shrub	Interior Upland Low and Tall Shrub	Interior Upland Rocky Barrens, Shrublands, and Forests	Fire/Spruce Beetle
50003	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Interior Upland Low and Tall Shrub	Interior Upland Ashy-Loamy Shrublands and Forests	Fire/Spruce Beetle
50004	Interior Upland Ashy-Loamy Mixed Forest	Interior Upland Mixed-Spruce Forest	Interior Upland Ashy-Loamy Shrublands and Forests	Fire/Spruce Beetle
50005	Interior Upland Ashy-Loamy Black Spruce Forest	Interior Upland Mixed-Spruce Forest	Interior Upland Ashy-Loamy Shrublands and Forests	Fire/Spruce Beetle
	Upland Ashy-Loamy-Rocky White Spruce Woodland	Interior Upland Mixed-Spruce Forest	Interior Upland Ashy-Loamy Shrublands and Forests	Fire/Spruce Beetle
50006	Interior Upland Rocky Mixed Forest	Interior Upland Mixed-Spruce Forest	Interior Upland Rocky Barrens, Shrublands, and Forests	Fire/Spruce Beetle
50007	Interior Upland Rocky White Spruce Woodland	Interior Upland Mixed-Spruce Forest	Interior Upland Rocky Barrens, Shrublands, and Forests	Fire/Spruce Beetle
50010	Upland Ashy-Loamy Birch-Poplar Forest	Interior Upland Broadleaf Forest	Interior Upland Ashy-Loamy Shrublands and Forests	Fire/Spruce Beetle
50011	Upland Rocky Birch-Poplar Forest	Interior Upland Broadleaf Forest	Interior Upland Rocky Barrens, Shrublands, and Forests	Erosion/Flash Floods
51002	Maritime Upland Rocky Alder Shrub	Maritime Upland Shrub and Graminoid Meadow	Maritime Upland Rocky Barrens, Shrublands, and Forests	Landslide/Avalanche/Flash Floods/Tidal Waves
	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Maritime Upland Shrub and Graminoid Meadow	Maritime Upland Rocky Barrens, Shrublands, and Forests	Landslide/Avalanche/Flash Floods/Tidal Waves
51003	Maritime Upland Ashy-Loamy Mixed Low Shrub	Maritime Upland Shrub and Graminoid Meadow	Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Landslides/Snow Drifts
	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Maritime Upland Shrub and Graminoid Meadow	Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Landslides/Snow Drifts
	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Maritime Upland Shrub and Graminoid Meadow	Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Landslides/Snow Drifts

Appendix 6. Cross/walk between aggregated ecotype code and abbreviated ecotype, map ecotype, soil landscape, and disturbance landscape, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Abbreviated Ecotype	Map Ecotype	Soil Landscape	Disturbance Landscape
51007	Upland Ashy-Loamy Birch-Poplar Forest	Maritime Upland Broadleaf Forest	Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Negligible
	Upland Rocky Birch-Poplar Forest	Maritime Upland Broadleaf Forest	Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Negligible
51008	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Upland Spruce Forest	Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Spruce Beetle/Wind Throw
	Upland Ashy-Loamy-Rocky White Spruce Woodland	Maritime Upland Spruce Forest	Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	Spruce Beetle/Wind Throw
51010	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Maritime Upland Spruce Forest	Maritime Upland Rocky Barrens, Shrublands, and Forests	Spruce Beetle/Wind Throw
70001	Interior Lowland Ashy-Loamy-Rocky Mixed Forest	Interior Lowland Mixed-Spruce Forest	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests	Fire/Spruce Beetle
70002	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Interior Lowland Broadleaf Forest	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests	Fire/Spruce Beetle
70003	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest	Interior Lowland Mixed-Spruce Forest	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests	Fire/Spruce Beetle
70004	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Interior Lowland Birch-Ericaceous Shrub	Interior Lowland Ashy-Loamy-Organic Shrublands and Forests	Fire/Spruce Beetle
70005	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Interior Lowland Birch-Ericaceous Shrub	Interior Lowland Organic-Rich Wet Meadows and Shrublands	Negligible
70007	Interior Lowland Organic-Rich Wet Sedge Meadow	Interior Lowland Wet Sedge Meadow and Bog	Interior Lowland Organic-Rich Wet Meadows and Shrublands	Catastrophic drainage/Drying/Paludification
	Lowland Organic-Rich Sedge-Shrub Bog	Interior Lowland Wet Sedge Meadow and Bog	Interior Lowland Organic-Rich Wet Meadows and Shrublands	Catastrophic drainage/Drying/Paludification
70008	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Interior Lowland Frozen Spruce Forest	Interior Lowland Frozen Loamy-Organic Bogs and Forests	Thermokarst/Fire/Spruce Beetle
	Interior Lowland Frozen Organic-Rich Dwarf Spruce Forest	Interior Lowland Frozen Spruce Forest	Interior Lowland Frozen Loamy-Organic Bogs and Forests	Thermokarst/Fire/Spruce Beetle
70009	Interior Lowland Frozen Organic-Rich Sedge-Shrub Bog	Interior Lowland Frozen Sedge-Shrub Bog	Interior Lowland Frozen Loamy-Organic Bogs and Forests	Thermokarst/Fire/Spruce Beetle
71001	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Maritime Lowland Sitka-Lutz Spruce Forest	Maritime Lowland Ashy-Loamy Forests	Spruce Beetle/Flooding
71002	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	Maritime Lowland Broadleaf Forest	Maritime Lowland Ashy-Loamy Forests	Flooding
71003	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub	Maritime Lowland Sweetgale-Willow-Ericaceous shrub	Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	Negligible
71004	Lowland Organic-Rich Sedge-Shrub Bog	Maritime Lowland Wet Sedge Meadow and Bog	Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	Negligible
	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Maritime Lowland Wet Sedge Meadow and Bog	Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	Negligible

Appendix 6. Cross/walk between aggregated ecotype code and abbreviated ecotype, map ecotype, soil landscape, and disturbance landscape, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Abbreviated Ecotype	Map Ecotype	Soil Landscape	Disturbance Landscape
90002	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Interior Lacustrine Low Shrub-Bluejoint Meadow	Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	Negligible
	Interior Lacustrine Ashy-Loamy-Rocky Low Shrub	Interior Lacustrine Low Shrub-Bluejoint Meadow	Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	Negligible
90003	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Interior Lacustrine Wet Sedge Meadow, Bogs, and Fens	Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	Lake Formation
	Interior Lacustrine Organic-rich Sedge Marsh	Interior Lacustrine Wet Sedge Meadow, Bogs, and Fens	Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	Lake Formation
	Interior Lacustrine Organic-rich Sedge-Shrub Bog	Interior Lacustrine Wet Sedge Meadow, Bogs, and Fens	Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	Lake Formation
100001	Riverine Silty-Sandy-Rocky Barrens	Riverine Barrens	Riverine Silty-Sandy-Rocky Barrens and Forests	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
100002	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Riverine Alder-Willow Shrub	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
100003	Riverine Silty-Sandy-Rocky Poplar Forest	Riverine Poplar Forest	Riverine Silty-Sandy-Rocky Barrens and Forests	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
100004	Riverine Silty-Sandy-Rocky Mixed Forest	Interior Riverine Mixed-Spruce Forest	Riverine Silty-Sandy-Rocky Barrens and Forests	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
100005	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Interior Riverine Mixed-Spruce Forest	Riverine Silty-Sandy-Rocky Barrens and Forests	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
100006	Interior Riverine Sandy Forb Meadow	Riverine Wet Sedge-Forb Meadow	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Wet Sedge-Forb Meadow	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
101002	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Riverine Alder-Willow Shrub	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
101003	Riverine Silty-Sandy-Rocky Poplar Forest	Riverine Poplar Forest	Riverine Silty-Sandy-Rocky Barrens and Forests	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
101004	Riverine Silty-Sandy-Rocky Mixed Forest	Maritime Riverine Mixed-Spruce Forest	Riverine Silty-Sandy-Rocky Barrens and Forests	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
101005	Maritime Riverine Silty-Sandy-Rocky Spruce Forest	Maritime Riverine Mixed-Spruce Forest	Riverine Silty-Sandy-Rocky Barrens and Forests	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
101006	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Riverine Wet Sedge-Forb Meadow	Riverine Sandy-Rocky-Organic Meadows and Shrublands	Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle
110001	Maritime Coastal Sandy-Rocky Saline Barrens	Maritime Coastal Saline Barrens	Maritime Coastal Sandy-gravelly Barrens and Meadows	Tides and Tidal Waves/Storm Surges and Erosion/Glacial Rebound
110002	Maritime Coastal Silty-Clayey Saline Barrens	Maritime Coastal Saline Barrens	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Tides and Tidal Waves/Storm Surges and Erosion/Glacial Rebound

Appendix 6. Cross/walk between aggregated ecotype code and abbreviated ecotype, map ecotype, soil landscape, and disturbance landscape, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Abbreviated Ecotype	Map Ecotype	Soil Landscape	Disturbance Landscape
110003	Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow	Maritime Coastal Meadows	Maritime Coastal Sandy-gravelly Barrens and Meadows	Tides and Tidal Waves/Storm Surges and Erosion/Glacial Rebound
110004	Maritime Coastal Loamy Saline Wet Sedge Meadow	Maritime Coastal Meadows	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Tides and Tidal Waves/Storm Surges and Erosion/Glacial Rebound
	Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	Maritime Coastal Meadows	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Tides and Tidal Waves/Storm Surges and Erosion/Glacial Rebound
110005	Maritime Coastal Saline Marestail Ponds and Marshes	Maritime Coastal Brackish Ponds and Marshes	Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	Tides and Tidal Waves/Storm Surges/Flooding
110010	Tidal River	Tidal River	Tidal River	Tides and Tidal Waves/Storm Surges/Flooding
130000	Nearshore Water	Nearshore Water	Nearshore Water	Tides and Storms/Ice flows
150000	Lowland Lake	Lowland Lake	Lake Water	Catastrophic drainage/Drying/Paludification
160000	Riverine Glacial River Water	Glacial and Non-Glacial River Water	Riverine Glacial River Water	Flooding/Glacial Outburst Floods
170000	Riverine Non-Glacial River Water	Glacial and Non-Glacial River Water	Riverine Non-Glacial River Water	Flooding
180000	Riverine Lake Water	Riverine Lake	Lake Water	Flooding/Sedimentation/Tapping/Paludification

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011.

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
10001	Northern Alpine Frozen, ashy-loamy-organic	Barren Land
10001	Northern Alpine Frozen, ashy-loamy-rocky	Barren Land
10001	Northern Alpine, ashy-loamy-organic	Barren Land
10001	Northern Alpine, ashy-loamy-rocky	Barren Land
10001	Northern Alpine, bedrock	Barren Land
10001	Northern Alpine, rocky	Barren Land
10001	Northern Alpine, sandy-rocky-organic	Barren Land
10002	Northern Alpine, bedrock	Deciduous Forest
10002	Northern Alpine, bedrock	Dwarf Shrub
10002	Northern Alpine, bedrock	Evergreen Forest
10002	Northern Alpine, bedrock	Graminoid/Herbaceous
10002	Northern Alpine, bedrock	Mixed Forest
10002	Northern Alpine, bedrock	Shrub/Scrub
10002	Northern Alpine, bedrock	Woody Wetlands
10002	Northern Alpine, rocky	Deciduous Forest
10002	Northern Alpine, rocky	Dwarf Shrub
10002	Northern Alpine, rocky	Evergreen Forest
10002	Northern Alpine, rocky	Graminoid/Herbaceous
10002	Northern Alpine, rocky	Mixed Forest
10002	Northern Alpine, rocky	Shrub/Scrub
10002	Northern Alpine, sandy-rocky-organic	Deciduous Forest
10002	Northern Alpine, sandy-rocky-organic	Dwarf Shrub
10002	Northern Alpine, sandy-rocky-organic	Evergreen Forest
10002	Northern Alpine, sandy-rocky-organic	Mixed Forest
10002	Northern Alpine, sandy-rocky-organic	Shrub/Scrub
10003	Northern Alpine Frozen, ashy-loamy-organic	Deciduous Forest
10003	Northern Alpine Frozen, ashy-loamy-organic	Dwarf Shrub
10003	Northern Alpine Frozen, ashy-loamy-organic	Evergreen Forest
10003	Northern Alpine Frozen, ashy-loamy-organic	Mixed Forest
10003	Northern Alpine Frozen, ashy-loamy-organic	Shrub/Scrub
10003	Northern Alpine Frozen, ashy-loamy-organic	Woody Wetlands
10003	Northern Alpine Frozen, ashy-loamy-rocky	Deciduous Forest
10003	Northern Alpine Frozen, ashy-loamy-rocky	Dwarf Shrub
10003	Northern Alpine Frozen, ashy-loamy-rocky	Evergreen Forest
10003	Northern Alpine Frozen, ashy-loamy-rocky	Graminoid/Herbaceous
10003	Northern Alpine Frozen, ashy-loamy-rocky	Mixed Forest
10003	Northern Alpine Frozen, ashy-loamy-rocky	Shrub/Scrub
10003	Northern Alpine Frozen, ashy-loamy-rocky	Woody Wetlands
10003	Northern Alpine Frozen, organic	Dwarf Shrub
10003	Northern Alpine, ashy-loamy-organic	Deciduous Forest
10003	Northern Alpine, ashy-loamy-organic	Dwarf Shrub
10003	Northern Alpine, ashy-loamy-organic	Evergreen Forest
10003	Northern Alpine, ashy-loamy-organic	Mixed Forest
10003	Northern Alpine, ashy-loamy-organic	Shrub/Scrub
10003	Northern Alpine, ashy-loamy-organic	Woody Wetlands
10003	Northern Alpine, ashy-loamy-rocky	Deciduous Forest
10003	Northern Alpine, ashy-loamy-rocky	Dwarf Shrub
10003	Northern Alpine, ashy-loamy-rocky	Evergreen Forest
10003	Northern Alpine, ashy-loamy-rocky	Graminoid/Herbaceous
10003	Northern Alpine, ashy-loamy-rocky	Mixed Forest
10003	Northern Alpine, ashy-loamy-rocky	Shrub/Scrub
10003	Northern Alpine, ashy-loamy-rocky	Woody Wetlands
11001	Maritime Volcanic Alpine, ashy-loamy-rocky	Barren Land
11001	Maritime Volcanic Alpine, bedrock	Barren Land

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
11001	Maritime Volcanic Alpine, rocky	Barren Land
11001	Southern Alpine Frozen, ashy-loamy-rocky	Barren Land
11001	Southern Alpine, ashy-loamy-rocky	Barren Land
11001	Southern Alpine, bedrock	Barren Land
11001	Southern Alpine, rocky	Barren Land
11002	Maritime Volcanic Alpine, bedrock	Dwarf Shrub
11002	Maritime Volcanic Alpine, bedrock	Evergreen Forest
11002	Maritime Volcanic Alpine, bedrock	Graminoid/Herbaceous
11002	Maritime Volcanic Alpine, bedrock	Shrub/Scrub
11002	Maritime Volcanic Alpine, rocky	Dwarf Shrub
11002	Maritime Volcanic Alpine, rocky	Shrub/Scrub
11002	Southern Alpine, bedrock	Deciduous Forest
11002	Southern Alpine, bedrock	Dwarf Shrub
11002	Southern Alpine, bedrock	Evergreen Forest
11002	Southern Alpine, bedrock	Graminoid/Herbaceous
11002	Southern Alpine, bedrock	Mixed Forest
11002	Southern Alpine, bedrock	Shrub/Scrub
11002	Southern Alpine, rocky	Deciduous Forest
11002	Southern Alpine, rocky	Dwarf Shrub
11002	Southern Alpine, rocky	Evergreen Forest
11002	Southern Alpine, rocky	Graminoid/Herbaceous
11002	Southern Alpine, rocky	Mixed Forest
11002	Southern Alpine, rocky	Shrub/Scrub
11003	Maritime Volcanic Alpine, ashy-loamy-rocky	Dwarf Shrub
11003	Maritime Volcanic Alpine, ashy-loamy-rocky	Evergreen Forest
11003	Maritime Volcanic Alpine, ashy-loamy-rocky	Graminoid/Herbaceous
11003	Maritime Volcanic Alpine, ashy-loamy-rocky	Shrub/Scrub
11003	Southern Alpine Frozen, ashy-loamy-organic	Shrub/Scrub
11003	Southern Alpine Frozen, ashy-loamy-rocky	Dwarf Shrub
11003	Southern Alpine, ashy-loamy-organic	Dwarf Shrub
11003	Southern Alpine, ashy-loamy-organic	Shrub/Scrub
11003	Southern Alpine, ashy-loamy-rocky	Deciduous Forest
11003	Southern Alpine, ashy-loamy-rocky	Dwarf Shrub
11003	Southern Alpine, ashy-loamy-rocky	Evergreen Forest
11003	Southern Alpine, ashy-loamy-rocky	Graminoid/Herbaceous
11003	Southern Alpine, ashy-loamy-rocky	Mixed Forest
11003	Southern Alpine, ashy-loamy-rocky	Shrub/Scrub
11004	Northern Alpine, ashy-loamy-organic	Emergent Herbaceous Wetlands
11004	Northern Alpine, ashy-loamy-rocky	Emergent Herbaceous Wetlands
11004	Northern Alpine, organic	Dwarf Shrub
11004	Northern Alpine, organic	Graminoid/Herbaceous
11004	Northern Alpine, organic	Shrub/Scrub
12019	Northern Alpine, organic	Barren Land
12019	Northern Alpine, water	Open Water
12019	Southern Alpine, water	Open Water
30001	Interior Glacial, ashy-loamy-rocky	Barren Land
30001	Interior Glacial, ashy-loamy-rocky	Dwarf Shrub
30001	Interior Glacial, bedrock	Barren Land
30001	Interior Glacial, bedrock	Dwarf Shrub
30001	Interior Glacial, organic	Barren Land
30001	Interior Glacial, rocky	Barren Land
30001	Interior Glacial, rocky	Dwarf Shrub
30001	Interior Glacial, rocky	Graminoid/Herbaceous

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
30001	Interior Glacial, sandy-rocky-organic	Barren Land
30001	Interior Glacier Ice/Perennial Snow, bedrock	Barren Land
30001	Interior Glacier Ice/Perennial Snow, bedrock	Dwarf Shrub
30001	Maritime Glacial, ashy-loamy-rocky	Barren Land
30001	Maritime Glacial, ashy-loamy-rocky	Dwarf Shrub
30001	Maritime Glacial, bedrock	Barren Land
30001	Maritime Glacial, bedrock	Dwarf Shrub
30001	Maritime Glacial, rocky	Barren Land
30001	Maritime Glacial, rocky	Dwarf Shrub
30001	Maritime Glacial, sandy-rocky-organic	Barren Land
30001	Maritime Glacier Ice/Perennial Snow, bedrock	Barren Land
30001	Maritime Glacier Ice/Perennial Snow, bedrock	Dwarf Shrub
30002	Interior Glacial, ashy-loamy-rocky	Shrub/Scrub
30002	Interior Glacial, bedrock	Deciduous Forest
30002	Interior Glacial, bedrock	Evergreen Forest
30002	Interior Glacial, bedrock	Mixed Forest
30002	Interior Glacial, bedrock	Shrub/Scrub
30002	Interior Glacial, rocky	Deciduous Forest
30002	Interior Glacial, rocky	Evergreen Forest
30002	Interior Glacial, rocky	Mixed Forest
30002	Interior Glacial, rocky	Shrub/Scrub
30002	Maritime Glacial, ashy-loamy-rocky	Deciduous Forest
30002	Maritime Glacial, ashy-loamy-rocky	Evergreen Forest
30002	Maritime Glacial, ashy-loamy-rocky	Mixed Forest
30002	Maritime Glacial, ashy-loamy-rocky	Shrub/Scrub
30002	Maritime Glacial, bedrock	Deciduous Forest
30002	Maritime Glacial, bedrock	Evergreen Forest
30002	Maritime Glacial, bedrock	Mixed Forest
30002	Maritime Glacial, bedrock	Shrub/Scrub
30002	Maritime Glacial, bedrock	Woody Wetlands
30002	Maritime Glacial, rocky	Deciduous Forest
30002	Maritime Glacial, rocky	Evergreen Forest
30002	Maritime Glacial, rocky	Mixed Forest
30002	Maritime Glacial, rocky	Shrub/Scrub
30002	Maritime Glacial, rocky	Woody Wetlands
30002	Maritime Glacial, sandy-rocky-organic	Deciduous Forest
30002	Maritime Glacial, sandy-rocky-organic	Evergreen Forest
30002	Maritime Glacial, sandy-rocky-organic	Shrub/Scrub
30002	Maritime Glacial, sandy-rocky-organic	Woody Wetlands
30002	Maritime Glacier Ice/Perennial Snow, bedrock	Shrub/Scrub
30003	Interior Glacier Ice/Perennial Snow, ashy-loamy-rocky	Barren Land
30003	Interior Glacier Ice/Perennial Snow, ashy-loamy-rocky	Shrub/Scrub
30003	Interior Glacier Ice/Perennial Snow, bedrock	Evergreen Forest
30003	Interior Glacier Ice/Perennial Snow, bedrock	Shrub/Scrub
30003	Interior Glacier Ice/Perennial Snow, rocky	Barren Land
30003	Interior Glacier Ice/Perennial Snow, rocky	Dwarf Shrub
30003	Interior Glacier Ice/Perennial Snow, rocky	Evergreen Forest
30003	Interior Glacier Ice/Perennial Snow, rocky	Shrub/Scrub
30003	Interior Glacier Ice/Perennial Snow, sandy-rocky-organic	Barren Land
30003	Interior Glacier Ice/Perennial Snow, snow-ice	Perennial Ice/Snow
30003	Maritime Glacier Ice/Perennial Snow, ashy-loamy-rocky	Barren Land
30003	Maritime Glacier Ice/Perennial Snow, ashy-loamy-rocky	Deciduous Forest
30003	Maritime Glacier Ice/Perennial Snow, ashy-loamy-rocky	Dwarf Shrub
30003	Maritime Glacier Ice/Perennial Snow, ashy-loamy-rocky	Evergreen Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
30003	Maritime Glacier Ice/Perennial Snow, ashy-loamy-rocky	Shrub/Scrub
30003	Maritime Glacier Ice/Perennial Snow, ashy-loamy-rocky	Woody Wetlands
30003	Maritime Glacier Ice/Perennial Snow, bedrock	Evergreen Forest
30003	Maritime Glacier Ice/Perennial Snow, bedrock	Mixed Forest
30003	Maritime Glacier Ice/Perennial Snow, rocky	Barren Land
30003	Maritime Glacier Ice/Perennial Snow, rocky	Deciduous Forest
30003	Maritime Glacier Ice/Perennial Snow, rocky	Dwarf Shrub
30003	Maritime Glacier Ice/Perennial Snow, rocky	Evergreen Forest
30003	Maritime Glacier Ice/Perennial Snow, rocky	Shrub/Scrub
30003	Maritime Glacier Ice/Perennial Snow, sandy-rocky-organic	Barren Land
30003	Maritime Glacier Ice/Perennial Snow, sandy-rocky-organic	Deciduous Forest
30003	Maritime Glacier Ice/Perennial Snow, sandy-rocky-organic	Shrub/Scrub
30003	Maritime Glacier Ice/Perennial Snow, silty-clayey	Barren Land
30003	Maritime Glacier Ice/Perennial Snow, snow-ice	Perennial Ice/Snow
30003	Maritime Glacier Ice/Perennial Snow, water	Open Water
30003	Maritime Volcanic Alpine, snow-ice	Perennial Ice/Snow
40001	Interior Subalpine Frozen, ashy-loamy-organic	Barren Land
40001	Interior Subalpine Frozen, ashy-loamy-rocky	Barren Land
40001	Interior Subalpine, ashy-loamy-organic	Barren Land
40001	Interior Subalpine, ashy-loamy-rocky	Barren Land
40001	Interior Subalpine, bedrock	Barren Land
40001	Interior Subalpine, organic	Barren Land
40001	Interior Subalpine, rocky	Barren Land
40001	Interior Subalpine, sandy-rocky-organic	Barren Land
40002	Interior Subalpine Frozen, ashy-loamy-organic	Dwarf Shrub
40002	Interior Subalpine Frozen, ashy-loamy-rocky	Dwarf Shrub
40002	Interior Subalpine, ashy-loamy-organic	Dwarf Shrub
40002	Interior Subalpine, ashy-loamy-rocky	Dwarf Shrub
40002	Interior Subalpine, bedrock	Dwarf Shrub
40002	Interior Subalpine, organic	Dwarf Shrub
40002	Interior Subalpine, rocky	Dwarf Shrub
40002	Interior Subalpine, sandy-rocky-organic	Dwarf Shrub
40003	Interior Subalpine, bedrock	Mixed Forest
40003	Interior Subalpine, bedrock	Shrub/Scrub
40003	Interior Subalpine, bedrock	Woody Wetlands
40003	Interior Subalpine, rocky	Mixed Forest
40003	Interior Subalpine, rocky	Shrub/Scrub
40003	Interior Subalpine, rocky	Woody Wetlands
40003	Interior Subalpine, sandy-rocky-organic	Mixed Forest
40003	Interior Subalpine, sandy-rocky-organic	Shrub/Scrub
40003	Interior Subalpine, sandy-rocky-organic	Woody Wetlands
40004	Interior Subalpine Frozen, ashy-loamy-organic	Deciduous Forest
40004	Interior Subalpine Frozen, ashy-loamy-rocky	Deciduous Forest
40004	Interior Subalpine, ashy-loamy-organic	Deciduous Forest
40004	Interior Subalpine, ashy-loamy-rocky	Deciduous Forest
40004	Interior Subalpine, bedrock	Deciduous Forest
40004	Interior Subalpine, rocky	Deciduous Forest
40004	Interior Subalpine, sandy-rocky-organic	Deciduous Forest
40005	Interior Subalpine, ashy-loamy-rocky	Graminoid/Herbaceous
40005	Interior Subalpine, ashy-loamy-rocky	Mixed Forest
40005	Interior Subalpine, bedrock	Graminoid/Herbaceous
40006	Interior Subalpine, ashy-loamy-organic	Evergreen Forest
40006	Interior Subalpine, ashy-loamy-rocky	Evergreen Forest
40006	Interior Subalpine, bedrock	Evergreen Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
40006	Interior Subalpine, organic	Evergreen Forest
40006	Interior Subalpine, rocky	Evergreen Forest
40006	Interior Subalpine, sandy-rocky-organic	Evergreen Forest
40006	Interior Subalpine Frozen, ashy-loamy-organic	Evergreen Forest
40006	Interior Subalpine Frozen, ashy-loamy-rocky	Evergreen Forest
40008	Interior Subalpine Frozen, ashy-loamy-organic	Mixed Forest
40008	Interior Subalpine Frozen, ashy-loamy-organic	Shrub/Scrub
40008	Interior Subalpine Frozen, ashy-loamy-organic	Woody Wetlands
40008	Interior Subalpine Frozen, ashy-loamy-rocky	Mixed Forest
40008	Interior Subalpine Frozen, ashy-loamy-rocky	Shrub/Scrub
40008	Interior Subalpine Frozen, ashy-loamy-rocky	Woody Wetlands
40009	Interior Subalpine Frozen, ashy-loamy-organic	Emergent Herbaceous Wetlands
40009	Interior Subalpine Frozen, ashy-loamy-rocky	Emergent Herbaceous Wetlands
40009	Interior Subalpine, ashy-loamy-organic	Emergent Herbaceous Wetlands
40009	Interior Subalpine, ashy-loamy-organic	Woody Wetlands
40009	Interior Subalpine, ashy-loamy-rocky	Emergent Herbaceous Wetlands
40009	Interior Subalpine, bedrock	Emergent Herbaceous Wetlands
40009	Interior Subalpine, organic	Emergent Herbaceous Wetlands
40009	Interior Subalpine, organic	Woody Wetlands
40009	Interior Subalpine, rocky	Emergent Herbaceous Wetlands
40010	Interior Subalpine, ashy-loamy-organic	Mixed Forest
40010	Interior Subalpine, ashy-loamy-organic	Shrub/Scrub
40010	Interior Subalpine, ashy-loamy-rocky	Shrub/Scrub
40010	Interior Subalpine, ashy-loamy-rocky	Woody Wetlands
40010	Interior Subalpine, organic	Shrub/Scrub
50001	Interior Upland, ashy-loamy-rocky	Barren Land
50001	Interior Upland, bedrock	Barren Land
50001	Interior Upland, rocky	Barren Land
50002	Interior Upland, ashy-loamy-rocky	Dwarf Shrub
50002	Interior Upland, bedrock	Dwarf Shrub
50002	Interior Upland, bedrock	Emergent Herbaceous Wetlands
50002	Interior Upland, bedrock	Shrub/Scrub
50002	Interior Upland, bedrock	Woody Wetlands
50002	Interior Upland, rocky	Dwarf Shrub
50002	Interior Upland, rocky	Emergent Herbaceous Wetlands
50002	Interior Upland, rocky	Shrub/Scrub
50002	Interior Upland, rocky	Woody Wetlands
50003	Interior Upland, ashy-loamy-rocky	Emergent Herbaceous Wetlands
50003	Interior Upland, ashy-loamy-rocky	Graminoid/Herbaceous
50003	Interior Upland, ashy-loamy-rocky	Shrub/Scrub
50003	Interior Upland, ashy-loamy-rocky	Woody Wetlands
50004	Interior Upland, ashy-loamy-rocky	Mixed Forest
50005	Interior Upland, ashy-loamy-rocky	Evergreen Forest
50006	Interior Upland, bedrock	Mixed Forest
50006	Interior Upland, rocky	Mixed Forest
50007	Interior Upland, bedrock	Evergreen Forest
50007	Interior Upland, rocky	Evergreen Forest
50010	Interior Upland, ashy-loamy-rocky	Deciduous Forest
50011	Interior Upland, bedrock	Deciduous Forest
50011	Interior Upland, rocky	Deciduous Forest
51001	Maritime Upland, ashy-loamy-rocky	Barren Land
51001	Maritime Upland, bedrock	Barren Land
51001	Maritime Upland, organic	Barren Land
51001	Maritime Upland, rocky	Barren Land

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
51001	Maritime Upland, sandy-rocky-organic	Barren Land
51001	Maritime Volcanic Upland, ashy-loamy-rocky	Barren Land
51001	Maritime Volcanic Upland, bedrock	Barren Land
51001	Maritime Volcanic Upland, rocky	Barren Land
51002	Maritime Upland, ashy-loamy-rocky	Dwarf Shrub
51002	Maritime Upland, bedrock	Dwarf Shrub
51002	Maritime Upland, bedrock	Emergent Herbaceous Wetlands
51002	Maritime Upland, bedrock	Graminoid/Herbaceous
51002	Maritime Upland, bedrock	Shrub/Scrub
51002	Maritime Upland, bedrock	Woody Wetlands
51002	Maritime Upland, organic	Dwarf Shrub
51002	Maritime Upland, rocky	Dwarf Shrub
51002	Maritime Upland, rocky	Emergent Herbaceous Wetlands
51002	Maritime Upland, rocky	Graminoid/Herbaceous
51002	Maritime Upland, rocky	Shrub/Scrub
51002	Maritime Upland, rocky	Woody Wetlands
51002	Maritime Upland, sandy-rocky-organic	Shrub/Scrub
51002	Maritime Volcanic Upland, ashy-loamy-rocky	Dwarf Shrub
51002	Maritime Volcanic Upland, bedrock	Dwarf Shrub
51002	Maritime Volcanic Upland, bedrock	Emergent Herbaceous Wetlands
51002	Maritime Volcanic Upland, bedrock	Graminoid/Herbaceous
51002	Maritime Volcanic Upland, bedrock	Shrub/Scrub
51002	Maritime Volcanic Upland, bedrock	Woody Wetlands
51002	Maritime Volcanic Upland, rocky	Dwarf Shrub
51002	Maritime Volcanic Upland, rocky	Emergent Herbaceous Wetlands
51002	Maritime Volcanic Upland, rocky	Graminoid/Herbaceous
51002	Maritime Volcanic Upland, rocky	Shrub/Scrub
51002	Maritime Volcanic Upland, rocky	Woody Wetlands
51003	Maritime Upland, ashy-loamy-rocky	Emergent Herbaceous Wetlands
51003	Maritime Upland, ashy-loamy-rocky	Graminoid/Herbaceous
51003	Maritime Upland, ashy-loamy-rocky	Shrub/Scrub
51003	Maritime Upland, ashy-loamy-rocky	Woody Wetlands
51003	Maritime Upland, organic	Shrub/Scrub
51003	Maritime Upland, organic	Woody Wetlands
51003	Maritime Upland, silty-clayey	Shrub/Scrub
51003	Maritime Upland, silty-clayey	Woody Wetlands
51003	Maritime Volcanic Upland, ashy-loamy-rocky	Emergent Herbaceous Wetlands
51003	Maritime Volcanic Upland, ashy-loamy-rocky	Graminoid/Herbaceous
51003	Maritime Volcanic Upland, ashy-loamy-rocky	Shrub/Scrub
51003	Maritime Volcanic Upland, ashy-loamy-rocky	Woody Wetlands
51007	Maritime Upland, ashy-loamy-rocky	Deciduous Forest
51007	Maritime Upland, bedrock	Deciduous Forest
51007	Maritime Upland, organic	Deciduous Forest
51007	Maritime Upland, rocky	Deciduous Forest
51007	Maritime Upland, sandy-rocky-organic	Deciduous Forest
51007	Maritime Upland, silty-clayey	Deciduous Forest
51007	Maritime Volcanic Upland, ashy-loamy-rocky	Deciduous Forest
51007	Maritime Volcanic Upland, bedrock	Deciduous Forest
51007	Maritime Volcanic Upland, rocky	Deciduous Forest
51008	Maritime Upland, ashy-loamy-rocky	Evergreen Forest
51008	Maritime Upland, ashy-loamy-rocky	Mixed Forest
51008	Maritime Upland, organic	Evergreen Forest
51008	Maritime Upland, organic	Mixed Forest
51008	Maritime Upland, silty-clayey	Evergreen Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
51008	Maritime Upland, silty-clayey	Mixed Forest
51008	Maritime Volcanic Upland, ashy-loamy-rocky	Evergreen Forest
51008	Maritime Volcanic Upland, ashy-loamy-rocky	Mixed Forest
51010	Maritime Upland, bedrock	Evergreen Forest
51010	Maritime Upland, bedrock	Mixed Forest
51010	Maritime Upland, rocky	Evergreen Forest
51010	Maritime Upland, rocky	Mixed Forest
51010	Maritime Upland, rocky	Open Water
51010	Maritime Upland, sandy-rocky-organic	Evergreen Forest
51010	Maritime Upland, sandy-rocky-organic	Mixed Forest
51010	Maritime Volcanic Upland, bedrock	Evergreen Forest
51010	Maritime Volcanic Upland, bedrock	Mixed Forest
51010	Maritime Volcanic Upland, rocky	Evergreen Forest
51010	Maritime Volcanic Upland, rocky	Mixed Forest
51010	Maritime Volcanic Upland, rocky	Open Water
70001	Interior Lowland Frozen, ashy-loamy-organic	Mixed Forest
70001	Interior Lowland Frozen, ashy-loamy-rocky	Mixed Forest
70001	Interior Lowland Frozen, organic	Mixed Forest
70001	Interior Lowland, ashy-loamy-organic	Mixed Forest
70001	Interior Lowland, ashy-loamy-rocky	Mixed Forest
70001	Interior Lowland, organic	Mixed Forest
70001	Interior Lowland, sandy-rocky-organic	Mixed Forest
70002	Interior Lowland Frozen, ashy-loamy-organic	Deciduous Forest
70002	Interior Lowland Frozen, ashy-loamy-rocky	Deciduous Forest
70002	Interior Lowland Frozen, organic	Deciduous Forest
70002	Interior Lowland, ashy-loamy-organic	Deciduous Forest
70002	Interior Lowland, ashy-loamy-rocky	Deciduous Forest
70002	Interior Lowland, organic	Deciduous Forest
70002	Interior Lowland, sandy-rocky-organic	Deciduous Forest
70003	Interior Lowland, ashy-loamy-organic	Evergreen Forest
70003	Interior Lowland, ashy-loamy-rocky	Evergreen Forest
70003	Interior Lowland, organic	Evergreen Forest
70003	Interior Lowland, sandy-rocky-organic	Evergreen Forest
70004	Interior Lowland, ashy-loamy-rocky	Dwarf Shrub
70004	Interior Lowland, ashy-loamy-rocky	Shrub/Scrub
70004	Interior Lowland, ashy-loamy-rocky	Woody Wetlands
70004	Interior Lowland, sandy-rocky-organic	Dwarf Shrub
70004	Interior Lowland, sandy-rocky-organic	Shrub/Scrub
70004	Interior Lowland, sandy-rocky-organic	Woody Wetlands
70005	Interior Lowland, ashy-loamy-organic	Dwarf Shrub
70005	Interior Lowland, ashy-loamy-organic	Shrub/Scrub
70005	Interior Lowland, ashy-loamy-organic	Woody Wetlands
70005	Interior Lowland, organic	Dwarf Shrub
70005	Interior Lowland, organic	Shrub/Scrub
70005	Interior Lowland, organic	Woody Wetlands
70007	Interior Lowland, ashy-loamy-organic	Emergent Herbaceous Wetlands
70007	Interior Lowland, ashy-loamy-organic	Graminoid/Herbaceous
70007	Interior Lowland, ashy-loamy-rocky	Emergent Herbaceous Wetlands
70007	Interior Lowland, ashy-loamy-rocky	Graminoid/Herbaceous
70007	Interior Lowland, organic	Emergent Herbaceous Wetlands
70007	Interior Lowland, organic	Graminoid/Herbaceous
70007	Interior Lowland, sandy-rocky-organic	Emergent Herbaceous Wetlands
70008	Interior Lowland Frozen, ashy-loamy-organic	Evergreen Forest
70008	Interior Lowland Frozen, ashy-loamy-rocky	Evergreen Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
70008	Interior Lowland Frozen, organic	Evergreen Forest
70009	Interior Lowland Frozen, ashy-loamy-organic	Dwarf Shrub
70009	Interior Lowland Frozen, ashy-loamy-organic	Emergent Herbaceous Wetlands
70009	Interior Lowland Frozen, ashy-loamy-organic	Graminoid/Herbaceous
70009	Interior Lowland Frozen, ashy-loamy-organic	Shrub/Scrub
70009	Interior Lowland Frozen, ashy-loamy-organic	Woody Wetlands
70009	Interior Lowland Frozen, ashy-loamy-rocky	Dwarf Shrub
70009	Interior Lowland Frozen, ashy-loamy-rocky	Emergent Herbaceous Wetlands
70009	Interior Lowland Frozen, ashy-loamy-rocky	Shrub/Scrub
70009	Interior Lowland Frozen, ashy-loamy-rocky	Woody Wetlands
70009	Interior Lowland Frozen, organic	Dwarf Shrub
70009	Interior Lowland Frozen, organic	Emergent Herbaceous Wetlands
70009	Interior Lowland Frozen, organic	Shrub/Scrub
70009	Interior Lowland Frozen, organic	Woody Wetlands
71001	Maritime Coastal, ashy-loamy-organic	Evergreen Forest
71001	Maritime Coastal, ashy-loamy-rocky	Evergreen Forest
71001	Maritime Coastal, organic	Evergreen Forest
71001	Maritime Coastal, sandy-rocky-organic	Evergreen Forest
71001	Maritime Coastal, silty-clayey	Evergreen Forest
71001	Maritime Lowland, ashy-loamy-organic	Evergreen Forest
71001	Maritime Lowland, ashy-loamy-organic	Mixed Forest
71001	Maritime Lowland, ashy-loamy-rocky	Evergreen Forest
71001	Maritime Lowland, ashy-loamy-rocky	Mixed Forest
71001	Maritime Lowland, organic	Evergreen Forest
71001	Maritime Lowland, organic	Mixed Forest
71001	Maritime Lowland, sandy-rocky-organic	Evergreen Forest
71001	Maritime Lowland, sandy-rocky-organic	Mixed Forest
71001	Maritime Lowland, silty-clayey	Evergreen Forest
71001	Maritime Lowland, silty-clayey	Mixed Forest
71001	Maritime Volcanic Lowland, ashy-loamy-organic	Evergreen Forest
71001	Maritime Volcanic Lowland, ashy-loamy-organic	Mixed Forest
71001	Maritime Volcanic Lowland, ashy-loamy-rocky	Evergreen Forest
71001	Maritime Volcanic Lowland, ashy-loamy-rocky	Mixed Forest
71001	Maritime Volcanic Lowland, sandy-rocky-organic	Evergreen Forest
71001	Maritime Volcanic Lowland, sandy-rocky-organic	Mixed Forest
71002	Maritime Lowland, ashy-loamy-organic	Deciduous Forest
71002	Maritime Lowland, ashy-loamy-rocky	Deciduous Forest
71002	Maritime Lowland, organic	Deciduous Forest
71002	Maritime Lowland, sandy-rocky-organic	Deciduous Forest
71002	Maritime Lowland, silty-clayey	Deciduous Forest
71002	Maritime Volcanic Lowland, ashy-loamy-organic	Deciduous Forest
71002	Maritime Volcanic Lowland, ashy-loamy-rocky	Deciduous Forest
71002	Maritime Volcanic Lowland, sandy-rocky-organic	Deciduous Forest
71003	Maritime Lowland, ashy-loamy-organic	Dwarf Shrub
71003	Maritime Lowland, ashy-loamy-organic	Shrub/Scrub
71003	Maritime Lowland, ashy-loamy-organic	Woody Wetlands
71003	Maritime Lowland, ashy-loamy-rocky	Dwarf Shrub
71003	Maritime Lowland, ashy-loamy-rocky	Shrub/Scrub
71003	Maritime Lowland, ashy-loamy-rocky	Woody Wetlands
71003	Maritime Lowland, organic	Shrub/Scrub
71003	Maritime Lowland, organic	Woody Wetlands
71003	Maritime Lowland, sandy-rocky-organic	Shrub/Scrub
71003	Maritime Lowland, sandy-rocky-organic	Woody Wetlands
71003	Maritime Lowland, silty-clayey	Shrub/Scrub

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
71003	Maritime Lowland, silty-clayey	Woody Wetlands
71003	Maritime Volcanic Lowland, ashy-loamy-organic	Dwarf Shrub
71003	Maritime Volcanic Lowland, ashy-loamy-organic	Shrub/Scrub
71003	Maritime Volcanic Lowland, ashy-loamy-organic	Woody Wetlands
71003	Maritime Volcanic Lowland, ashy-loamy-rocky	Dwarf Shrub
71003	Maritime Volcanic Lowland, ashy-loamy-rocky	Shrub/Scrub
71003	Maritime Volcanic Lowland, ashy-loamy-rocky	Woody Wetlands
71003	Maritime Volcanic Lowland, sandy-rocky-organic	Shrub/Scrub
71003	Maritime Volcanic Lowland, sandy-rocky-organic	Woody Wetlands
71004	Maritime Lowland, ashy-loamy-organic	Emergent Herbaceous Wetlands
71004	Maritime Lowland, ashy-loamy-organic	Graminoid/Herbaceous
71004	Maritime Lowland, ashy-loamy-rocky	Emergent Herbaceous Wetlands
71004	Maritime Lowland, organic	Emergent Herbaceous Wetlands
71004	Maritime Lowland, silty-clayey	Emergent Herbaceous Wetlands
71004	Maritime Lowland, silty-clayey	Graminoid/Herbaceous
71004	Maritime Volcanic Lowland, ashy-loamy-organic	Emergent Herbaceous Wetlands
71004	Maritime Volcanic Lowland, ashy-loamy-organic	Graminoid/Herbaceous
71004	Maritime Volcanic Lowland, ashy-loamy-rocky	Emergent Herbaceous Wetlands
150000	Interior Lacustrine, ashy-loamy-rocky	Barren Land
150000	Interior Lowland Frozen, ashy-loamy-rocky	Barren Land
150000	Interior Lowland, ashy-loamy-organic	Barren Land
150000	Interior Lowland, ashy-loamy-rocky	Barren Land
150000	Interior Lowland, organic	Barren Land
150000	Interior Lowland, sandy-rocky-organic	Barren Land
90002	Interior Lacustrine, ashy-loamy-organic	Deciduous Forest
90002	Interior Lacustrine, ashy-loamy-organic	Dwarf Shrub
90002	Interior Lacustrine, ashy-loamy-organic	Shrub/Scrub
90002	Interior Lacustrine, ashy-loamy-organic	Woody Wetlands
90002	Interior Lacustrine, ashy-loamy-rocky	Deciduous Forest
90002	Interior Lacustrine, ashy-loamy-rocky	Dwarf Shrub
90002	Interior Lacustrine, ashy-loamy-rocky	Emergent Herbaceous Wetlands
90002	Interior Lacustrine, ashy-loamy-rocky	Graminoid/Herbaceous
90002	Interior Lacustrine, ashy-loamy-rocky	Mixed Forest
90002	Interior Lacustrine, ashy-loamy-rocky	Shrub/Scrub
90002	Interior Lacustrine, ashy-loamy-rocky	Woody Wetlands
90002	Interior Lacustrine, organic	Dwarf Shrub
90002	Interior Lacustrine, rocky	Emergent Herbaceous Wetlands
90002	Interior Lacustrine, rocky	Mixed Forest
90002	Interior Lacustrine, rocky	Shrub/Scrub
90002	Interior Lacustrine, rocky	Woody Wetlands
90002	Interior Lacustrine, sandy-rocky-organic	Mixed Forest
90003	Interior Lacustrine, ashy-loamy-organic	Emergent Herbaceous Wetlands
90003	Interior Lacustrine, ashy-loamy-organic	Evergreen Forest
90003	Interior Lacustrine, ashy-loamy-organic	Graminoid/Herbaceous
90003	Interior Lacustrine, ashy-loamy-organic	Mixed Forest
90003	Interior Lacustrine, ashy-loamy-rocky	Evergreen Forest
90003	Interior Lacustrine, organic	Deciduous Forest
90003	Interior Lacustrine, organic	Emergent Herbaceous Wetlands
90003	Interior Lacustrine, organic	Evergreen Forest
90003	Interior Lacustrine, organic	Graminoid/Herbaceous
90003	Interior Lacustrine, organic	Mixed Forest
90003	Interior Lacustrine, organic	Shrub/Scrub
90003	Interior Lacustrine, organic	Woody Wetlands
90003	Interior Lacustrine, rocky	Evergreen Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
90003	Interior Lacustrine, sandy-rocky-organic	Evergreen Forest
100001	Interior Riverine (Glacial), ashy-loamy-organic	Barren Land
100001	Interior Riverine (Glacial), ashy-loamy-rocky	Barren Land
100001	Interior Riverine (Glacial), organic	Barren Land
100001	Interior Riverine (Glacial), rocky	Barren Land
100001	Interior Riverine (Glacial), sandy-rocky-organic	Barren Land
100001	Interior Riverine (Non-glacial), ashy-loamy-rocky	Barren Land
100001	Interior Riverine (Non-glacial), sandy-rocky-organic	Barren Land
100001	Maritime Lowland, ashy-loamy-organic	Barren Land
100001	Maritime Lowland, ashy-loamy-rocky	Barren Land
100001	Maritime Lowland, organic	Barren Land
100001	Maritime Lowland, sandy-rocky-organic	Barren Land
100001	Maritime Lowland, silty-clayey	Barren Land
100001	Maritime Riverine (Glacial), ashy-loamy-organic	Barren Land
100001	Maritime Riverine (Glacial), ashy-loamy-rocky	Barren Land
100001	Maritime Riverine (Glacial), organic	Barren Land
100001	Maritime Riverine (Glacial), rocky	Barren Land
100001	Maritime Riverine (Glacial), sandy-rocky-organic	Barren Land
100001	Maritime Riverine (Glacial), silty-clayey	Barren Land
100001	Maritime Volcanic Lowland, ashy-loamy-organic	Barren Land
100001	Maritime Volcanic Lowland, ashy-loamy-rocky	Barren Land
100001	Maritime Volcanic Lowland, sandy-rocky-organic	Barren Land
100002	Interior Riverine (Glacial), ashy-loamy-organic	Dwarf Shrub
100002	Interior Riverine (Glacial), ashy-loamy-organic	Shrub/Scrub
100002	Interior Riverine (Glacial), ashy-loamy-organic	Woody Wetlands
100002	Interior Riverine (Glacial), ashy-loamy-rocky	Dwarf Shrub
100002	Interior Riverine (Glacial), ashy-loamy-rocky	Shrub/Scrub
100002	Interior Riverine (Glacial), ashy-loamy-rocky	Woody Wetlands
100002	Interior Riverine (Glacial), organic	Shrub/Scrub
100002	Interior Riverine (Glacial), organic	Woody Wetlands
100002	Interior Riverine (Glacial), rocky	Dwarf Shrub
100002	Interior Riverine (Glacial), rocky	Shrub/Scrub
100002	Interior Riverine (Glacial), rocky	Woody Wetlands
100002	Interior Riverine (Glacial), sandy-rocky-organic	Dwarf Shrub
100002	Interior Riverine (Glacial), sandy-rocky-organic	Shrub/Scrub
100002	Interior Riverine (Glacial), sandy-rocky-organic	Woody Wetlands
100002	Interior Riverine (Non-glacial), ashy-loamy-organic	Dwarf Shrub
100002	Interior Riverine (Non-glacial), ashy-loamy-organic	Shrub/Scrub
100002	Interior Riverine (Non-glacial), ashy-loamy-organic	Woody Wetlands
100002	Interior Riverine (Non-glacial), ashy-loamy-rocky	Dwarf Shrub
100002	Interior Riverine (Non-glacial), ashy-loamy-rocky	Shrub/Scrub
100002	Interior Riverine (Non-glacial), ashy-loamy-rocky	Woody Wetlands
100002	Interior Riverine (Non-glacial), organic	Shrub/Scrub
100002	Interior Riverine (Non-glacial), organic	Woody Wetlands
100002	Interior Riverine (Non-glacial), rocky	Dwarf Shrub
100002	Interior Riverine (Non-glacial), rocky	Shrub/Scrub
100002	Interior Riverine (Non-glacial), rocky	Woody Wetlands
100002	Interior Riverine (Non-glacial), sandy-rocky-organic	Dwarf Shrub
100002	Interior Riverine (Non-glacial), sandy-rocky-organic	Shrub/Scrub
100002	Interior Riverine (Non-glacial), sandy-rocky-organic	Woody Wetlands
100003	Interior Riverine (Glacial), ashy-loamy-organic	Deciduous Forest
100003	Interior Riverine (Glacial), ashy-loamy-rocky	Deciduous Forest
100003	Interior Riverine (Glacial), organic	Deciduous Forest
100003	Interior Riverine (Glacial), rocky	Deciduous Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
100003	Interior Riverine (Glacial), sandy-rocky-organic	Deciduous Forest
100003	Interior Riverine (Non-glacial), ashy-loamy-organic	Deciduous Forest
100003	Interior Riverine (Non-glacial), ashy-loamy-rocky	Deciduous Forest
100003	Interior Riverine (Non-glacial), rocky	Deciduous Forest
100003	Interior Riverine (Non-glacial), sandy-rocky-organic	Deciduous Forest
100004	Interior Riverine (Glacial), ashy-loamy-organic	Mixed Forest
100004	Interior Riverine (Glacial), ashy-loamy-rocky	Mixed Forest
100004	Interior Riverine (Glacial), organic	Mixed Forest
100004	Interior Riverine (Glacial), rocky	Mixed Forest
100004	Interior Riverine (Glacial), sandy-rocky-organic	Mixed Forest
100004	Interior Riverine (Non-glacial), ashy-loamy-organic	Mixed Forest
100004	Interior Riverine (Non-glacial), ashy-loamy-rocky	Mixed Forest
100004	Interior Riverine (Non-glacial), organic	Mixed Forest
100004	Interior Riverine (Non-glacial), rocky	Mixed Forest
100004	Interior Riverine (Non-glacial), sandy-rocky-organic	Mixed Forest
100005	Interior Riverine (Glacial), ashy-loamy-organic	Evergreen Forest
100005	Interior Riverine (Glacial), ashy-loamy-rocky	Evergreen Forest
100005	Interior Riverine (Glacial), organic	Evergreen Forest
100005	Interior Riverine (Glacial), rocky	Evergreen Forest
100005	Interior Riverine (Glacial), sandy-rocky-organic	Evergreen Forest
100005	Interior Riverine (Non-glacial), ashy-loamy-organic	Evergreen Forest
100005	Interior Riverine (Non-glacial), ashy-loamy-rocky	Evergreen Forest
100005	Interior Riverine (Non-glacial), organic	Evergreen Forest
100005	Interior Riverine (Non-glacial), rocky	Evergreen Forest
100005	Interior Riverine (Non-glacial), sandy-rocky-organic	Evergreen Forest
100006	Interior Riverine (Glacial), ashy-loamy-organic	Emergent Herbaceous Wetlands
100006	Interior Riverine (Glacial), ashy-loamy-rocky	Emergent Herbaceous Wetlands
100006	Interior Riverine (Glacial), ashy-loamy-rocky	Graminoid/Herbaceous
100006	Interior Riverine (Glacial), organic	Emergent Herbaceous Wetlands
100006	Interior Riverine (Glacial), rocky	Emergent Herbaceous Wetlands
100006	Interior Riverine (Glacial), rocky	Graminoid/Herbaceous
100006	Interior Riverine (Glacial), sandy-rocky-organic	Emergent Herbaceous Wetlands
100006	Interior Riverine (Glacial), sandy-rocky-organic	Graminoid/Herbaceous
100006	Interior Riverine (Non-glacial), ashy-loamy-organic	Emergent Herbaceous Wetlands
100006	Interior Riverine (Non-glacial), ashy-loamy-organic	Graminoid/Herbaceous
100006	Interior Riverine (Non-glacial), ashy-loamy-rocky	Emergent Herbaceous Wetlands
100006	Interior Riverine (Non-glacial), organic	Emergent Herbaceous Wetlands
100006	Interior Riverine (Non-glacial), rocky	Emergent Herbaceous Wetlands
100006	Interior Riverine (Non-glacial), sandy-rocky-organic	Emergent Herbaceous Wetlands
100006	Interior Riverine (Non-glacial), sandy-rocky-organic	Graminoid/Herbaceous
101002	Maritime Riverine (Glacial), ashy-loamy-organic	Shrub/Scrub
101002	Maritime Riverine (Glacial), ashy-loamy-organic	Woody Wetlands
101002	Maritime Riverine (Glacial), ashy-loamy-rocky	Dwarf Shrub
101002	Maritime Riverine (Glacial), ashy-loamy-rocky	Shrub/Scrub
101002	Maritime Riverine (Glacial), ashy-loamy-rocky	Woody Wetlands
101002	Maritime Riverine (Glacial), organic	Dwarf Shrub
101002	Maritime Riverine (Glacial), organic	Shrub/Scrub
101002	Maritime Riverine (Glacial), organic	Woody Wetlands
101002	Maritime Riverine (Glacial), rocky	Dwarf Shrub
101002	Maritime Riverine (Glacial), rocky	Shrub/Scrub
101002	Maritime Riverine (Glacial), rocky	Woody Wetlands
101002	Maritime Riverine (Glacial), sandy-rocky-organic	Dwarf Shrub
101002	Maritime Riverine (Glacial), sandy-rocky-organic	Shrub/Scrub
101002	Maritime Riverine (Glacial), sandy-rocky-organic	Woody Wetlands

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
101002	Maritime Riverine (Glacial), silty-clayey	Dwarf Shrub
101002	Maritime Riverine (Glacial), silty-clayey	Shrub/Scrub
101002	Maritime Riverine (Glacial), silty-clayey	Woody Wetlands
101002	Maritime Riverine (Non-glacial), ashy-loamy-rocky	Woody Wetlands
101002	Maritime Riverine (Non-glacial), rocky	Shrub/Scrub
101002	Maritime Riverine (Non-glacial), rocky	Woody Wetlands
101003	Maritime Riverine (Glacial), ashy-loamy-organic	Deciduous Forest
101003	Maritime Riverine (Glacial), ashy-loamy-rocky	Deciduous Forest
101003	Maritime Riverine (Glacial), organic	Deciduous Forest
101003	Maritime Riverine (Glacial), rocky	Deciduous Forest
101003	Maritime Riverine (Glacial), sandy-rocky-organic	Deciduous Forest
101003	Maritime Riverine (Glacial), silty-clayey	Deciduous Forest
101003	Maritime Riverine (Non-glacial), rocky	Deciduous Forest
101004	Maritime Riverine (Glacial), ashy-loamy-organic	Mixed Forest
101004	Maritime Riverine (Glacial), ashy-loamy-rocky	Mixed Forest
101004	Maritime Riverine (Glacial), organic	Mixed Forest
101004	Maritime Riverine (Glacial), rocky	Mixed Forest
101004	Maritime Riverine (Glacial), sandy-rocky-organic	Mixed Forest
101004	Maritime Riverine (Glacial), silty-clayey	Mixed Forest
101005	Maritime Riverine (Glacial), ashy-loamy-organic	Evergreen Forest
101005	Maritime Riverine (Glacial), ashy-loamy-rocky	Evergreen Forest
101005	Maritime Riverine (Glacial), organic	Evergreen Forest
101005	Maritime Riverine (Glacial), rocky	Evergreen Forest
101005	Maritime Riverine (Glacial), sandy-rocky-organic	Evergreen Forest
101005	Maritime Riverine (Glacial), silty-clayey	Evergreen Forest
101005	Maritime Riverine (Non-glacial), ashy-loamy-rocky	Evergreen Forest
101005	Maritime Riverine (Non-glacial), rocky	Evergreen Forest
101005	Maritime Riverine (Non-glacial), sandy-rocky-organic	Evergreen Forest
101006	Maritime Riverine (Glacial), ashy-loamy-organic	Emergent Herbaceous Wetlands
101006	Maritime Riverine (Glacial), ashy-loamy-organic	Graminoid/Herbaceous
101006	Maritime Riverine (Glacial), ashy-loamy-rocky	Emergent Herbaceous Wetlands
101006	Maritime Riverine (Glacial), ashy-loamy-rocky	Graminoid/Herbaceous
101006	Maritime Riverine (Glacial), organic	Emergent Herbaceous Wetlands
101006	Maritime Riverine (Glacial), rocky	Emergent Herbaceous Wetlands
101006	Maritime Riverine (Glacial), sandy-rocky-organic	Emergent Herbaceous Wetlands
101006	Maritime Riverine (Glacial), silty-clayey	Emergent Herbaceous Wetlands
101006	Maritime Riverine (Glacial), silty-clayey	Graminoid/Herbaceous
110001	Maritime Coastal, ashy-loamy-rocky	Barren Land
110001	Maritime Coastal, rocky	Barren Land
110001	Maritime Coastal, sandy-rocky-organic	Barren Land
110001	Maritime Riverine (Tidal), ashy-loamy-rocky	Barren Land
110001	Maritime Riverine (Tidal), rocky	Barren Land
110001	Maritime Riverine (Tidal), sandy-rocky-organic	Barren Land
110002	Maritime Coastal, ashy-loamy-organic	Barren Land
110002	Maritime Coastal, organic	Barren Land
110002	Maritime Coastal, silty-clayey	Barren Land
110002	Maritime Coastal, silty-clayey	Marine Water
110002	Maritime Riverine (Tidal), ashy-loamy-organic	Barren Land
110002	Maritime Riverine (Tidal), silty-clayey	Barren Land
110003	Maritime Coastal, ashy-loamy-rocky	Shrub/Scrub
110003	Maritime Coastal, rocky	Deciduous Forest
110003	Maritime Coastal, rocky	Dwarf Shrub
110003	Maritime Coastal, rocky	Emergent Herbaceous Wetlands
110003	Maritime Coastal, rocky	Evergreen Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
110003	Maritime Coastal, rocky	Mixed Forest
110003	Maritime Coastal, rocky	Shrub/Scrub
110003	Maritime Coastal, rocky	Woody Wetlands
110003	Maritime Coastal, sandy-rocky-organic	Deciduous Forest
110003	Maritime Coastal, sandy-rocky-organic	Dwarf Shrub
110003	Maritime Coastal, sandy-rocky-organic	Emergent Herbaceous Wetlands
110003	Maritime Coastal, sandy-rocky-organic	Mixed Forest
110003	Maritime Coastal, sandy-rocky-organic	Shrub/Scrub
110003	Maritime Coastal, sandy-rocky-organic	Woody Wetlands
110003	Maritime Riverine (Tidal), ashy-loamy-rocky	Mixed Forest
110003	Maritime Riverine (Tidal), ashy-loamy-rocky	Shrub/Scrub
110003	Maritime Riverine (Tidal), rocky	Deciduous Forest
110003	Maritime Riverine (Tidal), rocky	Emergent Herbaceous Wetlands
110003	Maritime Riverine (Tidal), rocky	Graminoid/Herbaceous
110003	Maritime Riverine (Tidal), rocky	Mixed Forest
110003	Maritime Riverine (Tidal), rocky	Shrub/Scrub
110003	Maritime Riverine (Tidal), rocky	Woody Wetlands
110003	Maritime Riverine (Tidal), sandy-rocky-organic	Deciduous Forest
110003	Maritime Riverine (Tidal), sandy-rocky-organic	Emergent Herbaceous Wetlands
110003	Maritime Riverine (Tidal), sandy-rocky-organic	Mixed Forest
110003	Maritime Riverine (Tidal), sandy-rocky-organic	Shrub/Scrub
110003	Maritime Riverine (Tidal), sandy-rocky-organic	Woody Wetlands
110004	Maritime Coastal, ashy-loamy-organic	Deciduous Forest
110004	Maritime Coastal, ashy-loamy-organic	Emergent Herbaceous Wetlands
110004	Maritime Coastal, ashy-loamy-organic	Shrub/Scrub
110004	Maritime Coastal, ashy-loamy-organic	Woody Wetlands
110004	Maritime Coastal, ashy-loamy-rocky	Deciduous Forest
110004	Maritime Coastal, ashy-loamy-rocky	Dwarf Shrub
110004	Maritime Coastal, ashy-loamy-rocky	Emergent Herbaceous Wetlands
110004	Maritime Coastal, ashy-loamy-rocky	Mixed Forest
110004	Maritime Coastal, ashy-loamy-rocky	Woody Wetlands
110004	Maritime Coastal, organic	Deciduous Forest
110004	Maritime Coastal, organic	Dwarf Shrub
110004	Maritime Coastal, organic	Emergent Herbaceous Wetlands
110004	Maritime Coastal, organic	Mixed Forest
110004	Maritime Coastal, organic	Shrub/Scrub
110004	Maritime Coastal, organic	Woody Wetlands
110004	Maritime Coastal, silty-clayey	Deciduous Forest
110004	Maritime Coastal, silty-clayey	Dwarf Shrub
110004	Maritime Coastal, silty-clayey	Emergent Herbaceous Wetlands
110004	Maritime Coastal, silty-clayey	Graminoid/Herbaceous
110004	Maritime Coastal, silty-clayey	Mixed Forest
110004	Maritime Coastal, silty-clayey	Shrub/Scrub
110004	Maritime Coastal, silty-clayey	Woody Wetlands
110004	Maritime Riverine (Tidal), ashy-loamy-organic	Shrub/Scrub
110004	Maritime Riverine (Tidal), ashy-loamy-rocky	Evergreen Forest
110004	Maritime Riverine (Tidal), rocky	Evergreen Forest
110004	Maritime Riverine (Tidal), sandy-rocky-organic	Evergreen Forest
110004	Maritime Riverine (Tidal), silty-clayey	Deciduous Forest
110004	Maritime Riverine (Tidal), silty-clayey	Dwarf Shrub
110004	Maritime Riverine (Tidal), silty-clayey	Emergent Herbaceous Wetlands
110004	Maritime Riverine (Tidal), silty-clayey	Evergreen Forest
110004	Maritime Riverine (Tidal), silty-clayey	Graminoid/Herbaceous
110004	Maritime Riverine (Tidal), silty-clayey	Mixed Forest

Appendix 7. Cross-walk between aggregated ecotype code, map strata, and National Land Cover Dataset Landcover Class, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Aggregated Ecotype Code	Map Strata Class[1]	NLCD Landcover Class
110004	Maritime Riverine (Tidal), silty-clayey	Shrub/Scrub
110004	Maritime Riverine (Tidal), silty-clayey	Woody Wetlands
110005	Maritime Coastal, water	Open Water
110010	Maritime Riverine (Tidal), water	Barren Land
110010	Maritime Riverine (Tidal), water	Open Water
120000	Interior Lowland Frozen, ashy-loamy-rocky	Developed
120000	Interior Lowland, ashy-loamy-rocky	Developed
120000	Interior Riverine (Non-glacial), sandy-rocky-organic	Developed
120000	Interior Upland, ashy-loamy-rocky	Developed
120000	Interior Upland, bedrock	Developed
120000	Interior Upland, rocky	Developed
120000	Maritime Coastal, ashy-loamy-rocky	Developed
120000	Maritime Coastal, silty-clayey	Developed
120000	Maritime Lowland, ashy-loamy-rocky	Developed
120000	Maritime Volcanic Lowland, ashy-loamy-rocky	Developed
130000	Maritime Coastal, water	Marine Water
140000	Interior Glacial, water	Open Water
140000	Maritime Glacial, water	Open Water
150000	Interior Lowland, water	Open Water
150000	Maritime Lowland, water	Open Water
150000	Maritime Volcanic Lowland, water	Open Water
160000	Interior Riverine (Glacial), water	Open Water
160000	Maritime Riverine (Glacial), water	Open Water
170000	Interior Riverine (Non-glacial), water	Open Water
170000	Maritime Riverine (Non-glacial), water	Open Water
190000	Interior Subalpine, water	Open Water

[1]Map strata classes are the product of combining the ecoregion, physiography, general texture class, and permafrost layers spatially in ArcGIS

Appendix 8. Cross-walk between abbreviated ecotype and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011.

Abbreviated Ecotype	Aggregated Ecotype Code
Alpine Ashy-Loamy Dwarf Shrub Hummocks	11003
Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	11003
Alpine Ashy-Loamy-Rocky Moist Sedge Meadow	11003
Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	10003
Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	10003
Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	10003
Alpine Gelic Rocky Barrens	10001
Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra	10002
Alpine Gelic Rocky Dwarf Willow Tundra	10002
Alpine Gelic Rocky Lichen Tundra	10001
Alpine Lake	12019
Alpine Loamy-Organic Wet Sedge Meadow	11004
Alpine Rocky Barrens	11001
Alpine Rocky Dwarf Shrub Late-Lying Snowbanks	11005
Alpine Rocky Dwarf Shrub-Lichen Tundra	11002
Alpine Rocky Dwarf Willow Tundra	11002
Alpine Rocky Lichen Tundra	11001
Alpine Spring	12019
Glacial Sandy-Rocky Alder Shrub	30002
Glacial Sandy-Rocky Barrens	30001
Glacier	30003
Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	90002
Interior Lacustrine Ashy-Loamy-Rocky Low Shrub	90002
Interior Lacustrine Loamy-Organic Wet Sedge Meadow	90003
Interior Lacustrine Loamy-Rocky Barrens	NA
Interior Lacustrine Organic-rich Sedge Marsh	90003
Interior Lacustrine Organic-rich Sedge-Shrub Bog	90003
Interior Lowland Ashy-Loamy-Organic Black Spruce Forest	70003
Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	70004
Interior Lowland Ashy-Loamy-Rocky Mixed Forest	70001
Interior Lowland Frozen Loamy-Organic Black Spruce Forest	70008
Interior Lowland Frozen Organic-Rich Dwarf Spruce Forest	70008
Interior Lowland Frozen Organic-Rich Sedge-Shrub Bog	70009
Interior Lowland Organic-Rich Birch-Ericaceous Shrub	70005
Interior Lowland Organic-Rich Wet Sedge Meadow	70007
Interior Riverine Sandy Forb Meadow	100006
Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	100002
Interior Riverine Silty-Sandy-Rocky White Spruce Forest	100005
Interior Subalpine Ashy-Loamy Alder-Willow Shrub	40005
Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	40005
Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	40005
Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	40002
Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	40006
Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub	40008
Interior Subalpine Organic-rich Alder Tall Shrub	40010
Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog	40009
Interior Subalpine Rocky Alder-Willow Shrub	40003
Interior Subalpine Rocky Balsam Poplar Forest	40004
Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	50003
Interior Upland Ashy-Loamy Black Spruce Forest	50005
Interior Upland Ashy-Loamy Mixed Forest	50004
Interior Upland Rocky Alder Shrub	50002
Interior Upland Rocky Birch-Ericaceous Low Shrub	50002
Interior Upland Rocky Mixed Forest	50006

Appendix 8. Cross-walk between abbreviated ecotype and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Abbreviated Ecotype	Aggregated Ecotype Code
Interior Upland Rocky White Spruce Woodland	50007
Lowland Acidic Ashy-Loamy Birch-Poplar Forest	70002
	71002
Lowland Lake	150000
Lowland Organic-Rich Sedge-Shrub Bog	70007
	71004
Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	11003
Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	11003
Maritime Coastal Loamy Saline Wet Sedge Meadow	110004
Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	110004
Maritime Coastal Saline Marestail Ponds and Marshes	110005
Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow	110003
Maritime Coastal Sandy-Rocky Saline Barrens	110001
Maritime Coastal Silty-Clayey Saline Barrens	110002
Maritime Lacustrine Marestail Marsh	NA
Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	71001
Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub	71003
Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	71004
Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	101002
Maritime Riverine Silty-Sandy-Rocky Spruce Forest	101005
Maritime Upland Ashy-Loamy Mixed Low Shrub	51003
Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	51008
Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	51003
Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	51003
Maritime Upland Rocky Alder Shrub	51002
Maritime Upland Sandy-Rocky Alder-Willow Shrub	51002
Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	51010
NA - no plot data	40001
	50001
	51001
	120000
	140000
	190000
Nearshore Water	130000
Riverine Ashy-Loamy-Organic Wet Sedge Meadow	100006
	101006
Riverine Glacial River Water	160000
Riverine Lake Water	180000
Riverine Non-Glacial River Water	170000
Riverine Silty-Sandy-Rocky Barrens	100001
Riverine Silty-Sandy-Rocky Mixed Forest	100004
	101004
Riverine Silty-Sandy-Rocky Poplar Forest	100003
	101003
Tidal River	110010
Upland Ashy-Loamy Birch-Poplar Forest	50010
	51007
Upland Ashy-Loamy-Rocky White Spruce Woodland	50005
	51008
Upland Rocky Birch-Poplar Forest	50011
	51007

Appendix 9. Cross-walk between map ecotype classes and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011.

Map Ecotype	Aggregated Ecotype Code
Alpine Barrens and Lichen Tundra	11001
Alpine Dwarf Shrub Late-Lying Snowbanks	11005
Alpine Gelic Barrens and Lichen Tundra	10001
Alpine Gelic Meadows and Dwarf Shrub	10002
	10003
Alpine Lakes and Springs	12019
Alpine Meadows and Dwarf Shrub	11002
	11003
Alpine Wet Sedge Meadow	11004
Developed Land	120000
Glacial Alder Shrub	30002
Glacial and Non-Glacial River Water	160000
	170000
Glacial Barrens	30001
Glacial Lake	140000
Glaciers and Permanent Snow Fields	30003
Interior Lacustrine Low Shrub-Bluejoint Meadow	90002
Interior Lacustrine Wet Sedge Meadow, Bogs, and Fens	90003
Interior Lowland Birch-Ericaceous Shrub	70004
	70005
Interior Lowland Broadleaf Forest	70002
Interior Lowland Frozen Sedge-Shrub Bog	70009
Interior Lowland Frozen Spruce Forest	70008
Interior Lowland Mixed-Spruce Forest	70001
	70003
Interior Lowland Wet Sedge Meadow and Bog	70007
Interior Riverine Mixed-Spruce Forest	100004
	100005
Interior Subalpine Balsam Poplar Forest	40004
Interior Subalpine Barrens	40001
Interior Subalpine Dwarf Ericaceous Shrub	40002
Interior Subalpine Frozen Birch-Ericaceous Low Shrub	40008
Interior Subalpine Low-Tall Shrub and Graminoid Meadow	40003
	40005
	40010
Interior Subalpine Wet Sedge-Shrub Meadow and Bog	40009
Interior Subalpine White Spruce Woodland	40006
Interior Upland Barrens	50001
Interior Upland Broadleaf Forest	50010
	50011
Interior Upland Low and Tall Shrub	50002
	50003
Interior Upland Mixed-Spruce Forest	50004
	50005
	50006
	50007
Lowland Lake	150000
Maritime Coastal Brackish Ponds and Marshes	110005
Maritime Coastal Meadows	110003
	110004
Maritime Coastal Saline Barrens	110001
	110002
Maritime Lowland Broadleaf Forest	71002
Maritime Lowland Sitka-Lutz Spruce Forest	71001

Appendix 9. Cross-walk between map ecotype classes and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Map Ecotype	Aggregated Ecotype Code
Maritime Lowland Sweetgale-Willow-Ericaceous shrub	71003
Maritime Lowland Wet Sedge Meadow and Bog	71004
Maritime Riverine Mixed-Spruce Forest	101004
	101005
Maritime Upland Barrens	51001
Maritime Upland Broadleaf Forest	51007
Maritime Upland Shrub and Graminoid Meadow	51002
	51003
Maritime Upland Spruce Forest	51008
	51010
Nearshore Water	130000
Riverine Alder-Willow Shrub	100002
	101002
Riverine Barrens	100001
Riverine Lake	180000
Riverine Poplar Forest	100003
	101003
Riverine Wet Sedge-Forb Meadow	100006
	101006
Subalpine Lake	190000
Tidal River	110010

Appendix 10. Cross-walk between soil landscape classes and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011.

Soil Landscape	Aggregated Ecotype Code
Alpine Ashy-Loamy-Rocky Meadows and Shrublands	11003
Alpine Gelic Ashy-Loamy-Rocky Meadows and Shrublands	10003
Alpine Gelic Rocky Barrens and Shrublands	10001
	10002
Alpine Loamy-Organic Wet Sedge Meadows	11004
Alpine Rocky Barrens and Shrublands	11001
	11002
	11005
Developed Land	120000
Glacial Sandy-Rocky Barrens and Shrublands	30001
	30002
Glaciers and Permanent Snow Fields	30003
Interior Lacustrine Ashy-Loamy-Rocky Barrens, Meadows, and Shrublands	90002
Interior Lacustrine Loamy-Organic Wet Meadows, Bogs, and Fens	90003
Interior Lowland Ashy-Loamy-Organic Shrublands and Forests	70001
	70002
	70003
	70004
Interior Lowland Frozen Loamy-Organic Bogs and Forests	70008
	70009
Interior Lowland Organic-Rich Wet Meadows and Shrublands	70005
	70007
Interior Subalpine Ashy-Loamy-Rocky Meadows and Shrublands	40002
	40005
Interior Subalpine Ashy-Rocky-Organic Forests and Shrublands	40006
	40010
Interior Subalpine Frozen Ashy-Rocky-Organic Shrublands	40008
Interior Subalpine Organic-Rich Wet Meadow and Bogs	40009
Interior Subalpine Rocky Barrens, Shrublands, and Forests	40001
	40003
	40004
Interior Upland Ashy-Loamy Shrublands and Forests	50003
	50004
	50005
	50010
Interior Upland Rocky Barrens, Shrublands, and Forests	50001
	50002
	50006
	50007
	50011
Lake Water	12019
	140000
	150000
	180000
	190000
Maritime Coastal Loamy-Organic Brackish Wet Barrens, Meadows, and Marshes	110002
	110004
	110005
Maritime Coastal Sandy-gravelly Barrens and Meadows	110001
	110003
Maritime Lowland Ashy-Loamy Forests	71001
	71002
Maritime Lowland Ashy-Loamy-Organic Meadows and Shrublands	71003
	71004

Appendix 10. Cross-walk between soil landscape classes and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Soil Landscape	Aggregated Ecotype Code
Maritime Upland Ashy-Loamy-Rocky Meadows, Shrublands, and Forests	51003
	51007
	51008
Maritime Upland Rocky Barrens, Shrublands, and Forests	51001
	51002
	51010
Nearshore Water	130000
Riverine Glacial River Water	160000
Riverine Non-Glacial River Water	170000
Riverine Sandy-Rocky-Organic Meadows and Shrublands	100002
	100006
	101002
	101006
Riverine Silty-Sandy-Rocky Barrens and Forests	100001
	100003
	100004
	100005
	101003
	101004
	101005
Tidal River	110010

Appendix 11. Cross-walk between disturbance landscape classes and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011.

Disturbance Landscape	Aggregated Ecotype Code
Avalanche/Mass wasting/Erosion/Flash Floods	40003
	40004
Avalanche/Snow Drifts	40002
	40005
	40010
Avalanche/Snow Drifts/Fire/Spruce Beetle/Wind Throw	40006
Catastrophic drainage/Drying/Paludification	11004
	12019
	40009
	70007
	150000
	190000
Cryoturbation	10002
	10003
	11003
Erosion/Flash Floods	50011
Fire/Spruce Beetle	50002
	50003
	50004
	50005
	50006
	50007
	50010
	70001
	70002
	70003
	70004
Flooding	71002
	170000
Flooding/Glacial Outburst Floods	160000
Flooding/Sedimentation/Erosion/Beaver/Spruce Beetle	100001
	100002
	100003
	100004
	100005
	100006
	101002
	101003
	101004
	101005
	101006
Flooding/Sedimentation/Tapping/Paludification	180000
Lahars and Flash Floods (Volcanic Lahar)	NA
Lake Formation	90003
Landslide/Avalanche/Flash Floods/Tidal Waves	51002
Landslides/Snow drifts	51003
Mass wasting/Avalanche/Wind-scour/Snow Drifts	10001
	11001
	11002

Appendix 11. Cross-walk between disturbance landscape classes and aggregated ecotype code, Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Disturbance Landscape	Aggregated Ecotype Code
Negligible	51007
	70005
	71003
	71004
	90002
	120000
Rockfall/Avalanche	40001
	50001
	51001
Snow Drifts/Cryoturbation	11005
Spruce Beetle/Flooding	71001
Spruce Beetle/Wind Throw	51008
	51010
Surges/Ablation/Mass movement	30001
	30002
	30003
	140000
Thermokarst/Fire/Spruce Beetle	40008
	70008
	70009
Thick Ash/fall and Volcanic Ejecta (All other Volcanic)	NA
Tides and Storms/Ice flows	130000
Tides and Tidal Waves/Storm Surges and Erosion/Glacial Rebound	110001
	110002
	110003
	110004
Tides and Tidal Waves/Storm Surges/Flooding	110005
	110010

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011.

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Alpine	Alpine Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Ash-laden Loess, Colluvial fan deposit	Ashy, Rubbly	Acidic	Well drained	Ericaceous Dwarf Shrub Tundra, Cassiope Dwarf Shrub Tundra	Cassiope stelleriana-Luetkea pectinata
	Alpine Ashy-Loamy-Rocky Moist Sedge Meadow	Volcanic-pyroclastics	Pumiceous	Acidic	Well drained	Moist Sedge Meadow Tundra	Carex microchaeta-Luzula sp.
	Maritime Alpine Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Hillside Colluvium, Volcanic-pyroclastics	Ashy, Rubbly	Acidic, Circumneutral	Well drained	Ferns, Bluejoint-Herb, Fireweed	Calamagrostis canadensis-Angelica lucida
	Maritime Alpine Ashy-Loamy-Rocky Dwarf Vaccinium Tundra	Ash-laden Loess, Hillside Colluvium, Volcanic-pyroclastics	Ashy, Rubbly, Pumiceous	Acidic	Well drained	Vaccinium Dwarf Shrub Tundra	Vaccinium uliginosum-Carex microchaeta
	Alpine Ashy-Loamy Dwarf Shrub Hummocks	Ash-laden Loess	Ashy	Acidic, Circumneutral	Moderately well drained, Well drained	Cassiope Dwarf Shrub Tundra	Cassiope stelleriana-Luetkea pectinata
	Alpine Gelic Ashy-Loamy Dwarf Shrub Hummocks	Ash-laden Loess	Ashy	Acidic, Circumneutral	Well drained	Ericaceous Dwarf Shrub Tundra, Bluejoint Meadow	Vaccinium uliginosum-Carex microchaeta, Salix reticulata-Carex podocarpa
	Alpine Gelic Ashy-Loamy-Rocky Dwarf Ericaceous-Lichen Tundra	Ash-laden Loess, Ash-rich Colluvium, Undifferentiated Bedrock, Drumlins, Hillside Colluvium, Older Moraine, Older Till	Ashy, Rubbly, Gravelly, Blocky, Bouldery	Circumneutral, Acidic	Well drained, Somewhat excessively drained, Moderately well drained, Somewhat poorly drained	Ericaceous Dwarf Shrub Tundra, Cassiope Dwarf Shrub Tundra, Crowberry Dwarf Shrub Tundra, Ericaceous Dwarf Shrub–Lichen Tundra	Empetrum nigrum-Cladina sp., Cassiope stelleriana-Luetkea pectinata, Betula nana-Ledum decumbens-Cladina sp., Vaccinium uliginosum-Carex microchaeta,
	Alpine Gelic Ashy-Loamy-Rocky Moist Sedge Meadow	Ash-laden Loess, Hillside Colluvium, Till Sheet	Ashy, Rubbly	Acidic	Moderately well drained, Well drained	Moist Sedge–Shrub Tundra, Moist Sedge Meadow Tundra	Carex bigelowii-Dryas integrifolia, Carex microchaeta-Luzula sp.
	Alpine Gelic Rocky Barrens	Talus	Blocky	Circumneutral	Excessively drained	Partially Vegetated	Dryas integrifolia-Oxytropis nigrescens

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Alpine	Alpine Gelic Rocky Dwarf Shrub-Lichen Tundra	Bedrock, weathered or residual	Blocky	Acidic	Somewhat excessively drained	Dryas-Lichen Dwarf Shrub Tundra	Dryas integrifolia-Oxytropis nigrescens
	Alpine Gelic Rocky Dwarf Willow Tundra	Alluvial Fan Inactive Deposit, Solifluction Deposit	Gravelly, Rubbly	Circumneutral, Acidic	Excessively drained, Well drained	Willow Dwarf Shrub Tundra	Salix rotundifolia-Carex microchaeta, Salix reticulata-Carex podocarpa
	Alpine Gelic Rocky Lichen Tundra	Ash-laden Loess, Colluvial Deposit, Hillside Colluvium, Igneous Bedrock, Intrusive – mafic, Older Moraine, Older Till	Ashy, Blocky, Rubbly	Circumneutral, Acidic,	Well drained, Excessively drained, Somewhat excessively drained	Lichen, Crustose Lichen, Foliose and Fruticose Lichen,	Cladina arbuscula - Cladina stellaris, Umbilicaria sp.-Rhizocarpon geographicum-Hierochloe alpina
	Alpine Rocky Dwarf Shrub Late-Lying Snowbanks	Solifluction Deposit	Ashy	Circumneutral	Well drained	Willow Dwarf Shrub Tundra	Salix rotundifolia-Carex microchaeta
	Alpine Rocky Dwarf Shrub-Lichen Tundra	Colluvial Deposit	Rubbly, Blocky	Acidic	Somewhat excessively drained, Well drained	Dryas-Lichen Dwarf Shrub Tundra, Dryas Dwarf Shrub Tundra,	Dryas integrifolia-Cladina sp., Dryas integrifolia-Oxytropis nigrescens, Dryas integrifolia-Oxytropis nigrescens
	Alpine Rocky Dwarf Willow Tundra	Avalanche Deposit	Rubbly	Acidic	Somewhat excessively drained	Willow Dwarf Shrub Tundra	Salix rotundifolia-Carex microchaeta
	Alpine Rocky Lichen Tundra	Ash-laden Loess, Talus	Ashy, Blocky	Circumneutral	Well drained, Excessively drained	Foliose and Fruticose Lichen	Cladina arbuscula - Cladina stellaris, Umbilicaria sp.-Rhizocarpon geographicum-Hierochloe alpina
	Alpine Loamy-Organic Wet Sedge Meadow	Organic Fen, Till Sheet	Peat, Ashy	Acidic, Circumneutral	Very poorly drained, Somewhat poorly drained	Wet Sedge Meadow Tundra	Carex aquatilis-Salix fuscescens, Carex bigelowii-Dryas integrifolia

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Coastal	Maritime Coastal Silty-Clayey Saline Barrens	Active Tidal Flat	Gravelly, Loamy	Brackish	Very poorly drained, Somewhat poorly drained	Partially Vegetated, Halophytic Grass Wet Meadow, saline, Halophytic Sedge–Grass Wet Meadow, saline	Puccinellia phryganodes-Triglochin maritimum
	Maritime Coastal Loamy-Organic Brackish Wet Sedge-Grass Meadow	Active Tidal Flat, Inactive Tidal Flat	Ashy, Clayey, Loamy, Organic-rich	Brackish, Circumneutral, Acidic, Saline,	Moderately well drained, Somewhat poorly drained, Very poorly drained, Poorly drained	Halophytic Grass Wet Meadow, brackish, Halophytic Sedge Wet Meadow, Bluejoint-Herb, Halophytic Sedge Wet Meadow, brackish, Halophytic Sedge–Grass Wet Meadow, brackish,	Leymus mollis-Plantago maritime, Carex ramenskii-Triglochin maritimum, Carex lyngbyaei-Cicuta mackenzieana, Carex glareosa-Carex lyngbyaei-Potentilla egedii, Calamagrostis canadensis-Carex sp.
	Maritime Coastal Loamy Saline Wet Sedge Meadow	Active Tidal Flat, Inactive Tidal Flat	Clayey, Loamy	Brackish, Saline	Very poorly drained, Somewhat poorly drained, Moderately well drained, Poorly drained	Halophytic Sedge Wet Meadow, Halophytic Sedge Wet Meadow, saline, Halophytic Sedge Wet Meadow, brackish,	Carex ramenskii-Triglochin maritimum,
	Maritime Coastal Saline Marestail Marsh	Brackish Shallow Lake, Isolated	Loamy, Water	Saline, Brackish	Very poorly drained, Flooded	Four-leaf Marestail	Hippuris tetraphylla-Potamogeton sp.
	Maritime Coastal Sandy-Rocky Saline Barrens	Active Marine Beach, Active Tidal Flat	Sandy	Alkaline, Circumneutral	Excessively drained, Well drained	Partially Vegetated	Honckenya peploides-Stellaria humifusa
	Maritime Coastal Sandy-Rocky Beachgrass-Forb Meadow	Active Marine Beach, Coastal Active Dune, Coastal Inactive Dune, Coastal Inactive Dune, Volcanic-pyroclastics	Gravelly, Sandy, Ashy	Acidic, Circumneutral, Alkaline,	Somewhat excessively drained, Excessively drained, Well drained	Elymus, Mixed Herbs, Bluejoint-Herb	Leymus mollis-Lathyrus maritimus
Glaciated	Glacial Sandy-Rocky Alder Shrub	Ice-cored Glacial Moraine	Blocky, Bouldery	Acidic	Well drained, Moderately well drained	Open Tall Alder	Alnus crispa-Dryopteris dilatata

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Glaciated	Glacial Sandy-Rocky Barrens	Younger Moraine	Blocky	Circumneutral	Excessively drained	Partially Vegetated	Umbilicaria sp.-Rhizocarpon geographicum-Hierochloe alpina
Lacustrine	Interior Lacustrine Ashy-Loamy-Rocky Bluejoint Meadow	Lacustrine Deposit	Ashy, Loamy	Acidic	Well drained, Moderately well drained	Bluejoint Meadow, Moist Graminoid Meadow	Calamagrostis canadensis-Carex sp.
	Interior Lacustrine Ashy-Loamy-Rocky Low Shrub	Lacustrine Deposit	Gravelly	Circumneutral	Moderately well drained	Open Low Willow	Salix sp.-Calamagrostis canadensis
	Interior Lacustrine Loamy-Organic Wet Sedge Meadow	Braided Abandoned Overbank Deposit, Lacustrine Deposit	Peat, Organic-rich	Circumneutral, Acidic	Flooded, Poorly drained	Wet Sedge–Grass Meadow Tundra, Wet Sedge Meadow Tundra	Calamagrostis canadensis-Carex sp., Carex saxatilis-Carex aquatilis
	Interior Lacustrine Organic-rich Sedge Marsh	Lacustrine Deposit, Organic Fen, Shallow Isolated Lake,	Peat, Water	Acidic	Flooded, Very poorly drained	Fresh Sedge Marsh	Carex utriculata-Eriophorum angustifolium, Carex limosa-Menyanthes trifoliata
	Interior Lacustrine Organic-rich Sedge-Shrub Bog	Bogs, Organic Fen	Peat	Acidic, Circumneutral	Very poorly drained	Subarctic Lowland Sedge Bog Meadow, Subarctic Lowland Sedge-Moss Bog Meadow	Carex limosa-Salix fuscescens, Andromeda polifolia-Drosera rotundifolia-Sphagnum, Carex aquatilis-Salix fuscescens-Sphagnum sp.
	Interior Lacustrine Loamy-Rocky Barrens	Lacustrine Deposit	Bouldery	Circumneutral	Somewhat poorly drained	Wet Bryophyte	Juncus arcticus-Equisetum sp.
	Maritime Lacustrine Marestail Marsh	Brackish Shallow Lake, Isolated	Water	Acidic	Flooded	Common Marestail	Hippuris vulgaris-Sparganium angustifolium
Lowland	Interior Lowland Ashy-Loamy-Organic Black Spruce Forest	Ash-laden Loess, Loess, Older Till	Ashy, Organic-rich, Rubbly	Acidic	Moderately well drained, Well drained	Open Black Spruce Forest, Black Spruce Woodland	Picea mariana-Ledum decumbens-Cladina arbuscula

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Lowland	Interior Lowland Ashy-Loamy-Rocky Mixed Forest		Blocky, Loamy	no data	Moderately well drained, Poorly drained, Somewhat excessively drained, Well drained	Closed Spruce–Paper Birch, Open Spruce–Paper Birch, Open Paper Birch–Balsam Poplar–Spruce, Open Spruce-Balsam Poplar Forest	Picea glauca-Betula papyrifera var. kenaica, Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata, Picea glauca-Populus trichocarpa-Viburnum edule
	Interior Lowland Ashy-Loamy-Rocky Birch-Ericaceous Shrub	Ash-laden Loess	Ashy, Loamy	Circumneutral, Acidic	Well drained, Somewhat poorly drained	Open Low Mesic Shrub Birch-Ericaceous Shrub, Open Low Shrub Birch-Ericaceous Shrub Bog	Betula glandulosa-Ledum decumbens-Cladina sp.
	Lowland Acidic Ashy-Loamy Birch-Poplar Forest	no data	Blocky, Loamy, Rubbly	no data	Well drained, Moderately well drained, Somewhat excessively drained, Somewhat poorly drained	Open Black Cottonwood Forest, Open Balsam Poplar Forest, Open Paper Birch, Open Paper Birch–Balsam Poplar	Populus trichocarpa-Alnus sinuate, Populus balsamifera-Salix alaxensis, Populus trichocarpa-Viburnum edule, Betula papyrifera var. kenaica-Ledum decumbens,
	Interior Lowland Frozen Loamy-Organic Black Spruce Forest	Ash-laden Loess, Bogs, Glaciofluvial Outwash, Lowland Retransported Deposit	Ashy, Peat	Acidic	Well drained, Moderately well drained, Somewhat poorly drained,	Open Black Spruce Forest, Black Spruce Woodland	Picea mariana-Ledum decumbens-Cladina arbuscula, Picea mariana-Ledum decumbens-Sphagnum sp.,
	Interior Lowland Frozen Organic-Rich Dwarf Spruce Forest	Bogs	Peat	Acidic	Poorly drained	Dwarf Black Spruce Woodland	Picea mariana-Ledum decumbens-Sphagnum sp.
	Interior Lowland Frozen Organic-Rich Sedge-Shrub Bog	Lowland Polygon Bog	Peat	Acidic	Very poorly drained	Subarctic Lowland Sedge-Moss Bog Meadow	Betula nana-Ledum decumbens-Sphagnum sp.
	Interior Lowland Organic-Rich Birch-Ericaceous Shrub	Bogs, Glaciofluvial Outwash, Lowland Glaciolacustrine Deposit, Lowland Headwater Floodplain, Older Moraine	Peat, Organic-rich	Acidic, Circumneutral	Very poorly drained, Somewhat poorly drained, Flooded, Poorly drained	Open Low Mesic Shrub Birch-Ericaceous Shrub, Open Low Shrub Birch-Willow, Closed Low Shrub Birch–Ericaceous Shrub, Open Low Ericaceous Shrub Bog	Betula nana-Ledum decumbens-Sphagnum sp., Betula glandulosa-Ledum decumbens-Sphagnum sp., Myrica gale-Salix pulchra-Calamagrostis canadensis, Andromeda polifolia-Drosera rotundifolia-Sphagnum

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Lowland	Interior Lowland Organic-Rich Wet Sedge Meadow	Bogs, Lowland Headwater Floodplain, Meander Abandoned Overbank Deposit, Organic Fen	Peat, Organic-rich	Acidic, Circumneutral	Very poorly drained, Flooded	Subarctic Lowland Sedge-Moss Bog Meadow, Subarctic Lowland Sedge-Shrub Wet Meadow, Wet Sedge Meadow Tundra, Subarctic Lowland Sedge Wet Meadow	Carex limosa-Salix fuscescens, Carex aquatilis-Salix fuscescens
	Lowland Organic-Rich Sedge-Shrub Bog	Alluvial Fan Abandoned Deposit, Bogs	Organic-rich, Peat	Acidic	Very poorly drained	Subarctic Lowland Sedge-Moss Bog Meadow, Subarctic Lowland Sedge-Shrub Wet Meadow	Carex limosa-Salix fuscescens-Sphagnum sp., Andromeda polifolia-Drosera rotundifolia-Sphagnum, Carex aquatilis-Salix fuscescens-Sphagnum sp.
	Maritime Lowland Ashy-Loamy Sitka-Lutz Spruce Forest	Active Marine Beach, Fluvial, Undifferentiated	Ashy, Clayey	Circumneutral	Moderately well drained	Open Sitka Spruce Forest, Lutz Spruce Woodland	Picea × lutzii-Leymus mollis-Lathyrus maritimus, Picea × lutzii-Oplopanax horridus
	Maritime Lowland Ashy-Loamy-Organic Sweetgale-Willow-Ericaceous shrub	Abandoned Tidal Flat, Braided Abandoned Overbank Deposit, Inactive Tidal Flat	Organic-rich, Peat, Loamy, Ashy	Acidic, Brackish, Circumneutral	Very poorly drained, Poorly drained, Somewhat poorly drained	Open Low Sweetgale-Graminoid Bog, Open Low Willow, Open Tall Willow, Open Low Sweetgale–Graminoid Shrub Meadow (slightly brackish)	Myrica gale-Salix fuscescens-Carex lyngbyaei, Myrica gale-Salix pulchra-Calamagrostis canadensis,
	Maritime Lowland Organic-Rich Wet Sedge-Grass Meadow	Abandoned Tidal Flat, Alluvial Fan Abandoned Deposit, Bogs, Inactive Tidal Flat	Organic-rich, Peat	Circumneutral, Acidic	Very poorly drained	Subarctic Lowland Graminoid–Herb Wet Meadow, Bluejoint Meadow, Subarctic Lowland Sedge-Moss Bog Meadow, Halophytic Sedge Wet Meadow, brackish	Calamagrostis canadensis-Carex sp.
Riverine	Riverine Lake Water	Shallow Connected Riverine Lake	Water	Circumneutral	Flooded	Fresh Water	Carex saxatilis-Carex aquatilis

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Riverine	Interior Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Headwater Inactive Overbank Deposit	Gravelly, Bouldery, Loamy, Sandy	Circumneutral	Poorly drained, Somewhat excessively drained, Moderately well drained, Well drained	Open Low Willow, Open Tall Alder-Willow, Closed Tall Alder-Willow, Closed Tall Willow, Open Tall Willow, Closed Low Willow, Closed Tall Alder, Open Tall Alder	Salix alaxensis-Angelica lucida, Alnus sinuata-Salix alaxensis, Salix sp.-Calamagrostis canadensis, Myrica gale-Salix pulchra-Calamagrostis canadensis, Salix alaxensis-Alnus tenuifolia, Populus balsamifera-Alnus sp.
	Maritime Riverine Sandy-Rocky-Organic Alder-Willow Shrub	Alluvial Fan Coarse Active Channel, Alluvial Fan Fine-grained Inactive Channel, Braided Active Overbank Deposit, Braided Coarse Active Channel Deposit, Braided Inactive Overbank Deposit	Gravelly, Sandy, Bouldery	Acidic, Circumneutral	Moderately well drained, Well drained, Somewhat poorly drained, Very poorly drained	Open Tall Alder, Closed Tall Alder, Open Tall Alder-Willow, Open Low Willow–Graminoid Shrub Bog	Picea × lutzii-Alnus crispa, Alnus crispa-Dryopteris dilatata, Alnus crispa-Epilobium latifolium, Salix sp.-Calamagrostis canadensis
	Riverine Ashy-Loamy-Organic Wet Sedge Meadow	Alluvial Fan Overbank Deposit, Braided Overbank Deposit, Delta Inactive Overbank Deposit, Meander Inactive Overbank Deposit	Loamy, Ashy, Organic-rich	Circumneutral,	Flooded, Very poorly drained,	Fresh Sedge Marsh, Wet Graminoid Meadow, Wet Sedge Meadow Tundra	Carex lyngbyaei-Cicuta mackenzieana, Calamagrostis canadensis-Carex sp., Carex saxatilis-Carex aquatilis, Carex utriculata-Eriophorum angustifolium
	Riverine Silty-Sandy-Rocky Barrens	Alluvial Fan Coarse Active Channel, Braided Active Overbank Deposit	Gravelly, Sandy, Bouldery	Acidic, Circumneutral	Well drained, Very poorly drained, Moderately well drained	Partially Vegetated, Wet Bryophyte, Fireweed, Partially Vegetated	Epilobium latifolium, Juncus arcticus-Equisetum sp., Epilobium latifolium, Alnus crispa-Epilobium latifolium
	Riverine Silty-Sandy-Rocky Poplar Forest	Alluvial Fan Coarse Active Channel, Alluvial Fan Coarse Inactive Channel, Alluvial Fan Overbank Deposit, Braided Inactive Overbank Deposit, Moderately Steep Headwater Channel Deposit	Gravelly, Sandy, Bouldery	Circumneutral, Acidic	Well drained, Poorly drained, Moderately well drained, Excessively drained, Somewhat excessively drained	Balsam Poplar Woodland, Open Black Cottonwood Forest, Open Balsam Poplar Forest	Populus balsamifera-Viburnum edule, Populus trichocarpa-Oplopanax horridus, Populus balsamifera-Alnus sp., Populus trichocarpa-Alnus sinuata

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Riverine	Riverine Silty-Sandy-Rocky Mixed Forest	Moderately Steep Headwater Channel Deposit	Gravelly, Loamy, Sandy	Acidic	Well drained, Moderately well drained	Open Spruce-Balsam Poplar Forest, Open Spruce–Paper Birch, Spruce–Paper Birch Woodland, Open Paper Birch–Balsam Poplar–Spruce, Closed White Spruce–Paper Birch–Balsam Poplar	Picea glauca-Populus balsamifera-Viburnum edule, Picea glauca-Populus trichocarpa-Viburnum edule, Picea glauca-Betula papyrifera var. kenaica
	Interior Riverine Silty-Sandy-Rocky White Spruce Forest	Meander Inactive Overbank Deposit	Loamy, Sandy	Circumneutral	Poorly drained, Well drained	White Spruce Woodland, Open White Spruce Forest	Picea glauca-Alnus sp.
	Maritime Riverine Silty-Sandy-Rocky Spruce Forest	Alluvial Fan Inactive Deposit	Gravelly	Acidic	Poorly drained	Open Lutz Spruce	Picea × lutzii-Vaccinium ovalifolium
Subalpine	Interior Subalpine Ashy-Loamy Bluejoint-Forb Meadow	Ash-laden Loess, Hillside Colluvium	Ashy, Rubbly, Loamy	Acidic	Well drained, Moderately well drained	Fireweed, Mixed Herbs, Bluejoint Meadow, Bluejoint-Herb	Calamagrostis canadensis-Angelica lucida
	Interior Subalpine Ashy-Loamy-Rocky Dwarf Ericaceous Shrub	Ash-laden Loess, Glaciofluvial Outwash Channel Deposit, Older Till, Glaciofluvial Outwash Channel Deposit	Ashy, Bouldery	Circumneutral, Acidic	Well drained, Moderately well drained	Crowberry Dwarf Shrub Tundra	Empetrum nigrum-Cladina sp.
	Interior Subalpine Ashy-Loamy Alder-Willow Shrub	Ash-laden Loess, Ash-rich Colluvium, Hillside Colluvium, Upland Retransported Deposit	Ashy, Loamy	Acidic	Well drained, Moderately well drained	Closed Tall Alder, Open Low Willow–Graminoid Shrub Bog, Closed Low Willow	Alnus crispa-Dryopteris dilatata, Salix sp.-Calamagrostis canadensis
	Interior Subalpine Ashy-Loamy-Rocky Birch-Ericaceous Low Shrub	Ash-laden Loess, Ash-rich Colluvium, Hillside Colluvium	Ashy, Rubbly, Blocky	Acidic	Well drained	Closed Low Shrub Birch–Ericaceous Shrub, Open Low Mesic Shrub Birch-Ericaceous Shrub	Betula nana-Ledum decumbens-Cladina sp., Betula glandulosa-Ledum decumbens-Cladina sp.

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Subalpine	Interior Subalpine Organic-rich Alder Tall Shrub	Hillside Colluvium	Organic-rich, Peat	Acidic	Well drained	Closed Tall Alder, Closed Tall Alder-Willow	Alnus crispa-Dryopteris dilatata
	Interior Subalpine Ashy-Rocky-Organic White Spruce Woodland	Ash-laden Loess	Ashy, Organic-rich	Acidic	Well drained	White Spruce Woodland	Picea glauca-Vaccinium uliginosum-Sphagnum sp.
	Interior Subalpine Frozen Organic-Rich Birch-Ericaceous Low Shrub	Bogs	Peat	Acidic	Somewhat poorly drained	Open Low Mesic Shrub Birch-Ericaceous Shrub	Betula nana-Ledum decumbens-Sphagnum sp.
	Interior Subalpine Organic-Rich Wet Sedge-Shrub Meadow and Bog		Organic-rich		Poorly drained, Somewhat poorly drained, Very poorly drained	Wet Sedge–Willow Tundra	Carex aquatilis-Salix fuscescens-Sphagnum sp.
	Interior Subalpine Rocky Alder-Willow Shrub	Alluvial Fan Inactive Deposit, Avalanche Deposit, Colluvial fan deposit	Bouldery, Rubbly, Blocky	Acidic	Well drained	Open Tall Willow, Closed Tall Alder, Closed Low Willow	Salix alaxensis-Angelica lucida, Alnus crispa-Dryopteris dilatata
	Interior Subalpine Rocky Balsam Poplar Forest	Alluvial Fan Inactive Deposit	Bouldery	Circumneutral	Well drained	Open Balsam Poplar Forest	Populus balsamifera-Salix alaxensis
Upland	Interior Upland Ashy-Loamy Birch-Ericaceous Low Shrub	Ash-laden Loess, Loess, Older Moraine, Older Till	Ashy, Organic-rich	Acidic	Somewhat excessively drained, Well drained	Open Low Mesic Shrub Birch-Ericaceous Shrub, Open Low Shrub Birch-Willow, Closed Low Shrub Birch–Ericaceous Shrub	Betula glandulosa-Ledum decumbens-Cladina sp., Betula nana-Ledum decumbens-Cladina sp., Betula glandulosa-Ledum decumbens-Sphagnum sp.

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Upland	Interior Upland Ashy-Loamy Mixed Forest	Ash-laden Loess	Ashy, Blocky, Loamy	Acidic	Well drained, Moderately well drained	Open Quaking Aspen Forest, Open Quaking Aspen–Spruce, Open Spruce-Balsam Poplar Forest, Open Spruce–Paper Birch, Spruce–Aspen Woodland, Spruce–Paper Birch Woodland	Picea glauca-Populus tremuloides-Cornus canadensis, Picea mariana-Populus tremuloides-Vaccinium vitis-, Picea glauca-Betula papyrifera var. kenaica, Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata
	Interior Upland Ashy-Loamy Black Spruce Forest	Ash-laden Loess, Eolian Inactive Sand Dune, Older Moraine	Ashy, Rubbly	Acidic, Circumneutral	Well drained, Excessively drained, Somewhat excessively drained	Black Spruce Woodland, Open Black Spruce Forest	Picea mariana-Ledum decumbens-Cladina arbuscula, Picea mariana-Ledum decumbens-Sphagnum sp.
	Upland Ashy-Loamy Birch-Poplar Forest	Alluvial Fan Abandoned Deposit, Volcanic-pyroclastics	Bouldery, Ashy, Loamy	Circumneutral, Acidic	Well drained, Moderately well drained, Somewhat excessively drained	Open Balsam Poplar Forest, Balsam Poplar Woodland, Closed Paper Birch, Open Paper Birch,	Populus balsamifera-Alnus sp., Populus balsamifera-Viburnum edule, Betula papyrifera var. kenaica-Ledum decumbens, Populus trichocarpa-Viburnum edule, Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata
	Upland Ashy-Loamy-Rocky White Spruce Woodland	Ash-laden Loess, Hillside Colluvium, Older Till, Younger Moraine	Organic-rich, Ashy, Loamy	Acidic	Well drained, Excessively drained, Moderately well drained	White Spruce Woodland, Open Spruce–Paper Birch,	Picea glauca-Alnus sp., Picea glauca-Ledum decumbens, Picea glauca-Betula nana-Sterocaulon sp.
	Interior Upland Rocky Alder Shrub	no data	Blocky, Rubbly	no data	Moderately well drained, Well drained	Closed Tall Alder-Willow, Open Tall Alder	Alnus sinuata-Dryopteris dilatata
	Interior Upland Rocky Birch-Ericaceous Low Shrub	no data	Blocky, Rubbly	no data	Moderately well drained, Somewhat excessively drained, Well drained	Open Low Mesic Shrub Birch-Ericaceous Shrub, Open Low Shrub Birch-Willow	Betula nana-Ledum decumbens-Cladina sp., Betula glandulosa-Ledum decumbens-Cladina sp.

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Upland	Interior Upland Rocky Mixed Forest	no data	Blocky, Sandy	no data	Well drained, Moderately well drained	Open Spruce-Balsam Poplar Forest, Open Spruce–Paper Birch, Spruce–Paper Birch Woodland	Picea glauca-Populus trichocarpa-Viburnum edule, Picea glauca-Betula papyrifera var. kenaica
	Interior Upland Rocky White Spruce Woodland	Younger Moraine	Rubbly, Blocky, Sandy	Circumneutral	Excessively drained, Moderately well drained, Somewhat excessively drained, Well drained	White Spruce Woodland	Picea glauca-Betula nana-Sterocaulon sp., Picea glauca-Ledum decumbens, Picea glauca-Alnus sp.
	Upland Rocky Birch-Poplar Forest	Alluvial Terrace, Meander Inactive Overbank Deposit	Sandy, Gravelly, Sandy	Circumneutral	Moderately well drained, Well drained, Somewhat excessively drained	Balsam Poplar Woodland, Open Black Cottonwood Forest, Open Paper Birch	Populus balsamifera-Alnus sp., Populus trichocarpa-Oplopanax horridus, Betula papyrifera var. kenaica-Ledum decumbens, Betula papyrifera var. kenaica-Alnus sinuata-Dryopteris dilatata,
	Maritime Upland Ashy-Loamy-Rocky Bluejoint-Forb Meadow	Ash-laden Loess, Volcanic-pyroclastics	Ashy, Rubbly	Acidic	Well drained	Bluejoint-Herb, Mixed Herbs, Moist Graminoid Meadow	Calamagrostis canadensis-Angelica lucida
	Maritime Upland Ashy-Loamy-Rocky Alder-Willow Shrub	Alluvial Fan, Ash-laden Loess, Ash-rich Colluvium, Volcanic-pyroclastics	Ashy, Pumiceous, Rubbly	Acidic, Circumneutral	Well drained, Moderately well drained	Closed Tall Alder, Open Low Willow, Open Tall Alder, Closed Low Willow, Open Tall Willow, Open Low Alder	Alnus crispa-Dryopteris dilatata, Salix sp.-Calamagrostis canadensis
	Maritime Upland Ashy-Loamy Mixed Low Shrub	Ash-laden Loess	Ashy	Acidic	Moderately well drained, Well drained	Closed Low Salmonberry, Open Low Vaccinium Shrub	Rubus spectabilis-Oplopanax horridus, Vaccinium ovalifolium-Oplopanax horridus
	Maritime Upland Ashy-Loamy Sitka-Lutz Spruce Forest	Ash-laden Loess	Ashy, Loamy	Acidic	Moderately well drained, Well drained	Open Lutz Spruce, Open White Spruce Forest, White Spruce Woodland	Picea × lutzii-Oplopanax horridus

Appendix 12. Landscape relationships for ecotypes in Lake Clark National Park and Preserve, Alaska, 2011 (continued).

Physiography	Abbreviated Ecotype	Geomorphic Unit	Soil Texture	Soil-Water Chemistry	Drainage	VegetationTypes (Level IV)	Floristic Class
Upland	Maritime Upland Rocky Alder Shrub	Ash-rich Colluvium, Bedrock, weathered, Hillside Colluvium	Blocky, Rubbly	Acidic	Well drained	Closed Tall Alder	Alnus crispa-Dryopteris dilatata
	Maritime Upland Sandy-Rocky Alder-Willow Shrub	Abandoned Marine Beach, Fluvial, Undifferentiated, Volcanic-pyroclastics	Ashy, Bouldery, Sandy	Circumneutral, Acidic	Well drained	Open Tall Willow, Open Low Alder–Willow, Closed Tall Alder, Open Tall Alder	Salix sp.-Calamagrostis canadensis, Alnus crispa-Epilobium latifolium, Alnus sinuata-Dryopteris dilatata, Alnus crispa-Dryopteris dilatata
	Maritime Upland Sandy-Rocky Sitka-Lutz Spruce Forest	Abandoned Marine Beach, Coastal Inactive Dune, Inactive Marine Beach	Sandy	Acidic, Circumneutral	Somewhat excessively drained, Well drained	Open Lutz Spruce, Mixed Herbs, Elymus, Open White Spruce Forest	Picea × lutzii-Oplopanax horridus, Picea × lutzii-Leymus mollis-Lathyrus maritimus

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