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Natural Resource Stewardship and Science

Ecological Land Survey and Soil Landscapes Map for Aniakchak National Monument and Preserve, Alaska, 2014

Natural Resource Report NPS/ANIA/NRR—2016/1133

ON THIS PAGE
Top: Field team for the Aniakchak National Monument and Preserve Ecological Land Survey and Soil Landscape mapping project in 2014. Left to right, Gerald "JJ" Frost, Aaron Wells, Tracy Christopherson, and Ellen Trainor. Photography by Jairus Duncan.
Bottom: Vulcan Dome and volcanic springs near the headwaters of Surprise Lake below the rugged walls of Aniakchak Caldera. Photography by Tracy Christopherson.

ON THE COVER
Left: Tracy Christopherson describing soils amongst the beach rye and seaside ragwort at Aniakchak Bay. Photography by Gerald V. Frost.
Right, top: Meshik Lake below the weathered peaks and ridges of Pinnacle Mountain. Photography by Tracy Christopherson.
Right, bottom: Black Nose (foreground, right) and Surprise Lake (background) in Aniakchak Caldera. Photography by Gerald V. Frost.

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Contents

Contents (continued)

Contents (continued)

Page

Figures

Figures (continued)

Tables

Page

Tables (continued)

Tables (continued)

Page

Tables (continued)

Tables (continued)

Page

Tables (continued)

Page

Tables (continued)

Page

Appendices

How to Use this Ecological Land Survey and Mapping Product

Overview

An Ecological Land Survey (ELS) and land classification, in conjunction with a land-cover 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 to land resources. This section provides guidance on how to use this ELS and associated map products.

Purpose and Limitations

The purpose of an ELS is to classify and describe (with the support of field data) local-scale (thousands of square meters to hundreds of hectares) ecosystems while simultaneously informing the analysis and mapping of ecosystem components at the landscape scale (hundreds of hectares 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 in the products derived from where the two spatial scales overlap. Depending on the objectives of the end user, the two are often used in conjunction with one another.

This ELS provides 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 short sampling period, and the overall remote and diverse character of Aniakchak National Monument and Preserve (ANIA) resulted in a low sample size for some vegetation types, soils, and ecosystems. Therefore, the classification of ecotypes should not be considered exhaustive of the possible vegetation and soil types in ANIA. 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 ANIA, 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 and wildlife habitat), broad-scale management and planning, and development of stratified sampling designs for landscape-scale inventory and monitoring studies. Applications for which ELS mapping is not appropriate include site-specific management, planning, analysis, and study design. An Integrated Terrain Unit (ITU) approach (Jorgenson et al. 2003, Wells et al. 2012) to mapping geomorphology, soils, vegetation, and ecotypes is better suited for these finer-scale applications.

Guidelines for Use

Guidelines for two likely scenarios for using this ELS and associated mapping products are provided below. In both scenarios it is assumed that the researcher(s) has basic knowledge of common plant species in ANIA and soil sampling and GIS techniques. Additionally, the researcher(s) should use the Alaska Natural Heritage Program ANIA report entitled *Plant Associations, Vegetation Succession, and Earth Cover Classes* by Boucher et al. (2012) to supplement this document as needed.

Classification and Mapping: Field Applications

Under the first scenario, land managers and/or researchers are interested in classifying ecotypes and are either in the field in ANIA collecting data or in the office reviewing field data. If in the field, first locate a relatively homogeneous patch of vegetation with a suggested minimum area ranging between 314 m^2 (the area of an ELS plot) to 1,000 m^2 (one-tenth of one hectare) that is obviously associated with a specific landform or slope position. Landforms are any physical, recognizable form or feature on the earth's surface with a characteristic shape and range in composition that is created by natural processes (Schoenberger and Wysocki 2002).

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 Physiography and Ecotype Keys (see Figure 3 and Table 5, respectively) and follow the instructions 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 4, which provides a cross-walk between ecotypes (abbreviated and full), plant communities, and Viereck et al. (1992) Level IV vegetation classes included in each ecotype;
- Tables 2 and 138, which provide descriptions of generalized soil texture classes (used in the ecotype names) and soil subgroups described in the ecotype descriptions, respectively;
- Table 134, which provides a cross-walk between abbreviated ecotype names, Map Ecotype classes (see Figure 19), Soil Landscape classes (see Figure 20), and Disturbance Landscape classes (see Figure 21).
- Refer to the Plant Associations section beginning on page 53 of Boucher et al. (2012) for descriptions of plant associations mentioned in the ecotype descriptions.

The ecotype descriptions, descriptive tables of ecotype components (e.g., generalized soil texture classes), and ecotype key provide valuable information for classifying and describing ecotypes in the field and in the office from field data. Additionally, the Ecotype, Soil Landscape, and Disturbance Landscape maps in conjunction with the crosswalk in Appendix 4 and Table 134 provide the user with the spatial context of each ecotype in ANIA as it relates to the above three maps. The crosswalks also 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 Ecotype, Soil Landscape, and Disturbance Landscapes maps are provided below:

A. Use the Ecotype Key (Table 5) to determine the ecotype (e.g., Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub);
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 1 and 138, and Figures 10–13 for detailed information regarding the soil and environmental characteristics of the ecotype;
D. Refer to Table 134 and locate the ecotype name of interest in the list (e.g., Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub);
E. Follow the crosswalk in Table 134 to determine the Map Ecotype (e.g., Alpine Moist Crowberry Dwarf Shrub), Soil Landscape (e.g., Alpine Rocky Barrens and Dwarf Shrub), and Disturbance Landscape (e.g., Mass wasting and Landslide, Avalanche) classes within which the ecotype was aggregated for mapping. Additionally, Table 134 allows the user to see the other ecotypes aggregated with the ecotype of interest into each map class (e.g., Mass Wasting and Landslide, Avalanche).

Classification and Mapping: Office Applications

In the second scenario, ANIA land managers and/or researchers are in the office and are interested in the location of specific park resources (e.g., soils) in designing a landscape-scale management plan; a stratified sample design for inventory and monitoring; or in conducting 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, which include printed (see Figures 17–21) and digital (ArcGIS geodatabase) versions. The base maps, including Physiography (Figure 17) and Land Cover (Figure 18) represent useful stand-alone products that may be used in conjunction with one another. For more information regarding these map products the user is directed to 1) the results section for each base map (see Results: Ecosystem Mapping), and 2) Boucher et al. (2012) and USFWS (2007) for the Land Cover mapping.

The ecotype map (Figure 19) was 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). The map ecotypes were then aggregated into classes with similar soils (termed Soil Landscapes) and similar disturbance pathways (termed Disturbance Landscapes) to create the Soil Landscapes (Figure 20) and Disturbance Landscapes (Figure 21) maps. Users of these aggregated maps are directed to:

- The results section for each aggregated map (see Results: Ecosystem Mapping)
- Tables 132–133 and 135–137, which provide summaries of the areal extent of each map unit within each respective map;
- Table 134, which provides a cross-walk between abbreviated ecotype names, Map Ecotype classes (see Figure 19), Soil Landscape classes (see Figure 20), and Disturbance Landscape classes (see Figure 21);
- Appendix 4, which provides a cross-walk

between the land cover classes and the map ecotype classes;

- 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 Ecotype, Soil Landscape, and Disturbance Landscape maps in conjunction with the ecotype classification are provided below.

A. Refer to the Ecotype, Soil Landscape, or Disturbance Landscape maps (Figures 19–21) and choose the map class of interest (e.g., Map Ecotype "Alpine Dry Barrens");

B. Refer to Table 134 and locate the map class of interest in the sorted list;

C. Follow the crosswalk in Table 134 to determine the abbreviated ecotype names (e.g., Alpine Rocky Dry Barrens, Alpine Rocky-Ashy Moist Bryophyte) that were aggregated into the map class, and the Soil Landscape (e.g., Alpine Rocky Barrens and Dwarf Shrub), and Disturbance Landscape (e.g., Mass Wasting and Landslide, Avalanche) class within which the Map Ecotype was aggregated.

Refer to the Ecotype descriptions (see Results: Ecotypes and Plant Associations, below), Soil Landscape descriptions (see Results: Soil Landscapes), Tables 1 and 138, and Figures 10–13 for information regarding general environment, vegetation, and soils of the ecotypes and soil landscapes identified in Step C, above.

Executive Summary

This study was conducted to inventory and classify soils and vegetation within the ecosystems of Aniakchak National Monument and Preserve using an ecological land survey (ELS) approach. The classifications identified by the ELS were then mapped across the park, using an archive of Geographic Information System (GIS) and Remote Sensing (RS) datasets pertaining to land cover, topography, and glacial history. The description and mapping of the landform-vegetation-soil relationships identified by the ELS offers tools to support the design and implementation of future field- and RS-based studies; facilitates further analysis and contextualization of existing data; and informs natural resource management decisions.

We collected information on the geomorphic, topographic, hydrologic, pedologic, and vegetation characteristics of ecosystems within a network of 294 field plots, of which 90 were sampled by us in 2014, and 204 were sampled by the Alaska Natural Heritage Program (AKNHP) and NPS in 2009–2010. The plot network encompassed all of the major environmental gradients and landscape histories present in ANIA. Individual state-factors (e.g., soil pH, slope-aspect) and other ecosystem components (e.g., geomorphic unit, vegetation species-cover data) were measured or categorized using standard classification schemes developed for Alaska. We described and analyzed the hierarchical relationships among the ecosystem components to classify 48 ecotypes (local-scale ecosystems) that best partition the variation in soils, vegetation, and disturbance properties observed at field plots. From the 48 ecotypes, we developed classifications of soil landscapes and disturbance landscapes that could be mapped across the park.

Detailed soil descriptions for the 294 field plots pertained to 7 soil orders: Alfisols (<1% of plots), Andisols (49%), Entisols (24%), Histosols (6%), Inceptisols (17%), Mollisols (2%), and Spodosols (2%). Within these 7 soil orders, field plots corresponded to a total of 63 soil subgroups, the most common of which were Typic Vitricryands, Eutric Duricryands, Humic Vitricryands, Vitrandic Cryorthents, Vitrandic Cryofluvents, and Aquandic Cryaquents.

At the landscape scale (hundreds of hectares to thousands of square kilometers), soil formation in ANIA is driven in large measure by proximal distance to the active Aniakchak volcano. The 10 km diameter Aniakchak caldera, and it's steep tephra-covered slopes, are the result of a massive eruption ca. 3,590 cal yr B.P. (Bacon 2014). There is no portion of ANIA that in some way has not been influenced by volcanism. Yet the magnitude of that volcanic influence on soil development decreases with distance, on a generalized continuum from southwest to northeast. The Andisol soil order dominates the landscape in the western portion of ANIA, in areas surrounding the caldera. This is particularly true, in the older, more developed, pyroclastic flow deposits that blanket most river valleys within a 40 km radius of Surprise Lake. To the north and east of the Aniakchak caldera, the steep, rounded peaks of the Aleutian Mountains dominate the skyline. The accumulation rates of tephra in the Aleutian Mountains, are typically insufficient to support the development of Andisols. Soils here are relatively diverse when compared to western portions of ANIA, supporting the development of Entisols, Inceptisols, Spodosols, and Mollisols.

The field data, the classifications of ecotypes and soil landscapes, a pre-existing land-cover map developed by AKNHP, and ancillary GIS and RS data were used to produce a series of ecosystem maps for ANIA. Eight physiographic units capturing broad-scale divisions in landscape position, microclimate, and other state-factors were mapped using a combination rule-based modeling related to topography and surficial geology. The ecotypes classified using field data were aggregated into a reduced set of map ecotypes that could be mapped across the study domain; aggregation was based on similarities in vegetation structure, general soil texture, and successional processes. The map ecotypes were further organized into 26 soil landscape and 15 disturbance landscape classes. The most widespread soil landscapes include Alpine Rocky Barrens and Dwarf Shrub (29.6% of mapping area excluding Marine Water), Upland Ashy-Loamy-Rocky Forb Meadows and Alder Tall Shrub (21.2%), Volcanic Rocky Barrens, Lichen, and Beach Rye (13.8%), Upland Ashy-Rocky Barrens and Dwarf Shrub (11.9%), and Upland Ashy-Sandy-Rocky Willow Low and Tall Shrub (10.7%). The disturbance landscapes were derived from map ecotypes with broadly similar disturbance regimes. The most common disturbance landscape was Mass Wasting and Landslide (42.4% of mapping area excluding Marine Water). This disturbance landscape is associated with steep mountainsides that are common across the park, which are commonly affected by active hillslope processes.

The ELS approach to understanding landscape processes, their influence on ecosystem functions, and the environments in which they operate provides several benefits. First, landscapes are analyzed as ecological systems with function-

ally-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 ecosystem components into ecotypes with co-varying properties, allows users to partition the variability of a wide range of ecological characteristics. Additionally, the linkage of the land-cover map to climatic, physiographic, topographic, and volcanic history variables to develop ecosystem maps improves our ability to predict the susceptibility and response of ANIA ecosystems to a range of human impacts and natural forcings. It also facilitates the production of a variety of thematic maps for resource management applications and analyses.

Acknowledgements

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Glossary

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.

Acidic—soils with a pH value ≤5.5 in the upper 40 cm of the soil profile.

Alkaline—soils with a pH value >7.3 in the upper 40 cm of the soil profile.

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

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 p. 15 (Diagnostic Soil Characteristics for Mineral Soils: Andic Soil Properties) in Soil Survey Staff (2010) for more details.

Ash—tephra deposits whose intermediate axis measures 2 mm or less, which coincides with the size class requirements for soil particles (Schoenberger and Wysocki 2002).

Blocks—a volcanic pyroclast ejected in a solid state; having a diameter greater than 64 mm (Neuendorf et al. 2011).

Bombs—a volcanic pyroclast ejected while viscous and shaped while in flight. It is larger than 64 mm in diameter, and may be vesicular to hollow inside. Actual shape or form varies greatly (Neuendorf et al. 2011).

Brackish—soils with an electrical conductivity (EC) >800 μ and <16,000μ in the upper 40 cm of the soil profile.

Base Saturation—the relative availability of cations, calculated from cation exchange capacity.

Cations—positively charged soil particles (e.g., Ca, Mg, K, Na and H).

Cation Exchange Capacity—describes the holding capacity of a particular soil for positively-charged elements (i.e., cations).

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.

Circum-acidic—soils with a pH value of approximately 5.6–6.6 in the upper 40 cm of the soil surface.

Circum-alkaline—soils with a pH value of approximately 6.7–7.3 in the upper 40 cm of the soil profile.

Circum-neutral—soils that span the pH range of circum-acidic and circum-alkaline (5.6–7.3).

Coarse ash—pyroclastic ejecta that ranges in size from 0.06 mm (very fine sand) to 2.00 mm (coarse sand).

Cryic—soil temperature regime that occurs in cold-temperate climates. Soils in the cryic temperature regime have a mean annual soil temperature of 0–8°C at 50 cm depth 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.

Fine ash—pyroclastic ejecta that ranges in size from 0.01 mm (clay) to 0.05 mm (coarse silt).

Folistic epipedon—an accumulation of organic material at the surface that is ≥15 cm thick and is not saturated for 30 or more cumulative days in a normal growing season. Folistic epipedons often occur on stable slopes or well-drained glaciofluvial deposits in forested plant communities.

Halophyte—a plant adapted to living in a saline environment

Hemic—organic soil materials in an intermediate state of decomposition, more advanced than fibric soil materials, but less than sapric soil materials. The source of the organic material and the plant life-form from which it was derived remain identifiable, but species distinctions can no longer be made. Abbreviated as "Oe" in soil horizon descriptions.

Histic epipedon—an accumulation of organic material at the surface that is ≥20 cm and is saturated for ≥30 cumulative days in a normal growing season. Histic epipedons primarily occur on poorly drained soils in bogs and fens, but in temperate climates, may also form on steep mountain slopes on top of bedrock, or on late snowbed nivation hollows.

Ignimbrite—The deposit of a pyroclastic flow. Non-welded ignimbrites are distinct from their welded counterparts in both outcrop appearance and microscopic texture. The appearance will consist of pumice fragments and small, sparse lithic fragments, in a fine-grained matrix of lapilli and ash. Welded ignimbrite is the result of thick, hot ignimbrites that collapsed under their own weight and fused fragments together in a welded flow.

Lapilli—pyroclastic coarse fragments ranging in size from 2–64 mm (Neuendorf et al. 2011).

Little Ice Age—period of moderate global cooling that began approximately 500 years ago and ended approximately 160 years ago, during which time glaciers advanced in high-latitude regions of the world (Dahms 2002).

Mollic epipedon—a surface horizon of mineral soil that is dark colored and relatively thick, contains at least 5.8 g kg-1 organic carbon, is not massive, and hard or very hard when dry, has a base saturation >50% (Neuendorf et al. 2011).

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

Ordination—a statistical technique in which data from a large number of sites or populations are represented as points in a two- or three-dimensional coordinate frame.

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).

Podzolization—a process of soil formation especially in humid regions involving organic complexes contributing to the leaching of iron or alumina into subsurface horizons. This process contributes to the formation of Spodosol soil orders.

Pyroclastic Flow—a densely flowing current of pyroclastic material, usually very hot and composed of a mixture of gases and particles (Neuendorf et al. 2011).

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).

Saline—soils with an electrical conductivity (EC) >16,000µ in the upper 40 cm of the soil profile.

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.

Tephra—a general term used to describe volcanic ejecta of any size.

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 temperate climates. A udic soil moisture regime is one in which the upper meter of soil remains moist to wet throughout the growing season.

Vitric—ash particles that are typically coarse-ash grain size (0.062–2 mm) and have a 1500 kPa water retention of 15 percent or less on air-dried samples (Soil Survey Staff 2010).

Volcaniclastic—pertaining to all clastic volcanic materials formed by any process of fragmentation, dispersed by any kind of transporting agent, deposited in any environment, or mixed in any significant portion with nonvolcanic fragments (Neuendorf et al. 2011).

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.

Acronyms and Abbreviations

ABC—Alaska Beget Consulting

ABR—ABR, Inc. Environmental Research and Services

AKAP—Alaska High Altitude Photography Program

AKNHP—Alaska Natural Heritage Program

ALA—Herbarium at the University of Alaska Fairbanks

Al—aluminium

ANIA—Aniakchak National Monument and Preserve

AVC—Alaska Vegetation Classification

C—carbon

CEC—cation exchange capacity

CIR—color infrared

CIR—Colorado State University

EC—electrical conductivity

DEM—Digital Elevation Model

DU—Ducks Unlimited

ELS—Ecological Land Survey

Fe—iron

GIS—Geographic Information System

GPS—Geographic Positioning System

IDW—Inverse Distance Weighting

ITU—Integrated Terrain Unit

I&M—Inventory and Monitoring

KEFJ—Kenai Fjords National Park

LACL—Lake Clark National Park and Preserve

LIA—Little Ice Age

LOI—loss on ignition

N—nitrogen

NIR—near infrared

NLCD—National Land Cover Database

NMDS—Non-metric Multidimensional Scaling

NPS—National Park Service

NRCS—Natural Resource Conservation Service

PAM—Partitioning Around Medoids

PDS—Permanent Data Set

QAQC—Quality Assurance and Quality Control

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

RS—remote sensing

SRTM—Shuttle Radar Topography Mission

Si—silicon

SWAN—Southwest Alaska Network of National Parks

UAF—University of Alaska Fairbanks

USFWS—United States Fish and Wildlife Service

V—Verification

Introduction

To obtain information on baseline conditions and promote understanding of long-term changes in landscape characteristics and processes in Aniakchak National Monument and Preserve (ANIA), the National Park Service (NPS) has developed Inventory and Monitoring (I&M) programs for vegetation, terrestrial wildlife, fish, weather, and coastal and glacial processes. These programs help the NPS to detect natural changes in ecosystem structure and function; determine the role that human activities (e.g., introduction of invasive species, land disturbances) and large-scale forces (e.g., climate change, glacial dynamics, volcanism, wildfire) play in the changes observed; and inform predictions of future ecosystem trajectories. The I&M programs also help the NPS focus their efforts in managing and protecting park resources for the future. Soils provide fundamental controls on landscape and vegetation dynamics by greatly influencing plant community structure and composition, successional processes, food web dynamics, and a host of other ecosystem functions, and are therefore a key component of the I&M 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 classify and map soils and vegetation in ANIA.

The structure, function, and distribution of ecosystems are regulated largely along complex environmental gradients of energy, moisture, nutrients, and disturbance. These gradients are affected by many physical and biological landscape components, including climate, physiography, geomorphology, soils, hydrology, vegetation, and animals, which are collectively 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 classify and map local-scale ecosystems (ecotypes) in ANIA (Figure 1). We then integrated information from the ecotype classification with ancillary datasets to map soil landscapes across ANIA.

An ecological land classification also involves organizing ecosystem 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). Local-scale features (e.g., geomorphic units, vegetation) are nested hierarchically within landscape- and regional-scale components, (e.g., physiography and climate). At the global scale, climate—particularly temperature and precipitation—accounts for most of the variation and zonation of ecosystem structure and function (i.e., biomes) (Walter 1979, Vitousek 1994, Bailey 1998). Within a given climatic zone, landscape physiography (i.e., characteristic surficial materials, topography, disturbance regime, and microclimate) controls the rates and spatial arrangements of geomorphic processes and energy flow. These processes result in the formation of geomorphic units with characteristic lithologies, soil textures, and surface forms, which in turn affect soil properties and the movement of water (Wahrhaftig 1965, Swanson et al. 1988, Bailey 1996). The movement of water through soil strongly influences both plant water balance and the availability of nutrients, and is therefore a critical factor in determining the distribution and characteristics of vegetation (Fitter and Hay 1987, Oberbauer et al. 1989). Finally, vegetation provides habitat structure and energy that affect the distribution of many wildlife species. The interacting processes that operate across these ecosystem components at various spatio-temporal scales can also promote disturbances that greatly influence ecosystem development and succession (Watt 1947, Pickett et al. 1989, Walker and Walker 1991, Forman 1995). For example, the highly active tectonic and volcanic setting of the Alaska Peninsula has resulted in frequent and sometimes catastrophic disturbance events, such as explosive eruptions, pyroclastic flows, ashfall, and outburst floods, that have shaped the landscapes and ecosystems of ANIA.

To implement the ecological land classification, we used a hierarchical approach to mapping landscape-soil-vegetation relationships that incorporates readily mapped and/or modeled landscape features, including physiography, surface form (primarily slope characteristics), geomorphic unit, and vegetation. The hierarchical mapping approach, along with analysis of field data, allows for the classification and mapping of an enhanced set of ecotypes (local-scale ecosystems) and soil landscapes from existing land cover maps. This integrated approach has several benefits. First, it incorporates the important effects of geomorphic processes on natural disturbance regimes (e.g., landslides, channel migration) and the flow of energy and material. Second, it captures the diversity of environmental characteristics within the classification. Finally, it uses a systematic approach to classify landscape features for applied analyses across a range of spatial scales (patch to local to regional). For example, we can overlay spatial data regarding surficial and bedrock

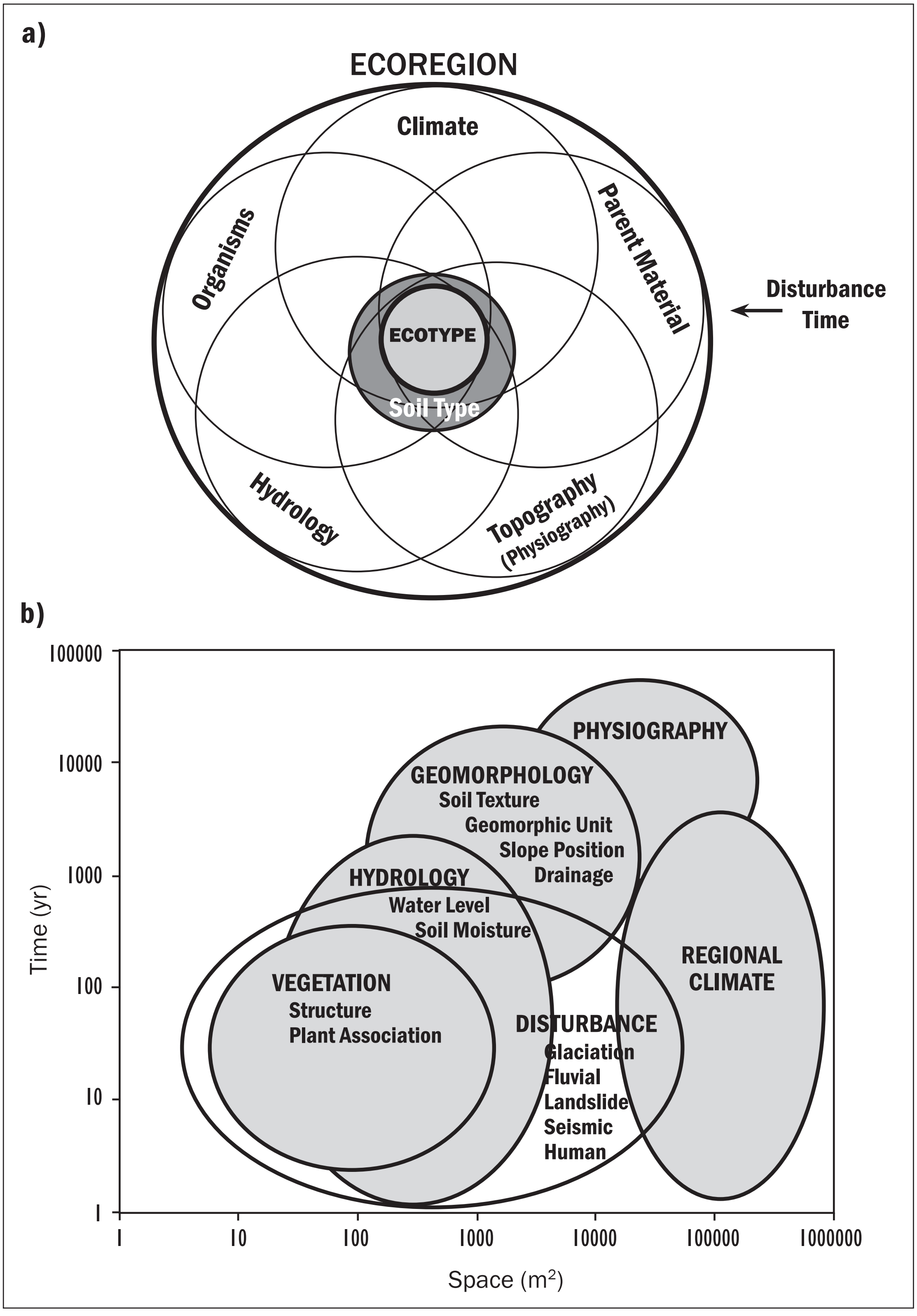


Figure 1. Interaction of interrelated state factors that control the structure and function of ecosystems (a) and the scale at which they operate (b).

geology over an existing land cover map to distinguish vegetation communities that were previously unmapped. To demonstrate an application of this approach, we analyzed the relationships among soils and ecotypes, and used these relationships to develop maps of soil and disturbance landscapes as part of the ANIA study effort. 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. Additionally, the maps provide information that can support the design and implementation of a range of field- and remote-sensing based natural resources studies, as well as provide important context and a basis for stratification during subsequent data analysis.

This report summarizes the results of an ELS to classify and map the ecosystems and soils of ANIA. We first compiled existing field-based vegetation and soils data, as well as ancillary Geographic Information System (GIS) and remote sensing (RS) environmental datasets from a variety of sources to develop a preliminary spatially-explicit conceptual model of soils in ANIA and identify data gaps. We then used the conceptual model to develop a stratified, gradient-oriented sampling scheme to collect field verification data in July 2014. We used our field verification data, in combination with field data collected by Alaska Natural Heritage Program (AKNHP) (Boucher et al. 2012) and a landcover map produced by the U.S. Fish and Wildlife Service (USFWS) and Ducks Unlimited (DU) (USFWS 2007) to create a soils map, following the soil landscape approach used by Jorgenson et al. for Wrangell-St. Elias National Park and Preserve (2008) and the Arctic Network of National Parks (Jorgenson et al. 2009). This approach included incorporating historical glacier extents, several additional existing GIS and RS data layers, rule-based modeling, and the analysis of geomorphology-soils-vegetation relationships. Specific objectives of this project were to:

1. Compile pre-existing data to prepare a conceptual soils model and identify data gaps;
2. Conduct field inventories of vegetation, soils and environmental characteristics in ANIA;
3. Analyze the comprehensive terrain-soil-vegetation dataset to classify ecotypes based on vegetation characteristics and relationships among ecosystem components;
4. Classify soil types based on field soil profile descriptions and laboratory analysis;
5. Develop maps using an existing land cover map, ABR's field data, ancillary datasets, and rule-based modeling;
6. Synthesize the results of the ELS and mapping for map users.

Study Area

ANIA is located on the eastern portion of the Alaska Peninsula, approximately 200 km southwest of King Salmon and 650 km southwest of Anchorage. ANIA is one of the most remote parklands in the United States; the nearest inhabited places are the native villages of Port Heiden on the Bering Sea coast, and Chignik on the Pacific coast. The ELS and mapping study area included the full legislative extent of ANIA, including the National Monument, National Preserve, and private inholdings. Additionally, to provide spatial context for soil, vegetation, and other ecosystem properties in peripheral portions of ANIA, the mapping area includes a 1.6 km buffer area surrounding the parkland boundary. The mapping area excluded marine waters, but included inland and estuarine waterbodies; the mapping area totals 2,731.3 km^2 (Figure 2).

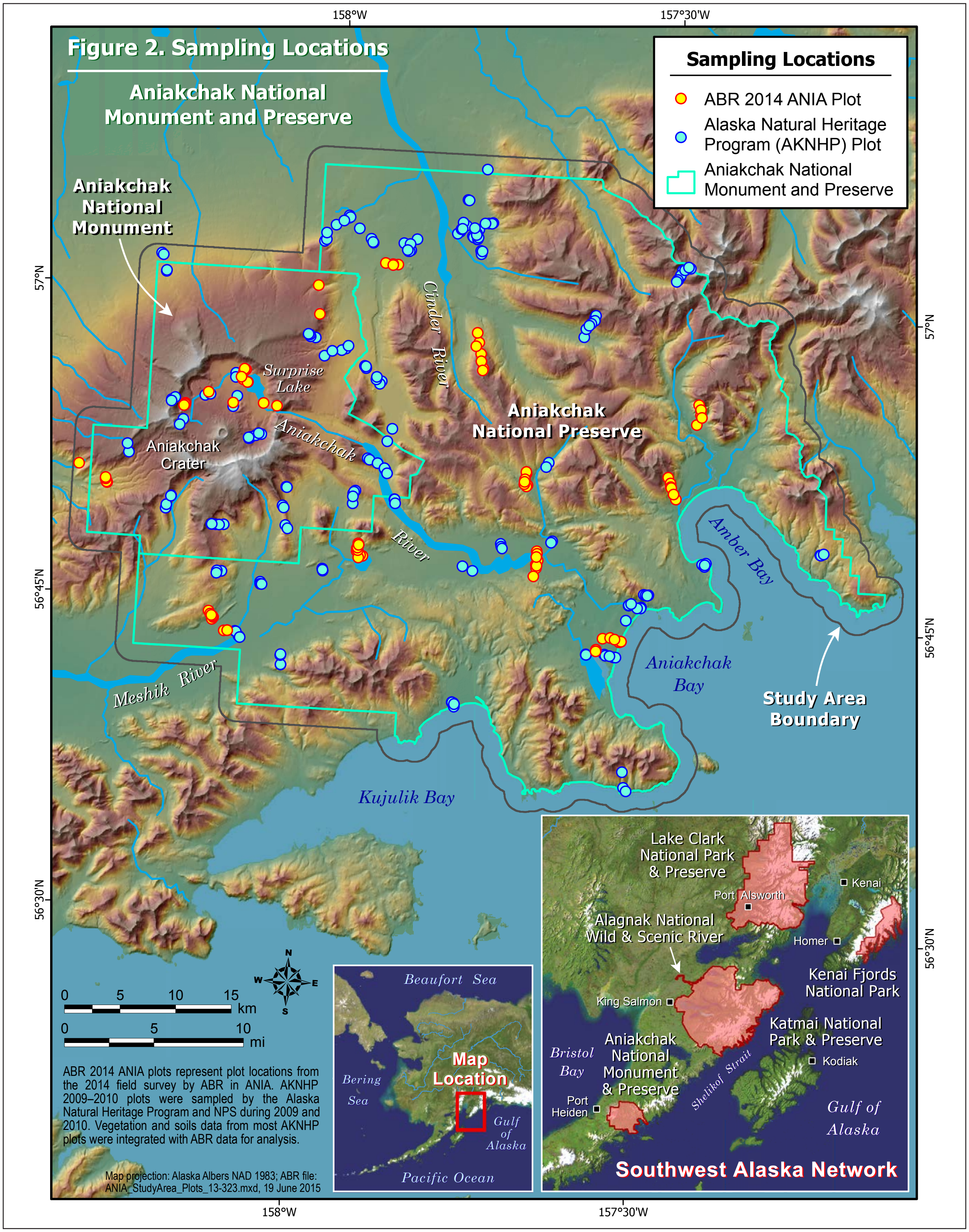


Figure 2. Sampling locations and study area boundary for the ecological land survey and soil landscapes mapping for Aniakchak National Monument and Preserve (ANIA), southwest Alaska.

Methods

Field Surveys

We sampled a total of 14 transects (toposequences) across ANIA during 16–21 July 2014. Field surveys were based out of Carol's Bed and Breakfast in Port Heiden, Alaska (AK), which served as a base for field crews returning from the field each evening. Field crews were deployed to field transects via R44 helicopter each morning where they traversed each transect by foot. Crews were picked up each evening at the transect end point and returned to Port Heiden. Transect locations were selected using a gradient-directed sampling scheme (Austin and Heyligers 1989) to gather the range of ecological conditions present within ANIA, and to provide the spatially-related data needed to interpret ecosystem and soils development. Transects were stratified within the major geologic units, physiographic units, vegetation types, elevation gradients, and volcanic histories that occur within ANIA.

We collected data at 74 Full Plots and 16 Verification (V) Plots for a total of 90 plots along the 14 transects. At each plot, environmental, vegetation, and soils attributes were described and measured; the data were recorded using proprietary digital data forms on ruggedized, GPS-enabled tablet computers. Three digital data forms were used, including 1) the ELS form for general environment and soil data, 2) the VEG form for vegetation composition and structure data, and 3) the SOIL_HORIZON form for detailed soil stratigraphic descriptions. Each digital data form featured built-in data dictionaries to enforce consistent data collection across multiple observers. At Full Plots we collected the complete suite of ELS and VEG data variables listed in Appendix 1. At V-Plots we collected a reduced set of ELS and VEG variables (Appendix 1); these plots were designed to maximize efficiency in the field while simultaneously collecting the most salient variables required for ecotype and soil classification.

All field plots were circular in shape with an approximate radius of 10 m, and were situated entirely within a single distinct vegetation type or photo-signature identified on satellite imagery. The plot center was established intuitively by the field crew leader in a homogeneous patch of vegetation that was at least ½ ha in area, and away from transitional areas between distinct vegetation types (ecotones). Plot locations were marked on high-resolution satellite imagery, and geospatial coordinates (i.e., latitude/longitude) and approximate elevations were recorded using a DeLORME Earthmate PN-60 recreation-grade GPS unit (accuracy ±3 m). A series of digital photographs were taken at each plot, including representative landscape- and ground cover views, and photos of the soil pit face.

We sampled soils using a combination of 1) field measurements of general physical and chemical soils characteristics recorded in the ELS form, 2) stratigraphic descriptions at both Full and Partial soil pits collected in the SOIL_HORIZON form, and 3) laboratory analysis of soil samples (see below). Detailed soil stratigraphic descriptions are time consuming to complete and, given the short duration of the field trip, a hybrid approach was required. Using this approach allowed us to maximize efficiency in the field while capturing the maximum amount of soils information in a short amount of time. The general soils attributes were collected at all plots and were selected because they represent soils information that is important for soil taxonomy and classification of ecotypes but that is rapid to collect. For instance, the surface organic mat thickness combined with soil moisture and depth to saturated soil are important criteria for determining if a soil has a histic epipedon. Soil stratigraphic descriptions at Partial soil pits are rapid to sample and provide more detail about a soil profile while allowing flexibility to complete some descriptors opportunistically. For instance, if a soil profile has a dark surface horizon that might meet the criteria for a mollic or umbric epipedon, which have specific color and base saturation requirements, then soil color would be described and a soil sample analyzed for base saturation. Soil stratigraphy descriptions at Full soil pits provide the most detailed soils information but require the most time to complete. We focused on sampling complete soil stratigraphy for soils that were representative of common ecosystems in ANIA.

Data on soils were collected from shallow soil pits (40–50 cm deep). General soils data collected in the ELS form at Full and Verification Plots are listed in Appendix 1 by Plot Type, and include those Data Attributes that begin with the "soil_" prefix. Soil stratigraphic descriptions were collected at 15 Full and 57 Partial soil pits. Appendix 1 lists the soil stratigraphic Data Attributes collected at both Full and Partial soil pits. Soil descriptions followed standard Natural Resources Conservation Service (NRCS) protocols (USDA NRCS 2007, Schoenberger et al. 2012), with the exception of the depth requirements of soil pits. Soils were classified to the subgroup level using the 11th edition of the Keys to Soil Taxonomy (Soil Survey Staff 2010). In stratified soils (e.g., floodplains), individual strata were grouped into broader horizons and denoted as such with notes describing the interbedded soil materials. Buried organic horizons ≥0.50 cm thick were designated as unique horizons, while those horizons <0.50 cm thick were grouped with adjacent mineral soils with descriptive notes included.

Vegetation composition and structure data were collected semiquantitatively. At all plots we visually estimated the live cover of all vascular and non-vascular plants present. In the event that we were unable to estimate cover for all species (e.g., early arrival of helicopter due to inclement weather) the plot flagged with a veg_completeness_code of "partial" (p). At full plots we estimated the percent cover of each plant growth form (e.g., needleleaf tree, tall shrub, low shrub, forb, moss, etc.) independently from the individual species cover estimates. Cover was estimated to the nearest 1% for species or growth forms with <10% cover, and to the nearest 5% for species or growth forms with 10–100% cover. Isolated individuals or species with very low cover were assigned a "trace" cover value of 0.1%. The independent estimate of cover by structure class was used for data quality assurance and control (QAQC) review in the office to check for gross errors in cover estimates and help reconcile potential inconsistencies between observers. A complete list of vegetation composition and structure attributes collected in the VEG form is provided in Appendix 1. Taxonomic nomenclature was based on Viereck and Little (2007) for trees and shrubs, Skinner et al. 2012 for grasses, and Hultén (1968) for all other vascular taxa. Voucher specimens were collected for species that were difficult to identify in the field; these were subsequently identified by Carolyn Parker at the University of Alaska Museum of the North Herbarium (ALA) in Fairbanks, AK. Nomenclature for bryophytes (mosses and liverworts) and lichens followed the National Plants Database (USDA NRCS 2015). Identification of bryophytes and lichens during field sampling was generally limited to dominant, readily-identified species. Dominant non-vascular species that we could not identify with confidence in the field were collected and sent to the Komarov Botanical Institute in St. Petersburg, Russia. Comprehensive lists of vascular and non-vascular plant species identified in ANIA are shown in Appendix 2. All plant specimens have been returned to the NPS.

Supplementary Field Data

We supplemented our field dataset with ground-based vegetation and soils data collected by AKNHP and NPS personnel in 2009–2010. This dataset was originally used to generate a vegetation classification and to assess the accuracy of a pre-existing vegetation map for ANIA (see GIS and Remote Sensing Data Compilation, below). The field data were collected using sampling protocols and metrics that were comparable to our methods. A comprehensive description of AKNHP field methods can be found in Boucher et al. (2012).

The AKNHP field dataset complemented our own field dataset by expanding the spatial distribution of field plots and providing a greater sample size. The AKNHP dataset consists of 204 field plots, of which all 204 plots had sufficient data for use in this study. We extracted data from the AKNHP database, recoded those data to our standard classification and coding system, and populated 44 data attributes in the ABR ANIA database (Table 1). AKNHP field photos and locations were used to assist in the data extraction and recoding process. We standardized the vegetation datasets by creating a crosswalk between the vascular plant taxonomy used in the AKNHP vegetation dataset and the taxonomic names in our dataset. The standardized vegetation and site data for the 204 AKNHP plots were pooled with vegetation and soils data from the 90 ABR plots from July 2014, providing a total of 294 plots for the ecotype analysis and classification of soil landscapes.

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 of the measured biophysical components.

Ecological Components

Geomorphic units were classified according to a system based on landform-soil relationships for Alaska, originally developed by Kreig and Reger (1982) 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 and Wysocki (2002). Microtopography was classified according to the periglacial system of Washburn (1973). Vegetation was generally classified in the field to the Alaska Vegetation Classification (AVC) (Viereck et al 1992) Level IV vegetation class. Plant associations were classified following the "Key to Plant Associations" in Boucher et al. (2012).

Ecotypes

We classified ecotypes using a three-step process: (1) the ecological components were individually classified for each

Table 1. Listing of ABR data attributes extracted from the Alaska Natural Heritage Program ANIA field database from Boucher et al. (2012) for use in classifying and mapping ecotypes and soils in Aniakchak National Monument and Preserve, Alaska, 2014.

ABR Database Table	ABR Database Column	AKNHP Database Table	AKNHP Database Column	ABR Notes
els	aspect_degrees	TBL_SITE	Aspect_Tru	
els	env_field_note	TBL_SITE	General_Soil_Comment	
els	final_elevation_m	TBL_SITE	altitude	
els	physiography_code	TBL_SITE	Physiography	
els	plot_id	TBL_SITE	Transect	
els	site_chemistry_code_calc	TBL_SoilProfile	pH	
els	site_ph_calc	TBL_SoilProfile	pH	
els	slope_degrees	TBL_SITE	Slope_deg	
els	soil_class_code	TBL_SoilProfile	all fields	in addition soil related fields in TBL_SITE and photos were used to classify soil subgroups
els	soil_dominant_mineral_code_40cm	TBL_SoilProfile	TextureUnder2mm, CourseFragmentPctVol	in addition soil photos were used to populate this data attribute
els	soil_dominant_texture_code_40cm	TBL_SoilProfile	TextureUnder2mm, CourseFragmentPctVol	in addition soil photos were used to populate this data attribute
els	soil_lithic_ynu_code	TBL_SoilProfile	Horizon	in addition soil photos were used to populate this data attribute
els	soil_moisture_code	TBL_SITE	SoilMoisture	
els	soil_observed_maximum_depth_cm	TBL_SITE	HoleDepth	
els	soil_rock_depth_probe_cm	TBL_SoilProfile	CourseFragmentPctVol	in addition soil photos were used to populate this data attribute
els	soil_root_depth_cm	TBL_SITE	CommonRootsDepth	
els	soil_surface_organic_thick_cm	TBL_SoilProfile	Horizon	
els	water_above_below_surface_code	TBL_SITE	WaterTableDepth	
els	water_depth_cm	TBL_SITE	WaterTableDepth	in addition soil photos were used to populate this data attribute
soil_horizon	bottom_depth_cm	TBL_SoilProfile	Depth_range	
soil_horizon	horizon_code	TBL_SoilProfile	Horizon	
soil_horizon	horizon_number	TBL_SoilProfile	Depth_order	
soil_horizon	horizon_ph	TBL_SoilProfile	pH	
soil_horizon	redox_soil_color_chroma_code	TBL_SoilProfile	MottleHueValueChroma	

Table 1. Continued.

ABR Database Table	ABR Database Column	AKNHP Database Table	AKNHP Database Column	ABR Notes
soil_horizon	redox_soil_color_hue_code	TBL_SoilProfile	MottleHueValueChroma	
soil_horizon	redox_soil_color_value_code	TBL_SoilProfile	MottleHueValueChroma	
soil_horizon	soil_boundary_distinctness_code	TBL_SoilProfile	BoundaryDistinctness	
soil_horizon	soil_boundary_topography_code	TBL_SoilProfile	BoundaryTopography	in addition soil related fields in TBL_SITE and photos were used to classify soil subgroups
soil_horizon	soil_color_chroma_code	TBL_SoilProfile	MatrixHueValueChroma	in addition soil photos were used to populate this data attribute
soil_horizon	soil_color_hue_code	TBL_SoilProfile	MatrixHueValueChroma	in addition soil photos were used to populate this data attribute
soil_horizon	soil_color_value_code	TBL_SoilProfile	MatrixHueValueChroma	in addition soil photos were used to populate this data attribute
soil_horizon	soil_horizon_field_note	TBL_SoilProfile	Remarks	
soil_horizon	soil_redox_abundance_code	TBL_SoilProfile	MottleQuantity	
soil_horizon	soil_redox_size_code	TBL_SoilProfile	MottleSizeClass	in addition soil photos were used to populate this data attribute
soil_horizon	soil_texture_code	TBL_SoilProfile	TextureUnder2mm	
soil_horizon	top_depth_cm	TBL_SoilProfile	Depth_range	
veg	litter_cover	TBL_SITE	LITTER_pct	
veg	surface_fragment_cover	TBL_SITE	SM_ROCK_pct + LG_ROCK_pct	
veg	veg_cutpoint_viereck_4_code	TBL_VegCover	SciName, COV	
veg	veg_floristic_class_code	TBL_VegCover	SciName, COV	
veg	veg_viereck_4_code	TBL_VegCover	SciName, COV	
veg	water_cover	TBL_SITE	SurfaceH20	
veg_cover	cover_percent	TBL_VegCover	COV	
veg_cover	veg_taxonomy_code	TBL_VegCover	SciName	

field plot; (2) relationships along transects were examined to characterize 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. (2008, 2009) that describes ecological characteristics (e.g., physiography, soil temperature, soil texture, soil 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. 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 (e.g., crest, upper slope, lower slope, toe, and flat).

For vegetation, we used the structural levels of the AVC system (Viereck et al. 1992), because they are readily identifiable on aerial photographs and use a typical species common name (e.g., Crowberry Dwarf Shrub). We used ordination and cluster analysis to aid in aggregating floristically-similar plots in the ecotype analysis. The raw vegetation cover data was transformed in several ways for the purpose of analysis using a database view.

First, vascular subspecies and varieties were aggregated to the species level, and non-vascular species were aggregated to genus level. Both transformations were required due to differences in taxonomic resolution between the ABR and AKNHP datasets. Second, unknown species codes, ground cover classes, and vascular taxa identified to genus level only were excluded from the analysis. Third, plots where the floristic_analysis_ynna_code field in the veg table is equal to "no" (n) were withheld from the analysis. This field was used to exclude water plots (i.e., plots representing waterbodies) and barrens (<5% live cover). Fourth, plots flagged with a veg_completeness_code of partial (p) where excluded from the analysis. Fifth, all vascular species with cover less than 1% and non-vascular species with cover less than or equal to 5% were excluded from the analysis. Additionally, any plots that had less than 2 species, after the exclusion of the species described above, were withheld from the ecotype floristic analysis. Lastly, The percent cover data were natural log transformed as follows: natural log(percent cover) + 0.1. The addition of 0.1 was required because the natural log of 1 is zero. Adding 0.1 sets cover values of 1 to 0.1 for use in the analysis. The natural log transformation was performed because it down-weights dominant species in the analysis. The final floristic analysis dataset had both raw and natural log transformed cover values, and one or the other used depending on the desired analysis.

The data were then ingested in R, an open-source language and environment for statistical computing (R Core Team, 2014). We split the dataset by physiographic class and analyzed plots within each physiography separately. For each physiography group, vegetation was clustered using the fixed clustering algorithm Partitioning Around Medoids (PAM) (Kaufman and Rousseeuw 1990). A Bray/Curtis dissimilarity matrix (Bray and Curtis 1957) was used to develop preliminary groupings of similar vegetation. We applied non-metric multidimensional scaling (NMDS) (Shepard 1962a&b, Kruskal 1964a&b) to the dissimilarity matrix to chart the plots in species space to assess their dispersion and identify outliers. For the ecotype analysis, we used the ordination plotting functions provided in the vegan (Oksanen et al. 2013) and rgl (Adler et al. 2014) R libraries to plot the NMDS ordinations for each physiography class as 3-dimensional; dynamic plots that could be rotated graphically and viewed from multiple perspectives. Plots identified as outliers in the floristic analysis were flagged as such in the database and withheld subsequent analysis.

We grouped soils based on similarities in general texture class (e.g., rocky, sandy, organic-rich); Table 2 provides descriptions of general texture classes used in the classification of ecotypes. We often grouped textural classes, because the vegetation associated with them was similar (e.g., Sandy-Rocky), and vegetation structures (e.g., open and closed shrub) were often grouped because their species composition and soils were similar. Additionally, soil subgroups were often combined because they featured soils with similar morphological and developmental characteristics and degree of soil development, with similar interpretation for use and management (e.g., Typic Vitricryands and Vitric Haplocryands).

Common relationships among ecosystem components were identified using contingency tables. The contingency tables sorted plots by physiography, dominant soil texture, soil chemistry (pH and salinity), soil moisture, surface organic thickness, depth to ≥15% rock fragments, vegetation structure, and plant association. From these tables, common associations were identified and unusual associations either were combined with those having similar characteristics or

Table 2. Description of fourteen generalized soil texture classes used in ecotype classification and mapping, including texture range and predominant soil orders, for Aniakchak National Monument and Preserve, southwest Alaska.

Generalized texture class	Texture range (< 2 mm)	Description	Predominant Soil Order(s)
Ashy-Loamy-Rocky	Silt loam to sandy loam	In upper 40 cm, mineral soil is dominated by fine volcanic ash (0.01-0.05 mm) and loamy material from other sources, >15% rock fragments (>2 mm) are common.	Andisols, Spodosols, and Inceptisols
Ashy-Rocky	Silt loam to sandy loam	In upper 40 cm, mineral soil is dominated by fine volcanic ash (0.01-0.05 mm), >15% rock fragments (>2 mm) is common, but often deeper then 20 cm in the profile.	Andisols
Ashy-Sandy-Rocky	Silt loam to sand	In upper 40 cm, mineral soil is a mixture of volcanic ash (0.01-2.00 mm) and sandy material from other sources, >15% rock fragments (> 2 mm) are common.	Andisols and Inceptisols
Loamy-organic	Silt loam to sandy loam	In upper 40 cm, soils with moderately thick (10-40 cm) to thick (≥ 40 cm) surficial organics over loamy mineral soil, >15% rock fragments are rare.	Andisols and Inceptisols
Organic-rich	Silt loam to sand	In upper 40 cm, soils with thick (≥ 40 cm) surficial organic horizons, mineral soil often stratified and below 20 cm, >15% rock fragments very rare.	Andisols and Histosols
Rocky	Silt loam to sand	In upper 40 cm, includes a variety of mineral soil textures, >15% rock fragments (>2 mm) very common.	Andisols and Entisols
Rocky-Ashy	Silt loam to sand	In upper 40 cm, mineral soil includes a variety of textures, ash is common but not always present, >15% rock fragments (> 2 mm) are very common.	Andisols, Entisols, Inceptisols, and Mollisols (Lithic subgroups)
Sandy	Loamy sand to sand	In upper 40 cm, sandy mineral soil, coarse-ash (0.05-2.00 mm) may ocurr, but not common, >15% rock fragments (> 2 mm) uncommon.	Entisols
Sandy-Loamy	Silt loam to sand	In upper 40 cm, a variety of mineral soil textures, sometimes stratified, volcanic ash common, >15% rock fragments (> 2 mm) uncommon.	Entisols and Inceptisols
Sandy-Loamy-Rocky	Silt loam to sand	In upper 40 cm, soils stratified, mineral textures alternating between loamy and sandy, volcanic ash uncommon, >15% rock fragments (> 2 mm) very common.	Entisols
Sandy-Organic	Sandy loam to sand	In upper 40 cm, sandy mineral soil, sometimes stratified, ash may be present, moderately thick (10-40 cm) surficial organics common, >15% rock fragments uncommon.	Entisols and Inceptisols (Histic subgroups)
Sandy-Rocky	Sandy loam to sand	In upper 40 cm, sandy mineral soil dominated by coarse ash (0.05-2.00 mm), >15% rock fragments very common.	Andisols and Entisols
Sandy-Rocky-Organic	Sandy loam to sand	In upper 40 cm, sandy mineral soil dominated by coarse ash (0.05-2.00 mm), sometimes stratified, >15% rock fragments common, and moderately thick (10-40 cm) surficial organics common.	Andisols and Inceptisols (Histic subgroups)
Silty-Sandy-Rocky	Silt loam to sandy loam	In upper 40 cm, soils stratified, with loamy and sandy material often dominated by volcanic ash, >15% rock fragments (> 2 mm) common.	Entisols

excluded as atypical (outliers). Ecotype names were then assigned based on the aggregated ecological components; e.g., Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest.

Soils

Samples from 82 distinct soil horizons were collected from 35 plots for use in laboratory analysis of soil chemical and physical properties. The number of horizons sampled at each plot ranged between 1 to 4. 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). The 82 soil samples were then reviewed and a subset of 42 samples was selected for laboratory analysis (Appendix 3—soil lab data combined).

Priority for selecting plots for analysis was based on secondary diagnostic horizons requiring laboratory data for taxonomic classification, spatial distribution within ANIA, whether or not a full soil characterization had been completed for the plot, and cost. For ANIA soil samples were not mixed for analysis, as was the case for previous national parks mapped by Wells et al. (2013, 2014). Rather, discrete soil samples were sent for analysis. This differs from how laboratory samples were handled previously because Near Infrared (NIR) spectroscopy analysis was not conducted for ANIA as it was for previous parks.

The air-dried and sieved samples were sent to 3 different laboratories, depending on the type of analysis required. In preparation for shipment, the 42 samples selected for analysis were sub-sampled, with each sub-sample stored in an individual resealable plastic bag and each bag labeled with pertinent plot information and the laboratory name to which it would be sent. A total of 67 subsamples were prepared for shipment. Of these 67 subsamples, 42 were shipped to the University of Fairbanks (UAF), Palmer Research Center (Laurie Wilson, Lab Manager), 14 were shipped to Colorado State University (CSU) (James R. Self, Lab Manager), and 11 were shipped to Alaska Beget Consulting (ABC) (Dr. James Beget, UAF).

UAF Palmer Research Center analyzed the soil samples for percent total carbon (C) and total nitrogen (N) using the combustion method with a LECO TruSpec CHN 1000 instrument. Particle size analysis was also conducted to determine the total percent of sand, silt and clay (Michaelson et al. 1992). Percent organic carbon was calculated by subtracting the percent inorganic carbon from total C (Bundy and Bremner 1972). The percent base saturation indicates what percent of the exchange sites are occupied by cations; percent base saturation can be calculated by dividing the milliequivalents of each cation from the CEC, by the total cation exchange capacity (CEC) (Michaelson et al. 1992). Additionally, two samples were designated for Loss on Ignition (LOI) analysis, which is a method for determining the percent organic matter content (Jackson 1958). Ammonium oxalate extracts of Iron (Fe), Aluminum (Al) and Silicon (Si) were run on 15 samples to provide data for substantiating andic soil properties on a variety of volcaniclastic deposits (i.e., tephra, ignimbrite, etc.) across the study area (Michaelson et al. 1992). Percent phosphate retention (New Zealand P Method) was also measured in the subset of 10 samples (Michaelson et al. 1992). These soil laboratory data are presented in Appendix 3.

CSU analyzed 14 samples for percent water retention at 1,500 kPa. This analysis was necessary for differentiating between the Andic and Vitric subgroups in NRCS soil taxonomy, 11th edition (Soil Survey Staff 2010). Soils developed in tephra that have a water retention at 1,500 kPa of 15% or less, should be classified in a Vitric subgroup.

ABC analyzed 11 soil horizons from 10 field plots for percent volcanic glass. Volcanic glass content is the percent (by grain count) of glass, glass-coated mineral grains, glass aggregates, and glassy materials in the 0.02–2.0 mm fraction (Soil Survey Staff 2010). Dr. Beget utilized the dispersal procedure as a means to separate the coarse silt and sand fraction for analyses, described in Step 7.11 on p. 43 of the *Soil Survey Laboratory Methods Manual*, version 42 (USDA NRCS 2004). After one hour of agitation, the fine silt and clay soil fraction that is in suspension is decanted from the beaker and the remaining sediment (0.02 to 2.0 mm) dried in an oven at 50° C. The *Keys to Soil Taxonomy* (Soil Survey Staff 2010) require that volcanic glass be quantified based off analysis of medium, coarse, and very coarse sand in order to classify Andic soil properties and Vitrandic subgroups. Wilson et. al (1999) suggests that a cost-effective alternative to analyzing each individual grain fraction for volcanic glass is analyzing a mixed 10 g sample with all three grain sizes at once. Beget analyzed the mixed 10 g sample (0.02–2.0 mm fraction) for tephra content by examining a grain mount thin section under a petrographic microscope. The percentage of glass in each sample was determined by identifying the volcanic material using optical mineralogical techniques, including the use of double light polarizing plates. Standard petrographic charts published by the American Geological Institute were then used to determine the percentage of volcanic particles present. The volcanic glass estimates are presented in Appendix 3, and the modal grain size and relevant notes are stored in the database deliverable.

We classified soils data to the subgroup level according to NRCS soil taxonomy, 11th Edition (Soil Survey Staff 2010). 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, pH, etc.) and by drawing inferences from the soil classifications from plots with full stratigraphic descriptions and soils laboratory data. For instance, Eutric Duricryands were classified based off of a cutpoint of ≥5.5 pH and a base saturation >50% (C-L Ping, personal communication, March, 2015). The actual diagnostic criterion, however, is based off of horizons that meet andic soil criteria and that have no more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl), at a depth between 25 and 50 cm either from the soil surface or the top of an organic horizon (Soil Survey Staff 2010).

Due to field and laboratory data limitations, we were unable to classify some of the AKNHP plots to the subgroup level. Assumptions of andic soil property development were applied broadly to AKNHP data, based off of the laboratory data that was available for the smaller subset of ABR plots.

Ecosystem Components Synthesis

A primary objective of this study was to identify relationships between ecosystem components (state-factors), vegetation, soil properties, and disturbance regimes. The purpose of ecosystem components synthesis is to identify the biophysical processes that underlie these relationships, thereby providing organizing principles for mapping ecological themes of interest using available GIS and RS data (see next section). We accomplished this by integrating the multivariate datasets described above for vegetation and soils into contingency tables. This process identifies common biophysical processes, such as sedimentation and paludification, that govern the development of vegetation and soils across the landscape. Knowledge of these processes and the environments in which they function provides a basis for "crosswalking" each ecotype into classifications pertaining to other ecosystem properties, such as soils and disturbance landscapes. The contingency table analysis also helps to evaluate how reliably specific landform-vegetation-soils relationships can be used to inform landscape interpretation and mapping. During ecosystem components synthesis, we grouped field plots that shared similar vegetation (ecotypes) and/or soil properties (soil landscapes). We also identified "outlier" field plots with unique or unusual combinations of physiography, texture, geomorphology, drainage, soil chemistry, vegetation, or other properties, and iteratively removed them from the contingency tables. We excluded outlier plots, because our primary goal was to identify widespread landform-vegetation-soil relationships for which generalization is appropriate and useful, and that can be readily and consistently mapped. The outliers may represent ecotones, rare types, or locations where vegetation and soils have been affected by local disturbance or other historical factors that are not readily interpreted.

Data and Reporting Compilation and Delivery

The field data, including tabular data, photos, plot locations, and list of collections were compiled onto a WD MyPassport 1TB external hard drive which was delivered with the final report. The hard drive also includes GIS and Remote Sensing files, the final report text and supporting files (e.g., figures), progress reports, and compliance and field safety documents. Table 3 provides a listing of all elements included with the data and report deliverable, including file paths on the external hard drive delivered with the report.

GIS and Remote Sensing Data Compilation

Overview

We evaluated available archives of GIS and RS data to support the description and mapping of ecotypes and soil landscapes within ANIA. These ancillary datasets pertain to a range of biological, physical, and climatic parameters (Table 3). Available GIS and RS datasets were integrated with field-based data, and analyzed to characterize and map the major biophysical components of the landscape that influence soil development and the spatial distribution of soil groups within ANIA. These biophysical components include ecoregion, physiography, geologic parent material, vegetation, and disturbance history. Unique combinations of these biophysical components were distinguished, and similar combinations aggregated together, using guidance from the field data and soil laboratory analysis to map the distribution of ecotypes and soil landscapes within ANIA. We briefly describe each dataset below and summarize any GIS preprocessing steps that were executed to support ecological analysis and mapping.

Naming Conventions

Throughout this section, GIS and RS datasets are referred to in italics, using a descriptive name (e.g., *USFWS Land Cover Map*). Text references of the names of individual data fields within GIS and RS datasets are italicized and placed in quotation marks (e.g., *USFWS Land Cover Map "Class_name"* field). Text references to the attributes stored in fields are presented in plain text, and are quoted in the case of non-

Table 3. Listing of all data and files compiled and delivered with the final report for the cological land survey and soils mapping for Aniakchak National Monument and Preserve, southwest Alaska.

Type	Origin	Deliverable Description	File Format	Path*
Compliance	NPS	Research Permit	PDF	R:\ANIA ELS and Soils Deliverable\Compliance\Research Permit
Field Data	ABR	Field photos	JPEG	R:\ANIA ELS and Soils Deliverable\Photos
Field Data	ABR	List of plant specimens collected	Microsoft Excel	R:\ANIA ELS and Soils Deliverable\Data\Plant_specimens
Field Data	ABR	List of remaining soil samples	Microsoft Excel	R:\ANIA ELS and Soils Deliverable\Data\Soil_samples
Field Data	ABR	List of rock samples collected	Microsoft Excel	R:\ANIA ELS and Soils Deliverable\Data\Rock_samples
Field Data	ABR	Original soil laboratory data files	Microsoft Excel	R:\ANIA ELS and Soils Deliverable\Data\Soil_lab_data_raw
Field Data	ABR	Tabular field data	Microsoft Access	R:\ANIA ELS and Soils Deliverable\Data\Tabular_field_data
GIS/RS	ABR	ABR Plot locations	Geodatabase	R:\ANIA ELS and Soils Deliverable\GIS\Plot_locations
GIS/RS	ABR	ANIA Disturbance Landscapes	Layer file	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ANIA Map Ecotypes	Layer file	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ANIA Physiography	Layer file	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ANIA Soil Landscapes	Layer file	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ANIA_Ecosystem_Mapping	Single band TIFF	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ANIA_study_area_1mile	Single band TIFF	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Study_Area
GIS/RS	ABR	Intermediate GIS and Remote Sensing files	Various	R:\ANIA ELS and Soils Deliverable\GIS\Original_Source
GIS/RS	ABR	Land Cover	Single band TIFF	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Land_Cover
GIS/RS	ABR	Land Cover x Physiography	Single band TIFF	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Land_Cover
GIS/RS	ABR	Land_Cover	Layer	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\Land_Cover
GIS/RS	ABR	Original field GPS files	GPS Exchange Files (gpx)	R:\ANIA ELS and Soils Deliverable\GIS\Plot_locations\Field_GPS_files
GIS/RS	ABR	SRTM filled by GeoEye DEM Hillshade, 30 m	Single band TIFF	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\DEM
GIS/RS	ABR	SRTM filled by GeoEye DEM, 30 m	Single band TIFF	R:\ANIA ELS and Soils Deliverable\GIS\Soil_LS_Model\DEM
GIS/RS	Pre-existing	Bedrock Geology Map	Polygon feature class	PDS\Albers\parks\ania\GRI\BedrockGeology.gdb
GIS/RS	Pre-existing	GeoEye DEM Hillshade, 30 m	Single band TIFF	PDS\DEM\GeoEye\ANIA\ania_a83hs
GIS/RS	Pre-existing	GeoEye DEM, 30 m	Single band TIFF	PDS\DEM\GeoEye\ANIA\ania_a83

Table 3. Continued.

Type	Origin	Deliverable Description	File Format	Path
GIS/RS	Pre-existing	Historical Airphotos—1957	Single band TIFFs	R:\ANIA ELS and Soils Deliverable\GIS\Historical_Air_Photos\1980s
GIS/RS	Pre-existing	Historical Airphotos—1983	3-band TIFFs	R:\ANIA ELS and Soils Deliverable\GIS\Historical_Air_Photos\1950s
GIS/RS	Pre-existing	IKONOS Mosaic—CIR	Layer file for symbolizing multiple 4-band TIFFs	PDS\IKONOS\ANIA\ANIA_Mosaic.gdb
GIS/RS	Pre-existing	IKONOS Mosaic—Natural Color	Layer file for symbolizing multiple 4-band TIFFs	PDS\IKONOS\ANIA\ANIA_Mosaic.gdb
GIS/RS	Pre-existing	Surficial Geology Map	Polygon feature class	PDS\Albers\parks\ania\GRI\SurficialGeology.gdb
GIS/RS	Pre-existing	USFWS Land Cover Map	Single band TIFF	PDS\Albers\parks\ania\base\biologic\statewid\
Presentation	ABR	NPS Soil Mapping Poster	PDF	R:\ANIA ELS and Soils Deliverable\Presentations
Report	ABR	Final report text and supporting files	Various	R:\ANIA ELS and Soils Deliverable\Reports_ABR_ANIA_NRTR
Report	ABR	Progress report	PDF	R:\ANIA ELS and Soils Deliverable\Reports_Progress
Report	ABR	Related Reports	PDF	R:\ANIA ELS and Soils Deliverable\Reports_Related
Safety	ABR	Field safety	Various	R:\ANIA ELS and Soils Deliverable\Safety&LessonsLearned

* Note the R:\ drive is the external hard drive delivered with the final report for the Ecological Land Survey and Soil Landscapes Map for Aniakchak National Monument and Preserve, Alaska, 2014 project. The PDS is the National Park Service Permanent Data Set.

numeric fields; e.g., *USFWS Land Cover Map, "Class_name"* value of "Mesic/Dry Grass Meadow."

The format and origin of datasets that we used to support the classification and mapping of ecosystem properties are presented in Table 3. Many of the ancillary datasets were obtained from the existing NPS data archive, while datasets that were modified, derived, or synthesized by us are provided in the GIS deliverable package accompanying this report. The filename and file path of each dataset in the deliverable package are also presented in Table 3.

Existing Data Sources

Digital Elevation Models (DEM)

We reviewed several available DEMs, including the *National Elevation Dataset* (2 arc-seconds), the *Shuttle Radar Topography Mission* (SRTM) *DEM* (30 m), the *ASTER Global DEM* (version 2; 1 arc-second), and the *GeoEye™ DEM* (30 m) that was generated to support development of the IKONOS base imagery mosaic for ANIA. All of the available DEMs were affected to some degree by spatial artifacts and/or areas of no data. For example, the *GeoEye™ DEM* does not encompass the full 1-mile buffer around the park boundary, and contains conspicuous, linear "seam line" artifacts along the margins of the individual image swaths used to produce the park-wide DEM. The *SRTM DEM* is comparatively free of artifacts, but contains several voids (patches with no data), typically on steep, north-facing slopes. After evaluating the available DEMs, *SRTM DEM* provided the single best DEM to support mapping and spatial analysis applications at ANIA. Voids in the *SRTM DEM* were filled using the *GeoEye™ DEM*, after adjusting the *GeoEye™ DEM* to correct for systematic offsets between the two datasets. This step eliminated all voids within the ANIA boundary, but a few very small voids remained within the 1-mile buffer in areas that were not covered by the *GeoEye™ DEM*. We used the SRTM filled by *GeoEye™ DEM* for spatial analysis, and the SRTM filled by *GeoEye™ DEM* Hillshade, which is symbolized to represent 3-dimensional terrain in an intuitive way, to facilitate interpretation and map production.

Land Cover

Two relatively recent land cover maps exist for ANIA. Ducks Unlimited (DU) and the U.S. Fish and Wildlife Service (USFWS) created the *USFWS Land Cover Map* in 1999 for the entire Alaska Peninsula (USFWS 2007), which includes all of the ANIA mapping area. The map was produced using a spectral classification of 30-m resolution Landsat imagery; the classification was informed by field observations made from a helicopter, and individual pixels were partitioned into land cover classes according to their spectral characteristics. The Multi-Resolution Land Characteristics Consortium used the National Land Cover Database (NLCD) to prepare the *NLCD 2011 Land Cover Map* (Homer et al. 2015). This map provides a land cover map for the entire state of Alaska using circa 2011 imagery. Like the *USFWS Land Cover Map*, the *NLCD 2011 Land Cover Map* was produced using 30-m resolution Landsat base imagery, but it groups land cover types into far fewer, more general categories that could be applied over the statewide mapping domain. After evaluating the two available map products, the *USFWS Land Cover Map* was by far the best to support ecological analysis and mapping tasks in ANIA, and this map is a key input for the suite of ELS maps presented in this report. Use of the *USFWS Land Cover Map* was also facilitated by AKNHP Field Plots acquired by AKNHP and NPS in 2009–2010, which were readily harmonized with our own field data. We clipped the complete *USFWS Land Cover Map* to a 1-mile buffer surrounding the ANIA boundary. Approximately 44.4 km^2 of the ANIA mapping area, however, was obscured by cloud and cloud shadow in the Landsat imagery used to produce the *USFWS Land Cover Map*. Additionally, approximately 96.3 km^2 of the mapping area was classified as "Snow/Ice" in the *USFWS Land Cover Map*; visual review of IKONOS high-resolution satellite imagery mosaics (described below) indicated that most "Snow/Ice" pertained to seasonal, rather than perennial snow cover. To map ecotypes and other ecosystem properties in areas affected by clouds and seasonal snow/ice in the *USFWS Land Cover Map*, we used map classes from the *NLCD 2011 Land Cover Map* as inputs for ELS mapping tasks.

Geologic Map

The distribution and characteristics of surficial and geologic parent materials are key factors influencing soil properties and development. We applied two GIS datasets, the Digital Surficial Units of the Aniakchak National Monument and Preserve and vicinity, Alaska *(Surficial Geology)*, and the Digital Geologic Units of the Aniakchak National Monument and Preserve and vicinity, Alaska *(Geologic Units)*, which were derived from USGS geologic maps as part of the Geologic Resources Inventory (GRI) program. Geologic mapping for ANIA primarily come from NPS GRI (2015). We applied the geologic maps primarily during the modeling of physiographic units across ANIA (see GIS Modeling and Ecosystem Components Synthesis, below).

Satellite Imagery

NPS provided a base imagery mosaic for ANIA that was developed using ortho-rectified, high-resolution imagery acquired by the IKONOS commercial satellite in the summers of 2005 and 2007. The mosaic was based on pan-sharpened, dynamic-range-adjusted imagery with a pixel size of 1-m. Four bands (R/G/B/NIR) were provided; these bands were used to produce natural color *(IKONOS Mosaic—Natural Color)* and color-infrared *(IKONOS Mosaic—CIR)* imagery products to support a variety of landscape interpretation and mapping tasks (hereafter, we refer to these datasets collectively as *IKONOS Mosaics*). Although the map products presented in this report are primarily derived from the *USFWS Land Cover Map* (which utilized 30-m Landsat data), we used the *IKONOS Mosaics* as a basemaps for photo-interpretation and digitization of some physiographic units (see below). The ortho-mosaics do contain some cloud contamination, and data are lacking for much of the 1-mile buffer area beyond the park boundary. To support imagery interpretation tasks in these areas, we supplemented the *IKONOS Mosaics* with the *Landsat Mosaic*, a mosaic of circa 2001 Landsat scenes containing 3 bands (R/G/NIR) at 30-m resolution that was produced to support production of the *NLCD 2011 Land Cover Map*.

Historical Aerial Orthophotos

Two sources of historical aerial photography provided valuable spatial and historical context for interpreting ecosystem characteristics and processes such as physiography, disturbance regime, succession, and long-term vegetation trends. For example, Riverine physiography pertains to floodplain areas that have experienced flooding within the last century; although these areas typically support characteristic landforms and early-successional vegetation that can be photo-interpreted using the *IKONOS Mosaics*, the historical airphotos provided direct evidence regarding the intensity and extent of floodplain disturbance over a 50-year period. *Historical Airphotos—1957* consist of panchromatic (black-and-white) airphotos acquired by the U.S. Air Force with approximate spatial resolution of 1 m. *Historical Airphotos—1983* consist of color-infrared airphotos acquired by the Alaska High Altitude Photography Program (AHAP) at a resolution of 1 m. All historical photography provided by NPS was scanned from original prints at 1,200–1,800 dpi and subsequently georeferenced and ortho-rectified using the *IKONOS Mosaics*.

GIS Modeling and Ecosystem Component Synthesis

Physiography

We delineated ANIA landscapes into seven physiographic units that partition the key geomorphic processes, environmental gradients, and landscape history attributes that control the development of landforms, vegetation, and soils across the park. The physiography map was a key input that, combined with the *USFWS Land Cover Map* and field data, informed the mapping of ecotypes, soil landscapes, and other ELS map themes. We developed the physiography map using a combination of approaches, including photo-interpretation, recoding of surficial geology units within the *Surficial Geology* ancillary dataset, and spatial modeling using the SRTM filled by *GeoEye™ DEM* to produce a raster-based map that matches the 30-m resolution of the *USFWS Land Cover Map*. Below we present brief definitions of the physiographic units and the methods used to delineate them. Because some map polygons could potentially be assigned to more than one physiographic class (e.g., estuaries could belong to either Coastal or Riverine physiography), we assigned physiography classes in the sequence presented below. Once a raster grid cell had been assigned to a physiographic class, it could not be reassigned to another class in a subsequent step. This process ensured that physiography classes were assigned based on the hydrologic properties and/or physical processes that were most relevant to ecosystem development. Two physiographic classes which were previously mapped at Kenai Fjords National Park (KEFJ) and Lake Clark National Park and Preserve (LACL)—glacial and subalpine—were not included in the ANIA classification, due to the very small extent of modern-day glaciers and absence of trees by which to distinguish upland and subalpine zones (see Wells et al. 2013, 2014).

Coastal

The Coastal physiographic unit includes intertidal and supratidal substrates that are regularly influenced by salt water, such as beaches, tidal flats, spits, and lagoons. The Coastal physiographic unit was photo-interpreted and manually digitized with reference to the *IKONOS Mosaics*. The coastal unit consists of a single belt lining the Pacific Ocean shoreline of ANIA; this belt becomes relatively wide in lagoons, river mouths and embayments (e.g., Amber Bay, Aniakchak Bay), but is very narrow along steep coastal headlands where there is very little areal cover of land that is directly affected by salt water.

Riverine

The Riverine physiographic unit encompasses channels, islands, and riverbanks (floodplains) that are regularly flooded under the present-day flow regime (flood return period ~100 years). ANIA supports a wide range of channel morphologies and riparian landforms, ranging from large, meandering floodplains (e.g., lower Aniakchak River) to a multitude of small, low-order streams. The Riverine physiographic unit does not include abandoned floodplain surfaces and terraces that are no longer regularly flooded. As for the Coastal physiographic unit, we manually digitized Riverine physiography with reference to the *IKONOS Mosaics*. Riverine physiographic boundaries were generally drawn along the margins of diagnostic landforms, such as cutbanks, channels, and point bars, as well as early-successional vegetation types (e.g., willow-dominated shrublands). Because the mapping of ecotypes involved integrating information from the physiography map and the 30-m resolution *USFWS Land Cover Map*, we generally delineated Riverine physiography only for floodplains >15 m in width. Many small headwater streams, and some larger streams with narrow, incised floodplains were not included in Riverine physiography.

Volcanic

The Volcanic physiographic unit corresponds to areas that suffered both direct, severe disturbance from volcanism during or after the caldera-forming eruption that occurred ca. 3,590 cal yr B.P (Bacon 2014), and remain in a early-successional state with little or no vegetation cover and no appreciable soil development. Volcanic physiography occurs at both low- and high elevations, where surficial materials consist of thick volcanic deposits such as tephra, pyroclasts, and lava; it primarily encompasses the Aniakchak Caldera and surrounding slopes, particularly on the Bering Sea side where tephra deposition during the caldera-forming eruption was particularly intense. We delineated Volcanic physiography using a two-step process. First, we created a copy of the *Surficial Geology* polygon map and viewed it as an overlay over the *IKONOS Mosaic*. Some *Surficial Geology* units with small spatial extents, such as "Cinder and spatter cones" and "Explosion debris" clearly met the criteria set for Volcanic physiography and the map polygons were assigned to Volcanic physiography. Other *Surficial Geology* units associated with volcanism, such as "Ash-flow and ash-fall deposits" and "Dacite flows," had been mapped over much larger extents which in many cases included well-vegetated areas. We flagged such map polygons as "potential volcanic" and then manually digitized the extent of Volcanic physiography within them with reference to the *IKONOS Mosaics*. Boundaries digitized for Volcanic physiography generally followed abrupt transitions between discontinuous, low-growing vegetation, and continuous vegetation (particularly areas with tall shrubs).

Lacustrine

Lacustrine areas correspond to freshwater lakes and ponds, shorelines, and recently-drained lake basins (approximately <50 years). ANIA possesses few large lakes relative to other Southwest Arctic Network (SWAN) parklands; the only lacustrine waterbodies in ANIA >8 ha in size are Surprise Lake and Meshik Lake. To delineate Lacustrine physiography, we first coded as Lacustrine all pixels classified as "Clear Water" and "Turbid/Shallow Water" in the *USFWS Land Cover Map*, except for those pixels that occurred in areas previously digitized as Riverine physiography (i.e., freshwater pixels that corresponded to rivers or streams). Next, we manually digitized recently-drained lakebeds adjacent to lakes and ponds, with reference to the *IKONOS Mosaics*. Finally, some additional areas were assigned during the ecotype mapping process; analysis of field plot data indicated that areas mapped as "Sparse Vegetation" in the *USFWS Land Cover Map* and which occurred in Lowland physiography represented small ponds and were best classified as Lacustrine.

Alpine

Alpine physiography encompasses high-elevation terrain that is dominated by low-growing alpine tundra and barrens. Tall shrubs are absent, plant productivity is low, and soil development is largely linked to hillslope and periglacial (freeze-thaw) processes. The Alpine physiographic unit does not include high-elevation occurrences of Volcanic physiography, where vegetation and soil characteristics primarily reflect recent volcanic disturbance. To delineate Alpine physiography, we first manually digitized a network of 5,620 breakpoints representing local-scale transitions between Alpine and Upland physiography across ANIA, with reference to the *IKONOS Mosaics*. Alpine/Upland breaks usually corresponded to the upper limit of tall shrub occurrence. We then used the breakpoints as inputs for the inverse distance weighting (IDW) interpolation tool in ArcMap to generate a continuous raster surface representing the Alpine/Upland transition across the park; we applied the default IDW interpolation parameters (power=2; variable search radius; 12 points). Pixel size in the raster surface was set to 30 m, to match the spatial resolutions of the *USFWS Land Cover Map* and the SRTM filled by *GeoEye™ DEM*. Finally, we compared the SRTM filled by *GeoEye™ DEM* to the Alpine/Upland raster surface, and recoded as Alpine all pixels with a local elevation greater than the elevation of the interpolated Alpine/Upland transition. The IDW interpolation approach had two advantages. First, it permitted the delineation of Alpine/Upland transition according to local landscape conditions, rather than an indiscriminant threshold elevation value. This was important because the elevation of the Alpine/Upland transition can vary considerably according to local factors such as slope angle, aspect, exposure to wind, and topographic position. Second, the IDW interpolation approach avoided the time-consuming task of digitizing the actual Alpine/Upland transitions across the entire park.

Lowland

Lowland physiography pertains to topographically flat (not necessarily low-elevation) areas that are not associated with modern floodplains or recently-drained lake basins. Lowland soils are generally poorly-drained, organic-rich, and tend to support hydrophytic vegetation. Delineation of Lowland physiography according to topography and landscape position criteria alone, however, is impractical in ANIA because of the widespread presence of coarse-textured, excessively drained volcanic materials in areas of flat terrain, particularly in the Cinder River and Albert Johnson Creek watersheds. We delineated Lowland physiography using a combination of rule-based geospatial modelling and visual photo-interpretation. The modelling step identified areas of potential lowland based on two criteria: (1) flat or nearly flat local topography; and (2) hydrologic connectivity to a continuous field of other flat pixels. The second criterion ensured that plateaus were not identified as Lowland. First, we used the Slope tool in ArcMap to generate a raster of "flat" pixels (slope angle ≤3 degrees) based on the SRTM filled by *GeoEye™ DEM*. Second, we used the Flow Direction and Flow Accumulation tools to calculate the hydrologic contributing area for each pixel in the DEM; any pixel which could potentially receive runoff from ≥100 pixels (9 ha) was defined as "potential lowland." Next, we used the Cost Distance tool to create a raster of "flat" pixels that had a continuous hydrologic connection to other flat pixels. In the last modelling step, we used the Con tool to remove from "potential lowland" all pixels that were part of a high-gradient drainage (i.e., with slope angle >3 degrees). Finally, we visually reviewed the "potential lowland" raster overlaid on the *IKONOS Mosaics* and digitized areas within the raster that were better classified as Upland physiography. Such areas mainly corresponded to well-drained substrates that lacked photo-signatures indicative of standing water, saturated soils, or hydrophytic vegetation.

Upland

The Upland unit generally corresponds to hillslopes that lay above the influence of saltwater intrusion and spray, and below the elevational limit of tall shrub development. All areas that were not assigned to a physiographic unit in previous landscape analysis steps were coded as Upland.

Bedrock Chemistry

The chemistry of dominant bedrock types in ANIA is acidic to circumacidic. Consequently, bedrock chemistry is not a primary driver of soil variability; thus, we did not incorporate a bedrock chemistry layer into the ecotype and soils landscape models.

Generalized Soil Texture

We did not develop a generalized soil texture layer for use in the ecotype and soils landscape models because of the relatively simple bedrock geology of ANIA. In addition, soils are dominated by very young volcanic materials comprising coarse fragments and/or bedrock in most of the park.

Land Cover/Physiography/Ecotype Crosswalk

After completing the ecotype classification, we created a table of all unique combinations of physiography and land cover class in the *USFWS Land Cover Map* and the *NLCD 2011 Land Cover Map*; values from the latter map were only used for pixels that were snow- or cloud-covered in the *USFWS Land Cover Map*. After referring to the keys and descriptions of land cover classes and plant associations in Boucher et al. (2012), we assigned each of the unique combinations to ecotype(s) (Appendix 4). Combinations of physiography and land cover class could usually be assigned to a single ecotype because many of the classes developed by USFWS and ABR emphasize the species and growth form of the dominant, canopy-forming vegetation. However, a few land cover classes, such as "Dwarf Shrub - Upland" were associated with multiple ecotypes and required aggregating similar ecotypes into map ecotypes (see below). After review of the ecological maps produced by crosswalking, we manually edited the extent of a rare vegetation type of particular interest for ecosystem monitoring, the scattered groves of balsam poplar *(Populus balsamifera)* which occur in the northern part of the park and represent the southwestern limit of tree growth on the Alaska Peninsula.

Map Ecotypes

Raster cells in the *USFWS Land Cover Map* and the *NLCD 2011 Land Cover Map* had been classified primarily according to their spectral characteristics in multi-spectral Landsat imagery at 30-m spatial resolution. These spectral characteristics are mainly produced by the biomass, structure, and foliar chemistry of vegetation and by the very different spectral properties of nonvegetated surfaces such as bedrock, volcanic debris, and surface water. As a result, vegetated ecotypes with similar biomass and structure (e.g., dwarf shrub) can have many spectral similarities despite substantial differences in species composition (e.g., crowberry versus mountain heather). To maintain distinctions between ecotypes with differences in soils, vegetation, and/or disturbance regime and to reduce the total number of ecotype classes mapped, we aggregated ecotypes with similar vegetation structure into a reduced set of map ecotypes, which could be readily cross-walked to the land cover classes in the *USFWS Land Cover Map* and the *NLCD 2011 Land Cover Map*.

Soil Landscapes

Soil-landscape associations, hereafter "soil landscapes," were identified to characterize and map landscape-scale relationships between soil type, physiography, and vegetation class (the latter usually related to one another via a successional sequence). Map ecotypes were aggregated into a reduced set of soil landscape classes to achieve the level of generalization appropriate for mapping across the park-wide study domain. Aggregating ecotypes to map ecotypes emphasized similarities in vegetation structure; for example, the ecotypes Lowland Organic-rich Wet Sedge-Shrub Bog Meadow and Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub were aggregated into the map ecotype, Lowland Wet Sedge-Shrub Bog Meadow. The focus of the soil landscape aggregation, however, was on characteristics of soils rather than vegetation. Map ecotypes represent similar vegetation types with potentially different soil textures, whereas soil landscapes represent aggregations of similar soil types. The soil landscapes were developed by cross-tabulating ecotypes and soil subgroups within contingency tables to identify associations of similar ecotypes with similar soil subgroups. The resulting associations were named based on physiography, soil texture, and the structure of canopy-forming vegetation (e.g., tall shrub, dwarf shrub, forb meadow, bog meadow).

We did not use the standard NRCS term "soil association," because that term is defined to include very different soils that are associated with each other along toposequences that repeat across the landscape. In addition, "soil associations" are recognized in soil mapping to be large map units with aggregated soil types. In this study, the term "soil landscape" refers to closely related soil types, and the mapping is based on patch-scale polygons.

Disturbance Landscapes

Disturbance processes play a pivotal role in the genesis and evolution of landforms, vegetation, and soils in ANIA. Important disturbance processes in ANIA, such as volcanism, landslides, and flooding, operate across a range of spatial scales, frequencies, and intensities. Nonetheless, many of the map ecotypes and soil landscapes can be grouped according to common disturbance regimes. Disturbance regime-landscape associations, or Disturbance Landscapes, were developed to characterize and map landscape-scale relationships among soil type, physiography, vegetation, and the natural disturbance processes with which they are most frequently associated. The resulting associations were named after the suite of processes and disturbance agents identified for each map ecotype.

Volcanism is a virtually ubiquitous source of disturbance on the Alaska Peninsula in general, and ANIA in particular. Eruptions, such as the 1931 eruption in Aniakchak Crater, trigger disturbance at local to landscape scales, while colossal events, such as the caldera-forming eruption, have induced catastrophic disturbance at regional scales. All ecotypes present in ANIA are vulnerable to volcanic disturbance to some extent. However, because the intensity of volcanism-related disturbance is primarily a function of proximity to a given eruption center rather than to landscape-scale factors such as vegetation, substrate, and topographic position, partitioning volcanic disturbance mechanisms within the disturbance landscape classification is somewhat problematic. We therefore emphasized volcanic disturbance for disturbance landscapes within the Volcanic physiographic unit.

Results

Ecotypes and Plant Associations

We identified a total of 45 ecotypes in ANIA based on analysis of field data obtained by AKNHP in 2009–2010 and ABR in 2014. Three additional ecotypes were identified based on qualitative field observations (i.e., no field data), including Riverine Rocky Barrens, Volcanic Lake, and Snow or Ice, for a total of 48 ecotypes. The spatial distribution, typical landscape position and geomorphic affinities, plant associations, dominant soil texture and chemistry, soil hydrologic characteristics, and soil subgroups of each ecotype are summarized in the Ecotype Descriptions section below. We have also included a key to ecotypes to aid in the identification of ecotypes in the field (see below).

A total of 55 previously described plant associations from Boucher et al. (2012) were represented within the 45 ecotypes classified from the field data (Table 4). An additional twenty-five previously undefined vegetation types also were found, of these 7 represent waterbody ecotypes, 7 represent barrens, and the remaining 11 represent vegetated terrestrial ecotypes that did not fit within the existing classification.

Twenty-three ecotypes were associated with one or two plant associations, and 35 plant associations described only one ecotype. These primarily represent narrowly-defined ecotypes (based on vegetation) with low within-ecotype variability in species composition, and plant associations that correspond to unique environmental conditions. For instance, the ecotype Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub and the plant association *Harrimanella stelleriana-Luetkea pectinata* represent a unique combination of ecotype and plant association. This ecotype occurs in late-lying snowbeds in the alpine and is consistently co-dominated by *Harrimanella stelleriana* and *Luetkea pectinata*. Fourteen ecotypes had three or more plants associations (Table 4). These include ecotypes that are more broadly defined (based on vegetation) with higher within ecotype variability in species composition. These ecotypes were often aggregated at the vegetation series level and so are similar, based on the dominant species, but have variable understory species composition. An example is the ecotype Upland Ashy-Rocky Moist Crowberry Dwarf Shrub, which is associated with 8 plant associations, including Empetrum nigrum, *Empetrum nigrum*/Lichen, *Empetrum nigrum-Arctostaphylos uva-ursi*, *Empetrum nigrum*/*Racomitrium* spp., *Empetrum nigrum-Vaccinium uliginosum*, *Empetrum nigrum*-Mixed Dwarf Shrub/Rock, *Empetrum nigrum*/*Lathyrus japonicus*, and *Empetrum nigrum*-Mixed Dwarf Shrub. These 8 plant associations have a common dominant species, *Empetrum nigrum*, but have otherwise unique species compositions. Additionally, 20 plant associations described more than one ecotype. This was primarily related to plant associations that occur in a variety of environments dominated by species with high environmental plasticity. For example, the plant association *Salix glauca-Salix barclayi* occurs in 4 ecotypes representing 2 physiography classes, including Riverine Sandy-Loamy Moist Willow Tall Shrub, Riverine Silty-Sandy-Rocky Moist Willow Low Shrub, Upland Ashy-Sandy-Rocky Moist Willow Low Shrub, and Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub. This plant association is co-dominated by *Salix glauca* and *S. barclayi*, two species that tolerate a diverse set of environmental conditions and disturbance processes, and that express two growth forms, include low (0.2–1.5 m) and tall shrub (>1.5 m).

Key to Ecotypes

The Key to Ecotypes (Table 5) for ANIA provides the end user of this Ecological Land Survey and Soils Landscape study 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, soils, slope, and elevation. The criteria used in the key were chosen for ease of identification in the field. A Geographic Positioning System (GPS), inclinometer (used for measuring slope gradient), and Electrical Conductivity (EC) meter (for coastal ecotypes) are useful tools to have available when using this key in the field. Additionally, an understanding of basic soil properties, including general soil texture (e.g. loamy vs. sandy) 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 Ecotype Key as these are often difficult to determine in the field. Extra time and specialized equipment and skills are required to excavate a full (1 m) soil pit for proper data collection and description. When determining an ecotype using the Key to Ecotypes, it is recommended that the reader compare the description (vegetation, soils, general environment) of the ecotype at the terminal node to that observed in the field before finalizing their selection. See below for instructions on using the Ecotype Key. See also the section entitled "How to use this Ecological Land Survey and Mapping" at the beginning of

Table 4. Crosswalk of ecotypes, plant communities, and AVC level IV vegetation classes, and number of field plots in Aniakchak National Monument and Preserve, southwest Alaska. Plant community classification follows Boucher et al. (2012). Vegetation classes follow Viereck et al. (1992).

Plot ecotype	Plant association	Vegetation class (Level IV)	Number of plots
Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub	*Harrimanella stelleriana-Luetkea pectinata*	Luetkea Dwarf Shrub Tundra	2
		Cassiope Dwarf Shrub Tundra	1
Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow	*Carex macrochaeta-Arctagrostis latifolia* ssp. *arundinacea*	Moist Grass-Herb Meadow Tundra	1
		Subarctic Lowland Sedge Moist Meadow	1
		Moist Sedge-Willow Tundra	1
	Calamagrostis canadensis-Carex macrochaeta	Bluejoint-Herb	2
		Bluejoint Meadow	1
	Angelica lucida-Heracleum maximum	Bluejoint-Herb	1
Alpine Rocky Dry Barrens	*Saxifraga* spp./Rock	Partially Vegetated	3
		Barren	2
Alpine Rocky-Ashy Moist Bryophyte	*Anthelia juratzkana-Gymnomitrion corallioides*	Partially Vegetated	3
		Dry Bryophyte	1
Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub	*Empetrum nigrum*	Crowberry Dwarf Shrub Tundra	6
		Ericaceous-Lichen Dwarf Shrub Tundra	1
	Empetrum nigrum-Mixed Dwarf Shrub/Rock	Crowberry Dwarf Shrub Tundra	2
		Ericaceous Dwarf Shrub Tundra	2
		Ericaceous-Lichen Dwarf Shrub Tundra	1
	Empetrum nigrum-Vaccinium uliginosum	Ericaceous Dwarf Shrub Tundra	2
		Ericaceous-Lichen Dwarf Shrub Tundra	1
		Crowberry Dwarf Shrub Tundra	1
	Empetrum nigrum/Pumice	Crowberry Dwarf Shrub Tundra	2
	Empetrum nigrum-Mixed Dwarf Shrub	Ericaceous-Lichen Dwarf Shrub Tundra	1
		Crowberry Dwarf Shrub Tundra	1

Table 4. Continued.

Plot ecotype	Plant association	Vegetation class (Level IV)	Number of plots
Alpine Rocky-Ashy Moist Willow Dwarf Shrub	*Salix arctica-Salix reticulata*	Willow Dwarf Shrub Tundra	4
	no class	Willow Dwarf Shrub Tundra	1
Coastal Brackish Water	no class	Brackish Water	1
Coastal Marine Water	no class	Marine Water	1
Coastal Sandy Moist Beach Rye-Forb Meadow	*Leymus mollis-Chamerion angustifolium*	Mixed Herbs	1
		Elymus	1
	Leymus mollis	Elymus	2
	Angelica lucida-Heracleum maximum	Mixed Herbs	1
Coastal Sandy Moist Brackish Beach Rye Meadow	*Leymus mollis-Honckenya peploides*	Elymus	2
		Mixed Herbs	1
	Leymus mollis	Elymus	2
Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow	*Poa eminens-Deschampsia beringensis-Festuca rubra*	Halophytic Grass Moist Meadow, brackish	1
	Poa eminens-Deschampsia beringensis	Halophytic Herb Wet Meadow	1
Coastal Sandy-Rocky Tidal Barrens	no class	Partially Vegetated	1
		Barren	1
Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow	*Carex lyngbyei*/Tidal Marsh	Halophytic Sedge Wet Meadow, saline	1
		Halophytic Sedge Wet Meadow, brackish	1
	Carex ramenskii	Halophytic Sedge Wet Meadow, saline	1
Lacustrine Loamy-Organic Wet Sedge-Forb Meadow	*Carex lyngbyei*/Freshwater Marsh	Subarctic Lowland Sedge Wet Meadow	2
	Carex lyngbyei-Comarum palustre	Subarctic Lowland Sedge Wet Meadow	2
	Carex lyngbyei-Carex saxatilis	Wet Sedge Meadow Tundra	1
		Subarctic Lowland Sedge Wet Meadow	1
	Carex saxatilis-Eriophorum angustifolium ssp. *subarcticum*	Subarctic Lowland Sedge Wet Meadow	1

Table 4. Continued.

Plot ecotype	Plant association	Vegetation class (Level IV)	Number of plots
Lacustrine Organic-rich Forb Marsh	*Menyanthes trifoliata*	Fresh Herb Marsh	3
		Subarctic Lowland Herb Bog Meadow	2
	Equisetum fluviatile	Fresh Herb Marsh	3
Lacustrine Rocky Drained Lake Barrens	no class	Barren	1
Lacustrine Sandy Grass Marsh	no class	Fresh Grass Marsh	1
Lowland Alkaline Lake Water	no class	Fresh Water	1
Lowland Organic-rich Wet Sedge Meadow	*Carex lyngbyei-Comarum palustre*	Wet Sedge-Herb Meadow Tundra	2
		Subarctic Lowland Graminoid-Herb Wet Meadow	1
		Subarctic Lowland Sedge Wet Meadow	1
	Carex saxatilis-Eriophorum angustifolium ssp. *subarcticum*	Subarctic Lowland Sedge-Shrub Wet Meadow	1
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	*Empetrum nigrum-Vaccinium uliginosum*/Wet *Carex* spp.	Subarctic Lowland Sedge-Shrub Wet Meadow	3
		Open Low Shrub Birch-Ericaceous Shrub Bog	3
	no class	Subarctic Lowland Sedge-Moss Bog Meadow	2
	Carex aquatilis	Subarctic Lowland Sedge Wet Meadow	2
Lowland Sandy-Organic Wet Willow Low Shrub	*Salix pulchra/Carex lyngbyei*	Open Tall Willow	1
		Open Low Willow	1
	Salix pulchra/Empetrum nigrum	Open Low Willow	1
Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub	*Empetrum nigrum-Vaccinium uliginosum*	Ericaceous Dwarf Shrub Tundra	3
Riverine Alkaline River Water	no class	Fresh Water	4
Riverine Loamy-Organic Wet Sedge Meadow	*Carex lyngbyei*/Freshwater Marsh	Subarctic Lowland Sedge Wet Meadow	2
Riverine Rocky Moist Alder-Willow Tall Shrub	*Salix alaxensis-Alnus viridis* ssp. *sinuata/Calamagrostis canadensis*	Open Tall Alder-Willow	1
		Closed Tall Alder-Willow	1
	Alnus viridis ssp. *sinuata/Calamagrostis canadensis*	Open Tall Alder	1
	Alnus viridis ssp. *sinuata*/Forb	Open Tall Alder	1

Table 4. Continued.

Plot ecotype	Plant association	Vegetation class (Level IV)	Number of plots
Riverine Sandy-Loamy Moist Forb Meadow	*Angelica lucida-Heracleum maximum*	Mixed Herbs	1
		Large Umbel	1
Riverine Sandy-Loamy Moist Willow Tall Shrub	*Salix alaxensis/Equisetum arvense*	Open Tall Willow	2
	Salix glauca-Salix barclayi	Open Tall Willow	2
	Salix glauca-Salix pulchra	Closed Tall Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	*Salix glauca-Salix barclayi*	Open Low Willow	2
		Closed Low Willow	1
	Salix glauca-Salix pulchra	Open Low Willow	2
		Closed Low Willow	1
	Salix alaxensis/Early-seral Riparian	Open Low Willow	1
		Moist Seral Grass-Herb Meadow	1
	Salix barclayi-Salix commutata	Open Low Willow	1
	Salix barclayi-Salix commutata/Empetrum nigrum	Open Low Willow	1
Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub	*Alnus viridis* ssp. *sinuata*/Forb	Open Tall Alder	5
		Closed Tall Alder	3
		Open Tall Alder-Willow	1
	Alnus viridis ssp. *sinuata*/Fern	Open Tall Alder	3
		Closed Tall Alder	3
	Alnus viridis ssp. *sinuata*	Closed Low Alder	1
		Open Tall Alder	1
		Closed Tall Alder	1
	Alnus viridis ssp. *sinuata/Calamagrostis canadensis*	Open Tall Alder	2
		Closed Tall Alder	1

Table 4. Continued.

Plot ecotype	Plant association	Vegetation class (Level IV)	Number of plots
Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest	*Populus balsamifera/Herbaceous*	Closed Balsam Poplar	3
		Open Balsam Poplar Forest	2
Upland Ashy-Loamy-Rocky Moist Forb Meadow	*Angelica lucida-Heracleum maximum*	Mixed Herbs	6
		Large Umbel	6
	Athyrium filix-femina	Mixed Herbs	2
		Ferns	1
Upland Ashy-Rocky Moist Crowberry Dwarf Shrub	*Empetrum nigrum*	Crowberry Dwarf Shrub Tundra	6
		Ericaceous-Lichen Dwarf Shrub Tundra	1
	Empetrum nigrum/Lichen	Ericaceous-Lichen Dwarf Shrub Tundra	2
		Crowberry Dwarf Shrub Tundra	2
	Empetrum nigrum-Arctostaphylos uva-ursi	Crowberry Dwarf Shrub Tundra	2
		Ericaceous Dwarf Shrub Tundra	1
	Empetrum nigrum/Racomitrium spp.	Crowberry Dwarf Shrub Tundra	3
	Empetrum nigrum-Vaccinium uliginosum	Ericaceous Dwarf Shrub Tundra	2
	Empetrum nigrum-Mixed Dwarf Shrub/Rock	Crowberry Dwarf Shrub Tundra	1
	Empetrum nigrum/Lathyrus japonicus	Crowberry Dwarf Shrub Tundra	1
	Empetrum nigrum-Mixed Dwarf Shrub	Open Low Mesic Shrub Birch-Ericaceous Shrub	1
Upland Ashy-Sandy-Rocky Moist Willow Low Shrub	*Salix glauca-Salix pulchra*	Open Low Willow	4
		Closed Low Willow	3
	no class	Open Low Willow	1
		Closed Low Willow	1
	Salix glauca-Salix pulchra/Empetrum nigrum	Open Low Willow	1
	Salix glauca-Salix barclayi	Open Low Willow	1

Table 4. Continued.

Plot ecotype	**Plant association**	**Vegetation class (Level IV)**	**Number of plots**
Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub	*Salix glauca-Salix pulchra*	Open Tall Willow	2
		Closed Tall Willow	1
	Salix glauca-Salix pulchra/Empetrum nigrum	Open Tall Willow	1
	Salix glauca-Salix barclayi	Closed Tall Willow	1
Upland Sandy-Rocky Dry Barrens	*Artemisia campestris* ssp. *borealis-Rumex beringensis-Festuca* spp./ Pumice	Partially Vegetated	4
		Barren	1
	no class	Barren	1
	Leymus mollis/Pumice	Partially Vegetated	1
	Arctostaphylos uva-ursi/Pumice	Partially Vegetated	1
	Empetrum nigrum/Pumice	Partially Vegetated	1
Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub	*Salix barclayi*	Closed Low Willow	1
	no class	Open Tall Willow	1
Volcanic Rocky Dry Barrens	*Saxifraga spp.*/Rock	Barren	3
		Partially Vegetated	1
	no class	Barren	3
	Luzula piperi/Pumice	Partially Vegetated	2
	Anthelia juratzkana-Gymnomitrion corallioides	Partially Vegetated	1
	Artemisia campestris ssp. *borealis-Rumex beringensis-Festuca* spp./ Pumice	Partially Vegetated	1
Volcanic Rocky Dry Lichen	*Stereocaulon vesuvianum-Racomitrium lanuginosum*	Lichen	1
		Foliose and Fruticose Lichen	1
Volcanic Rocky Moist Bryophyte	*Racomitrium* spp.	Dry Bryophyte	6
	Anthelia juratzkana-Gymnomitrion corallioides	Partially Vegetated	3
Volcanic Rocky Wet Sedge Meadow	*Carex lyngbyei*/Freshwater Marsh	Halophytic Sedge Marsh	1

Table 4. Continued.

Plot ecotype	Plant association	Vegetation class (Level IV)	Number of plots
Volcanic Rocky-Ashy Dry Dwarf Shrub	no class	Willow Dwarf Shrub Tundra	1
	Luetkea pectinata-Salix ovalifolia	Luetkea Dwarf Shrub Tundra	1
	Empetrum nigrum	Crowberry Dwarf Shrub Tundra	1
	Empetrum nigrum-Mixed Dwarf Shrub	Ericaceous-Lichen Dwarf Shrub Tundra	1
Volcanic Rocky-Ashy Moist Forb Meadow	no class	Ferns	1
	Angelica lucida-Heracleum maximum	Large Umbel	1
Volcanic Rocky-Ashy Wet Willow Low Shrub	*Salix alaxensis*/Early-seral Riparian	Open Low Willow	1
		Closed Low Willow	1
Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain	*Leymus mollis*	Elymus	2
		Partially Vegetated	1
	Leymus mollis/Pumice	Moist Seral Grass-Herb Meadow	1
		Elymus	1
Volcanic Streams and Springs	no class	Fresh Water	2

Table 5. Ecotype Key for Aniakchak National Monument.

Alpine Ecotype Key

1a. Site is covered by snow and/or ice, and the snow and/or ice persists through the entire year ....Snow or Ice

1b. Site not as above 2

2a. Total cover of vascular and non-vascular species <30% .... Alpine Rocky Barrens

2b. Total cover of either vascular and/or non-vascular plants ≥30%..3

3a. Total cover of vascular plants <30% AND cover of non-vascular species ≥30% ....Alpine Rocky Moist Bryophyte

3b. Total cover of vascular plants ≥30%..4

4a. Combined cover of dwarf shrubs ≥25% (sometimes as low as 15%) 5

5a. Vegetation is co-dominated (combined cover ≥25%) by *Harrimanella stelleriana* and *Luetkea pectinata* .... Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub

5b. Vegetation is dominated by *Empetrum nigrum*..........................Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub

5c. Vegetation is dominated by dwarf willows, most commonly *Salix reticulata*, *Salix arctica*, and/or *S. ovalifolia* .... Alpine Rocky-Ashy Moist Willow Dwarf Shrub

5d. Vegetation is dominated by species other than above.....................................Undefined alpine dwarf shrub type

4b. Dwarf shrub cover <25% 6

6a. Vegetation is dominated (cover ≥25%), either singly or in combination, by the graminoid species *Carex macrochaeta*, *Calamagrostis canadensis* and/or *Arctagrostis latifolia* ssp. *arundinacea*.. .... Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow

6b. Vegetation not as above ....Undefined alpine type

Coastal Ecotype Key

1a. Permanent waterbody...2

2a. Waterbody is an ocean or bay and water chemistry is saline, i.e., electrical conductivity ≥16,000 uS/cm ....Coastal Marine Water

2b. Waterbody is a tidally influenced lake or pond, or an estuary, and water chemistry is brackish, i.e., electrical conductivity 800 < 16,000 uS/cm .... Coastal Brackish Water

1b. Not a waterbody..3

3a. Site is located on active beach deposits or tidal flats and vegetation is barren or partially vegetated with total vascular plant cover <30% ....Coastal Sandy-Rocky Tidal Barrens

3b. Vegetation cover (vascular species only) ≥30% 4

4a. Site is located at or below average high tide line and experiences regular flooding by salt water............................... 5

5a. Vegetation dominated by the sedges *Carex ramenskii* and/or *C. lyngbyei* .... Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow

5b. Vegetation not as above ....Undefined coastal type

4b. Site is located at or above average high tide line on active or inactive beach deposits, beach ridges, or sand dunes, is not affected by normal high tides, but is affected regularly or irregularly by storm surges and/or salt spray 6

6a. *Leymus mollis* and/or *Calamagrostis canadensis* are the predominant graminiods, cover singly or in combination ≥30%.. 7

7a. *Leymus mollis* is the dominant graminoid AND sites regularly affected by salt spray or storm surges, the forbs *Honckenya peploides*, *Senecio pseudo-arnica*, and/or *Lathyrus japonicus*, and/or the sedge *Carex macrocephala* commonly present.................................Coastal Sandy Moist Brackish Beach Rye Meadow

7b. *Leymus mollis* and *Calamagrostis canadensis* co-dominate the graminoid layer AND sites affected irregularly by storm surges or salt spray; the forbs *Angelica lucida*, *Epilobium angustifolium*, *Fritillaria camschatcensis*, and/or *Lupinus nootkatensis* commonly present.......Coastal Sandy Moist Beach Rye-Forb Meadow

6b. Vegetation dominated by Poa eminens, the forbs *Potentilla egedii* ssp. *grandis* and *Triglochin maritimum* often co-dominant .... Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow

6c. Vegetation not as above ....Undefined coastal type

Lacustrine Ecotype Key

1a. Permanent waterbody..2

2a. Vascular species cover <10% .... Lowland Alkaline Lake Water

2b. Vascular species cover ≥10% 3

3a. Forb species, most commonly *Menyanthes trifoliata* and/or *Equisetum fluviatile*, with the greatest cover (either singly or combined) of any vascular plant.. Lacustrine Organic-rich Forb Marsh

3b. The grass *Arctophila fulva* with the greatest cover of any vascular plant .... Lacustrine Sandy Grass Marsh

3c. Vegetation not as above ....Undefined lacustrine type

1b. Not a permanent waterbody 4

4a. Vascular species cover <10% .... Lacustrine Rocky Drained Lake Barrens

4b. Vascular species cover ≥10% 5

5a. Vegetation dominated by wet sedges, namely *Carex lyngbyei* or *C. saxatilis* ssp. *laxa*; the forb *Potentilla palustris* is commonly co-dominant ....Lacustrine Loamy-Organic Wet Sedge-Forb Meadow

5b. The vegetation not as above ....Undefined lacustrine type

Lowland Ecotype Key

1a. Permanent waterbody..2

2a. Vascular species cover < 10% .... Lowland Alkaline Lake Water

2b. Vascular species cover ≥10% .... Go to Lacustrine Ecotype Key

1b. Not a permanent waterbody 3

3a. Low shrub cover ≥25%...4

4a. Willows (*Salix* spp.), namely *Salix pulchra* and/or *Salix commutata*, the dominant shrub .... Lowland Sandy-Organic Wet Willow Low Shrub

4b. Vegetation not as above...Undefined lowland low shrub type

3b. Low shrub cover <25% 5

5a. Dwarf shrub cover ≥25%...6

6a. *Empetrum nigrum* the dominant shrub.................Lowland Sandy Rocky-Organic Wet Crowberry Dwarf Shrub

6b. Vegetation not as above...Undefined lowland dwarf shrub type

5b. Dwarf shrub cover <25% 7

7a. The "coarse" sedges *Carex aquatilis* or *C. lyngbyaei* co-dominate with the "slender" sedges *Carex limosa*, *C. pluriflora*, and/or *C. rariflora* AND *Betula nana* with low to moderate cover (avg. 9%) AND combined cover of *Sphagnum* sp. ≥25% ....Lowland Organic-rich Wet Sedge-Shrub Bog Meadow

7b. The "coarse" sedges *Carex lyngbyaei* , *C. saxatilis*, *C. aquatilis* are dominant AND *Betula nana* absent or present at trace cover AND combined cover of *Sphagnum* spp. <25% ....Lowland Organic-rich Wet Sedge Meadow

7c. Vegetation not as above .... Undefined lowland type

Riverine Ecotype Key

1a. Permanent waterbody.......... Riverine Alkaline River Water

1b. Not a waterbody.......... 2

2a. Site is located on river bars and active channel deposits on alluvial fans and vegetation is barren or partially vegetated where total vascular plant cover <30%.......... Riverine Rocky Barrens

2b. Vegetation cover (vascular species only) ≥ 30%.......... 3

3a. Cover of low (0.2 to 1.5 m) and/or tall (>1.5 m) shrubs ≥25%.......... 4

4a. Cover of tall shrubs ≥25%.......... 5

5a. Vegetation is dominated or co-dominated (≥25% foliar cover) by *Alnus sinuata*; *Salix* spp. may or may not be co-dominant.......... Riverine Rocky Moist Alder-Willow Tall Shrub

5b. Vegetation is dominated (≥25% foliar cover) by *Salix* spp. (most commonly *Salix alaxensis*, *S. barclayi*, *S. glauca*, and/or *S. pulchra*) and *Alnus sinuata*, when present, occurs at low abundance (<25% foliar cover).......... Riverine Sandy-Loamy Moist Willow Tall Shrub

5c. Vegetation not as above.......... Undefined riverine tall shrub type

4b. Cover of low shrubs ≥25%.......... 6

6a. Vegetation is dominated (≥25% foliar cover) by *Salix* spp. (most commonly *Salix barclayi*, *S. commutata*, and/or *S. glauca*).......... Riverine Silty-Sandy-Rocky Moist Willow Low Shrub

6b. Vegetation not as above.......... Undefined riverine low shrub type

3b. Cover of low and/or tall shrubs <25%; vegetation instead dominated by herbaceous species.......... 7

7a. Soils are wet and saturated, water table at or near the soil surface.......... 8

8a. Vegetation dominated (≥25% foliar cover) by “coarse” sedges, most commonly *Carex lyngbyaei*.......... Riverine Loamy-Organic Wet Sedge Meadow

8b. Vegetation not as above.......... Undefined riverine wet herbaceous type

7b. Soils are moist, water table typically ≥ 40 cm below the soil surface.......... 9

9a. Vegetation dominated (≥25% foliar cover) by forb species, most commonly the large umbels *Angelica genuflexa*, *A. lucida*, and *Heracleum lanatum*.......... Riverine Sandy-Loamy Moist Forb Meadow

9b. Vegetation not as above.......... Undefined riverine moist herbaceous type

Upland Ecotype Key

1a. Total vascular plant cover <30%.......... Upland Sandy-Rocky Dry Barrens

1b. Total vascular plant cover ≥30%.......... 2

2a. Cover of *Populus balsamifera* ≥10%.......... Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest

2b. Cover of *Populus balsamifera* <10%.......... 3

3a. Vegetation dominated (≥25% foliar cover) by low or tall shrubs.......... 4

4a. Vegetation is dominated or co-dominated (≥25% foliar cover) by *Alnus sinuata*; *Salix* spp. may or may not be co-dominant.......... Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub

4b. Vegetation dominated by species other than *Alnus sinuata*.......... 5

5a. Vegetation is dominated by erect *Salix* spp. (most commonly *Salix barclayi*, *S. glauca*, and/or *S. pulchra*) and *Alnus sinuata*, when present, occurs at low abundance (<25% foliar cover).......... 6

6a. Cover of tall shrubs ≥25%.......... Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub

6b. Cover of tall shrubs <25% AND cover of low shrubs ≥ 25% .... Upland Ashy-Sandy-Rocky Moist Willow Low Shrub

5b. Vegetation dominated by species other than *Salix* spp. .... Undefined upland low or tall shrub type

3b. Cover of low and tall shrubs <25% 7

7a. Vegetation dominated by dwarf shrubs (≥25% foliar cover) 8

8a. Crowberry is the dominant shrub, foliar cover typically ≥25% (occasionally as low as 15%) .... Upland Ashy-Rocky Moist Crowberry Dwarf Shrub

8b. Crowberry is not the dominant shrub .... Undefined upland dwarf shrub type OR Return to Physiography Key

7b. Dwarf shrub cover <25% 9

9a. Combined cover of forbs ≥25% 10

10a. The forbs *Heracleum lanatum*, *Angelica lucida*, and/or E*pilobium angustifolium* dominant or co-dominant .... Upland Ashy-Loamy-Rocky Moist Forb Meadow

10b. Vegetation not as above .... Undefined upland forb-dominated type

9b. Combined cover of forbs <25% AND combined cover of graminoids ≥25% 11

11a. Vegetation is dominated (cover ≥25%), either singly or in combination, by the graminoid species *Carex macrochaeta*, *Calamagrostis canadensis* and/or *Arctagrostis latifolia* ssp. *arundinacea* AND site located near the upper elevational extent of low and tall shrubs, i.e., near the upland/alpine physiography break .... Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow

11b. Vegetation or environment not as above .... Undefined upland type

Volcanic Physiography Key

1a. Site is covered by snow and/or ice, and the snow and/or ice persists through the entire year .... Snow or Ice

1b. Site not as above 2

2a. Permanent waterbody 3

3a. Waterbody is a lake .... Volcanic Lake

3b. Waterbody is a stream or spring .... Volcanic Streams and Springs

2b. Not a permanent waterbody 4

4a. Total cover of vascular and non-vascular species <30% .... Volcanic Rocky Dry Barrens

4b. Total cover of either vascular and/or non-vascular plants ≥30% 5

5a. Total cover of vascular plants <30% AND cover of non-vascular species ≥ 30% 6

6a. Vegetation dominated by the lichen *Stereocaulon vesuvianum*; sites typically occurring on lava flows .... Volcanic Rocky Dry Lichen

6b. Vegetation dominated by mosses, most commonly *Racomitrium ericoides* and *R. lanuginosum* .... Volcanic Rocky Moist Bryophyte

6c. Vegetation not as above .... Undefined volcanic non-vascular type

5b. Total cover of vascular plants ≥30% 7

7a. Vegetation is dominated (≥25% foliar cover) by erect *Salix* spp. (most commonly *Salix alaxensis* and *S. barclayi*) 8

8a. Soils wet and saturated, water table at or near the soil surface, the forb *Epilobium palustre*, and the moss *Sanionia uncinata*, typically present in the understory .... Volcanic Rocky-Ashy Wet Willow Low Shrub

8b. Soils are moist, water table typically ≥40 cm below the soil surface .... Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub

7b. Cover of erect *Salix* spp. <25% 9

9a. Vegetation dominated by dwarf shrubs (combined cover ≥25%); characteristic species include *Salix ovalifolia*, *S. stolonifera*, *Empetrum nigrum*, and *Luetkea pectinata* .... Volcanic Rocky-Ashy Dry Dwarf Shrub

9b. Cover of dwarf shrubs <25% 10

10a. Vegetation dominated by forbs and soils moist, the water table ≥40 cm below the soil surface for most, if not all, of the growing season.............. Volcanic Rocky-Ashy Moist Forb Meadow

10b. Vegetation dominated by graminoids 11

11a. Soils wet and saturated, water table at or near the soil surface, vegetation dominated by the sedge *Carex lyngbyaei* .... Volcanic Rocky Wet Sedge Meadow

11b. Soils dry and rocky, water table well below 40 cm below the soil surface throughout the growing season AND the grass *Leymus mollis* with ≥25% foliar cover (occasionally as low as 8%) .... Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain

11c. Soils and/or environment not as above...................................... Undefined volcanic type this document for more information on when to use this Ecotype Key.

Instructions

1. When in the field in ANIA, select a homogeneous patch of vegetation at least 0.10 ha in area, avoiding transitions between vegetation types, landforms, or slope positions (i.e., ecotones).
2. Use the Key to Physiography Class for Aniakchak National Monument and Preserve (Figure 3) to determine the physiography class of the site selected in Step 1.
3. Go to the appropriate physiography section in the Key to Ecotypes (Table 5) and follow the leads to determine the ecotype in which you are standing.
4. To help verify the ecotype determined above refer to the Ecotype Descriptions section (below) and find the ecotype determined above. Read through the vegetation and environment description and review the common (≥60% frequency of occurrence) species in the constancy/cover table. Compare this to the vegetation and environment observed at the site selected in Step 1.
5. If the Key to Ecotypes leads to an “undefined” type go back to the beginning of the physiography section and work back through the key and subtract 5% from the species or lifeform cover cutpoints.
6. If, after adjusting the cover cutpoints, the Key to Ecotypes once again leads to an “undefined” type the below resource may be of use in understanding the vegetation and environment at the site selected in Step 1:
7. Plant Associations, Vegetation Succession, and Earth Cover Classes Aniakchak National Monument and Preserve Natural Resource Technical Report NPS/ANIA/NRTR—2012/557 (Boucher et al. 2012).
    a. Plant Associations, Vegetation Succession, and Earth Cover Classes Aniakchak National Monument and Preserve Natural Resource Technical Report NPS/ANIA/NRTR—2012/557 (Boucher et al. 2012).

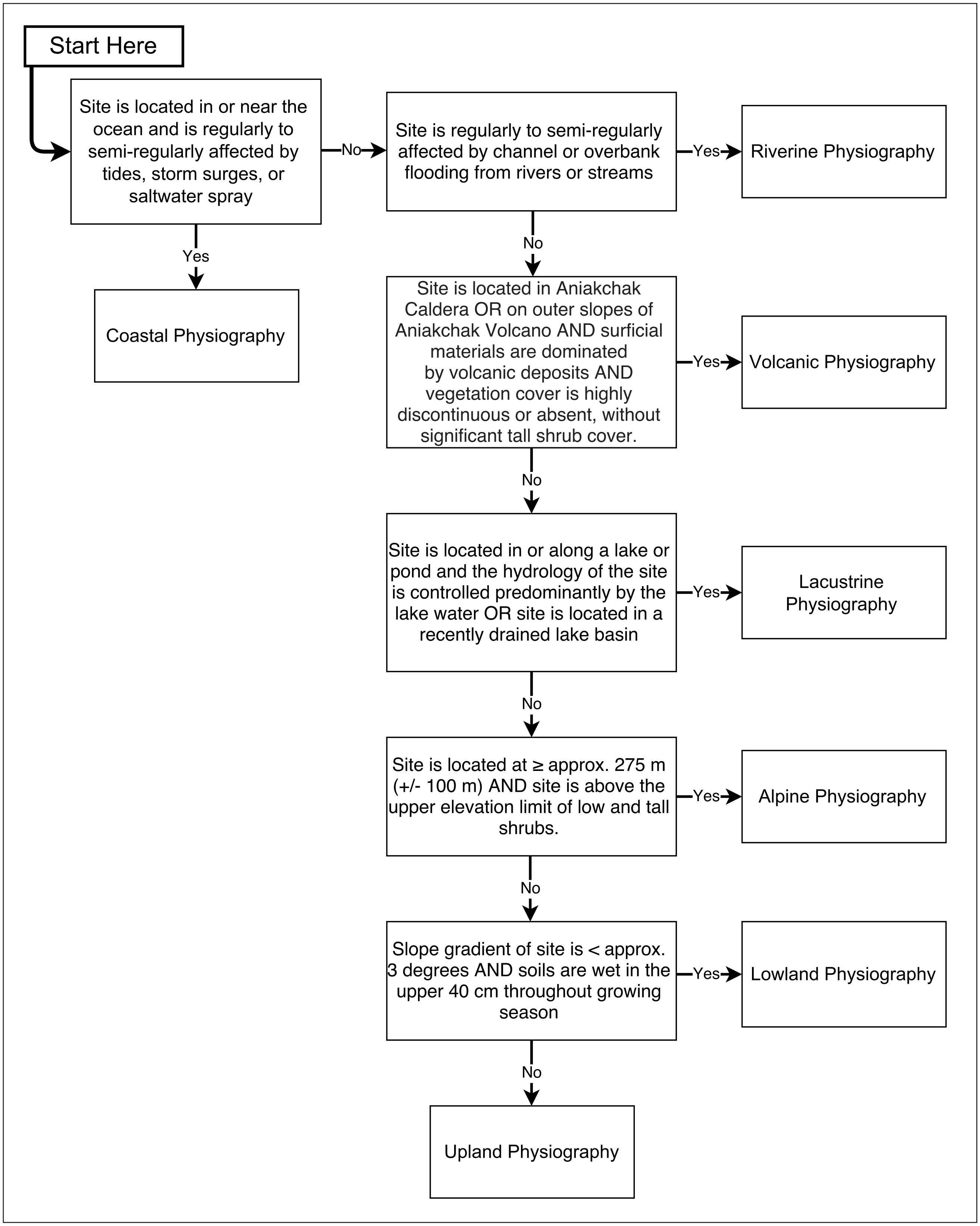
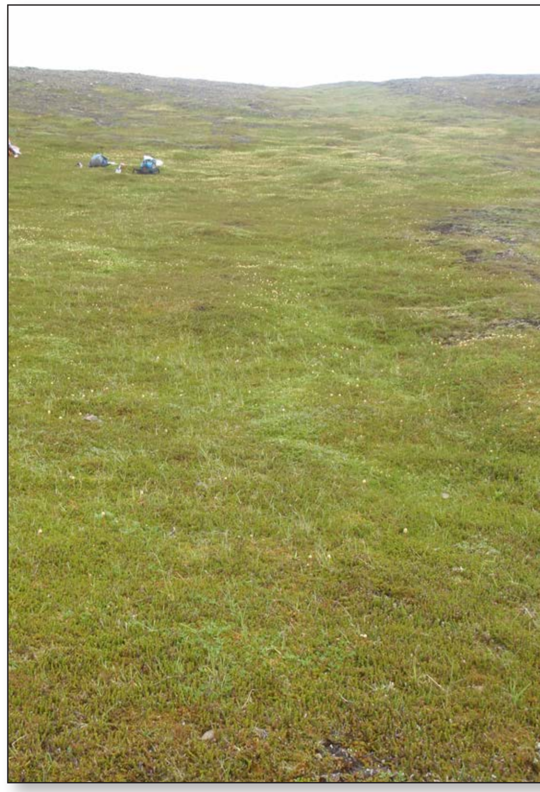


Figure 3. Key to Physiography Class for Aniakchak National Monument and Preserve, Alaska, 2014.

Ecotype Descriptions

Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub



The ecotype Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub occurs at high elevation (avg. 485 m) on concave slopes with late-lying snow or in sheltered drainages. This ecotype is of limited spatial extent in ANIA and is typically associated with north, northeast or east aspects, where the prevailing winds have favored deposition of fine ash following volcanic events and the development of loamy soil texture. Prevailing winds also favors deposition of wind-transported snow that melts out later in the summer. This ecotype may occur on any aspect, however, as long as the site is sheltered from wind scour. Vegetation corresponds to the *Harrimanella stelleriana-Luetkea pectinata* plant association. Dwarf evergreen shrubs are abundant in this plant association, with *Harrimanella stelleriana* and *Luetkea pectinata* being codominant. Other common dwarf shrubs include *Phyllodoce aleutica*, *Vaccinium uliginosum*, *Empetrum nigrum* and *Therorhodion camtschaticum*. Common herbaceous species include the forbs *Lycopodium sabinaefolium*, *Epilobium anagallidifolium*, and *Sedum rosea* ssp. *integrifolium*, and the grass *Vahlodea atropurpurea*. Common non-vascular species include the mosses *Rhytidiadelphus triquetrus*, *Racomitrium lanuginosum* and *Ptilium crista-castrensis*, as well as *Cladonia* and *Peltigera* lichens. Dominant textures were Ashy, Loamy, and Rubbly with soils that typically form in a thin mantle of eolian mineral soil over rocky residual or alluvial soil. The surface organic horizon is very thin (avg. 3.0 cm) and depth to 15% or more rock fragments is shallow (avg. 7 cm). Soils are generally acidic (avg. 4.6 pH), moderately well-developed Andisols and Spodosols. Soil subgroups include Andic Haplocryods, Spodic Haplocryands and Vitric Haplocryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 6–8.

Table 6. Constancy/Cover Table for Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Vaccinium uliginosum*	2.7	0.1	7	100
evergreen shrubs	*Cassiope lycopodioides*	5.1	0.1	10	67
evergreen shrubs	*Harrimanella stelleriana*	23.3	10.0	40	100
evergreen shrubs	*Luetkea pectinate*	46.7	40.0	60	100
evergreen shrubs	*Phyllodoce aleutica*	2.3	1.0	3	100
evergreen shrubs	*Therorhodion camtschaticum*	1.7	0.1	3	100
Forbs	*Sedum rosea* ssp. *integrifolium*	0.4	0.1	1	100
Mosses	*Rhytidiadelphus* sp.	31.0	0.1	80	100

Table 7. Environment Data Summary Table for Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	484.0	35.0	457.0	524.0	3
Slope (degrees)	23.0	6.0	16.0	26.0	3
Surface Organic Thickness (cm)	3.0	1.7	1.0	4.0	3
Depth to 15% Rock Fragments (cm)	7.0	1.4	6.0	8.0	2
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	3
Site pH	4.6	0.8	4.1	5.5	3
Electrical Conductivity (um)	-999.0	0.0	-999.0	-999.0	3

Table 8. Soil Horizon Table for Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	O	0.0–4.0	no data	fine sandy loam	10yr 3/1
2	A	4.0–6.0	no data	very fine sandy loam	10yr 2/1
3	C1	6.0–8.0	no data	coarse sand (0.5–1 mm)	7.5yr 3/3
4	Ab	8.0–10.0	no data	fine sandy loam	10yr 4/2
5	C2	10.0–36.0	no data	loam	10yr 4/4

Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow

The ecotype Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow occurs at high elevation (avg. 413 m) on mountain slopes where surface runoff is concentrated in drainageways and ephemeral streams. This ecotype occurs on a variety of aspects and on slopes less than 30 degrees (avg. 18 degrees). Vegetation corresponds to the *Calamagrostis canadensis-Carex macrochaeta* and *Carex macrochaeta-Arctagrostis latifolia* ssp. *arundinacea* plant associations. The dominant sedge is *Carex macrochaeta* and the co-dominant grasses are *Calamagrostis canadensis* and *Arctagrostis latifolia* ssp. *arundinacea*. *Vahlodea atropurpurea* is a common associate on some sites. Forbs with a high constancy include *Heracleum lanatum*, *Angelica lucida*, *Equisetum arvense*, and *Achillea millefolium*. Common mosses are *Rhytidiadelphus triquetrus* and *Hylocomium splendens*. Soils are moist and form in coarse ash or rocky tephra deposits with a dominant texture of Sandy, Rubby or Blocky. The depth to 15% or more rock fragments is shallow (avg. 16.6 cm). The surface organic horizon is typically thin (avg. 8.4 cm), but may accumulate to moderate thickness in favorable sites. Soil chemistry is circumneutral (avg. pH 5.8), and tpically has an EC <100 uS/cm. Well-developed A horizons, associated with high turnover of fine roots from abundant grass cover, contribute to mollic epipedons. Common soil subgroups include Humic Vitricryands, Typic Vitricryands and Folistic Haplocryepts. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 9–11.

Table 9. Constancy/Cover Table for Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix reticulata*	7.3	5	10	43
forbs	*Rubus arcticus*	5.3	1	10	57
grasses	*Arctagrostis latifolia* ssp. *arundinacea*	9.0	1	20	57
grasses	*Calamagrostis canadensis*	36.3	30	40	57
mosses	*Rhytidiadelphus* sp.	11.8	3	20	86
sedges	*Carex macrochaeta*	25.1	1	70	100

Table 10. Environment Data Summary Table for Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	413.0	89.0	296.0	547.0	7
Slope (degrees)	18.0	10.0	0.0	30.0	7
Surface Organic Thickness (cm)	8.4	4.1	4.0	16.0	7
Depth to 15% Rock Fragments (cm)	16.6	8.3	7.0	32.0	7
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	7
Site pH	5.8	0.2	5.5	6.2	6
Electrical Conductivity (um)	50.0	NA	50.0	50.0	1

Table 11. Soil Horizon Table for Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	O	0.0–4.0	no data	sand	10yr 4/1
2	A	4.0–11.0	no data	sand	10yr 2/1
3	A	11.0–16.0	no data	coarse sand (0.5–1 mm)	7.5yr 3/3
4	C	16.0–16.0	no data	very coarse sand (1–2 mm)	NA

Alpine Rocky-Ashy Moist Bryophyte

The ecotype Alpine Rocky-Ashy Moist Bryophyte occurs at high elevation (avg. 554 m) on gentle- to moderate mountain slopes (avg. 13 degrees) on a variety of aspects. Vegetation corresponds to the *Anthelia juratzkana-Gymnomitrion corallioides* plant association and live cover of the dominant species totals at least 30%. Numerous liverwort, moss, lichen, and vascular plant species are typically present, but with low cover. Common vascular species include the shrubs *Empetrum nigrum*, *Loiseleuria procumbens*, *Salix ovalifolia*, and *Therorhodion camtschaticum*, and the forbs *Lagotis glauca* and *Artemisia arctica*. Common nonvascular species include the liverworts *Anthelia juratzkana* and *Gymnomitrion corallioides*, and lichens including *Stereocaulon* spp., *Thamnolia vermicularis*, and *Cladina* spp. Dominant textures are Rubbly with 15% or greater rock fragments at the soil surface (avg. depth 0 cm). Surface organic horizons are very thin or absent (avg. 1.5 cm) and soil pH ranges from acidic to circumneutral (avg. 5.9). Soils are poorly-developed Andisols formed in coarse ash and lapilli, or moderately-developed Inceptisols formed in rocky sedimentary colluvium. Soil subgroups include Typic Vitricryands, Lithic Haplocryepts, and Typic Humicryepts. The well-developed cryptogamic crust in this ecotype can retard erosion by wind and water, help retain soil moisture during dry periods, slow evaporation rates, and enhance seedling establishment. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 12–14.

Table 12. Constancy/Cover Table for Alpine Rocky-Ashy Moist Bryophyte, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix ovalifolia*	2.3	1.0	5.0	75
evergreen shrubs	*Empetrum nigrum*	3.7	2.0	7.0	75
evergreen shrubs	*Loiseleuria procumbens*	3.3	1.0	6.0	75
evergreen shrubs	*Therorhodion camtschaticum*	1.7	1.0	3.0	75

Table 12. Continued.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Artemisia arctica*	0.1	0.1	0.1	75
forbs	*Lagotis glauca*	0.1	0.1	0.1	75
forbs	*Polygonum viviparum*	0.1	0.1	0.1	75
lichens	*Stereocaulon* sp.	9.0	8.0	10.0	50
rushes	*Luzula arcuata* ssp. *unalaschcensis*	0.4	0.1	1.0	75
sedges	*Carex microchaeta*	1.3	1.0	2.0	75

Table 13. Environment Data Summary Table for Alpine Rocky-Ashy Moist Bryophyte, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	554.0	66.0	489.0	645.0	4
Slope (degrees)	13.0	5.0	7.0	18.0	4
Surface Organic Thickness (cm)	1.5	1.3	0.0	3.0	4
Depth to 15% Rock Fragments (cm)	0.0	0.0	0.0	0.0	4
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	4
Site pH	5.9	0.9	4.6	6.5	4
Electrical Conductivity (um)	-999.0	0.0	-999.0	-999.0	4

Table 14. Soil Horizon Table for Alpine Rocky-Ashy Moist Bryophyte, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	O	0.0–3.0	no data	fine sand (0.1–.25 mm)	10yr 3/2
2	A	3.0–8.0	no data	fine sand (0.1–.25 mm)	10yr 2/1
3	C	8.0–11.0	no data	coarse sand (0.5–1 mm)	10yr 2/1
4	C	11.0–20.0	no data	very coarse sand (1–2 mm)	10yr 3/1

Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub

The ecotype Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub occurs at high elevation (avg. 366 m) on mountain slopes and benches on a variety of aspects and slope angles (avg. 10 degrees). Vegetation corresponds to the *Empetrum nigrum*, *Empetrum nigrum*-Mixed Dwarf Shrub/Rock, *Empetrum nigrum-Vaccinium uliginosum*, *Empetrum nigrum*/Pumice, and *Empetrum nigrum*-Mixed Dwarf Shrub plant associations. *Empetrum nigrum* dominates the dwarf shrub layer, but has a large range in cover from 7 to 80% (avg. 26.4%). Other shrubs with high constancy include *Vaccinium uliginosum*, *Therorhodion camtschaticum*, *Salix arctica*, *Salix reticulata*, and *Dryas octopetala*. Herbaceous species such as *Geum rossii* and *Carex microchaeta* are often present, but have low cover. Common non-vascular species include *Racomitrium* sp. and *Stereocaulon* sp. Soils may form in hillside colluvium, residual soil on shallow bedrock, or solifluction deposits. Dominant textures are Rocky or Sandy, but may include Ashy or Loamy classes in those instances where rock fragments are 20 cm or more below the soil surface. The depth to 15% or greater rock fragments ranges from 0 to 30 cm (avg. 4.8 cm). The surface organic horizon is typically very thin and ranged from 0 to 8 cm (avg. 3.2 cm). Soil chemistry is circumneutral (avg. 6.1 pH), and typically has an EC <50 uS/cm. Periglacial features, such as solifluction lobes, frost cracks, frost boils, and hummocks may be present. The slow downward movement of earthen material from gelifluction processes can facillitate the formation of a thick, humus-rich mollic epipedon (i.e., high organic carbon content and high base saturation). Soil subgroups in this ecotype with mollic epipedons include Humic Vitricryands, Lithic Haplocryolls, Typic Haplocryolls, Andic Haplocryolls and Lithic Argicryolls. The most common soil subgroup, Typic Vitricryands, lacks a mollic epipedon and formed in coarse ash and rocky tephra deposits. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 15–17.

Table 15. Constancy/Cover Table for Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix arctica*	3.2	0.1	10	75
deciduous shrubs	*Vaccinium uliginosum*	8.8	0.1	30	95
evergreen shrubs	*Empetrum nigrum*	26.4	7.0	80	100
evergreen shrubs	*Therorhodion camtschaticum*	1.5	0.1	5	95
forbs	*Geum rossii*	1.2	0.1	3	85

Table 16. Environment Data Summary Table for Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	366.0	90.0	265.0	580	20
Slope (degrees)	10.0	7.0	0.0	28	20
Surface Organic Thickness (cm)	3.2	2.5	0.0	8	19
Depth to 15% Rock Fragments (cm)	4.8	8.7	0.0	30	18
Water Table Depth (cm)	-999.0	0.0	-999.0	-999	20
Site pH	6.1	0.7	4.7	8	19
Electrical Conductivity (um)	20.0	NA	20.0	20	1

Table 17. Soil Horizon Table for Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–1.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	A	1.0–10.0	gravels (15–35%)	sandy loam	10yr 3/2
3	BA	10.0–25.0	gravels (15–35%)	sandy clay loam	2.5y 3/2
4	2C	25.0–45.0	very gravelly (35–60%)	loamy sand	NA

Alpine Rocky-Ashy Moist Willow Dwarf Shrub

The ecotype Alpine Rocky-Ashy Moist Willow Dwarf Shrub occurs at high elevation (avg. 471 m) on concave mountain slopes. This ecotype occurs on a variety of aspects; measured slope angles ranged from 2 to 33 degrees (avg. 19 degrees). Vegetation corresponds to the *Salix arctica-Salix reticulata* plant association. The co-dominant dwarf shrub species *Salix arctica* and *S. reticulata* had similar live cover (avg. cover 17.5% and 17.0% respectively). *S. ovalifolia*, though not always present, can occur with relatively high cover (avg. 25.0%). The herbaceous species *Sedum rosea* ssp. *integrifolium* has very high constancy, but provides little cover (avg. 2.2%). Other common herbaceous species with low cover include *Aconitum delphinifolium*, *Geum rossii*, and *Arnica lessingii*. The graminoid species *Poa arctica* and *Carex macrochaeta* are also well represented. Soils formed in an ash-rich colluvium over residual soil. Dominant textures are Loamy, Rubbly and Sandy with the depth to 15% or more rock fragments ranging from shallow to moderately deep (avg. 29.8 cm). The surface organic horizon is typically thin (avg. 4.2 cm). Soil chemistry is circumneutral (avg. 5.6 pH), and has an average EC of 117.5 uS/cm. This ecotype occurs on a variety of soil orders, including Entisols, Inceptisols, Alfisols, and Andisols. Soil subgroups include Typic Humicryepts, Vitrandic Cryorthents, Vitrandic Haplocryalfs, and Typic Vitricryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 18–20.

Table 18. Constancy/Cover table for Alpine Rocky-Ashy Moist Willow Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix arctica*	17.5	8.0	35	80
deciduous shrubs	*Salix reticulata*	17.0	3.0	30	100
deciduous shrubs	*Vaccinium uliginosum*	7.5	5.0	10	40
evergreen shrubs	*Therorhodion camtschaticum*	5.1	0.1	10	40
forbs	*Aconitum delphinifolium*	0.8	0.1	2	80
forbs	*Angelica lucida*	5.5	3.0	8	40
forbs	*Arnica lessingii*	0.3	0.1	1	80
forbs	*Geum rossii*	0.8	0.1	2	80
forbs	*Sedum rosea* ssp. *integrifolium*	2.2	0.1	7	100
mosses	*Sanionia uncinata*	45.1	0.1	90	40
sedges	*Carex bigelowii*	7.5	5.0	10	40
sedges	*Carex macrochaeta*	6.4	0.1	15	60

Table 19. Environment Data Summary table for Alpine Rocky-Ashy Moist Willow Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	471.0	177.0	259	663.0	5
Slope (degrees)	19.0	13.0	2	33.0	5
Surface Organic Thickness (cm)	4.2	3.9	0	10.0	5
Depth to 15% Rock Fragments (cm)	29.8	34.2	0	79.0	4
Water Table Depth (cm)	-999.0	0.0	-999	-999.0	5
Site pH	5.6	0.5	5	6.2	5
Electrical Conductivity (um)	117.5	55.6	50	180.0	4

Table 20. Soil Horizon table for Alpine Rocky-Ashy Moist Willow Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oe	0.0–6.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	10yr 2/1
2	A	6.0–12.0	no modifier (<15%)	silt loam	10yr 2/2
3	Bw	12.0–42.0	channery (15–35%)	fine sandy loam	10yr 3/2
4	Ab	42.0–53.0	very channery (35–60%)	silt loam	10yr 2/2
5	BC	53.0–65.0	extremely flaggy (60–90%)	silt loam	10yr 4/3
6	R	65.0–65.0	no modifier (<15%)	Not Available	n/a n/a/n/a

Alpine Rocky Dry Barrens

The ecotype Alpine Rocky Dry Barrens occurs at high elevation (avg. 435 m) on exposed slopes, summits, and ridgelines. Slope angles range from gentle to steep and this ecotype can occur on any aspect. Vegetation corresponds to the *Saxifraga* spp./Rock plant association and total cover of live vegetation is less than 30%. No single species is dominant and individual plants are scattered across a matrix of exposed mineral soil and rock fragments. Common species include the forbs *Geum rossii*, *Saxifraga bronchialis*, *Saxifraga serpyllifolia*, *Saxifraga oppositifolia*, and *Chrysosplenium wrightii*; the dwarf shrubs *Salix arctica* and *Salix stolonifera*; and the grass *Deschampsia sukatschewii*. Common non-vascular species include *Umbilicaria lichens*, and the mosses *Racomitrium lanuginosum*, *R. canescens*, and *R. fasciculare*. Soils may form in hillside colluvium, residual soil, or coarse ash with bombs, blocks or lapilli. Dominant textures are rocky, including Rubbly, Blocky, and Lithic Contact. Surface organic horizons are very thin to absent (avg. 0.6 cm) and depth to 15% or more rock fragments is shallow, ranging from the soil surface to a depth of 18 cm. Soil chemistry is circumneutral (avg. 6.6 pH) with an average EC of 110.0 uS/cm. Soils are poorly developed and include the Entisols and Inceptisols soil orders. Soil subgroups include Typic Cryorthents, Lithic Cryorthents, Vitrandic Humicryepts, Lithic Haplocryepts, and Lithic Humicryepts. Factors limiting plant growth include exposure to wind, winter desiccation, and the coarse-textured, excessively drained soils. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 21–23.

Table 21. Constancy/Cover table for Alpine Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix arctica*	0.3	0.1	1.0	80
evergreen shrubs	*Dryas octopetala*	0.6	0.1	2.0	80
forbs	*Chrysosplenium wrightii*	0.1	0.1	0.1	80
forbs	*Geum rossii*	0.6	0.1	1.0	100
forbs	*Saxifraga bronchialis s.l.*	0.1	0.1	0.1	100
forbs	*Saxifraga oppositifolia*	0.3	0.1	1.0	80
forbs	*Saxifraga serpyllifolia*	0.3	0.1	1.0	80

Table 22. Environment Data Summary table for Alpine Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	435.0	175.0	245.0	714.0	5
Slope (degrees)	7.0	10.0	0.0	24.0	5
Surface Organic Thickness (cm)	0.6	1.3	0.0	3.0	5
Depth to 15% Rock Fragments (cm)	3.6	8.0	0.0	18.0	5
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	5
Site pH	6.6	0.4	6.4	7.4	5
Electrical Conductivity (um)	110.0	75.5	30.0	180.0	3

Table 23. Soil Horizon table for Alpine Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C1	0.0–18.0	gravels (15–35%)	fine sand (0.1–.25 mm)	NA
2	C2	18.0–36.0	extremely cobbly (60–90%)	fine sand (0.1–.25 mm)	NA
3	R	36.0–36.0	no modifier (<15%)	Not Available	NA

Coastal Brackish Water

The ecotype Coastal Brackish Water includes lagoons, tidal guts, and the lowermost, tidally-affected reaches of rivers. The water is alkaline (8.4 pH) and brackish and ranges in EC from 8000–16,000 uS/cm. Table 24 presents a summary of a select set of environmental data for this ecotype.

Coastal Marine Water

The ecotype Coastal Marine Water includes brackish water in Amber, Aniakchak and Kujulik Bays, as well as nearshore waters off the coast of Capes Kumlik, Ayutka, and Kunmik. The water is alkaline (8.1 pH) and saline, with an EC >16000 uS/cm. Table 25 presents a summary of a select set of environmental data for this ecotype.

Table 24. Environment Data Summary table for Coastal Brackish Water, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	2.0	NA	2.0	2.0	1
Slope (degrees)	0.0	NA	0.0	0.0	1
Surface Organic Thickness (cm)	0.0	NA	0.0	0.0	1
Depth to 15% Rock Fragments (cm)	-999.0	NA	-999.0	-999.0	1
Water Table Depth (cm)	50.0	NA	50.0	50.0	1
Site pH	8.4	NA	8.4	8.4	1
Electrical Conductivity (um)	8000.0	NA	8000.0	8000.0	1

Table 25. Environment Data Summary table for Coastal Marine Water, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Slope (degrees)	0.0	NA	0.0	0.0	1
Surface Organic Thickness (cm)	0.0	NA	0.0	0.0	1
Depth to 15% Rock Fragments (cm)	-999.0	NA	-999.0	-999.0	1
Water Table Depth (cm)	-999.0	NA	-999.0	-999.0	1
Site pH	8.1	NA	8.1	8.1	1
Electrical Conductivity (um)	43000.0	NA	43000.0	43000.0	1

Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow

The ecotype Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow is of limited extent and occurs in infrequently-inundated coastal zones near sea level (e.g., mouth of Aniakchak River) on flat or gentle slopes (avg. 2 degrees). Vegetation corresponds to the *Poa eminens-Deschampsia beringensis-Festuca rubra* plant association. This ecotype typically supports several codominant herbaceous species, including *Potentilla egedii* ssp. *grandis*, T*riglochin maritimum*, and *Poa eminens*. The forb *Moehringia lateriflora* is a common associate, but has very low cover (avg. 0.1%). The dwarf shrub *Salix ovalifolia* and the grass *Deschampsia cespitosa s.l.* are often present in the understory. Soils form in stratified alluvial sediments with dominant texture classes of Sandy or Loamy. Soils are circumneutral (avg. 6.4 pH) and may be brackish following maritime flooding events. Surface organic horizons are thin (avg. 8.5 cm) and the depth to the water table is often within 100 cm of the soil surface. Soils are poorly developed Entisols, and include the soil subgroups Oxyaquic Cryofluvents and Aquic Cryofluvents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 26–28.

Table 26. Constancy/Cover table for Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix ovalifolia*	10.0	10.0	10.0	50
forbs	*Moehringia lateriflora*	0.1	0.1	0.1	100
forbs	*Potentilla egedii* ssp. *grandis*	32.5	5.0	60.0	100
forbs	*Triglochin maritimum*	18.5	7.0	30.0	100
grasses	*Deschampsia cespitosa s.l.*	12.0	12.0	12.0	50
grasses	*Deschampsia cespitosa* ssp. *beringensis*	7.0	7.0	7.0	50
grasses	*Festuca rubra s.l.*	7.0	7.0	7.0	50
grasses	*Festuca rubra* ssp. *arctica*	20.0	20.0	20.0	50
grasses	*Poa eminens*	17.5	15.0	20.0	100

Table 27. Environment Data Summary table for Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	8.0	1.0	7.0	8	2
Slope (degrees)	2.0	1.0	1.0	2	2
Surface Organic Thickness (cm)	8.5	0.7	8.0	9	2
Depth to 15% Rock Fragments (cm)	18.0	NA	18.0	18	1
Water Table Depth (cm)	-999.0	0.0	-999.0	-999	2
Site pH	6.4	0.8	5.8	7	2
Electrical Conductivity (um)	-999.0	0.0	-999.0	-999	2

Table 28. Soil Horizon table for Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–8.0	no data	slightly decomposed plant material (unsaturated Oi)	NA
2	A1	8.0–18.0	no data	clay loam	10yr 3/2
3	C1	18.0–21.0	no data	coarse sand (0.5–1 mm)	10yr 3/1
4	A2	21.0–23.0	no data	loam	10yr 3/2
5	C2	23.0–27.0	no data	coarse sand (0.5–1 mm)	10yr 3/1
6	C3	27.0–37.0	no data	fine sand (0.1–.25 mm)	10yr 3/1

Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow

The ecotype Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow occurs on inactive tidal flats and brackish marshes near estuaries and lagoons. Slopes are flat and water may be ponded at the surface for some time during the growing season. Vegetation corresponds to the *Carex ramenskii* plant association in frequently flooded areas with more saline soils, and to the *Carex lyngbyei*/Tidal Marsh plant association in less frequently flooded areas with lower salinity. Either *Carex ramenskii* or *Carex lyngbyei* form a near-monoculture. Other herbaceous species with high constancy, but low cover, include *Potentilla egedii* ssp. *grandis*, *Poa eminens*, and *Triglochin palustris*. Soils form in saturated anaerobic environments in alkaline (avg. 7.4 pH) and brackish alluvial parent material. The EC ranges from 800–16000 uS/cm. The depth to the water table ranges from 21.0 to 28.0 cm below the soil surface (avg. 24.5 cm). Soils on more recently flooded sites may lack a surface organic horizon, while sheltered areas may accumulate moderately-thick organic horizons (avg. 7.0 cm). Soils may be gravelly in areas where rock fragments (often pumice) are washed in via tidal rivers. Dominant textures include the Gravelly, Sandy, and Organic-rich classes. Soil orders include Aquents and Aquepts, and soil subgroups include Histic Cryaquepts. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 29–31.

Table 29. Constancy/Cover table for Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
sedges	*Carex lyngbyaei*	47.5	15	80	67
sedges	*Carex ramenskii*	48.5	7	90	67

Table 30. Environment Data Summary table for Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	5.0	2.0	3	6.0	3
Slope (degrees)	0.0	0.0	0	0.0	3
Surface Organic Thickness (cm)	7.0	6.1	0	11.0	3
Depth to 15% Rock Fragments (cm)	1.0	NA	1	1.0	1
Water Table Depth (cm)	-24.5	4.9	-28	-21.0	2
Site pH	7.4	0.4	7	7.6	3
Electrical Conductivity (um)	14700.0	NA	14700	14700.0	1

Table 31. Soil Horizon table for Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–6.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
2	Oe/Cg	6.0–25.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon	NA
3	Cg	25.0–35.0	no modifier (<15%)	silt loam	NA

Coastal Sandy-Rocky Tidal Barrens

The ecotype Coastal Sandy-Rocky Tidal Barrens occurs on active marine beaches and active tidal flats on flat to gentle slopes ranging from 0 to 10 degrees (avg. 2 degrees). Plant associations are *Triglochin maritimum* and *Puccinellia tenella*. Soils that are below the high tide line are experience persistent flooding by ocean water. Soils near the high tide line are regularly flooded, but the duration and frequency of these events is lower. Local-scale gradients of flooding frequency and duration (hydroperiod) are reflected by high variability of many soil characteristics. Very thin, buried organic horizons may be present at high tide line but are lacking at lower positions; EC measurements are lowest at high tide line and highest at the low tide line (EC range 800 to >16000 uS/cm). Surface organic horizons are patchy or absent. Soils are coarse marine sediments with a dominant soil texture class of Sandy or Rubbly. Due to the fluctuating water table, soils have abundant redoximorphic features associated with oxidation and were classified in an Oxyaquic subgroup. Typical suborders include Aquents, and typical subgroups include Oxyaquic Cryothents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 32–34.

Table 32. Constancy/Cover table for Coastal Sandy-Rocky Tidal Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Triglochin maritimum*	1	1	1	100
grasses	*Puccinellia tenella*	3	3	3	100

Table 33. Environment Data Summary table for Coastal Sandy-Rocky Tidal Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	4.0	1.0	3.0	4	2
Slope (degrees)	2.0	3.0	0.0	4	2
Surface Organic Thickness (cm)	0.0	0.0	0.0	0	2
Depth to 15% Rock Fragments (cm)	15.0	NA	15.0	15	1
Water Table Depth (cm)	0.0	NA	0.0	0	1
Site pH	7.7	0.4	7.4	8	2
Electrical Conductivity (um)	1270.0	NA	1270.0	1270	1

Table 34. Soil Horizon table for Coastal Sandy-Rocky Tidal Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C1	0.0–15.0	no modifier (<15%)	coarse sand (0.5–1 mm)	NA
2	C2	15.0–35.0	very gravelly (35–60%)	coarse sand (0.5–1 mm)	NA

Coastal Sandy Moist Beach Rye-Forb Meadow

The ecotype Coastal Sandy Moist Beach Rye-Forb Meadow occurs on inactive and active sand dunes, above the average high tide line. Vegetation corresponds to the *Leymus mollis-Chamerion angustifolium* and *Leymus mollis* plant associations. *Angelica lucida-Heracleum maximum* is also associated with this ecotype, since these large umbelliferous forbs tend to provide high canopy cover when present. *Leymus mollis* ssp. *mollis* is the dominant species; associates with high constancy and cover include *Angelica lucida* and *Calamagrostis canadensis*. The feathermosses *Rhytidiadelphus triquetrus*, *Pleurozium schreberi*, and *Hylocomium splendens* are often present on inactive dunes. Soils form in deep beach sand of volcanic origin and have a dominant texture class of Sandy. The surface organic horizon is usually very thin (avg. 3.6 cm). Rock fragment content is low or

absent in the upper 125 cm of the soil profile. Soil chemistry is circumneutral (avg. 6.8 pH), with an average EC of 50.0 uS/cm. Most soils in this ecotype are young and poorly developed. Older dunes, with tephra deposits, may weather into vitrandic subgroups of Entisols. Soil subgroups include Typic Cryopsamments and Vitrandic Cryopsamments. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 35–37.

Table 35. Constancy/Cover table for Coastal Sandy Moist Beach Rye-Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Angelica lucida*	5.2	0.1	15	100
forbs	*Epilobium angustifolium*	9.0	2.0	20	80
forbs	*Lupinus nootkatensis*	2.5	0.1	5	80
grasses	*Calamagrostis canadensis*	5.8	2.0	10	100
grasses	*Leymus mollis* ssp. *mollis*	24.2	4.0	47	100
mosses	*Hylocomium splendens*	27.5	15.0	40	40
mosses	*Pleurozium schreberi*	23.3	10.0	40	60
mosses	*Rhytidiadelphus squarrosus*	11.5	3.0	20	40
mosses	*Rhytidiadelphus triquetrus*	12.0	3.0	25	80

Table 36. Environment Data Summary table for Coastal Sandy Moist Beach Rye-Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	15.0	3.0	11.0	19.0	5
Slope (degrees)	9.0	12.0	2.0	30.0	5
Surface Organic Thickness (cm)	3.6	2.5	2.0	8.0	5
Depth to 15% Rock Fragments (cm)	-999.0	0.0	-999.0	-999.0	5
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	5
Site pH	6.8	0.7	5.8	7.6	5
Electrical Conductivity (um)	50.0	28.3	30.0	70.0	2

Table 37. Soil Horizon table for Coastal Sandy Moist Beach Rye-Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–4.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oe	4.0–8.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C	8.0–16.0	no modifier (<15%)	coarse sand (0.5–1 mm)	NA

Coastal Sandy Moist Brackish Beach Rye Meadow

The ecotype Coastal Sandy Moist Brackish Beach Rye Meadow forms narrow belts near the intertidal zone, on active sand dunes or beach berms. It encompasses the transition between the intertidal zone and young, inactive sand dunes. Vegetation corresponds to the *Leymus mollis-Honckenya peploides* and *Leymus mollis* plant associations and ranges from patchy cover to near-continuous, rank growth of *Leymus mollis*. Common herbaceous associates include the forbs *Honckenya peploides* s.l., *Senecio pseudo-arnica*, and *Lathyrus japonicus* s.l., and the sedge *Carex macrocephala*. Soils form in deep beach sand of volcanic origin and have a dominant texture class of Sandy. Rock fragment content is low or absent in the upper 125 cm of the soil profile. Soil chemistry is alkaline (avg. 7.4 pH), with a highly variable electrical conductivity that ranges from fresh to brackish (50–16,000 uS/cm). Depth to the water table varies with the tide, and soils do not readily form in the anaerobic conditions. Due to frequent flooding, surface organics are absent or extremely patchy. Soils are poorly developed Entisols, and include the soil subgroups Typic Cryopsamments and Oxyaquic Cryopsamments. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 38–40.

Table 38. Constancy/Cover table for Coastal Sandy Moist Brackish Beach Rye Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Honckenya peploides* s.l.	17.5	5	25	80
forbs	*Lathyrus japonicus* s.l.	7.7	5	13	60
forbs	*Senecio pseudoarnica*	7.5	3	10	80
grasses	*Leymus mollis* ssp. *mollis*	34.0	10	70	100
sedges	*Carex macrocephala*	6.7	5	10	60

Table 39. Environment Data Summary table for Coastal Sandy Moist Brackish Beach Rye Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	13.0	5.0	8.0	21	5
Slope (degrees)	25.0	13.0	4.0	35	5
Surface Organic Thickness (cm)	0.3	0.5	0.0	1	4
Depth to 15% Rock Fragments (cm)	-999.0	0.0	-999.0	-999	5
Water Table Depth (cm)	-999.0	0.0	-999.0	-999	5
Site pH	7.4	1.3	5.9	9	4
Electrical Conductivity (um)	50.0	NA	50.0	50	1

Table 40. Soil Horizon table for Coastal Sandy Moist Brackish Beach Rye Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C	0.0–40.0	no modifier (<15%)	coarse sand (0.5–1 mm)	NA

Lacustrine Loamy-Organic Wet Sedge-Forb Meadow

The ecotype Lacustrine Loamy-Organic Wet Sedge-Forb Meadow occurs on drained lakebeds and along lake and pond shorelines on flat to very gentle slopes (avg. 1 degree). Vegetation corresponds to the *Carex lyngbyei*/Freshwater Marsh, *Carex lyngbyei-Carex saxatilis*, *Carex lyngbyei-Comarum palustre*, and *Carex saxatilis-Eriophorum angustifolium* ssp. *subarcticum* plant associations. *Carex lyngbyei* and *Potentilla palustris* are co-dominant. Other important herbaceous species include *Equisetum fluviatile* and *Carex saxatilis* ssp. *laxa*. *Sphagnum* mosses have both high constancy and average cover. Soils form in saturated volcaniclastic deposits that over time accumulate moderately-thick surface organic mats. Surface organic horizons range from 6.0 to 40.0 cm (avg. 19.7 cm). Dominant texture classes include Organic-rich, Peat, Loamy and Sandy, with an average depth to 15% or greater rock fragments of 34.0 cm. Water may be ponded at the surface during a normal growing season. Typically the water table is within the rooting zone (avg. depth 13.6 cm). Soils are circumneutral with an average EC of 140.0 uS/cm. The development of a histic epipedon is common for this ecotype. Soil subgroups include Histic Cryaquepts, Histic Cryaquands, Fluvaquentic Cryohemists, Aquandic Dystrocryepts, and Typic Cryaquands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 41–43.

Table 41. Constancy/Cover table for Lacustrine Loamy-Organic Wet Sedge-Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Honckenya peploides* s.l.	17.5	5	25	80
forbs	*Lathyrus japonicus* s.l.	7.7	5	13	60
forbs	*Senecio pseudoarnica*	7.5	3	10	80
grasses	*Leymus mollis* ssp. *mollis*	34.0	10	70	100
sedges	*Carex macrocephala*	6.7	5	10	60

Table 42. Environment Data Summary table for Lacustrine Loamy-Organic Wet Sedge-Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	13.0	5.0	8.0	21	5
Slope (degrees)	25.0	13.0	4.0	35	5
Surface Organic Thickness (cm)	0.3	0.5	0.0	1	4
Depth to 15% Rock Fragments (cm)	-999.0	0.0	-999.0	-999	5
Water Table Depth (cm)	-999.0	0.0	-999.0	-999	5
Site pH	7.4	1.3	5.9	9	4
Electrical Conductivity (um)	50.0	NA	50.0	50	1

Table 43. Soil Horizon table for Lacustrine Loamy-Organic Wet Sedge-Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–4.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oe	4.0–8.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C	8.0–16.0	no modifier (<15%)	coarse sand (0.5–1 mm)	NA

Lacustrine Organic-rich Forb Marsh

The ecotype Lacustrine Organic-rich Forb Marsh is extensive in valley bottoms where welded pyroclastic flow deposits impede drainage, particularly in the Meshik River valley. This ecotype may also occur on flat, isolated relict lakebeds or along pond and lake margins. Vegetation corresponds to the *Menyanthes trifoliata* and *Equisetum fluviatile* plant associations. The forbs *Equisetum fluviatile* and *Menyanthes trifoliata* are the dominant species. The vascular plants *Parnassia palustris* and *Calamagrostis canadensis*, and *Sphagnum* and *Aulacomnium* mosses are common associates, but they provide little cover. Soils form in waterlogged coarse tephra and pyroclastic flow deposits. Standing water is present during a typical growing season, but the hydrology of this ecotype is highly sensitive to interannual variability in precipitation. The water table (avg. 9.1 cm above the soil surface) may drop significantly if inputs to the system in the form of rain and snowpack do not outweigh losses to the system. This ecotype supports both organic and mineral soils, with a variable surface organic mat ranging from 5.0 to 48.0 cm (avg. 30.8 cm). Dominant soil texture classes include Peat, Water and Pumiceous, with an average depth to 15% or more rock fragments of 37.0 cm. Soils range from circumneutral to alkaline and have an average EC of 145.0 uS/cm. Typical organic soil subgroups include Terric Cryofibrists and Hydric Cryohemists. Typical mineral soils include Typic Cryaquands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 44–46.

Table 44. Constancy/Cover table for Lacustrine Organic-rich Forb Marsh, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
ferns	*Equisetum fluviatile*	17.5	0.1	40	100
forbs	*Menyanthes trifoliata*	19.7	1.0	40	88

Table 45. Environment Data Summary table for Lacustrine Organic-rich Forb Marsh, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	34.0	20.0	9.0	69.0	8
Slope (degrees)	0.0	0.0	0.0	1.0	8
Surface Organic Thickness (cm)	30.8	18.7	5.0	48.0	4
Depth to 15% Rock Fragments (cm)	37.0	45.3	5.0	69.0	2
Water Table Depth (cm)	9.1	15.0	-6.0	30.0	7
Site pH	6.8	1.1	5.9	8.4	4
Electrical Conductivity (um)	145.0	63.6	100.0	190.0	2

Table 46. Soil Horizon table for Lacustrine Organic-rich Forb Marsh, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi1	0.0–9.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	7.5yr 2.5/1
2	Oi2	9.0–48.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	7.5yr 3/2

Lacustrine Rocky Drained Lake Barrens

The ecotype Lacustrine Rocky Drained Lake Barrens occurs on recently-drained lakebeds and represents the earliest successional stage on coarse lacustrine deposits in ANIA. One site was described on a flat surface at 22 m elevation. This ecotype is most extensive in the Aniakchak and Cinder River valleys, but isolated pockets may occur on young relict lakebeds that formed atop welded pyroclastic flow deposits. Vegetation cover is less than 5% and includes *Carex lyngbyaei*, *Equisetum arvense*, *Ranunculus reptans*, and *Alopecurus aequalis*. The water table lies below the soil surface and may vary widely between sites. Pedogenesis likely begins in an anaerobic, aquic moisture regime. Over time, the water table may drop enough to alter the soil moisture regime into an aerobic condition. A subsurface silica-cemented horizon, or duripan, may retard hydraulic conductivity within the rooting zone. The dominant soil texture class is Gravelly, and may include other classes such as Pumiceous, Rubbly and Sandy. Depth to greater than 15% rock fragments is usually within the upper 20cm of the soil profile (avg. 6.0 cm). Surface organic horizons are patchy or absent. Soils are circumneutral and the EC is generally low (<50.0 uS/cm). Typical soil subgroups may include Aquic Duricryands, Oxyaquic Duricryands, Aquic Cryorthents, or Oxyaquic Cryorthents. Typical mineral soils include Typic Cryaquands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 47–49.

Table 47. Constancy/Cover Table for Lacustrine Rocky Drained Lake Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
ferns	*Equisetum arvense*	0.1	0.1	0.1	100
forbs	*Ranunculus reptans*	0.1	0.1	0.1	100
grasses	*Alopecurus aequalis*	0.1	0.1	0.1	100
sedges	*Carex lyngbyaei*	2.0	2.0	2.0	100

Table 48. Environment Data Summary Table for Lacustrine Rocky Drained Lake Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	22.0	NA	22.0	22.0	1
Slope (degrees)	0.0	NA	0.0	0.0	1
Surface Organic Thickness (cm)	0.0	NA	0.0	0.0	1
Depth to 15% Rock Fragments (cm)	6.0	NA	6.0	6.0	1
Water Table Depth (cm)	-999.0	NA	-999.0	-999.0	1
Site pH	6.9	NA	6.9	6.9	1
Electrical Conductivity (um)	30.0	NA	30.0	30.0	1

Table 49. Soil Horizon Table for Lacustrine Rocky Drained Lake Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C1	0.0–6.0	ashy	sandy loam	NA
2	2C2	6.0–22.0	very gravelly (35–60%)	sand	NA
3	3Ab	22.0–26.0	ashy	silt loam	NA
4	3Ldi	26.0–44.0	ashy	fine sand (0.1–.25 mm)	NA
5	4C3	44.0–52.0	ashy	fine sand (0.1–.25 mm)	NA

Lacustrine Sandy Grass Marsh

The ecotype Lacustrine Sandy Grass Marsh occurs in shallow lake water and along shorelines; it is of limited spatial extent in ANIA. One site was described on a flat surface at 43 m elevation. Vegetation is an aquatic monculture of *Arctophila fulva*, with *Triglochin maritimum* possibly present, but at low cover. Soils form in sandy or rocky volcaniclastic parent material and dominant textures may include Sandy or Water classes. Soils are permanently flooded and develop in anaerobic conditions. The water table is above the soil surface (+4.0 cm) and a surface organic horizon is absent. Depth to 15% or greater rock fragments is typically greater than 20 cm below the soil surface (measured depth 65.0 cm). Soils range from circumneutral to alkaline and have a moderately high EC (100–800 uS/cm). Typical soil subgroups include Aquandic Cryaquents. The constancy/cover and environmental data summary tables are presented in Tables 50 and 51.

Table 50. Constancy/Cover Table for Lacustrine Sandy Grass Marsh, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Triglochin maritimum*	1	1	1	100
grasses	*Arctophila fulva*	9	9	9	100

Table 51. Environment Data Summary Table for Lacustrine Sandy Grass Marsh, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	43.0	NA	43.0	43.0	1
Slope (degrees)	0.0	NA	0.0	0.0	1
Surface Organic Thickness (cm)	0.0	NA	0.0	0.0	1
Depth to 15% Rock Fragments (cm)	65.0	NA	65.0	65.0	1
Water Table Depth (cm)	4.0	NA	4.0	4.0	1
Site pH	7.2	NA	7.2	7.2	1
Electrical Conductivity (um)	130.0	NA	130.0	130.0	1

Lowland Alkaline Lake Water

The ecotype Lowland Alkaline Lake Water includes freshwater lakes in all physiographic areas, except Volcanic, within the survey boundary. These lakes vary in size from shallow Meshik lake (surface area 26.7 hectares) to small lakes that have formed in concave depressions above impermeable, welded pyroclastic flow deposits. Water chemistry is typically alkaline (>7.3 pH) but may range to circumneutral (5.6–7.3 pH). EC values are expected to be relatively low (<150 uS/cm). The constancy/cover and environmental data summary are presented in Tables 52 and 53.

Table 52. Constancy/Cover Table for Lowland Alkaline Lake Water, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Potamogeton filiformis*	0.1	0.1	0.1	100
forbs	*Potamogeton perfoliatus ssp. richardsonii*	0.1	0.1	0.1	100
forbs	*Ranunculus trichophyllus*	0.1	0.1	0.1	100

Table 53. Environment Data Summary Table for Lowland Alkaline Lake Water, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	47	NA	47	47	1
Slope (degrees)	0	NA	0	0	1
Surface Organic Thickness (cm)	0	NA	0	0	1
Depth to 15% Rock Fragments (cm)	-999	NA	-999	-999	1
Water Table Depth (cm)	41	NA	41	41	1
Site pH	9	NA	9	9	1
Electrical Conductivity (um)	110	NA	110	110	1

Lowland Organic-rich Wet Sedge-Shrub Bog Meadow

The ecotype Lowland Organic-rich Wet Sedge-Shrub Bog Meadow occurs in flat or concave areas where a body of water has drained and/or become colonized by hydrophytic vegetation in a plant succession process known as paludification. This ecotype typicall occurs at low elevation (avg. 36 m) but was recorded as high as 300 m. Vegetation corresponds to the *Carex aquatilis* and *Empetrum nigrum-Vaccinium uliginosum*/Wet *Carex* spp. plant association. The shrub *Betula nana* and the sedge *Carex aquatalis* are co-dominant. *Salix reticulata*, *Vaccinium uliginosum* and *Empetrum nigrum* are common shrub associates. Common herbaceous species include *Equisetum arvense*, *Potentilla palustris*, and *Carex rariflora*. A variety of *Sphagnum* spp. are common in the ground layer. Soils form in anearobic moisture conditions, with the average depth to water table at 9.3 cm below the soil surface. Dominant texture classes are Peat, Organic-rich and Pumiceous and the formation of organic soils over time is common. Soils in this ecotype are circumneutral (avg. 6.1 pH), very poorly drained or flooded, and barring any recent flooding or groundwater upwelling, have an expected EC <100 uS/cm. Sandy or rocky volcaniclastic material is usually present within 100 cm of the soil surface. The depth to 15% or greater rock fragments ranges from 18.0 to 71.0 cm (avg. 33.3 cm). Soil subgroups include Histic Cryaquands, Fluvaquentic Cryohemists, Terric Cryofibrists, Fluvaquentic Cryofibrists, Typic Cryaquands and Terric Cryohemists. For mapping purposes, this ecotype was aggregated with Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub and mapped as Lowland Wet Sedge-Shrub Bog Meadow. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 54–56.

Table 54. Constancy/Cover table for Lowland Organic-rich Wet Sedge-Shrub Bog Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Betula nana*	9.1	1.0	30	100
deciduous shrubs	*Salix reticulata*	5.5	1.0	10	80
deciduous shrubs	*Vaccinium uliginosum*	7.7	1.0	30	70
evergreen shrubs	*Andromeda polifolia*	1.2	0.1	3	90
evergreen shrubs	*Empetrum nigrum*	8.8	0.1	20	80
ferns	*Equisetum arvense*	2.8	0.1	5	80
forbs	*Potentilla palustris*	2.5	0.1	7	90
mosses	*Sphagnum* sp.	34.9	10.0	80	80
sedges	*Carex aquatilis* s.l.	35.3	2.0	60	70
sedges	*Carex rariflora*	12.5	1.0	29	40

Table 55. Environment Data Summary table for Lowland Organic-rich Wet Sedge-Shrub Bog Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	36.0	16.0	8	68.0	10
Slope (degrees)	0.0	1.0	0	2.0	10
Surface Organic Thickness (cm)	30.9	11.1	11	40.0	10
Depth to 15% Rock Fragments (cm)	33.3	25.4	18	71.0	4
Water Table Depth (cm)	-9.3	9.5	-34	0.0	10
Site pH	6.1	0.7	5	7.1	10
Electrical Conductivity (um)	115.0	7.1	110	120.0	2

Table 56. Soil Horizon table for Lowland Organic-rich Wet Sedge-Shrub Bog Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–7.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
2	Oe	7.0–40.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon	NA

Lowland Organic-rich Wet Sedge Meadow

The ecotype Lowland Organic-rich Wet Sedge meadow occurs in riparian corridors on abandoned floodplains, old meander channels (oxbows), and in organic fens at low elevations. Vegetation corresponds to the *Carex lyngbyei-Comarum palustre* and *Carex saxatilis-Eriophorum angustifolium* ssp. subarcticum plant associations. *Carex lyngbyaei* and *Potentilla palustris* are the dominant vascular species, and *Sphagnum squarrosum* is the dominant moss; lichens are absent. Other common species include *Equisetum fluviatile*, *Stellaria longipes*, and *Andromeda polifolia*. *Carex saxatilis* ssp. *laxa* is not always present, but can occur at high cover values. Soils will likely have a moderately thick organic mat (avg. 39.0 cm) overlying mineral soil that may be stratified with varying soil textures related to alluvial deposition events. Dominant textures are Peat or Organic-rich, with an organic mat that is primarily comprised of fibers from graminoids and woody plant species. These soils are saturated and very poorly drained, and are usually flooded with water for part of the growing season. Soil pH is typically circumneutral (avg. 7.2 pH). Water table depth ranges from 1.0 to 25.0 cm below the soil surface (avg. 7.6 cm). The hydrology is characteristic of wetlands fed by runoff and/or groundwater with EC usually >100 uS/cm (avg. 136.7 uS/cm). Soil subgroups include Hydric Cryofibrists, Fluvaquentic Cryofibrists, Terric Cryohemists, Fluvaquentic Cryohemists, and Histic Cryaquands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 57–59.

Table 57. Constancy/Cover table for Lowland Organic-rich Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Menyanthes trifoliata*	8.5	8	9	40
forbs	*Potentilla palustris*	17.5	7	25	80
mosses	*Calliergonella cuspidata*	7.5	5	10	40
mosses	*Sphagnum squarrosum*	13.8	2	30	80
mosses	*Sphagnum teres*	15.0	15	15	40
sedges	*Carex lyngbyaei*	30.8	8	60	80

Table 58. Environment Data Summary table for Lowland Organic-rich Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	40.0	26.0	4.0	73.0	5
Slope (degrees)	0.0	0.0	0.0	1.0	5
Surface Organic Thickness (cm)	39.0	20.5	10.0	68.0	5
Depth to 15% Rock Fragments (cm)	-999.0	0.0	-999.0	-999.0	5
Water Table Depth (cm)	-7.6	9.8	-25.0	-1.0	5
Site pH	7.2	1.2	6.1	9.2	5
Electrical Conductivity (um)	136.7	25.2	110.0	160.0	3

Table 59. Soil Horizon table for Lowland Organic-rich Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oe1	0.0–3.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon	NA
2	Oe2	3.0–30.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon	NA

Lowland Sandy-Organic Wet Willow Low Shrub

The ecotype Lowland Sandy-Organic Wet Willow Low Shrub occurs in flat or concave areas at low elevations where groundwater inputs are common, such as Organic Fens. Vegetation corresponds to the *Salix pulchra*/*Carex lyngbyei* and *Salix pulchra*/*Empetrum nigrum* plant associations. Many species of *Salix* are typically present, but *Salix pulchra* is dominant. The sedge *Carex lyngbyaei* is co-dominant in the understory. Other important shrubs include *Salix commutata* and *Empetrum nigrum*. Common herbaceous species include *Equisetum arvense*, *Potentilla palustris*, and *Calamagrostis canadensis*. Several mosses occur with lower constancy, but occasionally with high cover, including *Rhytidiadelphus* sp., *Hylocomium splendens*, *Pleurozium schreberi*, *Aulacomnium* sp. and *Sphagnum* sp. Soils form in anearobic conditions, with the average depth to water table at 21.3 cm below the soil surface. Dominant texture classes are Sandy and Organic-rich, with an average surface organic thickness of 15.0 cm. Soils in this ecotype are circumneutral (avg. 6.2 pH) with an expected EC >100uS/cm. Sandy or rocky alluvium is typically present below the surface organic mat, within the upper 20 cm of the soil profile. Soil subgroups include Aquandic Cryaquents, Typic Cryaquands, and Histic Cryaquepts. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 60–62.

Table 60. Constancy/Cover Table for Lowland Sandy-Organic Wet Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix pulchra*	38.3	30	55	100
ferns	*Equisetum arvense*	9.0	8	10	67
forbs	*Potentilla palustris*	5.7	2	8	100
grasses	*Calamagrostis canadensis*	8.0	1	15	67
sedges	*Carex lyngbyaei*	22.5	5	40	67

Table 61. Environment Data Summary Table for Lowland Sandy-Organic Wet Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	29.0	24.0	6	53.0	3
Slope (degrees)	0.0	0.0	0	0.0	3
Surface Organic Thickness (cm)	15.0	7.0	7	20.0	3
Depth to 15% Rock Fragments (cm)	16.0	NA	16	16.0	1
Water Table Depth (cm)	-21.3	17.6	-40	-5.0	3
Site pH	6.2	0.2	6	6.4	3
Electrical Conductivity (um)	140.0	NA	140	140.0	1

Table 62. Soil Horizon Table for Lowland Sandy-Organic Wet Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–9.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	7.5yr 2.5/3
2	Oe	9.0–17.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon	7.5yr 2.5/2
3	Oa	17.0–20.0	no modifier (<15%)	highly decomposed plant material (unsaturated Oa)	7.5yr 2.5/1
4	C	20.0–24.0	no modifier (<15%)	loamy coarse sand	7.5yr 2.5/1
5	Cg	24.0–40.0	no modifier (<15%)	silt loam	10yr 2/1

Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub

The ecotype Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub typically occurs on substrates with a root-restricting layer in the subsurface. Features that impede rooting and drainage in ANIA include welded pyroclastic flow deposits and shallow depth to bedrock (≤50 cm). This ecotype occurs on flat to gently sloping (avg. 1 percent) valley bottoms or hillside benches, typically at low elevation. Vegetation corresponds to the *Empetrum nigrum-Vaccinium uliginosum* plant association. *Empetrum nigrum*, *Vaccinium uliginosum*, and *Salix reticulata* form a nearly continuous mat of dwarf shrub cover. Noteable herbaceous species in the understory with relatively high cover include *Lupinus nootkatensis*, *Juncus arcticus*, and *Carex dioica* ssp. *gynocrates*. Common mosses include *Racomitrium* sp. and *Ptilium crista-castrensis*. Soils form in anearobic conditions; the average recorded water table depth was 22.3 cm. Dominant texture classes are Sandy, Rubbly and Organic-rich, with an average surface organic thickness of 13.7 cm. Soils in this ecotype are circumneutral (avg. 6.1 pH). Stratified sandy or rocky volcaniclastic deposits are usually present beneath the organic mat on pyroclastic flow deposits, while bedrock occurs within 100 cm of the soil surface on hillside benches. Soil subgroups include Thaptic Cryaquands and Histic Lithic Cryaquepts. For mapping purposes, this ecotype was aggregated with Lowland Organic-rich Wet Sedge-Shrub Bog Meadow and mapped as Lowland Wet Sedge-Shrub Bog Meadow. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 63–65.

Table 63. Constancy/Cover table for Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Betula nana*	7.5	5.0	10	67
deciduous shrubs	*Salix reticulata*	13.7	1.0	25	100
deciduous shrubs	*Vaccinium uliginosum*	21.7	10.0	30	100
evergreen shrubs	*Empetrum nigrum*	23.3	15.0	30	100
ferns	*Equisetum arvense*	2.0	1.0	3	100
forbs	*Achillea millefolium*	0.7	0.1	1	100
forbs	*Rubus arcticus*	2.0	1.0	3	100
grasses	*Calamagrostis canadensis*	6.5	3.0	10	67
mosses	*Ptilium crista-castrensis*	12.5	5.0	20	67
mosses	*Racomitrium* sp.	17.5	5.0	30	67
sedges	*Carex aquatilis* s.l.	5.5	1.0	10	67
sedges	*Trichophorum caespitosum*	5.5	1.0	10	67

Table 64. Environment Data Summary table for Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	28.0	25.0	0.0	43.0	3
Slope (degrees)	1.0	2.0	0.0	4.0	3
Surface Organic Thickness (cm)	13.7	2.5	11.0	16.0	3
Depth to 15% Rock Fragments (cm)	17.0	1.4	16.0	18.0	2
Water Table Depth (cm)	-22.3	5.1	-28.0	-18.0	3
Site pH	6.1	0.8	5.5	6.7	2
Electrical Conductivity (um)	-999.0	0.0	-999.0	-999.0	3

Table 65. Soil Horizon Table for Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–7.0	no data	silt loam	10yr 5/3
2	Oe	7.0–9.0	no data	silt loam	10yr 4/2
3	COa	9.0–11.0	ashy	silt loam	10yr 3/1
4	OeC	11.0–22.0	no data	mucky peat (17–40% fibers, saturated Oe horizon	10yr 4/1
5	Cg	22.0–30.0	no data	very coarse sand (1–2 mm)	10yr 2/1

Riverine Alkaline River Water

The ecotype Riverine Alkaline River Water represents small headwater streams as well as larger rivers in ANIA. These perennial rivers are typically clear and alkaline (avg. 9.0 pH), with an average recorded EC of 103.3 uS/cm. Aniakchak River is the only river that begins in the Aniakchak Crater. Most other watersheds in ANIA originate from the flanks of the crater and dissect valleys filled with pyroclastic flow deposits. Smaller watersheds originate in the Aleutian Range and flow either northwest to Bristol Bay (e.g., Pumice Creek), or southeast to the Gulf of Alaska (e.g., Northeast Creek). Table 66 presents a summary of a select set of environmental data for this ecotype.

Table 66. Environment Data Summary Table for Riverine Alkaline River Water, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	67.0	73.0	14.0	174.0	4
Slope (degrees)	2.0	1.0	1.0	2.0	2
Surface Organic Thickness (cm)	0.0	0.0	0.0	0.0	4
Depth to 15% Rock Fragments (cm)	26.5	2.1	25.0	28.0	2
Water Table Depth (cm)	26.5	2.1	25.0	28.0	2
Site pH	9.0	1.2	7.8	10.3	4
Electrical Conductivity (um)	103.3	92.9	40.0	210.0	3

Riverine Loamy-Organic Wet Sedge Meadow

The ecotype Riverine Loamy-Organic Wet Sedge Meadow occurs on inactive floodplain deposits along meandering rivers and small streams. Vegetation corresponds to the *Carex lyngbyei*/Freshwater Marsh plant association. *Carex lyngbyaei* dominates the overstory, with *Equisetum arvense* and *Equisetum fluviatile* present in the understory. Soils form in saturated alluvial sediments with the water table often ponded at the surface (avg. 1.0 cm above the soil surface). Dominant soil texture class is Organic-rich, with an average surface organic thickness of 20.0 cm. Soils in this ecotype are circumneutral (avg. 6.3 pH). Soil subgroups include Histic Cryaquepts and Aquandic Cryaquents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 67–69.

Table 67. Constancy/Cover Table for Riverine Loamy-Organic Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
ferns	*Equisetum arvense*	0.1	0.1	0.1	100
sedges	*Carex lyngbyaei*	94.0	90.0	98.0	100

Table 68. Environment Data Summary Table for Riverine Loamy-Organic Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	42.0	13.0	33.0	51.0	2
Slope (degrees)	0.0	0.0	0.0	0.0	2
Surface Organic Thickness (cm)	20.0	14.1	10.0	30.0	2
Depth to 15% Rock Fragments (cm)	-999.0	0.0	-999.0	-999.0	2
Water Table Depth (cm)	1.0	12.7	-8.0	10.0	2
Site pH	6.3	0.2	6.1	6.4	2
Electrical Conductivity (um)	-999.0	0.0	-999.0	-999.0	2

Table 69. Soil Horizon table for Riverine Loamy-Organic Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi/OeC	0.0–30.0	no data	peat (>40% fibers, saturated Oi horizon)	10yr 4/1
2	Cg	30.0–35.0	no data	coarse sand (0.5–1 mm)	7.5yr 3/2

Riverine Rocky Barrens

The ecotype Riverine Rocky Barrens is common on sand and cobble bars on the active floodplains of rivers and streams throughout ANIA. Dominant soil textures are Sandy, Gravelly, Rubbly and Bouldery. The surface organic horizon is absent or patchy, and buried organic horizons of any thickness are highly unlikely. Soils are dry to moist, moderately well drained to somewhat poorly drained, and range from circumneutral to alkaline. This ecotype is flooded annually to semi-annually and experiences active erosion and sedimentation processes. Vegetation cover is sparse but can include scattered, early-successional herbaceous plants. Soils are poorly developed Entisols, and likely include the soil subgroups of Aquic Cryorthents, Oxyaquic Cryorthents and Typic Cryorthents.

Riverine Rocky Moist Alder-Willow Tall Shrub

The ecotype Riverine Rocky Moist Alder-Willow Tall Shrub is extensive in ANIA and occurs on coarse alluvial sediments on active and inactive floodplain surfaces, as well as on alluvial fan deposits. Vegetation corresponds to the *Salix alaxensis-Alnus viridis* ssp. *sinuata/Calamagrostis canadensis*, *Alnus viridis* ssp. *sinuata*/Forb, and *Alnus viridis* ssp. *sinuata/Calamagrostis canadensis* plant associations. The shrubs *Alnus sinuata* and *Salix alaxensis* dominate the overstory and form an upright canopy that is >1.5 m in height. *Calamagrostis canadensis* dominates the understory with at least 15.0% canopy cover. Common herbaceous species include *Heracleum lanatum*, *Epilobium angustifolium*, and *Angelica genuflexa*. *Rhytidiadelphus* mosses are common, and have relatively high cover, with the most common species being *Rhytidiadelphus triquetrus*. Sites with a frequent flood return interval form in stratified sandy and rocky alluvial sediments, and lack a surface organic mat. Less frequently disturbed sites may accumulate a very thin layer of surface organics (avg. 1.8 cm), and/or a thin mantle of coarse-ashy tephra, which overlies stratified sandy and rocky alluvial sediments. Dominant texture classes are Bouldery and Sandy, with a depth to 15% or greater rock fragments ranging from 0 to 22.0 cm (avg. 9.5 cm). Soils range from circumneutral to alkaline (avg. 7.0 pH) and are expected to have an EC >100 us/cm (avg. 130.0 uS/cm). Soils are poorly developed Entisols and include the soil subgroups Typic Cryofluvents, Typic Cryorthents, and Vitrandic Cryofluvents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 70–72.

Table 70. Constancy/Cover table for Riverine Rocky Moist Alder-Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Alnus sinuata*	35.0	25.0	60.0	100
deciduous shrubs	*Salix alaxensis*	55.0	50.0	60.0	50
ferns	*Equisetum arvense*	21.0	12.0	30.0	50
forbs	*Achillea borealis*	5.1	0.1	10.0	50
forbs	*Angelica genuflexa*	5.0	0.1	10.0	75
forbs	*Artemisia tilesii* s.l.	2.4	0.1	4.0	75
forbs	*Cardamine umbellata*	0.7	0.1	1.0	75
forbs	*Epilobium angustifolium*	1.8	0.1	5.0	100
forbs	*Heracleum lanatum*	4.8	3.0	8.0	100
forbs	*Stellaria crispa*	0.1	0.1	0.1	75
grasses	*Calamagrostis canadensis*	15.0	10.0	20.0	100
mosses	*Rhytidiadelphus triquetrus*	17.0	0.1	50.0	75

Table 71. Environment Data Summary table for Riverine Rocky Moist Alder-Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	26.0	18.0	0.0	41.0	4
Slope (degrees)	1.0	1.0	0.0	2.0	4
Surface Organic Thickness (cm)	1.8	2.1	0.0	4.0	4
Depth to 15% Rock Fragments (cm)	9.5	9.7	0.0	22.0	4
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	4
Site pH	7.0	0.4	6.5	7.5	4
Electrical Conductivity (um)	130.0	127.3	40.0	220.0	2

Table 72. Soil Horizon table for Riverine Rocky Moist Alder-Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C	0.0–22.0	extremely cobbly (60–90%)	very coarse sand (1–2 mm)	NA

Riverine Sandy-Loamy Moist Forb Meadow

The ecotype Riverine Sandy-Loamy Moist Forb Meadow tends to occur in a mosiac with Riverine shrub ecotypes. It is most closely associated with inactive floodplains and terraces, occupying slopes that range from flat to gentle (avg. 11 degrees). Vegetation corresponds to the *Angelica lucida-Heracleum* maximum plant association. The herbaceous overstory is dominated by large umbelliferous forbs, such as *Heracleum lanatum*, *Angelica lucida*, and *Angelica genuflexa*. Herbaceous species that dominate the understory include *Equisetum arvense*, *Epilobium angustifolium*, *Hordeum brachyantherum*, and *Calamagrostis canadensis*. Species with 100% constancy, but low cover values, include *Achillea millefolium*, *Rubus arcticus*, *Trientalis europaea*, *Phleum alpinum*, and *Anthoxanthum hirtum*. Mosses and lichens are absent or rare. Soils form in deep, fine-texured alluvial sediments that over time develop productive, humus-rich mineral soils. Dominant soil textures are Loamy and Sandy, with an average surface organic horizon thickness of 2.5 cm. Soils are cirumneutral (avg. 6.0 pH), well- to moderately-well drained, and have a water table depth below the primary rooting zone (>40 cm below the soil surface). Soil subgroups include Fluventic Humicryepts and Oxyaquic Cryofluvents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 73–75.

Table 73. Constancy/Cover table for Riverine Sandy-Loamy Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
ferns	*Equisetum arvense*	12.5	10.0	15.0	100
forbs	*Achillea millefolium*	6.0	2.0	10.0	100
forbs	*Angelica genuflexa*	11.5	3.0	20.0	100
forbs	*Angelica lucida*	12.5	5.0	20.0	100
forbs	*Castilleja unalaschcensis*	7.0	7.0	7.0	50
forbs	*Epilobium angustifolium*	20.0	20.0	20.0	50
forbs	*Heracleum lanatum*	12.5	5.0	20.0	100
forbs	*Rubus arcticus*	1.1	0.1	2.0	100
forbs	*Trientalis europaea*	0.1	0.1	0.1	100
grasses	*Anthoxanthum hirtum*	0.1	0.1	0.1	100
grasses	*Calamagrostis canadensis*	6.0	5.0	7.0	100
grasses	*Hordeum brachyantherum*	11.5	10.0	13.0	100
grasses	*Phleum alpinum*	0.1	0.1	0.1	100
grasses	*Poa arctica* s.l.	20.0	20.0	20.0	50

Table 74. Environment Data Summary table for Riverine Sandy-Loamy Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	28.0	13.0	18.0	37.0	2
Slope (degrees)	11.0	15.0	0.0	21.0	2
Surface Organic Thickness (cm)	2.5	0.7	2.0	3.0	2
Depth to 15% Rock Fragments (cm)	-999.0	0.0	-999.0	-999.0	2
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	2
Site pH	6.0	0.6	5.5	6.4	2
Electrical Conductivity (um)	-999.0	0.0	-999.0	-999.0	2

Table 75. Soil Horizon Table for Riverine Sandy-Loamy Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–2.0	no data	slightly decomposed plant material (unsaturated Oi)	NA
2	A1	2.0–25.0	no data	clay loam	2.5y 3/2
3	A2	25.0–40.0	no data	loam	2.5y 3/2

Riverine Sandy-Loamy Moist Willow Tall Shrub

The ecotype Riverine Sandy-Loamy Moist Willow Tall Shrub is extensive along low-gradient sections of the larger river corridors, occurring on inactive floodplains and terrace deposits with flat to very gentle slopes. Vegetation corresponds to the *Salix alaxensis/Equisetum arvense*, *Salix glauca-Salix barclayi*, and *Salix glauca-Salix pulchra* plant associations. This ecotype represents the mid-seral stage of riverine succession with either an open (25–75% cover) or closed (>75% cover) tall shrub canopy. Tall willows (canopy >1.5 m heigh) are very prominent in this ecotype. *Salix glauca* is the most common dominant, but *Salix pulchra* can be co-dominant. Other *Salix* species, primarily *S. alaxensis* and *S. barclayi* can also be abundant (>30% cover). A diverse assemblage of herbaceous plants is usually present in the understory, with *Equisetum arvense*, *Heracleum lanatum*, and *Calamagrostis canadensis* having both high constancy and high average cover values. Lichen cover is uncommon, but moss species such as *Hylocomium splendens* and *Rhytidiadelphus* sp. can be prominent on infrequently flooded sites. Soils form in well-drained, stratified alluvial sediments with a dominant texture of Loamy and Sandy. Depth to rock fragments and the water table is typically well below the primary rooting zone (>40 cm below the soil surface). Surface organic horizons are thin, ranging from 2.0 to 8.0 cm (avg. 5.6 cm) thickness. Soils are circumneutral (avg. 6.2 pH) with an average recorded EC of 55.0 uS/cm. Soils are weakly developed Entisols and Inceptisols, but have been stable long enough for ash-rich alluvium to weather into short-range-order minerals with or without volcanic glass. Soil subgroups include Vitrandic Haplocryepts, Vitrandic Cryfluvents, Andic Cryofluvents and Andic Humicryepts. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 76–78.

Table 76. Constancy/Cover table for Riverine Sandy-Loamy Moist Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix alaxensis*	52.5	50.0	55	40
deciduous shrubs	*Salix barclayi*	35.0	30.0	40	40
deciduous shrubs	*Salix glauca*	30.5	2.0	70	80
deciduous shrubs	*Salix pulchra*	16.7	10.0	30	60
ferns	*Equisetum arvense*	15.0	2.0	50	100
forbs	*Angelica genuflexa*	7.4	0.1	12	60
forbs	*Heracleum lanatum*	12.3	0.1	30	80
forbs	*Polemonium acutiflorum*	0.6	0.1	2	80
forbs	*Rubus arcticus*	0.3	0.1	1	80
grasses	*Calamagrostis canadensis*	15.3	1.0	25	60
mosses	*Hylocomium splendens*	13.5	7.0	20	40

Table 77. Environment Data Summary table for Riverine Sandy-Loamy Moist Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	46.0	22.0	21.0	69.0	5
Slope (degrees)	0.0	0.0	0.0	1.0	5
Surface Organic Thickness (cm)	5.6	2.3	2.0	8.0	5
Depth to 15% Rock Fragments (cm)	-999.0	0.0	-999.0	-999.0	5
Water Table Depth (cm)	-200.0	NA	-200.0	-200.0	1
Site pH	6.2	0.5	5.7	7.1	5
Electrical Conductivity (um)	55.0	49.5	20.0	90.0	2

Table 78. Soil Horizon Table for Riverine Sandy-Loamy Moist Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–6.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	A	6.0–20.0	no modifier (<15%)	coarse sandy loam	NA
3	C	20.0–27.0	no modifier (<15%)	loamy coarse sand	NA
4	BAb	27.0–45.0	ashy	loamy fine sand	NA

Riverine Silty-Sandy-Rocky Moist Willow Low Shrub

The ecotype Riverine Silty-Sandy-Rocky Moist Willow Low Shrub is extensive on active and inactive floodplain surfaces throughout ANIA. It is also apparent along small channels that dissect coarse ash and lapilli deposits on backslope and footslope hillside positions. It occurs on a variety of aspects, on flat or gentle slopes (avg. 2 degrees), and across a wide elevation gradient ranging from 11 to 238 m (avg. 101 m). This low shrub ecotype represents early- to mid-seral stages in riverine vegetation succession. Vegetation corresponds to the *Salix alaxensis*/Early-seral Riparian, *Salix barclayi-Salix commutata*, *Salix barclayi-Salix commutata/Empetrum nigrum*, *Salix glauca-Salix barclayi*, and *Salix glauca-Salix pulchra* plant associations. *Salix barclayi* and *S. glauca* are co-dominant in the shrub overstory. Other willow species include *S. alaxensis*, *S. commutata*, and *S. pulchra*. The understory is often diverse, with *Equisetum arvense*, *Achillea millefolium*, *Epilobium angustifolium*, *Heracleum lanatum*, *Rubus arcticus*, *Sanguisorba stipulata* and *Carex macrochaeta* comprising the majority of the herbaceous cover. Mosses in the genera *Rhytidiadelphus* have relatively low constancy, but can be abundant on infrequently flooded sites. Common lichens include *Lobaria* sp. and *Peltigera* sp. Soils form in highly stratified alluvial sediments primarily composed of sands and gravels. Dominant texture classes include Sandy, Gravelly, Loamy and Pumiceous, with an average depth to >15% rock fragments at 20.0 cm below the soil surface. A fluctuating water table within the rooting zone is characteristic of this ecotype; anearobic soil moisture conditions can occur but they do not persist throughout the growing season. Surface organic horizon is thin, ranging from 0.0 to 10.0 cm (avg. 4.3 cm) thickness. Soils are circumneutral (avg. 6.3 pH) with an expected EC >100 uS/cm. Soils are poorly developed Entisols or weakly developed Inceptisols. Soil subgroups include Vitrandic Cryofluvents, Oxyaquic Cryofluvents, Typic Cryofluvents and Aquandic Haplocryepts. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 79–81.

Table 79. Constancy/Cover table for Riverine Silty-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix alaxensis*	52.5	50.0	55	40
deciduous shrubs	*Salix barclayi*	35.0	30.0	40	40
deciduous shrubs	*Salix glauca*	30.5	2.0	70	80
deciduous shrubs	*Salix pulchra*	16.7	10.0	30	60
ferns	*Equisetum arvense*	15.0	2.0	50	100
forbs	*Angelica genuflexa*	7.4	0.1	12	60
forbs	*Heracleum lanatum*	12.3	0.1	30	80
forbs	*Polemonium acutiflorum*	0.6	0.1	2	80
forbs	*Rubus arcticus*	0.3	0.1	1	80
grasses	*Calamagrostis canadensis*	15.3	1.0	25	60
mosses	*Hylocomium splendens*	13.5	7.0	20	40

Table 80. Environment Data Summary table for Riverine Silty-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	101.0	79.0	11.0	238.0	10
Slope (degrees)	2.0	2.0	0.0	8.0	10
Surface Organic Thickness (cm)	4.3	3.4	0.0	10.0	10
Depth to 15% Rock Fragments (cm)	20.0	8.6	11.0	30.0	4
Water Table Depth (cm)	-100.0	NA	-100.0	-100.0	1
Site pH	6.3	0.5	5.2	7.2	10
Electrical Conductivity (um)	120.0	NA	120.0	120.0	1

Table 81. Soil Horizon Table for Riverine Silty-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	O	0.0–4.0	no data	sandy loam	10yr 2/1
2	CA	4.0–7.0	no data	loamy sand	10yr 3/1
3	Ab	7.0–8.0	no data	loam	10yr 2/1
4	C1	8.0–35.0	no data	fine sandy loam	10yr 4/2
5	C2	35.0–42.0	no data	sand	7.5yr 3/2

Snow or Ice

This ecotype represents late lying snow and ice fields as described by Boucher et al. (2012). It occurs on high mountain summits, north-facing slopes, and areas characterized by persistent windloading of snow. No plots were described in this ecotype

Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub

The ecotype Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub is extensive throughout ANIA and was observed at elevations ranging from 0 to 420 m (avg. 177 m). This ecotype may occur on a variety of aspects, but typically does not occur above 300 m on north-facing slopes. This ecotype occurs on a wide range of topographic positions, from flat to gently-sloping abandoned floodplains to steep montane backslopes (max. recorded angle 44 degrees). Vegetation corresponds to the *Alnus viridis* ssp. *sinuata*/*Calamagrostis canadensis*, *Alnus viridis* ssp. *sinuata*/Forb, *Alnus viridis* ssp. *sinuata*, and *Alnus viridis* ssp. *sinuata*/Fern plant associations. *Alnus viridis* ssp. *sinuata* is the dominant species and often forms a dense canopy. Other common overstory shrubs include *Rubus spectabilis*, *Sambucus racemosa*, *Salix pulchra*, and *Salix glauca*. The understory in this ecotype is quite variable depending on the density of the shrub canopy, with high understory diversity in some open stands and very low diversity in closed stands. The grass *Calamagrostis canadensis* is the most common understory associate (avg. cover 17.7%); other herbaceous species with an average cover value ≥0% include the fern *Athyrium filix-femina* ssp. *cyclosorum*, and the forb *Veratrum viride* ssp. *eschscholtzii*. The feathermoss *Rhytidiadelphus triquetrus* is common, with a high constancy and average cover of 25.0%. Other common mosses include *Hylocomium splendens*, *Brachythecium reflexum*, and *Rhytidiadelphus loreus*. Lichen species such as *Peltigera* sp. and *Hypogymnia* sp. have a relatively high constancy, but cover is very low. Soils form in a variety of substrates ranging from volcaniclastic ashfall deposits, to rocky colluvium on sedimentary mountain slopes, to highly stratified rocky and loamy alluvial parent material. Dominant texture classes include Rubbly, Loamy, and Pumiceous or Sandy coarse-ash deposits. Less common in this ecotype are Ashy texture classes where the dominant mineral material is comprised of fine ash. The depth to greater than 15% rock fragments varies, but is generally within 100 cm of the soil surface (avg. 17.8 cm). Soils are predominantly moist, moderately- to well drained; water table depth may fluctuate seasonally. While rare, moderately thick organic mats may form at the surface (max. 15.0 cm), yet a thin accumulation of organic material is most common (avg. 7.7 cm). Due to the wide range in parent material, the soil chemistry is variable, ranging from acidic to circumneutral (avg. pH 5.4), with an average recorded EC value of 67.0 uS/cm. Soil profiles usually support mid- to late seral stages of vegetation and range from weakly developed Inceptisols with andic soil properties on steep slopes (>10 degrees), to weakly developed Andisols on moderate to gentle slopes (<10 degrees). Andisol subgroups include Humic Vitricryands, Oxyaquic Duricryands, Spodic Haplocryands, Typic Vitricryands, and Vitric Haplocryands. Inceptisol subgroups include Andic Haplocryepts, Andic Humicryepts, Folistic Dystrocryepts, Oxyaquic Haplocryepts, Vitrandic Dystrocryepts, Vitrandic Haplocryepts, and Vitrandic Humicryepts. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 82–84.

Table 82. Constancy/Cover table for Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Alnus sinuata*	69.3	35.0	95	100
ferns	*Athyrium filix-femina* ssp. *cyclosorum*	10.5	0.1	45	43
forbs	*Rubus arcticus*	5.4	0.1	20	57
grasses	*Calamagrostis canadensis*	17.7	1.0	60	90

Table 83. Environment Data Summary table for Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	177.0	122.0	0.0	420.0	21
Slope (degrees)	15.0	12.0	0.0	44.0	21
Surface Organic Thickness (cm)	7.7	4.6	0.0	15.0	21
Depth to 15% Rock Fragments (cm)	17.8	27.9	3.0	110.0	14
Water Table Depth (cm)	-32.0	NA	-32.0	-32.0	1
Site pH	5.4	0.8	3.8	6.9	21
Electrical Conductivity (um)	67.0	39.5	20.0	120.0	10

Table 84. Soil Horizon Table for Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–7.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	7.5yr 3/1
2	OeC	7.0–11.0	ashy	moderately decomposed plant material (unsaturated Oe)	7.5yr 2.5/1
3	A	11.0–21.0	gravels (15–35%)	coarse sandy loam	7.5yr 3/2
4	Bw1	21.0–47.0	ashy	sandy loam	10yr 3/2
5	Bw2	47.0–69.0	gravels (15–35%)	coarse sandy loam	7.5yr 3/2

Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest

The ecotype Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest is of very limited extent. It is restricted to small, isolated areas in the northern portion of ANIA in the Cinder River watershed at an average elevation of 84 m. This ecotype represents the western limit of trees on the Alaska peninsula. Vegetation corresponds to the only forested plant association in the study area, *Populus balsamifera*/Herbaceous. Many stands are decadent and are likely patches of genetic clones. This ecotype is associated with old alluvial sediments, most of which are abandoned channel deposits that once dissected the pyroclastic flow deposits that blanket the Cinder River valley. This ecotype occurs on gently sloping (avg. 6 degrees) or undulating terrain and favors west- and south-facing aspects. *Populus balsamifera* dominates the tree canopy, with shrubs such as *Salix glauca*, *S. pulchra*, and *S. barclayi* in the understory with low cover. Forbs are diverse in the understory; species with high constancy and high average cover include *Heracleum lanatum* and *Epilobium angustifolium*. Forbs with high constancy and low average cover include *Geranium erianthum*, *Artemisia tilesii* s.l., *Pyrola asarifolia*, and *Trientalis europaea*. Other common herbaceous species include *Equisetum arvense*, *Athyrium filix-femina* s.l., and *Calamagrostis canadensis*. The forest floor has a nearly continuous mat of feathermosses comprised primarily of *Rhytidiadelphus* spp. and *Hylocomium splendens*; the high moss abundance contributes to a relatively well-developed organic mat (avg. thickness of 6.2 cm). Dominant soil texture classes include Pumiceous and

Sandy, and rock fragments are typically encountered within the upper 20 cm of the soil profile (avg. depth 16.3 cm). Due to the stratified nature of these soils, texture classes may also include Loamy and Ashy when thick horizons comprised of these materials dominate the upper portion of the soil profile. Soils are somewhat excessively- to well-drained with a water table >100 cm below the soil surface. Soil chemistry is circumneutral (avg 6.2 pH) and bioavailable phoshorous may be limited to vegetation due to the high phosphate retention of weathered fine-ash deposits. This ecotype represents late-seral vegetation succession on moderately well- to well-developed Andisols and Spodosols. Common soil subgroups include Typic Vitricryands, Andic Haplocryods, and Andic Humicryods. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 85–87.

Table 85. Constancy/Cover table for Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix glauca*	5.3	1.0	10	80
deciduous shrubs	*Salix pulchra*	7.5	5.0	10	40
deciduous trees	*Populus balsamifera*	56.0	30.0	70	100
ferns	*Athyrium filix-femina* s.l.	5.3	1.0	10	80
ferns	*Equisetum arvense*	13.8	0.1	30	80
forbs	*Artemisia tilesii* s.l.	2.3	1.0	3	80
forbs	*Epilobium angustifolium*	11.0	5.0	15	100
forbs	*Geranium erianthum*	4.2	0.1	15	100
forbs	*Heracleum lanatum*	22.0	5.0	30	100
forbs	*Pyrola asarifolia*	2.0	1.0	5	80
forbs	*Trientalis europaea*	0.6	0.1	1	80
grasses	*Calamagrostis canadensis*	8.3	3.0	15	80
grasses	*Poa palustris*	5.5	1.0	10	40
mosses	*Hylocomium splendens*	5.3	1.0	10	60
mosses	*Rhytidiadelphus* sp.	8.3	5.0	10	60

Table 86. Environment Data Summary table for Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	84.0	16.0	66	109.0	5
Slope (degrees)	6.0	9.0	0	21.0	5
Surface Organic Thickness (cm)	6.2	3.0	2	10.0	5
Depth to 15% Rock Fragments (cm)	16.3	4.9	10	21.0	4
Water Table Depth (cm)	-999.0	0.0	-999	-999.0	5
Site pH	6.2	0.1	6	6.4	5
Electrical Conductivity (um)	50.0	NA	50	50.0	1

Table 87. Soil Horizon Table for Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–3.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oe	3.0–8.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	EC	8.0–15.0	ashy	loamy sand	2.5y 3/2
4	Bsh	15.0–27.0	very gravelly (35–60%)	loamy coarse sand	7.5yr 3/4
5	2C	27.0–47.0	extremely gravelly (60–90%)	coarse sand (0.5–1 mm)	7.5yr 3/4
6	3Btsb	47.0–60.0	ashy	sandy loam	7.5yr 2.5/2

Upland Ashy-Loamy-Rocky Moist Forb Meadow

The ecotype Upland Ashy-Loamy-Rocky Moist Forb Meadow is common at low to middle elevations (avg. 145 m) on moderately steep, south-facing mountain slopes and gentle alluvial fans. Typical geomorphic units include Tephra, Hillside Colluvium, and Alluvial Fan Abandoned Deposit. The most common plant association is *Angelica lucida-Heracleum lanatum*, which is dominated by the large umbelliferous forbs *Heracleum lanatum* and/or *Angelica lucida*. Second-most common is the *Athyrium filix-femina* plant association, which is dominated by the robust fern *Athyrium filix-femina*. Both plant associations feature a diverse variety of understory forbs; *Epilobium angustifolium*, *Equisetum arvense*, *Geranium erianthum*, and *Moehringia lateriflora* are among the most common associates. Grasses and sedges are somewhat less common with the exception of *Carex macrochaeta* and *Calamagrostis canadensis*, which frequently occur with low to moderate cover. Shrubs are generally rare with the exception of *Rubus spectabilis*, which may occur at moderately high abundance on sites that experience periodic disturbance (e.g., rockfall, landslide). Common mosses include *Rhytidiadelphus squarrosus* and *Hylocomium splendens*. Soils are moist and acidic to circumneutral (measured pH range 5.1–7.0). Dominant soil textures are rather variable; this ecotype commonly occurs on Ashy and Loamy soils with few coarse fragments, but was also found rocky soils, including Rubbly, Pumiceous, and Bouldery. The surface organic horizon is typically thin (avg. 7.7 cm) and the depth to 15% rock fragments, when they occur, is shallow to moderately deep (avg. 28 cm). Soils were generally moderately well- to well-developed and classified as Andisols, and Inceptisols, including Andic intergrades. Common soil subgroups include Andic Haplocryepts, Spodic Vitricryands, and Typic Vitricryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 88–90.

Table 88. Constancy/Cover table for Upland Ashy-Loamy-Rocky Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
ferns	*Athyrium filix-femina* ssp. *cyclosorum*	10.7	1.0	28	47
ferns	*Equisetum arvense*	3.1	0.1	10	87
forbs	*Angelica lucida*	9.9	1.0	50	93
forbs	*Epilobium angustifolium*	9.0	2.0	30	93
forbs	*Geranium erianthum*	5.4	0.1	15	80
forbs	*Heracleum lanatum*	20.9	4.0	75	93
forbs	*Moehringia lateriflora*	0.6	0.1	2	80
forbs	*Solidago lepida*	6.2	1.0	10	40
grasses	*Calamagrostis canadensis*	5.9	0.1	18	87
mosses	*Hylocomium splendens*	6.6	0.1	20	60
mosses	*Rhytidiadelphus squarrosus*	11.7	1.0	50	60

Table 89. Environment Data Summary table for Upland Ashy-Loamy-Rocky Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	145.0	88.0	36.0	268	15
Slope (degrees)	19.0	12.0	0.0	35	15
Surface Organic Thickness (cm)	7.7	3.1	4.0	16	15
Depth to 15% Rock Fragments (cm)	28.1	26.4	5.0	89	8
Water Table Depth (cm)	-999.0	0.0	-999.0	-999	15
Site pH	5.9	0.6	5.1	7	15
Electrical Conductivity (um)	72.0	45.4	20.0	180	10

Table 90. Soil Horizon Table for Upland Ashy-Loamy-Rocky Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–2.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oe	2.0–8.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	AOa	8.0–10.0	no modifier (<15%)	highly decomposed plant material (unsaturated Oa)	NA
4	A	10.0–16.0	ashy	silt loam	7.5yr 3/2
5	Bw1	16.0–32.0	ashy	sandy loam	NA
6	Bw2	32.0–46.0	no modifier (<15%)	sandy loam	NA

Upland Ashy-Rocky Moist Crowberry Dwarf Shrub

The ecotype Upland Ashy-Rocky Moist Crowberry Dwarf Shrub is extensive throughout ANIA, favoring flat to gently sloping terrain (<15 degrees) on tephra or pyroclastic flow deposits. This ecotype ranges in elevation from 10 to 302 m, but is best developed on warmer, west and south-facing aspects above aprox. 200 m. Periglacial features, such as frost-crack polygons and hummocks are prevalent in this ecotype across the broad elevation spectrum. Vegetation corresponds to 8 out of the 10 plant associations dominated by *Empetrum nigrum*, excluding only those characteristic of wet sites and mid-seral coastal dunes. A wide variety of associate shrub species contribute to the shrub canopy, however the average cover of any one associate is generally low (<5%). There are two exceptions: *Vaccinium uliginosum* and *Arctostaphylos uva-ursi*, which, when present, have an average cover >10%. Except for early-seral vegetation on young surfaces, or on disturbance-prone substrates (i.e., frost heave, or wind erosion), *Empetrum nigrum* forms a nearly continuous mat of dwarf shrub cover. Herbaceous species are variable with low cover, and may include *Geum rossii*, *Rubus arcticus*, *Epilobium angustifolium*, *Trisetum spicatum*, and *Carex macrochaeta*. Fruticose and foliose lichens usually are well reprensented and are dominated by *Thamnolia vermicularis*, *Stereocaulon* sp., *Cladina* sp., *Cladonia* sp., and *Lobaria* sp. The mosses *Racomitrium lanuginosum* and *Racomitrium canescens* are very common, having both high constancy and cover. Dominant texture classes include Rubbly, Pumiceous, Sandy and Ashy with coarse-ash deposits comprising the majority of the coarse silt and sand size fraction. Surface organic thickness is generally very thin to thin (avg. 5.0 cm), with the greatest rates of organic matter accumulation occurring on Loamy or Ashy soils. The depth to greater than 15% rock fragments is predominantly shallow (avg. 26.2 cm). Soils are well- to somewhat excessively well-drained, with a depth to water table typically well below the primary rooting zone (>40 cm). Soils on pyroclastic flow deposits may be contain a root-restricting layer, such as a silica-cemented duripan, which can retard drainage and reduce infiltration rates. Soil chemistry is circumneutral (avg. pH 6.0) and the EC is generally quite low (< 50 uS/cm). Soils that have formed in redistributed volcaniclastic deposits (i.e., small dunes) often have buried A- or O- horizons which irregularly increase organic carbon content with depth and support the formation of Thaptic or Humic intergrades. Soils are moderately well developed Andisols and Inceptisols and include the subgroups Andic Dystrocryepts, Eutric Duricryands, Humic Vitricryands, Thaptic Vitricryands, Typic Duricryands, Typic Haplocryands, Typic Vitricryands, Vitrandic Cryopsamments, and Vitric Haplocryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 91–93.

Table 91. Constancy/Cover table for Upland Ashy-Rocky Moist Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix arctica*	3.1	0.1	10	91
deciduous shrubs	*Vaccinium uliginosum*	10.7	0.1	50	82
evergreen shrubs	*Empetrum nigrum*	43.9	15.0	80	100
mosses	*Racomitrium* sp.	19.1	1.0	60	45

Table 92. Environment Data Summary table for Upland Ashy-Rocky Moist Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	141.0	98.0	10.0	302.0	22
Slope (degrees)	4.0	5.0	0.0	17.0	20
Surface Organic Thickness (cm)	5.0	3.7	0.0	15.0	22
Depth to 15% Rock Fragments (cm)	26.2	36.7	0.0	115.0	12
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	22
Site pH	6.0	0.7	4.1	6.9	21
Electrical Conductivity (um)	33.3	15.3	20.0	50.0	3

Table 93. Soil Horizon Table for Upland Ashy-Rocky Moist Crowberry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–4.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oe	4.0–9.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C	9.0–11.0	ashy	very fine sandy loam	NA
4	2A	11.0–23.0	ashy	sandy loam	10yr 3/2
5	2Bjj	23.0–48.0	ashy	fine sandy loam	10yr 2/2

Upland Ashy-Sandy-Rocky Moist Willow Low Shrub

The ecotype Upland Ashy-Sandy-Rocky Moist Willow Low Shrub is extensive throughout ANIA, occuring on gentle to moderate (avg. 8 degrees) backslopes, footslopes and toeslopes of mountains and hills. This ecotype favors concave slope positions or ephemeral drainageways that channel surface water run-off that helps maintain moist soil conditions. It was observed across a variety of aspects and at elevations ranging from 9 to 210 m (avg. 122 m). Vegetation corresponds best to the *Salix glauca-Salix pulchra* plant association, but may also include the *Salix glauca-Salix barclayi* and *Salix glauca-Salix pulchra/Empetrum nigrum* plant associations. *Salix glauca* and *S. pulchra* are co-dominant in the low shrub overstory. This ecotype usually has high willow diversity, with *S. barclayi*, *S. commutata*, *S. sitchensis*, and *S. alaxensis* frequently contributing to the overstory. This ecotype tends to favor recruitment and establishment of graminoids in the underrstory rather than forbs. The grass *Calamagrostis canadensis* is almost always present (91% constancy); the sedge *Carex macrochaeta* occurs with somewhat lower constancy, but when present it can dominate the understory (max. cover 50.0%). Forbs with high constancy, but low cover values include *Epilobium angustifolium*, *Heracleum lanatum*, *Rubus arcticus*, *Sanguisorba stipulata*, and *Angelica lucida*. Moss cover is relatively abundant, with the feathermosses *Hylocomium splendens*, *Rhytidiadelphus triquetrus*, and *Ptilium crista-castrensis* comprising the majority of the moss mat. Soils may form in ashy, rocky, loamy, sandy or pumiceous eolian, colluvial, or alluvial deposits. The depth to greater than 15% rock fragments is highly variable, but is typically shallow (avg. 14.0 cm). Surface organic horizons are generally thin (avg. 8.5 cm), but may become moderately thick at sites with more favorable soil moisture conditions. The water table is generally well below the primary rooting zone (>40 cm) and soils are well- to somewhat excessively drained. Soil chemistry is circumneutral (avg. 5.8 pH) and the EC is variable (avg. 93.3 uS/cm). Soils with a dominant texture class of Ashy, Loamy or Organic-rich classify primarily into the Haplocryands great group, while coarser soils with a dominant texture class of Pumiceous or Sandy classify as Vitricyrands. Barring disturbance, soils in this ecotype will form spodic horizons over time regardless of texture. Typical soil subgroups for finer-textured soils include Andic Dystrocryepts, Folistic Haplocryands, Spodic Haplocryands, Spodic Vitricryands and Vitrandic Humicryepts. Typical subgroups for soils forming in coarse-ash or lapilli, include Thaptic Vitricryands, Typic Vitricryands, and Spodic Vitricryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 94–96.

Table 94. Constancy/Cover table for Upland Ashy-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix barclayi*	11.0	2.0	40	55
deciduous shrubs	*Salix glauca*	32.4	7.0	60	82
deciduous shrubs	*Salix pulchra*	25.4	5.0	65	100
evergreen shrubs	*Empetrum nigrum*	14.4	1.0	50	45
ferns	*Equisetum arvense*	3.3	0.1	10	82
forbs	*Angelica lucida*	3.8	0.1	10	82
forbs	*Epilobium angustifolium*	5.2	1.0	10	91
forbs	*Heracleum lanatum*	4.0	1.0	10	91
forbs	*Rubus arcticus*	2.3	0.1	6	91
forbs	*Sanguisorba stipulata*	5.1	1.0	30	82
grasses	*Calamagrostis canadensis*	6.9	1.0	25	91
mosses	*Hylocomium splendens*	12.3	3.0	30	82
mosses	*Ptilium crista-castrensis*	13.6	3.0	30	45
mosses	*Rhytidiadelphus triquetrus*	14.5	2.0	35	55
sedges	*Carex macrochaeta*	9.9	0.1	50	55

Table 95. Environment Data Summary table for Upland Ashy-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	122.0	71.0	9.0	210.0	11
Slope (degrees)	8.0	4.0	2.0	14.0	10
Surface Organic Thickness (cm)	8.5	4.3	4.0	20.0	11
Depth to 15% Rock Fragments (cm)	14.0	9.7	5.0	28.0	5
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	11
Site pH	5.8	0.3	5.4	6.3	10
Electrical Conductivity (um)	93.3	70.9	30.0	170.0	3

Table 96. Soil Horizon Table for Upland Ashy-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–8.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	A	8.0–13.0	no modifier (<15%)	sandy loam	NA
3	Bw	13.0–20.0	no modifier (<15%)	sandy loam	7.5yr 3/3
4	AE	20.0–28.0	no modifier (<15%)	sandy loam	10yr 3/3
5	Bs	28.0–32.0	very gravelly (35–60%)	sandy loam	NA
6	CB	32.0–45.0	no modifier (<15%)	loamy sand	NA

Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub

The ecotype Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub is similar to, but less extensive then, Upland Ashy-Sandy-Rocky Moist Willow Low Shrub ecotype. Willows form an open to closed canopy that is >1.5 m height. This ecotype ocurs on flat to very gentle slopes (<5 degrees) on terraces, abandoned floodplains, or deep, non-welded pyroclastic flow deposits. It was observed at elevations below 75 m (avg. 61 m). This ecotype may occur on hillslope postions >5 degrees at sites sheltered from prevailing winds and with adequate soil moisture conditions. Vegetation corresponds best to the *Salix glauca-Salix pulchra* plant association, but may also include the *Salix glauca-Salix barclayi* and *Salix glauca-Salix pulchra/Empetrum nigrum* plant associations. *Salix glauca* and *S. pulchra* are co-dominant in the tall shrub overstory. Herbaceous species with high average cover include *Epilobium angustifolium*, *Epilobium anagallidifolium*, and *Calamagrostis canadensis*. Moss cover is high and may form a continuous mat at the surface. Feathermosses are common, including *Hylocomium splendens*, *Rhytidiadelphus loreus*, *R. triquetrus*, and *Ptilium crista-castrensis*. Soils form primarily in coarse-textured alluvium or colluvium comprised of volcaniclastic material. The depth to greater than 15% rock fragments is shallow (avg. 24.5 cm) and surface organic horizons are thin (avg. 7.2 cm). The water table table is generally well below the primary rooting zone (>40 cm) and soils are well- to moderately well-drained. Soil chemistry is circumneutral (avg. 6.1 pH). Soils are generally weakly developed Andisols, but may weather into Spodic or Humic intergrades over time. Common soil subgroups include Typic Vitricryands, Humic Vitricryands, and Spodic Vitricryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 97–99.

Table 97. Constancy/Cover table for Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix barclayi*	11.3	1.0	30	60
deciduous shrubs	*Salix glauca*	39.0	20.0	60	100
deciduous shrubs	*Salix pulchra*	30.0	20.0	50	80
evergreen shrubs	*Empetrum nigrum*	25.0	0.1	70	60
ferns	*Equisetum arvense*	7.6	0.1	15	40
forbs	*Achillea millefolium*	2.0	1.0	5	80
forbs	*Angelica lucida*	2.3	0.1	5	80
forbs	*Epilobium angustifolium*	12.3	4.0	20	80
forbs	*Lupinus nootkatensis*	2.8	0.1	5	80

Table 97. Continued.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Rubus arcticus*	1.4	1.0	3	100
forbs	*Solidago multiradiata s.l.*	0.8	0.1	1	80
forbs	*Trientalis europaea*	0.6	0.1	1	100
grasses	*Calamagrostis canadensis*	14.0	1.0	30	80
mosses	*Hylocomium splendens*	18.3	10.0	30	60
mosses	*Pleurozium schreberi*	5.1	0.1	10	40
mosses	*Ptilium crista-castrensis*	12.5	5.0	20	40
mosses	*Rhytidiadelphus loreus*	50.0	50.0	50	40
mosses	*Rhytidiadelphus* sp.	18.0	6.0	30	40

Table 98. Environment Data Summary table for Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	61.0	13.0	39.0	73.0	5
Slope (degrees)	4.0	7.0	0.0	15.0	5
Surface Organic Thickness (cm)	7.2	3.0	3.0	10.0	5
Depth to 15% Rock Fragments (cm)	24.5	7.3	17.0	33.0	4
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	5
Site pH	6.1	0.4	5.6	6.6	5
Electrical Conductivity (um)	30.0	NA	30.0	30.0	1

Table 99. Soil Horizon Table for Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–3.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oe	3.0–10.0	ashy	moderately decomposed plant material (unsaturated Oe)	7.5yr 2.5/2
3	EC	10.0–16.0	ashy	coarse sand (0.5–1 mm)	NA
4	A/Oa/Bw	16.0–32.0	ashy	sandy loam	10yr 2/2
5	2BC	32.0–48.0	extremely gravelly (60–90%)	sand	5yr 3/4

Upland Sandy-Rocky Dry Barrens

The ecotype Upland Sandy-Rocky Dry Barrens occurs primarily on welded pyroclastic flow deposits in valley bottoms on flat to gentle slopes (<5 degrees). Upland barren sites that occur outside of valley bottoms are generally wind-scoured summits or very shallow to bedrock. This ecotype was described at elevations ranging from 27 to 226 m (avg. 67 m). Vegetation corresponds to the sparse and non-vascular plant associations of *Artemisia campestris* ssp. *borealis-Rumex beringensis-Festuca* spp./Pumice plant association, *Arctostaphylos uva-ursi*/Pumice, *Empetrum nigrum*/Pumice, and *Leymus mollis*/Pumice. Barren pumice is the dominant cover for this ecotype. Dwarf shrubs, such as *Arctostaphylos uva-ursi*, and *Empetrum nigrum* may be present. Vascular species diversity may be high but provide little cover; species with high constancy include *Equisetum arvense*, *Artemisia borealis*, and *Deschampsia cespitosa* s.l. Non-vascular species, such as *Stereocaulon* sp., *Peltigera* sp., and *Racomitrium* sp. may be present, with low cover. Dominant soil texture classes are Gravelly, Pumiceous, Rubbly and Sandy, with an average depth to greater than 15% rock fragments ocurring at the soil surface (0 cm). Surface organic horizons are absent or patchy (avg. 0.6 cm). Soil productivity is poor due to low nutrient availability, increasing alkalinity with depth, and a root restricting layer often within 100 cm of the soil surface. Common soil subgroups include Eutric Duricryands, Lithic Cryorthents, and Vitrandic Cryorthents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 100–102.

Table 100. Constancy/Cover table for Upland Sandy-Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Artemisia borealis*	0.1	0.1	0.1	78

Table 101. Environment Data Summary table for Upland Sandy-Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	67.0	61.0	27.0	226.0	9
Slope (degrees)	1.0	1.0	0.0	4.0	9
Surface Organic Thickness (cm)	0.6	1.7	0.0	5.0	9
Depth to 15% Rock Fragments (cm)	0.0	0.0	0.0	0.0	8
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	9
Site pH	6.8	0.3	6.6	7.3	9
Electrical Conductivity (um)	50.0	NA	50.0	50.0	1

Table 102. Soil Horizon Table for Upland Sandy-Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C	1.0–5.0	extremely gravelly (60–90%)	sand	NA
2	AC	5.0–10.0	very gravelly (35–60%)	loamy sand	NA
3	Bqmt	10.0–33.0	extremely gravelly (60–90%)	sandy loam	10yr 4/3
4	Bqm	33.0–47.0	extremely gravelly (60–90%)	sand	NA

Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub

The ecotype Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub is of limited extent in ANIA and occurs in ephemeral drainage channels that carve through very thick coarse tephra deposits in Volcanic physiography. Incised drainage channels provide a sheltered micro-climate which reduces soil erosion, increases soil moisture, and supports shrub recruitment and advancement. This ecotype was described at elevations ranging from 291 to 336 m (avg. 314 m). Vegetation corresponds to the *Salix barclayi* plant association. *Salix barclayi* dominates the low shrub overstory, and may be co-dominant with *Salix alaxensis* in some instances. Other willow species with moderate to low abundance include *Salix sitchensis* and *Salix glauca*. Common herbaceous species in the understory include *Heracleum lanatum*, *Pyrola asarifolia*, *Epilobium angustifolium*, and *Achillea millefolium*. The grass *Vahlodea atropurpurea* is common to this ecotype, but foliar cover is generally low. Lichen species are absent, but once mosses establish, the cover is generally high. Non-vascular species include *Drepanocladus* sp. and *Rhytidiadelphus squarrosus*. Dominant soil texture classes are Pumiceous and Sandy, with an average depth to greater than 15% rock fragments of 9.5 cm below the soil surface. Soil moisture is a limiting factor for growing conditions in much of the Volcanic physiography, and this ecotype is one of 3 with adequate soil moisture to support substantial plant growth. The relatively stable, sheltered environment lends to very thin to thin accumulations of organic matter at the surface (avg. 7.0 cm). Soils range from well- to moderately well-drained, and the depth to water table often fluctuates with the season. Soils are circumneutral (avg. 6.8 pH) and likely become increasingly alkaline with depth. Soils have not had sufficient time to weather for andic soil properties to develop from tephra parent material, and are either poorly developed Entisols, or weakly developed Andisols. Common soil subgroups include Vitrandic Cryorthents and Oxyaquic Vitricryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 103–105.

Table 103. Constancy/Cover table for Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix alaxensis*	12.5	10.0	15	100
deciduous shrubs	*Salix barclayi*	37.5	15.0	60	100
deciduous shrubs	*Salix glauca*	10.0	10.0	10	50
deciduous shrubs	*Salix sitchensis*	20.0	20.0	20	50
forbs	*Achillea millefolium*	10.0	10.0	10	50

Table 103. Continued.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Angelica lucida*	1.6	0.1	3	100
forbs	*Epilobium angustifolium*	8.0	1.0	15	100
forbs	*Heracleum lanatum*	20.0	10.0	30	100
forbs	*Lupinus nootkatensis*	6.5	5.0	8	100
forbs	*Pyrola asarifolia*	19.0	8.0	30	100
forbs	*Rubus arcticus*	6.0	2.0	10	100
grasses	*Vahlodea atropurpurea*	1.1	0.1	2	100
mosses	*Drepanocladus* sp.	15.0	15.0	15	50
mosses	*Rhytidiadelphus squarrosus*	15.0	15.0	15	50
sedges	*Carex macrochaeta*	3.5	2.0	5	100

Table 104. Environment Data Summary table for Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	314.0	32.0	291.0	336.0	2
Slope (degrees)	3.0	0.0	3.0	3.0	2
Surface Organic Thickness (cm)	4.5	2.1	3.0	6.0	2
Depth to 15% Rock Fragments (cm)	9.5	0.7	9.0	10.0	2
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	2
Site pH	6.8	0.2	6.6	6.9	2
Electrical Conductivity (um)	70.0	NA	70.0	70.0	1

Table 105. Soil Horizon Table for Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–3.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	OeOa	3.0–11.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C	11.0–30.0	extremely gravelly (60–90%)	coarse sand (0.5–1 mm)	NA

Volcanic Lake

This ecotype occurs exclusively within the Aniakchak Caldera and represents Surprise Lake and an unnamed maar located below Blacknose. Water chemistry is influenced in part or wholly by volcanic hydrology, including volcanic streams and springs. No plots were described in this ecotype.

Volcanic Rocky-Ashy Dry Dwarf Shrub

The ecotype Volcanic Rocky-Ashy Dry Dwarf Shrub is of patchy extent in ANIA, and represents mid- to late seral vegetation succession in the Volcanic physiography. It occurs primarily on stabilized tephra deposits with a high content of coarse-ash, lapilli, bombs and/or volcanic blocks in the soil profile. This ecotype may favor warm west- and south-facing aspects, and was observed at elevations ranging from 370 m to 501 m (avg. 440 m). It occurs on a broad range of slope severity, ranging from flat to 35 degrees (avg. 14 degrees). Vegetation on Sandy and Ashy sites correspond best to *Empetrum nigrum*-Mixed Dwarf Shrub and *Empetrum nigrum* plant associations. Rocky sites favor *Luetkea pectinata-Salix ovalifolia* plant association. This ecotype has a high diversity of shrubs, with *Empetrum nigrum*, *Luetkea pectinata*, *Salix stolonifera*, and *Salix ovalifolia* contributing significantly to the overstory. Herbaceous species have generally low cover values, with *Sibbaldia procumbens*, *Arnica lessingii*, and *Epilobium latifolium* being the most common. Non-vascular species are abundant, with the liverwort *Gymnomitrion corallioides*, and a variety of mosses and lichens contributing to near continous ground cover. Lichen species include *Stereocaulon vesuvianum* and *Solorina crocea*. Common moss species are *Racomitrium* sp. and *Bryum* sp. Dominant soil textures are Blocky, Pumiceous, Rubbly and Sandy, with the average depth to greater than 15% rock fragments ocurring at the soil surface (0 cm). Surface organic thickness is very thin (avg. 1.8 cm) and site chemistry is circumneutral (avg. 5.6). Soils are somewhat excessively- to excessively well-drained and the water table is deep to very deep (>100 cm). Landform stability supports the development of weakly developed Andisols in relatively young substrate. Common soil subgroups include Typic Vitricryands and Vitrandic Cryorthents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 106–108.

Table 106. Constancy/Cover table for Volcanic Rocky-Ashy Dry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix ovalifolia*	8.3	5.0	10.0	75
deciduous shrubs	*Vaccinium uliginosum*	2.0	0.1	5.0	75
evergreen shrubs	*Empetrum nigrum*	25.0	10.0	40.0	50
evergreen shrubs	*Therorhodion camtschaticum*	1.0	0.1	2.0	75
forbs	*Arnica lessingii*	0.1	0.1	0.1	75
forbs	*Sibbaldia procumbens*	1.3	1.0	2.0	75

Table 107. Environment Data Summary table for Volcanic Rocky-Ashy Dry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	440.0	56.0	370.0	501	4
Slope (degrees)	14.0	15.0	0.0	35	4
Surface Organic Thickness (cm)	1.8	1.7	0.0	4	4
Depth to 15% Rock Fragments (cm)	0.0	0.0	0.0	0	3
Water Table Depth (cm)	-999.0	0.0	-999.0	-999	4
Site pH	5.6	0.4	5.2	6	4
Electrical Conductivity (um)	50.0	NA	50.0	50	1

Table 108. Soil Horizon Table for Volcanic Rocky-Ashy Dry Dwarf Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	CA	0.0–10.0	gravels (15–35%)	loamy sand	NA
2	C	10.0–42.0	extremely stoney (60–90%)	sand	NA

Volcanic Rocky-Ashy Moist Forb Meadow

The ecotype Volcanic Rocky-Ashy Moist Forb Meadow is of limited extent in ANIA, and typically occurs on stable sites in close proximity to active or ephemeral drainage channels in Aniakchak Caldera. Overbank deposits and subsurface hydrology provide necessary soil texture and moisture conditions to support development of relatively lush vegetation. This ecotype was described at two plots, one near the Aniakchak caldera freshwater spring at the head of Surprise Lake, and the other on a non-incised, ephemeral drainage channel in re-worked tephra deposits near the center of the Caldera. The vegetation at the head of Surprise Lake corresponds to the *Angelica lucida-Heracleum maximum* plant association in which large umbels dominate the overstory, *Heracleum lanatum* being the most common. On the non-incised, ephemeral drainage channel the vegetation was not assigned a plant association as it did not fit one of the published classes. The vegetation here was characterized by a low to moderate cover of *Lupinus nootkatensis*, *Achillea borealis*, and *Alopecurus magellanicus*. In both vegetation types shrub cover was extremely low but *Salix alaxensis* was nearly always present. Despite having low total cover, there is a relatively high diversity of grass species, with *Leymus mollis* ssp. *mollis* and *Agrostis exarata* having a high constancy. Non-vascular species are abundant, with *Rhytidiadelphus loreus*, *Racomitrium ericoides*, *Rhytidiadelphus squarrosus* and *Plagiomnium cuspidatum* having the highest average

cover values. Soils form in coarse-textured ash-rich alluvium, and are not highly stratified. Dominant soil texture classes are Gravelly and Rubbly, with the depth to greater than 15% rock fragments ocurring near the soil surface (avg. 1.0 cm). Site and soil moisture conditions support substantial organic matter accumulation (avg. 4.0 cm), and soils are typically moderately well- to somewhat poorly drained. Despite the depth to water table sometimes ocurring within 100 cm of the soil surface, soils are forming in an aerated soil moisture regime, whereby oxygenated water is moving through the soil profile typically early in the growing season. Soils are circumneutral (avg. 6.3 pH) and have a low EC (avg. 40 uS/cm). Soils are young, poorly developed Entisols, and classify as Vitrandic Cryofluvents or Vitrandic Cryorthents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 109–111.

Table 109. Constancy/Cover table for Volcanic Rocky-Ashy Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix alaxensis*	0.1	0.1	0.1	100
forbs	*Achillea borealis*	3.5	2.0	5.0	100
forbs	*Angelica lucida*	8.0	8.0	8.0	50
forbs	*Epilobium latifolium*	0.6	0.1	1.0	100
forbs	*Heracleum lanatum*	38.0	38.0	38.0	50
forbs	*Lupinus nootkatensis*	8.5	2.0	15.0	100
grasses	*Agrostis exarata*	0.6	0.1	1.0	100
grasses	*Leymus mollis* ssp. *mollis*	3.0	3.0	3.0	100
mosses	*Plagiomnium cuspidatum*	18.0	18.0	18.0	50
mosses	*Racomitrium ericoides*	40.0	40.0	40.0	50
mosses	*Rhizomnium pseudopunctatum*	6.0	6.0	6.0	50
mosses	*Rhytidiadelphus loreus*	15.1	0.1	30.0	100
mosses	*Rhytidiadelphus squarrosus*	20.0	20.0	20.0	50

Table 110. Environment Data Summary table for Volcanic Rocky-Ashy Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	360.0	35.0	335.0	385.0	2
Slope (degrees)	3.0	1.0	2.0	3.0	2
Surface Organic Thickness (cm)	4.0	2.8	2.0	6.0	2

Table 110. Continued.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Depth to 15% Rock Fragments (cm)	1.0	1.4	0.0	2.0	2
Water Table Depth (cm)	-47.0	NA	-47.0	-47.0	1
Site pH	6.3	1.5	5.2	7.3	2
Electrical Conductivity (um)	40.0	0.0	40.0	40.0	2

Table 111. Soil Horizon Table for Volcanic Rocky-Ashy Moist Forb Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	A	0.0–6.0	fine gravelly (2–5mm, 15–35%)	highly decomposed plant material (unsaturated Oa)	10yr 2/1
2	AC	6.0–32.0	extremely gravelly (60–90%)	coarse sand (0.5–1 mm)	10yr 3/1
3	C	32.0–47.0	extremely gravelly (60–90%)	coarse sand (0.5–1 mm)	NA

Volcanic Rocky-Ashy Wet Willow Low Shrub

The ecotype Volcanic Rocky-Ashy Wet Willow Low Shrub is restricted to wetland areas within the Aniakchak caldera. This ecotype was described at two plots that were mostly flat (avg. 1 degree) and at a similar elevation (avg. 331 m). Vegetation corresponds to the *Salix alaxensis*/Early-seral Riparian plant association. This ecotype has a wide diversity of *Salix* sp., but only one dominates the overstory: *Salix alexensis*. Herbaceous species with high constancy but low cover values include *Achillea borealis*, *Epilobium palustre*, *Lupinus nootkatensis*, *Rubus arcticus*, *Arctagrostis latifolia* s.l., and *Sanionia uncinata*. Non-vascular species contribute to near continuous ground cover, with the mosses *Racomitrium canescens* and *Rhytidiadelphus squarrosus* being the most dominant. Soils form in highly stratified alluvium, comprised of buried organic horizons, ash, and rocky volcaniclastic material. This ecotype is poorly drained, with soils forming in an anearobic soil moisture regime. The depth to water table is typically shallow (avg. -21.0 cm). Dominant soil texture classses are Gravelly and Pumiceous, with an average depth to greater than 15% rock fragments of 8.5 cm below the soil surface. Surface organic thickness ranges from very thin to absent (avg. 1.0 cm). Soils are circumneutral and the EC is variable (avg. 280.0 uS/cm). Soils are poorly developed, young deposits of volcaniclastic material that undergo frequent flood disturbances. Typical subgroups include Typic Cryaquands and Aquandic Cryaquents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 112–114.

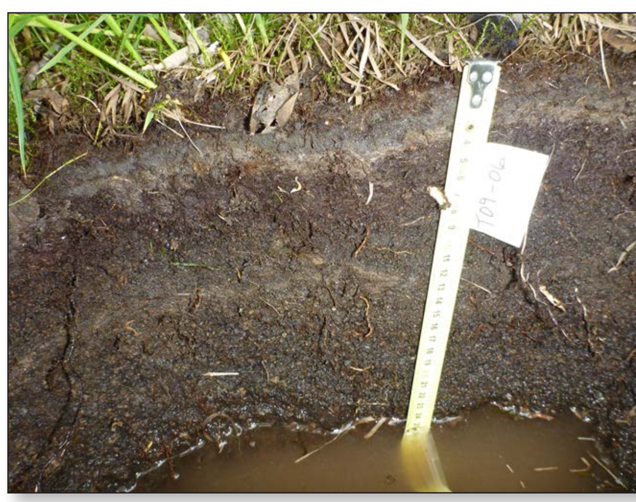


Table 112. Constancy/Cover table for Volcanic Rocky-Ashy Wet Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix alaxensis*	45.0	15.0	75.0	100
forbs	*Achillea borealis*	1.0	1.0	1.0	100
forbs	*Epilobium palustre*	0.1	0.1	0.1	100
forbs	*Lupinus nootkatensis*	2.0	1.0	3.0	100
forbs	*Pyrola grandiflora*	10.0	10.0	10.0	50
forbs	*Rubus arcticus*	2.6	0.1	5.0	100
grasses	*Arctagrostis latifolia* s.l.	0.6	0.1	1.0	100
mosses	*Racomitrium canescens*	65.0	65.0	65.0	50
mosses	*Rhytidiadelphus squarrosus*	15.0	15.0	15.0	50
mosses	*Sanionia uncinata*	9.0	3.0	15.0	100
sedges	*Carex macrochaeta*	10.0	10.0	10.0	50

Table 113. Environment Data Summary table for Volcanic Rocky-Ashy Wet Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	331.0	6.0	327.0	335.0	2
Slope (degrees)	1.0	1.0	0.0	1.0	2
Surface Organic Thickness (cm)	1.0	0.0	1.0	1.0	2
Depth to 15% Rock Fragments (cm)	8.5	3.5	6.0	11.0	2
Water Table Depth (cm)	-21.0	4.2	-24.0	-18.0	2
Site pH	6.5	0.0	6.5	6.5	2
Electrical Conductivity (um)	280.0	311.1	60.0	500.0	2

Table 114. Soil Horizon Table for Volcanic Rocky-Ashy Wet Willow Low Shrub, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–1.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Cg	1.0–4.0	ashy	loamy very fine sand	NA
3	Oe	4.0–6.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
4	2C	6.0–32.0	extremely gravelly (60–90%)	sand	NA

Volcanic Rocky Dry Barrens

The ecotype Volcanic Rocky Dry Barrens is extensive throughout the Volcanic physiography, ocurring on a variety of aspects and slope severity. The parent material for this ecotype includes very thick tephra deposits and shallow residual soils forming on igneous extrusive bedrock. This ecotype represents land that has been recently disturbed by volcanic events, and subsequently disturbed by eolian, colluvial or alluvial processes. This ecotype is either barren or sparsely vegetated. Vegetation corresponds to sparse and non-vascular plant associations: *Artemisia campestris* ssp. *borealis-Rumex beringensis-Festuca* spp./Pumice, *Luzula piperi*/Pumice, and most commonly, *Saxifraga* spp./Rock. Stable, more mesic sites, may develop a cryptogamic crust which corresponds to the *Anthelia juratzkana-Gymnomitrion corallioides* plant association. Barren pumice is the dominant cover for this ecotype. Dwarf shrub species diversity is high, with *Salix ovalifolia* being the most common. Canopy cover of vascular and non-vascular species is low and on average, rarely exceeds 5%. One exception to this, is the liverwort *Gymnomitrion corallioides* which over time, contributes to a well-developed cryptogamic crust. Common vascular species include *Artemisia borealis*, *Epilobium latifolium*, and *Deschampsia sukatschewii*. Common non-vascular species include *Stereocaulon* sp. and *Racomitrium ericoides*. Dominant soil texture classes include Fragmental, Pumiceous, Rubbly, Sandy, and Lithic for sites that have bedrock within 20 cm of the soil surface. Surface organics are typically absent, but may accumulate in depressions or erosion channels that best support early seral vegetation. Soils are dry and range from somewhat excessively- to excessively well-drained. Soil chemistry ranges from circumneutral to alkaline (avg. 6.3 pH), with pH increasing with depth. Soils have low productivity and are limited by soil moisture retention and soil erosion from high winds. Typical soil subgroups include Eutric Duricryands, Typic Vitricryands, and Vitrandic Cryorthents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 115–117.

Table 115. Constancy/Cover table for Volcanic Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix ovalifolia*	3.4	0.1	15.0	50
deciduous shrubs	*Salix reticulata*	0.1	0.1	0.1	30
forbs	*Artemisia borealis*	0.6	0.1	2.0	40
forbs	*Campanula lasiocarpa* s.l.	0.1	0.1	0.1	30
forbs	*Epilobium latifolium*	0.1	0.1	0.1	40
forbs	*Saxifraga lyallii* ssp. *hultenii*	2.0	2.0	2.0	10
forbs	*Saxifraga serpyllifolia*	0.1	0.1	0.1	30
grasses	*Deschampsia sukatschewii*	2.1	0.1	6.0	30
lichens	*Stereocaulon* sp.	0.3	0.1	1.0	40
liverworts	*Gymnomitrion corallioides*	8.5	2.0	15.0	20
mosses	*Racomitrium ericoides*	1.7	1.0	2.0	30
rushes	*Luzula wahlenbergii* ssp. *wahlenbergii*	1.4	0.1	3.0	30

Table 116. Environment Data Summary table for Volcanic Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	543.0	236.0	225.0	888.0	11
Slope (degrees)	10.0	8.0	0.0	23.0	11
Surface Organic Thickness (cm)	0.5	1.2	0.0	4.0	11
Depth to 15% Rock Fragments (cm)	0.0	0.0	0.0	0.0	10
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	11
Site pH	6.3	0.7	5.3	7.7	10
Electrical Conductivity (um)	30.0	10.0	20.0	40.0	3

Table 117. Soil Horizon Table for Volcanic Rocky Dry Barrens, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	AC	0.0–6.0	very gravelly (35–60%)	sand	NA
2	C1	6.0–18.0	gravels (15–35%)	loamy sand	NA
3	C2	18.0–23.0	extremely gravelly (60–90%)	sand	NA
4	2C3	23.0–42.0	gravels (15–35%)	loamy sand	NA

Volcanic Rocky Dry Lichen

The ecotype Volcanic Rocky Dry Lichen is widespread on blocky lava flows within the caldera, but uncommon elsewhere in ANIA. Two plots were described at a similar elevation (avg. 483 m) for vegetation composition; however no soil profiles were recorded. Vegetation corresponds to the S*tereocaulon vesuvianum-Racomitrium lanuginosum* plant association. There is low diversity and low abundance of herbaceous species. Graminoids have the highest abundance with *Poa arctica* s.l., *Luzula arcuata* ssp. *unalaschcensis*, and *Carex pyrenaica* ssp. *micropoda* having the highest average cover values. Non-herbaceous species contribute to near continuous ground cover, with lichens having a greater abundance then mosses. *Stereocaulon vesuvianum* is dominant for this ecotype, with other common non-vascular species including Gymnomitrion corallioides and *Racomitrium lanuginosum*. Soils are fragmental (>90% rock) and are expected to have a shallow depth to lava bedrock. Surface organic horizons are absent and the depth to greater than 15% rock fragments occurs at the soil surface. A soil pH of 5.0 and EC of 30.0 uS/cm were recorded at one plot. Typical soil subgroups likely include Lithic Cryorthents and Typic Cryorthents. The constancy/cover and environmental data summary are presented in Tables 118–119.

Table 118. Constancy/Cover table for Volcanic Rocky Dry Lichen, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
lichens	*Cladonia* sp.	6	6	6	50
lichens	*Stereocaulon* sp.	50	50	50	50
lichens	*Stereocaulon vesuvianum*	75	75	75	50
liverworts	*Gymnomitrion corallioides*	10	10	10	50
mosses	*Racomitrium* sp.	20	20	20	50

Table 119. Environment Data Summary table for Volcanic Rocky Dry Lichen, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	483	2	481	484	2
Slope (degrees)	7	NA	7	7	1
Surface Organic Thickness (cm)	0	NA	0	0	1
Depth to 15% Rock Fragments (cm)	0	0	0	0	2
Water Table Depth (cm)	-999	0	-999	-999	2
Site pH	5	NA	5	5	1
Electrical Conductivity (um)	30	NA	30	30	1

Volcanic Rocky Moist Bryophyte

This ecotype is similar to the Alpine Rocky-Ashy Moist Bryophyte ecotype, except that it occurs in the Volcanic physiography on more recently disturbed sediments, and the non-herbaceous cover is influenced more by mosses than by liverworts. The Volcanic Rocky Moist Bryophyte ecotype occured on flat to very steep slopes (avg. 16 degrees), and at elevations ranging from 361 m to 770 m (avg. 504 m). This ecotype is extensive in the Volcanic physiography, occuring in or adjacent to the Aniakchak caldera, and represents early vegetation succession on young volcaniclastic deposits. Vegetation corresponds to several of the sparse and non-vascular plant associations, including *Racomitrium* spp. and *Anthelia juratzkana-Gymnomitrion corallioides*. Mosses dominate this ecotype with *Racomitrium ericoides*, *R. lanuginosum*, and *Bryum* sp. being the most common. Lichens and liverworts are also fairly abundant, with *Stereocaulon alpinum* and *Gymnomitrion corallioides* being the most common. A variety of dwarf shrubs, such as *Salix ovalifolia*, *S. rotundifolia*, and *Empetrum nigrum* may be present, but cover values are generally <5%. Common herbaceous species with low cover include *Sibbaldia procumbens*, *Epilobium latifolium*, *Trisetum spicatum*, and *Luzula wahlenbergii* ssp. *wahlenbergii*. Domi-

nant soil texture classes include Blocky, Pumiceous, Rubbly and Sandy with an average depth to greater than 15% rock fragments occurring at 0.8 cm below the soil surface. Soils are moist and range from somewhat excessively to excessively well-drained. Surface organic matter accumulation is absent or very thin (avg. 0.9 cm). Soil chemistry is circumneutral (avg. 6.2 pH) and EC is variable (avg. 150.0 uS/cm). Soils range from poorly developed Entisols to weakly developed Andisols and include the soil subgroups Eutric Duricryands, Lithic Vitricryands, Typic Vitricryands, Vitrandic Cryorthents, and Vitric Haplocryands. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 120–122.

Table 120. Constancy/Cover table for Volcanic Rocky Moist Bryophyte, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
mosses	*Racomitrium* sp.	20	0.1	50	44

Table 121. Environment Data Summary table for Volcanic Rocky Moist Bryophyte, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	504.0	127.0	361.0	770.0	9
Slope (degrees)	16.0	14.0	0.0	47.0	9
Surface Organic Thickness (cm)	0.9	1.2	0.0	3.0	8
Depth to 15% Rock Fragments (cm)	0.8	1.5	0.0	4.0	8
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	9
Site pH	6.2	0.9	5.2	7.6	8
Electrical Conductivity (um)	150.0	155.6	40.0	260.0	2

Table 122. Soil Horizon Table for Volcanic Rocky Moist Bryophyte, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–2.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	CA	2.0–34.0	very gravelly (35–60%)	sandy loam	2.5y 4/2
3	C	34.0–45.0	extremely gravelly (60–90%)	sand	10yr 4/2

Volcanic Rocky Wet Sedge Meadow

One plot was described in the Volcanic Rocky Wet Sedge Meadow ecotype. This ecotype is of very limited extent, occupying wetland areas within the Aniakchak caldera. This is one of the more productive ecotypes in the Volcanic physiography, demonstrated by a significant accumulation of organic material at the soil surface (18.0 cm). Vegetation corresponds to the *Carex lyngbyei*/Freshwater Marsh plant association. The freshwater meadow is dominated by *Carex lyngbyaei* and has low species diversity. Dwarf shrubs with low cover may be present, including *Salix alaxensis* and *S. barclayi*. Moss cover is generally low and dominated by *Sphagnum squarrosum*, *S. teres* and *Pseudobryum cinclidioides*. The soil moisture regime for this ecotype may fluctuate with local hydrology, and while the soils are likely always saturated, soils may not always develop in anearobic conditions. Dominant soil texture classes may include Rubbly, Pumiceous, Blocky or Sandy, and the depth to greater than 15% rock fragments is within the upper 20 cm of the soil profile. This ecotype may be flooded seasonally with a depth to water table ranging from just above, to just below, the soil surface. Soil chemistry is influenced by alkaline freshwater springs in the caldera (8.5 pH), and electrical conductivity was low (180 uS/cm). The single soil profile described in this ecotype was classified as an Aquandic Cryaquents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 123–125.

Table 123. Constancy/Cover table for Volcanic Rocky Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
deciduous shrubs	*Salix alaxensis*	0.1	0.1	0.1	100
deciduous shrubs	*Salix barclayi*	0.1	0.1	0.1	100
forbs	*Potentilla palustris*	3.0	3.0	3.0	100
mosses	*Pseudobryum cinclidioides*	2.0	2.0	2.0	100
mosses	*Sphagnum squarrosum*	7.0	7.0	7.0	100
mosses	*Sphagnum teres*	3.0	3.0	3.0	100
mosses	*Warnstorfia sarmentosa*	0.1	0.1	0.1	100
sedges	*Carex lyngbyaei*	25.0	25.0	25.0	100

Table 124. Environment Data Summary table for Volcanic Rocky Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	329.0	NA	329.0	329.0	1
Slope (degrees)	0.0	NA	0.0	0.0	1
Surface Organic Thickness (cm)	18.0	NA	18.0	18.0	1
Depth to 15% Rock Fragments (cm)	18.0	NA	18.0	18.0	1
Water Table Depth (cm)	9.0	NA	9.0	9.0	1
Site pH	8.5	NA	8.5	8.5	1
Electrical Conductivity (um)	180.0	NA	180.0	180.0	1

Table 125. Soil Horizon Table for Volcanic Rocky Wet Sedge Meadow, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi1	0.0–4.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
2	Oi2	4.0–17.0	ashy	peat (>40% fibers, saturated Oi horizon)	NA
3	C	17.0–35.0	extremely gravelly (60–90%)	coarse sand (0.5–1 mm)	NA

Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain

The ecotype Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain typically ocurrs on deep tephra deposits, on a variety of slopes (avg. 9 degrees), and may favor north to east aspects where sites leeward to the prevailing winds may accumulate a thick, coarse-ashy mantle. This ecotype was described on a variety of volcanic landforms, including but not limited to, inactive vents, inactive dunes on cinder plains, and non-welded pyroclastic flow deposits. Vegetation corresponds to the herbaceous plant associations of *Leymus mollis* and *Leymus mollis*/Pumice. This ecotype is dominated by the graminoid *Leymus mollis*, the foliar cover of which is wide ranging (8.0–60.0, avg. 24.6) depending on landform and soil conditions. Other common herbaceous species include *Equisetum arvense*, *Achillea millefolium*, *Epilobium angustifolium*, and *Sibbaldia procumbens*. Bryophyte cover may include *Polytrichum* sp., *Racomitrium* sp., and *Kiaeria starkei*. Dominant soil texture classes include Rubbly and Sandy and the average depth to greater than 15% rock fragments typically occurs at the soil surface (0.0 cm). Soils are dry, excessively well-drained, and organic matter does not readily appreciate at the soil surface. Soils are circumneutral (avg. 5.9 pH) and the alkalinity may increase with depth in the soil profile. Typical soil subgroups include Typic Vitricryands, Vitrandic Cryofluvents and Vitrandic Cryorthents. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 126–128.

Table 126. Constancy/Cover table for Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
forbs	*Achillea millefolium*	3.8	0.1	10	80
forbs	*Epilobium angustifolium*	7.0	2.0	12	40
grasses	*Agrostis mertensii*	5.1	0.1	10	40
grasses	*Leymus mollis* ssp. *mollis*	24.6	8.0	60	100
grasses	*Poa arctica* s.l.	5.1	0.1	10	40

Table 127. Environment Data Summary table for Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	311.0	128.0	144.0	438.0	5
Slope (degrees)	9.0	9.0	2.0	25.0	5
Surface Organic Thickness (cm)	0.0	0.0	0.0	0.0	5
Depth to 15% Rock Fragments (cm)	0.0	0.0	0.0	0.0	3
Water Table Depth (cm)	-999.0	0.0	-999.0	-999.0	5
Site pH	5.9	0.4	5.6	6.5	5
Electrical Conductivity (um)	-999.0	0.0	-999.0	-999.0	5

Table 128. Soil Horizon Table for Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C1	0.0–32.0	extremely gravelly (60–90%)	very coarse sand (1–2 mm)	NA
2	C2	32.0–47.0	extremely gravelly (60–90%)	Not Available	NA

Volcanic Streams and Springs

The ecotype Volcanic Streams and Springs is restricted to freshwater streams and brackish warm springs in the Aniakchak caldera. This is an aquatic ecotype that supports algae and a limited variety of herbaceous species, with *Carex lyngbyaei* being the most common. According to a NPS water quality investigation in 2003, temperatures at warm springs within the caldera had limiting physical (i.e., high temperature) and chemical characteristics (i.e., high pH and low dissolved oxygen) that were restricting juvenile and adult salmonid migration (Bennett 2004). Water quality is circumneutral (pH = 6.2) with a low EC in freshwater streams, and alkaline (pH = 8.2) with a slightly bracking EC (1110 uS/cm) in warm springs. Soil subgroups were not classified for this ecotype. The constancy/cover table, environmental data summary table, and a representative soil horizon table for this ecotype are presented in Tables 129–131.

Table 129. Constancy/Cover table for Volcanic Streams and Springs, Aniakchak National Monument and Preserve, Alaska, 2014.

Lifeform	Scientific name	Average cover (%)	Minimum Cover (%)	Maximum Cover (%)	Constancy (%)
sedges	*Carex lyngbyaei*	0.1	0.1	0.1	100

Table 130. Environment Data Summary table for Volcanic Streams and Springs, Aniakchak National Monument and Preserve, Alaska, 2014.

Data attribute	Average	Standard Deviation	Minimum	Maximum	n
Elevation (m)	331.0	3.0	329.0	333.0	2
Slope (degrees)	1.0	1.0	0.0	1.0	2
Surface Organic Thickness (cm)	0.0	0.0	0.0	0.0	2
Depth to 15% Rock Fragments (cm)	20.5	20.5	6.0	35.0	2
Water Table Depth (cm)	20.5	20.5	6.0	35.0	2
Site pH	7.2	1.4	6.2	8.2	2
Electrical Conductivity (um)	630.0	678.8	150.0	1110.0	2

Table 131. Soil Horizon Table for Volcanic Streams and Springs, Aniakchak National Monument and Preserve, Alaska, 2014.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	W	0.0–20.0	no modifier (<15%)	Not Available	NA

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 4–9). Vegetation classes follow the AVC (Viereck et al. 1992). Six toposequences representing distinct ecosystems within the study area are described below. At Aniakchak Bay, the toposequence is characteristic of the transition from coastal environments to upland and lowland environments along sections of coastline in the larger bays in ANIA (Figure 4). The toposequence begins at Aniakchak Bay on Active Sandy Marine Beach deposits. The unvegetated sandy beach rises from the waters of Aniakchak Bay at a slope of 4 degrees. Abundant flotsam arranged in drift lines marks recent high tide lines. Further up the beach a band of driftwood indicates the high energy of this beach during fall storm events. The driftwood abuts the lower edge of a coastal levee formed from wave action. Further inland, Coastal Active Dunes, followed by Coastal Inactive Dunes, were encountered. Both types of dunes prominently feature *Leymus mollis*. However, the species associated with *Leymus mollis* shift from halophytic forbs closer to the bay (*Carex macrocephala*, *Honckenya peploides*, and *Senecio pseudoarnica*), to non-halophytic forbs and grasses further from the influence of salt spray and storm surges, (*Angelica lucida*, *Lupinus nootkatensis*, *Epilobium angustifolium*, and *Calamagrostis canadensis*). The dune soils are sandy with few to no rock fragments in the upper soil profile. A thin surface organic layer is evident on inactive dunes indicating a period of relative stability compared to the active dunes, which lack a surface organic layer. The transition from Coastal to Upland physiography is marked by a predominance of woody vegetation. Crowberry Dwarf Shrub Tundra predominates on Eolian Abandoned Sand Dunes. The dunes here are more subtle than those closer to the beach and eolian processes are no longer shaping these dunes. The soils are sandy and feature a thin surface organic horizon over an AC horizon characterized by an appreciation of organic carbon. Below the AC is a buried horizon (2BAb), representing the former soil surface before it was buried by wind-transported sands during a time when these dunes were still active. The toposequence then crosses a series of Ancient Marine Beach Ridge Deposits dominated by Open Tall Alder. The soils feature a thick (23 cm) surface organic horizon indicating these ridges have been stable for some time, perhaps upwards of 1 to 2 centuries. The lower portion of the surface organic layer features sands intermixed with highly decomposed organic matter. The intermixed sands indicate a time when these sites were transitioning to inactive and still received periodic eolian sands. Following the beach ridges is a Meander Abandoned Channel Deposit interpreted as a former channel of the Aniakchak River. The environment transition from Upland to Lowland physiography is marked by numerous small freshwater ponds and soils that remain wet in the upper 40 cm throughout the growing season. The vegetation in the lowlands is dominated by Subarctic Lowland Graminoid-Herb Wet Meadow and the soils feature thick peat deposits.

The Aniakchak Caldera toposequence describes a Volcanic physiography sequence near the headwaters of Surprise Lake (Figure 5). The toposequence begins at the footslope of the steep caldera walls on a barren Colluvial Fan deposit. The soils were dry, sandy, extremely gravelly Vitrandic Cryorthents. Adjacent to the Colluvial Fan on the toeslope was a Large Umbel meadow growing in soils formed from undifferentiated tephra. The soils were similar to that on the fan but were moist and featured a thin organic-rich A horizon at the surface indicating a slightly more advanced stage of soil development. The water table in mid-July was 47 cm below the soil surface and is a strong driver of the development of lush vegetation at this site. Further along on the toposequence, several Headwater Streams dissect the landscape, forming the headwaters of Surprise Lake. In between the streams is Lowland Headwater Floodplain with Halophytic Sedge Marsh dominated by *Carex lyngbyaei* and abundant surface water. Fresh flood debris was observed on the floodplain suggesting that these sites are flooded regularly by the headwater streams, and perhaps also by Surprise Lake, as the lake level fluctuates following annual or seasonal trends. The soils in the sedge marsh featured a moderately thick surface organic layer over reworked volcaniclastic deposits. Open Low Willow predominated on a slightly higher Floodplain Step further along the toposequence. Again the soils were wet and formed from tephra deposits reworked by fluvial processes. A buried organic horizon in this soil indicates this fluvial surface is periodically stable for several years in between sedimentation events. A warm spring with a narrow fringe of *Carex lyngbyaei* was located at the foot of Bolshoi Dome. The spring water had a moderately high electrical conductivity indicating abundant dissolved minerals and salts. Bolshoi Dome was characterized by Dry Bryophyte on the north-facing slope, barrens at the Crest, and Crowberry Dwarf Shrub on the south-facing slope. Barrens characterizes much of the caldera floor on the other side of Bolshoi Dome. Soils were dry, sandy, and very to extremely gravelly. The lack of soil moisture, and in places the presence of a root-restricting duripan in the upper soil profile, are the most important limiting factors to vegetation establishment and soil development in Volcanic Physiography.

The Aniakchak River Valley toposequence describes the transition from upland to lacustrine to riverine environments in middle to lower portions of the Aniakchak River Valley (Figure 6). The toposequence begins on the toeslope of a larger mountain slope. The soils were formed from an Alluvial Fan Abandoned Deposit and were loamy, and well-developed. The soils featured translocated iron and aluminum lower in the soil profile indicating this site has been relatively stable for some time. A B-horizon (3Bsb) buried beneath a very gravelly C horizon (2C) indicates a time when the alluvial fan was more active. Below the toe slope the toposequence transitions to the valley bottom where a series of small lakes, several of them in various stages of drainage, are located. The lakes, lake margins, and recently drained lake bottoms represent Lacustrine physiography. In the recently drained lake bottoms the vegetation is Barrens and the soils were sandy and moist. The water table was not encountered within the upper 40 cm. The soils in a drained lake bottom record a history of periodic flooding and sedimentation events from the nearby Aniakchak River and past draining events. For instance, stratified lake deposits (3Ldi), indicative of an aquatic environment, occur below a buried A-horizon, indicating a period of lake drainage and vegetation and soil development. The A-horizon itself is buried beneath two C horizons reflecting at least two distinct large sedimentation events. A thin veneer of lacustrine deposits at the surface indicate the lake was flooded in the recent past. However, in 2014 no surface water was present in the lake basin. In between the lakes are Open Tall Alder on undulating Undifferentiated Coarse Channel Deposits in Upland physiography. The soils were formed from tephra reworked by alluvial processes and were gravelly to extremely gravelly loamy sands with a thin organic surface layer. Following after the alder stand, a partially drained lake basin dominated by Wet Sedge Meadow Tundra was present. Soils were wet and featured a thin organic horizon over a narrow limnic horizon (Ldi). Similar to the fully drained lake basin, a series of coarse alluvial deposits (Cg1 and Cg2 horizons) follow separated by a thin buried limnic horizon (Ldib) reflecting a period of stability between large sedimentation events. The C horizons were gleyed, the result of anaerobic soil conditions. Next along the toposequence is a transition back to Upland physiography. Crowberry Dwarf Shrub Tundra occurs on a thin layer of fine textured tephra over a sandy, very gravelly pyroclastic flow deposit. The shallow depth to droughty, coarse-textured soils and a root-restricting duripan in the upper portion of the soils combine to limit the vegetation to dwarf shrub. As the toposequence approaches the Aniakchak River, the environment shifts from Upland to Riverine as marked by a short steep bank down to a Meander Inactive Overbank Deposit and vegetation dominated by Closed Tall Willow. The soils here feature a very thin organic surface horizon over a series of sandy C-horizons. A step lower on the floodplain, the Closed tall alder dominates the shrub layer on Meander Active Overbank Deposits. Finally, the toposequence ends on Meander Active Channel Deposits on a barren Point Bar. Sedimentation and erosion from channelized flooding occurs regularly as marked by the absence of a surface organic layer and coarse, rocky soils.

The Cinder River Valley toposequence describes the transition from upland to riverine environments in the Cinder River Valley near Lava Creek (Figure 7). The toposequence begins in the uplands on an Alluvial Fan Abandoned Deposit dominated by a Large Umbel meadow. The alluvial fan is no longer active, and the site has been relatively stable for some time as evidenced by the moderately-well developed soils. The soils have developed in volcanic ash reworked by alluvial processes, and are characterized by translocation of iron and aluminum from higher in soil profile (AE-horizon) to lower in the soil profile (Bs1- and Bs2-horizons). Adjacent to the alluvial fan was Closed Tall Willow on tephra reworked by wind to form an undulating surface form. The tephra deposits form a thick blanket of fine volcanic ash material over coarse-textured Pyroclastic Flow Deposits. In stark contrast to the willow stands are adjacent areas of Barrens. These barren areas occur where the fine ashy material is absent, and the soils are formed from sandy and extremely gravelly Pyroclastic Flow Deposits. The soils here featured a dense, partially cemented duripan within 10 cm of the soil surface. The duripan is root restrictive, yet allows water to infiltrate, and severely limits the vegetative potential of these sites that have high drought potential. Further along the toposequence, small, semi-circular stands of Open Balsam Poplar Forest occur throughout a matrix of Closed Tall Willow on Undifferentiated Coarse Abandoned Channel Deposits over Pyroclastic Flow Deposits. These forested stands represent the furthest south extension of the range of *Populus balsamifera* on the Alaska Peninsula. The stands typically feature older, larger trees in the center, and are progressively younger towards the edge suggesting a clonal reproductive pathway. The soils here have formed in reworked tephra and feature

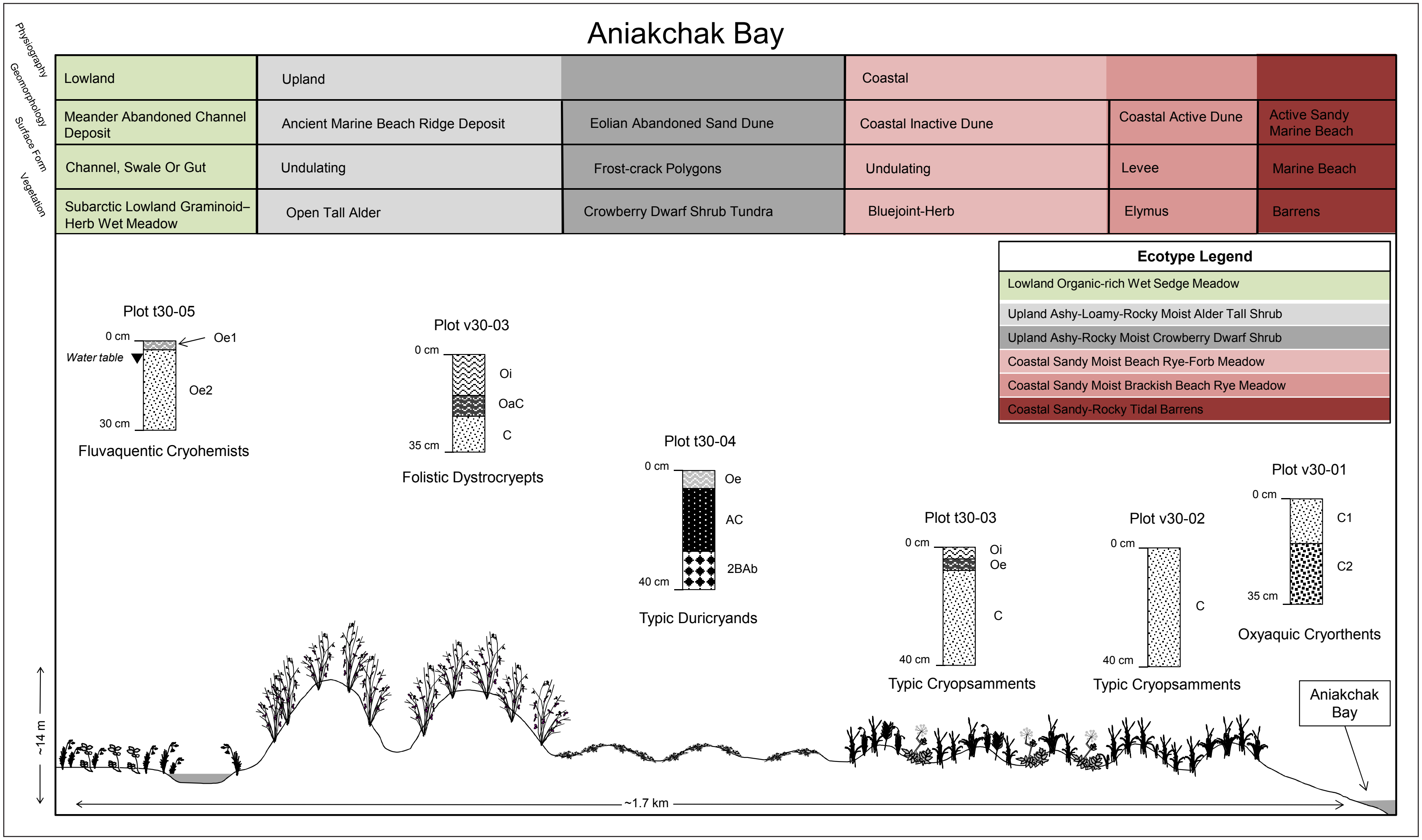


Figure 4. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils at Aniakchak Bay, Aniakchak National Monument and Preserve, Alaska, 2014.

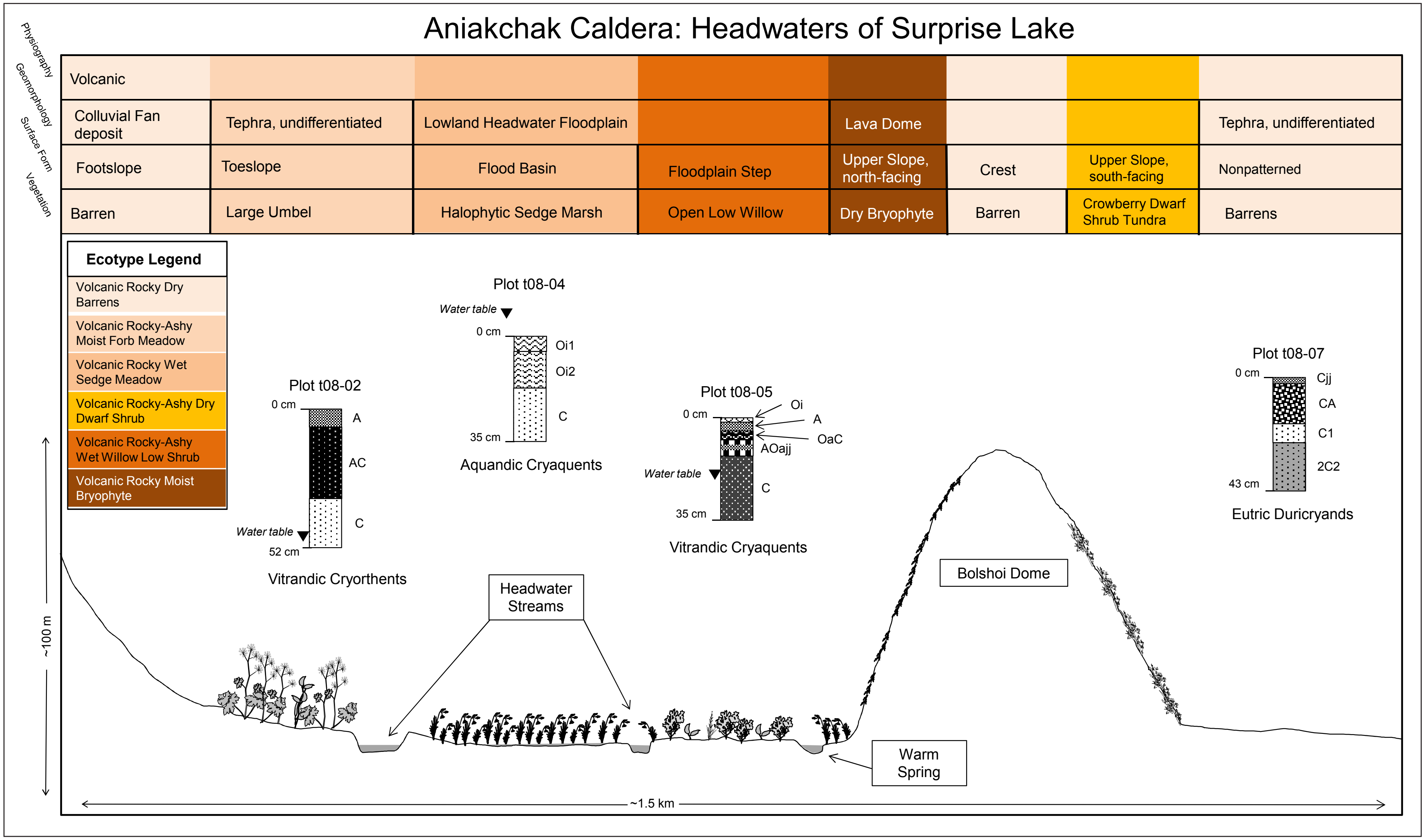


Figure 5. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils at the headwaters of Surprise Lake in Aniakchak Caldera, Aniakchak National Monument and Preserve, Alaska, 2014.

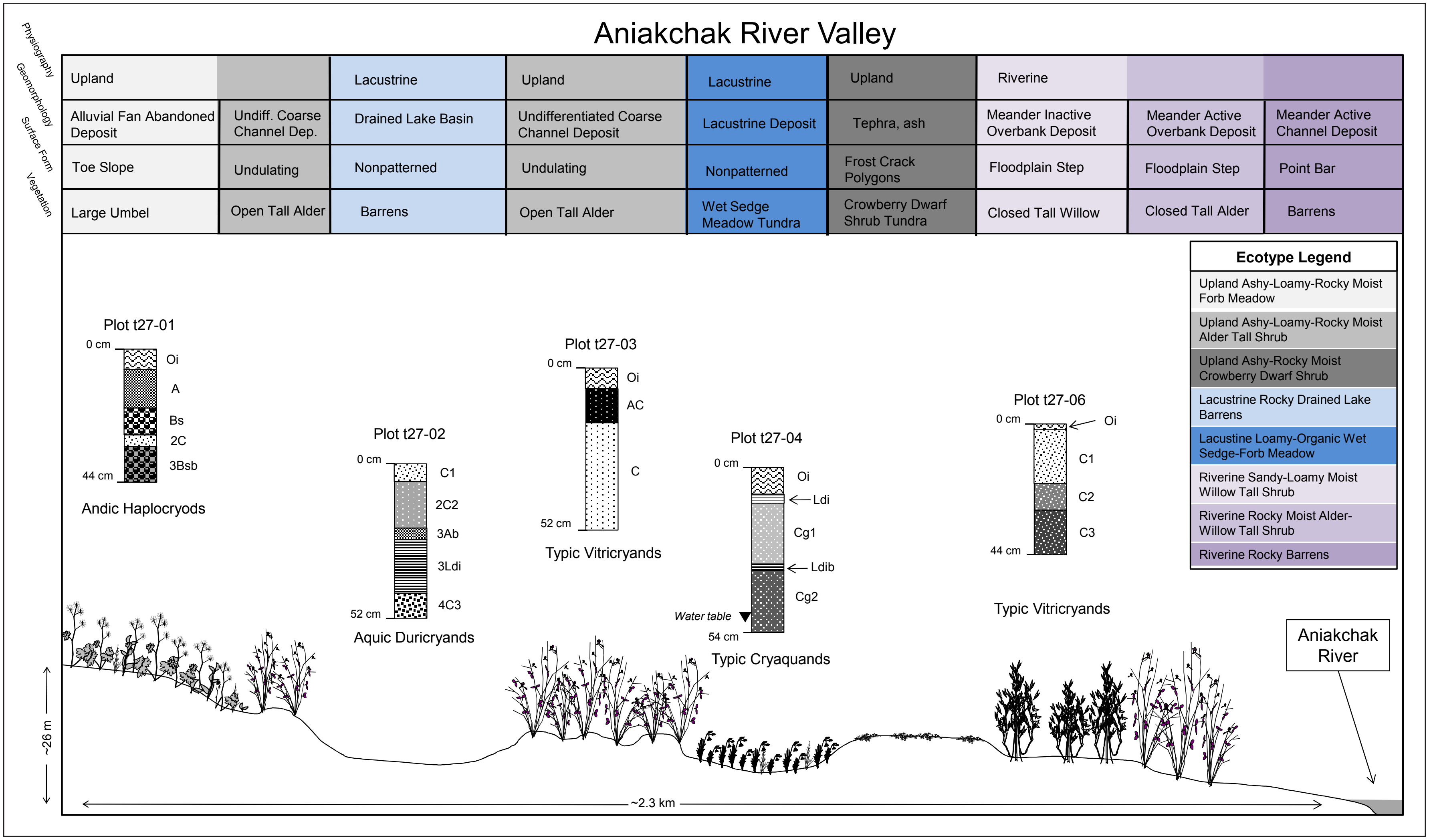


Figure 6. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils in the Aniakchak River Valley, Aniakchak National Monument and Preserve, Alaska, 2014.

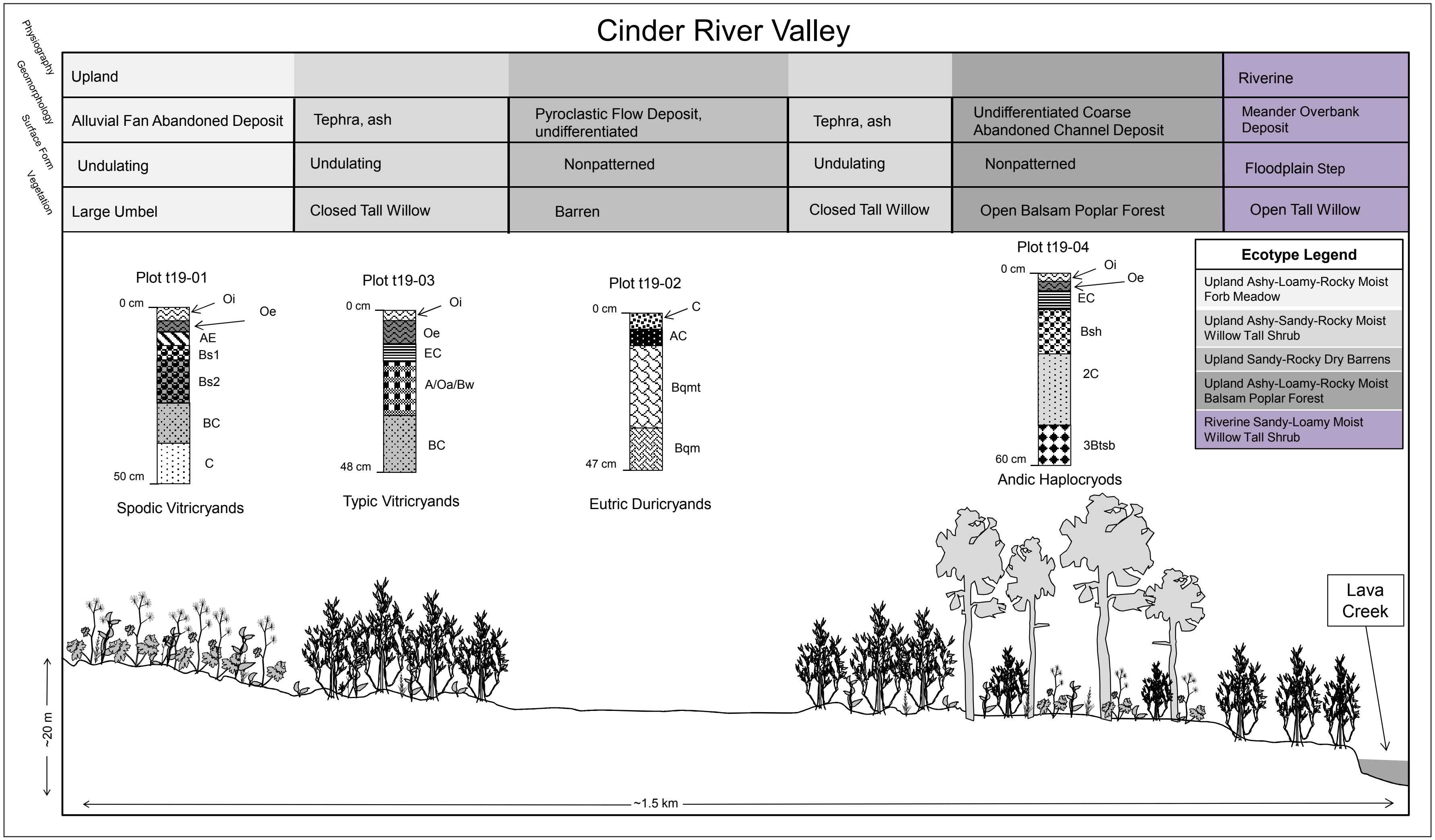


Figure 7. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils in the Cinder River Valley, Aniakchak National Monument and Preserve, Alaska, 2014.

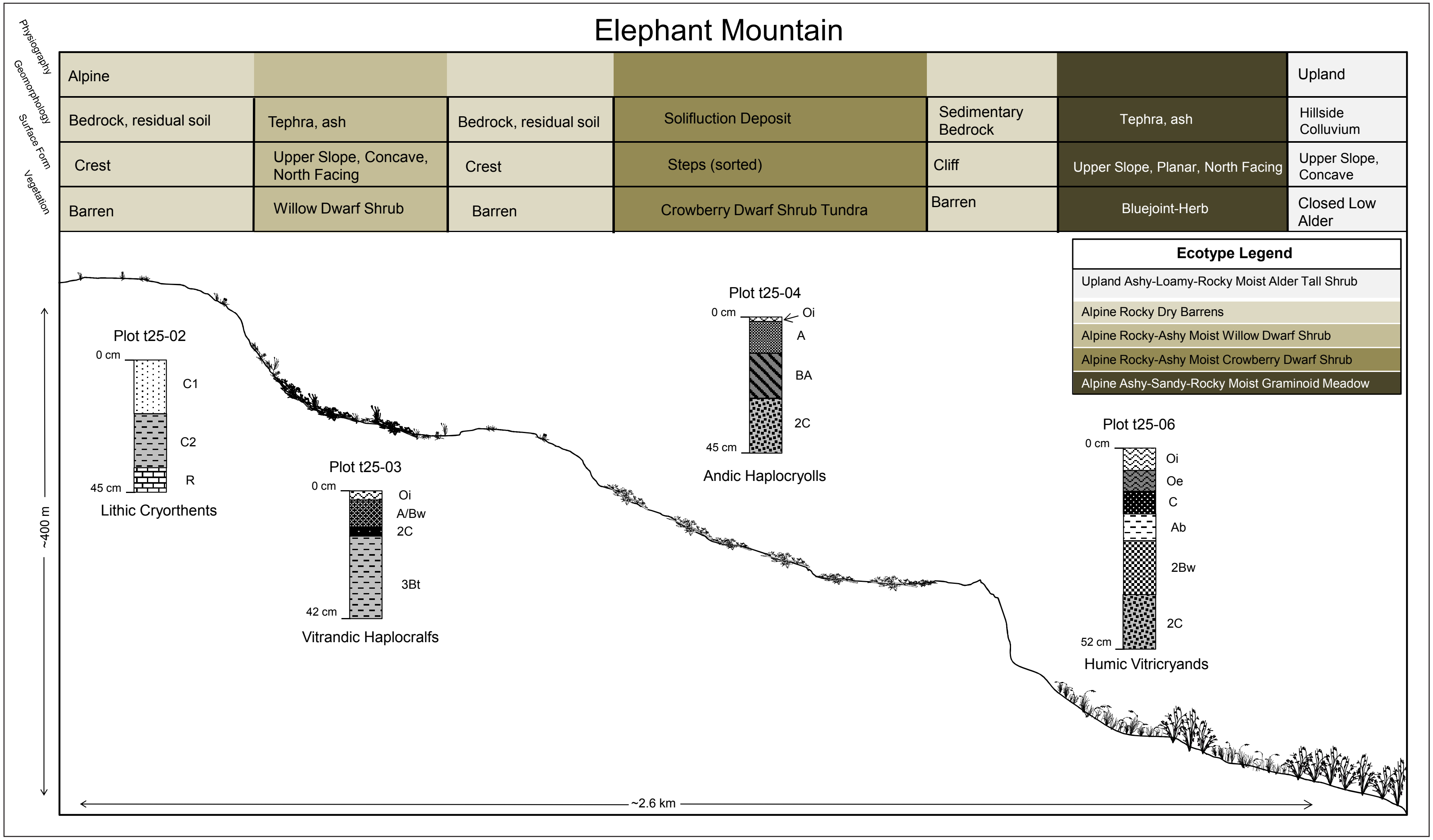


Figure 8. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils at Elephant Mountain, Aniakchak National Monument and Preserve, Alaska, 2014.

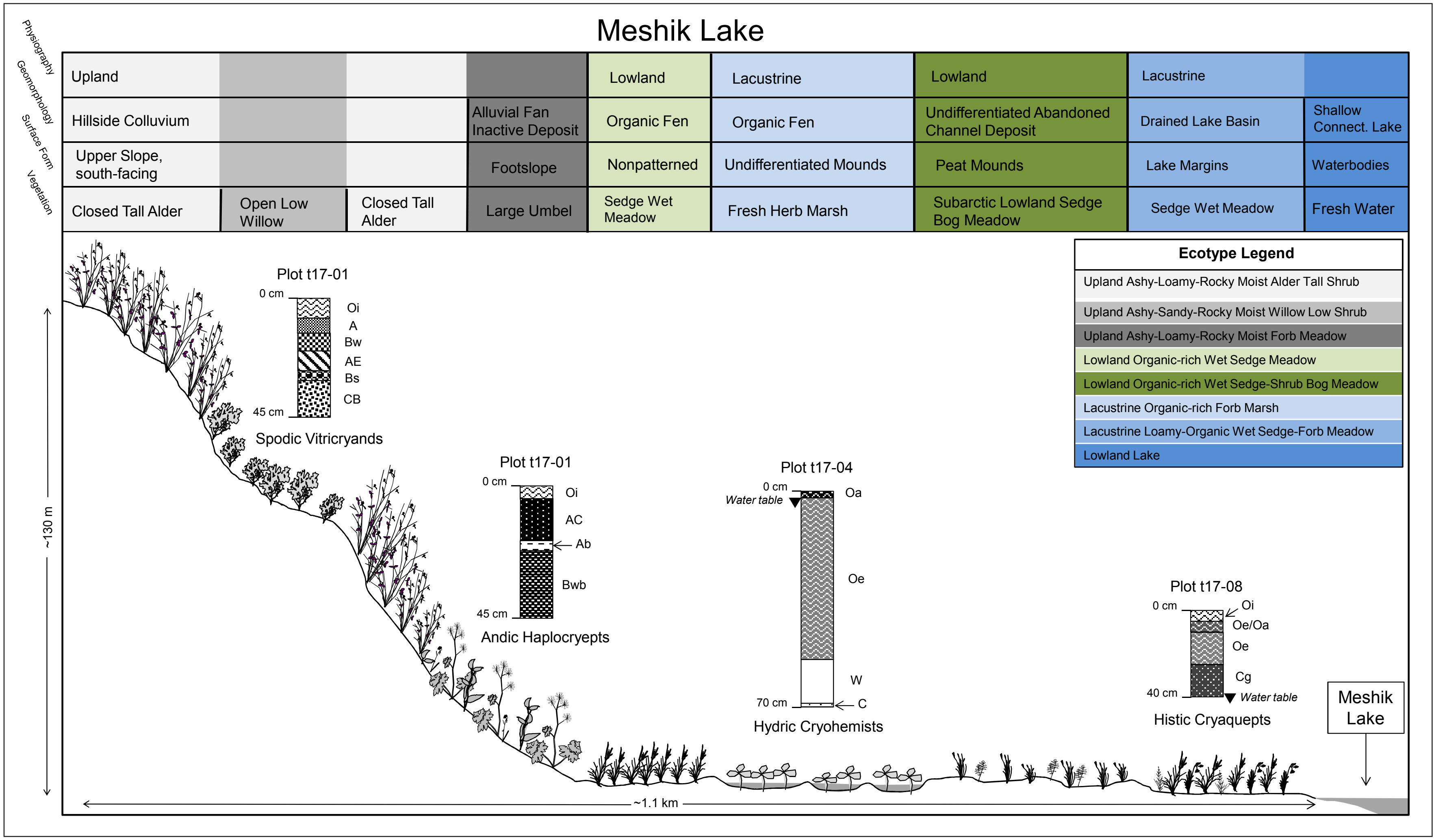


Figure 9. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils at Meshik Lake, Aniakchak National Monument and Preserve, Alaska, 2014.

translocated iron, aluminum, and organic carbon in the upper profile (Bsh). Below the Bsh horizon an extremely gravelly, coarse sandy horizon overlies a buried B-horizon suggesting a past fluvial deposition, and marking the transition to Pyroclastic Flow Deposits lower in the soil profile. The toposequence next steps down to the narrow floodplain of Lava Creek dominated by Open Tall Willow and stratified alluvial soils.

The Elephant Mountain toposequence describes an alpine to upland transition beginning at the northern summit of Elephant Mountain and traversing north (Figure 8). At the summit, the geomorphology and soils are controlled by sedimentary bedrock and the vegetation is sparse and classifed as Barrens. The moss *Racomitrium fasciculare* is the most prominent species, while forbs such as *Saxifraga serpyllifolia*, *Geum rossii*, *Lagotis glauca* ssp. *glauca*, and *Papaver alboroseum* occur scattered across the rocky soil surface. The soils were shallow to bedrock (45 cm), sandy, and extremely cobbly. Off the summit, on the adjacent backslope Willow Dwarf Shrub dominates on a concave, north-facing upper slope. The rocky clay-rich soils formed in deep tephra over sedimentary bedrock. Along the ridgeline that this toposequence follows, several smaller crests occur periodically. These lower crests are barren and have shallow, rocky soils. Lower down on the ridge, Crowberry Dwarf Shrub Tundra dominates on Solifluction Deposits. Sorted ground, in the form of steps, suggests that frost action in the soils is prominent at this site. The soils feature a very thin organic cap and an appreciation of organic carbon in the upper soil profile, lending to dark colored soil materials at this site. A Bluejoint-Herb meadow was encountered on a north-facing slope below a Sedimentary Bedrock Cliff. The soils formed in deep tephra and feature the thickest surface organic layer encountered on this toposequence (9 cm) over dark sandy ash. The sandy ash overlies a buried A-horizon, which represents the former soil surface before the sandy ash was deposited in a relatively recent eruption. Lower on the toposequence, Closed Low Alder occurs on upper slopes, marking the transition to Upland physiography. On south-facing slopes, the alder line often extends higher in elevation than on north-facing slopes and near the transition between Upland and Alpine physiography, stands of alder and alpine graminoid meadows may occur together as a mosaic.

The Meshik Lake toposequence describes the transition from Upland to Lowland to Lacustrine physiography in the Meshik River Valley near Meshik Lake (Figure 9). The toposequence begins in the uplands on a south-facing mountain slope in Closed Tall Alder. The soils have formed in deep, coarse tephra and are not well developed largely due to the steep, unstable slope. Below the alder on a slightly gentler slope, Open Low Willow occurred on soils in the early stages of iron and aluminum translocation, evidenced by an AE horizon over Bs horizon. The slightly concave nature of this site allows for fines to accumulate and the lower slope angle makes this site more stable, resulting in more advanced stages of soil development than steeper slopes. On the footslope of the mountain, a Large Umbel meadow occurred on an Alluvial Fan Inactive Deposit. The soils have formed from tephra and sedimentary colluvium reworked by alluvial processes. The stratigraphy of the soil profile suggests a history of deposition events at this site. Specifically, the weakly developed B horizon (Bw) lower in the soil profile, overlain by a buried A-horizon reflects a time period when this site sat dormant with little to no deposition. The AC horizon overlying the buried A horizon represents a relatively recent depositional event (i.e., likely within the last century) as indicated by the thin surface organic layer. Thus, the soils indicate that this site is likely to remain stable for a number of years and experience only episodic flooding and sediment deposition events. The toposequence next reaches the valley bottom, marking the transition to Lowland physiography, where the soils were wet and organic-rich and the vegetation was Sedge Wet Meadow dominated by *Carex lyngbyaei*. A series of small ponds dominated by *Menyanthes trifoliata* and representing a Lacustrine physiography followed. No surface water was present in the ponds in July 2014, however, which was unexpected given the vegetation. Rather, the water table was just below the soil surface, and field observations indicated that surface water was present earlier in the year. As the toposequence approaches Meshik Lake, the vegetation shifted to Subarctic Lowland Sedge Bog Meadow, marking a shift back to Lowland physiography. *Sphagnum* sp. dominate the non-vascular layer and vascular plant species composition takes on a boggy aspect, including such species as *Carex limosa*, *Betula nana*, *Andromeda polifolia*, and *Saxifraga hirculus*. The toposequence again transitions to Lacustrine physiography at an old shoreline of Meshik Lake. After stepping down onto a geomorphic surface that was once part of Meshik Lake, the vegetation shifts to Sedge Wet Meadow. The soils feature a moderately thick surface organic horizon over a gleyed, sandy C-horizon, the former lake bed of Meshik Lake. At the shores of Meshik Lak, a narrow band of Arctophila fulva, an aquatic grass, was present.

Hierarchical Organization of Ecological Components

We developed hierarchical relationships among ecological components by successively grouping data from the 294 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-rich soils) 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. 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., coastal dunes) were associated only with a few distinct vegetation types.

Results from this analysis were used in several ways. First, they were used to assess how ecosystems respond to an evolving landscape influenced by a variety of geomorphic processes within Alpine, Volcanic, 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 influence 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 land cover map (Appendix 4) and created maps that describe landscape characteristics, such as an ecotypes, soil landscapes, and disturbance regime (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 13% of the observations (37 plots) were excluded from the table because of inconsistencies among physiography, soil texture, geomorphology, drainage, and vegetation. We excluded these points because our primary goal was to identify the most distinct and consistent trends, not necessarily to include every plot. We believe that there is an upper limit to our ability to describe landscape patterns; there will always be a proportion (in this case 13%) of sites that do not conform to the overall relationships among factors. These sites may be: (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

The environmental parameters elevation, slope gradient, surface organic thickness, pH, Depth to ≥15% Rock Fragments, and water table depth were summarized (mean and standard deviation) for comparing differences among ecotypes (Figures 10–13). We excluded ecotypes with insufficient data (n < 3) and ecotypes that represent waterbodies.

Elevation ranged from sea level along the coast to nearly 900 m in the high mountains. In general, elevation ranged broadly between ecotypes occurring in different physiography classes, and less so between ecotypes within each physiography (Figure 10). Alpine and Volcanic ecotypes had the highest average elevation, while as to be expected, coastal ecotypes had the lowest average elevation. Ecotypes with the highest average elevations include Volcanic Rocky Dry Barrens and Alpine Rocky-Ashy Moist Bryophyte, ecotypes with the lowest elevations include Coastal Sandy Moist Beach Rye-Forb Meadow, Coastal Sandy Moist Brackish Beach Rye Meadow, Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow. The ecotypes Volcanic Rocky Dry Barrens and Alpine Rocky Dry Barrens had the most variable elevations, while the Coastal, Lacustrine, and Lowland ecotype were the least variable in their elevation range.

Slope gradient ranged widely between ecotypes both within and between physiography classes (Figure 10). For instance, average slope gradient for Coastal ecotypes ranges between 0° for Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow to 25° for Coastal Sandy Moist Brackish Beach Rye Meadow. Average slope gradient was consistently the lowest in Lacustrine, Lowland, and Riverine ecotypes, while average slope gradient in Alpine and Volcanic ecotypes was consistently the highest. The ecotypes Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow, Volcanic Rocky-Ashy

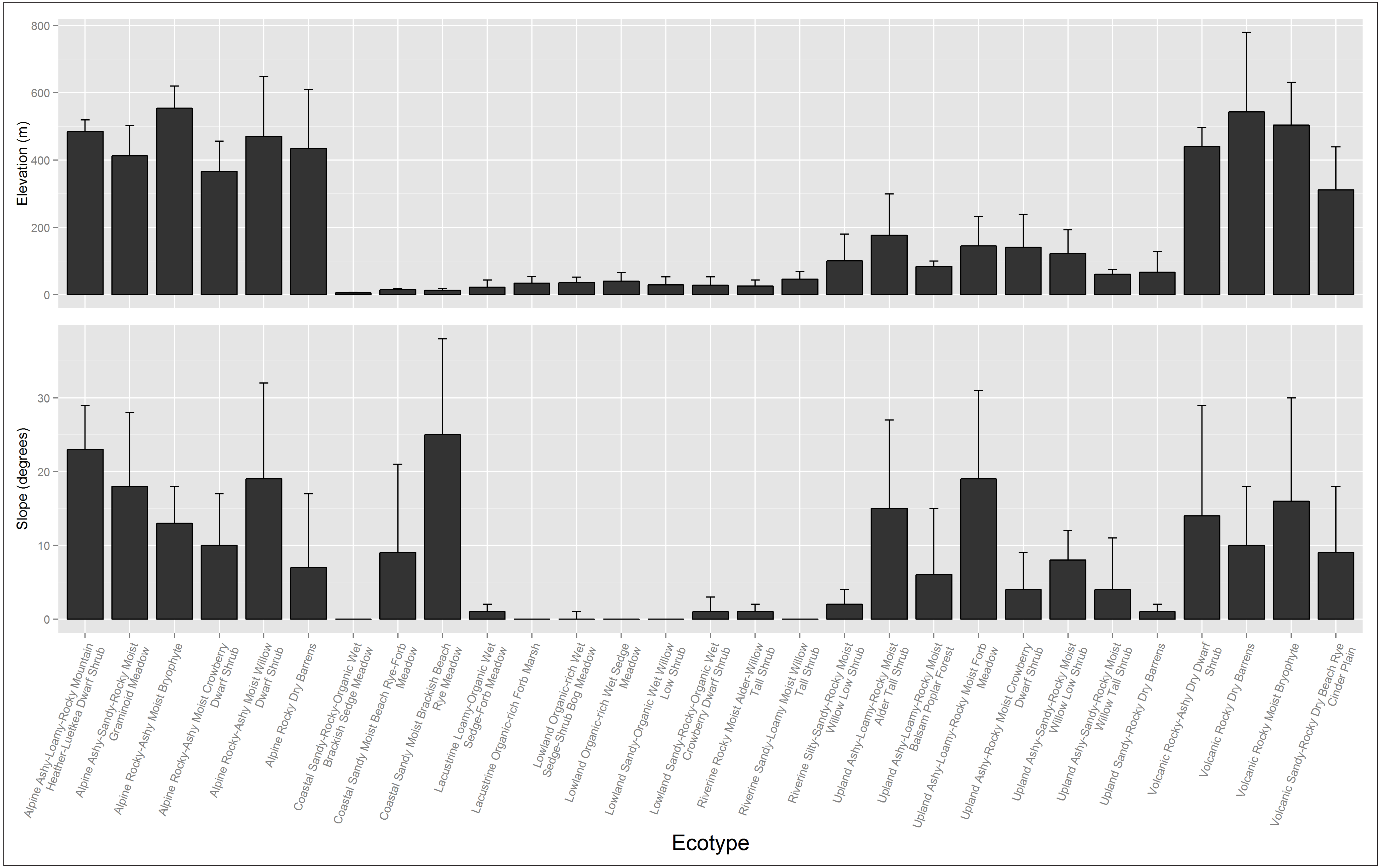


Figure 10. Barcharts displaying the average and standard deviation of elevation (top) and slope gradient (bottom) for terrestrial ecotypes with ≥3 plots in Aniakchak National Monument and Preserve, Alaska, 2014.

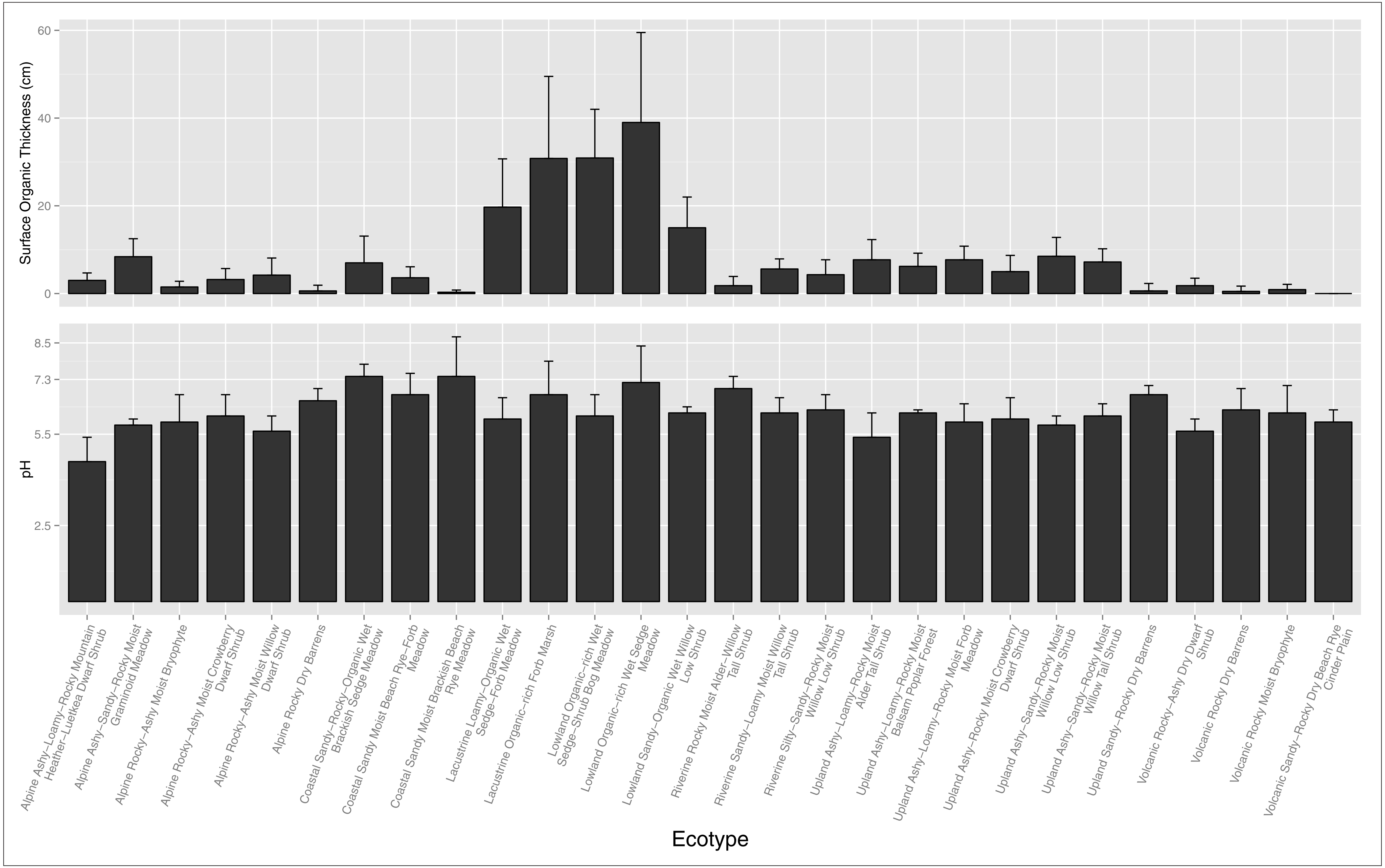


Figure 11. Barcharts displaying the average and standard deviation of surface organic thickness (top) and site pH (bottom) for terrestrial ecotypes with ≥3 plots in Aniakchak National Monument and Preserve, Alaska, 2014.

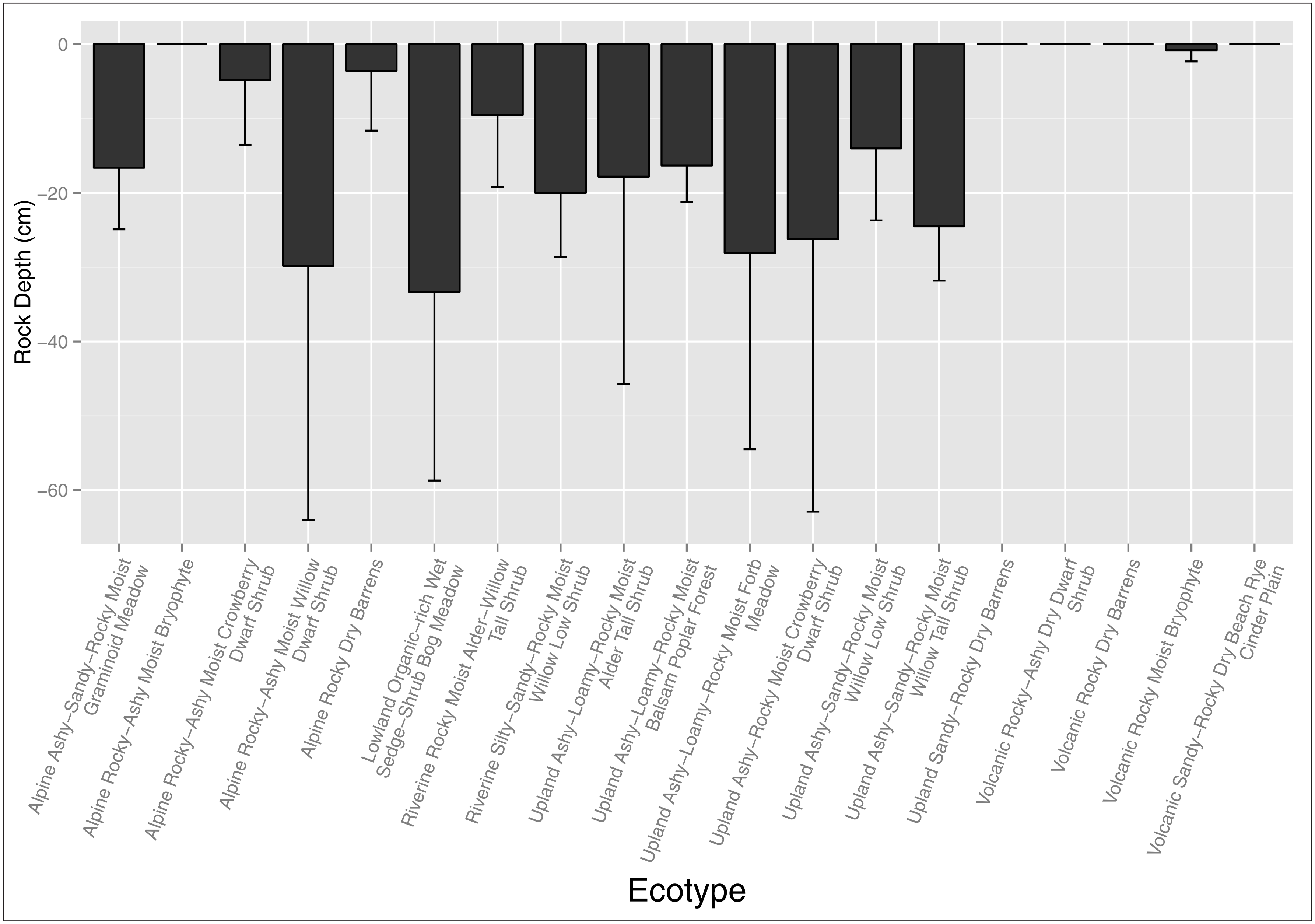


Figure 12. Barcharts displaying the average and standard deviation of depth to ≥15% rock fragments for terrestrial ecotypes with ≥3 plots in Aniakchak National Monument and Preserve, Alaska, 2014.

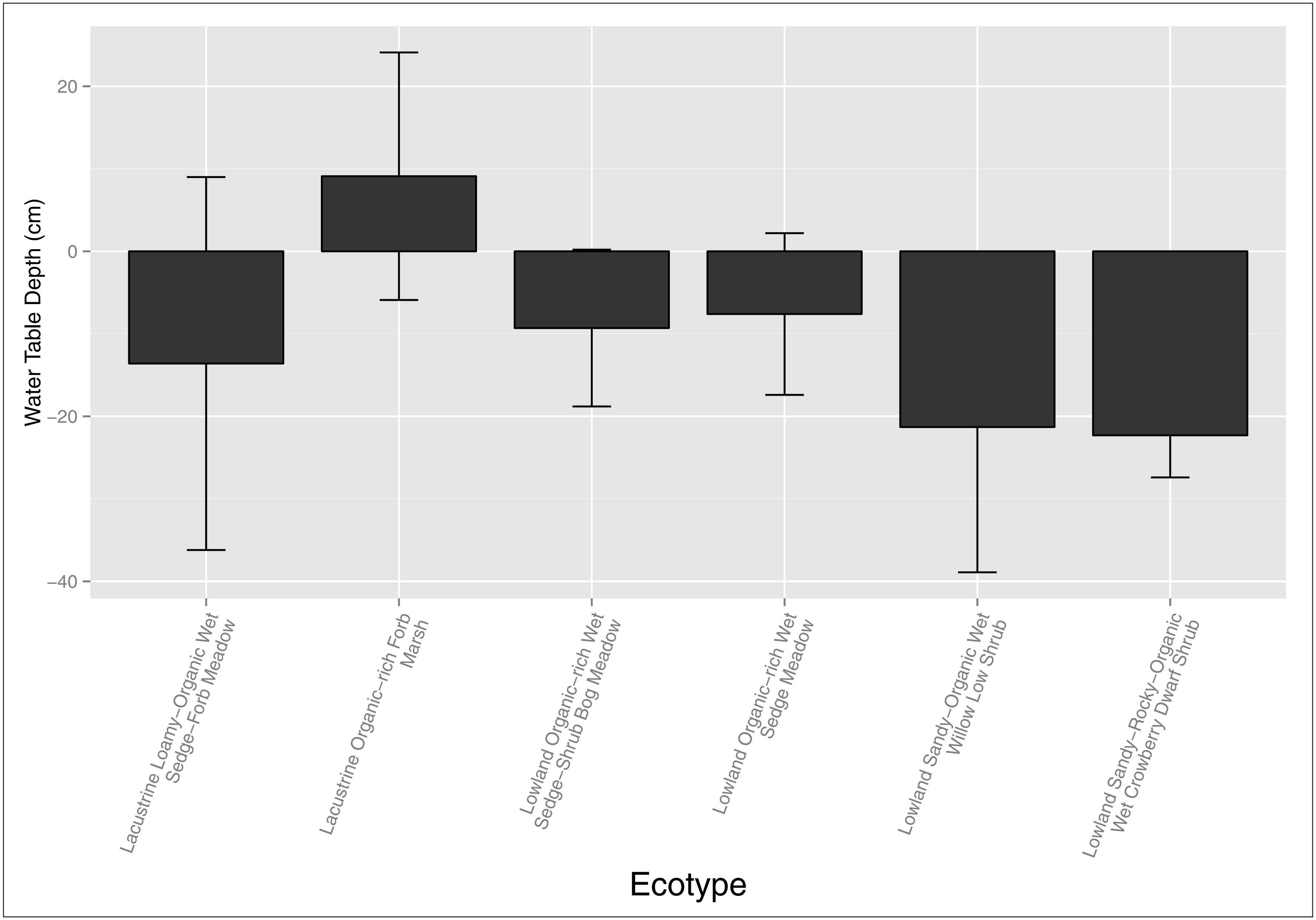


Figure 13. Barcharts displaying the average and standard deviation of water table depth for terrestrial ecotypes with ≥3 plots in Aniakchak National Monument and Preserve, Alaska, 2014.

Dry Dwarf Shrub, and Volcanic Rocky Moist Bryophyte had the most variable elevations, while Lacustrine, Lowland, and Riverine ecotypes varied the least.

Average surface organic thickness showed large differences among ecotypes (Figure 11). Ecotypes where surface organic accumulations were thin to absent included areas with severe climate and soil conditions (e.g., Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain); areas with frequent flooding and sediment deposition (e.g., Riverine Rocky Moist Alder-Willow Tall Shrub); and areas with persistent eolian sediment deposition (e.g., Coastal Sandy Moist Brackish Beach Rye Meadow). The highest average surface organic thicknesses were found in Lowland and Lacustrine environments that feature wet soils and a high rate of organic matter accumulation relative to decomposition. Ecotypes with thin to moderately thick average surface organic thickness are those ecotypes in moist, relatively stable environments where the rate of organic matter accumulation matches or slightly exceeds decomposition rates.

Average site pH in ANIA was typically circumneutral (approx. 5.6–7.2) in large part due to the periodic addition of volcanic ash into the soils, which replaces base cations leaching out of the soils over time. However, site pH values ranged widely, from 3.8–10.3 among physiography and ecotype. Ecotypes with the lowest (most acidic) pH values occurred in the ecotypes Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub and Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub (Figure 11). In the former, the ericaceous shrubs decompose to form organic acids, while in the latter, nitrogen fixation occuring in tall alder stands lowers the pH. Ecotypes with the highest (most alkaline) pH occurred in coastal environments with frequent flooding by saltwater or salt spray, including Coastal Sandy Moist Brackish Beach Rye Meadow and Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow.

A total of 19 ecotypes had a sufficient sample size of Depth to ≥15% Rock Fragments to summarize in Figure 12, while 22 ecotypes did not have a sufficient sample size to summarize here. The remaining 4 ecotypes had sufficient sample size but ≥15% rock fragments were not encountered within the sampling depth indicating that rock fragments are characteristically absent in the upper soil profiles in these ecotypes, including Coastal Sandy Moist Beach Rye-Forb Meadow, Coastal Sandy Moist Brackish Beach Rye Meadow, Lowland Organic-rich Wet Sedge Meadow, and Riverine Sandy-Loamy Moist Willow Tall Shrub. Of those ecotypes with sufficient data, those with the deepest average depth to ≥15% rock fragments include Alpine Rocky-Ashy Moist Willow Dwarf Shrub, Lowland Organic-rich Wet Sedge-Shrub Bog Meadow, Upland Ashy-Loamy-Rocky Moist Forb Meadow, and Upland Ashy-Rocky Moist Crowberry Dwarf Shrub. The ecotypes with the shallowest depth to ≥15% rock fragments and the lowest variability include the Volcanic ecotypes in Figure 12, Alpine Rocky-Ashy Moist Bryophyte, and Upland Sandy-Rocky Dry Barrens. Depth to ≥15% rock fragments is consistent at the soil surface. The ecotypes with the highest variability include Alpine Rocky-Ashy Moist Willow Dwarf Shrub and Upland Ashy-Rocky Moist Crowberry Dwarf Shrub.

A total of 6 ecotypes had a sufficient sample size and measurable Water Table Depth to summarize in Figure 13, while another 6 ecotypes did not have a sufficient sample size to summarize here. Ecotypes with insufficient data include Coastal Marine Water, Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow, Lacustrine Rocky Drained Lake Barrens, Riverine Sandy-Loamy Moist Forb Meadow, Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub, and Volcanic Rocky Dry Lichen. The remaining 19 ecotypes had sufficient sample size but the water table was not encountered within the sampling depth indicating that the water table is characteristically not present in the upper soil profiles in these ecotypes. Of those ecotypes with sufficient data, and for which the water table was encountered within the sampling depth, those with the lower average water table include Lowland Sandy-Organic Wet Willow Low Shrub and Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub. Lacustrine Organic-rich Forb Marsh had the highest average water table of all ecotypes.

Vegetation Composition

Species Summary

We classified a total of 48 ecotypes in ANIA; these ecotypes correspond to 51 AVC vegetation classes at the plot level (Table 4). Some ecotypes correspond to multiple AVC classes because the degree of canopy closure represented in AVC classes pertaining to low and tall shrublands and to balsam poplar forests (e.g., the ecotype Riverine Sandy-Loamy Moist Willow Tall Shrub) includes the AVC classes open tall willow and closed tall willow. The AVC vegetation classes identified in ANIA include 2 barren or partially vegetated classes, 6 dwarf shrub classes (≤0.20 m), 5 forb meadow classes, 2 forest classes, 16 graminoid classes, 5 low shrub classes (0.20–1.5 m), 3 aquatic emergent classes, 3 nonvascular-dominated classes, 6 tall shrub classes (≥1.5 m height), and 3 water classes. ABR and AKNHP collectively recorded 322 vascular and 91 non-vascular species in ANIA (Appendix 2).

These species totals should be considered an approximate minimum number of species in ANIA, because our sampling methods were not designed to support a comprehensive floristic inventory (see Lipkin 2005), which was beyond the scope of this study.

Ordination of Vegetation

In addition to the single-factor comparisons of environmental variables by ecotype, 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 by physiography (Figures 14–16). For the report figures, we plotted the ordinations in 2 dimensions for those physiography classes with ≥ non-outlier 30 plots, and displayed each ecotype using a unique symbol. The ordinations are displayed in the two-dimensions which best illustrated the distinctions between ecotypes. Outliers were 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.

The alpine ordination (Figure 14) reveals a gradient from more exposed sites on the left side of NMDS axis 1 corresponding to the ecotype Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub, to more sheltered sites on the right side corresponding to the ecotype Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow. An elevation gradient is reflected along axis 2 with lower elevation sites at the bottom and higher elevations at the top corresponding to the ecotype Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub. The alpine ecotypes have high within ecotype similarity in species composition and are distinct from each other as indicated by the minimal overlap between the ecotype point clouds.

The upland ordination (Figure 15) reveals a gradient from the driest soil moisture on the left side of axis 1, corresponding to Upland Ashy-Rocky Moist Crowberry Dwarf Shrub, to sites with higher soil moisture on the right side of axis 1 corresponding to to the ecotypes Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub and Upland Ashy-Loamy-Rocky Moist Forb Meadow. A slope gradient is reflected along axis 2; the sites with the lowest slopes on the lower end of Axis 2, and sites with the highest slopes on the upper end. Upland Ashy-Rocky Moist Crowberry Dwarf Shrub, Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub, and Upland Ashy-Loamy-Rocky Moist Forb Meadow were the most floristically distinct upland ecotypes. The ecotypes Upland Ashy-Sandy-Rocky Moist Willow Low Shrub and Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub were similar to one another floristically as illustrated by the overlapping points for these two ecotypes; the primary difference between these two being willow height. The ecotype Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest appears indistinct in the ordination; the points are spread out across the right side of of the ordination. This ecotype appears in the ordination to be the most similar in floristic composition to Upland Ashy-Loamy-Rocky Moist Forb Meadow as illustrated by the overlapping points clouds for these two ecotypes. This pattern reflects the similarity of the forb-dominated understory of the balsam poplar ecotype to the moist forb ecotype. However, while the understory of the balsam poplar ecotype may be similar to the moist forb ecotype, the key difference between this ecotype and all others is that the forest canopy is dominated by *Populus balsamifera*.

The lowland ordination (Figure 16) reveals a gradient from acidic, bog environments on the left side of axis 2 corresponding to Lowland Organic-rich Wet Sedge-Shrub Bog Meadow, to fens with higher pH on the right side of axis 1, corresponding to Lacustrine Loamy-Organic Wet Sedge-Forb Meadow. Axis 2 represents a gradient in Water Table Depth from lower (i.e., deeper below the soil surface) at the bottom of axis 2 to higher Water Table Depth near the top, corresponding to Lacustrine Organic-rich Forb Marsh. Lacustrine Organic-rich Forb Marsh, Lowland Organic-rich Wet Sedge-Shrub Bog Meadow, and Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub were the most floristically distinct upland ecotypes. Lacustrine Loamy-Organic Wet Sedge-Forb Meadow, Lowland Organic-rich Wet Sedge Meadow, and Lowland Sandy-Organic Wet Willow Low Shrub were similar to one another floristically as illustrated the overlapping points for these three ecotypes. The latter is differentiated from the former two by the dominance of willow. The two wet sedge ecotypes, although similar floristically, occur in distinct environments, as indicated by their respective physiography classes.

Ecosystem Mapping

Physiography

We classified and mapped a total of 8 physiographic classes in ANIA (Table 132, Figure 17). Three physiographic classes account for >90% of the park: Upland (43.8% of study area excluding marine water), Alpine (31.1%), and Volcanic

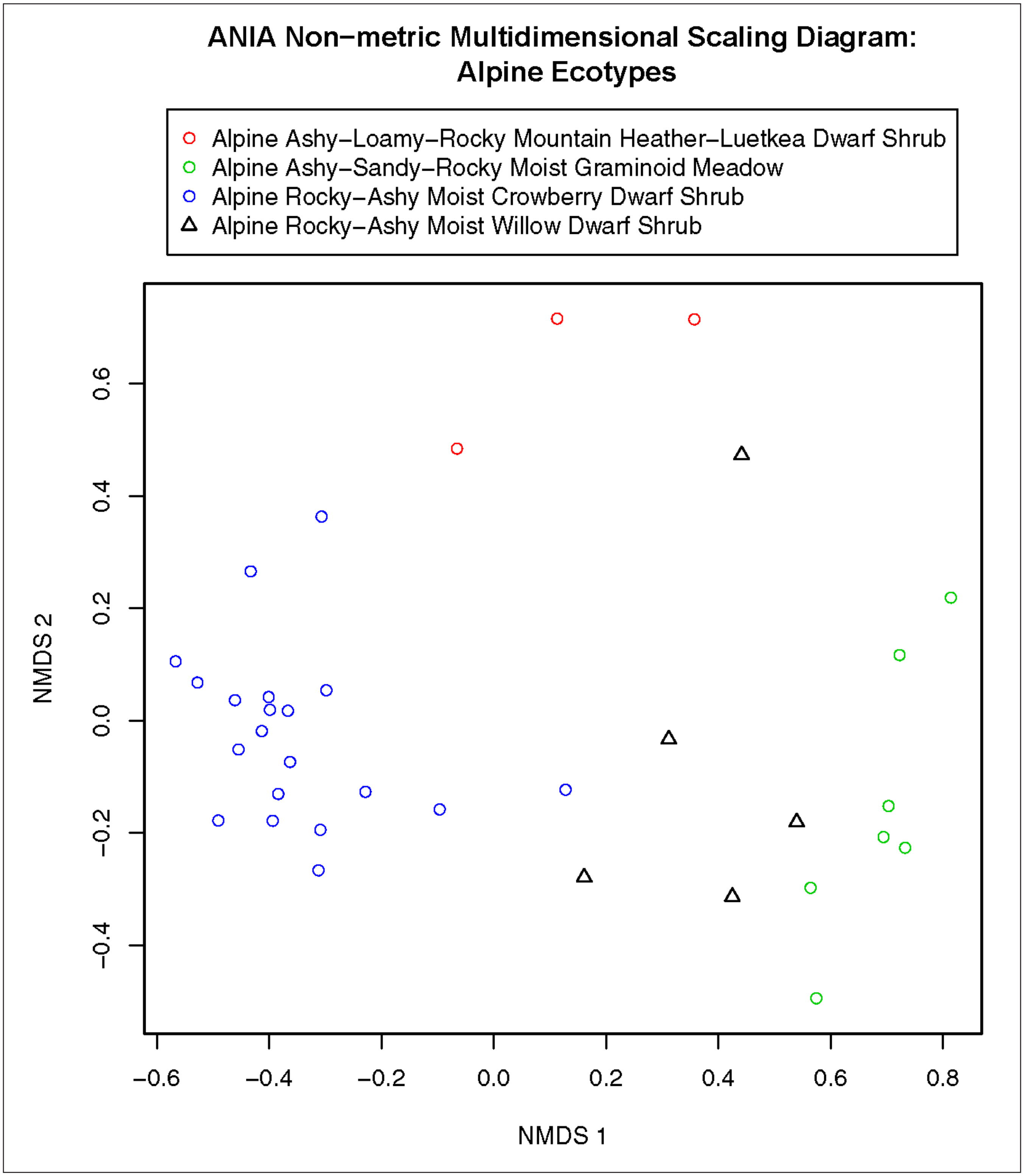


Figure 14. Non-metric multidimensional scaling of species composition for alpine ecotypes in Aniakchak National Monument and Preserve, Alaska, 2014.

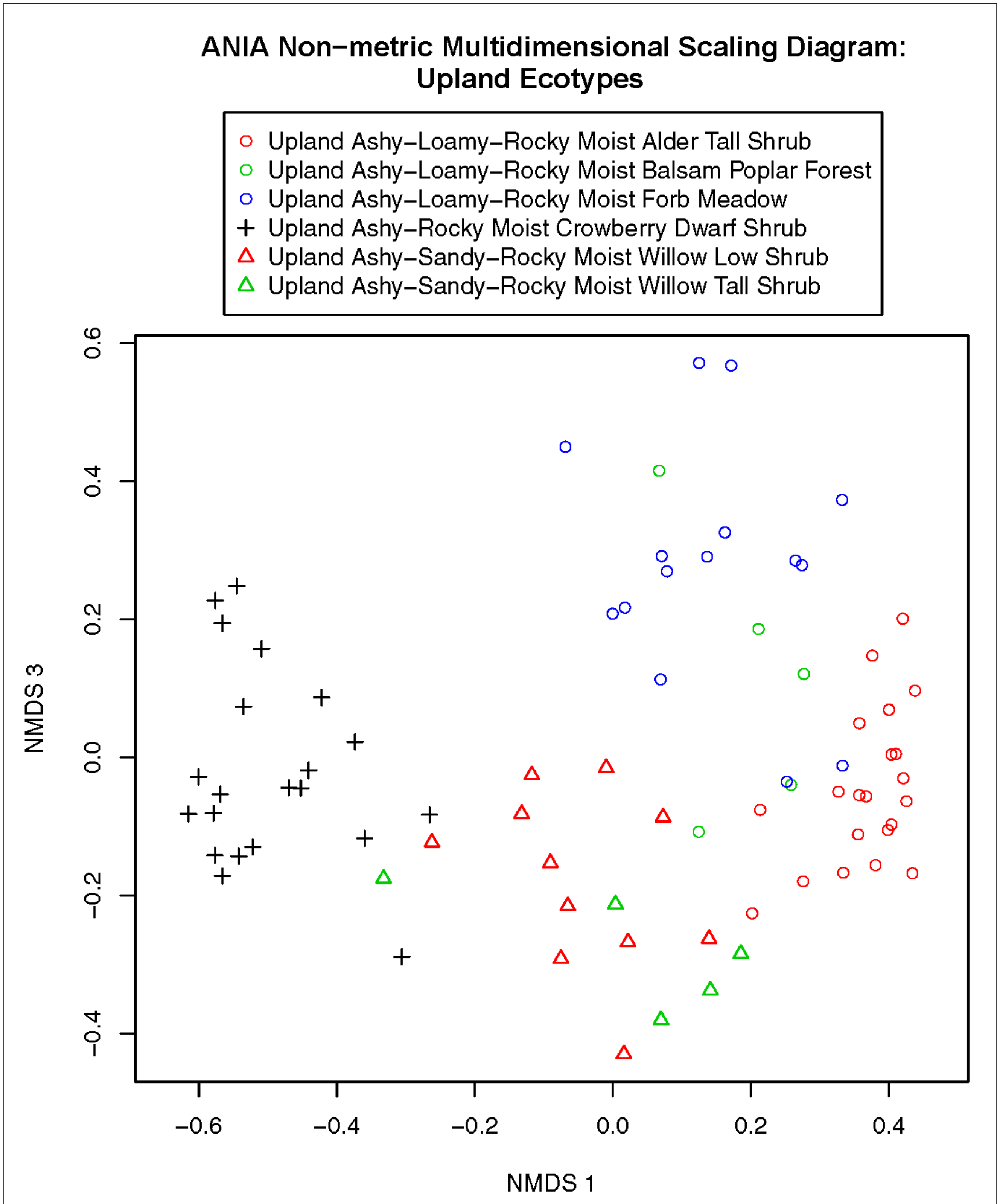


Figure 15. Non-metric multidimensional scaling of species composition for upland ecotypes in Aniakchak National Monument and Preserve, Alaska, 2014.

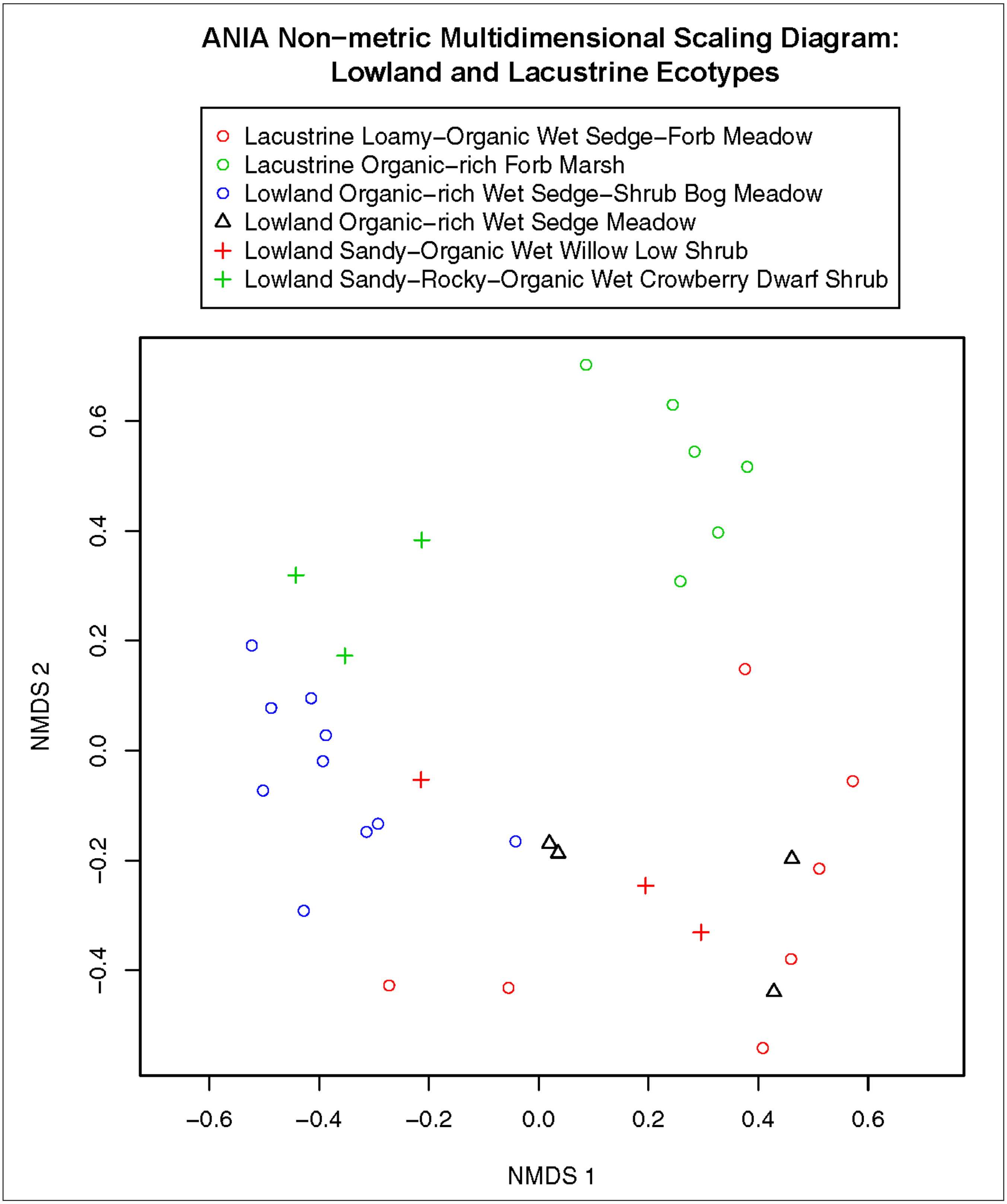


Figure 16. Non-metric multidimensional scaling of species composition for lowland and lacustrine ecotypes in Aniakchak National Monument and Preserve, Alaska, 2014.

Table 132. Area (km²) of physiographic classes mapped in Aniakchak National Monument and Preserve, southwest Alaska.

Physiography Class	Area (km²)	% of study area*
Alpine	851.7	31.1
Coastal	20.0	0.7
Coastal Marine	165.0	--
Lacustrine	11.1	0.4
Lowland	127.9	4.7
Riverine	67.3	2.5
Upland	1199.0	43.8
Volcanic	457.9	16.7
Grand Total	2899.9	100.0

* % study area excludes Coastal Marine.

(16.7%). Lowland (4.7%) and Riverine (2.5%) physiography is also fairly common, while the Coastal and Lacustrine classes have a very limited distribution (<1%). We also map nearshore marine waters of Amber, Aniakchak, and Kujulik bays as Coastal Marine physiography, but exclude this class in computing percent cover of physiography classes within the study area.

Land Cover

The USFWS land cover classification (USFWS 2007) distinguished 35 land cover classes in ANIA (Figure 18, Table 133). Dwarf Shrub-Upland was the most extensive land cover class (21.2% of study area excluding Ocean Water), followed by Rock/Gravel (15.3%), and Tall Shrub-Alder (12.4%); together, these three land cover classes accounted for almost half of the ANIA study area. Additional common land cover classes include Low Shrub-Willow (6.9%), Tall Shrub-Willow (6.7%), and Dwarf Shrub-Other (6.2%). Eighteen of the remaining USFWS land cover classes had very limited distributions (<1%). A total of 5.1% of the mapping area was mapped as Cloud, Cloud Shadow, or Snow/Ice in the *USFWS Land Cover Map*. For these areas, NLCD 2011 land cover classes were substituted for the USFWS classes. Widespread NLCD 2011 land over classes include Barren Land (2.8%), Dwarf Shrub (1.4%), and Shrub/Scrub (0.7%).

Map Ecotypes

We mapped a total of 39 ecotypes in ANIA (Figure 19, Tables 134 and 135). Four map ecotypes accounted for ~65% of the mapping area: Alpine Moist Crowberry Dwarf Shrub (22.4% of mapping area excluding Marine Water), Upland Moist Alder Tall Shrub (19.0%), Volcanic Dry Lichen and Barrens (13.8%), and Upland Crowberry Dwarf Shrub (10.6%). Twenty-five map ecotypes, including all of the map ecotypes within the Coastal, Lacustrine, and Riverine physiographic units, had very limited distributions (<1%). Shrub-dominated ecotypes encompass 71% of the mapping area, of which 37.6% is dominated by dwarf shrubs, 7.8% by low shrubs, and 25.6% by tall shrubs. Ecotypes pertaining to barren areas occur over 21.6% of the mapping area.

Soil Landscapes

We classified and mapped a total of 26 soil landscapes in ANIA . The map of soil landscapes was developed by aggregating and recoding the 39 map ecotypes into a reduced set of 26 soil landscapes (Figure 20, Table 136). The soil landscapes are named by their physiography, generalized texture, and dominant vegetation structure(s). Five widespread soil landscapes accounted for >85% of the study area: Alpine Rocky Barrens and Dwarf Shrub (29.6% of mapping area excluding Marine Water), Upland Ashy-Loamy-Rocky Forb Meadows and Alder Tall Shrub (21.2%), Volcanic Rocky Barrens, Lichen, and Beach Rye (13.8%), Upland Ashy-Rocky Barrens and Dwarf Shrub (11.9%), and Upland Ashy-Sandy-Rocky Willow Low and Tall Shrub (10.7%). Fifteen soil landscapes have a very limited distribution in ANIA (<1%) in ANIA.

Disturbance Landscapes

We classified and mapped 15 disturbance landscape across ANIA (Figure 21, Table 137). Three disturbance landscapes encompass >85% of the mapping area, all of which pertain largely to hillslope processes: Mass Wasting and Landslide (42.4% of mapping area excluding Marine Water), Mass Wasting and Landslide, and Avalanche (31.1%), and Volcanism, Mass Wasting and Landslide, Eolian (13.8%). Other common disturbance landscapes include Drying, Paludification (4.8%) and Flooding, Sedimentation, Erosion (2.5%).

Map Accuracy Assessment

Although the field plots sampled by AKNHP and ABR in ANIA were used to derive classification systems for ecotypes, soil landscapes, and disturbance landscapes, they were not used to construct the *USFWS Land Cover Map* (USFWS 2007), which served as the primary input in the landscape modeling and mapping presented in this report. The network of field plots, therefore, provide a means by which to assess the strength and limitations of the ecotype map. We caution, however, that the areal footprint of ABR field plots (circular with radius of approximately 10 m) is substantially smaller than the footprint of a single 30 × 30 m pixel in the Landsat-

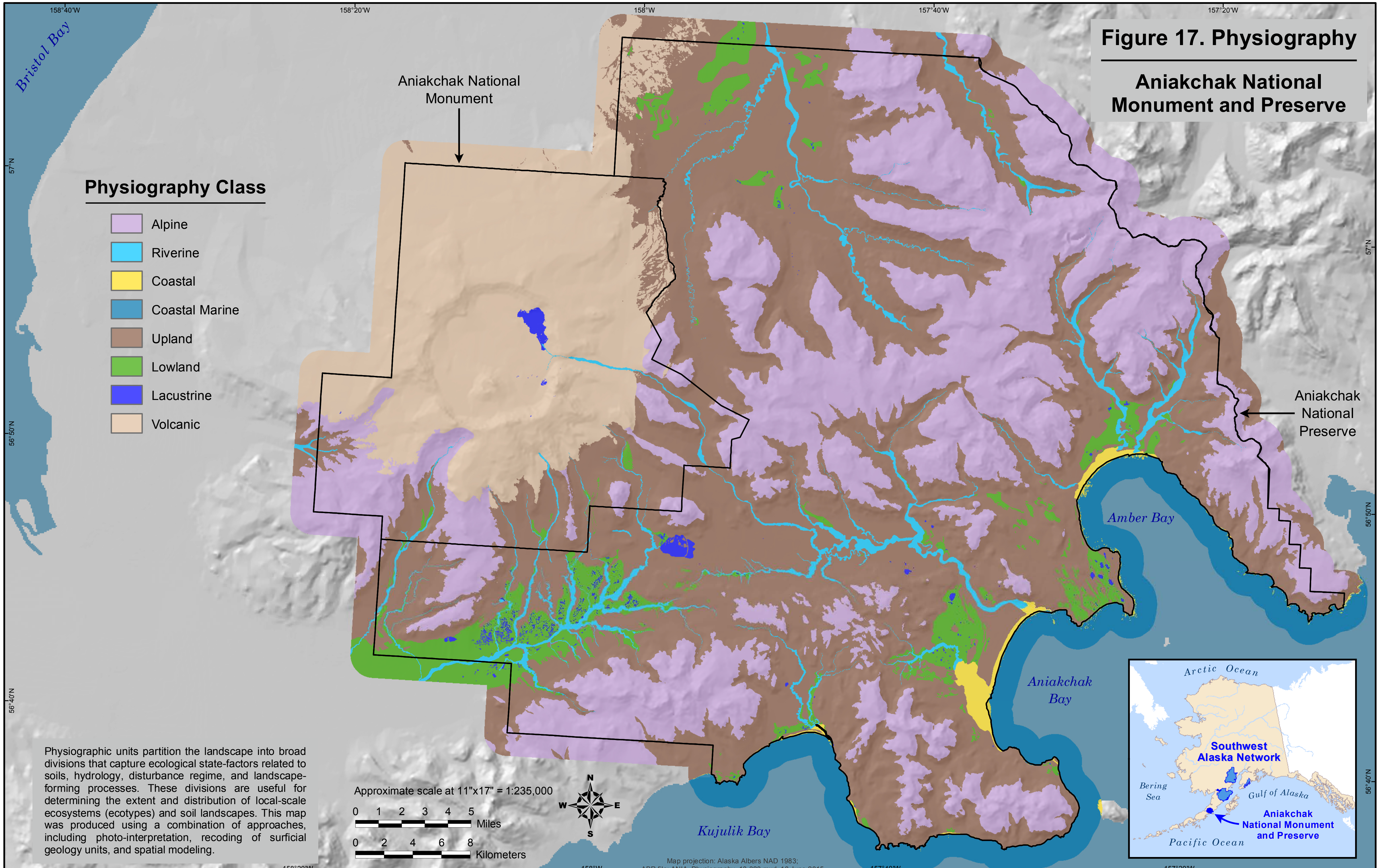


Figure 17. Physiography map for Aniakchak National Monument and Preserve, southwest Alaska.

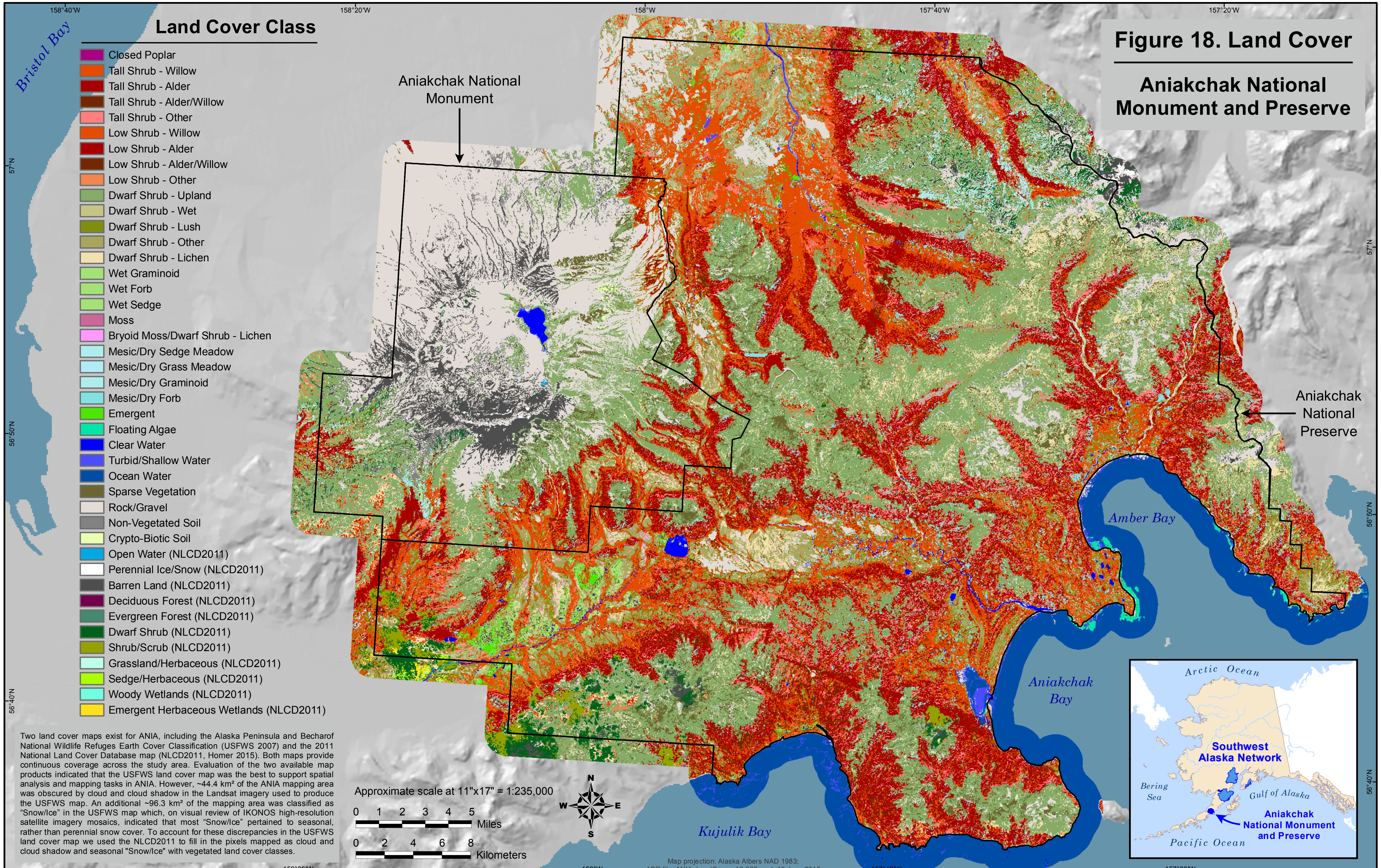


Figure 18. Land-cover map for Aniakchak National Monument and Preserve, southwest Alaska. Adapted from Alaska Peninsula/Becharof National Wildlife Refuges Earth Cover Classification map of USFWS (2007) and National Land Cover Dataset 2011 (Homer et al. 2015).

Table 133. Area (km²) of land-cover classes mapped in Aniakchak National Monument and Preserve, southwest Alaska. Adapted from Alaska Peninsula/Becharof National Wildlife Refuges Earth Cover Classification map of USFWS (2007) and National Land Cover Dataset 2011 (Homer et al. 2015).

Land Cover Class	Area (km²)	% of study area*
Alaska Peninsula/Becharof National Wildlife Refuges Earth Cover Classification (USFWS 2007)		
Bryoid Moss/Dwarf Shrub - Lichen	1.5	0.1
Clear Water	10.5	0.4
Closed Poplar	0.2	<0.1
Crypto-Biotic Soil	1.4	0.1
Dwarf Shrub - Lichen	93.9	3.4
Dwarf Shrub - Lush	66.4	2.4
Dwarf Shrub - Other	170.2	6.2
Dwarf Shrub - Upland	581.0	21.2
Dwarf Shrub - Wet	19.6	0.7
Emergent	7.0	0.3
Floating Algae	4.1	0.1
Low Shrub - Alder	26.5	1.0
Low Shrub - Alder/Willow	16.8	0.6
Low Shrub - Other	68.3	2.5
Low Shrub - Willow	187.9	6.9
Mesic/Dry Forb	50.8	1.9
Mesic/Dry Graminoid	0.6	<0.1
Mesic/Dry Grass Meadow	31.4	1.1
Mesic/Dry Sedge Meadow	11.3	0.4
Moss	0.1	<0.1
Non-Vegetated Soil	18.4	0.7
Ocean Water	157.5	--
Rock/Gravel	418.3	15.3
Sparse Vegetation	77.8	2.8
Tall Shrub - Alder	340.7	12.4
Tall Shrub - Alder/Willow	84.1	3.1
Tall Shrub - Other	103.0	3.8
Tall Shrub - Willow	183.2	6.7
Turbid/Shallow Water	11.8	0.4
Wet Forb	<0.1	<0.1
Wet Graminoid	9.0	0.3
Wet Sedge	5.8	0.2
National Land Cover Dataset 2011 (Homer 2015)		
Barren Land	76.6	2.8
Deciduous Forest	<0.1	<0.1
Dwarf Shrub	39.1	1.4
Emergent Herbaceous Wetlands	1.3	<0.1
Evergreen Forest	<0.1	<0.1

Table 133. Continued.

Land Cover Class	Area (km²)	% of study area*
Grassland/Herbaceous	0.3	<0.1
Open Water	0.3	<0.1
Perennial Ice/Snow	2.8	0.1
Sedge/Herbaceous	0.6	<0.1
Shrub/Scrub	19.6	0.7
Woody Wetlands	<0.1	<0.1
Grand Total	**2899.9**	**100.0**

* % study area exlcudes Ocean Water.

based land cover map. Additionally, many map ecotypes are of very limited spatial extent and are represented by only one or a few field plots. Therefore, while it is possible to make qualitative statements regarding map accuracy for common map classes, we do not present a formal, quantitative accuracy assessment using the combined set of AKNHP and ABR field plots. A formal accuracy assessment of the USFWS land cover map is available in Boucher et al. (2012).

Four map ecotypes—Alpine Moist Crowberry Dwarf Shrub, Upland Moist Alder Tall Shrub, Volcanic Dry Lichen and Barrens, and Upland Crowberry Dwarf Shrub—together account for over 60% of the ANIA mapping area. Comparison of map ecotype determinations at field plots located within these map units provide some indication of how well these major ecotypes are represented in the ecotype map. Alpine Moist Crowberry Dwarf Shrub was the most widespread map ecotype and encompasses 21.1% of the mapping area. Twenty-two field plots were sampled in this map ecotype, of which 12 were correctly mapped (54.5%). Most of the incorrectly mapped field plots were assigned to other dwarf shrub, low shrub, or barren map ecotypes. Upland Moist Tall Alder Shrub accounted for 17.9% of the mapping area; of 21 field plots assigned to this map ecotype, only 8 were correctly mapped (38.1%). Most of the remaining field plots were mapped to dwarf shrub ecotypes. Volcanic Dry Lichen and Barrens accounts for 13.0% of the mapping area; of 21 field plots in this ecotype, 19 were correctly mapped (90.5%). Upland Crowberry Dwarf Shrub encompasses 10.0% of the mapping area; of 22 field plots in this map ecotype, 12 were correctly mapped (54.5%), with most of the remaining plots mapped as another dwarf shrub ecotype, or a barren ecotype. Map accuracies for these common map ecotypes indicate that while ecotypes with highly distinctive spectral signatures, such as the Volcanic Dry Lichen and Barrens map ecotype, are readily mapped, many of the vegetated ecotypes are commonly confused with one another. For example, the total cover and biomass of vegetation in dwarf shrub ecotypes can vary considerably; dwarf shrub patches with continuous cover and high biomass can frequently be confused with low- and even tall-shrub ecotypes, while patches with discontinuous vegetation cover can resemble barren ecotypes. Other, less extensive ecotypes, such as Upland Moist Forb Meadow, typically occur in small, irregularly shaped patches within a matrix of other ecotypes (e.g., tall shrub ecotypes). These can be particularly difficult to map using 30 m Landsat imagery; for example, only 1 of 16 field plots assigned to Upland Moist Forb Meadow was correctly mapped (6.3%). On the other hand, some spatially restricted map ecotypes were mapped very well, such as Upland Moist Willow Tall Shrub (80% of field plots correctly mapped) and Upland Dry Barrens (90%). In addition to issues related to the spatial resolution of Landsat imagery and the spectral similarity of many vegetated ecotypes, some of the disagreement between field plots and mapped units are likely attributable to vegetation changes (i.e., ecological succession) that have occurred between the mid-1990s, when the Landsat imagery used to create the USFWS land cover map was acquired, and the collection of field data in 2014 (see Factors Influencing Ecosystem Development, below).

Soil Landscapes

Summary of Soil Characteristics

Soil Classification

Of the 294 plots included in the ecotype analysis, soils data sufficient for classifying soil subgroups was available for 250 plots. Soils from 7 orders of soil taxonomy were encountered during field sampling: Alfisols, Andisols, Entisols, Histosols, Inceptisols, Mollisols, and Spodosols (Table 138). Sixty-three soil subgroups were identified during field sampling, although approximately half of the subgroups (30) were rare (<3 observations).

Alfisols (well-developed, clay-rich soils) accounted for <1% of observations, and included one soil subgroup: Vitrandic

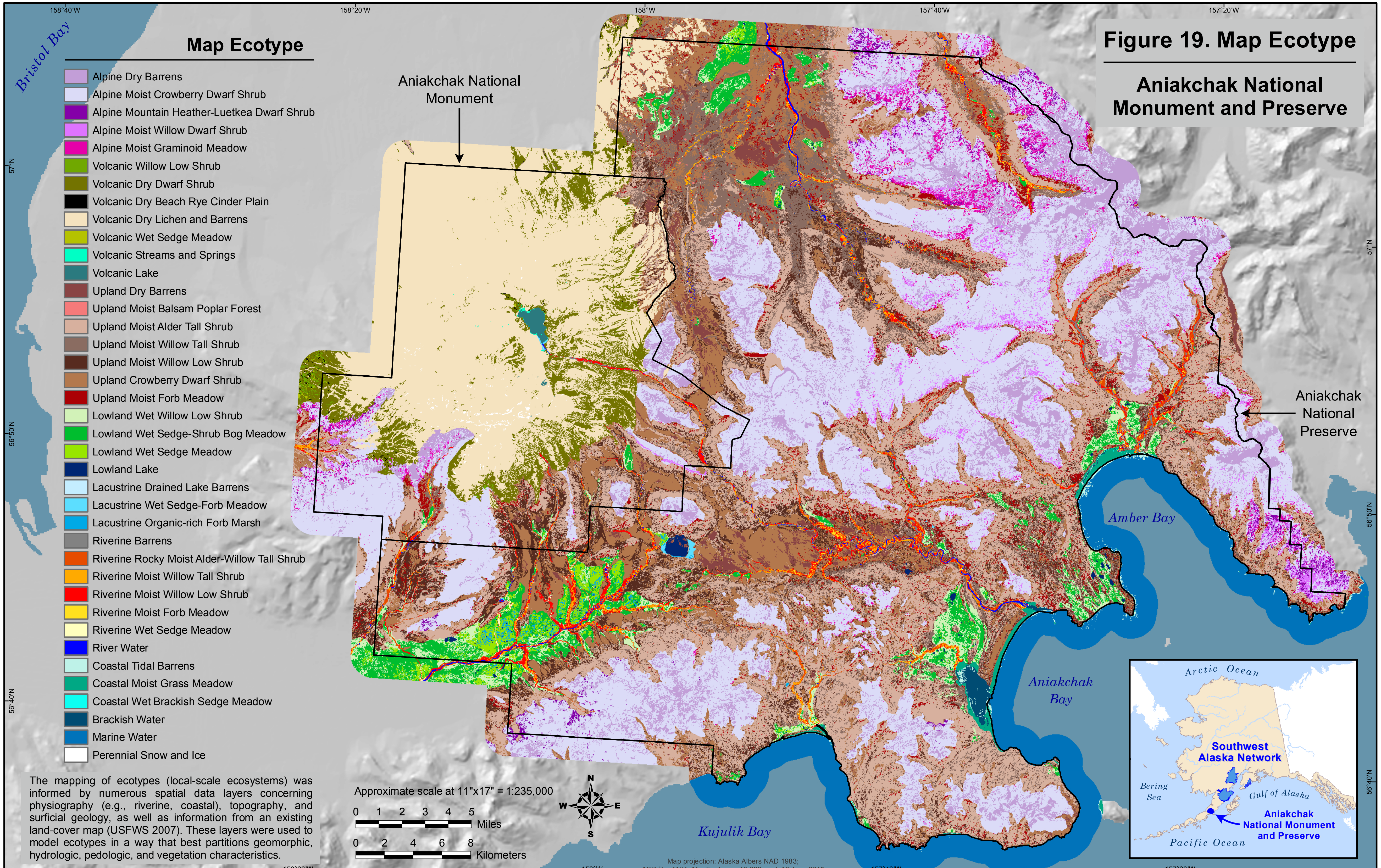


Figure 19. Map ecotypes for Aniakchak National Monument and Preserve, southwest Alaska.

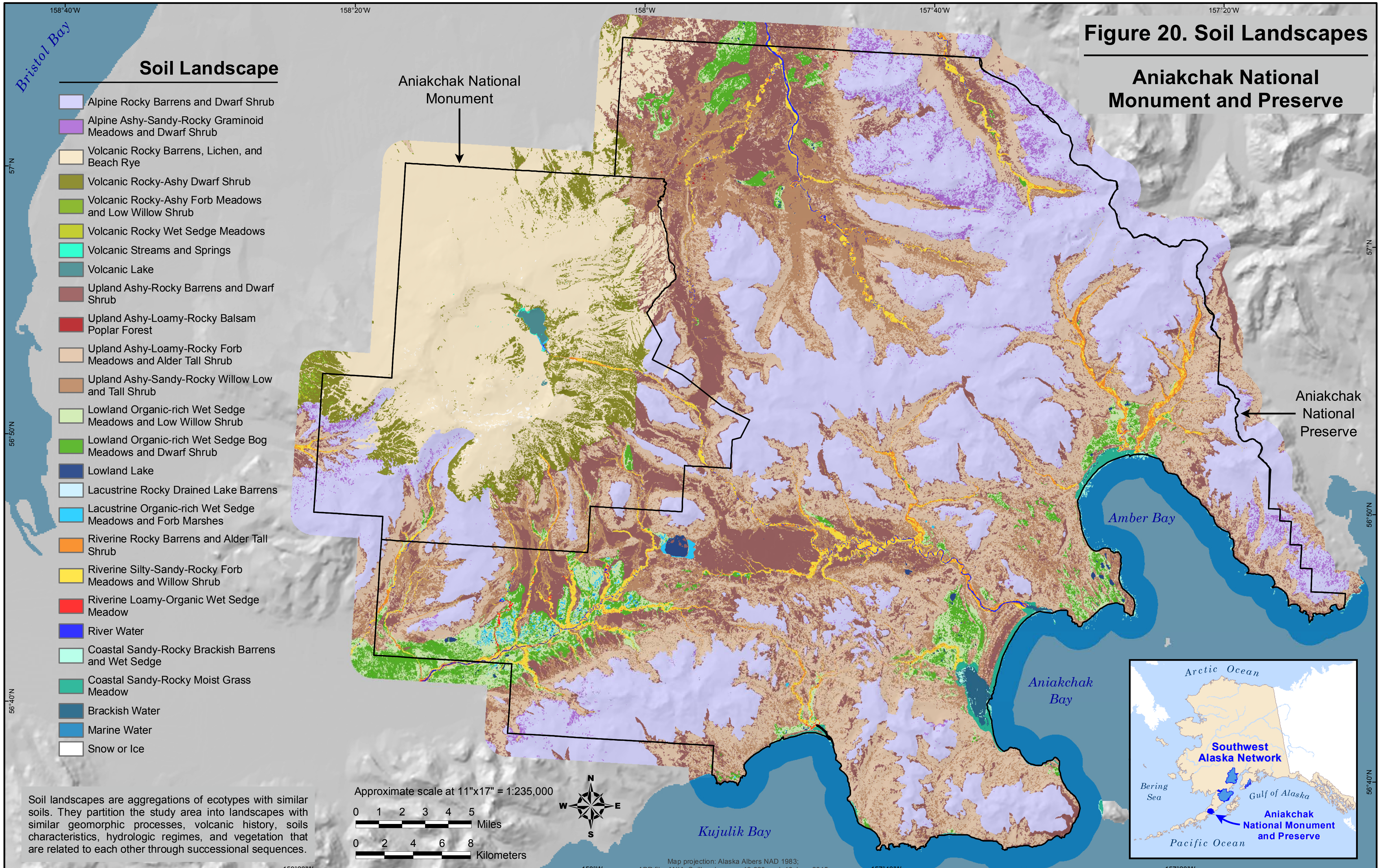


Figure 20. Soil landscapes map for Aniakchak National Monument and Preserve, southwest Alaska.

Table 134. Crosswalk of map ecotypes with plot ecotype names, soil landscapes, and disturbance landscapes identified in Aniakchak National Monument and Preserve, southwest Alaska.

Map Ecotype	**Ecotype**	**Soil Landscape**	**Disturbance Landscape**
Alpine Dry Barrens	Alpine Rocky-Ashy Moist Bryophyte	Alpine Rocky Barrens and Dwarf Shrub	Mass Wasting and Landslide, Avalanche
Alpine Dry Barrens	Alpine Rocky Dry Barrens	Alpine Rocky Barrens and Dwarf Shrub	Mass Wasting and Landslide, Avalanche
Alpine Moist Crowberry Dwarf Shrub	Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub	Alpine Rocky Barrens and Dwarf Shrub	Mass Wasting and Landslide, Avalanche
Alpine Moist Graminoid Meadow	Alpine Ashy-Sandy-Rocky Moist Graminoid Meadow	Alpine Ashy-Sandy-Rocky Graminoid Meadows and Dwarf Shrub	Mass Wasting and Landslide, Avalanche
Alpine Moist Willow Dwarf Shrub	Alpine Rocky-Ashy Moist Willow Dwarf Shrub	Alpine Rocky Barrens and Dwarf Shrub	Mass Wasting and Landslide, Avalanche
Alpine Mountain Heather-Luetkea Dwarf Shrub	Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub	Alpine Ashy-Sandy-Rocky Graminoid Meadows and Dwarf Shrub	Mass Wasting and Landslide, Avalanche
Brackish Water	Coastal Brackish Water	Brackish Water	Tides and Tidal Wave, Storm Surge, Isostatic and Seismic Adjustment
Coastal Moist Grass Meadow	Coastal Sandy-Loamy-Rocky Moist Bluegrass Meadow	Coastal Sandy-Rocky Moist Grass Meadow	Tides and Tidal Wave, Storm Surge, Isostatic and Seismic Adjustment
Coastal Moist Grass Meadow	Coastal Sandy Moist Beach Rye-Forb Meadow	Coastal Sandy-Rocky Moist Grass Meadow	Tides and Tidal Wave, Storm Surge, Isostatic and Seismic Adjustment
Coastal Moist Grass Meadow	Coastal Sandy Moist Brackish Beach Rye Meadow	Coastal Sandy-Rocky Moist Grass Meadow	Tides and Tidal Wave, Storm Surge, Isostatic and Seismic Adjustment
Coastal Tidal Barrens	Coastal Sandy-Rocky Tidal Barrens	Coastal Sandy-Rocky Brackish Barrens and Wet Sedge	Tides and Tidal Wave, Storm Surge, Isostatic and Seismic Adjustment
Coastal Wet Brackish Sedge Meadow	Coastal Sandy-Rocky-Organic Wet Brackish Sedge Meadow	Coastal Sandy-Rocky Brackish Barrens and Wet Sedge	Tides and Tidal Wave, Storm Surge, Isostatic and Seismic Adjustment
Lacustrine Drained Lake Barrens	Lacustrine Rocky Drained Lake Barrens	Lacustrine Rocky Drained Lake Barrens	Drying, Paludification
Lacustrine Organic-rich Forb Marsh	Lacustrine Organic-rich Forb Marsh	Lacustrine Organic-rich Wet Sedge Meadows and Forb Marshes	Drying, Paludification
Lacustrine Wet Sedge-Forb Meadow	Lacustrine Loamy-Organic Wet Sedge-Forb Meadow	Lacustrine Organic-rich Wet Sedge Meadows and Forb Marshes	Drying, Paludification
Lowland Lake	Lowland Alkaline Lake Water	Lowland Lake	Drainage, Sedimentation
Lowland Wet Sedge Meadow	Lowland Organic-rich Wet Sedge Meadow	Lowland Organic-rich Wet Sedge Meadows and Low Willow Shrub	Drying, Paludification
Lowland Wet Sedge-Shrub Bog Meadow	Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	Lowland Organic-rich Wet Sedge Bog Meadows and Dwarf Shrub	Drying, Paludification

Table 134. Continued.

Map Ecotype	Ecotype	Soil Landscape	Disturbance Landscape
Lowland Wet Sedge-Shrub Bog Meadow	Lowland Sandy-Rocky-Organic Wet Crowberry Dwarf Shrub	Lowland Organic-rich Wet Sedge Bog Meadows and Dwarf Shrub	Drying, Paludification
Lowland Wet Willow Low Shrub	Lowland Sandy-Organic Wet Willow Low Shrub	Lowland Organic-rich Wet Sedge Meadows and Low Willow Shrub	Drying, Paludification
Marine Water	Coastal Marine Water	Marine Water	Marine Water
Perennial Snow and Ice	Snow or Ice	Snow or Ice	Ablation
Riverine Barrens	Riverine Rocky Barrens	Riverine Rocky Barrens and Alder Tall Shrub	Flooding, Sedimentation, Erosion
Riverine Moist Forb Meadow	Riverine Sandy-Loamy Moist Forb Meadow	Riverine Silty-Sandy-Rocky Forb Meadows and Willow Shrub	Flooding, Sedimentation, Erosion
Riverine Moist Willow Low Shrub	Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	Riverine Silty-Sandy-Rocky Forb Meadows and Willow Shrub	Flooding, Sedimentation, Erosion
Riverine Moist Willow Tall Shrub	Riverine Sandy-Loamy Moist Willow Tall Shrub	Riverine Silty-Sandy-Rocky Forb Meadows and Willow Shrub	Flooding, Sedimentation, Erosion
Riverine Rocky Moist Alder-Willow Tall Shrub	Riverine Rocky Moist Alder-Willow Tall Shrub	Riverine Rocky Barrens and Alder Tall Shrub	Flooding, Sedimentation, Erosion
Riverine Wet Sedge Meadow	Riverine Loamy-Organic Wet Sedge Meadow	Riverine Loamy-Organic Wet Sedge Meadow	Flooding, Sedimentation, Erosion
River Water	Riverine Alkaline River Water	River Water	Flooding, Sedimentation, Erosion
Upland Crowberry Dwarf Shrub	Upland Ashy-Rocky Moist Crowberry Dwarf Shrub	Upland Ashy-Rocky Barrens and Dwarf Shrub	Mass Wasting and Landslide
Upland Dry Barrens	Upland Sandy-Rocky Dry Barrens	Upland Ashy-Rocky Barrens and Dwarf Shrub	Mass Wasting and Landslide, Eolian
Upland Moist Alder Tall Shrub	Upland Ashy-Loamy-Rocky Moist Alder Tall Shrub	Upland Ashy-Loamy-Rocky Forb Meadows and Alder Tall Shrub	Mass Wasting and Landslide
Upland Moist Balsam Poplar Forest	Upland Ashy-Loamy-Rocky Moist Balsam Poplar Forest	Upland Ashy-Loamy-Rocky Balsam Poplar Forest	Windthrow, Pests and Pathogens
Upland Moist Forb Meadow	Upland Ashy-Loamy-Rocky Moist Forb Meadow	Upland Ashy-Loamy-Rocky Forb Meadows and Alder Tall Shrub	Mass Wasting and Landslide
Upland Moist Willow Low Shrub	Upland Ashy-Sandy-Rocky Moist Willow Low Shrub	Upland Ashy-Sandy-Rocky Willow Low and Tall Shrub	Mass Wasting and Landslide
Upland Moist Willow Tall Shrub	Upland Ashy-Sandy-Rocky Moist Willow Tall Shrub	Upland Ashy-Sandy-Rocky Willow Low and Tall Shrub	Mass Wasting and Landslide

Table 134. Continued.

Map Ecotype	Ecotype	Soil Landscape	Disturbance Landscape
Volcanic Dry Beach Rye Cinder Plain	Volcanic Sandy-Rocky Dry Beach Rye Cinder Plain	Volcanic Rocky Barrens, Lichen, and Beach Rye	Volcanism, Mass Wasting and Landslide, Eolian
Volcanic Dry Dwarf Shrub	Volcanic Rocky-Ashy Dry Dwarf Shrub	Volcanic Rocky-Ashy Dwarf Shrub	Volcanism, Mass Wasting and Landslide
Volcanic Dry Lichen and Barrens	Volcanic Rocky Dry Barrens	Volcanic Rocky Barrens, Lichen, and Beach Rye	Volcanism, Mass Wasting and Landslide, Eolian
Volcanic Dry Lichen and Barrens	Volcanic Rocky Dry Lichen	Volcanic Rocky Barrens, Lichen, and Beach Rye	Volcanism, Mass Wasting and Landslide, Eolian
Volcanic Dry Lichen and Barrens	Volcanic Rocky Moist Bryophyte	Volcanic Rocky Barrens, Lichen, and Beach Rye	Volcanism, Mass Wasting and Landslide, Eolian
Volcanic Lake	Volcanic Lake	Volcanic Lake	Volcanism, Drainage, Sedimentation
Volcanic Streams and Springs	Volcanic Streams and Springs	Volcanic Streams and Springs	Volcanism, Flooding, Sedimentation, Erosion
Volcanic Wet Sedge Meadow	Volcanic Rocky Wet Sedge Meadow	Volcanic Rocky Wet Sedge Meadows	Volcanism, Mass Wasting and Landslide, Drying, Paludification
Volcanic Willow Low Shrub	Volcanic Ashy-Sandy-Rocky Moist Willow Low Shrub	Volcanic Rocky-Ashy Forb Meadows and Low Willow Shrub	Volcanism, Mass Wasting and Landslide
Volcanic Willow Low Shrub	Volcanic Rocky-Ashy Moist Forb Meadow	Volcanic Rocky-Ashy Forb Meadows and Low Willow Shrub	Volcanism, Mass Wasting and Landslide
Volcanic Willow Low Shrub	Volcanic Rocky-Ashy Wet Willow Low Shrub	Volcanic Rocky-Ashy Forb Meadows and Low Willow Shrub	Volcanism, Mass Wasting and Landslide
not mapped	Lacustrine Sandy Grass Marsh	not mapped	not mapped

Table 135. Area of map ecotypes in Aniakchak National Monument and Preserve, southwest Alaska.

Map ecotype	Area (km²)	% of study area*
Alpine Dry Barrens	164.1	6.0
Alpine Moist Crowberry Dwarf Shrub	612.7	22.4
Alpine Moist Graminoid Meadow	25.3	0.9
Alpine Moist Willow Dwarf Shrub	33.9	1.2
Alpine Mountain Heather-Luetkea Dwarf Shrub	15.7	0.6
Brackish Water	5.3	0.2
Coastal Moist Grass Meadow	9.2	0.3
Coastal Tidal Barrens	5.4	0.2
Coastal Wet Brackish Sedge Meadow	0.1	0.0
Lacustrine Drained Lake Barrens	<0.1	<0.1
Lacustrine Organic-rich Forb Marsh	3.4	0.1
Lacustrine Wet Sedge-Forb Meadow	0.9	<0.1
Lowland Lake	4.1	0.2
Lowland Wet Sedge Meadow	18.4	0.7
Lowland Wet Sedge-Shrub Bog Meadow	65.3	2.4
Lowland Wet Willow Low Shrub	44.2	1.6
Marine Water	165.0	--
Perennial Snow and Ice	1.7	0.1
River Water	5.4	0.2
Riverine Barrens	6.2	0.2
Riverine Moist Forb Meadow	2.8	0.1
Riverine Moist Willow Low Shrub	24.5	0.9
Riverine Moist Willow Tall Shrub	15.3	0.6
Riverine Rocky Moist Alder-Willow Tall Shrub	11.9	0.4
Riverine Wet Sedge Meadow	1.2	<0.1
Upland Crowberry Dwarf Shrub	288.7	10.6
Upland Dry Barrens	38.0	1.4
Upland Moist Alder Tall Shrub	519.2	19.0
Upland Moist Balsam Poplar Forest	0.2	<0.1
Upland Moist Forb Meadow	59.5	2.2
Upland Moist Willow Low Shrub	141.5	5.2
Upland Moist Willow Tall Shrub	151.8	5.6
Volcanic Dry Beach Rye Cinder Plain	0.8	<0.1
Volcanic Dry Dwarf Shrub	75.2	2.8
Volcanic Dry Lichen and Barrens	377.5	13.8
Volcanic Lake	2.7	0.1
Volcanic Streams and Springs	0.3	<0.1
Volcanic Wet Sedge Meadow	0.4	<0.1
Volcanic Willow Low Shrub	2.0	0.1
Grand Total	2899.9	100.0

*% study area excludes marine water

Table 136. Area of soil landscape classes mapped in Aniakchak National Monument and Preserve, southwest Alaska.

Map ecotype	Area (km²)	% of study area*
Alpine Ashy-Sandy-Rocky Graminoid Meadows and Dwarf Shrub	41.0	1.5
Alpine Rocky Barrens and Dwarf Shrub	810.7	29.6
Brackish Water	5.3	0.2
Coastal Sandy-Rocky Brackish Barrens and Wet Sedge	5.6	0.2
Coastal Sandy-Rocky Moist Grass Meadow	9.2	0.3
Lacustrine Organic-rich Wet Sedge Meadows and Forb Marshes	4.3	0.2
Lacustrine Rocky Drained Lake Barrens	<0.1	<0.1
Lowland Lake	4.1	0.2
Lowland Organic-rich Wet Sedge Bog Meadows and Dwarf Shrub	65.3	2.4
Lowland Organic-rich Wet Sedge Meadows and Low Willow Shrub	62.6	2.3
Marine Water	165.0	--
River Water	5.4	0.2
Riverine Loamy-Organic Wet Sedge Meadow	1.2	<0.1
Riverine Rocky Barrens and Alder Tall Shrub	18.1	0.7
Riverine Silty-Sandy-Rocky Forb Meadows and Willow Shrub	42.6	1.6
Snow or Ice	1.7	0.1
Upland Ashy-Loamy-Rocky Balsam Poplar Forest	0.2	<0.1
Upland Ashy-Loamy-Rocky Forb Meadows and Alder Tall Shrub	578.7	21.2
Upland Ashy-Rocky Barrens and Dwarf Shrub	326.7	11.9
Upland Ashy-Sandy-Rocky Willow Low and Tall Shrub	293.3	10.7
Volcanic Lake	2.7	0.1
Volcanic Rocky Barrens, Lichen, and Beach Rye	378.3	13.8
Volcanic Rocky Wet Sedge Meadows	0.4	<0.1
Volcanic Rocky-Ashy Dwarf Shrub	75.2	2.8
Volcanic Rocky-Ashy Forb Meadows and Low Willow Shrub	2.0	0.1
Volcanic Streams and Springs	0.3	<0.1
Grand Total	2899.9	100.0

*% study area excludes marine water

Haplocryalfs. Alfisols typically form in cool, humid climates with thick accumulations of translocated clay. The single plot sampled in this soil order was located on an upper north-facing slope in the Alpine. Soils were formed tephra over colluvium derived from sandstone and siltstone bedrock. While it is unlikely that Alfisols are common across the entirety of ANIA, it is possible that Alfisols are more common in older, more stable environments in the Aleutian Range with sandstone and siltstone parent material, and are simply underrepresented in the dataset.

Andisols were by far the most common soil order found, accounting for 49% of observations and including 20 observed subgroups, the three most common being Typic Vitricryands, Eutric Duricryands, and Humic Vitricryands. 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 across all physiography types (except Coastal), but were most commonly found in Upland and Volcanic environments. In Upland environments, Andisols were most commonly associated with Hillside Colluvium; Pyroclastic Flow Deposit, undifferentiated; and Tephra, ash. In Volcanic Environments, Andisols were most commonly sampled on Tephra, undifferentiated.

Entisols accounted for 24% of observations and included 13 observed subgroups; the three most common included

Vitrandic Cryorthents, Vitrandic Cryofluvents, and Aquandic Cryaquents. 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 (<14 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, areas affected by recent volcanism) or sometimes due to intensive land use management practices. Entisols occurred across all physiography types with exception of Laucustrine, but were most common in Coastal, Riverine, and Volcanic environments. In Coastal areas, Entisols were most commonly associated with Active Sandy Marine Beach and Coastal Active Dunes. In Riverine environments, Entisols were most commonly associated with Alluvial Fan Inactive Deposits and Meander Coarse Inactive Channel Deposits. In Volcanic environments, Entisols were most commonly associated with Lowland Headwater Floodplain; Tephra, undifferentiated; and Bedrock, residual soil.

Histosols accounted for 6% of observations and included 6 observed subgroups, the three most common including Fluvaquentic Cryohemists, Terric Cryofibrists, and Terric Cryohemists. Histosols are soils formed in thick (≥20 cm) organic material that are wet throughout the growing season. Histosols occurred exclusively in Lacustrine and Lowland environments, and were sampled most commonly associated with Organic Fen and Bog geomorphic units.

Inceptisols accounted for 17% of observations and included 17 observed subgroups, the three most common including Histic Cryaquepts, Andic Haplocryepts, and Vitrandic Humicryepts. Inceptisols are soils that are moderately developed and do not meet the requirements for any other soil order. They are characterized by distinct horizon development and mild weathering and translocation of materials to lower in the soil profile. Inceptisols occurred across all physiography types with exception of Volcanic, but were most common in Alpine and Upland environments. In Alpine environments, Inceptisols were most commonly associated with Bedrock, residual soil. In Upland environments, they were most commonly associated with Hillside Colluvium and Tephra, ash.

Mollisols accounted for 2% of observations, and included 4 subgroups, the most common being Lithic Haplocryolls. 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 found exclusively in Alpine environments and were strongly correlated with the ecotype Alpine Rocky-Ashy Moist Crowberry Dwarf Shrub.

Spodosols accounted for less than 2% of observations and included 2 observed subgroups, including Andic Haplocryods and Andic Humicryods. Spodosols are soils that have accumulations of translocated humus and aluminum and/or iron in the mineral subsurface. Spodosols occurred most commonly in Uplands on older, stable geomorphic landscapes, including forb meadows on Alluvial Fan Abandoned Deposits, and balsam poplar forests on Undifferentiated Coarse Abandoned Channel Deposit over lahar deposits. In ANIA spodosols were always associated with a thin (5–10 cm thick) layer of volcanic ash 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 thickness of the volcanic ash deposits were insufficient to classify these soils into the Andisols soil order, but were sufficient to classify them into Andic Subgroups.

Classification and Description of Soil Landscapes

Alpine Ashy-Sandy-Rocky Graminoid Meadows and Dwarf Shrub—This soil landscape encompasses two map ecotypes: Alpine Moist Graminoid Meadow and Alpine Mountain Heather-Luetkea Dwarf Shrub. It is found in mountainous areas above the limit of tall shrub growth, on coarse-textured colluvium or residuum with ash deposits either mantled at the surface or mixed into the surficial parent material. Dwarf ericaceous shrubs and alpine sedges, grasses, and forbs characterize the vegetation. This soil landscape is most prominent in the alpine zone of the Aleutian Range in the eastern portion of the study area. Soils are typically moist, well drained, and have had sufficient time for primary alumino-silicates to weather into short-range-order-materials. Andisols are the most common soil order. Over time, stable soils may weather into Spodic intergrades of Andisols, or Andic intergrades of Spodosols. Common soil subgroups include Andic Haplocryods, Humic Vitricryands, Spodic Haplocryands, Typic Haplocryepts, Typic Vitricryands, and Vitric Haplocryands. This soil landscape is rare, encompassing 1.5% of the study area.

Alpine Rocky Barrens and Dwarf Shrub—This soil landscape encompasses four map ecotypes: Alpine Dry Barrens, Alpine Moist Crowberry Dwarf Shrub, and Alpine Moist Willow Dwarf Shrub. It is extensive throughout the study area in mountainous areas above the limit of tall shrub growth. Vegetation ranges from barren to discontinous cover

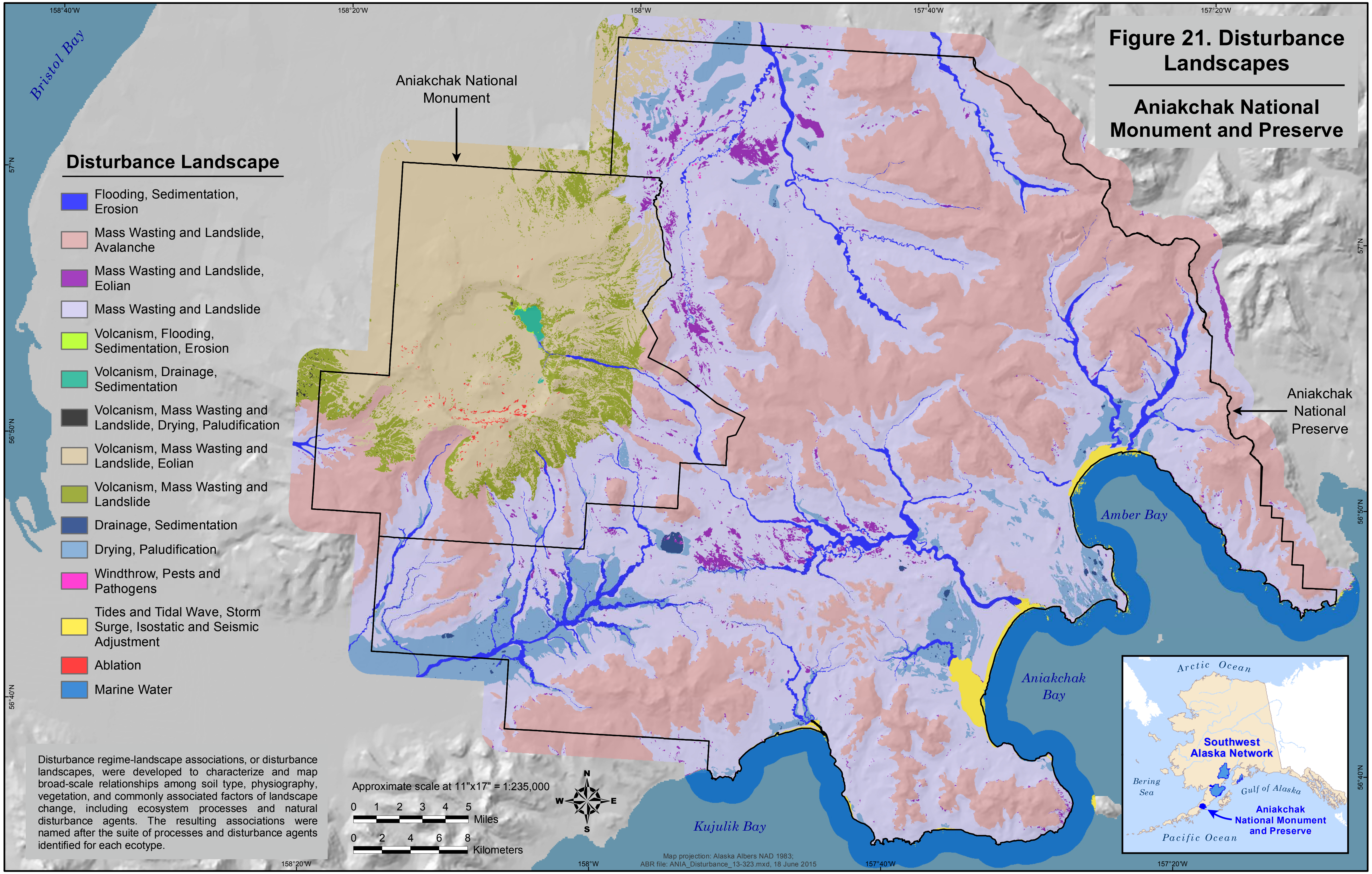


Figure 21. Disturbance landscapes map for Aniakchak National Monument and Preserve, southwest Alaska.

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Table 137. Area of disturbance landscape classes mapped in Aniakchak National Monument and Preserve, southwest Alaska.

Disturbance landscape	Area (km²)	% of study area*
Ablation	1.7	0.1
Drainage, Sedimentation	4.1	0.2
Drying, Paludification	132.2	4.8
Flooding, Sedimentation, Erosion	67.3	2.5
Marine Water	165.0	--
Mass Wasting and Landslide	1160.7	42.4
Mass Wasting and Landslide, Avalanche	851.7	31.1
Mass Wasting and Landslide, Eolian	38.0	1.4
Tides and Tidal Wave, Storm Surge, Isostatic and Seismic Adjustment	2<0.1	0.7
Volcanism, Drainage, Sedimentation	2.7	0.1
Volcanism, Flooding, Sedimentation, Erosion	0.3	<0.1
Volcanism, Mass Wasting and Landslide	77.3	2.8
Volcanism, Mass Wasting and Landslide, Drying, Paludification	0.4	<0.1
Volcanism, Mass Wasting and Landslide, Eolian	378.3	13.8
Windthrow, Pests and Pathogens	0.2	<0.1
Grand Total	2899.9	100.0

*% study area excludes marine water

dominated by dwarf shrubs. Soils are often shallow (<50 cm) or moderately deep (51 to 100 cm) to bedrock, and usually have abundant rock fragments at or near the soil surface (0 to 20 cm). Soils range from dry to moist depending on site characteristics. The degree of soil development in this soil landscape is highly variable, due to the range in parent material and the time since last disturbance. Soils forming in sedimentary parent material relatively distant from the caldera express the greatest degree of pedogenesis, with soil orders such as Mollisols, or Mollic intergrades of Inceptisols being possible. Soils forming in closer proximity to the caldera, on rubbly pyroclastic flow deposits, express the lowest degree of pedogenesis with soil orders such as Inceptisols and Andisols being the most prominent. Evidence of argillic horizon formation (clay appreciation) was recorded in this soil landscape, but this stage in soil formation is believed to be rare and of limited extent in the study area. The most prevalent soil subgroup in this soil landscape are Typic Vitricryands. Other common soil subgroups include Andic Haplocryepts, Andic Haplocryolls, Humic Vitricryands, Lithic Cryorthents, Lithic Haplocryepts, Lithic Haplocryolls, Lithic Humicryepts, Typic Haplocryolls, Typic Humicryepts, Typic Vitricryands, Vitrandic Cryorthents, Vitrandic Humicryepts, and Vitric Haplocryands. This is the most common soil landscape class, encompassing 29.6% of the study area.

Brackish Water—This soil landscape corresponds to the Brackish Water map ecotype. It is restricted to the Pacific coast in the south of the study area, and is of very limited extent. The most extensive patch occurs in the estuaries adjacent to Aniakchak Bay, where freshwater from Black Creek and the Aniakchak River mix with saline water. No soil profiles were described, but the water is alkaline (8.4 pH) and brackish and ranges in EC from 8000 to16,000 uS/cm. This soil landscape class is rare, encompassing 0.2% of the study area.

Coastal Sandy-Rocky Brackish Barrens and Wet Sedge—This soil landscape encompasses two map ecotypes: Coastal Tidal Barrens and Coastal Wet Brackish Sedge Meadow. It covers a very small proportion of the study area, but is common along the Pacific coast. This soil landscape occurs primarily on active beach deposits, as well as on tidal flats at the mouths of rivers and creeks. Additionally, this soil landscape is distributed in estuarine environments adjacent to the Brackish Water soil landscape. Soils are typically sandy and gravelly with an alkaline and brackish chemistry. This soil landscape characterizes wet meadows with halophytic vegetation. Soils that form in brackish estuaries are flooded

Table 138. Description of soil subgroups found in Aniakchak National Monument and Preserve, Alaska, 2014. 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). Descriptions have been generalized in many cases for readability. For official criteria for each soil subgroup, please refer to Soil Survey Staff (1999) and USDA NRCS (2010).

Soil Taxonomic Class				
Soil 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.
			Vitrandic Haplocryalfs	Haplocryalfs 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) of volcanic glass and accumulations of aluminum and iron in the soil subsurface.
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 periods of time (>50 years).
	Aquands			Andisols that have a thick (>20 cm) organic surface layer and are saturated for most, if not all, of the growing season.
		Cryaquands		Aquands that have formed in a cryic soil temperature regime.
			Histic Cryaquands	Cryaquands 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.
			Thaptic Cryaquands	Cryaquands that have a buried A- or O-horizon that is ≥10 cm thick. The material above the buried organic rich horizon is typically comprised of volcaniclastic material, or tephra-rich, loess deposits.
			Typic Cryaquands	Cryaquands that are typical for this great group.
	Cryands			Andisols that have formed in a cryic soil temperature regime.
		Duricryands		Cryands that have in 75% or more of the pedon, within 100 cm from the soil surface, a cemented horizon.
			Aquic Duricryands	Duricryands 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. Duricryands are prone to episaturation soil moisture conditions, whereby water moves laterally through the soil profile, on top of the cemented horizon.
			Eutric Duricryands	Duricryands that have weathered along an allophanic pathway (i.e., increased phosphate retention, higher pH, higher base saturation), as opposed to a podzolization pathway (i.e., increased iron and aluminum).
			Eutric Oxyaquic Duricryands	Similar chemical and physical properties as Eutric Duricryands, except that they experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
			Oxyaquic Duricryands	Duricryands that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.

Table 138. Continued.

Soil Taxonomic Class				
Soil Order	**Suborder**	**Great Group**	**Subgroup**	**Description**
Andisols (cont.)	Cryands (cont.)	Duricryands (cont.)	Typic Duricryands	Duricryands 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.
			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.
			Spodic Haplocryands	Haplocryands that have thick accumulations of translocated organic matter and Aluminum (Al), or organic matter, Al, and Iron (Fe).
			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.
		Vitricryands		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.
			Humic Vitricryands	Vitricryands that have a thick dark carbon-rich surface horizon and characteristically have a higher soil pH (>5.5).
			Lithic Vitricryands	Vitricryands that have bedrock contact within 50 cm of the mineral soil surface.
			Oxyaquic Vitricryands	Vitricryands that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
			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 ≥10 cm 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.
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.
	Fluvents			Entisols that have buried soil horizon(s) with an appreciation of organic carbon typically resulting from periodic flooding events.

Table 138. Continued.

Soil Taxonomic Class				
Soil Order	**Suborder**	**Great Group**	**Subgroup**	**Description**
Entisols (cont.)	Fluvents (cont.)	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.
			Andic Cryofluvents	Cryofluvents forming in weathered volcanic ejecta or pyroclastic materials and that do not meet the requirement for Andisols.
			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 (≥8 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.
			Lithic Cryorthents	Cryorthents that have bedrock contact within 50 cm 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.
	Psamments			Entisols that are sandy (soil texture class of loamy fine sand or sand) and have low abundance (<35%) of rock fragments (>2 mm).
		Cryopsamments		Psamments that have formed in a cryic soil temperature regime.
			Oxyaquic Cryopsamments	Cryopsamments that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
			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.
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.

Table 138. Continued.

Soil Taxonomic Class				
Soil Order	**Suborder**	**Great Group**	**Subgroup**	**Description**
Histosols (cont.)	Fibrists (cont.)	Cryofibrists (cont.)	Hydric Cryofibrists	Cryofibrists that have a layer of water within a depth of 0 to 160 cm from the soil surface (e.g. floating organic mat).
			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.
	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.
			Hydric Cryohemists	Cryohemists that have a layer of water within a depth of 0 to 160 cm from the soil surface (e.g., floating organic mat).
			Terric Cryohemists	Cryohemists that have a layer of mineral soil 30cm or more thick that has its upper boundary within 60 to 160 cm.
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 have formed in a cryic soil temperature regime.
			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.
			Histic Lithic 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 have bedrock contact within 50 cm of the mineral soil surface. These soils do not meet the requirements for Histosols.
	Cryepts			Inceptisols that have formed in a cryic soil temperature regime.
		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.
			Aquandic Dystrocryepts	Dystrocryepts that have a saturated anaerobic soil environment and redoximorphic depletions within 75 cm of the mineral soil surface and are forming in weathered volcanic ejecta or pyroclastic materials. These soils do not meet the requirement for Andisols.
			Andic Dystrocryepts	Dystrocryepts forming in weathered volcanic ejecta or pyroclastic materials and do not meet the requirement for Andisols.
			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.
			Typic Dystrocryepts	Dystrocrypets that are considered typical for this great group.

Table 138. Continued.

Soil Taxonomic Class				
Soil Order	**Suborder**	**Great Group**	**Subgroup**	**Description**
Inceptisols (cont.)	Cryepts (cont.)	Dystrocryepts (cont.)	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.
			Aquandic Haplocryepts	Haplocryepts that have a saturated anaerobic soil environment and redoximorphic depletions within 75 cm of the mineral soil surface and are forming in weathered volcanic ejecta or pyroclastic materials. These soils do not meet the requirement for Andisols.
			Andic Haplocryepts	Haplocryepts forming in weathered volcanic ejecta or pyroclastic materials and do not meet the requirement for Andisols.
			Lithic Haplocryepts	Haplocryepts that have bedrock contact within 50 cm of the mineral soil surface.
			Oxyaquic Haplocryepts	Haplocryepts that do not remain saturated throughout the growing season, but do 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.
			Typic Haplocryepts	Haplocryepts that are considered typical for this great group.
			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.
		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 ejecta or pyroclastic materials and do not meet the requirement for Andisols.
			Fluventic Humicryepts	Humicryepts have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
			Lithic Humicryepts	Humicryepts that have bedrock contact within 50 cm of the mineral soil surface.
			Typic Humicryepts	Humicryepts that are considered typical for this great group.
			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
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.
		Argicryolls		Cryolls that have an argillic horizon, i.e., a soil horizon with a significantly higher percentage of clay than an overlying horizon.
			Lithic Argicryolls	Argicryolls that have bedrock contact within 50 cm of the mineral soil surface.
		Haplocryolls		Mollisols that do not classify into any other great group of Cryolls.

Table 138. Continued.

Soil Taxonomic Class				
Soil Order	**Suborder**	**Great Group**	**Subgroup**	**Description**
Mollisols (cont.)	Cryolls (cont.)	Haplocryolls (cont.)	Andic Haplocryolls	Haplocryolls forming in weathered volcanic ejecta or pyroclastic materials and do not meet the requirement for Andisols.
			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.
		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 ejecta or pyroclastic materials.
		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 ejecta or pyroclastic materials.

or permanently saturated, and classify into Aquent or Aquept suborders. Soils that form on active beach deposits, with a fluctuating water table dependant on the tide, classify as Oxyaquic Cryorthents. This soil landscape class is rare, encompassing 0.2% of the study area.

Coastal Sandy-Rocky Moist Grass Meadow—This soil landscape encompasses a single map ecotype, Coastal Moist Grass Meadow. Of the two coastal soil landscapes, this one extends the farthest inland. The Coastal Sandy-Rocky Moist Grass Meadow represents vegetation succession on inactive beach deposits, as well as on active and inactive sand dunes. This soil landscape rarely occurs outside of large protected bays with sandy shores, due to the fact that the deposition and accumulation of deep sandy deposits is necessary for this soil landscape to develop. When rocks do occur in the soil profile, they are generally well below the primary rooting zone (>40 cm). Soil chemistry is non-brackish (EC <800 uS/cm) and ranges from alkaline to circum-basic on active coastal deposits, to circum-neutral on inactive dunes. The greatest extent of this soil landscape occurs on sand dunes adjacent to Aniakchak, Amber and Kujulik Bays. The predominant subgroup for this soil landscape are Typic Cryopsamments. Other common subgroups include Oxyaquic Cryofluvents, Oxyaquic Cryopsamments, and Vitrandic Cryopsamments. This soil landscape class is rare, encompassing 0.3% of the study area.

Lacustrine Organic-rich Wet Sedge Meadows and Forb Marshes—This soil landscape encompasses two map ecotypes: Lacustrine Organic-rich Forb Marsh and Lacustrine Wet Sedge-Forb Meadow. It is of limited extent in the study area, and occurs almost exclusively at the outlet of Surprise Lake in the caldera, and within the Meshik River valley. One explanation for the limited extent of this soil landscape, is the presence of a cemented horizon (i.e., welded ignimbrite) at depth. Pyroclastic flow deposits once flowed from the caldera through present-day river valleys, reaching the Bering Sea and north Pacific on either side of the Alaska Peninsula. Some pyroclastic flows were hot enough to weld the ignimbrite into a soil horizon cemented by silica. This cemented horizon, or duripan, in the subsurface soil of the Meshik River valle, reduces water infiltration rates and water holding capacity. The depth to water table for this soil landscape is ponded at or near the soil surface. Soils form in saturated, anaerobic conditions and may accumulate moderately thick surface organic horizons over time. This soil landscape appears to be sensitive to fluctuations in average annual precipitation whereby aquatic sites, with hydrophytic vegetation, lack ponded water at the surface in a low snow and/or low rainfall year. The lithological discontinuity in this soil (i.e., loamy or organic lacustrine deposits over rubbly welded or non-welded pyroclastic flow deposits) may further inhibit the water holding capacity of these soils from one growing season to the next. Vegetation is characterized by wet herbaceous meadows and marshes. The formation of organic soils, or histic epipedons on mineral soils, is common for this soil landscape. Typical soil subgroups include Aquandic Dystrocryepts, Fluvaquentic Cryohemists, Histic Cryaquands, Histic Cryaquepts, Hydric Cryohemists, Terric Cryofibrists, and Typic Cryaquands. This soil landscape class is rare, encompassing 0.2% of the study area.

Lacustrine Rocky Drained Lake Barrens—This soil landscape corresponds to the Lacustrine Drained Lake Barrens map ecotype. This soil landscape is of extremely limited extent in the study area and was mapped exclusively in the dry, rocky barrens associated with the spring seasonal high water mark of Surprise Lake. This soil landscape also occurs elsewhere in the study area, but usually could not be mapped because the features are usually too small to resolve in the 30 m resolution Landsat imagery used to produce the USFWS Land Cover Map. It is also possible that some of these basins were full of water at the time that base imagery was acquired. Drained lake sediments were present in the Aniakchak River valley, near the confluence of the North Fork of the Aniakchak River, at the time that ABR completed this study. This soil landscape is associated with lakes that formed above welded ignimbrite deposits in old pyroclastic flow deposits. Vegetation is barren or sparsely vegetated. One plot was sampled and classified as an Aquic Duricryands. This soil landscape class is extremely rare, encompassing <0.1% of the study area.

Lowland Lake—This soil landscape corresponds to the Lowland Lake map ecotype. It includes freshwater lakes in all physiographic areas, except Volcanic, within the survey boundary. These lakes vary in size from the largest, Meshik Lake (surface area 26.7 ha), to the small unnamed lakes (<5 ha). The Lowland Lake soil landscape formed in concave depressions above impermeable, welded pyroclastic flow deposits or above bedrock-controlled benches near the coast. Water chemistry is typically alkaline (>7.3 pH) but may range to circumneutral (5.6 to 7.3 pH). EC values are expected to be relatively low (<150 uS/cm). The vast majority of lakes in ANIA are shallow lakes, including Meshik, and over time they are succestible to filling in with vegetation through a process known as paludification. This soil landscape class is rare, encompassing 0.2% of the study area.

Lowland Organic-rich Wet Sedge Bog Meadows and Dwarf Shrub—This soil landscape corresponds to the Lowland Wet Sedge-Shrub Bog Meadow map ecotype. It is often spatially associated with both the Lowland Lake and the Lowland Organic-rich Wet Sedge Meadows and Low Willow Shrub soil landscapes, as it represents the late successional stage linking these soil landscapes within a successional sequence. Soils typically exhibit a lithological discontinuity of moderately thick to thick surface organics over tephra-rich lacustrine deposits over coarse, welded ignimbrite. Soils that formed in paludified lakes above bedrock generally have moderately thick organic horizons over tephra-rich lacustrine deposits and bedrock. The bedrock-controlled wetlands ocurr almost exclusively in the vicinity of Cape Ayutka, on the marine terrace that separates Aniakchak Bay from Amber Bay. The Lowland Organic-rich Wet Sedge Bog Meadows and Dwarf Shrub soil landscape is associated with wet, bog vegetation dominated by dwarf ericaceous shrubs, sedges and mosses. Soils are saturated, form in an anaerobic moisture environment, and have a water table at or near the soil surface. Soil chemistry ranges from acidic to circum-acidic (5.0 to 7.0 pH) due to the acidifying influence of Sphagnum mosses. Organic soils or mineral soils with histic epipedons are likely to develop in this soil landscape. Common soil subgroups include Fluvaquentic Cryofibrists, Fluvaquentic Cryohemists, Histic Cryaquands, Histic Lithic Cryaquepts, Terric Cryofibrists, Terric Cryohemists, Thaptic Cryaquands and Typic Cryaquands. This soil landscape class is rare, encompassing 2.4% of the study area.

Lowland Organic-rich Wet Sedge Meadows and Low Willow Shrub—This soil landscape includes two map ecotypes: Lowland Wet Sedge Meadow and Lowland Wet Willow Low Shrub. It is spatially associated with both the Lowland Lake and Lowland Organic-rich Wet Sedge Bog Meadows and Dwarf Shrub soil landscapes, as it represents the early- to mid vegetation succession stage for these three soil landscapes. Vegetation is dominated by hydrophytic sedges and/or low willows. Soils are saturated, form in an anaerobic moisture environment, and have a water table at or near the soil surface. Soils from this soil landscape are very similar to the Lowland Organic-rich Wet Sedge Bog Meadows and Dwarf Shrub, in that they typically develop moderately thick to thick surface organic horizons over time and are classified either as organic soils or mineral soils with histic epipedons. This soil landscape differs from the bog soil landscape in that the hydrologic regime is dominated by freshwater inputs (e.g., groundwater or inflowing streams) in a fen system, as opposed to precipitation in a bog system. Soils typically exhibit a lithological discontinuity of moderately thick to thick surface organics over tephra-rich lacustrine deposits over coarse welded ignimbrite. Soils that formed in paludified lakes above bedrock, generally have moderately thick organic horizons over tephra-rich lacustrine deposits over bedrock. Soil chemistry ranges from circum-neutral to alkaline (6.0 to 9.2 pH). Typical soil subgroups include Fluvaquentic Cryofibrists, Fluvaquentic Cryohemists, Histic Cryaquands, Histic Lithic Cryaquepts, Terric Cryofibrists, Terric Cryohemists, Thaptic Cryaquands, and Typic Cryaquands. This soil landscape class is rare, encompassing 2.3% of the study area.

Marine Water—This soil landscape encompasses one map ecotype, Marine Water, and represents saline waters of the Pacific Ocean that bound the study area to the southeast. Small inclusions of marine waters were mapped in coastal features, like Brackish Lagoons. This soil landscape was excluded from study area estimates of cover.

Riverine Loamy-Organic Wet Sedge Meadow—This soil landscape encompasses one map ecotype, Riverine Loamy-Organic Wet Sedge Meadow. It has a limited spatial extent in the study area, and is most widespread along Lava Creek to the northeast and the Meshik River to the southwest. This soil landscape often occurs near the confluence of smaller drainage channels with larger river systems. The geomorphology for this soil landscape includes inactive floodplains along meandering rivers and small streams. Vegetation is dominated by hydrophytic sedges. Soils form in saturated alluvial sediments with the water table often ponded just above the soil surface. Soils are usually stratified with buried organic horizons. They occur on surfaces adjacent to flowing water that do not flood every year. The longer flood return intervals supports the accumulation of moderately thick organic mats over time. Poorly developed Entisols or weakly developed Inceptisols with histic epipedons are the result. Typical soil subgroups include Histic Cryaquepts and Aquandic Cryaquents. This soil landscape class is extremely rare, encompassing <0.1% of the study area.

Riverine Rocky Barrens and Alder Tall Shrub—This soil landscape encompasses two map ecotypes: Riverine Barrens and Riverine Rocky Moist Alder-Willow Tall Shrub. It occurs on coarse alluvial sediments on active and inactive floodplains and is present, to some degree, in every major watershed in the study area. Vegetation cover ranges from barrens on frequently flooded surfaces, to dense tall shrub thickets on infrequently flooded surfaces. Sites with a frequent flood return period form in stratified sandy and rocky alluvial sediments, and lack a surface organic mat. Less frequently disturbed sites may accumulate a very thin layer of surface organics, and/or a thin mantle of coarse-ashy tephra, which overlies stratified sandy and rocky alluvial sediments. The rocky parent material is primarily volcaniclastic coarse fragments that have been transported downstream, but may include sedimentary rock fragments from the Aleutian Range. Soils are well drained with a water table usually 100 cm below the soil surface. The soils are young, poorly developed Entisols. Typical soil subgroups include Typic Cryofluvents, Typic Cryorthents, Vitrandic Cryofluvents, and Typic Cryofluvents. This soil landscape class is rare, encompassing 0.7% of the study area.

Riverine Silty-Sandy-Rocky Forb Meadows and Willow Shrub—This soil landscape encompasses three map ecotypes: Riverine Moist Forb Meadow, Riverine Moist Willow Low Shrub, and Riverine Moist Willow Tall Shrub. It occurs primarily on active and inactive overbank deposits along riparian corridors. Of the three soil landscapes that characterize alluvial soils, this one is the most extensive. Vegetation succession is in mid- to late seral stage. Low and tall willow communities dominate this soil landscape, and to a lesser extent, moist herbaceous meadows. Soils are less likely to be disturbed by flooding events and express the greatest degree of pedogenesis within the three Riverine soil landscapes. Soils often have sufficient time to weather short-range-order materials or metal-humus complexes, and express andic soil properties in weakly developed Entisols and Inceptisols. Soils are moist, well drained, and the depth to water table is typically greater than 100 cm.. Soils are stratified with varying soil textures and often have buried organic horizons lower in the soil profile. Typical soil subgroups include Andic Cryofluvents, Andic Humicryepts, Aquandic Haplocryepts, Fluventic Humicryepts, Oxyaquic Cryofluvents, Typic Cryofluvents, Vitrandic Cryofluvents, Vitrandic Haplocryepts. This soil landscape class is rare, encompassing 1.6% of the study area.

River Water—This soil landscape encompasses one map ecotype, Riverine Water, and represents non-glacial rivers and streams in ANIA. River Water includes both small headwater streams, and large rivers that receive their water from non-glacial sources and are characterized by being clear, predominantly silt-free, and having a circum-basic to alkaline water chemistry. Examples include the Aniakchak and Meshik Rivers. This soil landscape class is rare, encompassing 0.2% of the study area.

Snow or Ice—This soil landscape encompasses the Perennial Snow and Ice map ecotype. It includes areas of persistent snow and ice cover. It occurs only on the north-facing slopes of Aniakchak Peak. This soil landscape class is rare, encompassing 0.1% of the study area.

Upland Ashy-Loamy-Rocky Balsam Poplar Forest—This soil landscape encompasses one map ecotype, Upland Moist Balsam Poplar Forest. It occurs in small, isolated pockets in the northern portion of ANIA in the Cinder River valley. This soil landscape represents the western limit of trees on the Alaska Peninsula, and includes some of the most well-developed soils in the study area. Soils tend to be highly stratified as they are former alluvial sediments comprised primarily of volcaniclastic materials. Unlike the majority of Andisols in this study area that form via an allophanic pathway, this soil landscape expresses a podzolization pedogenic pathway, forming Spodosols or Spodic intergrades of Andisols. Common soil subgroups include Typic Vitricryands, Andic Haplocryods, and Andic Humicryods. This soil landscape class is extremely rare, encompassing <0.1% of the study area.

Upland Ashy-Loamy-Rocky Forb Meadows and Alder Tall Shrub—This soil landscape includes two map ecotypes: Upland Moist Alder Tall Shrub and Upland Moist Forb Meadow. It is the second-most extensive soil landscape in the study area and occurs across broad elevation gradients (0–420 m), a variety of aspects, and in a wide range of parent materials. The tall alder communities often forms a mosaic with the forb meadows, whereby the alder occupies steeper slopes or convex positions, and the herbaceous meadows are on more stable planar or concave slopes. Coarse fragments may be of volcaniclastic or sedimentary origin, with rocks usually within 30 cm of the soil surface. In contrast, herbaceous meadows often have a loamy or tephra-rich, loess mantle as opposed to soils forming under alder communities. Soils are generally moist, well drained, and have a water table >100 cm deep. Exceptions include alder communities with a fluctuating water table due to seasonal surface water run-off over an impermeable duripan, or in perennial drainage channels on steep slopes. Over time, moderately thick surface organic horizons may develop; such soils are classified as Inceptisols with folistic epipedons. The rough slope break of 30 degrees influences both vegetation, and soil development in this soil landscape. Steep slopes greater than 30 degrees typically lack herbaceous meadows and the Andisol soil order, and are limited in pedogenesis, forming weakly developed Inceptisols or poorly developed Entisols. Slopes less than 30 degrees can accommodate either tall shrub or meadow, and barring disturbance, may weather to well developed Andisols or moderately developed Inceptisols. Typical soil subgroups include Andic Haplocryepts, Andic Humicryepts, Folistic

Dystrocryepts, Folistic Haplocryands, Humic Vitricryands, Oxyaquic Cryorthents, Oxyaquic Duricryands, Oxyaquic Haplocryepts, Spodic Haplocryands, Spodic Vitricryands, Typic Cryorthents, Typic Dystrocryepts, Typic Haplocryepts, Typic Vitricryands, Vitrandic Cryorthents, Vitrandic Dystrocryepts, Vitrandic Haplocryepts, Vitrandic Humicryepts, and Vitric Haplocryands. This soil landscape class is the second most common, encompassing 21.2% of the study area.

Upland Ashy-Rocky Barrens and Dwarf Shrub—This soil landscape encompasses two map ecotypes: Upland Crowberry Dwarf Shrub and Upland Dry Barrens. It is extensive in the study area, and occupies different geomorphic landscape positions along a west-to-east gradient extending from Aniakchak Crater. West of the Cinder and Aniakchak River watersheds, this soil landscape primarily occupies low sloping valley bottoms (0 to 15 degrees) where pyroclastic flows once surged from the Aniakchak volcano to the sea on either side of the Alaska Peninsula. Farther away from Aniakchak Crater, in the rugged terrain of the Aleutian Range, this soil landscape is typically found on steep backslope positions and active river valleys with barren or dwarf shrub cover. Due to the resolution of the Landsat base imagery used in the land cover mapping, a riverine barrens with dwarf shrub could not be mapped; however, in terms of vegetation and soil development, these aggregated upland and riverine soils behave similarly. The two major differences are disturbance pathway (i.e., frequent flooding in riverine area versus no flooding on slopes), and the lack of pyroclastic flow deposits in the eastern part of the study area (e.g., Yantarni Creek). Soils are coarse-textured, range from moderately well to well-drained, and typically have greater than 15% rock fragments within 20 cm of the soil surface. Soils that formed on pyroclastic flow deposits with welded ignimbrite have a root-restricting horizon, or duripan, at depth. Presence of a duripan in the soil profile may retard water infiltration rates and slow vegetation establishment and succession. Soils that form on steep mountain backslopes are comprised of coarse-textured, rocky colluvium, and are prone to erosion. This soil landscape was undersampled in the eastern part of the study area in the Aleutian Range; it is assumed that poorly developed Entisols or weakly developed Inceptisols form in those environments. Soils that formed in the western part of the study area were well represented in the field dataset, and readily weather into weakly developed Andisols. Typical soil subgroups for the western portion of the study area include Andic Dystrocryepts, Eutric Duricryands, Folistic Vitricryands, Humic Vitricryands, Thaptic Vitricryands, Typic Duricryands,Typic Haplocryands,Typic Vitricryands, Vitrandic Cryopsamments, Vitrandic Cryorthents, and Vitric Haplocryands. This soil landscape is the fourth most common, encompassing 11.9% of the study area.

Upland Ashy-Sandy-Rocky Willow Low and Tall Shrub—This soil landscape encompasses two map ecotypes: Upland Moist Willow Low Shrub and Upland Moist Willow Tall Shrub. It occurs on gentle to moderate slopes (0 to 15 degrees) in broad river valleys, primarily on toeslope and footslope positions. The vegetation in this soil landscape represents mid- to late- seral succession on non-welded pyroclastic flow deposits, rocky colluvium, and abandoned floodplain or terrace deposits. Low or tall willow dominates the overstory. Soils are moist, well drained, and typically have greater than 15% rock fragments within the upper 20cm of the soil profile. Both allophanic and non-allophanic Andisols are possible. Non-allophanic Andisols are more acidic (pH <5.6) and tend to form weak spodic horizon via the podzolization process (Lundstrom et al. 2000). The most common soil subgroup for this soil landscape are Typic Vitricryands. Other soil subgroups include Andic Dystrocryepts, Folistic Haplocryands, Humic Vitricryands, Spodic Haplocryands, Spodic Vitricryands, Thaptic Vitricryands, and Vitrandic Humicryepts. This soil landscape is the fifth most common, encompassing 10.7% of the study area.

Volcanic Lake—This soil landscape corresponds to the Volcanic Lake map ecotype. It occurs exclusively within the Aniakchak Caldera and represents Surprise Lake and an unnamed maar located below Blacknose. Water chemistry is influenced in part or wholly by volcanic hydrology, including volcanic streams and springs. No plots were described in this ecotype. This soil landscape class is rare, encompassing 0.1% of the study area.

Volcanic Rocky-Ashy Dwarf Shrub—This soil landscape corresponds to the Volcanic Dry Dwarf Shrub map ecotype. It occurs primarily on the slopes of the Anicakchak caldera, on a variety of aspects at high elevation (approx. >274 m). Vegetation represents early succession on young volcaniclastic deposits with an overstory dominated by dwarf shrubs. Soils range from dry to moist, well- to somewhat excessively well-drained, and are typically rocky throughout the soil profile. Soils are poorly developed Andisols or weakly developed Entisols. Soil subgroups include Typic Vitricryands and Vitrandic Cryorthents. This soil landscape class is rare, encompassing 2.8% of the study area.

Volcanic Rocky-Ashy Forb Meadows and Low Willow Shrub—This soil landscape encompasses one map ecotype, Volcanic Willow Low Shrub. It is of limited extent in the study area, occurring largely on the outer flanks of the caldera near the transition to upland physiography. The greatest spatial coverage is near the headwaters of Barbara Creek, in the southwestern portion of the Volcanic physiography. In the caldera, this soil landscape is of limited extent but is closely associated with the Volcanic Rocky Wet Sedge Meadows soil landscape, as the two often occur adjacent to one another. Vegetation is characterized by either large umbel meadows, or low shrub overstory dominated by willows. Soils range from moist to wet, with a water table typically within the primary rooting zone at some time during the growing season (15–50 cm). Soils are often rocky throughout and range from weakly developed Entisols to poorly developed Andisols. Soil subgroups include Aquandic Cryaquents, Oxyaquic Vitricryands, Typic Cryaquands, Vitrandic Cryofluvents, and Vitrandic Cryorthents. This soil landscape class is rare, encompassing 0.1% of the study area.

Volcanic Rocky Barrens, Lichen, and Beach Rye—This soil landscape encompasses two map ecotypes: Volcanic Dry Beach Rye Cinder Plain and Volcanic Dry Lichen and Barrens. It occurs on a variety of volcanic landforms, including the caldera rim and surrounding slopes, as well as tephra and lava deposits within the caldera. Soils are rocky and young, with a depth to abundant coarse fragments typically at or near the soil surface. Soil chemistry ranges from being alkaline to circumneutral (5.0 to 7.7 pH). Soils range from dry to moist and somewhat excessively- to excessively well drained. In rare cases, this soil landscape is characterized by a unique hydrology, whereby subsurface water movement may be restricted and lead to episodes of saturation during the growing season, may occur on sites with welded ignimbrite within the upper 100 cm of the soil profile. This is the most extensive soil landscape in the Volcanic physiography, occurring on slopes ranging from 0 to 47 degrees, and elevation ranging from 144 m to 888 m. Vegetation cover ranges from barren or patchy to lichen or graminoid cover. Soils range from weakly developed Entisols to poorly developed Andisols. Soil subgroups include Eutric Duricryands, Lithic Vitricryands, Oxyaquic Duricryands, Typic Cryorthents, Typic Vitricryands, Vitrandic Cryofluvents, Vitrandic Cryorthents, Vitric Haplocryands. This soil landscape is the third most common, occupying 13.8% of the study area.

Volcanic Rocky Wet Sedge Meadows—This soil landscape encompasses one map ecotype, Volcanic Wet Sedge Meadow. This soil landscape is of very limited extent, occupying wetland areas near the headwaters of Surprise Lake within the Aniakchak caldera. This is one of the more productive ecotypes in the Volcanic physiography, demonstrated by a significant accumulation of organic material at the soil surface (18.0 cm). The freshwater meadows are dominated by *Carex lyngbyaei* and have low species diversity. The soil moisture regime for this ecotype may fluctuate with local hydrology, and while the soils are likely always saturated, soils may not always develop in anaerobic conditions. Dominant soil texture classes may include Rubbly, Pumiceous, Blocky or Sandy, and the depth to greater than 15% rock fragments is within the upper 20 cm of the soil profile. This ecotype may be flooded seasonally with a depth to water table ranging from just above, to just below, the soil surface. Soil chemistry is influenced by alkaline freshwater springs in the caldera (8.5 pH), and electrical conductivity was low (180 uS/cm). One plot, Aquandic Cryaquents, was described and classified in this soil landscape. This soil landscape class is extremely rare, encompassing <0.1% of the study area.

Volcanic Streams and Springs—This soil landscape encompasses one map ecotype, Volcanic Streams and Springs. It is restricted to freshwater streams and brackish warm springs in the Aniakchak caldera. This is an aquatic soil landscape that supports algae and a limited variety of herbaceous species. According to a NPS water quality investigation in 2003, temperatures at warm springs within the caldera had limiting physical (i.e., high temperature) and chemical characteristics (i.e., high pH and low dissolved oxygen) that were restricting juvenile and adult salmonid migration (Bennett 2004). Water quality is circumneutral (pH = 6.2) with a low EC in freshwater streams, and alkaline (pH = 8.2) with a slightly brackish EC (1110 uS/cm) in warm springs. Soil subgroups were not classified for this ecotype. This soil landscape class is extremely rare, encompassing <0.1% of the study area.

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 ANIA is synthesized below, based on our results and a review of the relevant literature.

Tectonic Setting and Physiography

ANIA is situated on the Alaska Peninsula, an approximately 800 km long southwest extension of mainland Alaska, separating the Pacific Ocean to the east from the Bering Sea to the west (Detterman et al. 1996). The Aleutian Range, formed from uplifted Mesozoic sedimentary rocks, predominates in northern and eastern ANIA. Bedrock is predominantly interbedded sandstone and shale. To the southwest, Aniakchak Volcano dominates the landscape, including the Aniakchak Caldera composed of Quaternary volcanic bedrock and associated volcanic deposits, including volcanic ash and lahar deposits.

Climate

ANIA experiences a maritime climate regime characterized by cool summers and mild winters, with frequent cloud-cover throughout the year. The central Alaska Peninsula lies in a region of persistent low pressure often referred to as the "Aleutian low" and experiences frequent storms, especially in fall and winter. A significant regional climate gradient exists across the park, with much more precipitation and somewhat milder winters along the Pacific coast, where the north Pacific Ocean moderates diurnal and seasonal changes in air temperature and provides a ready source of moisture for storms. At Chignik, on the Pacific coast approximately 55 km southwest of the park, the mean summer temperature (June–August) is 11.0°C, the mean winter temperature (December–February) is -2.8°C, and the the mean annual temperature is 3.6°C (period of record 1927–1978) (WRCC 2015a). Total precipitation at Chignik averages 211.5 cm. At Port Heiden, on the Bering Sea coast approximately 20 km west of ANIA, the mean summer temperature is 10.3 °C, the mean winter temperature is -5.1°C, and the mean annual temperature is 2.4°C (period of record 1942–1988) (WRCC 2015b). Total precipitation at Port Heiden averages only 38.6 cm. In addition to the regional-scale climate gradient, strong elevational climate gradients are prevalent at the landscape-scale due to ANIA's mountainous terrain. This topographic relief has strong effects on temperature and precipitation regime. After encountering mountainous terrain, moisture-laden air from the north Pacific is forced upward and undergoes adiabatic cooling, which lowers the moisture-holding capacity of the air and results in abundant precipitation at high elevations. Thus. the rim of Aniakchak Crater and the high ridges of the Aleutian Range receive much more abundant winter snowfall than areas at low elevation.

The elevational climate gradients described above have a strong influence on geomorphic- and soil-development processes that result in recurring, predictable patterns of soil landscape distribution. For example, in cold alpine environments, soil development is very slow due to the low rates of organic input, soil respiration, and microbial decomposition. Alpine areas tend to be dominated by weakly-developed soil orders, such as Entisols and Inceptisols, even in areas with relatively old surficial deposits (e.g., exposed ridges where tephra deposits tend to be removed by hillslope processes and wind). In contrast, soils at low elevation usually exhibit stronger soil development, such as Spodosols, which are strongly leached and have high concentrations of weathered iron and aluminum.

ANIA's location at high latitude also results in strong local-scale differences in microclimate, due to differences in insolation as a function of slope and aspect. North-facing slopes are strongly shaded and therefore tend to have lower soil temperatures, lower evapotranspiration rates, fewer frost-free days, more persistent snow-cover, and higher available soil water during the growing season, compared to south-facing slopes (Barry and Van Wie 1974). Additionally, redistribution of snow by wind results in sharp, local-scale contrasts in snowpack depth and persistence, which affect physical and chemical weathering processes. For example, nivation hollows are a geomorphic feature frequently associated with snowbed microsites. Here, repetitive cycles of freeze-thaw at the base of the snowpack tend to promote frost-shattering. Additionally, infiltration of abundant snowmelt leaches cations from the soil and promotes acidic soil chemistry.

Due to the rugged terrain of ANIA and the high snowfall in alpine terrain, local-scale differences in the depth and persistence of the snowpack lead to strong contrasts in vegetation composition and structure, particularly in Alpine and physiography. Differences in snow regime are largely the result of the redistribution of snow by wind (Johnson and Billings 1962). Convex slope positions are the most exposed to wind, and are areas of net snow loss during the winter. Exposed slopes therefore are less protected from winter desiccation and removal of fine-textured material, and usually have lower available water. Vegetation is often sparse and discontinuous, and soils tend to be rocky and poorly developed (e.g., Alpine Rocky Dry Barrens ecotype). Concave slope positions develop much thicker, persistent snowpacks. These slope positions usually have moister soils, and the snow protects vegetation from winter desiccation and abrasion by spindrift. For example, the Alpine Ashy-Loamy-Rocky Mountain Heather-Luetkea Dwarf Shrub ecotype is a good indicator of snowbed microsites. Such sites are more likely to retain fine-textured material that is deposited by wind, or weathered *in situ*. As a result, soils in these areas tend to be finer in texture and support greater vegetation cover.

Volcanism

Volcanic events have continuously shaped, and reshaped landscapes of the Alaska Peninsula. The renowned volcanic landscapes in and near Aniakchak Crater first drew widespread attention in the 1930s (Hubbard 1935) and later motivated the area's designation as a national parkland. The Alaska Peninsula comprises the northernmost part of the Pacific "Ring of Fire" (Gaul 2007), a highly active subduction zone that extends along the eastern Aleutian Arc. Over 40 historically active volcanoes exist within the Aleutian Arc, one of which—Aniakchak volcano—has had an overwhelming influence on past and present-day ecosystems of ANIA. Aniakchak volcano has been active since the early Pleistocene (~850,000 YBP) (Neal et al. 2001) and at least 40 eruption events are thought to have occurred over the last 10,000 years (Riehle et al. 1999). Thus, eruptive products have been progressively stacked one upon another, and modified both by direct and indirect impacts of subsequent volcanism, Pleistocene glacial dynamics, and other disturbance mechanisms such as the outburst flood of Aniakchak's caldera lake ~900 YBP (McGimsey et al. 1994, Waythomas et al. 1996). Modern-day surficial features of ANIA, however, predominantly reflect the caldera-forming eruption of Aniakchak ca. 3,590 cal yr B.P, which had catastrophic regional-scale impacts and affected the global climate system (Miller and Smith 1987, Bacon et al. 2014). Additionally, many intracaldera features, such as Vent Mountain, Vulcan Dome, Bolshoi Dome, and Main Crater are the result of smaller eruptions during the late Holocene, the most recent of which took place in 1931.

Given the near-total mortality of vegetation and the immense volume of volcanic material deposited on the landscape during the caldera-forming eruption, large portions of ANIA remain in early stages of ecological succession. Early-successional environments are abundant in the northwestern quarter of the park near Aniakchak Crater, especially on the caldera's northern and western flanks, where large volumes of tephra were carried by prevailing winds at the time of the caldera-forming eruption. Valleys to the east and south of the caldera, such as the Cinder River watershed, were affected by large, highly mobile pyroclastic flows (Miller and Smith 1977, Riehle et al. 1987, Beget and Anderson 1992, Neal et al. 2001, VanderHoek and Myron 2004). Much of Aniakchak Caldera and the flanks of Aniakchak volcano still resemble a barren moonscape. Yet, vegetation development has been relatively swift in recent decades in some areas. Comparison of high-resolution aerial and satellite photography from 1957, 1983, and 2007 reveal conspicuous increases in cover of willow and alder shrubs on the northern flanks of Aniakchak volcano (Figure 22). Shrub increase in these areas illustrate transitions from primary successional ecotypes, such as Volcanic Rocky Dry Barrens and Volcanic Rocky Moist Bryophyte, to Upland Ashy-Sandy-Rocky Moist Willow Low Shrub. Over the past 50 years, shrubland development has been most apparent as infilling along the margins of pre-existing shrub stands, and along small drainages that dissect the thick tephra deposits. These patterns likely reflect the ameliorating effects of concave, moisture-gathering landscape positions, as well as the presence of established vegetation, which provides protection from wind and a ready source of seed. Photo comparisons of pyroclastic deposits in the Cinder River valley also indicate dramatic local-scale differences in the pace and trajectory of vegetation development (Figure 23). Here, tall shrub increase is apparent across much of the landscape, but remarkably little change has occurred on barren pyroclastic deposits. The lack of vegetation development on some pyroclastic deposits is likely due to the presence of an underlying duripan, or root-restricting layer, associated with welded pyroclasts. In Aniakchak caldera, where extensive vegetation mortality occurred following the eruption of 1931, primary succession has been very slow except in favorable microenvironments such as the alluvial flats at the head of Surprise Lake, and the sheltered coves along the lake's southwest shore (Figure 24). Repeated ground photographs vividly illustrate the rapid pace of vegetation

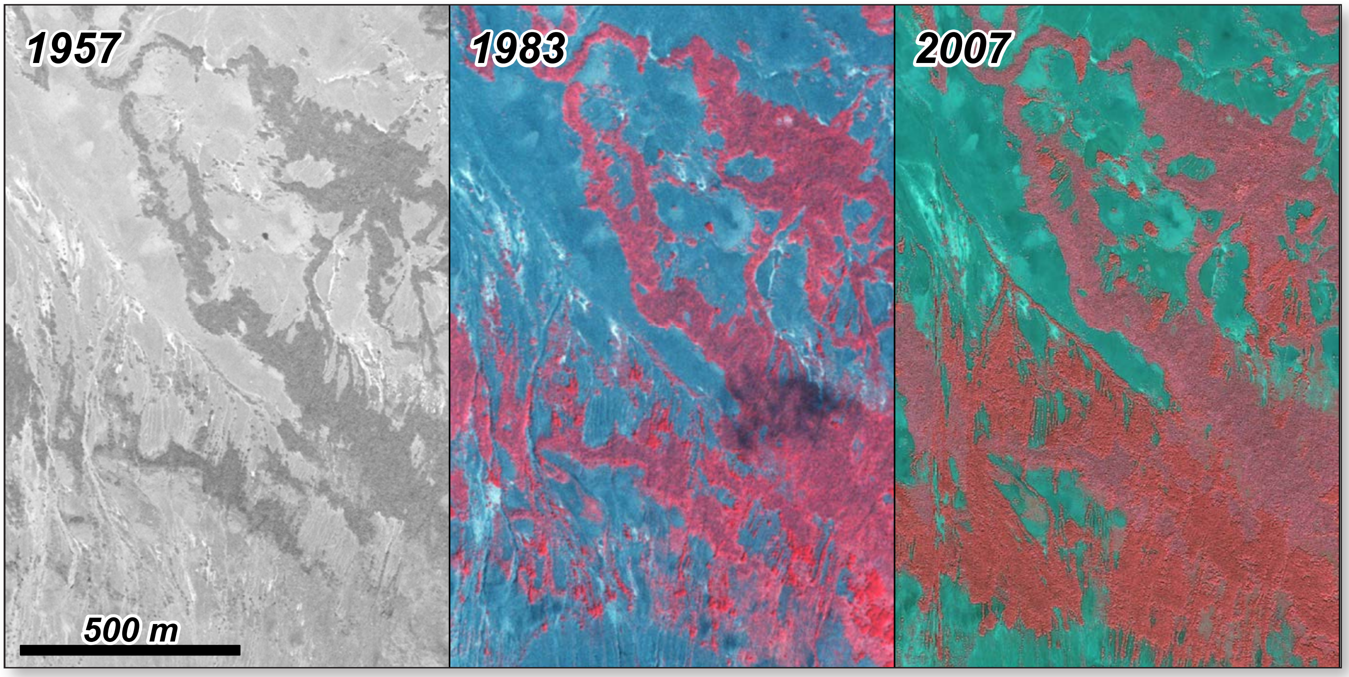

Figure 22. Comparison of shrub cover on tephra deposits mantling northeast flank of Aniakchak volcano in 1957 (panchromatic airphoto), 1983 (CIR airphoto), and 2007 (CIR satellite image). In the CIR imagery, willow shrublands are pinkish and alder shrublands are scarlet. Cover of willow and especially alder has increased dramatically over the 50-year interval.

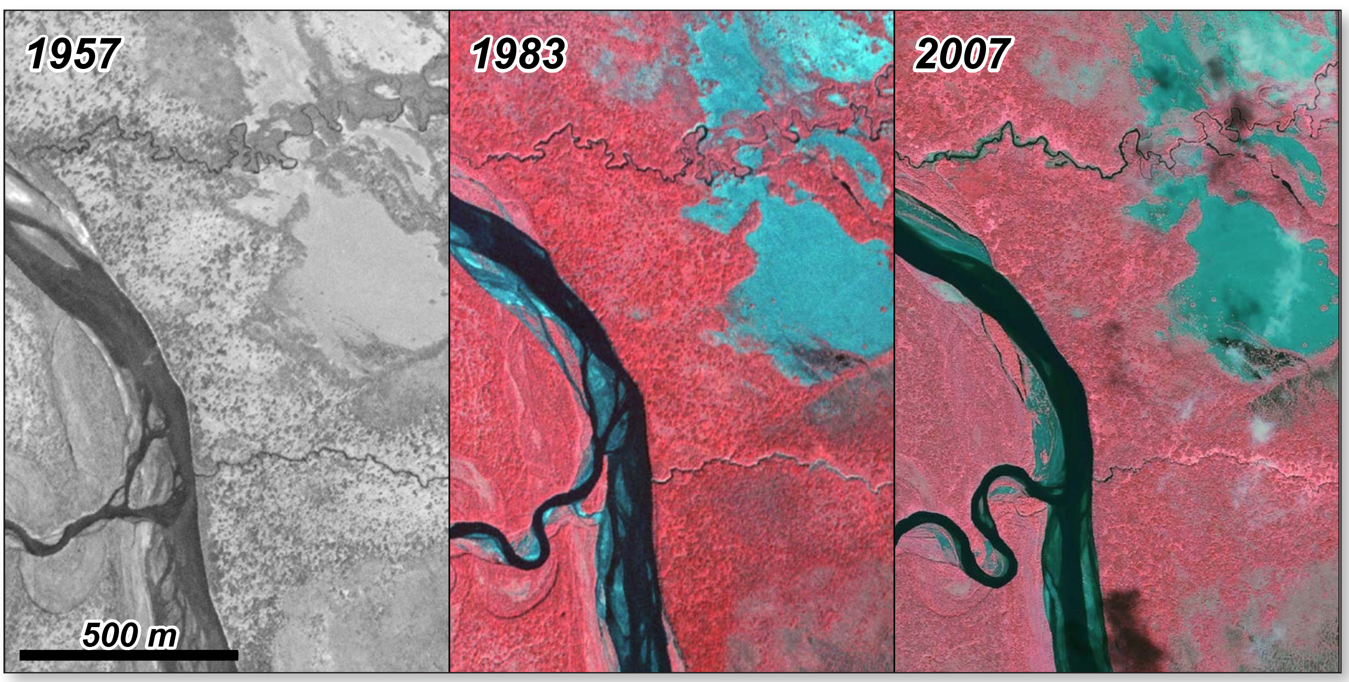

Figure 23. Comparison of shrub cover on Cinder River floodplain and pyroclastic deposits in 1957 (panchromatic airphoto), 1983 (CIR airphoto), and 2007 (CIR satellite image). There has been a general increase in vegetation cover, particularly of shrubs, on the floodplain adjacent uplands over the 50-year interval; however, remarkably little change is evident on the barren pyroclastic deposit at upper right.

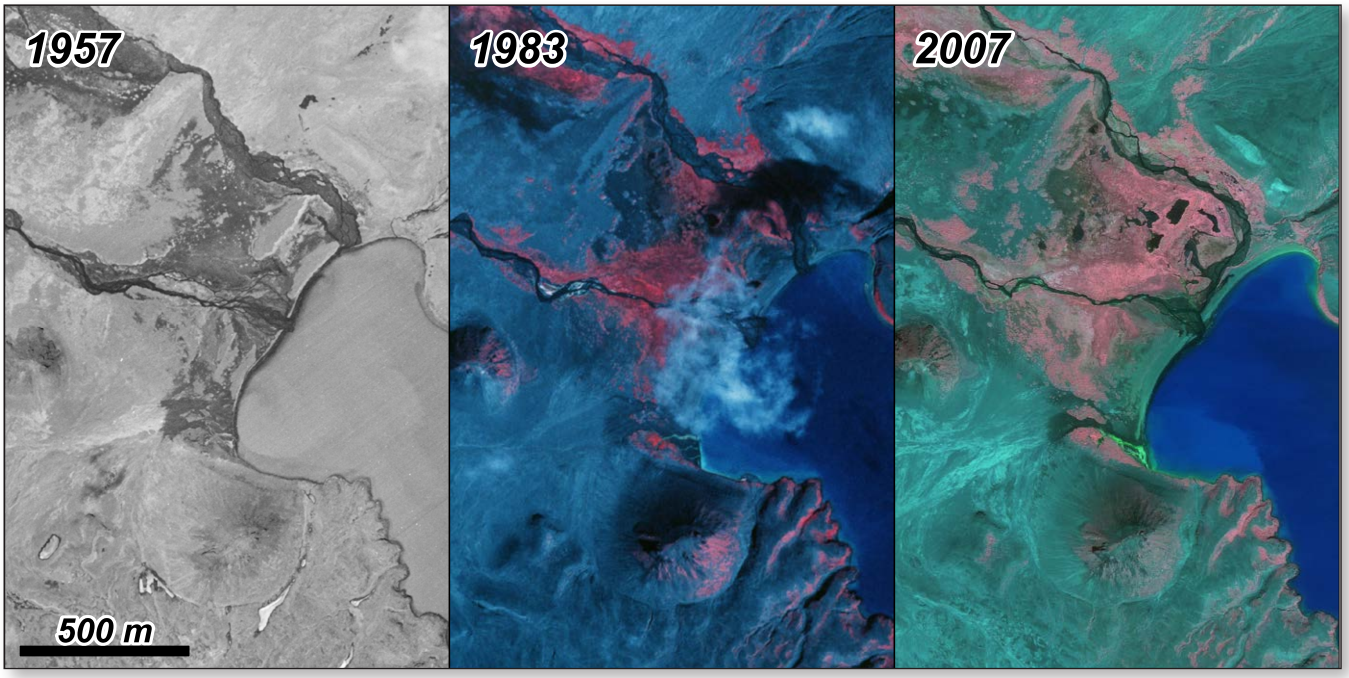

Figure 24. Comparison of vegetation cover in Aniakchak Caldera near upper Surprise Lake in 1957 (panchromatic airphoto), 1983 (CIR airphoto), and 2007 (CIR satellite image). Note partial cloud cover in 1983 photo. Vegetation cover has increased on alluvial flats adjacent to the two streams entering Surprise Lake, but much of the caldera floor remains barren.

recovery near springs after the 1931 eruption near the head of Surprise Lake (Figure 25). The key environmental factors favoring vegetation development in this area appear to be access to soil moisture, accumulation and retention of fine-textured soil particles, and sheltered landscape position favoring the retention of winter snow cover. These factors likely account for general patterns of vegetation development throughout volcanic landscapes of ANIA (see Jorgenson et al. 2006). The very recent eruptive history of Aniakchak, and ongoing seismic activity within the caldera indicate that future volcanic disturbance is likely, although the potential for a major eruption is currently thought to be low (Bacon et al. 2014).

Depending on the origin and makeup of eruption products, soils that form in volcanic ash can have distinct chemical and physical properties, such as 1) a cemented layer that impedes drainage and restricts plant rooting (e.g., welded pyroclastic deposits); 2) high concentrations of phosphorus and other nutrients; 3) a high proportion of volcanic glass or iron- and aluminum-rich minerals with weak crystalline structure that makes them highly susceptible to weathering; 4) low bulk density (i.e., a high ratio of pore space to soil particles) lending to a light, fluffy texture, high water holding capacity and erosion resistance; 5) accumulation of soil organic matter (Ugolini and Dahlgren 2002); 6) progressive development of highly acidic pH and aluminum toxicity during weathering; and 7) a very high phosphorus-binding-capacity that can lead to severe phosphorus limitations over time (Nanzyo 2002). Local- and landscape-scale variability in these attributes can directly influence the pace and trajectory of vegetation and soils development. For example, phosphorus-rich soils are more likely to support vegetation development, including recruitment and growth of nitrogen-fixing species such as *Alnus sinuata*. This species is common in many young shrublands on volcanic deposits and can strongly influence chemistry and microenvironmental conditions due to its tall stature and nitrogen-rich litter inputs.

Glaciations

Glacial dynamics are accompanied by powerful erosional and depositional processes, the effects of which can be highly persistent on the landscape. Although glaciers in ANIA today occur only as small hanging glaciers on the north-facing slopes of Aniakchak Peak, the Aleutian Range and the former Aniakchak stratovolcano were extensively glaciated during the Pleistocene epoch (~2.6 Ma–12 Ka). The U-shaped morphology of some of ANIA's intermontane valleys, particularly in the northeastern part of the park (e.g., upper Pumice Creek), and the conspicuous cirques carved into ridges of

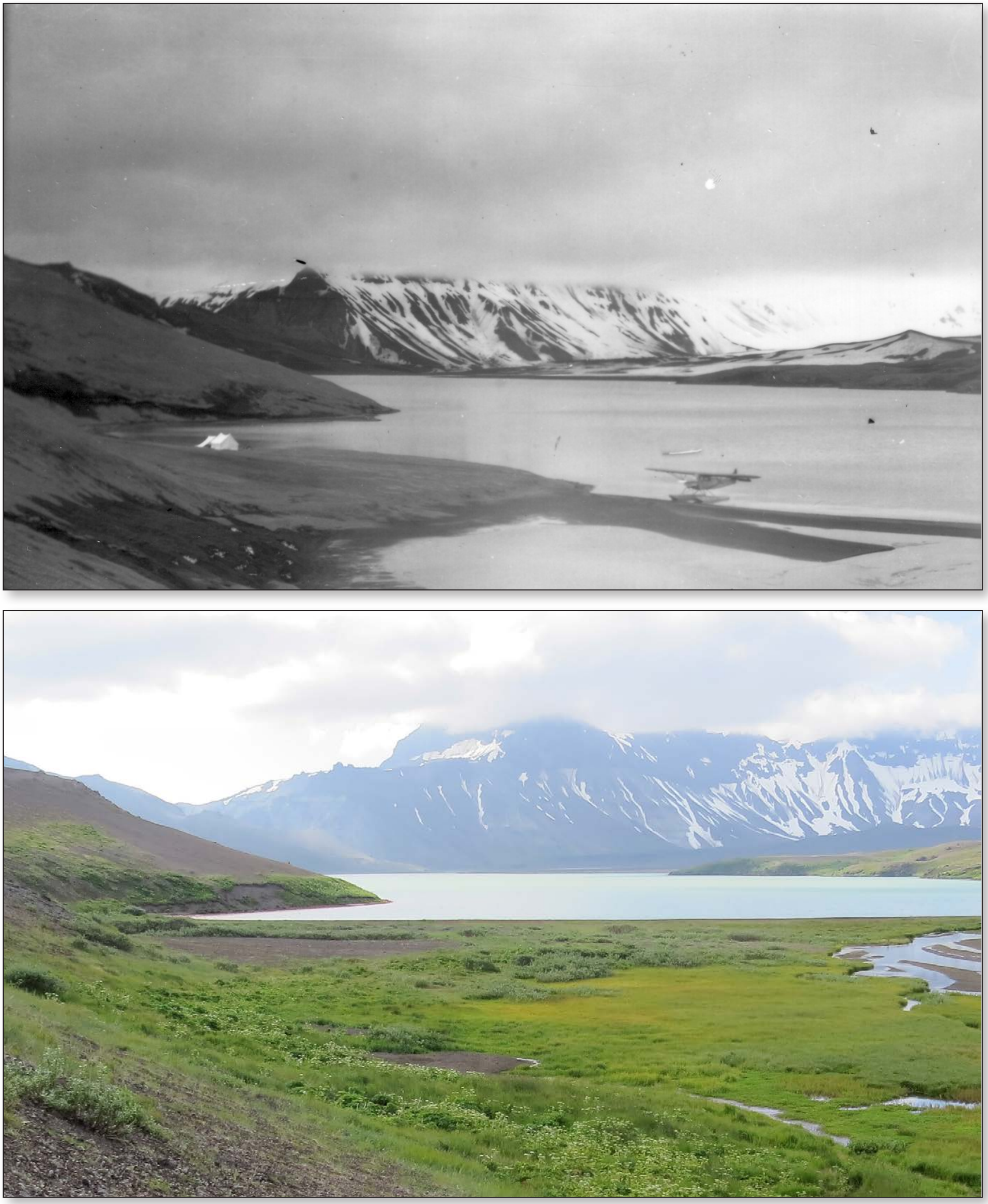

Figure 25. Northwest end of Surprise Lake and source spring (foreground) in 1932 (B. Hubbard) and 2014 (G. Frost). Retransportation and deposition of 1931 tephra has reduced the size of Surprise Lake; relatively lush vegetation has developed on the alluvial flats. The 1932 image provided courtesy of Archives & Special Collections, Santa Clara University Library under an Image Use Agreement letter.

the Aleutian Range are the results of glacial erosion. Yet, the influence of Pleistocene glaciation on geomorphology and ecosystem properties of ANIA has been greatly obscured by the immense volumes of volcanic material deposited on the landscape during the Holocene eruptive history of Aniakchak volcano (12 Ka–present). Thus, the effect of glaciation on ecosystem development in ANIA is mainly reflected in the general topographic attributes of the Aleutian Range and its intermontane valleys, with comparatively little influence on present-day surficial materials and soil development.

Coastal Processes

Coastal processes play a large role in the evolution of SWAN landscapes. Coastal physiography is of limited extent in ANIA (<1% of study area), but coastal environments are of high priority for monitoring efforts as they provide important habitats for wildlife. The coastal environments of ANIA can be divided into three broad categories: (1) coastal cliffs, headlands, and rocky shores of the outer coast that are exposed to the north Pacific Ocean and associated with high-energy wave action; (2) sandy embayments and dune systems; and (3) tidal flats and lagoons in the vicinity of the outlets of larger rivers and streams.

Coastal cliffs and headlands are dominated by bedrock and talus. Vegetation is sparse or absent on exposed surfaces, which are subject to long-period swells, storm surges, and wind-driven salt spray. Bedrock-dominated surfaces are very resistant to physical weathering, and bedrock coasts are often armored by colluvial talus deposits. Nonetheless, bedrock cliffs and slopes can become undermined over time by high-energy wave action, which promotes slope failure and the maintenance of a sparsely-vegetated bedrock- and talus-dominated coastline.

Sand beaches of Amber, Aniakchak, and Kujulik Bays, though somewhat protected relative to coastal cliffs and headlands, are nonetheless subject to high-energy ocean swell in addition to short-period wave action from local winds. The rivers that empty into these bays serve as a source of sediment, which nourishes sand beaches and provides material for forming eolian dunes. Dunes are prominent inland of the larger bays; their evolution is influenced by episodic storm and saltwater intrusion events, coastal erosion and aggradation, eolian processes, and the stabilizing effects of vegetation development. Although infrequent, tsunamis can also be induced by tectonic activity in the Pacific region and by local- or regional-scale volcanism (e.g., pyroclastic flows).

The coastal salt marshes and lagoons comprise high-value habitats for brown bears, fishes, and other wildlife. The watersheds supply sediments, which provide the material by which salt marshes are formed and maintained. Tides represent the most conspicuous coastal process influencing soils and vegetation. Two approximately 12 hour lunar tide cycles (one low and one high tide) occur each day, with an average amplitude of about 3 m at Anchorage Bay near the village of Chignik. Slight changes in elevation in tidal marshes, on the order of several centimeters to one meter, can have disproportionate effects 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 to the high tide line. Soils in lower elevations in salt marshes are flooded for longer periods, sometimes permanently, resulting in the development of anaerobic soil conditions and 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 sparse meadows of extremely salt-tolerant plants, such as *Puccinellia* grasses. 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. Beach ridges and dunes occur at elevations well above high tide, and are not directly influenced by tides or storm surges. The sandy soils are well drained and typically include Typic Crypsamments. Early vegetation succession begins with *Leymus mollis*. Beach ridges and dunes may eventually become disjunct from the active wave front (i.e., abandoned) due to a combination of processes, including glacial rebound and beach accretion. Vegetation succession parallels beach ridge and dune abandonment, shifting from herbaceous meadows to alder or willow shrublands. Tidal rivers carry salt water into the upper reaches of salt marshes and provide pathways for nutrients and travel for mammals and fish. Salmon return each year to spawn in the upper freshwater reaches of the tidal rivers, and their decomposed carcasses contribute marine-derived nutrients to adjacent floodplains (Naiman et al. 2002). These coastal marshes and tidal rivers also are important for brown bears, as salt marsh vegetation and salmon are valuable food sources.

Factors Affecting Soil and Vegetation Formation

At the landscape scale (hundreds of hectares to thousands of square kilometers), soil formation in ANIA is driven in large measure by proximal distance to the active Aniakchak volcano. The 10 km diameter Aniakchak caldera, and it's steep tephra-covered slopes, are the result of a massive eruption ca. 3,590 cal yr B.P. (Bacon 2014). There is no portion of ANIA that in some way has not been influenced by volcanism. Yet the magnitude of volcanic influence on soil development decreases with distance, on a generalized continuum from southwest to northeast. The Andisol soil order dominates the landscape in the western portion of ANIA, in areas surrounding the caldera. This is particularly true, in the older, more developed, pyroclastic flow deposits that blanket most river valleys within a 40-km radius of Surprise Lake.

To the north and east of the Aniakchak caldera, the steep, rounded peaks of the Aleutian Mountains dominate the skyline. Since glacial ice retreated from this region (~12 ka), fine and coarse ash deposits from eruptions in the Aleutian arc have been deposited over time. Subsequent tephra transfer occurs via wind or water, and is either mixed into, or layered on top of, soils that were otherwise forming in rocky sedimentary or metasedimentary parent material. The accumulation rates of tephra in the Aleutian Mountains, are typically insufficient to support the development of Andisols. Soils here are relatively diverse when compared to western portions of ANIA, supporting the development of Entisols, Inceptisols, Spodosols, and Mollisols. Although data is limited in the mountainous regions of the monument, it is assumed that Andic-intergrades of these soil orders are fairly common on leeward or sheltered slope positions (i.e., north-facing shoulder, footslope positions, etc.) where volcanic ash is likely to accumulate from eolian or colluvial processes.

At the local-scale volcanism has had an enduring effect on the landscape in and around Aniakchak Volcano by providing the parent materials and landforms upon which soil development and vegetation succession occur. Volcanic processes, particularly mass-movement of surficial materials via pyroclastic flow processes have resulted in a wide range of geomorphic landforms and parent material, including tephra deposits, debris avalanches, lahar deposits, and welded- and non-welded ignimbrite. In volcanic physiography, soil moisture and degree of exposure to strong winds as expressed through elevation, slope aspect, and microtopography are two important environmental factors controlling vegetation and soil development. For instance, the extensive volcanic barrens in and around Aniakchak Caldera are the result of insufficient available soil moisture and persistent strong winds. The coarse-textured volcanic soils hold little moisture, and when combined with the desiccating effect and physical damage caused by persistent strong winds, preclude vegetation establishment. At the same time, the lack of moisture combined with cold temperatures at higher elevations impedes the chemical weathering of soil parent materials thus slowing soil development. In volcanic physiography, areas of the landscape with well developed vegetation and soils are limited to sheltered microsites, including incised drainage channels, or areas with a shallow water table, like the headwaters of Surprise Lake.

In upland physiography, vegetation and soil development show a similar parallelism as in volcanic physiography. For instance, in the Cinder River Valley, upland barrens occur where coarse-textured lahar deposits occur at the soil surface. Just under the surface lies a duripan, a root restricting soil layer partially cemented by silica. While the duripan restricts root penetration it allows water to percolate through, resulting in extreme desiccation at the soil surface but restricting roots from penetrating into the soil to access moisture at greater depths. Adjacent to the barrens, well-developed vegetation occurs on thick deposits of fine-textured volcanic ash that lack the restrictive duripan and that presumably have greater soil water-holding-capacity.

In lowland and lacustrine physiography, soil and vegetation development are controlled largely by groundwater hydrology that in turn, is strongly influenced by subsurface geomorphology and surface water inputs. For instance, in the Meshik River valley, the surficial geology is characterized by swamp deposits and alluvium (Wilson 2008). While published literature on the subsurface geomorphology of the Meshik Valley is lacking, field observations made in 2014 suggest that the subsurface geomorphology is characterized by rocky tephra deposits. The rocky subsurface soils allow groundwater to pass through readily, making the wetlands and waterbodies in the Meshik Valley prone to drying. This was particularly evident in 2014 when warmer than normal temperatures and below normal precipitation occurred at nearby Cold Bay (Wendler et al. 2014). We observed numerous marshes dominated by *Menyanthes trifoliata*, a semi-aquatic forb, with no standing water and several recently drained lakes.

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Appendix 1. List of field data attributes recorded by ABR, Inc. at Ecological Land Survey field plots, including the plot and soil pit types at which each attribute was recorded. Aniakchak National Monument and Preserve, 2014.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
ELS	els	Full and Verification Plots	aspect_declin_degrees	Declination setting of the compass used to record aspect in degrees. East is negative, west is positive, zero is magnetic north.
ELS	els	Full and Verification Plots	aspect_degrees	Slope aspect at the plot, recorded in degrees.
ELS	els	Full and Verification Plots	camera_code	Name of the stand-alone camera used to record plot photos.
ELS	els	Full and Verification Plots	camera_photo_number_list	List of file names for field photos taken at the plot.
ELS	els	Full and Verification Plots	disturbance_class_code	Disturbance class, either natural or human induced.
ELS	els	Full and Verification Plots	els_plot_type_code	Single letter code to identify the type of plot.
ELS	els	Full and Verification Plots	env_field_note	Relevant notes recorded in the field by environmental data observer.
ELS	els	Full and Verification Plots	env_field_plot_id	The plot_id as it was first recorded in the field.
ELS	els	Full and Verification Plots	env_field_start_timestamp	Timestamp recorded when the environmental data collection form is initialized at the plot.
ELS	els	Full and Verification Plots	env_observer_code	Initials of the field environmental observer.
ELS	els	Full and Verification Plots	env_tablet_code	Unique identifying code for the tablet computer used to record the general environment data in the field.
ELS	els	Full and Verification Plots	env_tablet_gps_accuracy_m	Reported accuracy of the GPS location, as reported by GPS on the tablet used to collect environmental data. Units are meters. The tablet GPS location is generally not the highest quality location.
ELS	els	Full and Verification Plots	env_tablet_gps_elevation_m	Elevation of the plot, as recorded by GPS on the tablet used to collect environmental data. Units are meters. The tablet GPS location is generally not the highest quality location.
ELS	els	Full and Verification Plots	env_tablet_gps_lat_dd84	Latitude of the plot, as recorded by GPS on the tablet used to collect environmental data. Units are decimal degrees and horizontal datum is WGS1984. The tablet GPS location is generally not the highest quality location.
ELS	els	Full and Verification Plots	env_tablet_gps_long_dd84	Longitude of the plot, as recorded by GPS on the tablet used to collect environmental data. Units are decimal degrees and horizontal datum is WGS1984. The tablet GPS location is generally not the highest quality location.
ELS	els	Full and Verification Plots	env_tablet_gps_timestamp	Date and time that the plot location was recorded the tablet used to collect the general environment data.
ELS	els	Full and Verification Plots	field_ecotype_calc	Individual plot ecotype. This is a six letter code combination for physiography, dominant texture, moisture, soil chemistry, and vegetation structure.

160

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
ELS	els	Full and Verification Plots	handheld_gps_code	Name of the stand-alone handheld GPS unit used to record plot locations and tracks.
ELS	els	Full and Verification Plots	macrotopography_code	Mesoscale descriptor of surface form, evaluated over a broad area (tens of meters to hundreds of meters).
ELS	els	Full and Verification Plots	microtopography_code	Microscale descriptor of surface form, evaluated in immediate vicinity of plot (meters to tens of meters).
ELS	els	Full and Verification Plots	physiography_code	General description of landscape unit and depositional process.
ELS	els	Full and Verification Plots	plot_radius_code	The area evaluated for an individual plot.
ELS	els	Full and Verification Plots	project_id	Unique ABR accounting code identifying the year and project code.
ELS	els	Full and Verification Plots	rock_collected	Marked yes/true if a rock sample was collected for analysis
ELS	els	Full and Verification Plots	slope_degrees	Slope gradient at the plot, recorded in degrees.
ELS	els	Full and Verification Plots	soil_collected	Marked yes/true if a soil sample was collected for analysis.
ELS	els	Full and Verification Plots	soil_dominant_mineral_code_40cm	Most abundant mineral soil type in the upper 40 cm of the profile.
ELS	els	Full and Verification Plots	soil_dominant_texture_code_40cm	Most abundant soil material, mineral or organic, in the upper 40 cm of the profile.
ELS	els	Full and Verification Plots	soil_ec_us_at_10cm	Measured electrical conductivity (EC) in microsiemens (ÂµS) of saturated soil paste at 10cm.
ELS	els	Full and Verification Plots	soil_moisture_code	A measure of the representative soil moisture within the upper 40 cm of the soil profile.
ELS	els	Full and Verification Plots	soil_observed_maximum_depth_cm	The deepest depth (cm) evaluated at a plot by any method (e.g. frost probe, pit, etc.).
ELS	els	Full and Verification Plots	soil_ph_at_10cm	Measured pH of saturated soil paste at 10cm.
ELS	els	Full and Verification Plots	soil_rock_depth_probe_cm	Depth in centimeters from soil surface to the upper depth of a horizon with >15% rock fragments.
ELS	els	Full and Verification Plots	soil_sample_method_code	The means by which the soil profile was described (e.g. pit, plug, auger, etc.).
ELS	els	Full and Verification Plots	soil_surface_organic_thick_cm	The total thickness in centimeters of uninterrupted surface organic material from the soil surface
ELS	els	Full and Verification Plots	soil_thaw_depth_probe_cm	The depth in centimeters from the soil surface to frozen ground,typically measured with a thaw depth probe.
ELS	els	Full and Verification Plots	surface_terrain_code	Terrain unit code describing the present the geomorphic deposition and form.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
ELS	els	Full and Verification Plots	veg_structure_ecotype_code	Simplified vegetation structure code, which is a component of the field ecotype calculated field.
ELS	els	Full and Verification Plots	water_above_below_surface_code	Describes whether the water level is above or below the soil surface.
ELS	els	Full and Verification Plots	water_depth_cm	The depth from the soil surface to the water table. Recorded as a negative value if water table is below the soil surface, and positive if above the soil surface.
ELS	els	Full and Verification Plots	water_ec_us	The electrical conductivity (EC) of water in microsiemens (ÂµS). This data is recorded if there is standing water in the soil pit at any depth.
ELS	els	Full and Verification Plots	water_ph	The pH of the water. This data is recorded if there is standing water in the soil pit at any depth.
ELS	els	Full Plots Only	cryoturb_ynu_code	Marked yes if frost churned (i.e. cryoturbated) soil is present within the profile, at any depth.
ELS	els	Full Plots Only	drainage_code	The typical drainage of a site.
ELS	els	Full Plots Only	env_observation_uuid	Auto-generated universally unique identifier populated when the environmental field form is initialized at a plot.
ELS	els	Full Plots Only	frost_boil_cover_percent	Marked yes if active frost boils, sorted and/or non-sorted circles are present within the plot radius
ELS	els	Full Plots Only	microrelief_code	Typical height of surface roughness in centimeters.
ELS	els	Full Plots Only	nwi_water_regime_code	National Wetlands Inventory Water Regime classification.
ELS	els	Full Plots Only	plot_uuid	Universal unique identifier for each plot.
ELS	els	Full Plots Only	soil_andic_ynu_code	Marked yes if andic soil properties are present. Andic properties are related to soils derived from volcanic ash.
ELS	els	Full Plots Only	soil_class_code	The soil taxonomic class from the Keys to Soil Taxonomy United States Department of Agriculture, Natural Resources Conservation Service.
ELS	els	Full Plots Only	soil_cumul_ash_thick_40cm	Cumulative thickness in centimeters of volcanic ejecta from the soil surface to a depth of 40 cm.
ELS	els	Full Plots Only	soil_cumul_organic_thick_40cm	Sum of all organic horizons from the soil surface to a depth of 40 cm.
ELS	els	Full Plots Only	soil_effervescent_ynu_code	A yes is recorded if soil reacts to 1M HCl. This is a test for calcareous soils.
ELS	els	Full Plots Only	soil_hydrogen_sulfide_ynu_code	Marked yes if sulphur is smelled at the plot and/or hydrogen sulfide is present in the soil profile

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
ELS	els	Full Plots Only	soil_lithic_ynu_code	Marked yes if bedrock (i.e. lithic contact) is encountered within the upper 50cm of the soil profile. This does not include highly weathered bedrock (i.e. paralithic contact)
ELS	els	Full Plots Only	soil_loess_thick_cm	Thickness in centimeters of eolian deposited silts (may contain very fine sands).
ELS	els	Full Plots Only	soil_low_chroma_deplet_depth_cm	The depth in centimeters at which a reduced soil matrix is first encountered. A reduced matrix is defined as >50% of the surface area of one to several soil horizons with colors from the gleyed page or with chroma value <= 2).
ELS	els	Full Plots Only	soil_low_chroma_matrix_depth_cm	The depth in centimeters at which low chroma mottles (gleyed color page or chroma value <= 2) are first encountered.
ELS	els	Full Plots Only	soil_permafrost_ynu_code	Marked yes if the soil has remained frozen for two or more consecutive years, at any depth.
ELS	els	Full Plots Only	soil_ph_at_30cm	Measured pH of saturated soil paste at 30cm.
ELS	els	Full Plots Only	soil_profile_described	Marked yes/true if a complete soil profile description was completed.
ELS	els	Full Plots Only	soil_root_depth_cm	The depth in centimeters at which the majority of roots fall out in the profile.
ELS	els	Full Plots Only	soil_saturated_at_30cm_ynu_code	Marked yes if a soil is saturated within 30 cm of the soil surface.
ELS	els	Full Plots Only	subsurface_terrain_code	Terrain unit code for describing a lithological discontinuity representing a previous, underlying geomorphic surface. If one does not exist or is unknown, then the subsurface geomorphic unit is the same as the surface geomorphic unit.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	bottom_depth_cm	The depth in centimeters of the lower boundary for a soil horizon.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	horizon_code	Master and transitional horizons and layers.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	plot_uuid	Universal unique identifier for each plot.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	project_id	Unique ABR accounting code identifying the year and project code.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_horizon_field_horizon_id	Unique number identifying the soil horizon beginning at one for the upper most horizon and enumerated in increments of one for each subsequent horizon.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_horizon_field_note	Relevant notes about the soil horizon recorded in the field by soil observer.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_horizon_field_plot_id	The plot_id as it was first recorded in the field.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_horizon_field_timestamp	Date and time that the soil pit description was initiated.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_horizon_observation_uuid	Universal unique identifier for each soil horizon.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_horizon_observer_code	Initials of the field soils observer.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_pit_code	Choice list includes full, partial and wetlands. Wetlands are used for wetland delineations, Full includes complete soil profile descriptions, and Partial soil pits are rapid (and incomplete) soil profile descriptions.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_tablet_code	Unique identifying code for the tablet computer used to record the soil horizon data in the field.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_tablet_gps_accuracy_m	Accuracy of the soil pit lat/long in meters as recorded by the tablet computer GPS.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_tablet_gps_elevation_m	Elevation of the soil pit in meters above sea level as recorded by the tablet computer GPS.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_tablet_gps_lat_dd84	Latitude of the soil pit in decimal degrees WGS84 as recorded by the tablet computer GPS.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_tablet_gps_long_dd84	Longitude of the soil pit in decimal degrees WGS84 as recorded by the tablet computer GPS.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_tablet_gps_timestamp	Date and time that the soil pit location was recorded.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_texture_code	Soil texture code is the numerical proportion of the sand, silt, and clay separates in the fine-earth (<2mm) fraction.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	soil_texture_modifier_code	Soil texture modifier that incorporates both the approximate percentage of coarse fragments (i.e., >2mm fraction) and the dominant rock size.
SOIL_HORIZON	soil_horizon	Full and Partial Soil Pits	top_depth_cm	The depth in centimeters of the upper boundary for a soil horizon.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	bould_fragment_percent	Field estimate of percent boulders (>600 mm in diameter)
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	bould_soil_fragment_shape_code	Description of the relative roundness, or shape of boulders.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	clay_percent	Estimate of the percent clay in the fine earth fraction of mineral soil horizons.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	cobble_fragment_percent	Field estimate of percent cobbles (>76 to 250 mm in diameter)
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	cobble_soil_fragment_shape_code	Description of the relative roundness, or shape of cobbles.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	gravel_fragment_percent	Field estimate of percent gravels (>2 to 76 mm in diameter)
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	gravel_soil_fragment_shape_code	Description of the relative roundness, or shape of gravels.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	horizon_ec_us	Measured electrical conductivity (EC) for each horizon in microsiemens (ÂµS) of a saturated soil paste.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	horizon_ph	Horizon pH measurement.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	horizon_soil_effervescence_code	The reaction of a soil sample to 1M HCl. Used to identify the presence or absence of calcium carbonate in a horizon.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	redox_soil_color_chroma_code	The color chroma of redoximorphic features according to the Munsell soil-color charts.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	redox_soil_color_hue_code	The color hue of redoximorphic features according to the Munsell soil-color charts.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	redox_soil_color_value_code	The color value of redoximorphic features according to the Munsell soil-color charts.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	sandy_percent	Estimate of the percent sand in the fine earth fraction of mineral soil horizons.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_boundary_distinctness_code	Distinctness is a classification of the vertical distance through which the bottom of one horizon grades, or transitions, into another.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_boundary_topography_code	Topography is a classification of the lateral undulation and continuity of the boundary between horizons.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_color_chroma_code	Soil matrix chroma according to the Munsell soil-color charts.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_color_hue_code	Soil matrix hue according to the Munsell soil-color charts.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_color_value_code	Soil matrix value according to the Munsell soil-color charts.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_ice_structure_code	The dominant ice form for a horizon.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_peat_code	Classification of dominant source of organic material.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_redox_abundance_code	A classification of the range in percent surface area covered for redoximorphic features in a horizon based on ocular estimates of percent cover.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_redox_code	The type of redoximorphic feature that is present. Redoximorphic features are color patterns in a soil caused by loss (depletion) or gain (concentration).
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_redox_contrast_code	A classification of the color difference, or contrast, between the redoximorphic feature and the horizon matrix color.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_redox_size_code	A classification of the size range of redoximorphic features for a horizon.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_rupture_resist_block_code	A classification of the estimated force required to rupture (break) a soil unit (ped).
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_secondary_texture_code	If more than one soil texture is present, either in a stratified or broken horizon, then the second and less prevalant texture is recorded.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_structure_code	The classification of the dominant type of soil unit (ped) by horizon.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_structure_grade_code	A classification of the degree of soil structure development, ranging from structureless to strong.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	soil_structure_size_code	A classification of the size range, or diameter, of a structure type.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	stone_fragment_percent	Field estimate of percent stones (>250 to 600 mm in diameter)
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	stone_soil_fragment_shape_code	Description of the relative roundness, or shape of stones.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	temperature_c	Soil temperature recorded in degrees Celcius.
SOIL_HORIZON	soil_horizon	Full Soil Pits Only	temperature_depth_cm	Depth in centimeters where soil temperature was recorded.
VEG	veg	Full and Verification Plots	camera_code	Code detailing the name of the camera that was used for data collection
VEG	veg	Full and Verification Plots	camera_photo_number_list	List of file names for field photos taken at the plot.
VEG	veg	Full and Verification Plots	plot_uuid	Universal unique identifier for each plot.
VEG	veg	Full and Verification Plots	project_id	Unique ABR accounting code identifying the year and project code.
VEG	veg	Full and Verification Plots	veg_completeness_code	Degree of intensity in vegetation sampling. Typically T plots are complete (c), V plots are partial (p) or dominants are (d).
VEG	veg	Full and Verification Plots	veg_cutpoint_viereck_4_code	If vegetation is on the cusp between two veg_class4 classes, an alternative vegetation class is selected. If vegetation is not on the cusp then the cutpoint will be the same as veg_viereck_4_code.
VEG	veg	Full and Verification Plots	veg_field_note	Relevant notes recorded in the field by vegetation observer.
VEG	veg	Full and Verification Plots	veg_field_plot_id	The plot_id as it was first recorded in the field.
VEG	veg	Full and Verification Plots	veg_field_start_timestamp	Timestamp recorded when the vegetation data collection form is initialized at the plot.
VEG	veg	Full and Verification Plots	veg_field_viereck_4_code	The vegetation class from the Level IV of the Alaska Vegetation Classifcation (Viereck), as recorded in the field.
VEG	veg	Full and Verification Plots	veg_observation_uuid	Auto-generated universally unique identifier populated when the veg structure field form is initialized at a plot.
VEG	veg	Full and Verification Plots	veg_observer_code	Initials of the field botanist.
VEG	veg	Full and Verification Plots	veg_tablet_code	Unique identifying code for the tablet computer used to record the vegetation structure data in the field.
VEG	veg	Full and Verification Plots	veg_tablet_gps_accuracy_m	Reported accuracy of the GPS location, as reported by GPS on the tablet used to collect vegetation data. Units are meters. The tablet GPS location is generally not the highest quality location.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
VEG	veg	Full and Verification Plots	veg_tablet_gps_elevation_m	Elevation of the plot, as recorded by GPS on the tablet used to collect vegetation data. Units are meters. The tablet GPS location is generally not the highest quality location.
VEG	veg	Full and Verification Plots	veg_tablet_gps_lat_dd84	Latitude of the plot, as recorded by GPS on the tablet used to collect vegetation data. Units are decimal degrees and horizontal datum is WGS1984. The tablet GPS location is generally not the highest quality location.
VEG	veg	Full and Verification Plots	veg_tablet_gps_long_dd84	Longitude of the plot, as recorded by GPS on the tablet used to collect vegetation data. Units are decimal degrees and horizontal datum is WGS1984. The tablet GPS location is generally not the highest quality location.
VEG	veg	Full and Verification Plots	veg_tablet_gps_timestamp	Date and time that the plot location was recorded the tablet used to collect vegetation data.
VEG	veg	Full Plots Only	bare_soil_cover	Total % cover of all bare mineral soil (< 2 mm). This does not include rock fragments, moss/lichens, or litter.
VEG	veg	Full Plots Only	bedrock_cover	Total % cover of all exposed bedrock.
VEG	veg	Full Plots Only	broadleaf_tree_cover	Total % cover of all broadleaf tree species, including seedlings, but excluding dwarfed trees, see below.
VEG	veg	Full Plots Only	broadleaf_tree_crown_code	Typical position of broadleaf trees in the canopy.
VEG	veg	Full Plots Only	broadleaf_tree_size_code	Typical size class of broadleaf trees.
VEG	veg	Full Plots Only	cladonia_cladina_cover	Total % cover of all species of cladonia and cladina.
VEG	veg	Full Plots Only	dwarf_broadleaf_tree_cover	Total % cover of broadleaf trees growing in a dwarfed condition (~3-4m max ht) due to environmental constraints, typically high wind or persistent drought.
VEG	veg	Full Plots Only	dwarf_broadleaf_tree_crown_code	Typical position of dwarf broadleaf trees in the canopy.
VEG	veg	Full Plots Only	dwarf_broadleaf_tree_size_code	Typical size class of dwarf broadleaf trees.
VEG	veg	Full Plots Only	dwarf_needleleaf_tree_cover	Total % cover of needleleaf trees growing in a dwarfed condition (~3-4m max ht) due to environmental constraints, e.g. high elevation, shallow active layer.
VEG	veg	Full Plots Only	dwarf_needleleaf_tree_crown_cod	Typical position of dwarf needleleaf trees in the canopy.
VEG	veg	Full Plots Only	dwarf_needleleaf_tree_size_code	Typical size class of dwarf needleleaf trees.
VEG	veg	Full Plots Only	dwarf_shrub_cover	Total % cover of all species of dwarf (<0.2 m) shrubs.
VEG	veg	Full Plots Only	feathermoss_cover	Total % cover of all feather mosses (e.g. hylspl, tomnit, pticri, plesch). Leave blank if unsure.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
VEG	veg	Full Plots Only	forbs_cover	Total % cover of all forb species (includes club mosses, equisetum).
VEG	veg	Full Plots Only	graminoids_cover	Total % cover of all live gramminoids (exclude standing litter unless current year growth).
VEG	veg	Full Plots Only	litter_alone_cover	Total % cover of litter with no canopy above, litter exposed directly to the sky (i.e., no overtopping vegetation). This is typically a small number.
VEG	veg	Full Plots Only	litter_cover	Total % cover of all litter on plot. Typically this is a large number.
VEG	veg	Full Plots Only	low_shrub_cover	Total % cover of all species of low (0.2--1.5 m) shrubs.
VEG	veg	Full Plots Only	needleleaf_tree_cover	Total % cover of all needleleaf tree species, including seedlings, but excluding dwarfed trees, see below.
VEG	veg	Full Plots Only	needleleaf_tree_crown_code	Typical position of needleleaf trees in the canopy.
VEG	veg	Full Plots Only	needleleaf_tree_size_code	Typical size class of needleleaf trees.
VEG	veg	Full Plots Only	other_cover	Total % cover of abiotic ground cover types not already described.
VEG	veg	Full Plots Only	sphagnum_cover	Total % cover of all sphagnum moss species.
VEG	veg	Full Plots Only	standing_dead_cover	Total % cover of all standing dead trees.
VEG	veg	Full Plots Only	surface_fragment_cover	Total percent cover of all exposed coarse fragments (> 2 mm), e.g., gravels, cobbles, stones, boulders.
VEG	veg	Full Plots Only	tall_shrub_cover	Total % cover of all species of tall (>1.5 m) shrubs.
VEG	veg	Full Plots Only	total_lichens_cover	Total % cover of all lichens, including crustose lichens.
VEG	veg	Full Plots Only	total_mosses_cover	Total % cover of all mosses.
VEG	veg	Full Plots Only	water_cover	Total % cover of standing water above the soil surface.
VEG	veg	Full Plots Only	whole_tussocks_cover	Total % cover of whole tussocks mounds.
VEG	veg_cover	Full Plots Only	cover_percent	Percent cover of the species within the plot area, based on ocular estimation.
VEG	veg_cover	Full Plots Only	plot_uuid	Universal unique identifier for each plot.
VEG	veg_cover	Full Plots Only	project_id	Unique ABR accounting code identifying the year and project code.
VEG	veg_cover	Full Plots Only	specimen_collected	Identifies vegetation species for which field collections were made. Field collections are submitted to experts for verification of unknown specimens or specimes for which the field identification is uncertain.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
VEG	veg_cover	Full Plots Only	veg_cov_field_note	Relevant notes about the vegetation species recorded in the field by the botanist.
VEG	veg_cover	Full Plots Only	veg_cov_field_plot_id	The plot_id as it was first recorded in the field.
VEG	veg_cover	Full Plots Only	veg_cov_field_timestamp	Timestamp recorded when the vegetation cover record was recorded at the plot.
VEG	veg_cover	Full Plots Only	veg_cov_observation_uuid	Auto-generated universally unique identifier populated when the veg cover field form is initialized at a plot.
VEG	veg_cover	Full Plots Only	veg_cov_observer_code	Initials of the field botanist.
VEG	veg_cover	Full Plots Only	veg_cov_tablet_code	Unique identifying code for the tablet computer used to record the vegetation cover data in the field.
VEG	veg_cover	Full Plots Only	veg_field_taxonomy_code	The species code recorded in the field.

Appendix 2. List of vascular and non-vascular plant taxa found in Aniakchak National Monument and Preserve, Alaska, including the Alaska Natural Heritage Program State ranking for rare taxa (all other blank) and the AKEPIC (2014) invasiveness ranking for non-native taxa (all others blank). Species list based on data from the present study by ABR, Inc. Environmental Research and Services (Data Origin = abr) and data gathered by Alaska Natural Heritage program (Boucher et al. 2012; Data Orgin = aknhp). A data origin with both "abr" and "aknhp" indicates the taxa was encountered during both studies.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Deciduous Shrubs	*Alnus sinuata* (Regel ex DC) Rydb.	alnsin	{abr,aknhp}		
Deciduous Shrubs	*Arctous alpina* (L.) Nied	arcalp1	{abr,aknhp}		
Deciduous Shrubs	*Betula nana* L.	betnan	{abr,aknhp}		
Deciduous Shrubs	*Rubus spectabilis* Pursh	rubspe	{abr,aknhp}		
Deciduous Shrubs	*Salix alaxensis* (Andersson) Coville	salala	{abr,aknhp}		
Deciduous Shrubs	*Salix arctica* Pall.	salarc	{abr,aknhp}		
Deciduous Shrubs	*Salix barclayi* Andersson	salbar1	{abr,aknhp}		
Deciduous Shrubs	*Salix commutata* Bebb	salcom	{abr,aknhp}		
Deciduous Shrubs	*Salix fuscescens* Andersson	salfus	{abr,aknhp}		
Deciduous Shrubs	*Salix glauca* L.	salgla	{abr,aknhp}		
Deciduous Shrubs	*Salix ovalifolia* Trautv.	salova	{abr,aknhp}		
Deciduous Shrubs	*Salix polaris* Wahlenb.	salpol1	{abr}		
Deciduous Shrubs	*Salix pulchra* Cham.	salpul1	{abr,aknhp}		
Deciduous Shrubs	*Salix reticulata* L.	salret	{abr,aknhp}		
Deciduous Shrubs	*Salix richardsonii* Hook.	salric1	{aknhp}		
Deciduous Shrubs	*Salix rotundifolia* Trautv.	salrot	{abr,aknhp}		
Deciduous Shrubs	*Salix sitchensis* Sanson ex Bong.	salsit	{abr,aknhp}		
Deciduous Shrubs	*Salix stolonifera* Coville	salsto	{abr,aknhp}		
Deciduous Shrubs	*Sambucus racemosa* L.	samrac	{abr,aknhp}		
Deciduous Shrubs	*Vaccinium ovalifolium* Sm.	vacova	{aknhp}		
Deciduous Shrubs	*Vaccinium uliginosum* L.	vaculi	{abr,aknhp}		
Deciduous Trees	*Populus balsamifera* L.	popbal	{abr,aknhp}		
Evergreen Shrubs	*Andromeda polifolia* L.	andpol	{abr,aknhp}		
Evergreen Shrubs	*Arctostaphylos uva-ursi* (L.) Spreng.	arcuva	{abr,aknhp}		
Evergreen Shrubs	*Cassiope lycopodioides* (Pall.) D. Don	caslyc	{aknhp}		
Evergreen Shrubs	*Diapensia lapponica* L.	dialap	{abr,aknhp}		
Evergreen Shrubs	*Dryas integrifolia* M. Vahl	dryint	{aknhp}		
Evergreen Shrubs	*Dryas octopetala* L.	dryoct	{abr,aknhp}		
Evergreen Shrubs	*Empetrum nigrum* L.	empnig	{abr,aknhp}		
Evergreen Shrubs	*Harrimanella stelleriana* (Pall.) Coville	harste	{aknhp}		
Evergreen Shrubs	*Ledum decumbens* (Aiton) Lodd. ex Steud.	leddec	{abr,aknhp}		
Evergreen Shrubs	*Loiseleuria procumbens* (L.) Desv.	loipro	{abr,aknhp}		
Evergreen Shrubs	*Luetkea pectinata* (Pursh) Ktze.	luepec	{aknhp}		
Evergreen Shrubs	*Oxycoccus microcarpus* Turcz. ex Rupr.	oxymic	{aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Evergreen Shrubs	*Phyllodoce aleutica* (Spreng.) A. A. Heller	phyale	{aknhp}		
Evergreen Shrubs	*Therorhodion camtschaticum* (Pall.) Small	thecam	{abr,aknhp}		
Evergreen Shrubs	*Vaccinium vitis-idaea* L.	vacvit	{abr,aknhp}		
Ferns and allies	*Athyrium filix-femina* (L.) Roth	athfem	{aknhp}		
Ferns and allies	*Athyrium filix-femina* (L.) Roth ssp. *cyclosorum* (Rupr.) C. Chr.	athfil	{abr}		
Ferns and allies	*Botrychium alaskense* W.H.Wagner	botala	{aknhp}	S3	
Ferns and allies	*Botrychium lanceolatum* (Gmel.) Angstr.	botlan	{aknhp}		
Ferns and allies	*Botrychium lunaria* (L.) Sw.	botlun	{abr,aknhp}		
Ferns and allies	*Botrychium minganense* Victorin	botmin	{aknhp}		
Ferns and allies	*Botrychium pinnatum* H. St. John	botpin	{abr}		
Ferns and allies	*Dryopteris dilatata* (Hoffm.) A.Gray ssp. *americana* (Fisch.) Hult.	drydil	{abr,aknhp}		
Ferns and allies	*Equisetum arvense* L.	equarv	{abr,aknhp}		
Ferns and allies	*Equisetum fluviatile* L. ampl. Ehrh.	equflu	{abr,aknhp}		
Ferns and allies	*Equisetum palustre* L.	equpal	{abr}		
Ferns and allies	*Equisetum pratense* L.	equpra	{abr}		
Ferns and allies	*Equisetum variegatum* Schleich.	equvar	{abr,aknhp}		
Ferns and allies	*Equisetum variegatum* ssp. *variegatum* Schleich. ex F. Weber & D. Mohr	equvar1	{aknhp}		
Ferns and allies	*Gymnocarpium dryopteris* (L.) Newm.	gymdry	{abr,aknhp}		
Ferns and allies	*Lycopodium alpinum* L.	lycalp	{abr,aknhp}		
Ferns and allies	*Lycopodium annotinum* L.	lycann	{aknhp}		
Ferns and allies	*Lycopodium clavatum* L.	lyccla	{aknhp}		
Ferns and allies	*Lycopodium sabinaefolium* Willd.	lycsab1	{aknhp}		
Ferns and allies	*Lycopodium selago* L.	lycsel	{abr,aknhp}		
Ferns and allies	*Thelypteris phegopteris* (L.) Slosson	thephe	{abr,aknhp}		
Ferns and allies	*Woodsia ilvensis* (L.) R. Br.	wooilv	{aknhp}		
Forbs	*Achillea borealis* Bong	achbor	{abr}		
Forbs	*Achillea millefolium* L.	achmil	{abr,aknhp}		
Forbs	*Aconitum delphinifolium* DC.	acodel	{abr,aknhp}		
Forbs	*Actaea rubra* (Ait.) Willd.	actrub	{abr,aknhp}		
Forbs	*Androsace chamaejasme* Wulfen ex Host	andcha1	{aknhp}		
Forbs	*Anemone richardsonii* Hook.	aneric	{abr,aknhp}		
Forbs	*Angelica genuflexa* Nutt.	anggen	{abr,aknhp}		
Forbs	*Angelica lucida* L.	angluc	{abr,aknhp}		
Forbs	*Antennaria alpina* (L.) Gaertn.	antalp	{aknhp}		
Forbs	*Antennaria friesiana* ssp. *neoalaskana* (A.E. Porsild) Bayer & Stebbins	antneo	{aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Forbs	*Antennaria friesiana* (Trautv.) Ekman	antfri	{aknhp}		
Forbs	*Antennaria monocephala* DC.	antmon	{abr,aknhp}		
Forbs	*Antennaria monocephala* ssp. *philonipha* (A.E. Porsild) Hultén	antphi	{aknhp}		
Forbs	*Arabidopsis lyrata* ssp. *lyrata* (L.) O'Kane & Al-Shehbaz	aralyr1	{aknhp}		
Forbs	*Arabis lyrata* L. ssp. *kamchatica* (Fisch.) Hult.	aralyr	{aknhp}		
Forbs	*Armeria maritima* (Mill.) Willd.	armmar1	{aknhp}		
Forbs	*Armeria maritima* (Mill.) Willd. ssp. *arctica* (Cham.) Hult.	armmar	{abr}		
Forbs	*Arnica amplexicaulis* Nutt.	arnamp	{aknhp}		
Forbs	*Arnica lessingii* Greene	arnles	{abr,aknhp}		
Forbs	*Artemisia arctica* Less.	artarc2	{abr,aknhp}		
Forbs	*Artemisia arctica* Less. ssp. *arctica*	artarc1	{abr,aknhp}		
Forbs	*Artemisia borealis* Pall.	artbor	{abr,aknhp}		
Forbs	*Artemisia globularia* Bess.	artglo2	{abr,aknhp}		
Forbs	*Artemisia glomerata* Ledeb.	artglo1	{abr}		
Forbs	*Artemisia tilesii* Ledeb.	arttil	{abr,aknhp}		
Forbs	*Aster sibiricus* L.	astsib	{abr,aknhp}		
Forbs	*Astragalus alpinus* L.	astalp1	{abr,aknhp}		
Forbs	*Astragalus alpinus* L. ssp. *arcticus* (Bunge) Hultén	astarc	{aknhp}		
Forbs	*Astragalus polaris* Benth.	astpol	{abr}		
Forbs	*Atriplex alaskensis* S. Watson	atrala	{aknhp}		
Forbs	*Barbarea orthoceras* Ledeb.	barort	{aknhp}		
Forbs	*Cakile edentula* Bigel. Hook	cakede	{aknhp}		
Forbs	*Calla palustris* L.	calpal2	{abr}		
Forbs	*Calliergonella cuspidata* (Hedw.) Loeske	calcus	{abr}		
Forbs	*Caltha palustris L.*	calpal1	{abr}		
Forbs	*Campanula lasiocarpa* Cham.	camlas	{abr,aknhp}		
Forbs	*Cardamine pratensis* L. ssp. *angustifolia* (Hook.) O.E. Schultz	carpra1	{abr}		
Forbs	*Cardamine umbellata* Greene	carumb	{abr,aknhp}		
Forbs	*Castilleja unalaschcensis* (Cham. & Schlecht.) Malte	casuna	{abr,aknhp}		
Forbs	*Cerastium beeringianum* Cham. & Schlecht.	cerbee1	{abr}		
Forbs	*Cerastium beeringianum* Cham. & Schlecht. var. *beeringianum*	cerbee3	{aknhp}		
Forbs	*Chrysanthemum arcticum* L.	chrarc	{abr,aknhp}		
Forbs	*Chrysanthemum bipinnatum* L.	chrbip	{aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Forbs	*Chrysosplenium wrightii* Fr. And Sav.	chrwri	{abr,aknhp}		
Forbs	*Cicuta mackenzieana* Raup	cicmac	{abr}		
Forbs	*Circaea alpina* L.	ciralp	{abr,aknhp}		
Forbs	*Claytonia chamissoi* Esch.	clacha	{abr}		
Forbs	*Claytonia sarmentosa* C. Meyer	clasar	{abr,aknhp}		
Forbs	*Claytonia sibirica* L.	clasib	{abr,aknhp}		
Forbs	*Coeloglossum viride* (L.) Hartm. ssp. *bracteatum* (Muhl.) Hult.	coebra	{aknhp}		
Forbs	*Coeloglossum viride* (L.) Hartm. ssp. *viride* (Lindl.) Schulze	coevir	{abr}		
Forbs	*Conioselinum chinense* L. BSP.	conchi	{abr,aknhp}		
Forbs	*Coptis asplenifolia* Salisb.	copasp	{abr}		
Forbs	*Cornus canadensis* L.	corcan	{aknhp}		
Forbs	*Cornus suecica* L.	corsue	{abr,aknhp}		
Forbs	*Cypripedium guttatum* Sw.	cypgut	{aknhp}		
Forbs	*Draba borealis* DC.	drabor	{aknhp}		
Forbs	*Draba lonchocarpa* Rydb.	dralon2	{abr}		
Forbs	*Drosera rotundifolia* L.	drorot	{abr,aknhp}		
Forbs	*Epilobium anagallidifolium* Lam.	epiana	{abr,aknhp}		
Forbs	*Epilobium angustifolium* L.	epiang	{abr,aknhp}		
Forbs	*Epilobium behringianum* Haussk.	epibeh	{abr,aknhp}		
Forbs	*Epilobium glandulosum* Lehm.	epigla	{abr,aknhp}		
Forbs	*Epilobium hornemannii* Rchb.	epihor1	{aknhp}		
Forbs	*Epilobium hornemannii* Reichb. ssp. *hornemannii*	epihor	{abr,aknhp}		
Forbs	*Epilobium latifolium* L.	epilat	{abr,aknhp}		
Forbs	*Epilobium leptocarpum* Haussk.	epilep	{abr}		
Forbs	*Epilobium palustre* L.	epipal	{abr,aknhp}		
Forbs	*Erigeron peregrinus* (Pursh) Greene	eriper	{abr,aknhp}		
Forbs	*Euphrasia mollis* (Ledeb.) Wettst.	eupmol	{abr}		
Forbs	*Fritillaria camschatcensis* (L.) Ker-Gawl.	fricam	{abr,aknhp}		
Forbs	*Galium aparine* L.	galapa	{aknhp}		
Forbs	*Galium boreale L.*	galbor	{abr,aknhp}		
Forbs	*Galium trifidum* L.	galtri	{aknhp}		
Forbs	*Galium trifidum* L. ssp. *columbianum* (Rydb.) Hult.	galtri3	{abr}		
Forbs	*Galium trifidum* L. ssp. *trifidum*	galtri1	{abr,aknhp}		
Forbs	*Galium triflorum* Michx.	galtri2	{abr,aknhp}		
Forbs	*Gentiana aleutica* Cham. & Schlecht.	genale	{abr}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Forbs	*Gentiana algida* Pallas	genalg	{abr,aknhp}		
Forbs	*Gentiana propinqua* Richards. ssp. *arctophila* (Griseb.) Hult.	genarc	{aknhp}		
Forbs	*Geranium erianthum* DC.	gereri	{abr,aknhp}		
Forbs	*Geum macrophyllum* Willd.	geumac	{aknhp}		
Forbs	*Geum macrophyllum* Willd. ssp. *macrophyllum*	geumac1	{abr}		
Forbs	*Geum rossii* (R. Br.) Ser.	geuros	{abr,aknhp}		
Forbs	*Glaux maritima* L.	glamar	{aknhp}		
Forbs	*Heracleum lanatum* Michx.	herlan	{abr,aknhp}		
Forbs	*Heuchera glabra* Willd.	heugla	{abr,aknhp}		
Forbs	*Hieracium triste* Willd.	hietri	{aknhp}		
Forbs	*Hippuris montana* Ledeb.	hipmon	{aknhp}		
Forbs	*Hippuris tetraphylla L.F.*	hiptet	{abr}		
Forbs	*Hippuris vulgaris* L.	hipvul	{aknhp}		
Forbs	*Honckenya peploides* (L.) Ehrh.	honpep	{abr,aknhp}		
Forbs	*Koenigia islandica* L.	koeisl	{abr,aknhp}		
Forbs	*Lagotis glauca* Gaertn.	laggla1	{aknhp}		
Forbs	*Lagotis glauca* Gaertn. ssp. *glauca*	laggla	{abr}		
Forbs	*Lathyrus japonicus* Willd.	latjap	{aknhp}		
Forbs	*Lathyrus maritimus* (L.) Bigelow	latmar1	{aknhp}		
Forbs	*Lathyrus maritimus* L. ssp. *maritimus*	latmar	{abr}		
Forbs	*Lathyrus palustris* L. ssp. *pilosus* (Cham.) Hult.	latpal	{aknhp}		
Forbs	*Leptarrhena pyrolifolia* (D. Don) R. Br. ex Ser.	leppyr2	{aknhp}		
Forbs	*Ligusticum scoticum L.*	ligsco1	{aknhp}		
Forbs	*Listera cordata* (L.) R. Br.	liscor	{abr,aknhp}		
Forbs	*Lloydia serotina* (L.) Rchb.	lloser	{aknhp}		
Forbs	*Lupinus nootkatensis Donn*	lupnoo	{abr,aknhp}		
Forbs	*Melandrium apetalum* (L.) Fenzl.	melape	{aknhp}		
Forbs	*Menyanthes trifoliata* L.	mentri	{abr,aknhp}		
Forbs	*Mertensia maritima* (L.) Gray	mermar1	{aknhp}		
Forbs	*Mertensia maritima* (L.) S.F. Gray ssp. *maritima*	mermar	{abr}		
Forbs	*Mimulus guttatus* DC.	mimgut	{abr}		
Forbs	*Minuartia arctica* (Stev.) Aschers. & Graebn	minarc	{abr,aknhp}		
Forbs	*Minuartia macrocarpa* (Pursh) Ostenf.	minmac	{abr,aknhp}		
Forbs	*Minuartia rossii* (R. Br.) Graebn.	minros	{aknhp}		
Forbs	*Minuartia rossii* (R.Br.) Graebn. var. *elegans* (Cham. & Schlt.) Hult.	minros2	{abr}		
Forbs	*Minuartia rubella* (Wahlenb.) Graebn.	minrub	{aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Forbs	*Moehringia lateriflora* (L.) Fenzl	moelat	{abr,aknhp}		
Forbs	*Moneses uniflora* (L.) Gray	monuni	{abr}		
Forbs	*Montia fontana* ssp. *fontana* L.	monfon	{abr}		
Forbs	*Myosotis alpestris* F. W. Schmidt ssp. *asiatica* Vestergr.	myoasi	{abr,aknhp}		
Forbs	*Oxyria digyna* (L.) Hill	oxydig	{abr,aknhp}		
Forbs	*Oxytropis borealis* DC.	oxybor	{aknhp}		
Forbs	*Oxytropis maydelliana* Trautv.	oxymay	{aknhp}		
Forbs	*Oxytropis nigrescens* (Pall.) Fisch.	oxynig	{abr,aknhp}		
Forbs	*Oxytropis nigrescens* ssp. *bryophila* (Greene) Hultén	oxybry1	{aknhp}		
Forbs	*Oxytropis viscida* Nutt.	oxyvis	{abr,aknhp}		
Forbs	*Papaver alaskanum* Hultén	papala	{abr,aknhp}		
Forbs	*Papaver alboroseum* Hult.	papalb	{abr}		
Forbs	*Parnassia kotzebuei Cham. & Schlecht.*	parkot	{abr,aknhp}		
Forbs	*Parnassia palustris* L.	parpal	{abr,aknhp}		
Forbs	*Pedicularis capitata* Adams.	pedcap	{abr}		
Forbs	*Pedicularis kanei* Durand ssp. *kanei*	pedkan	{abr,aknhp}		
Forbs	*Pedicularis labradorica* Wirsing	pedlab	{aknhp}		
Forbs	*Pedicularis langsdorffii* Fisch.	pedlan3	{aknhp}		
Forbs	*Pedicularis langsdorffii* Fisch. ssp. *langsdorffii*	pedlan2	{aknhp}		
Forbs	*Pedicularis macrodonta* Richards.	pedmac	{aknhp}		
Forbs	*Pedicularis parviflora* J.E. Sm. ssp. *pennellii* (Hult.) Hult.	pedpen	{aknhp}		
Forbs	*Pedicularis sudetica* Willd.	pedsud	{aknhp}		
Forbs	*Pedicularis sudetica* Willd. ssp. *albolabiata* Hultén	pedalb	{abr}		
Forbs	*Pedicularis sudetica* Willd. ssp. *pacifica* Hult.	pedpac	{aknhp}		
Forbs	*Pedicularis verticillata* L.	pedver	{abr,aknhp}		
Forbs	*Petasites frigidus (L.) Franchet*	petfri	{abr,aknhp}		
Forbs	*Petasites hyperboreus* Rydb.	pethyp	{aknhp}		
Forbs	*Petesites sagittatus* (Banks) Gray	petsag	{abr}		
Forbs	*Pinguicula vulgaris* L.	pinvul1	{aknhp}		
Forbs	*Platanthera convallariaefolia* (Fisch.) Lindl.	placon	{abr}		
Forbs	*Platanthera dilatata* Pursh	pladil	{abr,aknhp}		
Forbs	*Platanthera dilatata* var. *chlorantha* Hultén	plachl	{aknhp}		
Forbs	*Platanthera hyperborea* (L.) Lindl.	plahyp	{aknhp}		
Forbs	*Polemonium acutiflorum* Willd.	polacu	{abr,aknhp}		
Forbs	*Polygonum viviparum* L.	polviv	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Forbs	*Potamogeton filiformis* Pers.	potfil	{abr}		
Forbs	*Potamogeton pectinatus* L.	potpec	{aknhp}		
Forbs	*Potamogeton perfoliatus* L. ssp. *richardsonii* (Benn.) Hultén	potric	{abr}		
Forbs	*Potentilla egedii* Wormsk. ssp. *grandis* (Torr. & Gray) Hult.	potege	{abr,aknhp}		
Forbs	*Potentilla hyparctica* Malte	pothyp	{abr}		
Forbs	*Potentilla palustris* (L.) Scop.	potpal	{abr,aknhp}		
Forbs	*Potentilla villosa* Pall.	potvil	{abr,aknhp}		
Forbs	*Prenanthes alata* (Hook.) Dietr.	preala	{abr,aknhp}		
Forbs	*Primula cuneifolia* Ledeb.	pricun2	{aknhp}		
Forbs	*Pyrola asarifolia* Michx.	pyrasa	{abr,aknhp}		
Forbs	*Pyrola grandiflora* Radius	pyrgra	{abr}		
Forbs	*Pyrola minor* L.	pyrmin	{aknhp}		
Forbs	*Pyrola secunda* L.	pyrsec1	{abr,aknhp}		
Forbs	*Ranunculus eschscholtzii* Schlecht.	ranesc	{abr}		
Forbs	*Ranunculus flammula* L.	ranfla1	{aknhp}		
Forbs	*Ranunculus hyperboreus* Rottb.	ranhyp	{abr}		
Forbs	*Ranunculus reptans* L.	ranrep	{abr}		
Forbs	*Ranunculus trichophyllus* Chaix	rantri	{abr}		
Forbs	*Rhinanthus minor* L.	rhimin1	{aknhp}		
Forbs	*Rhinanthus minor* ssp. *borealis* (Sterneck) Á. Löve	rhimin	{abr}		
Forbs	*Rubus arcticus* L.	rubarc1	{abr,aknhp}		
Forbs	*Rubus arcticus* L. ssp. *arcticus*	rubarc2	{abr}		
Forbs	*Rubus arcticus* L. ssp. *stellatus* (Sm.) Boiv. Emend. Hultén	rubste	{aknhp}		
Forbs	*Rubus chamaemorus* L.	rubcha	{aknhp}		
Forbs	*Rumex aquaticus* L.	rumaqu	{aknhp}		
Forbs	*Rumex arcticus* Trautv.	rumarc	{abr,aknhp}		
Forbs	*Rumex beringensis* Jurtzev & Petrovsky	rumber	{abr,aknhp}		
Forbs	*Rumex fenestratus* Greene	rumfen	{abr,aknhp}		
Forbs	*Sagina intermedia* Fenzl	sagint	{abr,aknhp}		
Forbs	*Sanguisorba stipulata* Raf.	sansti	{abr,aknhp}		
Forbs	*Saxifraga bronchialis* L.	saxbro	{abr,aknhp}		
Forbs	*Saxifraga caespitosa* L.	saxcae	{abr}		
Forbs	*Saxifraga eschscholtzii* Sternb.	saxesc	{abr}		
Forbs	*Saxifraga ferruginea* Graham	saxfer	{abr}		
Forbs	*Saxifraga flagellaris* Willd.	saxfla	{abr}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Forbs	*Saxifraga foliolosa* R. Br.	saxfol	{aknhp}		
Forbs	*Saxifraga hirculis* L.	saxhir	{abr,aknhp}		
Forbs	*Saxifraga lyallii* Engler ssp. *hultenii* (Cald. & Sav.) Cald. & Sav.	saxlya	{aknhp}		
Forbs	*Saxifraga oppositifolia* L.	saxopp	{abr,aknhp}		
Forbs	*Saxifraga punctata* L.	saxpun	{abr,aknhp}		
Forbs	*Saxifraga punctata* L. ssp. *nelsoniana* (D. Don) Hult.	saxnel	{abr}		
Forbs	*Saxifraga rivularis L.*	saxriv	{aknhp}		
Forbs	*Saxifraga serpyllifolia* Pursh	saxser	{abr,aknhp}		
Forbs	*Saxifraga unalaschcensis* Sternb.	saxuna	{abr}		
Forbs	*Sedum rosea* (L.) Scop. ssp. *integrifolium* (Raf.) Hult.	sedros	{abr,aknhp}		
Forbs	*Senecio ogotorukensis* Packer	senogo	{aknhp}		
Forbs	*Senecio pseudoarnica* Less.	senpse	{abr,aknhp}		
Forbs	*Senecio resedifolius* Less.	senres	{abr,aknhp}		
Forbs	*Sibbaldia procumbens* L.	sibpro	{abr,aknhp}		
Forbs	*Silene acaulis* L.	silaca	{abr,aknhp}		
Forbs	*Solidago lepida* DC.	sollep	{abr,aknhp}		
Forbs	*Solidago multiradiata* Ait.	solmul3	{abr,aknhp}		
Forbs	*Solidago multiradiata* Ait. var. multiradiata	solmul1	{abr,aknhp}		
Forbs	*Sparganium angustifolium* Michx.	spaang	{aknhp}		
Forbs	*Spiranthes romanzoffiana* Cham.	spirom	{abr,aknhp}		
Forbs	*Stellaria borealis* Bigelow	stebor	{aknhp}		
Forbs	*Stellaria calycantha* (Ledeb.) Bong.	stecal	{abr,aknhp}		
Forbs	*Stellaria calycantha* (Ledeb.) Bong. ssp. interior Hult.	steint1	{aknhp}		
Forbs	*Stellaria crassifolia* Ehrh.	stecra	{aknhp}		
Forbs	*Stellaria crispa* Cham. & Schlecht.	stecri	{abr,aknhp}		
Forbs	*Stellaria humifusa* Rottb.	stehum	{abr,aknhp}		
Forbs	*Stellaria longipes* Goldie	stelon1	{abr,aknhp}		
Forbs	*Stellaria sitchana* Steud var. *bongardiana* (Fern.) Hult.	stebon	{abr}		
Forbs	*Streptopus amplexifolius* (L.) DC.	stramp	{abr,aknhp}		
Forbs	*Swertia perennis* L.	sweper	{abr,aknhp}		
Forbs	*Taraxacum alaskanum* Rydb.	tarala	{abr}		
Forbs	*Taraxacum ceratophorum* (Ledeb.) DC.	tarcer	{aknhp}		
Forbs	*Taraxacum phymatocarpum* J. Vahl	tarphy	{aknhp}		
Forbs	*Tellima grandiflora* (Pursh) Dougl.	telgra	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Forbs	*Thalictrum alpinum* L.	thaalp	{abr,aknhp}		
Forbs	*Tofieldia coccinea* Richards.	tofcoc	{abr,aknhp}		
Forbs	*Tofieldia pusilla* (Michx.) Pers.	tofpus	{abr}		
Forbs	*Trientalis europaea* L.	trieur3	{abr,aknhp}		
Forbs	*Trientalis europaea* L. ssp. *arctica* (Fisch.) Hult.	trieur1	{aknhp}		
Forbs	*Trientalis europaea* L. ssp. *europaea*	trieur2	{abr}		
Forbs	*Triglochin maritimum* L.	trimar	{abr,aknhp}		
Forbs	*Triglochin palustris* L.	tripal	{abr,aknhp}		
Forbs	*Valeriana capitata* Pall.	valcap	{abr,aknhp}		
Forbs	*Veratrum viride* Ait. ssp. *Eschscholtzii* (Gray) Love & Love	vervir	{abr,aknhp}		
Forbs	*Veronica americana* Schwein.	verame	{abr,aknhp}		
Forbs	*Veronica stelleri* Pall.	verste	{aknhp}		
Forbs	*Veronica wormskjoldii* Roem & Schult.	verwor	{aknhp}		
Forbs	*Viola adunca* Sm.	vioadu	{aknhp}		
Forbs	*Viola epipsila* Ledeb.	vioepi1	{aknhp}		
Forbs	*Viola epipsila* Ledeb. ssp. *repens* (Turcz.) Becker	vioepi	{abr}		
Forbs	*Viola langsdorffii* Fisch.	violan	{abr,aknhp}		
Forbs	*Viola selkirkii* Pursh	viosel	{abr,aknhp}	S3S4	
Grasses	*Agrostis exarata* Trin.	agrexa	{abr,aknhp}		
Grasses	*Agrostis mertensii* Trin.	agrmer	{aknhp}		
Grasses	*Agrostis scabra* Willd.	agrsca	{abr,aknhp}		
Grasses	*Alopecuris aequalis* Sobol.	aloaeq	{abr}		
Grasses	*Alopecurus magellanicus* Lam.	alomag	{abr,aknhp}		
Grasses	*Anthoxanthum arcticum* Veldkamp	antarc	{abr}		
Grasses	*Anthoxanthum hirtum* (Schrank) Y. Schouten & Veldkamp	anthir	{abr,aknhp}		
Grasses	*Anthoxanthum monticola* ssp. *alpinum* (Sw. ex Willd.) Soreng	antalp1	{abr,aknhp}		
Grasses	*Arctagrostis latifolia* (R. Br.) Griseb.	arclat	{abr,aknhp}		
Grasses	*Arctagrostis latifolia* ssp. *arundinacea* (Trin.) Tzvelev	arcaru	{aknhp}		
Grasses	*Arctophila fulva* (Trin.) Anderss.	arcful	{abr}		
Grasses	*Calamagrostis canadensis* (Michx.) P. Beauv.	calcan	{abr,aknhp}		
Grasses	*Calamagrostis deschampsioides* Trin.	caldes	{abr,aknhp}		
Grasses	*Calamagrostis stricta* ssp. *inexpansa* (A. Gray) C.W. Greene	caline1	{aknhp}		
Grasses	*Deschampsia cespitosa* (L.) P. Beauv.	desces	{abr,aknhp}		
Grasses	*Deschampsia cespitosa* ssp. *beringensis* (Hultén) W.E. Lawr.	desber1	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Grasses	*Deschampsia sukatschewii* (Popl.) Roshev.	dessuk	{abr,aknhp}		
Grasses	*Dupontia fisheri* R. Br.	dupfis1	{aknhp}		
Grasses	*Dupontia fisheri* ssp. *psilosantha* (Rupr.) Hultén	duppsi1	{abr}		
Grasses	*Festuca altaica* Trin.	fesalt	{abr,aknhp}		
Grasses	*Festuca brachyphylla* Schult. & Schult. f.	fesbra	{aknhp}		
Grasses	*Festuca brevissima* Yurtsev	fesbre	{abr,aknhp}		
Grasses	*Festuca rubra* L.	fesrub	{abr,aknhp}		
Grasses	*Festuca rubra* ssp. *arctica* (Hack.) Govor.	fesarc	{aknhp}		
Grasses	*Festuca rubra* ssp. *pruinosa* (Hack.) Piper	fesrub3	{abr}		
Grasses	*Festuca rubra* ssp. *rubra* L.	fesrub1	{aknhp}		
Grasses	*Festuca vivipara* (L.) Sm.	fesviv	{abr}		
Grasses	*Hordeum brachyantherum* Nevski	horbra	{abr,aknhp}		
Grasses	*Leymus mollis* (Trin.) Pilg. ssp. *mollis* (Trin.) Hultén	leymol	{abr,aknhp}		
Grasses	*Phleum alpinum* L.	phlalp	{abr,aknhp}		
Grasses	*Poa abbreviata* R. Br.	poaabb	{abr}		
Grasses	*Poa alpina* L.	poaalp1	{abr,aknhp}		
Grasses	*Poa arctica* R. Br.	poaarc	{abr,aknhp}		
Grasses	*Poa arctica* ssp. *lanata* (Scribn. & Merr.) Soreng	poalan1	{aknhp}		
Grasses	*Poa eminens* J. Presl	poaemi	{abr,aknhp}		
Grasses	*Poa glauca* M. Vahl.	poagla	{abr}		
Grasses	*Poa macrocalyx* Trautv. & C. A. Mey.	poamac	{abr,aknhp}		
Grasses	*Poa palustris* L.	poapal	{abr,aknhp}		
Grasses	*Poa paucispicula* Scribn. & Merr.	poapau	{aknhp}		
Grasses	*Poa pratensis* L.	poapra	{aknhp}		
Grasses	*Poa pratensis* ssp. *alpigena* (Lindm.) Hiitonen	poaalp3	{aknhp}		
Grasses	*Poa pratensis* ssp. *angustifolia* (L.) Lej.	poaang1	{aknhp}		
Grasses	*Poa pratensis* ssp. *irrigata* (Lindm.) Lindb.	poairr	{aknhp}		52
Grasses	*Poa stenantha* Trin.	poaste	{aknhp}		
Grasses	*Puccinellia nutkaensis* (Presl) Fern. & Weath.	pucnut	{abr}		
Grasses	*Puccinellia tenella* (Lange) Holmb. ex Porsild	pucten1	{aknhp}		
Grasses	*Trisetum spicatum* (L.) K. Richt.	trispi1	{abr,aknhp}		
Grasses	*Vahlodea atropurpurea* (Wahlenb.) Fr, ex Hartm.	vahatr	{abr,aknhp}		
Lichens	*Alectoria nigricans* (Ach.) Nyl.	alenig	{abr}		
Lichens	*Alectoria ochroleuca* (Hoffm.) A. Massal.	aleoch	{abr}		
Lichens	*Bryoria nitidula* (Th. Fr.) Brodo & D. Hawksw.	brynit	{abr}		
Lichens	*Cetraria aculeata* (Schreber) Fr.	cetacu	{abr}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Lichens	*Cetraria ericetorum* Opiz	ceteri	{aknhp}		
Lichens	*Cetraria islandica* (L.) Ach.	cetisl	{aknhp}		
Lichens	*Cetraria islandica* (L.) Ach. ssp. *islandica*	cetisl2	{abr}		
Lichens	*Cetraria laevigata* Rass.	cetlae	{abr}		
Lichens	*Cetrariella delisei* (Bory ex Schaerer) Kärnefelt & Thell	cetdel	{abr}		
Lichens	*Cladina mitis* (Sandst.) Hustich	clamit	{abr}		
Lichens	*Cladina rangiferina* (L.) Nyl.	claran	{aknhp}		
Lichens	*Cladonia chlorophaea* (Flörke ex Sommerf.) Sprengel	clachl	{abr}		
Lichens	*Cladonia cornuta* (L.) Hoffm.	clacor	{abr}		
Lichens	*Cladonia squamosa* Hoffm.	clasqu	{abr}		
Lichens	*Flavocetraria cucullata* (Bellardi) Kärnefelt & Thell	flacuc	{abr,aknhp}		
Lichens	*Lobaria linita* (Ach.) Rabenh.	loblin	{abr}		
Lichens	*Nephroma arcticum* (L.) Torss.	neparc	{aknhp}		
Lichens	*Ochrolechia frigida* (Sw.) Lynge	ochfri	{abr}		
Lichens	*Peltigera aphthosa* (L.) Willd.	pelaph	{abr,aknhp}		
Lichens	*Peltigera canina* (L.) Willd.	pelcan	{abr,aknhp}		
Lichens	*Peltigera polydactylon* (Neck.) Hoffm.	pelpol	{abr}		
Lichens	*Solorina crocea* (L.) Ach.	solcro	{abr,aknhp}		
Lichens	*Sphaerophorus fragilis* (L.) Pers.	sphfra	{abr}		
Lichens	*Sphaerophorus globosus* (Hudson) Vainio	sphglo	{abr}		
Lichens	*Stereocaulon alpinum* Laurer ex Funck	stealp	{abr}		
Lichens	*Stereocaulon paschale* (L.) Hoffm.	stepas	{abr}		
Lichens	*Stereocaulon vesuvianum* Pers.	steves	{abr}		
Lichens	*Thamnolia vermicularis* (Sw.) Ach. ex Schaerer	thaver	{abr,aknhp}		
Lichens	*Varicellaria rhodocarpa* (Körber) Th. Fr.	varrho	{abr}		
Liverworts	*Gymnomitrion corallioides* Nees	gymcor	{abr}		
Liverworts	*Marchantia polymorpha* L.	marpol	{abr}		
Liverworts	*Ptilidium ciliare* (L.) Hampe	pticil	{abr}		
Mosses	*Aongstroemia longipes* (Somm.) B.S.G.	aonlon	{aknhp}		
Mosses	*Aulacomnium palustre* (Hedw.) Schwaegr.	aulpal	{abr}		
Mosses	*Aulacomnium turgidum* (Wahlenb.) Schwaegr.	aultur	{abr}		
Mosses	*Brachythecium erythrorrhizon* Schimp. in B.S.G.	braery	{abr}		
Mosses	*Brachythecium ornellanum* (Molendo) Venturi et Bott.	braorn	{abr}		
Mosses	*Brachythecium reflexum* (Starke in Web.et Mohr) Schimp.	braref	{abr}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Mosses	*Bryum weigelii* Spreng.	brywei	{abr}		
Mosses	*Calliergon giganteum* (Schimp.) Kindb.	calgig	{abr}		
Mosses	*Calliergon stramineum* (Brid.) Kindb.	calstr	{abr}		
Mosses	*Campylium polygamum* (B.S.G.) C.Jens.	campol	{abr}		
Mosses	*Campylium stellatum* (Hedw.) C.Jens.	camste1	{abr}		
Mosses	*Cinclidium stygium* Sw. in Schrad.	cinsty	{abr}		
Mosses	*Cinclidium subrotundum* Lindb.	cinsub	{abr}		
Mosses	*Climacium dendroides* (Hedw.) Web. et Mohr.	cliden	{abr}		
Mosses	*Dicranoweisia crispula* (Hedw.) Lindb. ex Milde	diccri	{abr}		
Mosses	*Dicranum majus* Sm.	dicmaj	{abr}		
Mosses	*Dicranum scoparium* Hedw.	dicsco	{aknhp}		
Mosses	*Dicranum spadiceum* Zett.	dicspa	{abr}		
Mosses	*Drepanocladus revolvens* (Sw.) Warnst.	drerev	{abr}		
Mosses	*Hylocomium splendens* (Hedw.) B.S.G.	hylspl	{abr,aknhp}		
Mosses	*Hypnum revolutum* (Mitt.) Lindb.	hyprev	{abr}		
Mosses	*Kiaeria glacialis* (Berggr.) I. Hagen	kiagla	{abr}		
Mosses	*Kiaeria starkei* (F. Weber. et D. Mohr) I. Hagen	kiasta	{abr}		
Mosses	*Limprichtia revolvens* (Sw.) Loeske	limrev	{abr}		
Mosses	*Meesia triquetra* (Richter) Aongstr.	meetri	{abr}		
Mosses	*Philonotis fontana* (Hedw.) Brid.	phifon	{abr}		
Mosses	*Plagiomnium cuspidatum* (Hedw.) T. Kop.	placus	{abr}		
Mosses	*Plagiomnium ellipticum* (Brid.) T.Kop.	plaell	{abr}		
Mosses	*Plagiomnium medium* (Bruch & Schimp. in B.S.G.) T. Kop.	plamed	{abr}		
Mosses	*Pleurozium schreberi* (Brid.) Mitt.	plesch	{abr,aknhp}		
Mosses	*Polytrichum commune* Hedw.	polcom	{aknhp}		
Mosses	*Polytrichum juniperinum* Hedw.	poljun	{abr}		
Mosses	*Polytrichum strictum* Brid.	polstr	{abr}		
Mosses	*Pseudobryum cinclidioides* (Hüb.) T. Kop.	psecin	{abr}		
Mosses	*Ptilium crista-castrensis* (Hedw.) De Not.	pticri	{abr,aknhp}		
Mosses	*Racomitrium canescens* (Hedw.) Brid.	raccan	{abr,aknhp}		
Mosses	*Racomitrium ericoides* (Web. ex Brid.) Brid.	raceri	{abr}		
Mosses	*Racomitrium fasciculare* (Hedw.) Brid.	racfas	{abr}		
Mosses	*Racomitrium lanuginosum* (Hedw.) Brid.	raclan	{abr,aknhp}		
Mosses	*Rhizomnium glabrescens* (Kindb.) T. Kop.	rhigla	{aknhp}		
Mosses	*Rhizomnium gracile* T. Kop.	rhigra	{aknhp}		
Mosses	*Rhizomnium magnifolium* (Horik.) T. Kop.	rhimag	{abr}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Mosses	*Rhizomnium pseudopunctatum* (Bruch & Schimp.) T. Kop.	rhipse	{abr}		
Mosses	*Rhytidiadelphus loreus* (Hedw.) Warnst.	rhylor	{abr,aknhp}		
Mosses	*Rhytidiadelphus squarrosus* (Hedw.) Warnst.	rhysqu	{abr}		
Mosses	*Rhytidiadelphus triquetrus* (Hedw.) Warnst.	rhytri	{abr,aknhp}		
Mosses	*Sanionia uncinata* (Hedw.) Loeske	sanunc	{abr}		
Mosses	*Schistidium papillosum* Culm.	schpap	{abr}		
Mosses	*Scorpidium scorpioides (*Hedw.) Limpr.	scosco	{abr}		
Mosses	*Sphagnum angustifolium* (Russ. ex Russ.) C.Jens	sphang	{abr}		
Mosses	*Sphagnum compactum* DC. in Lam. et DC.	sphcom	{abr}		
Mosses	*Sphagnum fuscum* (Schimp.) Klinggr.	sphfus	{aknhp}		
Mosses	*Sphagnum rubellum* Wils.	sphrub	{abr}		
Mosses	*Sphagnum squarrosum* Crome	sphsqu	{abr,aknhp}		
Mosses	*Sphagnum teres* (Schimp.) Ã…ngstr. in Hartm.	sphter	{abr}		
Mosses	*Timmia austriaca* Hedw.	timaus	{abr}		
Mosses	*Tomentypnum nitens* (Hedw.) Loeske	tomnit	{abr,aknhp}		
Mosses	*Warnstorfia exannulata* (Guemb. in B.S.G.) Loeske	warexa	{abr}		
Mosses	*Warnstorfia sarmentosa* (Wahlenb.) Hedenaes	warsar	{abr}		
Rushes	*Juncus arcticus* ssp. *ater* (Rydb.) Hultén	junate	{aknhp}		
Rushes	*Juncus arcticus* Willd.	junarc	{abr,aknhp}		
Rushes	*Juncus biglumis* L.	junbig	{abr}		
Rushes	*Juncus castaneus* Sm. ssp. *leucochlamys* (Zinz.) Hult.	junleu	{aknhp}		
Rushes	*Juncus drummondii* E. M	jundru	{aknhp}		
Rushes	*Juncus triglumis* L. ssp. *albescens* (Lange) Hultén	junalb	{aknhp}		
Rushes	*Luzula arcuata* ssp. *arcuata* (Wahlenb.) Sw.	luzarc3	{aknhp}		
Rushes	*Luzula arcuata* (Wahlenb.) Sw.	luzarc2	{abr,aknhp}		
Rushes	*Luzula arcuata* (Wahlenb.) Sw. ssp. *Unalaschcensis* (Buchenau) Hult.	luzuna	{aknhp}		
Rushes	*Luzula multiflora* (Retz.) Lej.	luzmul	{abr,aknhp}		
Rushes	*Luzula multiflora* (Retz.) Lej. ssp. *multiflora* var. *kjellmaniana* (Miyabe & Kudo) Sam.	luzkje	{abr}		
Rushes	*Luzula multiflora* ssp. *frigida* (Buchenau) V.I. Krecz.	luzfri	{abr,aknhp}		
Rushes	*Luzula multiflora* ssp. *kobayasii* (Satake) Hultén	luzkob	{aknhp}		
Rushes	*Luzula parviflora* (Ehrh.) Desv.	luzpar	{aknhp}		
Rushes	*Luzula tundricola* Gorodk.	luztun	{aknhp}		
Rushes	*Luzula wahlenbergii* Rupr. ssp. *piperi* (Cov.) Hult.	luzpip	{abr}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Rushes	*Luzula wahlenbergii* Rupr. ssp. *wahlenbergii*	luzwah	{abr,aknhp}		
Sedges	*Carex anthoxanthea* Presl	carant	{aknhp}		
Sedges	*Carex aquatilis* Wahlenb.	caraqu1	{aknhp}		
Sedges	*Carex aquatilis* Wahlenb. ssp. *aquatilis*	caraqu	{abr}		
Sedges	*Carex bigelowii* Torr.	carbig	{abr,aknhp}		
Sedges	*Carex capillaris* L.	carcap1	{aknhp}		
Sedges	*Carex chordorrhiza* Ehrh.	carcho	{aknhp}		
Sedges	*Carex circinnata* C. A. Mey.	carcir	{abr,aknhp}		
Sedges	*Carex dioica* ssp. *gynocrates* (Wormsk.) Hult.	cardio	{aknhp}		
Sedges	*Carex enanderi Hultén*	carena	{aknhp}		
Sedges	*Carex gmelinii* Hook. & Arn.	cargme	{aknhp}		
Sedges	*Carex kelloggii* W. Boott	carkel	{abr}		
Sedges	*Carex lachenalii* Schkuhr.	carlac	{abr}		
Sedges	*Carex limosa* L.	carlim	{abr,aknhp}		
Sedges	*Carex livida* (Wahlenb.) Willd.	carliv	{aknhp}		
Sedges	*Carex lyngbyaei* Hornem.	carlyn	{abr,aknhp}		
Sedges	*Carex mackenziei* V. Krecz.	carmac2	{abr}		
Sedges	*Carex macloviana* d'Urv. ssp. *pachystachya* (Cham.) Hult.	carmac3	{aknhp}		
Sedges	*Carex macrocephala Willd.*	carmac4	{abr,aknhp}		
Sedges	*Carex macrochaeta* C.A. Mey.	carmac1	{abr,aknhp}		
Sedges	*Carex microchaeta* Holm.	carmic1	{aknhp}		
Sedges	*Carex nesophila* Holm.	carnes	{abr,aknhp}		
Sedges	*Carex nigricans* C.A. Meyer	carnig	{aknhp}		
Sedges	*Carex norvegica* Retz.	carnor	{aknhp}		
Sedges	*Carex pluriflora* Hult.	carplu	{abr,aknhp}		
Sedges	*Carex podocarpa* C. B. Clarke	carpod	{abr}		
Sedges	*Carex pyrenaica* Wahlenb. ssp. *micropoda* (C. A. Meyer) Hult.	carmic3	{abr,aknhp}		
Sedges	*Carex ramenskii* Kom.	carram	{abr,aknhp}		
Sedges	*Carex rariflora* (Wahlenb.) Smith	carrar	{aknhp}		
Sedges	*Carex saxatilis* L. ssp. laxa (Trautv.) Kalela	carsax	{abr,aknhp}		
Sedges	*Carex stylosa* C. A. Mey	carsty	{aknhp}		
Sedges	*Carex tenuiflora* Wahlenb.	carten	{abr,aknhp}		
Sedges	*Carex vaginata* Tausch	carvag	{abr}		
Sedges	*Carex williamsii* Britt.	carwil	{aknhp}		
Sedges	*Eleocharis kamtschatica* (C.A. Meyer) V. Komarov	elekam	{aknhp}		

Appendix 2. Continued.

Lifeform	Scientific name	ABR species code	Data origin	Alaska rare rank	AKEPIC invasive-ness rank
Sedges	*Eleocharis palustris* (L.) Roem. & Schult.	elepal	{abr}		
Sedges	*Eriophorum angustifolium* Honck.	eriang1	{aknhp}		
Sedges	*Eriophorum angustifolium* Honck. ssp. *subarcticum* (V. Vassiljev) Hult.	eriang	{abr,aknhp}		
Sedges	*Eriophorum gracile* Koch	erigra1	{aknhp}		
Sedges	*Eriophorum russeolum* Fries	erirus	{abr,aknhp}		
Sedges	*Trichophorum caespitosum* (L.) Hartm.	tricae	{aknhp}		

Appendix 3. Chemical and physical laboratory data for 42 soil horizons across 16 plots, Aniakchak National Monument and Preserve, Alaska, 2014.

	Depth	100 C Oven Dry (%)											Air Dry (%)		
Unique ID	(cm)	Total C	Total N	Sand	Silt	Clay	Organic C	BS[1]	Fe	A1	Si	LOI[2]	PO_4[3]	15 Bar[4]	Glass[5]
ania_t02-01_2014	9-11	2.90	0.10	53.6	38.8	7.6	2.90	28.05	0.86	0.45	0.22	NA	47.06	12.4	NA
ania_t02-01_2014	11-23	4.88	0.17	56.6	38.8	4.6	4.88	28.03	NA	NA	NA	NA	NA	NA	NA
ania_t02-01_2014	23-48	2.69	0.10	61.6	33.8	4.6	2.68	20.49	1.16	1.20	0.53	NA	86.86	10.1	43
ania_t07-01_2014	0-2	0.19	<.01	74.6	13.8	11.6	0.17	NA	NA	NA	NA	NA	NA	NA	NA
ania_t07-01_2014	2-8	0.14	<.01	59.2	27.2	13.6	0.13	NA	NA	NA	NA	NA	NA	NA	NA
ania_t07-01_2014	8-18	0.04	<.01	78.8	11.6	9.6	0.03	100.00	2.84	0.68	0.45	NA	40.20	7.7	NA
ania_t07-01_2014	18-35	0.04	<.01	80.2	11.2	8.6	0.03	84.82	3.62	0.79	0.56	NA	44.44	8.9	0
ania_t08-02_2014	0-6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	11.15	NA	NA	NA
ania_t08-02_2014	6-32	0.44	<.01	83.2	13.2	3.6	0.44	54.47	0.48	0.18	0.11	NA	15.52	37.6	95
ania_t08-02_2014	32-47	0.16	<.01	89.2	6.2	4.6	0.16	100.00	0.48	0.14	0.09	NA	14.57	6.5	NA
ania_t09-01_2014	2-34	0.32	<.01	69.6	22.8	7.6	0.32	89.18	0.99	0.68	0.80	NA	29.28	5.0	62
ania_t19-02_2014	10-33	NA	NA	63.6	31.8	4.6	NA	NA	NA	NA	NA	NA	NA	NA	NA
ania_t19-04_2014	8-15	0.80	0.02	84.6	9.8	5.6	0.80	NA	NA	NA	NA	NA	NA	NA	NA
ania_t19-04_2014	15-27	1.30	0.08	77.6	17.8	4.6	1.30	58.23	0.53	0.40	0.13	NA	46.02	24.0	94
ania_t19-04_2014	47-60	4.77	0.31	56.7	37.6	5.7	4.76	38.29	1.63	1.50	0.60	NA	92.33	10.6	91
ania_t25-03_2014	3-12	2.35	0.07	58.6	15.8	25.6	2.34	78.00	NA	NA	NA	NA	NA	NA	NA
ania_t25-03_2014	12-15	0.70	0.01	93.6	0.8	5.6	0.70	69.90	NA	NA	NA	NA	NA	NA	NA
ania_t25-03_2014	15-42	1.30	0.08	52.0	16.4	31.6	1.29	NA	NA	NA	NA	NA	NA	NA	NA
ania_t26-01_2014	11-21	2.40	0.13	61.6	28.8	9.6	2.40	45.86	NA	NA	NA	NA	NA	NA	NA
ania_t26-01_2014	21-47	2.10	0.12	64.9	22.2	12.9	2.09	40.05	1.52	1.40	0.59	NA	84.47	16.6	82
ania_t26-01_2014	47-69	2.40	0.15	67.6	20.8	11.6	2.39	27.89	NA	NA	NA	NA	NA	NA	NA
ania_t26-02_2014	0-4	0.86	0.03	67.6	21.8	10.6	0.85	65.99	NA	NA	NA	NA	NA	NA	NA
ania_t26-02_2014	4-16	1.18	0.09	66.8	20.6	12.6	1.18	50.47	NA	NA	NA	NA	NA	NA	NA
ania_t26-02_2014	16-27	0.86	0.04	48.8	29.6	21.6	0.85	82.59	1.54	0.79	0.31	NA	49.24	12.7	2
ania_t26-02_2014	27-47	0.68	<.01	40.8	37.6	21.6	0.67	NA	NA	NA	NA	NA	NA	NA	NA
ania_t27-01_2014	7-17	3.30	0.28	70.8	25.6	3.6	3.30	35.05	NA	NA	NA	NA	NA	NA	NA
ania_t27-01_2014	19-28	3.36	0.30	50.8	44.6	4.6	3.36	45.25	1.79	1.04	0.36	NA	88.25	19.2	4
ania_t27-01_2014	28-32	0.89	0.08	74.4	10.0	15.6	0.87	NA	NA	NA	NA	NA	NA	NA	NA
ania_t27-01_2014	32-44	2.52	0.23	38.4	52.0	9.6	2.51	NA	NA	NA	NA	NA	NA	NA	NA

Appendix 3. Continued.

Unique ID	Depth (cm)	100 C Oven Dry (%)											Air Dry (%)		
		Total C	Total N	Sand	Silt	Clay	Organic C	BS[1]	Fe	A1	Si	LOI[2]	PO_4[3]	15 Bar[4]	Glass[5]
ania_t30-04_2014	6-27	0.76	0.04	94.4	0.0	5.6	0.76	40.89	NA	NA	NA	NA	NA	NA	NA
ania_t30-04_2014	27-40	3.10	0.17	76.4	16.0	7.6	3.07	27.36	1.00	0.68	0.27	NA	66.76	9.7	96
ania_t31-04_2014	5-8	5.66	0.48	68.4	26.0	5.6	5.65	33.91	NA	NA	NA	NA	NA	NA	NA
ania_t31-04_2014	8-31	4.90	0.30	67.6	24.8	7.6	4.89	NA	NA	NA	NA	NA	NA	NA	NA
ania_t31-04_2014	31-55	3.20	0.20	69.6	22.8	7.6	3.19	6.81	1.23	1.57	1.19	NA	91.34	10.8	45
ania_t33-01_2014	0-6	4.21	0.32	57.6	35.8	6.6	4.20	24.41	NA	NA	NA	NA	NA	NA	NA
ania_t33-01_2014	6-32	6.08	0.46	49.6	40.8	9.6	6.07	12.84	NA	NA	NA	NA	NA	NA	NA
ania_t33-01_2014	32-50	2.21	0.18	67.6	21.8	10.6	2.21	NA	NA	NA	NA	NA	NA	NA	NA
ania_t33-03_2014	6-12	NA	NA	NA	NA	NA	NA	30.74	NA	NA	NA	NA	NA	NA	NA
ania_t33-03_2014	12-42	NA	NA	NA	NA	NA	NA	22.71	NA	NA	NA	NA	NA	NA	NA
ania_t33-03_2014	42-53	NA	NA	NA	NA	NA	NA	23.82	NA	NA	NA	NA	NA	NA	NA
ania_v02-01_2014	11-12	1.27	<.01	42.0	41.6	16.4	1.27	NA	0.85	0.64	0.19	NA	60.46	NA	NA

1 Percent Base Saturation

2 Percent Loss on Ignition (Organic Matter)

3 Percent Phosphate Retention

4 Percent 15 Bar Water Retention

5 Percent Volcanic Glass Estimate

Appendix 4. Crosswalk between map ecotypes and land cover classes of USFWS (2007) and NLCD (2011), and the total area of each unique combination of ecotypes and classes, Aniakchak National Monument and Preserve, Alaska, 2014. Combinations with mapped areas <0.1 km² are not shown.

Map ecotype	Land cover class	Area (km^2)
Alpine Dry Barrens	Rock/Gravel	85.0
Alpine Dry Barrens	Sparse Vegetation	54.7
Alpine Dry Barrens	Barren Land (NLCD2011)	15.2
Alpine Dry Barrens	Non-Vegetated Soil	7.8
Alpine Dry Barrens	Perennial Ice/Snow (NLCD2011)	1.1
Alpine Dry Barrens	Crypto-Biotic Soil	0.3
Alpine Moist Crowberry Dwarf Shrub	Dwarf Shrub - Upland	439.4
Alpine Moist Crowberry Dwarf Shrub	Dwarf Shrub - Lichen	70.8
Alpine Moist Crowberry Dwarf Shrub	Dwarf Shrub (NLCD2011)	29.7
Alpine Moist Crowberry Dwarf Shrub	Low Shrub - Other	15.5
Alpine Moist Crowberry Dwarf Shrub	Tall Shrub - Alder	15.3
Alpine Moist Crowberry Dwarf Shrub	Low Shrub - Willow	14.2
Alpine Moist Crowberry Dwarf Shrub	Tall Shrub - Other	9.3
Alpine Moist Crowberry Dwarf Shrub	Low Shrub - Alder	7.3
Alpine Moist Crowberry Dwarf Shrub	Low Shrub - Alder/Willow	4.1
Alpine Moist Crowberry Dwarf Shrub	Tall Shrub - Alder/Willow	3.0
Alpine Moist Crowberry Dwarf Shrub	Tall Shrub - Willow	3.0
Alpine Moist Crowberry Dwarf Shrub	Dwarf Shrub - Wet	1.2
Alpine Moist Graminoid Meadow	Mesic/Dry Grass Meadow	11.0
Alpine Moist Graminoid Meadow	Mesic/Dry Forb	8.4
Alpine Moist Graminoid Meadow	Mesic/Dry Sedge Meadow	5.3
Alpine Moist Graminoid Meadow	Wet Graminoid	0.5
Alpine Moist Graminoid Meadow	Mesic/Dry Graminoid	0.1
Alpine Moist Willow Dwarf Shrub	Dwarf Shrub - Other	33.9
Alpine Mountain Heather-Luetkea Dwarf Shrub	Dwarf Shrub - Lush	10.0
Alpine Mountain Heather-Luetkea Dwarf Shrub	Shrub/Scrub (NLCD2011)	5.7
River Water	Clear Water	3.4
River Water	Turbid/Shallow Water	1.9
River Water	Open Water (NLCD2011)	0.1
Riverine Barrens	Rock/Gravel	5.7
Riverine Barrens	Sparse Vegetation	0.5
Riverine Barrens	Non-Vegetated Soil	0.1
Riverine Moist Forb Meadow	Mesic/Dry Forb	1.5
Riverine Moist Forb Meadow	Mesic/Dry Grass Meadow	1.1
Riverine Moist Forb Meadow	Mesic/Dry Sedge Meadow	0.2
Riverine Moist Willow Low Shrub	Low Shrub - Willow	9.5
Riverine Moist Willow Low Shrub	Dwarf Shrub - Other	6.1

Appendix 4. Continued.

Map ecotype	Land cover class	**Area (km^2)**
Riverine Moist Willow Low Shrub	Dwarf Shrub - Lush	3.3
Riverine Moist Willow Low Shrub	Low Shrub - Other	2.4
Riverine Moist Willow Low Shrub	Dwarf Shrub - Upland	1.6
Riverine Moist Willow Low Shrub	Dwarf Shrub - Wet	0.4
Riverine Moist Willow Low Shrub	Low Shrub - Alder/Willow	0.4
Riverine Moist Willow Low Shrub	Dwarf Shrub - Lichen	0.3
Riverine Moist Willow Low Shrub	Dwarf Shrub (NLCD2011)	0.3
Riverine Moist Willow Low Shrub	Low Shrub - Alder	0.2
Riverine Moist Willow Tall Shrub	Tall Shrub - Willow	15.3
Riverine Rocky Moist Alder-Willow Tall Shrub	Tall Shrub - Alder	6.0
Riverine Rocky Moist Alder-Willow Tall Shrub	Tall Shrub - Alder/Willow	3.2
Riverine Rocky Moist Alder-Willow Tall Shrub	Tall Shrub - Other	2.0
Riverine Rocky Moist Alder-Willow Tall Shrub	Shrub/Scrub (NLCD2011)	0.7
Riverine Wet Sedge Meadow	Emergent	0.5
Riverine Wet Sedge Meadow	Wet Sedge	0.5
Riverine Wet Sedge Meadow	Wet Graminoid	0.1
Brackish Water	Turbid/Shallow Water	2.3
Brackish Water	Ocean Water	2.3
Brackish Water	Clear Water	0.6
Brackish Water	Floating Algae	0.1
Coastal Moist Grass Meadow	Tall Shrub - Willow	1.8
Coastal Moist Grass Meadow	Low Shrub - Willow	1.6
Coastal Moist Grass Meadow	Dwarf Shrub - Lush	1.0
Coastal Moist Grass Meadow	Dwarf Shrub - Other	0.7
Coastal Moist Grass Meadow	Mesic/Dry Forb	0.6
Coastal Moist Grass Meadow	Mesic/Dry Grass Meadow	0.6
Coastal Moist Grass Meadow	Tall Shrub - Alder	0.5
Coastal Moist Grass Meadow	Tall Shrub - Alder/Willow	0.5
Coastal Moist Grass Meadow	Dwarf Shrub - Other	0.4
Coastal Moist Grass Meadow	Low Shrub - Other	0.4
Coastal Moist Grass Meadow	Low Shrub - Alder/Willow	0.2
Coastal Moist Grass Meadow	Tall Shrub - Willow	0.2
Coastal Moist Grass Meadow	Dwarf Shrub - Lush	0.2
Coastal Moist Grass Meadow	Low Shrub - Willow	0.1
Coastal Moist Grass Meadow	Tall Shrub - Alder	0.1
Coastal Moist Grass Meadow	Dwarf Shrub - Upland	0.1
Coastal Moist Grass Meadow	Tall Shrub - Other	0.1
Coastal Tidal Barrens	Rock/Gravel	3.5

Appendix 4. Continued.

Map ecotype	Land cover class	Area (km^2)
Coastal Tidal Barrens	Rock/Gravel	1.5
Coastal Tidal Barrens	Sparse Vegetation	0.2
Coastal Tidal Barrens	Non-Vegetated Soil	0.1
Coastal Wet Brackish Sedge Meadow	Wet Sedge	0.1
Coastal Wet Brackish Sedge Meadow	Emergent	0.1
Marine Water	Ocean Water	155.2
Marine Water	Turbid/Shallow Water	5.6
Marine Water	Floating Algae	3.9
Marine Water	Clear Water	0.3
Upland Crowberry Dwarf Shrub	Dwarf Shrub - Other	103.3
Upland Crowberry Dwarf Shrub	Dwarf Shrub - Upland	69.6
Upland Crowberry Dwarf Shrub	Low Shrub - Other	44.0
Upland Crowberry Dwarf Shrub	Dwarf Shrub - Lush	38.4
Upland Crowberry Dwarf Shrub	Dwarf Shrub - Lichen	17.0
Upland Crowberry Dwarf Shrub	Dwarf Shrub - Wet	10.9
Upland Crowberry Dwarf Shrub	Emergent	1.8
Upland Crowberry Dwarf Shrub	Dwarf Shrub (NLCD2011)	1.8
Upland Crowberry Dwarf Shrub	Bryoid Moss/Dwarf Shrub - Lichen	1.4
Upland Crowberry Dwarf Shrub	Wet Sedge	0.4
Upland Crowberry Dwarf Shrub	Moss	0.1
Upland Dry Barrens	Rock/Gravel	31.4
Upland Dry Barrens	Sparse Vegetation	4.9
Upland Dry Barrens	Turbid/Shallow Water	1.1
Upland Dry Barrens	Non-Vegetated Soil	0.4
Upland Dry Barrens	Floating Algae	0.1
Upland Dry Barrens	Barren Land (NLCD2011)	0.1
Upland Moist Alder Tall Shrub	Tall Shrub - Alder	315.8
Upland Moist Alder Tall Shrub	Tall Shrub - Other	89.0
Upland Moist Alder Tall Shrub	Tall Shrub - Alder/Willow	74.2
Upland Moist Alder Tall Shrub	Low Shrub - Alder	18.7
Upland Moist Alder Tall Shrub	Low Shrub - Alder/Willow	11.3
Upland Moist Alder Tall Shrub	Shrub/Scrub (NLCD2011)	10.0
Upland Moist Alder Tall Shrub	Ocean Water	0.1
Upland Moist Balsam Poplar Forest	Closed Poplar	0.2
Upland Moist Forb Meadow	Mesic/Dry Forb	37.5
Upland Moist Forb Meadow	Mesic/Dry Grass Meadow	15.8
Upland Moist Forb Meadow	Mesic/Dry Sedge Meadow	4.9
Upland Moist Forb Meadow	Wet Graminoid	0.9

Appendix 4. Continued.

Map ecotype	Land cover class	Area (km^2)
Upland Moist Forb Meadow	Mesic/Dry Graminoid	0.4
Upland Moist Willow Low Shrub	Low Shrub - Willow	141.5
Upland Moist Willow Tall Shrub	Tall Shrub - Willow	151.8
Lowland Wet Sedge Meadow	Wet Graminoid	7.2
Lowland Wet Sedge Meadow	Wet Sedge	4.8
Lowland Wet Sedge Meadow	Emergent	4.5
Lowland Wet Sedge Meadow	Emergent Herbaceous Wetlands (NLCD2011)	1.3
Lowland Wet Sedge Meadow	Sedge/Herbaceous (NLCD2011)	0.6
Lowland Wet Sedge-Shrub Bog Meadow	Dwarf Shrub - Other	23.1
Lowland Wet Sedge-Shrub Bog Meadow	Dwarf Shrub - Lush	13.4
Lowland Wet Sedge-Shrub Bog Meadow	Dwarf Shrub - Wet	7.1
Lowland Wet Sedge-Shrub Bog Meadow	Dwarf Shrub (NLCD2011)	5.7
Lowland Wet Sedge-Shrub Bog Meadow	Low Shrub - Other	4.6
Lowland Wet Sedge-Shrub Bog Meadow	Dwarf Shrub - Lichen	4.0
Lowland Wet Sedge-Shrub Bog Meadow	Mesic/Dry Forb	2.7
Lowland Wet Sedge-Shrub Bog Meadow	Mesic/Dry Grass Meadow	2.4
Lowland Wet Sedge-Shrub Bog Meadow	Dwarf Shrub - Upland	1.0
Lowland Wet Sedge-Shrub Bog Meadow	Mesic/Dry Sedge Meadow	0.6
Lowland Wet Sedge-Shrub Bog Meadow	Rock/Gravel	0.3
Lowland Wet Sedge-Shrub Bog Meadow	Grassland/Herbaceous (NLCD2011)	0.3
Lowland Wet Sedge-Shrub Bog Meadow	Mesic/Dry Graminoid	0.1
Lowland Wet Sedge-Shrub Bog Meadow	Bryoid Moss/Dwarf Shrub - Lichen	0.1
Lowland Wet Willow Low Shrub	Low Shrub - Willow	20.5
Lowland Wet Willow Low Shrub	Tall Shrub - Willow	11.1
Lowland Wet Willow Low Shrub	Tall Shrub - Alder/Willow	3.1
Lowland Wet Willow Low Shrub	Shrub/Scrub (NLCD2011)	3.1
Lowland Wet Willow Low Shrub	Tall Shrub - Alder	2.8
Lowland Wet Willow Low Shrub	Tall Shrub - Other	2.7
Lowland Wet Willow Low Shrub	Low Shrub - Alder/Willow	0.6
Lowland Wet Willow Low Shrub	Low Shrub - Alder	0.1
Lacustrine Organic-rich Forb Marsh	Sparse Vegetation	3.2
Lacustrine Organic-rich Forb Marsh	Clear Water	0.1
Lacustrine Wet Sedge-Forb Meadow	Dwarf Shrub - Other	0.3
Lacustrine Wet Sedge-Forb Meadow	Dwarf Shrub - Lush	0.1
Lacustrine Wet Sedge-Forb Meadow	Low Shrub - Willow	0.1
Lacustrine Wet Sedge-Forb Meadow	Dwarf Shrub - Upland	0.1
Lacustrine Wet Sedge-Forb Meadow	Dwarf Shrub - Wet	0.1
Lacustrine Wet Sedge-Forb Meadow	Tall Shrub - Alder/Willow	0.1

Appendix 4. Continued.

Map ecotype	Land cover class	**Area (km²)**
Lowland Lake	Clear Water	2.1
Lowland Lake	Clear Water	1.4
Lowland Lake	Turbid/Shallow Water	0.5
Volcanic Lake	Clear Water	2.6
Volcanic Lake	Open Water (NLCD2011)	0.1
Perennial Snow and Ice	Perennial Ice/Snow (NLCD2011)	1.7
Volcanic Dry Beach Rye Cinder Plain	Mesic/Dry Grass Meadow	0.5
Volcanic Dry Beach Rye Cinder Plain	Mesic/Dry Sedge Meadow	0.3
Volcanic Dry Dwarf Shrub	Dwarf Shrub - Upland	69.2
Volcanic Dry Dwarf Shrub	Dwarf Shrub - Other	2.4
Volcanic Dry Dwarf Shrub	Dwarf Shrub - Lichen	1.8
Volcanic Dry Dwarf Shrub	Dwarf Shrub (NLCD2011)	1.7
Volcanic Dry Dwarf Shrub	Dwarf Shrub - Lush	0.1
Volcanic Dry Lichen and Barrens	Rock/Gravel	290.9
Volcanic Dry Lichen and Barrens	Barren Land (NLCD2011)	61.3
Volcanic Dry Lichen and Barrens	Sparse Vegetation	14.2
Volcanic Dry Lichen and Barrens	Non-Vegetated Soil	9.9
Volcanic Dry Lichen and Barrens	Crypto-Biotic Soil	1.2
Volcanic Streams and Springs	Turbid/Shallow Water	0.3
Volcanic Wet Sedge Meadow	Wet Graminoid	0.4
Volcanic Willow Low Shrub	Low Shrub - Other	1.3
Volcanic Willow Low Shrub	Low Shrub - Willow	0.4
Volcanic Willow Low Shrub	Low Shrub - Alder	0.2
Volcanic Willow Low Shrub	Low Shrub - Alder/Willow	0.1

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