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Natural Resource Stewardship and Science

Ecological Land Survey and Soil Landscapes Map for Alagnak Wild River, Alaska, 2014

Natural Resource Technical Report NPS/ALAG/NRR—2016/1359

ON THIS PAGE
The 2014 Alagnak Wild River Ecological Land Survey and Soil Landscapes mapping team aboard a jet boat on the Alagnak River. Aaron Wells (front, center), and in back from left to right, Erin Johnson, Tracy Christopherson, and Janet Kidd. Photograph by Alaska Trophy Adventures guide service.

ON THE COVER
Clockwise from top left: Andic Haplocryepts on an ancient terrace, Alagnak Wild River, 2014; the bright white horizon consists of volcanic ash from the 1912 eruption of Novarupta in nearby Katmai National Park and Preserve. Oblique aerial photograph of the Alagnak River and surrounding uplands looking west. River reflections, lower Alagnak River. Oxyaquic Cryorthents on a river bar, Alagnak Wild River, 2014.
Photographs by Aaron F. Wells.

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Executive Summary

This study was conducted to inventory and classify soils and vegetation within the ecosystems of Alagnak Wild River (ALAG) 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 and topography. 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 132 field plots, of which 96 were sampled by us in 2014, and 36 were sampled by the Alaska Natural Heritage Program (AKNHP) in 2010. The plot network encompassed all of the major environmental gradients and landscape histories present in ALAG. 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 26 ecotypes (local-scale ecosystems) that best partition the variation in soils, vegetation, and disturbance properties observed at field plots. From the 26 ecotypes, we developed classifications of soil landscapes and disturbance landscapes that could be mapped across the park.

Detailed soil descriptions for the 132 field plots pertained to 7 soil orders: Alfisols (5% of plots), Andisols (4%), Entisols (18%), Gelisols (12%), Histosols (13%), Inceptisols (40%), and Spodosols (8%). Within these 7 soil orders, field plots corresponded to a total of 63 soil subgroups, the most common of which were Andic Haplocryepts, Fluventic Haplocryepts, Folistic Dystrocryepts, Andic Haplocryalfs, Histic Cryaquepts, Oxyaquic Cryofluvents, and Fluvaquentic Historthels.

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 ALAG. Three physiographic units capturing broad-scale divisions in landscape position, microclimate, and other state-factors were mapped using a combination of rule-based modeling related to topography and interpretation of satellite imagery. The ecotypes classified using field data were aggregated into a reduced set of 22 map ecotypes that could be mapped across the study domain; aggregation was based on similarities in vegetation structure, general soil texture, and successional processes. Three map ecotypes accounted for ~50% of the mapping area: Upland Ashy-Loamy-Rocky White Spruce Woodland (37.6% of mapping area), Upland Frozen Organic-rich Birch-Tussock Low Shrub (8.6%), and Riverine Circumneutral River Water (8.4%). The map ecotypes were further organized into 11 soil landscape, 7 disturbance landscape, and 8 great group classes.Two widespread soil landscapes accounted for >50% of the study area: Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands (39.8% of mapping area) and Riverine Silty-Sandy-Rocky Shrublands and Forests (13.2%). The disturbance landscapes were derived from map ecotypes with broadly similar disturbance regimes. Two disturbance landscapes, including Windthrow, Fire, Pests and Pathogens (48.3%) and Flooding, Sedimentation, Erosion (24.8%); encompass nearly three quarters of the mapping area. We prepared a map of soil Great Groups by aggregating ecotypes with similar Great Group classifications and naming the mapping classes after the most common Great Groups in each class. Two great group mapping classes encompassed 58% of the mapping area, including Haplocryands-Haplocryods-Haplocryalfs (44.8%) and Cryofluvents (13.2%).

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 functionally-related parts, recognizing the importance of geomorphic and hydrologic processes to disturbance regimes, the flow of energy and material, and ecosystem development. This hierarchical approach, which incorporates numerous 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 ALAG 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

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 Geographic Information System (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 data and map products from these two spatial scales are useful independent of one another, the real power of an ELS lies in the products that are derived from where these 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 relatively short sampling period, and the overall remote and diverse character of Alagnak Wild River (ALAG) 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 ALAG. Second, the short sampling window did not allow us to conduct an accuracy assessment of the maps provided as part of this ELS. Third, the map series produced as part of this ELS provides a landscape-scale view of ecosystem components with an 0.8-ha minimum map polygon size at a map scale of 1:24,000. While this scale of mapping is appropriate for remote parks like ALAG, 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 ALAG and soil sampling and GIS techniques. Additionally, the researcher(s) should use the Alaska Natural Heritage Program ALAG report entitled Alagnak Wild River: Land cover Classes and Plant Associations by Boucher and Flagstad (2014) 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 ALAG 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 (0.1 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 (Schoeneberger 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 36, which provide descriptions of generalized soil texture classes (used in the ecotype names) and soil subgroups described in the ecotype descriptions, respectively;
- Table 30, which provides a cross-walk between plot ecotype names, Map Ecotype classes (see Figure 6), Soil Landscape classes (see Figure 7), Disturbance Landscape classes (see Figure 8), and Great Group classes (see Figure 9).
- Refer to the Plant Associations section beginning on page 48 of Boucher and Flagstad (2014) 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, Disturbance Landscape, Great Group maps in conjunction with the crosswalk in Appendix 5 and Table 30 provide the user with the spatial context of each ecotype in ALAG 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, Disturbance Landscapes, and Great Group maps are provided below:

A. Use the Ecotype Key (Table 5) to determine the ecotype (e.g., Upland Frozen-Organic-rich Tussock Meadow);

B. Refer to the ecotype descriptions (see Results: Ecotypes and Floristic Associations, below) for information regarding general environment, vegetation, and soils;

C. Refer to Tables 2 and 36 for information regarding the soil characteristics of the ecotype;

D. Refer to Table 30 and locate the plot ecotype name of interest in the list (e.g., Upland Frozen-Organic-rich Tussock Meadow);

E. Follow the crosswalk in Table 30 to determine the Map Ecotype (e.g., Alpine Moist Crowberry Dwarf Shrub), Soil Landscape (e.g., Upland Frozen Organic-rich Birch-Tussock Low Shrub), Disturbance Landscape (e.g., Thermokarst), and Great Group (e.g., Historthels-Histoturbels) classes within which the ecotype was aggregated for mapping. Additionally, Table 30 allows the user to see the other ecotypes aggregated with the ecotype of interest into each map class.

Classification and Mapping: Office Applications

In the second scenario, ALAG 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 landscape-level 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 4–9) and digital (ArcGIS geodatabase) versions. The base maps, including Physiography (Figure 4) and Land Cover (Figure 5) 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 and Flagstad (2014) for the Land Cover mapping.

The ecotype map (Figure 6) 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 7), Disturbance Landscapes (Figure 8), and Great Group (Figure 9) maps. Users of these aggregated maps are directed to:

- The results section for each aggregated map (see Results: Ecosystem Mapping)
- Tables 28–29 and 31–34, which provide summaries of the areal extent of each map unit within each respective map;
- Table 30, which provides a cross-walk between abbreviated ecotype names, Map

Ecotype classes (see Figure 6), Soil Landscape classes (see Figure 7), Disturbance Landscape (see Figure 8), and Great Group classes (see Figure 9);

- Appendix 5, 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, Disturbance Landscape, and Great Group maps in conjunction with the ecotype classification are provided below.

1. Refer to the Ecotype, Soil Landscape, Disturbance Landscape, or Great Group maps (Figures 6–9) and choose the map class of interest (e.g., Map Ecotype "Riverine Sandy-Organic Wet Graminoid Meadow");
2. Refer to Table 30 and locate the map class of interest in the sorted list;
3. Follow the crosswalk in Table 30 to determine the abbreviated ecotype names (e.g., "Riverine Sandy-Organic Wet Grass Meadow," "Riverine Sandy-Organic Wet Sedge Meadow") that were aggregated into the map class, and the Soil Landscape (e.g., "Riverine Sandy-Rocky Barrens and Wet Meadows"), Disturbance Landscape (e.g., "Flooding, Sedimentation, Erosion"), and Great Group ("Cryaquents") classes 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), and Tables 2 and 36 for information regarding general environment, vegetation, and soils of the ecotypes and soil landscapes identified in Step C, above.

Introduction

To obtain information on baseline conditions and promote understanding of long-term changes in landscape characteristics and processes in Alagnak Wild River (ALAG), 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 1) detect changes in ecosystem structure and function; 2) determine the roles played in those changes by human activities (e.g., introduction of invasive species, land disturbances) and large-scale forces (e.g., climate change, glacial dynamics, volcanism, wildfire); and 3) inform predictions of future ecosystem trajectories. 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 park ecosystems. In support of the NPS I&M objectives described above, ABR, Inc.—Environmental Research & Services (ABR) worked with the NPS to conduct an Ecological Land Survey (ELS) designed to classify and map soils and vegetation in ALAG.

The structure, function, and distribution of ecosystems are regulated 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 ALAG (Figure 1). We then integrated information from the ecotype classification with ancillary datasets to map soil landscapes across ALAG.

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 spatial and 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 and the resulting ash-fall that have shaped the landscapes and ecosystems of ALAG.

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 on surficial and bedrock geology over an existing land cover map to distinguish vegetation communities that were previously unmapped. To demonstrate an ap-

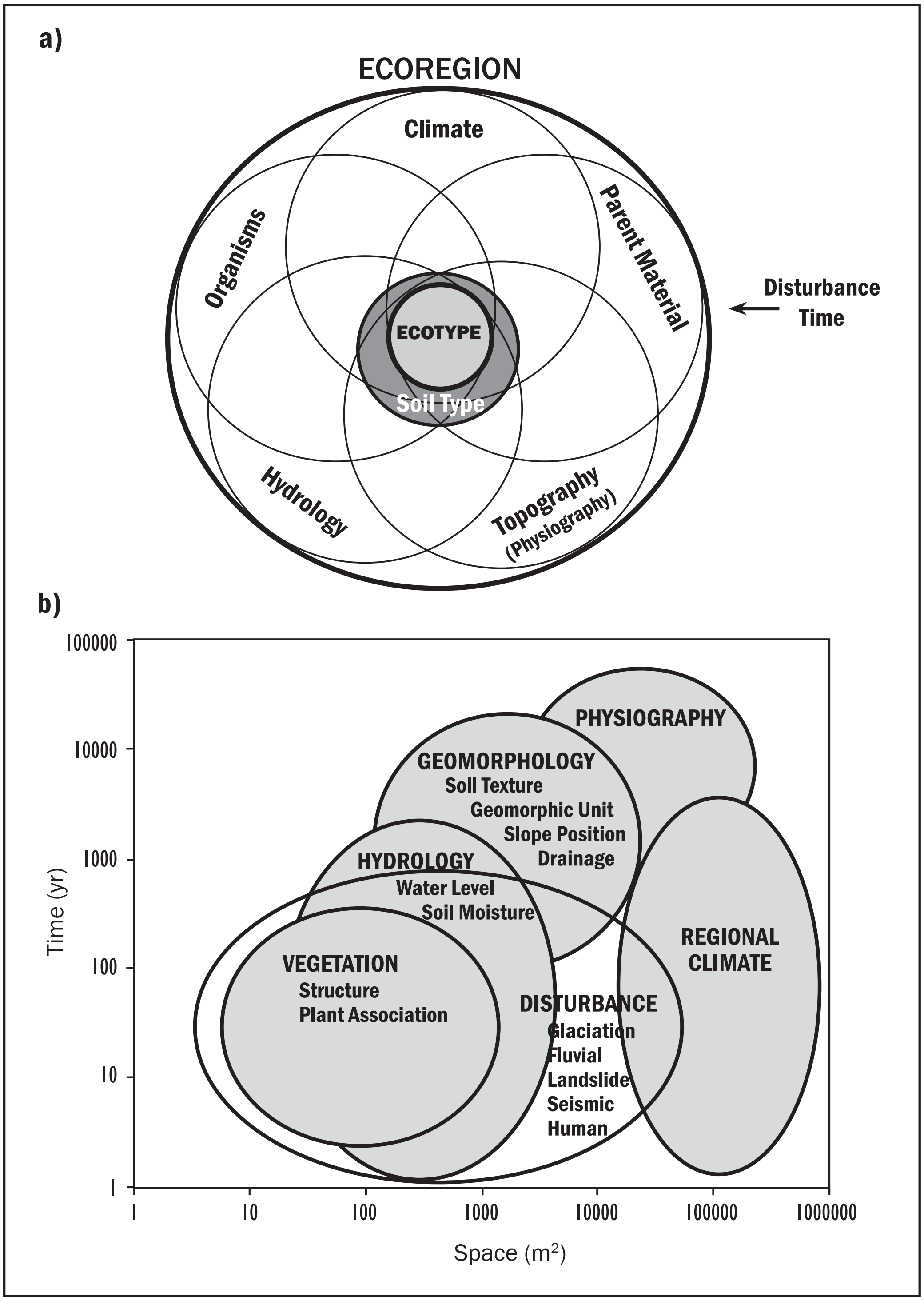

Figure 1. Interaction of interrelated state factors that control the structure and function of ecosystems (a) and the scale at which they operate (b).

plication of this approach, as part of the ALAG study effort, we analyzed the relationships among soils and ecotypes and used these relationships to develop maps of soil and disturbance landscapes. The maps can serve as a spatial database to aid resource managers in evaluating ecological impacts and developing land management strategies appropriate for a diversity of landscape conditions. Additionally, the maps provide end users 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 future study design development and data analysis.

This report summarizes the results of an ELS to classify and map the ecosystems and soils of ALAG. 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. We used these data to develop a preliminary spatially-explicit conceptual model of soils in ALAG and identify data gaps. We then used the conceptual model to develop a stratified, gradient-oriented sampling scheme to collect field verification data. We used our field verification data, in combination with field data collected by Alaska Center for Conservation Science (ACCS, formerly Alaska Natural Heritage Program) and an existing landcover map (Boucher and Flagstad 2014) to create a soils map, following the soil landscape approach used by Wells et al. for Lake Clark National Park and Preserve (2013), Kenai Fjords National Park (2014), Aniakchak National Monument and Preserve (2016), Wrangell-St. Elias National Park and Preserve (Jorgenson et al. 2008a) and the Arctic Network of National Parks (Jorgenson et al. 2009). This approach included incorporating several existing GIS and RS data layers, rule-based modeling, and the analysis of relationships among geomorphology, soils, and 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 soils, vegetation, and environmental characteristics in ALAG;
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 local-scale ecosystems (ecotypes) and soil landscapes 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

ALAG is located on the northwestern portion of the Alaska Peninsula, approximately 50 km northeast of King Salmon and 400 km west-southwest of Anchorage. ALAG encompasses approximately 110 km portion of the Alagnak River, together with its floodplain and adjacent lands. The eastern and roughly half of the southern boundary of ALAG are coincident with the boundary of Katmai National Park and Preserve. ALAG begins approximately 11 river kilometers downstream of Kukaklek Lake, the source of the Alagnak River, and extends downstream to within approximately 30 river kilometers of the confluence of the Alagnak with the Kvichak River. The mapping area totals 12,507.4 ha (Figure 2).

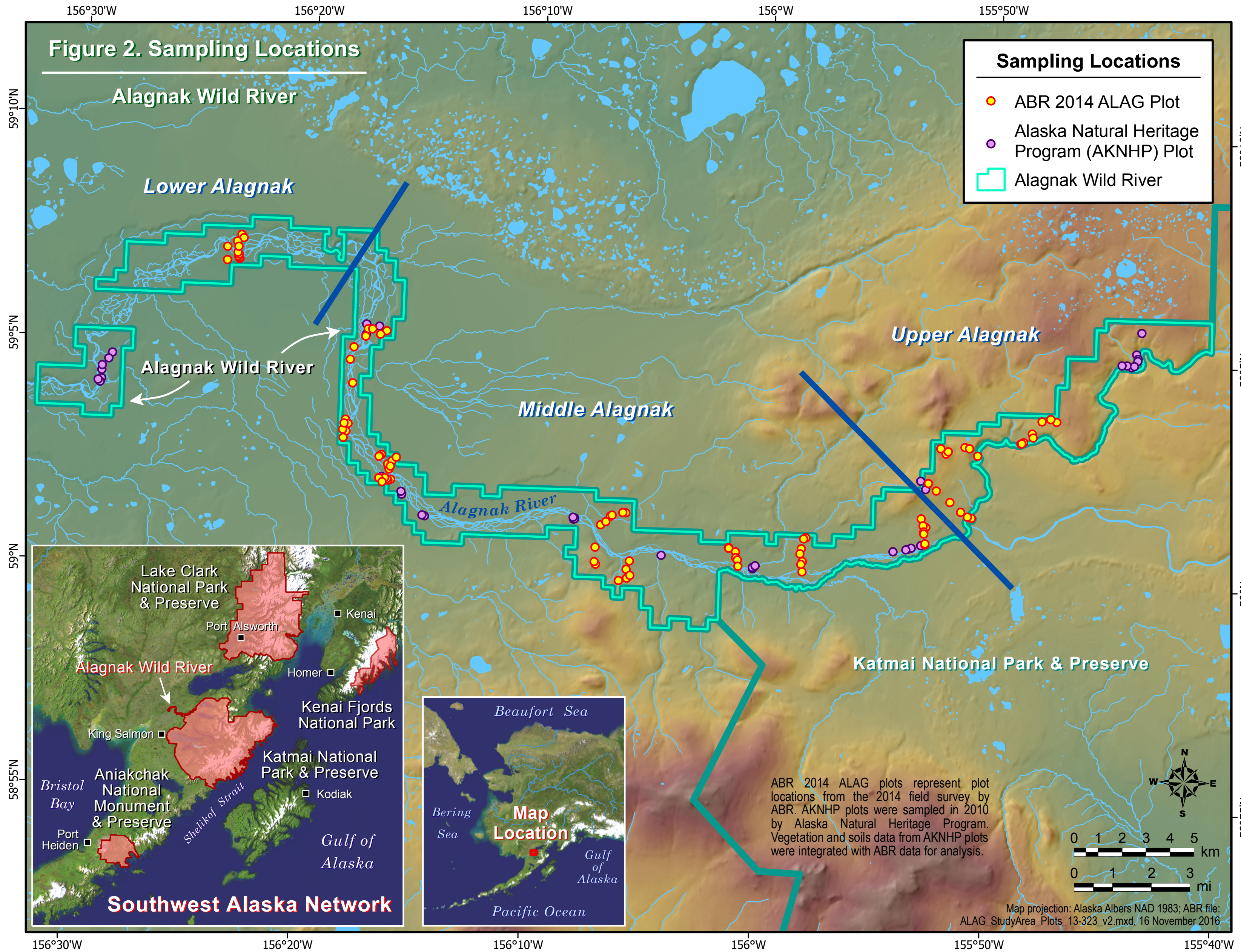

Figure 2. Sampling locations, study area boundary, and the bounds of the upper, middle, and lower study area for the ecological land survey and soil landscapes mapping for Alagnak Wild River (ALAG), southwest Alaska.

Methods

Field Surveys

We sampled a total of 15 transects (toposequences) across ALAG during 12–18 August 2014. Field surveys were based out of Alaska Trophy Adventure Lodge, which served as a base for field crews returning from the field each evening. Field crews were deployed to field transects via jet boat each morning where they traversed each transect by foot. Crews were picked up each evening at the transect end point and returned to the lodge. Transect locations were selected using a gradient-directed sampling scheme (Austin and Heyligers 1989) to gather the range of ecological conditions present within ALAG, 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 ALAG.

We collected data at 72 Full Plots and 24 Verification (v) Plots for a total of 96 plots along the 15 transects (Figure 2). 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 attributes listed in Appendix 1. At V-Plots we collected a reduced set of ELS and VEG data attributes (Appendix 1); these plots were designed to maximize efficiency in the field while simultaneously collecting the most salient data attributes required for ecotype classification.

All field plots were circular in shape with an approximate radius of 10 m, and each was situated entirely within a single distinct vegetation type or photo-signature identified on aerial or satellite imagery (see GIS AND REMOTE SENSING DATA COMPILATION: Aerial and Satellite Imagery for more details regarding imagery used). The plot center was established by the field crew leader in a homogeneous patch of vegetation that was at least ½ ha in area. Transitional areas between distinct vegetation types (ecotones) were avoided. 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 was taken at each plot, including representative landscape- and ground cover views and photos of the soil pit face.

We collected information on 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). At Full soil pits we collected the complete suite of soil horizon data attributes listed in Appendix 1. At Partial soil pits we collected a reduced set of soil horizon data attributes (Appendix 1); these pits were designed to maximize efficiency in the field while simultaneously collecting the most salient data attributes required for soil classification. Detailed soil stratigraphic descriptions are time consuming to complete and, given the limited time available in the field, a hybrid approach was required. Using this approach allowed us to maximize efficiency in the field while optimizing the amount of soils information obtained. The general soils attributes, which were collected at all plots, provide information that is important for soil taxonomy and classification of ecotypes and can be collected rapidly. 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 can be made rapidly 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 ALAG.

Data on soils were collected from shallow 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 6 Full and 65 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, Schoeneberger et al. 2012), with the exception of the depth requirements for 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 individual species, both vascular and nonvascular. 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%. 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 was flagged with a veg_completeness_code of “partial” (p).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 any 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 (KBI) in St. Petersburg, Russia. Non-vascular specimens were split in two with half the specimen remaining in Alaska and the other half sent to the the KBI. In the case of specimens too small to split the entire specimen was sent to KBI. Specimens sent to KBI were not returned and, following identification, were destroyed. Comprehensive lists of vascular and non-vascular plant species identified in ALAG are provided in Appendix 2, which includes the Alaska state rankings for rare taxa (AKNHP 2016) and the invasiveness rankings AKEPIC (2016) for non-native taxa. Appendix 3 provides a synonymy table between plant taxonomic names used by ABR and those accepted by the Integrated Taxonomic Information System (ITIS 2015). All vascular plant specimens, and all remaining non-vascular specimens, have been returned to the NPS.

Supplementary Field Data

We supplemented our field dataset with ground-based vegetation and soils data collected in 2010 by Alaska Natural Heritage Program (AKNHP; now Alaska Center for Conservation Science) personnel in 2010. This dataset was originally used to generate a vegetation classification and to develop a land cover map for ALAG (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 and Flagstad (2014).

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 95 field plots, of which 36 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 43 data attributes in the ABR ALAG 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 36 AKNHP plots were pooled with vegetation and soils data from the 96 ABR plots from August 2014, providing a total of 132 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.

Table 1. Listing of ABR data attributes extracted from the Alaska Natural Heritage Program ALAG field database from Boucher and Flagstad (2014) for use in classifying and mapping ecotypes and soils in Alagnak Wild River, AK, 2014.

ABR Database Table	ABR Database Column	AKNHP Database Table	AKNHP Database Column	ABR Notes
els	aspect_degrees	TBL_SITE	Aspect_Tru	
els	els_plot_type_code	TBL_SITE	LC_PA_Or_B	
els	env_field_note	TBL_SITE	SiteMemo	
els	final_elevation_m	ALAG2010trimbles	GPS_Height	
els	physiography_code	TBL_SITE	Physiography	
els	plot_id	TBL_SITE	Transect	
els	slope_degrees	TBL_SITE	Slope_deg	
els	soil_class_code	TBL_SoilProfile	all fields	in addition soil related fields in TBL_SoilSITE 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_SoilSITE	SoilMoisture	
els	soil_observed_maximum_depth_cm	TBL_SoilSITE	HoleDepth	
els	soil_permafrost_ynu_code	TBL_SoilSITE	PermafrostDepth	
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_SoilSITE	CommonRootsDepth	
els	soil_surface_organic_thick_cm	TBL_SoilProfile	Horizon	
els	soil_thaw_depth_probe_cm	TBL_SoilSITE	General Soil Memo	
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	

Table 1. Continued.

ABR Database Table	ABR Database Column	AKNHP Database Table	AKNHP Database Column	ABR Notes
soil_horizon	redox_soil_color_chroma_code	TBL_SoilProfile	MottleHueValueChroma	
soil_horizon	redox_soil_color_hue_code	TBL_SoilProfile	MottleHueValueChroma	
soil_horizon	redox_soil_color_value_code	TBL_SoilProfile	MottleHueValueChroma	
soil_horizon	soil_secondary_texture_code	TBL_SoilProfile	TextureUnder2mm	
soil_horizon	soil_boundary_distinctness_code	TBL_SoilProfile	BoundaryDistinctness	
soil_horizon	soil_boundary_topography_code	TBL_SoilProfile	BoundaryTopography	
soil_horizon	soil_color_chroma_code	TBL_SoilProfile	MatrixHueValueChroma	
soil_horizon	soil_color_hue_code	TBL_SoilProfile	MatrixHueValueChroma	
soil_horizon	soil_color_value_code	TBL_SoilProfile	MatrixHueValueChroma	
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	
soil_horizon	soil_texture_code	TBL_SoilProfile	TextureUnder2mm	
soil_horizon	top_depth_cm	TBL_SoilProfile	Depth_range	
veg	veg_cutpoint_viereck_4_code	TBL_VegCover	SciName, COVER	
veg	veg_floristic_class_code	TBL_VegCover	SciName, COVER	
veg	veg_viereck_4_code	TBL_VegCover	SciName, COVER	
veg_cover	cover_percent	TBL_VegCover	COVER	
veg_cover	veg_taxonomy_code	TBL_VegCover	SciName	

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 and Flagstad (2014).

Ecotypes

We classified ecotypes using a three-step process: (1) the ecological components were individually classified for each 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. Next, non-vascular species were aggregated to genus level, and non-vascular genera included in the floristic analysis were limited to *Sphagnum* sp., *Hylocomium* sp., and *Pleurozium* sp. 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) were excluded from the analysis. Fifth, all vascular and non-vascular species with cover less than 1% 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, 2016). 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. 2016) and rgl (Adler et al. 2016) 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 from 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., Loamy-Organic), and vegetation

Table 2. Description of nine generalized soil texture classes used in ecotype classification and mapping, including texture range and predominant soil orders, for Alagnak Wild River, 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 andic subgroups of Inceptisols
Frozen-Organic-rich	Sandy clay loam to loamy fine sand	Soils permanently frozen in upper meter with thick (≥40 cm) surficial organic horizons, mineral soil when present often stratified and below 20 cm, >15% rock fragments very rare.	Gelisols and Histosols
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.	Inceptisols
Organic-rich	Loamy very fine sand to very fine sandy loam	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.	Histosols
Rocky	Loamy sand to sand	In upper 40 cm, soils sandy and >15% rock fragments (>2 mm) very common.	Entisols
Rocky-Loamy-Organic	Silt loam to loamy sand	In upper 40 cm, >15% rock fragments (>2 mm) very common, mineral soils predominantly stratified silt loams, sandy loams, and sands beneath moderately thick (10–40 cm) surficial organics.	Inceptisols
Rocky-Organic	Silt loam to loamy sand	In upper 40 cm, moderately thick (10–40 cm) surficial organics over unstratified mineral soils with >15% rock fragments (>2 mm).	Inceptisols
Sandy-Organic	Sand	In upper 40 cm, soil with moderately thick (10–40 cm) to thick (≥40 cm) surficial organics, mineral soils sandy with sands often infused into soil organic materials, >15% rock fragments (>2 mm) uncommon.	Entisols and Histosols
Silty-Sandy-Rocky	Silt loam to sand	In upper 40 cm, soils stratified, mineral textures alternating between loamy and sandy, organic horizons <10 cm in total thickness, >15% rock fragments (>2 mm) very common.	Entisols and Inceptisols

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 for use and management (e.g., Spodic Haplocryands and Andic Haplocryods). Common relationships among ecosystem components were identified using contingency tables. The contingency tables sorted plots by physiography, dominant soil texture, 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 excluded as atypical (outliers). Ecotype names were then assigned based on the aggregated ecological components; e.g., Lowland Organic-rich Wet Sedge-Shrub Bog Meadow.

Soils

Samples from 79 distinct soil horizons were collected from 37 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 79 soil samples were then reviewed and a subset of 30 samples was selected for laboratory analysis (Appendix 4).

Priority for selecting plots for analysis was based on secondary diagnostic horizons requiring laboratory data for taxonomic classification, spatial distribution within ALAG, whether or not a full soil characterization had been completed for the plot, and cost. For ALAG 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 ALAG 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 30 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 36 subsamples were prepared for shipment. Of these 36 subsamples, 21 were shipped to the University of Fairbanks (UAF), Palmer Research Center (Laurie Wilson, Lab Manager), 8 were shipped to Colorado State University (CSU) (James R. Self, Lab Manager), and 7 were shipped to Alaska Beget Consulting (ABC) (Dr. James Beget, UAF). All soil sub-samples sent to laboratories for analysis were destroyed as part of the analysis. Any soil samples remaining after preparation of the sub-samples have been returned to the NPS.

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 14 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 14 samples (Michaelson et al. 1992). These soil laboratory data are presented in Appendix 4.

CSU analyzed 8 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 7 soil horizons 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 4, 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 $Al3+$ (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, o 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 Western Digital (WD) MyPassport 1TB external hard drive which was delivered to NPS with the final 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. Note that in the tabular field data values of -999 indicate no data for a given attribute.

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 ALAG. 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 ALAG. These biophysical components include

Table 3. Listing of all data and files compiled and delivered with the final report for the ecological land survey and soils mapping for Alagnak Wild River, southwest Alaska.

Type	Origin	Deliverable Description	File Format	Path*
Compliance	NPS	Research Permit	PDF	R:\ALAG_ELS_and_Soils_Deliverable\Compliance\Research Permit
Field Data	ABR	Field photos	JPEG	R:\ALAG_ELS_and_Soils_Deliverable\Photos
Field Data	ABR	List of plant specimens collected	Microsoft Excel	R:\ALAG_ELS_and_Soils_Deliverable\Data\Plant_specimens
Field Data	ABR	List of remaining soil samples	Microsoft Excel	R:\ALAG_ELS_and_Soils_Deliverable\Data\Soil_samples
Field Data	ABR	Original soil laboratory data files	Microsoft Excel	R:\ALAG_ELS_and_Soils_Deliverable\Data\Soil_lab_data_raw
Field Data	ABR	Tabular field data	Microsoft Access	R:\ALAG_ELS_and_Soils_Deliverable\Data\Tabular_field_data
GIS/RS	ABR	ABR Plot locations	Geodatabase	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Plot_locations
GIS/RS	Pre-existing	AKNHP Land cover Plot locations	Shapefile	PDS\Landcover_data\FieldDataViewers\LC_FDVs\ALAG_LC2012\Spatial
GIS/RS	ABR	ALAG Disturbance Landscapes	Layer file	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ALAG Map Ecotypes	Layer file	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ALAG Physiography	Layer file	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ALAG Soil Landscapes	Layer file	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ALAG Great Groups	Layer file	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	ALAG_Ecosystem_Mapping	Geodatabase	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Soil_LS_Model\Outputs
GIS/RS	ABR	Intermediate GIS and Remote Sensing files	Various	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Original_Source
GIS/RS	Pre-existing	Land Cover	unknown	PDS\Albers\parks\katm
GIS/RS	ABR	Land_Cover	Layer	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Soil_LS_Model\Land_Cover
GIS/RS	ABR	Original field GPS files	GPS Exchange Files (gpx)	R:\ALAG_ELS_and_Soils_Deliverable\GIS\Plot_locations\Field_GPS_files
GIS/RS	Pre-existing	SPOT DEM	TIFF	PDS\DEM\SPOT\KATM\
GIS/RS	Pre-existing	IKONOS Mosaic—Natural Color	Mosaic Dataset	PDS\IKONOS\KATM\IKONOS.gdb\KatmFinal\KATM20m.tif
Report	ABR	Final report text and supporting files	Various	R:\ALAG_ELS_and_Soils_Deliverable\Reports_ABR_ALAG_NRTR
Report	ABR	Progress report	PDF	R:\ALAG_ELS_and_Soils_Deliverable\Reports_Progress
Report	ABR	Related Reports	PDF	R:\ALAG_ELS_and_Soils_Deliverable\Reports_Related
Safety	ABR	Field safety	Various	R:\ALAG_ELS_and_Soils_Deliverable\Safety&LessonsLearned

*The PDS is the National Park Service Permanent Dataset. All other files were delivered on an external hard drive that accompanied the final report for the Ecological Land Survey and Soil Landscapes Map for Alagnak Wild River, Alaska, 2014 project.

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 ALAG. 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., AKNHP 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., AKNHP Land Cover Map "*LC_Name*" field). Text references to the attributes stored in fields are presented in plain text, and are quoted in the case of non-numeric fields; e.g.,AKNHP Land Cover Map, "*LC_Name*" value of "Mixed Low/Dwarf Shrub-Sedge."

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 used the Satellite Pour l'Observation de la Terre (SPOT) DEM (20 m) prepared for Katmai National Park and Preserve (KATM) and ALAG by SPOT Image Corp. The KATM SPOT DEM was used as input into the Spatial Analyst Tools in ArcToolBox™ to calculate a slope raster for ALAG.

Land Cover

The AKNHP Land Cover Map for ALAG prepared by the AKNHP (Boucher and Flagstad 2014) was delineated over orthorectified 1-m resolution IKONOS satellite imagery acquired in 2006. A minimum map unit of 0.8 ha was assigned to terrestrial land cover classes, while riverine islands and waterbodies were mapped at a finer scale. We used the AKNHP Land Cover Map as the land cover input for the ecotype and soil landscape mapping. Specifically, a copy was made of the AKNHP Land Cover Map, including all land cover data attributes and map polygons and named the ALAG_Ecosystem_Mapping layer. The ALAG_Ecosystem_Mapping layer line work was then modified to develop the ecotype and soil landscape mapping products as described in the section GIS MODELING AND ECOSYSTEM COMPONENT SYNTHESIS, below.

Aerial and Satellite Imagery

We used the KATM IKONOS, an orthorectified multi-spectral 1-m resolution IKONOS satellite imagery mosaic acquired in 2006 by GeoEye, LLC for KATM and ALAG, as the primary imagery for mapping. Secondarily we used a mosaic of digital aerial photography that covers the entirety of ALAG. The ALAG Aerial Photo Mosaic was taken at 1:15,840-scale (three flight lines) and 1:24,000-scale (four flight lines) in 2000.

GIS Modeling and Ecosystem Component Synthesis

Physiography

We delineated ALAG landscapes into three 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 land cover map attribute from the ALAG_Ecosystem_Mapping layer and field data, informed the mapping of ecotypes, soil landscapes, and other ELS map themes. We developed the physiography map using the ALAG_Ecosystem_Mapping layer as the base. We then used a combination of approaches, including photointerpretation, verification using field data, and spatial modeling using the KATM SPOT DEM to produce a polygon-based map that matches the applicable map scale of the AKNHP Land Cover Map. Because some map polygons could potentially be assigned to more than one physiographic class (e.g., wetlands could belong to Lowland or Riverine physiography), we assigned physiography classes in the sequence presented below. Once a polygon 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. Below we present brief definitions of the physiographic units and the methods used to delineate each.

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). ALAG supports a range of channel morphologies and riparian landforms, ranging from a broad, meandering floodplain (e.g., lower Alagnak River), to an anastamosing plane form (e.g., middle Alagnak 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 flooded regularly. To begin mapping riverine physiography, the ALAG_Ecosystem_Mapping layer was symbolized on the "*floodplain*" field and riverine physiography was preliminarily assigned to all polygons with values "Alagnak active floodplain" and "Secondary Stream". We then reviewed all preliminary physiography polygons beginning at field transect locations that traversed from riverine to lowland or upland physiography. When assessing the "floodplain" land cover polygons with respective to the plot data, we focused primarily on soil attributes that indicate period flooding and sedimentation, including surface organic thickness and degree of interbedding of organic and mineral soil layers. Soils with less than approximately 10 cm of organic material at the soil surface were considered riverine. Secondarily we used field notes and photos of disturbance observations, including recent sediment deposition or erosion and drift lines to determine if a site was riverine physiography. When polygons were encountered that were determined not to fit riverine physiography we edited the polygons as needed be better fit our concepts of riverine physiography. The edited polygons were then assigned the appropriate physiography class.

Lowland and Upland

Lowland physiography comprises 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 and organic-rich, and tend to support hydrophytic vegetation. Delineation of Lowland physiography based on topography and landscape position criteria alone, however, is impractical in ALAG because of the widespread presence of well-drained soil in areas of flat terrain on ancient terraces and glacio-fluvial outwash deposits.

The Upland unit generally corresponds to hillslopes that lie below the elevational upper limit of tall shrub development. All areas that were not assigned to a physiographic unit in previous landscape analysis steps were coded as Upland.

We delineated Lowland and Upland physiography using a combination of rule-based geospatial modeling and visual photo interpretation. The modeling step identified 1) areas of hydrophytic vegetation based on land cover map classes from the ALAG_Ecosystem_Mapping layer, and 2) slope criteria. Polygons with the land cover classes "Wet Herbaceous" or "Water" in with the "*LC_Name*" or "*LC_Name2*" field were assigned to Lowland. Polygons with the land cover class "Low Shrub Wetland" in the "*LC_Name*" field were all assigned to lowland, while those polygons with the same land cover class in the "*LC_Name2*" were reviewed manually and assigned to either upland or lowland. Next, a slope raster calculated from the KATM SPOT DEM was used to calculate zonal slope statistics, including average, min, max, and standard deviation, for each polygon using the Spatial Analyst Tools in ArcToolBoxTM, The zonal statistics were then used to assign upland physiography to polygons using the following rules: polygons with a minimum slope ≥3°, polygons with a mean slope ≥9°, and polygons with a mean slope between 3° and 9° and the mean minus 1.5*standard deviation ≥0. Following the assignment of Upland physiography based on slope criteria the remaining polygons without a physiography assigned were reviewed and physiography assigned manually. Beginning at field transect locations that traversed across areas of questionable physiography, we focused on soil and vegetation attributes of field plots to help make physiography determinations. Depth to water table, soil drainage, presence of redoximorphic features, surface organic thickness, and presence of hydrophytic plants were important criteria for decision making. As part of this process, some ALAG_Ecosystem_Mapping layer mappolygons were edited to better distinguish between upland and lowland areas. Some areas of lacustrine and subalpine physiography were identified in ALAG. However, given their limited extent and low sample sizes, the lacustrine and subalpine areas were aggregated with lowland and upland, respectively, for the purposes of ecosystem classification and mapping.

Bedrock Chemistry

The chemistry of dominant bedrock types in the upper ALAG study area is acidic to circumacidic. In the middle and lower ALAG study area, bedrock exposures are rare and surficial deposits are more important in controlling ecosystem processes. 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 and surficial geology of ALAG.

Land Cover/Physiography/Map Ecotype Crosswalk

After completing the ecotype classification, we created a table of all unique combinations of physiography and land cover classes from the ALAG_Ecosystem_Mapping layer. After referring to the keys and descriptions of land cover classes and plant associations in Boucher and Flagstad (2014), we reviewed the unique combinations and attempted to assign an ecotype to each. Combinations of physiography and land cover class could usually be assigned to a single ecotype because many of the classes developed by AKNHP and ABR emphasize the species and growth form of the dominant, canopy-forming vegetation. However, a few land cover classes, such as "Mixed Broadleaf/Needleleaf" were associated with multiple ecotypes and required aggregating similar ecotypes into map ecotypes for the purposes of the land cover/physiography/ecotype crosswalk (see below).

Map Ecotypes

Polygons in the AKNHP Land Cover Map were delineated based on interpreting photo-signatures in the high-resolution aerial photography. These photo-signatures are produced almost entirely by the structure (growth-form and density) of the uppermost, canopy-forming layer of vegetation; attributes that are readily visible from a passing aircraft or satellite. As a result, ecotypes with similar vegetation structure (e.g., dwarf shrub) but different species composition (e.g., dominated by birch vs. willow) often share similar photo signatures. 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 crosswalked to the the land cover classes. Once ecotypes were aggregated to map ecotype classes the land cover/physiography/map ecotype crosswalk was completed by assigning map ecotypes to each unique combination of physiography and land cover class.

Soil Landscapes

Soil-landscape associations, hereafter "soil landscapes," were identified to characterize and map landscape-scale relationships between soil type, physiography, and vegetation 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 parkwide study domain. In aggregating ecotypes into map ecotypes, we emphasized similarities in vegetation structure. 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 ALAG. Important disturbance processes in ALAG, such as wildfire, thermokarst, 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.

Soil Great Group Mapping

The Keys to Soil Taxonomy (Soil Survey Staff 2010) is a nationally accepted hierarchical classification of soils prepared by the USDA Natural Resource Conservation Service (NRCS). The Keys to Soil Taxonomy splits soils out into 12 soil order within which soils are further broken down into Suborders, Great Groups, and Subgroups. We prepared a map of soil Great Groups by aggregating ecotypes with similar Great Group classifications and naming the mapping classes after the most common Great Groups in each class.

ALAG Ecosystem Mapping

The final ALAG_Ecosystem_Mapping layer includes data attribute fields for land cover class ("*LC_Code*", "*LC_Name*"), “*Physiography*”, map ecotype (“*meco_code*”, “*meco_title*”), soil landscape (“*sola_code*”, “*sola_title*”), disturbance landscapes (“*dila_code*”, “*dila_title*”), and soil great group (“*gg_code*”, “*gg_title*”). These data fields were used to symbolize the ALAG_Ecosystem_Mapping layer on each theme to create maps for this report and to create layer files for each theme for the GIS and data deliverable that accompanies this report.

Results and Discussion

Ecotypes and Plant Associations

We identified a total of 26 ecotypes in ALAG, based on analysis of field data obtained by AKNHP in 2010 and ABR in 2014. 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 provided a key to ecotypes to aid in the identification of ecotypes in the field (see below). A total of 40 previously described plant associations from Boucher and Flagstad (2014) and Boggs et al. (2003) were represented within the 26 ecotypes (Table 4). An additional fifteen undefined plant associations also were found. Of these, 4 are waterbody ecotypes, 2 are barrens, and the remaining 9 are vegetated terrestrial ecotypes that did not fit within the existing classification. Thirteen ecotypes were associated with one or two defined plant associations, and 26 plant associations described only one ecotype. The ecotypes associated with one or two defined plant associations 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 Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub and the plant association *Empetrum nigrum* represent a unique combination of ecotype and plant association. This ecotype occurs the highest elevations in the study area and is consistently dominated by *Empetrum nigrum*. Nine ecotypes had three or more defined plant associations (Table 4). These include ecotypes with relatively high 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 Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub, which is associated with 8 plant associations, consisting of *Salix alaxensis*/*Calamagrostis canadensis-Equisetum arvense*, *Salix alaxensis-Salix pulchra*, *Salix barclayi*/*Calamagrostis canadensis*, *Salix barclayi*/Mixed herbaceous, *Salix barclayi-Salix alaxensis*, *Salix bebbiana*, *Salix pulchra*/*Calamagrostis canadensis*, *Salix pulchra-Salix barclayi*. These 8 plant associations have a common dominant genus, *Salix* spp., but have otherwise distinct species compositions. Additionally, 14 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 barclayi*/Mixed herbaceous occurs in 3 ecotypes that are components of 2 physiography classes, including Lowland Organic-rich Wet Willow Low and Tall Shrub, Riverine Silty-Sandy-Rocky Moist Willow Low Shrub, Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub. This plant association is co-dominated by *Salix barclayi*, a species that tolerates a diverse set of environmental conditions and disturbance processes, and that expresses two growth forms, low (0.2–1.5 m) and tall (>1.5 m) shrub.

Key to Ecotypes

The Key to Ecotypes (Table 5) for ALAG 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) and inclinometer (used for measuring slope gradient) 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. Technical soil properties such as particle size and diagnostic subsurface horizons were purposely excluded from the Ecotype Key. Determining these properties depends on excavating a full (1 m) soil pit, which requires considerable time as well as specialized skills and equipment. 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 this document for more information on when to use this Ecotype Key.

Table 4. Crosswalk of ecotypes, plant associations, and Alaska Vegetation Classification (Viereck et al. 1992) level IV vegetation classes, and number of field plots in Alagnak Wild River, southwest Alaska. Plant community classification follows Boucher and Flagstad (2014).

Plot ecotype	Plant association	Vegetation class (Level IV)	Number of plots
Lowland Loamy-Organic Sweetgale-Willow Low Shrub	*Myrica gale-Salix pulchra*	Open Low Sweetgale-Graminoid Bog	2
Lowland Loamy-Organic Sweetgale-Willow Low Shrub	*Myrica gale*	Open Low Sweetgale-Graminoid Bog	1
Lowland Loamy-Organic Sweetgale-Willow Low Shrub	*Myrica gale-Betula nana*	Open Low Shrub Birch-Ericaceous Shrub Bog	1
Lowland Organic-rich Wet Sedge Meadow	*Eriophorum angustifolium*	Fresh Sedge Marsh	1
Lowland Organic-rich Wet Sedge Meadow	*Carex aquatilis-Comarum palustre*	Subarctic Lowland Sedge-Moss Bog Meadow	1
Lowland Organic-rich Wet Sedge Meadow	*Carex aquatilis-Comarum palustre*	Subarctic Lowland Sedge-Shrub Wet Meadow	1
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	*Carex pluriflora-Comarum palustre*	Subarctic Lowland Sedge-Moss Bog Meadow	2
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	No class	Subarctic Lowland Sedge-Moss Bog Meadow	2
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	*Carex aquatilis-Comarum palustre*	Subarctic Lowland Sedge Wet Meadow	1
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	*Betula nana-Ledum palustre* ssp. *decumbens/Sphagnum* spp.	Subarctic Lowland Sedge-Shrub Wet Meadow	1
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	No class	Subarctic Lowland Sedge Wet Meadow	1
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	*Eriophorum russeolum*	Subarctic Lowland Sedge-Moss Bog Meadow	1
Lowland Organic-rich Wet Willow Low and Tall Shrub	*Salix pulchra-Salix barclayi*	Open Low Willow	1
Lowland Organic-rich Wet Willow Low and Tall Shrub	*Salix barclayi/Mixed herbaceous*	Open Low Willow–Graminoid Shrub Bog	1
Lowland Organic-rich Wet Willow Low and Tall Shrub	*Salix barclayi/Equisetum arvense*	Open Low Willow	1
Lowland Rocky-Loamy-Organic Spruce Forest and Woodland	*Picea glauca/Ericaceous shrubs*	Open White Spruce Forest	1
Lowland Rocky-Loamy-Organic Spruce Forest and Woodland	No class	White Spruce Woodland	1
Riverine Circumneutral River Water	No class	Fresh Water	3
Riverine Grass Marsh	*Arctophila fulva*	Fresh Grass Marsh	1
Riverine Rocky Barrens and Partially Vegetated	No class	Partially Vegetated	1
Riverine Rocky Barrens and Partially Vegetated	No class	Barren	1
Riverine Sandy-Organic Wet Grass Meadow	*Calamagrostis canadensis*-Wetland	Bluejoint Meadow	5
Riverine Sandy-Organic Wet Grass Meadow	*Calamagrostis canadensis*-Forb	Bluejoint-Herb	1

Table 4. Continued.

Plot ecotype	**Plant association**	**Vegetation class (Level IV)**	**Number of plots**
Riverine Sandy-Organic Wet Sedge Meadow	*Carex lyngbyei-Comarum palustre*	Subarctic Lowland Sedge Wet Meadow	2
Riverine Sandy-Organic Wet Sedge Meadow	*Carex lyngbyei-Comarum palustre*	Fresh Sedge Marsh	2
Riverine Sandy-Organic Wet Sedge Meadow	*Carex utriculata*	Subarctic Lowland Sedge Wet Meadow	1
Riverine Sandy-Organic Wet Sedge Meadow	*Carex lyngbyei*	Fresh Sedge Marsh	1
Riverine Sandy-Organic Wet Sedge Meadow	*Carex pluriflora-Comarum palustre*	Subarctic Lowland Sedge-Moss Bog Meadow	1
Riverine Sandy-Organic Wet Sedge Meadow	*Carex lyngbyei-Carex aquatilis*	Subarctic Lowland Sedge Wet Meadow	1
Riverine Sandy-Organic Wet Sedge Meadow	*Carex lyngbyei-Calamagrostis canadensis*	Subarctic Lowland Sedge Wet Meadow	1
Riverine Silty-Sandy-Rocky Alder Tall Shrub	*Alnus incana* ssp. *tenuifolia/Calamagrostis canadensis*	Closed Tall Alder	1
Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	*Salix pulchra-Salix barclayi*	Open Low Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	*Salix barclayi/Mixed herbaceous*	Open Low Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	*Salix pulchra/Calamagrostis canadensis*	Open Low Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix pulchra/Calamagrostis canadensis*	Open Tall Willow	3
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix barclayi-Salix alaxensis*	Open Tall Willow	2
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix bebbiana*	Closed Tall Willow	2
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix alaxensis/Calamagrostis canadensis-Equisetum arvense*	Open Tall Willow	2
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix alaxensis-Salix pulchra*	Open Tall Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix alaxensis-Salix pulchra*	Closed Tall Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix pulchra-Salix barclayi*	Closed Tall Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix barclayi*/Mixed herbaceous	Open Low Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix bebbiana*	Open Tall Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix pulchra/Calamagrostis canadensis*	Closed Tall Willow	1
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	*Salix barclayi/Calamagrostis canadensis*	Open Tall Willow	1
Riverine Silty-Sandy-Rocky Spruce-Balsam Poplar Forest	*Populus balsamifera/Alnus incana* ssp. *tenuifolia/Calamagrostis canadensis*	Open Balsam Poplar Forest	1

Table 4. Continued.

Plot ecotype	**Plant association**	**Vegetation class (Level IV)**	**Number of plots**
Riverine Silty-Sandy-Rocky Spruce-Balsam Poplar Forest	*Picea glauca-Populus balsamifera-Betula papyrifera* var. *kenaica/Viburnum edule*	Open Spruce-Balsam Poplar Forest	1
Riverine Silty-Sandy-Rocky Spruce-Birch Forest	*Picea glauca-Betula papyrifera* var. *kenaica/Calamagrostis canadensis*	Open Spruce–Paper Birch	1
Riverine Silty-Sandy-Rocky Spruce-Birch Forest	*Picea glauca-Betula papyrifera* var. *kenaica/Betula nana-Ericaceous* shrubs	Open Spruce–Paper Birch	1
Riverine Silty-Sandy-Rocky Spruce-Birch Forest	*Betula papyrifera* var. *kenaica/Alnus incana* ssp. *tenuifolia/Calamagrostis canadensis*	Open Paper Birch	1
Upland Ashy-Loamy-Rocky Balsam Poplar Forest	No class	Open Balsam Poplar Forest	1
Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes	*Betula papyrifera* var. *kenaica/Calamagrostis canadensis*	Open Paper Birch	1
Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes	*Betula papyrifera* var. *kenaica/Equisetum sylvaticum*	Closed Paper Birch	1
Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes	No class	Paper Birch Woodland	1
Upland Ashy-Loamy-Rocky Birch Forest, steep slopes	*Picea glauca-Betula papyrifera* var. *kenaica*	Open Paper Birch	1
Upland Ashy-Loamy-Rocky Birch Forest, steep slopes	No class	Open Dwarf Paper Birch	1
Upland Ashy-Loamy-Rocky Birch Forest, steep slopes	*Betula papyrifera* var. *kenaica/Calamagrostis canadensis*	Open Tall Shrub Birch	1
Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub	*Empetrum nigrum*	Ericaceous–Lichen Dwarf Shrub Tundra	4
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Picea glauca/Ericaceous* shrubs	White Spruce Woodland	7
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Picea glauca-Betula papyrifera* var. *kenaica/Betula nana-Ericaceous* shrubs	Spruce–Paper Birch Woodland	2
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Picea glauca/Ericaceous* shrubs	Dwarf White Spruce Woodland	1
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Betula nana-Ledum* spp.	Ericaceous–Lichen Dwarf Shrub Tundra	1
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Picea glauca/Ericaceous* shrubs	Spruce–Paper Birch Woodland	1
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Betula nana-Ledum* spp.	Ericaceous Dwarf Shrub Tundra	1
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Salix glauca/Betula nana*	Open Low Shrub Birch-Willow	1
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Picea glauca/Ericaceous* shrubs	Open White Spruce Forest	1
Upland Ashy-Loamy-Rocky White Spruce Woodland	*Picea glauca-Betula papyrifera* var. *kenaica/Betula nana-Ericaceous* shrubs	White Spruce Woodland	1
Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub	*Betula nana-Ledum palustre* ssp. *decumbens/Sphagnum* spp.	Ericaceous–Lichen Dwarf Shrub Tundra	2

Table 4. Continued.

Plot ecotype	**Plant association**	**Vegetation class (Level IV)**	**Number of plots**
Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub	*Betula nana-Ledum palustre* ssp. *decumbens/Sphagnum* spp.	Subarctic Lowland Sedge-Shrub Wet Meadow	1
Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub	*Betula nana-Ledum* spp.	Ericaceous Dwarf Shrub Tundra	1
Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub	*Betula nana-Ledum palustre* spp. *decumbens/Sphagnum* spp.	Ericaceous Dwarf Shrub Tundra	1
Upland Frozen-Organic-rich Tussock Meadow	*Betula nana-Ledum palustre* spp. *decumbens/Sphagnum* spp.	Open Mixed Low Shrub–Sedge Tussock Tundra	4
Upland Frozen-Organic-rich Tussock Meadow	*Mixed Ericaceous* Shrub	Tussock Tundra–Ericaceous	1
Upland Loamy-Organic Birch-Willow Low Shrub	*Salix glauca/Betula nana*	Open Low Shrub Birch-Willow	2
Upland Loamy-Organic Birch-Willow Low Shrub	*Betula nana-Ledum* spp.	Open Low Mesic Shrub Birch-Ericaceous Shrub	1
Upland Loamy-Organic White Spruce-Birch Forest	*Picea glauca-Betula papyrifera* var. *kenaica/Calamagrostis canadensis*	Open Spruce–Paper Birch	1
Upland Loamy-Organic White Spruce-Birch Forest	No class	White Spruce Woodland	1
Upland Loamy-Organic White Spruce-Birch Forest	*Betula papyrifera* var. *kenaica/Calamagrostis canadensis*	Open Paper Birch	1
Upland Loamy-Organic White Spruce-Birch Forest	*Picea glauca-Betula papyrifera* var. *kenaica*	Open Spruce–Paper Birch	1
Upland Rocky-Organic Alder-Willow Tall Shrub	No class	Open Tall Alder	1
Upland Rocky-Organic Alder-Willow Tall Shrub	*Alnus incana* ssp. *tenuifolia/Calamagrostis canadensis*	Closed Tall Alder	1
Upland Rocky-Organic Alder-Willow Tall Shrub	*Salix pulchra-Salix barclayi*	Closed Tall Willow	1

Instructions

1. When in the field in ALAG, 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 Alagnak Wild River (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. 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:
   A. Alagnak Wild River: Landcover Classes and Plant Associations. Natural Resource Technical Report NPS/ALAG/NRTR—2014/927 (Boucher and Flagstad 2014).

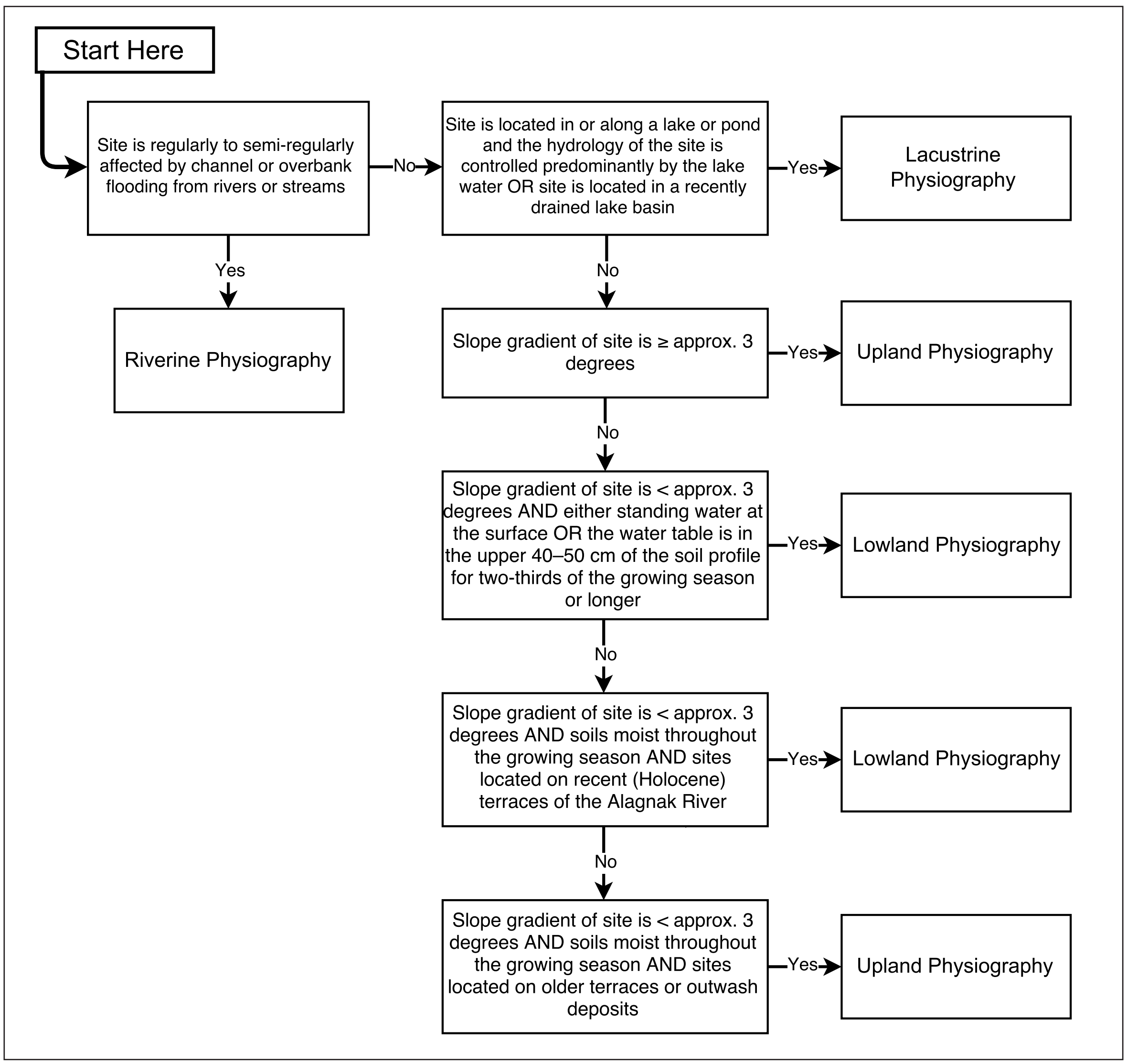

Figure 3. Key to Physiography Class for Alagnak Wild River, Alaska, 2014. This key can be used as a stand alone to identify physiography class and/or in conjunction with the Ecotype Key (see Table 5) to classify ecotypes in the field.

Table 5. Ecotype Key for Alagnak Wild River.

Lacustrine Ecotype Key

Lacustrine physiography was aggregated with lowland physiography for the purposes of ecosystem classification and mapping due to the limited extent and low sample size of lacustrine areas in ALAG. As such, please refer to the Lowland Ecotype Key, below.

Lowland Ecotype Key

1a. Permanent waterbody..2

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

2b. Vascular species cover ≥10% .... Undefined type

1b. Not a permanent waterbody..3

3a. Tree cover ≥25% 4

4a. White spruce (*Picea glauca*) cover > 10% and compromises >75% of total tree cover.. Lowland Rocky-Loamy-Organic Spruce Forest and Woodland

4b. Vegetation not as above..Undefined lowland forest or woodland type

3b. Tree cover < 25%..5

5a. Shrub cover ≥25% 6

6a. Tall shrub (≥1.5 m) cover ≥25% 7

7a. Willow (Salix sp.) cover ≥25% ....Lowland Organic-rich Wet Willow Low and Tall Shrub

7b. Vegetation not as above..Undefined lowland tall shrub type

6b. Low shrub (0.2–1.5 m) cover ≥25% 8

8a. Sweetgale (*Myrica gale*) the dominant low shrub or co-dominant with willows (*Salix* sp.) .... Lowland Loamy-Organic Sweetgale-Willow Low Shrub

8b. Willow (*Salix* sp.) cover ≥25% ....Lowland Organic-rich Wet Willow Low and Tall Shrub

8c. Vegetation not as above ....Undefined lowland low shrub type

6c. Dwarf shrub (<0.2 m) cover ≥25% .... Undefined lowland dwarf shrub type

5b. Shrub cover < 25%..10

10a. The "slender" sedges including *Carex chordorrhiza*, *C. limosa*, *C. pluriflora*, *C. rariflora*, *C. rotundata*, and/or *C. williamsii* the dominant graminoid AND the dwarf shrubs *Salix fuscescens*, *Oxycoccus microcarpus*, and/or *Andromeda polifolia* commonly present at low cover (<10%) AND combined cover of *Sphagnum* sp. ≥25% .... Lowland Organic-rich Wet Sedge-Shrub Bog Meadow

10b. The "coarse" sedges *C. aquatilis* and/or *Eriophorum angustifolium* are dominant AND *Betula nana* absent or present at trace cover AND combined cover of *Sphagnum* spp. typically < 25%..Lowland Organic-rich Wet Sedge Meadow

10c. Vegetation not as above ....Undefined lowland type

Riverine Ecotype Key

1a. Permanent waterbody and vascular plant cover < 25% ....

2a. Vascular species cover <10% .... Riverine Circumneutral River Water

2b. Vascular species cover ≥10% 3

3a. Arctophila fulva is the dominant grass .... Riverine Grass Marsh

3b. Vegetation not as above .... Undefined type

1b. Not a waterbody 4

4a. Site is located on river bars and active channel deposits vegetation is barren or partially vegetated with total vascular plant cover <30% .... Riverine Rocky Barrens and Partially Vegetated

4b. Vegetation cover (vascular species only) ≥30% 5

5a. Tree cover ≥10% 6

6a. Broadleaf and needleleaf species contribute 25–75% of the total tree cover 7

7a. White spruce (*Picea glauca*) and balsam poplar (*Populus balsamifera*) co-dominate the tree canopy .... Riverine Silty-Sandy-Rocky Spruce-Balsam Poplar Forest

7b. White spruce (*Picea glauca*) and Kenai paper birch (*Betula kenaica*) co-dominate the tree canopy .... Riverine Silty-Sandy Rocky Spruce-Birch Forest

7c. Vegetation not as above .... Undefined riverine mixed forest type

6b. Vegetation not as above .... Undefined riverine forest type

5b. Tree cover <10% 8

8a. Shrub cover ≥25% 9

9a. Tall shrub (≥1.5 m) cover ≥25% 10

10a. Vegetation is dominated (≥ 25%) by alders (*Alnus* sp.) .... Riverine Silty-Sandy-Rocky Alder Tall Shrub

10b. Vegetation dominated by willows (*Salix* sp.) .... Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub

10c. Vegetation not as above .... Undefined riverine tall shrub type

9b. Low shrub (0.2–1.5 m) cover ≥25% 11

11a. Vegetation is dominated by willows (*Salix* sp.) .... Riverine Silty-Sandy-Rocky Moist Willow Low Shrub

11b. Vegetation not as above .... Undefined riverine low shrub type OR try the Lowland Ecotype Key

9c. Dwarf shrub (<0.2 m) cover ≥25% .... Undefined riverine dwarf shrub type

8b. Shrub cover < 25% 12

12a. Vegetation is dominated (≥ 25%) by sedges .... Riverine Sandy-Organic Wet Sedge Meadow

12b. Vegetation is dominated (≥ 25%) by grasses 13

13a. *Arctophila fulva* is the dominant grass .... Riverine Grass Marsh

13b. *Calamagrostis canadensis* is the dominant grass .... Riverine Sandy-Organic Wet Grass Meadow

12c. Vegetation not as above .... Undefined riverine herbaceous type

Upland Ecotype Key

1a. Total vascular plant cover <30% .... Undefined upland barrens or partially vegetated type

1b. Total vascular plant cover ≥30% 2

2a. Tree cover ≥10% 3

3a. Needleleaf tree cover compromises >75% of total tree cover 4

4a. White spruce cover ≥ 10% .... Upland Ashy-Loamy-Rocky White Spruce Woodland

4b. Vegetation not as above .... Undefined upland needleleaf forest type

3b. Broadleaf tree cover comprises >75% of total tree cover 5

5a. Balsam poplar (*Populus balsamifera*) the dominant broadleaf tree .... Upland Ashy-Loamy-Rocky Balsam Poplar Forest

5b. Kenai paper birch (*Betula kenaica*) the dominant broadleaf tree 6

6a. Slope gradient ≤10 degrees .... Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes

6b. Slope gradient >10 degrees .... Upland Ashy-Loamy-Rocky Birch Forest, steep slopes

5c. Vegetation not as above .... Undefined upland broadleaf forest type

3c. Broadleaf and needleleaf species contribute 25–75% of the total tree cover 7

7a. White spruce (*Picea glauca*) and Kenai paper birch (*Betula kenaica*) co-dominate the tree canopy 8

8a. Kenai paper birch (*Betula kenaica*) stunted, less than approximately 3 m in height .... Upland Ashy-Loamy-Rocky White Spruce Woodland

8b. Kenai paper birch not stunted, greater than approximately 3 m in height .... Upland Loamy-Organic White Spruce-Birch Forest

7b. Vegetation not as above .... Undefined upland mixed forest type

2b. Tree cover < 10% 9

9a. Tall shrub (≥1.5 m) cover ≥25% 10

10a. Alder (*Alnus* sp.) and/or willow (*Salix* sp.) cover ≥ 25% .... Upland Rocky-Organic Alder-Willow Tall Shrub

10b. Vegetation not as above .... Undefined upland tall shrub type

9b. Tall shrub cover < 25% 11

11a. Low shrub (0.20–1.5 m) cover ≥25% 12

12a. Combined cover of *Betula nana* and *Ledum decumbens* ≥30% AND cover of *Eriophorum vaginatum* ≥5% AND cover of tussocks ≥25% .... Upland Frozen-Organic-rich Tussock Meadow

12b. *Betula nana* co-dominant with *Ledum decumbens* AND *Rubus chamaemorus* present AND total cover of *Sphagnum* mosses ≥ 5% .... Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub

12c. *Betula nana* co-dominant with willow (*Salix* spp.) AND total cover of *Sphagnum* mosses < 5% .... Upland Loamy-Organic Birch-Willow Low Shrub

12d. Vegetation not as above .... Undefined upland low shrub type

11b. Low shrub cover <25% 13

13a. Dwarf shrub (<0.20 m) cover ≥25% 14

14a. *Empetrum nigrum* ≥25% (may be as low as 10–15% when total vascular cover <50%) .... Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub

14b. Vegetation not as above .... Undefined upland dwarf shrub type

13b. Dwarf shrub cover <25% 15

15a. Cover of *Eriophorum vaginatum* ≥5% and cover of tussocks ≥25% .... Upland Frozen-Organic-rich Tussock Meadow

15b. *Eriophorum vaginatum* ≥5% OR tussock cover < 25%............ .... Undefined upland type

Ecotype Descriptions

Lowland Lake

The Lowland Lake ecotype comprises freshwater lakes in areas below treeline. They are generally shallow and small in size, and occur primarily in depressions in glacial deposits. This ecotype is not extensive within the study area, and most Lowland Lakes are in the northeast portion. Water chemistry, measured at one location, was alkaline (pH 8.0).

Lowland Loamy-Organic Sweetgale-Willow Low Shrub

Lowland Loamy-Organic Sweetgale-Willow Low Shrub is the most extensive of the lowland ecotypes within the study area. It occurs on flat or concave abandoned riverine deposits outside the 100-year floodplain, where the ground water hydrology is linked to river processes. The soils are wet and poorly drained, with an average depth to water table of -20.3 cm. Vegetation corresponds to the *Myrica gale* and *Myrica gale-Salix pulchra* plant associations. *Myrica gale* is dominant, with *Potentilla palustris* and *Calamagrostis canadensis* consistently co-occurring. Other important shrubs include *Salix fuscescens*, *Salix pulchra*, and *Betula nana*. Common herbaceous species include *Equisetum arvense*, *Carex pluriflora*, and *C. canescens*. A diversity of non-vascular species may be present, with the mosses *Sphagnum angustifolium* and *S. teres* being the most common . Thick surface organic horizons (avg. 23.3 cm) and a lack of interbedded mineral soil material in the upper profile indicate that overbank flooding and sedimentation occur rarely, if ever, in this ecotype. Soils may support permafrost, or a deep seasonal frost that persists in the profile late into the growing season. Dominant soil textures include Peat, Organic-rich and Loamy. Soils are typically circumneutral (avg. 5.6 pH), with electrical conductivity (EC) <100 uS/cm. Typical soil subgroups include Terric Cryohemists, Histic Cryaquepts, and Terric Cryohemists (Table 6).

Table 6. Soil Horizon for Lowland Loamy-Organic Sweetgale-Willow Low Shrub, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0-12.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
2	Oe/C	12.0-23.0	ashy	mucky peat (17–40% fibers, saturated Oe horizon)	NA
3	Oe	23.0-40.0	no modifier (<15%)	mucky peat (17-40% fibers, saturated Oe horizon)	NA

Lowland Organic-Rich Wet Sedge-Shrub Bog Meadow

The ecotype Lowland Organic-rich Wet Sedge-Shrub Bog Meadow occurs on flat or concave areas, including abandoned river channels and paludified lakes, and flat or gently sloping river terraces where the local hydrology is predominantly influenced by surface water runoff from adjacent upland areas. Vegetation corresponds to the *Betula nana-Ledum palustre* ssp. *decumbens/Sphagnum* spp., *Carex aquatilis-Comarum palustre*, *Carex pluriflora-Comarum palustre*, and *Eriophorum russeolum* plant associations. Non-vascular species, such as the mosses *Pleurozium schreberi* and *Sphagnum* spp., are typically abundant. Low and dwarf shrubs, including *Salix fuscescens*, *Andromeda polifolia*, *Oxycoccus microcarpus*, *Betula nana*, and *Ledum palustre* are common associates. Herbaceous species with high constancy (>60%), but generally low cover (<10%) include *Potentilla palustris*, *Calamagrostis canadensis* and *Carex aquatilis* ssp. *aquatilis*. Soils form in poorly to very poorly drained, anaerobic moisture conditions, with an average depth to the water table of -16.4 cm. This ecotype is a productive environment for the development of organic soils, and the average thickness of the organic mat is 51.5cm. The dominant soil texture class is Peat, with an average depth to >15% rock fragments of 77.0 cm. The insulating properties of the surface peat support the development and maintenance of permafrost (average. thaw depth 39.5 cm) at some sites. Soils in this ecotype are circumneutral (avg. 5.9 pH), with an average EC of 60.0 uS/cm. Typical soil subgroups include Fluvaquentic Cryohemists, Fluvaquentic Hemistels, Sphagnic Cryofibrists, Sphagnic Fibristels, Terric Cryofibrists and Terric Cryohemists (Table 7).

Table 7. Soil Horizon for Organic-Rich Wet Sedge-Shrub Bog Meadow, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi1	0.0–10.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
2	Oi2	10.0–15.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
3	C	15.0–19.0	ashy	very fine sandy loam	NA
4	Oe1	19.0–45.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
5	Oe2	45.0–52.0	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, cut-off meander channels (oxbows), and organic fens. This ecotype occurs predominantly below the Nonvianuk River confluence, where the Alagnak River transitions from a meandering to an anastomosing river system. Vegetation corresponds to the *Eriophorum angustifolium* and *Carex aquatilis-Comarum palustre* plant associations. *Carex aquatilis* (average cover 35%) or *Eriophorum angustifolium* (average cover 45%) co-dominate with *Potentilla palustris* (avg. cover 33%). Vascular species with high constancy (>60%), but generally low cover values (<10%), include *Salix fuscescens*, *Betula nana*, and *Epilobium palustre*. The most common non-vascular plants are *Sphagnum* mosses. Soils in this ecotype form under anaerobic conditions and are very poorly drained; they are typically circumneutral and have EC >100 uS/cm. This ecotype is expected to be flooded at least part of the growing season. Soils may support permafrost, or a deep seasonal frost that persists late into the growing season. Dominant texture classes are Peat and Organic-rich, with a moderately thick to thick surface organic mat (avg. 37.7 cm). Typical soil subgroups include Fluvaquentic Cryofibrists, Fluvaquentic Historthels, and Histic Cryaquepts (Table 8).

Table 8. Soil Horizon for Lowland Organic-Rich Wet Sedge Meadow, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–18.0	no data	peat (>40% fibers, saturated Oi horizon)	10yr 2/1
2	C	18.0–21.0	ashy	very fine sand (0.05–0.1 mm)	7.5yr 8/1
3	Oeb	21.0–31.0	no data	mucky peat (17–40% fibers, saturated Oe horizon)	10yr 3/1

Lowland Organic-Rich Wet Willow Low and Tall Shrub

In the upper Alagnak River corridor, the ecotype Lowland Organic-rich Wet Willow Low and Tall Shrub most commonly occurs on gentle to strongly sloping (2–10 degrees) foot slopes and toe slopes, slope fens, and in areas of slopewash on concave slope positions. In the mid- to lower river corridor, this ecotype is most often associated with nearly level to gently sloping (1–5 degrees) terrace positions. Vegetation corresponds to the *Salix barclayi/Equisetum arvense*, *Salix barclayi*/Mixed herbaceous, and *Salix pulchra-Salix barclayi* plant associations. *Salix barclayi* is the dominant shrub species, and is sometimes co-dominant with *S. pulchra*. Common associated shrub species include *Betula nana*, *Empetrum nigrum*, and *Oxycoccus microcarpus*. *Picea glauca* seedlings are common in this ecotype, but tree cover is generally low (avg. 5.5%). Herbaceous species, such as *Equisetum arvense*, *Calamagrostis canadensis*, and *Carex aquatilis* contribute significant cover to the understory. *Sphagnum* mosses are the dominant non-vascular plants. Soils in this ecotype form primarily in very poorly drained, anaerobic conditions. However, aerobic conditions may be encountered in some geomorphic positions, such as on slope fens. The average depth to the water table is -11.0 cm. The dominant soil textures for this ecotype are Peat and Organic-rich, and surface organic thickness ranges from moderately thick to thick (avg. 25.7 cm). The depth to >15 % rock fragments varies with landform and slope position; ranging from moderately deep to deep (50–150 cm) on gentle to strongly sloping positions, and very deep (>150 cm) on flat positions. Soils in this ecotype are circumneutral (avg. 6.7 pH), with an average EC of 75.0 uS/cm. This ecotype may be indicative of thermokarst and shrub expansion into recently melted permafrost, particularly on terrace landform positions. Common soil subgroups include Histic Cryaquepts, Terric Cryohemists, and Fluvaquentic Historthels (Table 9).

Table 9. Soil Horizon for Lowland Organic-Rich Wet Willow Low and Tall Shrub, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–13.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
2	Oe	13.0–28.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon)	NA
3	OeC	28.0–48.0	ashy	mucky peat (17–40% fibers, saturated Oe horizon)	NA

Lowland Rocky-Loamy-Organic Spruce Forest and Woodland

The ecotype Lowland Rocky-Loamy-Organic Spruce Forest and Woodland occurs on nearly level recent (Holocene) terraces and abandoned floodplain deposits that are no longer associated with the present fluvial regime, or where flooding is rare. Vegetation corresponds to the *Picea glauca*/Ericaceous shrubs and *Picea glauca*/*Salix pulchra* plant associations. *Picea glauca* is the dominant species and *Betula kenaica* also occurs in the tree canopy. The understory is dominated by Ericaceous shrubs, including *Vaccinium uliginosum*, *Empetrum nigrum*, and *Vaccinium vitis-idaea*. *Salix pulchra* is the most common and abundant willow species, and *Dasiphora fruiticosa* is always present in the low shrub layer. Common herbaceous species include *Calamagrostis* *canadensis*, and *Rubus arcticus*. A variety of mosses and lichens occur in this ecotype, the most common of which, are *Pleurozium schreberi*, *Sanionia uncinata*, *Ptilidium ciliare*, and *Peltigera aphthosa*. Dominant soil texture classes include Gravelly, Loamy and Organic-rich. Surface organic horizons range from thin to moderately thick (avg. 14.7) and overlay rocky alluvium, with many inclusions of retransported volcanic ash. Soils are moist and range from somewhat poorly drained to moderately well drained. Soils in this ecotype have a shallow depth to >15% rock fragments (avg. 31.6 cm), and the water table is generally moderately deep (50–100 cm) to deep (>100 cm). Soils in this ecotype are acidic (avg. 5.2 pH) with a relatively high EC (avg. 107.1 uS/cm). Soils are moderately well-developed Inceptisols. Soil subgroups include Andic Haplocryepts, Fluventic Dystrocryepts, Fluventic Haplocryepts, and Folistic Dystrocryepts (Table 10).

Table 10. Soil Horizon for Lowland Rocky-Loamy-Organic Spruce Forest and Woodland, Alagnak Wild River, Alaska, 2016.

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)	NA
2	Oe	7.0–20.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	OaA	20.0–25.0	no modifier (<15%)	highly decomposed plant material (unsaturated Oa)	NA
4	Bw1	25.0–33.0	ashy	silt loam	7.5yr 3/2
5	C	33.0–36.0	no modifier (<15%)	loamy fine sand	2.5yr 3/6
6	Bw2	36.0–42.0	ashy	loam	10yr 4/3

Riverine Circumneutral River Water

The ecotype Riverine Circumneutral River Water represents the portion of the Alagnak River that flows through the study area. The Alagnak River has a snowmelt-driven hydrograph, with peak discharge in mid-June to early July (Curan 2003). The water is circumneutral to alkaline (avg. 7.3 pH) and rich in calcium bicarbonate, with an average EC of 46.7 uS/cm. The Alagnak River drains an area of 3,600 square kilometers, originating from moraine-impounded Kukaklek Lake in Katmai National Park and Preserve and draining into the Kvichak River near Bristol Bay (Curan 2003). The Nonvianuk River, flowing from Nonvianuk Lake, is the largest tributary of Alagnak. Upstream of the Nonvianuk River confluence, the Alagnak River is predominantly fed by outflow from Kukaklek Lake, with lesser inputs from small headwater streams draining from volcanic and sedimentary uplands. The Nonvianuk River contributes significantly to the Alagnak River flows below the confluence, where the Alagnak flows through old glaciofluvial outwash sediments (Curan 2003).

(No soil photo.)

Riverine Grass Marsh

Riverine Grass Marsh is the least extensive ecotype within the study area. This ecotype occurs in small patches on active floodplains, and is often submerged by water from the Alagnak River. Because of the small patch size, Riverine Grass Marsh was not mapped separately, but was included within the Riverine Circumneutral River Water map ecotype. The vegetation in this ecotype corresponds to the *Arctophila fulva* plant association. Vegetation in the one plot we sampled was dominated by *Arctophila fulva*. Only a few other species were present; these included *Equisetum fluviatile*, *Hippuris vulgaris*, *Rumex aquaticus*, and *Cicuta mackenzieana*. Soils are wet, ranging from flooded to very poorly drained. The water table is expected to be above, or only slightly below, the soil surface. Soils are assumed to be sandy and gravelly stratified alluvium with aerobic soil moisture conditions during most of the growing season. Expected soil subgroups include Aquic Cryofluvents, Typic Cryaquents, and Histic Cryaquepts.

(No soil photo.)

Riverine Rocky Barrens and Partially Vegetated

The ecotype Riverine Rocky Barrens and Partially Vegetated occurs on active sand and cobble bars along the Alagnak River. This ecotype does not correspond to a recognized plant association, but falls within the barrens (bbg) and Partially Vegetated (bpv) level 4 vegetation classes from Viereck et al. (1992). This ecotype is flooded annually to semi-annually and experiences active erosion and sedimentation processes. Soils range from moist to wet, and form in aerobic soil moisture conditions. The average depth to water table is -32.5 cm. Dominant soil textures range from gravelly to extremely cobbly, with >15% rock fragments at the soil surface. Soil chemistry is circumneutral to alkaline (avg. 7.3 pH), with an average EC of 50.0 uS/cm. Oxyaquic Cryorthents are the typical soil subgroup (Table 11).

Table 11. Soil Horizon for Riverine Rocky Barrens and Partially Vegetated, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	C	0.0–48.0	extremely gravelly (60–90%)	coarse sand (0.5–1 mm)	NA

Riverine Sandy-Organic Wet Grass Meadow

The ecotype Riverine Sandy-Organic Wet Grass Meadow occurs on active channel and overbank deposits on nearly level floodplain surfaces. For mapping, this ecotype was combined with the Riverine Sandy-Organic Wet Sedge Meadow ecotype to create the Riverine Sandy-Organic Wet Graminoid Meadow map ecotype, due to the difficulty of differentiating between sedge- and grass-dominated sites on the imagery. The Riverine Sandy-Organic Wet Grass Meadow ecotype is associated with active floodplain surfaces along the Alagnak and its associated tributary streams, below the Nonvianuk River confluence. Vegetation corresponds to the *Calamagrostis canadensis*-Wetland and *Calamagrostis canadensis*-Forb plant associations. *Calamagrostis canadensis* forms a near monoculture on sites in the *Calamagrostis canadensis*-Wetland plant association. There is greater species diversity in the *Calamagrostis canadensis*-Forb plant association, with common herbaceous species including *Carex lyngbyaei*, *Equisetum arvense*, and *Epilobium palustre*. The moss *Calliergon stramineum* is present at some sites and can have relatively high cover values (>20%). Shrubs are relatively uncommon, but *Salix barclayi*, *S. bebbiana*, *S. pulchra*, and *Alnus tenuifolia* may be present. Soils range from moist to wet and from somewhat poorly to poorly drained. Conditions for soil formation are anaerobic for at least part of the growing season. The depth to water table averages -25.8 cm, but is sensitive to seasonal peak flow on the Alagnak River and may also fluctuate considerably during the growing season. Soil chemistry is circumneutral and average EC is 166.7 uS/cm. Dominant soil texture classes are Sandy and Organic-rich, with an average depth to >15% rock fragments of 21.8 cm. Surface organic horizons range from patchy to thin (avg. 5.7 cm). Typical soil subgroups include Typic Cryaquents, Aquic Cryofluvents, and less commonly, Oxyaquic Cryofluvents or Histic Cryaquents (Table 12).

Table 12. Soil Horizon for Riverine Sandy-Organic Wet Grass Meadow, Alagnak Wild River, Alaska, 2016.

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	OeC	2.0–8.0	no modifier (<15%)	silt (0.002–0.05 mm)	NA
3	C	8.0–25.0	no modifier (<15%)	sand	10yr 4/2
4	Cg1	25.0–29.0	very gravelly (35–60%)	loamy sand	NA
5	Cg2	29.0–42.0	extremely gravelly (60–90%)	coarse sand (0.5–1 mm)	NA

Riverine Sandy-Organic Wet Sedge Meadow

The ecotype Riverine Sandy-Organic Wet Sedge Meadow occurs on active and inactive channel deposits along the Alagnak River below the Nonvianuk River confluence. For mapping, this ecotype was combined with the Riverine Sandy-Organic Wet Grass Meadow ecotype to create the Riverine Sandy-Organic Wet Graminoid Meadow map ecotype, due to the difficulty of differentiating between sedge- and grass-dominated sites on the imagery. Floristic associations include *Carex lyngbyei*, *Carex lyngbyei-Calamagrostis canadensis*, *Carex lyngbyei-Carex aquatilis*, *Carex lyngbyei-Comarum palustre*, *Carex pluriflora-Comarum palustre*, and *Carex utriculata*. The sedge *Carex lyngbyaei* is dominant, often comprising >50% cover (avg. 56.9%). Other common sedges include *Carex utriculata*, *C. pluriflora*, *C. aquatilis*, and *Eriophorum angustifolium*. Other common herbaceous species include *Potentilla palustris*, *Calamagrostis canadensis*, and *Equisetum fluviatile*. Shrub cover is generally low, with *Salix* spp. the most commonly seen. Mosses, particularly *Sphagnum teres* and *S. angustifolium*, are relatively abundant. A substantial portion of the ground surface in this ecotype is occupied by water. Compared to the Riverine Sandy-Organic Wet Grass Meadow ecotype, the sedge ecotype is consistently wetter with an average depth to water table of -2.0 cm. Soils are wet, range from flooded to very poorly drained, and form in anaerobic conditions for most of the growing season. Soil chemistry is circumneutral (avg. 6.6 pH) with an average EC of 130.0 uS/cm. A variety of general soil texture classes occur in this ecotype, including Loamy, Organic-Rich, Peat and Sandy. Rock fragments are typically moderately deep in the soil profile (avg. 52.6 cm). The formation of thick saturated organic horizons, or histic epipedons, is common, particularly on less frequently flooded geomorphic surfaces. Surface organics are typically moderately deep to deep (avg. 27.0 cm), but may be as thin as 9 cm on the most fluvially active sites. Typical soil subgroups include Hydric Cryofibrists, Histic Cryaquepts, and Typic Cryaquents (Table 13).

Table 13. Soil Horizon for Riverine Sandy-Organic Wet Sedge Meadow, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–3.0	no modifier (<15%)	peat (>40% fibers, saturated Oi horizon)	NA
2	Oe	3.0–10.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon)	NA
3	Cg1	10.0–21.0	no modifier (<15%)	fine sandy loam	10yr 4/2
4	Cg2	21.0–42.0	no modifier (<15%)	sand	NA

Riverine Silty-Sandy-Rocky Alder Tall Shrub

The ecotype Riverine Silty-Sandy-Rocky Alder Tall Shrub was described at one field plot, located in the lower braided portion of the Alagnak River. In addition, a small area of this ecotype was mapped along an unnamed tributary stream of the Alagnak. This ecotype is associated with active overbank deposits on nearly flat floodplain surfaces. Vegetation corresponds to the *Alnus incana* ssp. *tenuifolia*/*Calamagrostis canadensis* plant association. In the one plot sampled, *Alnus tenuifolia* was dominant, with *Calamagrostis canadensis* as a co-dominant. Other vascular species with relatively high cover values (>20%), included *Salix pulchra*, *Equisetum arvense*, and *Potentilla palustris*. Soils are expected to be very poorly drained, with a shallow (<50 cm) water table that is regulated by the hydrology of the Alagnak River. Despite being saturated, soils form primarily in aerobic conditions. Dominant soil texture classes are expected to be Sandy, Loamy or Rocky with an average depth to >15% rock fragments occurring within the upper 50 cm of the soil profile. A patchy, thin organic horizon may form at the surface, but it is susceptible to erosion during flood events. Common soil subgroups are likely to include Oxyaquic Cryofluvents and Oxyaquic Cryorthents (Table 14).

Table 14. Soil Horizon for Riverine Silty-Sandy-Rocky Alder Tall Shrub, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oe	0.0–4.0	no data	mucky peat (17–40% fibers, saturated Oe horizon)	10yr 2/2
2	C1	4.0–18.0	no data	silt loam	10yr 3/3
3	C2	18.0–25.0	no data	coarse sand (0.5–1 mm)	7.5yr 4/1

Riverine Silty-Sandy-Rocky Moist Willow Low Shrub

The ecotype Riverine Silty-Sandy-Rocky Moist Willow Low Shrub occurs throughout the study area but is most prevalent in the braided section of the Alagnak River. This ecotype occurs on nearly level inactive channel deposits and active overbank deposits, and is associated with early floodplain vegetation succession. Vegetation corresponds to the *Salix barclayi*/Mixed herbaceous, *Salix pulchra*/*Calamagrostis canadensis*, and *Salix pulchra*-*Salix barclayi* plant associations. *Salix barclayi* and *S. pulchra* are co-dominant, forming a low shrub (0.2–1.5 m) canopy. The understory includes numerous herbaceous species; the most common are *Calamagrostis canadensis*, *Dasiphora fruticosa*, *Rubus arcticus*,

and *Potentilla palustris*. A diversity of mosses co-occur in the understory, including *Pleurozium schreberi*, *Sphagnum* sp., *Hylocomium splendens*, and *Polytrichum commune*. Soils range from moist to wet, and are somewhat poorly to poorly drained. The average depth to the water table is -30.0 cm. General soil textures range from coarse-textured Bouldery or Gravelly classes, to finer-textured Loamy or Organic-rich classes. The average depth to >15% rock fragments is 25.0 cm. Surface organic thickness ranges from patchy to very thin, and buried organic horizons are common in the stratified alluvial parent material. Soil chemistry is acidic (avg. 5.2 pH), with an average EC of 115.0 uS/cm. Soil subgroups encountered included Fluventic Haplocryepts and Typic Cryofluvents. Oxyaquic Cryofluvents and Aquic Cryofluvents are also likely to be associated with this ecotype (Table 15).

Table 15. Soil Horizon for Riverine Silty-Sandy-Rocky Moist Willow Low Shrub, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi/Oe	0.0–5.0	no data	peat (>40% fibers, saturated Oi horizon)	10yr 2/1
2	Oe	5.0–10.0	no data	mucky peat (17–40% fibers, saturated Oe horizon)	10yr 3/2
3	C1	10.0–12.0	ashy	very fine sand (0.05–0.1 mm)	7.5yr 8/1
4	OaA	12.0–23.0	no data	muck (<17% fibers, saturated Oa horizon)	10yr 2/2
5	C2	23.0–32.0	very cobbly (35–60%)	loamy sand	10yr 4/1

Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub

Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub is the most widely distributed vegetated ecotype within the riverine physiography class. It occurs on active overbank deposits on nearly level floodplain surfaces that are less frequently flooded than the Riverine Silty-Sandy-Rocky Moist Willow Low Shrub ecotype. This ecotype is most common in the middle portion of the study area, below the confluence of the Nonvianuk River, where the Alagnak River floodplain is most heavily anastomosed. Vegetation corresponds to the *Salix alaxensis/Calamagrostis canadensis-Equisetum arvense*, *Salix alaxensis-Salix pulchra*, *Salix pulchra/Calamagrostis canadensis*, *Salix barclayi*/Mixed herbaceous, *Salix barclayi-Salix alaxensis*, *Salix bebbiana*, *Salix pulchra/Calamagrostis canadensis*, and *Salix pulchra-Salix barclayi* plant associations. *Salix pulchra*, *S. alaxensis*, *S. barclayi*, *S. bebbiana*, or a combination of these species, form a tall shrub (>1.5 m)

layer. *Calamagrostis canadensis* and *Potentilla palustris* are ubiquitous in the understory. Other common herbaceous species include *Polemonium acutiflorum*, *Rubus arcticus*, and *Equisetum arvense*. Lichen cover is sparse or absent. However, a variety of mosses are present, commonly including *Sphagnum* sp., *Rhytidiadelphus loreus*, *R. squarrosus*, and *Sanionia uncinata*. Soils are Bouldery, Gravelly, or Loamy. The average depth to >15% rock fragments is 27.9 cm and surface organic horizons are generally thin (avg. 5.6 cm). Soil parent material is stratified alluvium and buried organic horizons are common. Soils are moist and range from poorly to somewhat poorly drained, with an average depth to water table of -38.3 cm. Soil chemistry is circumneutral (avg. 5.8 pH), with an average EC of 85.0 uS/cm. Soils range from poorly developed Entisols to weakly developed Inceptisols. Fluventic Haplocryepts, Oxyaquic Cryofluvents, Typic Cryofluvents are common soil subgroups, while Aquic Cryofluvents occur less commonly (Table 16).

Table 16. Soil Horizon for Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub, Alagnak Wild River, Alaska, 2016.

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	Oe	1.0–6.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C1	6.0–18.0	no modifier (<15%)	loam	10yr 2/1
4	C2	18.0–45.0	extremely gravelly (60–90%)	sand	NA

Riverine Silty-Sandy-Rocky Spruce-Balsam Poplar Forest
The ecotype Riverine Silty-Sandy-Rocky Spruce-Balsam Poplar Forest is associated with inactive overbank deposits on nearly level floodplain surfaces. For mapping, this ecotype was combined with the Riverine Silty-Sandy-Rocky Spruce-Birch Forest ecotype to create the Riverine Silty-Sandy-Rocky White Spruce-Broadleaf Forest map ecotype, due to the difficulty of distinguishing birch and poplar on the imagery. Both the Spruce-Balsam Poplar and Spruce-Birch ecotypes are associated with late floodplain vegetation succession. However, the Spruce-Balsam Poplar ecotype generally occurs on younger sediments that are more prone to flood disturbance than the sites where Spruce-Birch ecotype is found. The Spruce-Balsam Poplar ecotype is most widespread in the downstream portion of the study area, and along small tributary streams in the upstream portion.

Vegetation corresponds to the *Betula papyrifera* var. *kenaica*/*Alnus incana* ssp. *tenuifolia*/*Calamagrostis canadensis*, *Picea glauca-Populus balsamifera-Betula papyrifera* var. *kenaica*/*Viburnum edule*, and *Populus balsamifera*/*Alnus incana* ssp. *tenuifolia*/*Calamagrostis canadensis* plant associations. *Populus balsamifera* dominates the overstory, with *Betula kenaica* and *Picea glauca* co-occurring in the forest canopy. Deciduous shrubs are abundant, with *Alnus tenuifolia*, *Viburnum edule*, *Salix pulchra* and *Betula nana* being the most common. *Calamagrostis canadensis*, *Rubus arcticus*, and *Trientalis europaea* are ubiquitous in the understory. The abundance of feather mosses in this ecotype reflects the mesic conditions and relative stability (i.e., low flood return interval) of this landform. Common feather moss species include *Hylocomium splendens*, *Rhytidiadelphus triquetrus*, *Pleurozium schreberi*, and *Ptilium crista-castrensis*. Dominant soil texture classes include Gravelly and Loamy, with a shallow depth to >15% rock fragments (avg. 13.0 cm). Surface organic thickness ranges from thin to very thin (avg. 5.0 cm). Soils may have a thin horizon of buried ash just below the surface organic mat. However, the primary parent material for this ecotype is stratified alluvium. Soils are moist and range from somewhat poorly to moderately well drained. The water table was not encountered in the 40 cm at the 2 sites sampled in this ecotype. Soil chemistry is circumneutral (avg. 6.2 pH), with an average EC of 110.0 uS/cm. Soils range from poorly developed Entisols to weakly developed Inceptisols. Common soil subgroups include Oxyaquic Cryofluvents, Typic Cryofluvents, Oxyaquic Haplocryepts, and Fluventic Haplocryepts. No soil horizon is available for this ecotype.

Riverine Silty-Sandy-Rocky Spruce-Birch Forest

The ecotype Riverine Silty-Sandy-Rocky Spruce-Birch Forest is associated with inactive overbank deposits grading towards abandoned overbank deposits on nearly level floodplain surfaces. For mapping, this ecotype was combined with the Riverine Silty-Sandy-Rocky Spruce-Balsam Poplar Forest ecotype to create the Riverine Silty-Sandy-Rocky White Spruce-Broadleaf Forest map ecotype, due to the difficulty of differentiating between birch and poplar on the imagery. Both the Spruce-Balsam Poplar and Spruce-Birch ecotypes are associated with late floodplain vegetation succession, however the Spruce-Birch Forest ecotype is composed of older sediments that are less prone to flood disturbance than the the substrates occupied by the Spruce-Balsam Poplar ecotype. The Spruce-Birch ecotype is most widespread in the downstream portion of study area and along small tributary streams in the upstream portion. Vegetation corresponds to the *Picea glauca-Betula papyrifera* var. *kenaica*/ *Betula nana-Ericaceous* shrubs and *Picea glauca-Betula papyrifera* var. *kenaica*/*Calamagrostis canadensis* plant associations. *Betula kenaica* is dominant in the overstory, or in some cases co-dominant with *Picea glauca*. This ecotype is rich in both deciduous and evergreen shrubs. The most common deciduous shrubs include *Salix pulchra*, *Vaccinium uliginosum*, and*Alnus tenuifolia*, while typical evergreen shrubs are *Vaccinium vitis-idaea*, *Empetrum nigrum*, and *Ledum decumbens*. Common herbaceous species in the understory include *Equisetum arvense*, *Rubus arcticus*, *Sanguisorba stipulata*, and *Calamagrostis canadensis*. Similar to the Spruce-Poplar ecotype, non-vascular cover is dominated by feather moss species, including *Hylocomium splendens*, *Ptilium crista-castrensis*, and *Pleurozium schreberi*. Dominant soil texture classes include Gravelly and Loamy with an average depth to >15% rock fragments of 12.0 cm. Surface organic thickness ranges from thin to very thin (avg. 6.0 cm). Soils may have a thin horizon of buried volcanic ash just below the surface organic mat; however the primary parent material for this ecotype is stratified alluvium. Soils are moist, range from somewhat poorly to moderately well drained, and the depth to water table is expected to be moderately deep to deep (>50 cm). Soils are weakly developed Inceptisols and may exhibit early signs of podzolization (i.e., albic and/or spodic horizon development). Typical soil subgroups include Fluventic Dystrocryepts, Fluventic Haplocryepts, Typic Cryofluvents, and Oxyaquic Cryofluvents (Table 17).

Table 17. Soil Horizon for Riverine Silty-Sandy-Rocky Spruce-Birch Forest, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–2.0	no data	silt loam	7.5yr 3/2
2	C	2.0–6.0	ashy	very fine sand (0.05–0.1 mm)	7.5yr 2.5/1
3	OaAb	6.0–14.0	no data	highly decomposed plant material (un-saturated Oa)	7.5yr 3/2
4	Ab	14.0–25.0	no data	sandy loam	7.5yr 3/3

Upland Ashy-Loamy-Rocky Balsam Poplar Forest

The ecotype Upland Ashy-Loamy-Rocky Balsam Poplar Forest ecotype occupies <4 acres within the study area and is represented by a single plot. It is mapped in two isolated patches on a hillslope above the Alagnak River, upstream of the Nonvianuk River confluence. This ecotype occurs on gently sloping to moderately steep upper and lower backslope positions. This ecotype does not correspond to any currently-defined plant association, but does fit within the Level IV vegetation class Open Balsam Poplar Forest (Viereck et al. 1992). Parent material at the plot consisted of of a thin surface organic mat (10.0 cm), over a thin horizon of volcanic ash (5.0 cm), over Loamy or Gravelly colluvium originating from sedimentary rock. Soil chemistry at the plot was circumneutral (6.0 pH) and the EC was 190.0 uS/cm. Soil was moist and well drained, and a water table was not

encountered in the upper 70.0 cm of the soil profile. Soils are expected to be weakly developed Inceptisols, which would be classified as Andic Haplocryepts if sufficient weathered volcanic ash (≥ 18.0 cm) is present, or otherwise as Typic Haplocryepts (Table 18).

Table 18. Soil Horizon for Upland Ashy-Loamy-Rocky Balsam Poplar Forest, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi1	0.0–2.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oi2	2.0–10.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
3	C1	10.0–14.0	ashy	loamy very fine sand	10yr 7/2
4	C2	14.0–16.0	ashy	very fine sandy loam	10yr 5/3
5	Oa	16.0–21.0	no modifier (<15%)	highly decomposed plant material (unsaturated Oa)	NA
6	A	21.0–27.0	no modifier (<15%)	silt loam	7.5yr 2.5/1
7	BA	27.0–43.0	ashy	silt loam	7.5yr 3/3

Upland Ashy-Loamy-Rocky Birch Forest, Gentle Slopes
The ecotype Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes, occurs on old glaciofluvial deposits, terraces, inactive alluvial fans, and abandoned overbank deposits. This ecotype primarily occurs on nearly level to gently sloping landforms, on slopes ranging from 0–10 degrees. Vegetation corresponds to the *Betula papyrifera* var. *kenaica*/*Calamagrostis canadensis* and *Betula papyrifera* var. *kenaica*/*Equisetum sylvaticum* plant associations. The overstory is dominated by the deciduous tree *Betula kenaica*. The understory is dominated by the grass *Calamagrostis canadensis*, and other common herbaceous species include *Vaccinium vitis-idaea*, *Gymnocarpium dryopteris*, and *Equisetum sylvaticum*. This ecotype supports productive moss cover. Mosses and liverworts with higher constancy and cover values include *Pleurozium schreberi*, *Ptilium crista-castrensis*, *Tomentypnum nitens*, and *Ptilidium ciliare*. Lichens, including most commonly *Cladonia* and *Cladina* spp., are typically present but at low abundance. Dominant soil texture classes include Ashy, Bouldery or Gravelly with an average depth to >15% rock fragments of 29.5 cm. Soils are moist and well drained, and the average depth to water table is >100 cm. Soil profiles in this ecotype often include a thin (avg. 11.0 cm) surface organic horizon over a moderately thick layer of volcanic

ash (avg. 26.7 cm), which in turn overlies rocky alluvium or colluvium. Soil chemistry is acidic (avg. 4.9 pH) and average EC is 145.0 uS/cm. Moderately well-developed Inceptisols and Spodosols with andic soil properties are common in this ecotype, including Andic Haplocryepts and Andic Haplocryods. Less common are weakly-developed Alfisols, such as Andic Haplocryalfs (Table 19).

Table 19. Soil Horizon for Upland Ashy-Loamy-Rocky Birch Forest, Gentle Slopes, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi1	0.0–3.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oi2	3.0–12.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
3	C	12.0–14.0	ashy	very fine sandy loam	10yr 8/1
4	AOa	14.0–16.0	ashy	silt loam	NA
5	Bs	16.0–27.0	ashy	sandy loam	7.5yr 3/3
6	Bsh	27.0–40.0	ashy	coarse sandy loam	7.5yr 2.5/2

Upland Ashy-Loamy-Rocky Birch Forest, Steep Slopes
The ecotype Upland Ashy-Loamy-Rocky Birch Forest, steep slopes, occurs on hillside backslope positions, and river terrace risers, where the slope gradient is greater than 10 degrees. Vegetation corresponds to the *Betula papyrifera* var. *kenaica*/*Calamagrostis canadensis* and *Picea glauca-Betula papyrifera* var. *kenaica* plant associations. The overstory is dominated primarily by *Betula kenaica*; however mixed forested stands, with *Picea glauca* or *Populus tremuloides* may also occur. The steeper slopes in this ecotype are more prone to disturbance, as evidenced by the presence of early successional species such as the forb *Epilobium angustifolium* and the moss *Polytrichum strictum*. This ecotype supports a variety of deciduous and evergreen shrubs, but total cover of any one shrub species is generally low (<15%). Ericaceous shrubs, such as *Vaccinium vitis-idaea*, *Ledum decumbens*, and *Empetrum nigrum*, are common in the understory. The most common deciduous shrubs are *Betula glandulosa*, *Spiraea stevenii*, and a variety of *Salix* species. Herbaceous cover is generally limited to scattered individuals of *Epilobium angustifolium*, *Calamagrostis canadensis* and *Equisetum arvense*, with few other species present. The lichen species with the highest constancy is *Peltigera aphthosa* (67%), but lichen cover is dominated by a variety of *Cladina* and *Cladonia* lichen species. Soil texture classes include Ashy, Loamy and Gravelly or Bouldery, with an average depth to >15% rock fragments of 80 cm. Parent material is composed of a thin surface organic horizon over volcanic ash over rocky colluvium. Moderately thick (>20 cm) accumulations of tephra play a significant role in the physical and chemical soil properties of this ecotype. Soil chemistry is acidic (avg. 4.6 pH), and the average EC is 56.7 uS/cm. Soils are moist

and well drained, and lack a water table within the upper 100 cm of the soil profile. Moderately well-developed Inceptisols and Spodosols with andic soil properties are associated with this ecotype, including Andic Haplocryods, Typic Haplocryods, and Fluventic Dystrocryepts (Table 20).

Table 20. Soil Horizon for Upland Ashy-Loamy-Rocky Birch Forest, Steep Slopes, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–10.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	C	10.0–17.0	ashy	loamy very fine sand	NA
3	E	17.0–21.0	ashy	silt loam	NA
4	Bs	21.0–30.0	ashy	fine sandy loam	NA
5	CB	30.0–42.0	no modifier (<15%)	loamy fine sand	NA

Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub

The ecotype Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub occurs on summit and shoulder positions of highly weathered volcanic or sedimentary hills in the eastern portion of the study area, and on old glaciofluvial deposits buried by tephra in the western portion of the study area. Vegetation corresponds to the *Empetrum nigrum* plant association. The dominant species in this ecotype is the dwarf evergreen shrub *Empetrum nigrum*. This ecotype has high Ericaceous shrub and willow diversity; the most common species are *Vaccinium uliginosum*, *Ledum decumbens*, *Betula nana*, and *Salix arctica*. *Picea glauca* may be present at very low cover values (<3.0%). Diversity of herbaceous species is generally low, the most common are graminoids such as *Carex bigelowii*, *Calamagrostis canadensis*, and *Festuca altaica*. Forb cover ranges from trace to <5.0%, the most common of which are *Pedicularis langsdorffii*, *Epilobium angustifolium*, and *Lupinus nootkatensis*. The ground is covered by a nearly continuous mat of lichens and, to a lesser extent, mosses. Common lichens include *Cladonia uncialis*, *Flavocetraria cucullata*, *Cladina rangiferina*, and *Cladina arbuscular*, while typical moss species are *Pleurozium schreberi* and *Polytrichum juniperinum*. Soil textures are Ashy or Gravelly, with an average depth to >15% rock fragments of 18.0 cm. Surface organic horizon thickness ranges from very thin to thin (avg. 5.5 cm). Soils in this ecotype form on older, more stable surfaces, that have had sufficient time to accumulate moderately thick ash deposits (avg. 17 cm) in the upper part of the soil profile. Soils are moist and well drained, and the average depth to the water table is >100 cm. Soil chemistry is acidic (avg. 5.0 pH), with an average EC of 75.0 uS/cm. Soil genesis in the older, fine-textured glaciofluvial deposits can support the development of a weak argillic horizon formed by the translocation of clay to lower in the soil profile. Soil development ranges from moderately-well developed Inceptisols and Spodosols, to weakly-developed Alfisols. Common soil subgroups include Andic Haplocryepts, Andic Haplocryalfs, and Typic Humicryods (Table 21).

Table 21. Soil Horizon for Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oe	0.0–3.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
2	C	3.0–4.0	ashy	very fine sandy loam	NA
3	A	4.0–16.0	coarse gravelly (20–76mm, 15–35%)	silt loam	NA
4	Oab	16.0–21.0	no modifier (<15%)	highly decomposed plant material (unsaturated Oa)	NA
5	Bt1	21.0–28.0	ashy	loam	NA
6	Bt2	28.0–41.0	fine gravelly (2–5mm, 15–35%)	loam	NA

Upland Ashy-Loamy-Rocky White Spruce Woodland

The ecotype Upland Ashy-Loamy-Rocky White Spruce Woodland is the most common of the upland ecotypes, comprising more than one third of the study area (approx. 37%). It is associated with older, more stable landforms, such as glaciofluvial outwash deposits and ancient terraces. It also occurs on nearly level to gently sloping (avg. 1 degree) foot slopes or toe slopes. Vegetation corresponds to the *Betula nana-Ledum* spp., *Picea glauca*/Ericaceous shrubs, *Picea glauca-Betula papyrifera* var. *kenaica*/*Betula nana*-Ericaceous shrubs, and *Salix glauca*/*Betula nana* plant associations. *Picea glauca* is the dominant tree species in this ecotype. Scattered, stunted *Betula kenaica* (<10 m in height) are also present in the tree canopy. Shrub cover is robust, and is dominated by ericaceous species such as *Ledum decumbens*, *Vaccinium vitis-idaea*, and *Empetrum nigrum*. Non-ericaceous shrubs, including *Betula glandulosa*, *B. nana*, and *Salix glauca* and, comprise a smaller proportion of the shrub cover. Diversity and cover of herbaceous species tend to be low; typical species are *Calamagrostis canadensis* and *Epilobium angustifolium*. Frost hummocks are prevalent, and the microtopography supports a diversity of non-vascular species. Mosses dominate in the concave or nearly level inter-hummock areas, while lichen cover is high on the convex portions of the hummocks. The most common and abundant moss species include *Pleurozium schreberi* and *Ptilium crista-castrensis*. The liverwort *Ptilidium ciliare* is also common. Lichens associated with this ecotype include *Peltigera aphthosa*, *Cladina* sp. and *Cladonia* sp. Soil texture classes include Ashy, Bouldery, Gravelly, Loamy or Organic-rich. Soils have had sufficient time to accumulate moderately thick volcanic ash deposits (avg. 22.1 cm) in the upper part of the soil profile, and depth to >15% rock fragments (avg. 40.2 cm) is relatively deep compared to other Upland ecotypes. A moderately thick (avg. 11.2 cm) surface organic layer that classifies as a folistic epipedon occasionally occurs in this ecotype. Soils are moist and well drained, and the average depth to the water table is >100 cm. Soil chemistry ranges from acidic to circumneutral (avg. 4.5 pH), with an average EC of 88.2 uS/cm. Soil development ranges from weakly developed Alfisols and moderately-well developed Spodosols and Andisols, to well-developed Inceptisols. Typical soil subgroups include Andic Haplocryalfs, Andic Haplocryepts, Andic Haplocryods, Folistic Dystrocryepts, Spodic Dystrocryepts, Spodic Haplocryands, Typic Haplocryands and Typic Haplocryods (Table 22).

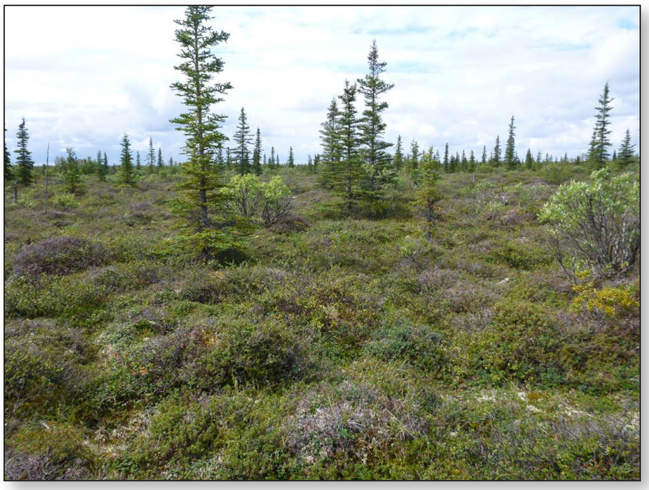

Table 22. Soil Horizon for Upland Ashy-Loamy-Rocky White Spruce Woodland, Alagnak Wild River, Alaska, 2016.

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	2.0–6.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C	6.0–9.0	ashy	loamy fine sand	NA
4	AE	9.0–20.0	ashy	silt loam	NA
5	Bsh	20.0–28.0	ashy	loam	NA
6	Bs	28.0–42.0	extremely stoney (60–90%)	loam	NA

Upland Frozen-Oganic-Rich Birch-Ericaceous Low Shrub
The ecotype Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub occurs on nearly level to gently sloping foot slopes and toe slopes (avg. 3 degrees), as well as on bogs and abandoned alluvial fan deposits. This ecotype is widespread throughout the study area and ranks second among the ecotypes for total extent (approx. 8.6% of the study area). For mapping, it ecotype was combined with the Upland Frozen-Organic-rich Tussock Meadow ecotype to create the Upland Frozen Organic-rich Birch-Tussock Low Shrub map ecotype. Vegetation in the Organic-rich Birch-Ericaceous Low Shrub ecotype corresponds to the *Betula nana-Ledum palustre* ssp. *decumbens*/*Sphagnum* spp. and *Betula nana-Ledum* spp. plant associations. Trace cover of *Picea glauca* is common in this otherwise shrub-dominated ecotype. *Betula nana*, *Ledum decumbens*, *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, and *Empetrum nigrum* co-occur in the shrub canopy. Sedges, such as *Carex bigelowii* and *Eriophorum vaginatum*, as well as the forb *Rubus chamaemorus*, are the most common herbaceous species. Frost hummocks are prevalent, and

the microtopography supports a diversity of non-vascular species. Mosses dominate in the concave or nearly level inter-hummock areas, while lichen cover is high on the convex portions of the hummocks. The most common and abundant moss species are *Pleurozium schreberi* and *Sphaghum* ssp., while important lichen species include *Flavocetraria cucullata*, *Cladina* sp. and *Cladonia* sp. Soil texture classes include Organic-rich and Peat, due to the moderately thick (avg. 16.6 cm) accumulation of organic material at the surface. The average depth to >15% rock fragments is 56.5 cm. Soils in this ecotype are unusual in that they support permafrost at some sites, with an average thaw depth of 34.0 cm. This ecotype is vulnerable to disturbances such as wildfire or a warming climate, as it falls within the zone of isolated permafrost (Jorgenson 2008). The water table is at or above the permafrost, at an average depth of -41.3 cm below the soil surface. Soils are generally wet and poorly drained Histosols or Gelisols. Soil chemistry ranges from circumneutral to acidic (avg. 5.5 pH) and the average EC is 78.0 uS/cm. Typical soil subgroups include Fluvaquentic Historthels, Fluvaquentic Sapristels, Typic Historthels, and Typic Histoturbels (Table 23).

Table 23. Soil Horizon for Upland Frozen-Organic-Rich Birch-Ericaceous Low Shrub, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–15.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	C	15.0–19.0	ashy	loamy very fine sand	NA
3	Oe	19.0–26.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon)	NA
4	Oa	26.0–40.0	no modifier (<15%)	muck (<17% fibers, saturated Oa horizon)	NA
5	Af	40.0–41.0	very gravelly (35–60%)	silt loam	NA

Upland Frozen-Organic-Rich Tussock Meadow

The ecotype Upland Frozen-Organic-rich Tussock Meadow occurs on nearly level slopes on terrace and bog deposits. For mapping, this ecotype was combined with the Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub ecotype to create the Upland Frozen Organic-rich Birch-Tussock Low Shrub map ecotype. Vegetation corresponds to the *Betula nana-Ledum palustre* ssp. *decumbens/Sphagnum* spp. and Mixed Ericaceous Shrub plant associations. The tussock-forming sedge, *Eriophorum vaginatum*, characterizes this ecotype. Tussocks tend to co-occur with robust shrub cover, which is dominated by members of the Ericaceae family. The most common shrub species include *Ledum decumbens*, *Betula nana*, *Vaccinium vitis-idaea*, and *Empetrum nigrum*. Other tussock-forming graminoids, such as *Carex bigelowii* may be present, but in general herbaceous species diversity is low. Diversity is high, however, in the moss and lichen ground cover. Common mosses include *Pleurozium schreberi* and *Sphagnum* sp., while important lichens include *Flavocetraria cucullata*, *Cladina* sp., and *Thamnolia vermicularis*. Soil texture classes include Organic-rich and Peat, associated with the moderately thick accumulation of organic material at the surface (avg. 24.0 cm). The average depth to >15% rock fragments is 89.5 cm. Soils in this ecotype have the capacity to support permafrost, with an average thaw depth of 44.3 cm. This ecotype is vulnerable to disturbances such as wildfire or a warming climate, as it falls within the zone of isolated permafrost (Jorgenson 2008). The water table is generally at, or just above the permafrost table, at an average depth of -43.5 cm. Soils range from moist to wet, somewhat poorly to poorly drained Histosols or Gelisols. Soil chemistry is acidic (avg. 4.8 pH), and has an average EC of 74.0 uS/cm. Hemic horizons, i.e., moderately decomposed organic material, is common for the soils in this ecotype. Typical soil subgroups include Histic Cryaquepts, Terric Cryohemists, Terric Hemistels, and Typic Histoturbels (Table 24).

Table 24. Soil Horizon for Upland Frozen-Organic-Rich Tussock Meadow, Alagnak Wild River, Alaska, 2016.

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)	5yr 3/4
2	C	6.0–8.0	ashy	loamy very fine sand	10yr 7/2
3	Oe	8.0–25.0	no modifier (<15%)	mucky peat (17–40% fibers, saturated Oe horizon)	5yr 4/3
4	OaCjj	25.0–36.0	no modifier (<15%)	muck (<17% fibers, saturated Oa horizon)	7.5yr 2.5/2
5	Cf1	36.0–42.0	no modifier (<15%)	very fine sandy loam	7.5yr 3/3
6	Cf2	42.0–43.0	no data	Not Available	NA

Upland Loamy-Organic Birch-Willow Low Shrub

The ecotype Upland Loamy-Organic Birch-Willow Low Shrub occurs on nearly level slopes of terraces, abandoned alluvial fans, and old glaciofluvial deposits. This ecotype is spatially associated with the Upland Ashy-Loamy-Rocky White Spruce Woodland ecotype for those areas where forested cover is less than 10%. It is associated with the *Betula nana-Ledum* spp. and *Salix glauca/Betula nana* plant associations. Willow species, including *Salix glauca*, *S. pulchra*, and/or *S. bebbiana* are co-dominant with *B. nana*. Other common shrub species include *Vaccinium vitis-idaea*, *Vaccinium uliginosum*, and *Ledum decumbens*. Graminoids, such as *Calamagrostis canadensis* and *Carex bigelowii* are often present, but their cover is generally low (<2.0%). Forbs are typically sparse, with the most common species being *Campanula lasiocarpa* and *Epilobium angustifolium*. The moss *Pleurozium schreberi* and the liverwort *Ptilidium ciliare* are ubiquitous in the ground cover. Common lichen species include *Cladina rangiferina*, *Peltigera aphthosa*, and *Nephroma arcticum*. Soil texture classes include Organic-rich, Loamy and Ashy. Soils in this ecotype occasionally develop a moderately thick (avg. 18 cm) surface organic mat that classifies as a folistic epipedon. Older soils in this ecotype, that accumulate thick organic mats (≥40 cm), have the potential to support permafrost deep (>100 cm) in the soil profile. Soil parent material is often an unsaturated organic mat over tephra deposits (avg. 22.7 cm) overlying rocky colluvium or alluvium. The average depth to >15% rock fragments is 57.0 cm. Soils are moist and well drained, and an average depth to the water table is >100 cm. Soil chemistry is acidic (avg.

3.6 pH), and has an avg. EC of 143.3 uS/cm. This relatively high EC may be associated with fire history, as this ecotype represents a fire seral community. Soils are well-developed Inceptisols, Andisols, and occasionally Gelisols. Typical soil subgroups include Andic Dystrocryepts and Spodic Haplocryands, and less commonly Typic Histoturbels (Table 25).

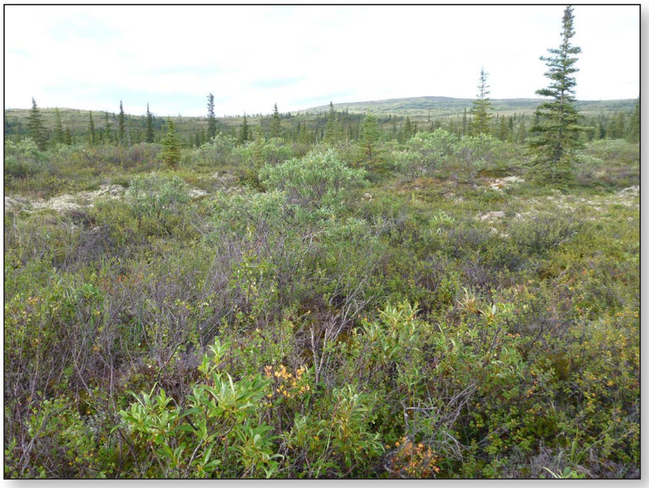

Table 25. Soil Horizon for Upland Loamy-Organic Birch-Willow Low Shrub, Alagnak Wild River, Alaska, 2016.

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	Oe	8.0–14.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C/Oe	14.0–18.0	ashy	loamy very fine sand	NA
4	Bs	18.0–50.0	ashy	loam	NA
5	C	50.0–61.0	no modifier (<15%)	sandy loam	NA

Upland Loamy-Organic White-Spruce-Birch Forest

The ecotype Upland Loamy-Organic White Spruce-Birch Forest occurs on nearly level to moderately steep slopes (avg. 7 degrees) along terrace risers, bluffs, and backslope positions of hills and mountains. Vegetation corresponds to the *Betula papyrifera* var. *kenaica*/*Calamagrostis canadensis*, *Picea glauca-Betula papyrifera* var. *kenaica*, and *Picea glauca-Betula papyrifera* var. *kenaica*/*Calamagrostis canadensis* plant associations. *Betula kenaica* and *Picea glauca* are co-dominant in the forest canopy. Shrub cover is generally low with the exception of moist concave landscape positions or recently disturbed sites, which may have moderately high cover of *Alnus fruticosa* and *Salix barclayi*. Common herbaceous species include *Equisetum pratense*, *Cornus suecica*, and *Calamagrostis canadensis*. Common non-vascular species include the feather mosses *Hylocomium splendens*, *Pleurozium schreberi*, and *Ptilium crista-castrensis*. Soil texture classes include Ashy, Loamy, and Organic-rich. Surface organic horizon thickness ranges from thin to moderately thick

(avg. 16.0 cm), and depth to >15% rock fragments is shallow (avg. 26.3 cm). Soils are moist and well drained, and have the average depth to the water table is >100 cm. Soil chemistry is acidic (avg. 4.5 pH), with an average EC of 120.0 uS/cm. Soils are moderately well-developed Inceptisols and Spodosols. Typical soil subgroups include Andic Haplocryods, Folistic Dystrocryepts, and Typic Haplocryepts (Table 26).

Table 26. Soil Horizon for Upland Loamy-Organic White Spruce-Birch Forest, Alagnak Wild River, Alaska, 2016.

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–15.0	no modifier (<15%)	slightly decomposed plant material (unsaturated Oi)	NA
2	Oe/C	15.0–23.0	ashy	moderately decomposed plant material (unsaturated Oe)	NA
3	Oa	23.0–31.0	no modifier (<15%)	highly decomposed plant material (unsaturated Oa)	NA
4	Bw	31.0–52.0	very gravelly (35–60%)	sandy loam	NA

Upland Rocky-Organic Alder-Willow Tall Shrub

The ecotype Upland Rocky-Organic Alder-Willow Tall Shrub occurs almost exclusively in the eastern portion of the study area. This ecotype is associated with gently sloping to moderately steep hillslope positions (avg. 6 degrees). Vegetation corresponds to the *Alnus incana* ssp. *tenuifolia/Calamagrostis canadensis* and *Salix pulchra-Salix barclayi* plant associations. The tall shrubs *Alnus tenuifolia*, *A. fruiticosa*, or *Salix pulchra* dominate the shrub canopy. Other common shrub species include *Ribes hudsonianum* and *Salix barclayi*. The understory is dominated by ferns and horsetails, including *Dryopteris dilatata* ssp. *americana*, *Equisetum arvense*, and *E. sylvaticum*. Other common herbaceous species include *Calamagrostis canadensis*, *Sanguisorba stipulata*, and *Trientalis europaea*. Few moss and lichen species are present, and non-vascular cover is generally low (avg. <2.0%). Soil texture classes include Organic-rich, Gravelly and Bouldery. Complete soils data was available for a single plot in this ecotype represented by Open Tall Alder vegetation, where the depth to >15% rock fragments was 28.0 cm. The surface organic thickness was 21.0 cm, the soil chemistry was acidic (3.5 pH), and the EC was 170.0 uS/cm. The acidic pH in this plot is the result of the addition of nitrogen to the soils by the alders through the process of nitrogen fixation. Soil chemistry in stands dominated by willows, which are not nitrogen fixers, is expected to be mildly acidic to circumneutral. Soils are moist and well drained, and have the average depth to the water table is >100 cm. Soil genesis is expected to range from moderately well-developed Inceptisols to weakly developed Spodosols. Typical soil subgroups include Folistic Dystrocryepts, Spodic Dystrocryepts, Typic Dystrocryepts, Folistic Haplocryods, or Typic Haplocryods (Table 27).

Table 27. **Soil Horizon for** Upland Rocky-Organic Alder-Willow Tall Shrub**, Alagnak Wild River, Alaska, 2016.**

Horizon number	Horizon code	Depth Range (cm)	Texture Modifier	Texture	Horizon Color
1	Oi	0.0–5.0	no modifier (<15%)	slightly decomposed plant material (un-saturated Oi)	NA
2	Oe	5.0–21.0	no modifier (<15%)	moderately decomposed plant material (unsaturated Oe)	NA
3	C	21.0–28.0	ashy	loamy fine sand	NA
4	Oab	28.0–31.0	no modifier (<15%)	highly decomposed plant material (un-saturated Oa)	NA
5	Ab	31.0–48.0	very cobbly (35–60%)	silt loam	NA

Relationships Among Ecological Components

Toposequences

The classification of ecotypes (local-scale ecosystems) was based on the survey of ecological components (topography, geomorphology, soil, hydrology, permafrost, and vegetation) in the field 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 (Appendices 6–8). Vegetation classes follow the AVC (Viereck et al. 1992). Three toposequences are presented each of which represents distinct environments within the study area. Appendix 6 illustrates a toposequence from upland to riverine representing upper ALAG upstream of the Nonvianuk River confluence (Figure 2). Appendix 7 illustrates a toposequence representing the middle ALAG downstream of the Nonvianuk River confluence where the Alagnak River features an anastomosing planform (Figure 2). Appendix 8 illustrates a toposequence representing the lower ALAG where the Alagnak River widens and changes to a predominantly meandering planform (Figure 2).

Hierarchical Organization of Ecologcial Components

We developed hierarchical relationships among ecological components by successively grouping data from the 132 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.

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., active river bars) 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 Riverine, Lowland, and Upland areas. Identifying the changing patterns in geomorphic units and vegetation across space, 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 5) 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 10% of the observations (13 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 10%) 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.

Vegetation Composition

Species Summary

We classified a total of 26 ecotypes in ALAG; these ecotypes correspond to 51 AVC vegetation classes at the plot level (Table 4). Several ecotypes correspond to multiple AVC classes because of the degree of canopy closure represented in the AVC open and closed canopy classes. For example, the ecotype Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub includes the AVC vegetation classes Open Tall Willow (25–75% canopy closure) and Closed Tall Willow (>75% canopy closure). The AVC vegetation classes identified in

ALAG include 3 barren or partially vegetated classes, 4 broadleaf forest classes, 3 mixed forest classes, 2 needleleaf forest classes, 2 dwarf forest classes, 8 graminoid-dominated classes, 2 dwarf shrub classes (≤0.20 m), 7 low shrub classes (0.20–1.5 m), 5 tall shrub classes (≥1.5 m height), and 1 water class. ABR and AKNHP collectively recorded 180 vascular and 92 non-vascular species in ALAG (Appendix 2). These species totals should be considered approximate minimum numbers of species occurring in ALAG. Our sampling methods were not designed to support a comprehensive floristic inventory (see Carlson and Lipkin 2003), which was beyond the scope of this study.

Ecosystem Mapping

Physiography

We classified and mapped 3 physiographic classes in ALAG (Figure 4, Table 28). The Upland class accounted for 61.7% % of the study area, while Riverine and Lowland physiography occupied 24.8% and 13.5 %, respectively.

Land Cover

The land cover map presented here as part of the ABR ALAG_Ecosystem_Mapping layer contains the same 20 land cover classes for ALAG as the AKNHP ALAG Land Cover Map (see Table 1 and Figure 4 in Boucher and Flagstad 2014). However, as the result of polygon edits during the physiography mapping, the line work for and areal extent of land cover classes in the ABR ALAG_Ecosystem_Mapping layer differ slightly from the AKNHP ALAG Land Cover Map. Here we present the land cover map (Figure 5) and areal extent of the land cover classes from the ALAG_Ecosystem_Mapping layer (Table 29). Spruce Woodland was the most extensive land cover class (17.2% of study area), followed by Mixed Broadleaf/Needleleaf Forest (13.0%), and Mixed Broadleaf/Needleleaf Woodland (10.7%); together, these three land cover classes accounted for just over one third of the ALAG study area. Additional common (>5%) land cover classes consist of Water (8.6%), Tall Willow Shrub (8.2%), Mixed Low/Dwarf Shrub (7.9%), Open Spruce Forest (7.2%), and Mixed Low/Dwarf Shrub-Sedge (5.3%).

Map Ecotypes

We mapped 22 ecotypes in ALAG (Figure 6, Tables 30 and 31). Combined, the three most common map ecotypes accounted for ~50% of the study area: Upland Ashy-Loamy-Rocky White Spruce Woodland (37.6% of mapping area), Upland Frozen Organic-rich Birch-Tussock Low Shrub (8.6%), and Riverine Circumneutral River Water (8.4%). Five map ecotypes, including Upland Ashy-Loamy-Rocky Birch Forest, steep slopes; Riverine Sandy-Loamy-Rocky Alder Tall Shrub; Upland Loamy-Organic Birch-Willow Low Shrub; Lowland Lake; Riverine Rocky Barrens and Partially Vegetated; and Upland Ashy-Loamy-Rocky Balsam Poplar Forest; had very limited distributions (<1%). Forest- and woodland-dominated ecotypes occupied just over half of the mapping area.

Soil Landscapes

We classified and mapped 11 soil landscapes in ALAG. The map of soil landscapes was developed by aggregating the 22 map ecotypes into a set of 11 soil landscapes (Figure 7, Table 32). The soil landscapes are named by their physiography, generalized texture, and dominant vegetation structure(s). Two widespread soil landscapes accounted for >50% of the study area: Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands (39.8% of mapping area) and Riverine Silty-Sandy-Rocky Shrublands and Forests (13.2%). Additional common (>5%) soil landscapes include Upland Frozen Organic-rich Low Shrublands and Tussock Meadow (8.6%), River (8.4%), Upland Rocky-Loamy-Organic Tall Shrublands and Forests (8.3%), and Lowland Organic-rich Wet Shrublands and Sedge Meadows (6.4%).

Disturbance Landscapes

We classified and mapped 7 disturbance landscape across ALAG (Figure 8, Table 33). Two disturbance landscapes, including "Windthrow, Fire, Pests and Pathogens" (48.3%) and "Flooding, Sedimentation, Erosion" (24.8%); account for nearly three quarters of the study area. Other common disturbance landscapes include "Drying, Paludification" (11.0%) and "Thermokarst" (8.6%).

Soil Great Group Mapping

We classified 8 great group mapping classes and water across ALAG (Figure 9, Table 34). Two great group mapping classes encompassed 58% of the mapping area, including Haplocryands-Haplocryods-Haplocryalfs (44.8%) and Cryofluvents (13.2%). Other common great group mapping classes include: Historthels-Histoturbels (8.6%), Haplocryods-Haplocryepts (8.3%), and Cryofibrists-Cryaquepts (6.4%). Water encompassed 8.6% of the mapping area.

Map Accuracy

The classification systems for ecotypes, soil landscapes, and disturbance landscapes were derived using both the field plots sampled by AKNHP and those sampled by ABR. However, the ABR plots were not used to construct the AKNHP land cover map (Boucher and Flagstad 2014), which served

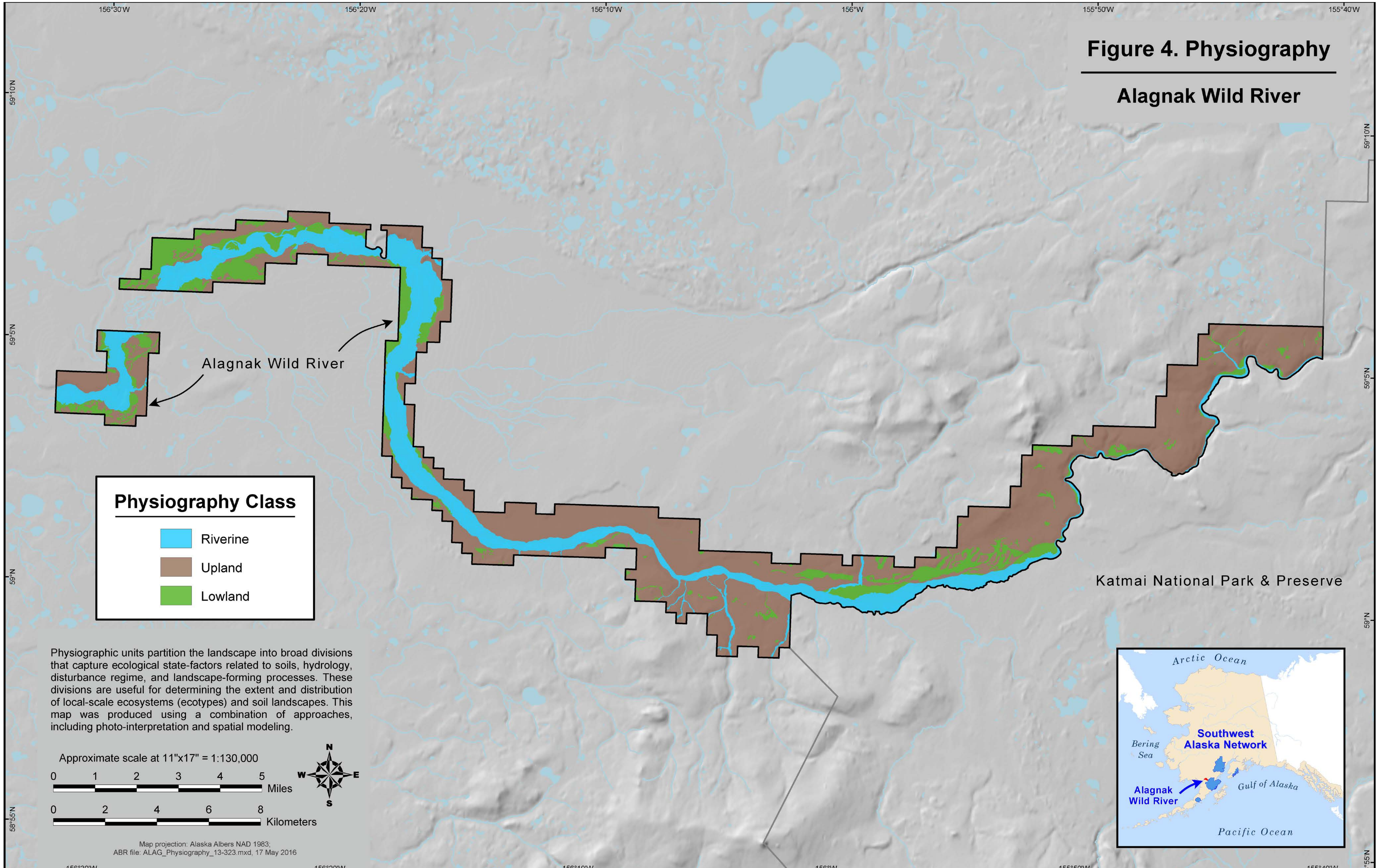

Figure 4. Physiography map for Alagnak Wild River, southwest Alaska.

Table 28. Area (ha) of physiographic classes mapped in Alagnak Wild River, southwest Alaska.

Physiography	Area (ha)	% of study area
Lowland	1690.2	13.5%
Riverine	3099.6	24.8%
Upland	7717.6	61.7%
Grand Total	12507.4	100.0%

as the primary input in the landscape modeling and mapping presented in this report. The network of ABR field plots, therefore, provide a means by which to assess the strength and limitations of the land cover map. We caution, however, that the areal footprint of ABR field plots (circular with radius of approximately 10 m) is substantially smaller than most of the land cover map polygons. Additionally, a number of land cover classes are of limited spatial extent and are represented by only one or a few field plots. Therefore, while we present estimates of map accuracy for the most common classes this should not be considered a formal, quantitative accuracy assessment Rather, the accuracy estimates below provide guidelines for making qualitative statements regarding map accuracy for the common land cover classes.

For the land cover accuracy assessment we focused on land cover classes that comprised >5% of the study area and within which 3 or more ABR field plots were located. Six land cover classes met the criteria: Spruce Woodland, Mixed Broadleaf/Needleleaf Forest, Tall Willow Shrub, Mixed Low/Dwarf Shrub, Open Spruce Forest, and Mixed Low/Dwarf Shrub-Sedge (Table 35). To begin, a spatial join between the AKNHP land cover map and the ABR plot feature class was performed. The primary land cover class was then compared to the AVC Level IV vegetation classes assigned to the ABR plots that fell within each land cover class. A fuzzy accuracy assessment was performed by assigning 100 percent accuracy for vegetation classes that matched the land cover class and partial accuracy for vegetation classes that were similar but not the same. For example, for the land cover class "Open Spruce Forest" a AVC Level IV vegetation class of Open White Spruce Forest would receive 100% accuracy, while a vegetation class of White Spruce Woodland would receive 75% accuracy, a vegetation class of Spruce–Paper Birch Woodland would receive 50% accuracy, and a vegetation class of Ericaceous–Lichen Dwarf Shrub Tundra would receive an accuracy of 0%.

A total of 12 ABR plots fell within the most common land cover class, Spruce Woodland. This land cover class was determined to have a fuzzy accuracy of 56.3% (Table 35). Just over half of the plots (7 out of 12) that fell within this land cover were classified as a forested type, with most of these classified as the AVC Level IV vegetation class White Spruce Woodland. The remaining 5 plots were classified as dwarf and low shrub types. In some cases this is the result of the small size of the ABR plots relatively to low tree cover (10–25%) in woodlands, such that the ABR plots encompassed areas of <10% tree cover within a stand where overall tree cover was in the 10–25% range.

The next most common land cover class assessed was Mixed Broadleaf/Needleleaf Forest, which received a fuzzy accuracy of 55.6%. Of the 9 ABR plots located in this class, 8 were classified as forested, but 2 only were classified as mixed broadleaf/needleleaf forest (Open Spruce–Paper Birch). The remaining plot was classified as the non-forest type Subarctic Lowland Sedge-Shrub Wet Meadow.

The land cover class Tall Willow Shrub received a fuzzy accuracy of 60.4%. A total of 12 ABR plots were located in this land cover class; 8 were willow dominated plots, and 5 of these were classified as tall willow. Bluejoint Meadow was the non-willow class most often misclassified as Tall Willow Shrub, a result consistent with the description of the Tall Willow Shrub class by Boucher and Flagstad (2014) as "interspersed with the Wet Herbaceous" class.

A total of 6 ABR plots fell within the land cover class Mixed Low/Dwarf Shrub which was assigned a fuzzy accuracy of 83.3%. This land cover class is described as being dominated by *Betula nana* and *Ledum decumbens*, with willows sometime co-dominant. All 6 plots were classified as low or dwarf shrub dominated. Three plots were classified as ericaceous dwarf shrub types, 2 were classified as Open Low Willow, and 1 as Open Mixed Low Shrub–Sedge Tussock Tundra.

A total of 11 plots fell within Open Spruce Forest, which was determined to have a fuzzy accuracy of 65.9% (Table 35). Nearly all (10 out of 11) of the plots that fell within this land cover were classified as forested types, with most classified as the AVC Level IV vegetation class White Spruce Woodland.

Seven ABR plots were in Mixed Low/Dwarf Shrub-Sedge, which was assigned a fuzzy accuracy of 82.1%. Five of the 7 plots were classified as dwarf or low shrub types with strong sedge components, i.e.Open Mixed Low Shrub–Sedge Tussock Tundra, Subarctic Lowland Sedge-Shrub Wet Meadow, and Tussock Tundra–Ericaceous. The remaining two plots were classified as Fresh Sedge Marsh and Ericaceous Dwarf Shrub Tundra.

Table 29. Area (ha) of land cover classes mapped in Alagnak Wild River, southwest Alaska.

Land Cover Class	Area (ha)	% of Study Area
Barren	9.4	0.1%
Birch Forest	395.3	3.2%
Birch Woodland	16.9	0.1%
Closed Spruce Forest	9.6	0.1%
Dwarf Shrub	132.0	1.1%
Dwarf Shrub-Lichen	503.4	4.0%
Low Shrub Wetland	498.7	4.0%
Low Willow Shrub	297.7	2.4%
Mesic Herbaceous Meadow	16.2	0.1%
Mixed Broadleaf/Needleleaf Forest	1621.7	13.0%
Mixed Broadleaf/Needleleaf Woodland	1340.5	10.7%
Mixed Low/Dwarf Shrub	994.2	7.9%
Mixed Low/Dwarf Shrub-Sedge	663.6	5.3%
Open Spruce Forest	900.8	7.2%
Poplar Forest	2.5	0.0%
Spruce Woodland	2145.7	17.2%
Tall Alder Shrub	266.8	2.1%
Tall Willow Shrub	1028.7	8.2%
Water	1077.3	8.6%
Wet Herbaceous	586.4	4.7%
Grand Total	12507.4	100.0%

The average fuzzy map accuracy of the 6 most common land cover classes was 64.9%. An accuracy assessment was not conducted for the ELS map products. However the above accuracy assessment of the land cover map provides some insights into map classes that may be commonly confused. The most common mapping errors for forested classes were between woodland (10–25% tree cover) and open forest (25–59% tree cover), and between needleleaf and mixed broadleaf-needleleaf forests. In the ecotype map it follows that woodland and mixed forest ecotypes may be confused with one another, e.g., Upland Ashy-Loamy-Rocky White Spruce Woodland and Upland Loamy-Organic White Spruce-Birch Forest. Tall Willow Shrub was confused most commonly with Low Willow Shrub and Bluejoint Meadow. In the ecotype map tall (>1.5 m) and low (0.2–1.5 m) willow ecotypes are may be confused in some cases, e.g., Riverine Silty-Sandy-Rocky Moist Willow Low Shrub and Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub. In addition, some areas mapped as Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub likely compass a mosaic of tall willow stands and graminoid meadows. The low and dwarf shrub land cover types had the highest accuracy of all land cover classes assessed (~80%). Within this group, the most common mapping errors were between dwarf and low shrub types, and between types with and without a strong sedge component. In upland environments this source of error was reduced by combining the ecotypes Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub and Upland Frozen-Organic-rich Tussock Meadow into a single map ecotype (Upland Frozen Organic-rich Birch-Tussock Low Shrub). In addition, the physiography mapping serves to reduce these types of errors; the majority of lowland areas mapped as the land cover classes Mixed Low/Dwarf Shrub and Mixed Low/Dwarf Shrub-Sedge were assigned to the map ecotype Lowland Organic-rich Wet Sedge-Shrub Bog Meadow (Appendix 5). In contrast, upland areas mapped as the above land cover classes were primarily assigned to the map ecotype Upland Frozen Organic-rich Birch-Tussock Low Shrub.

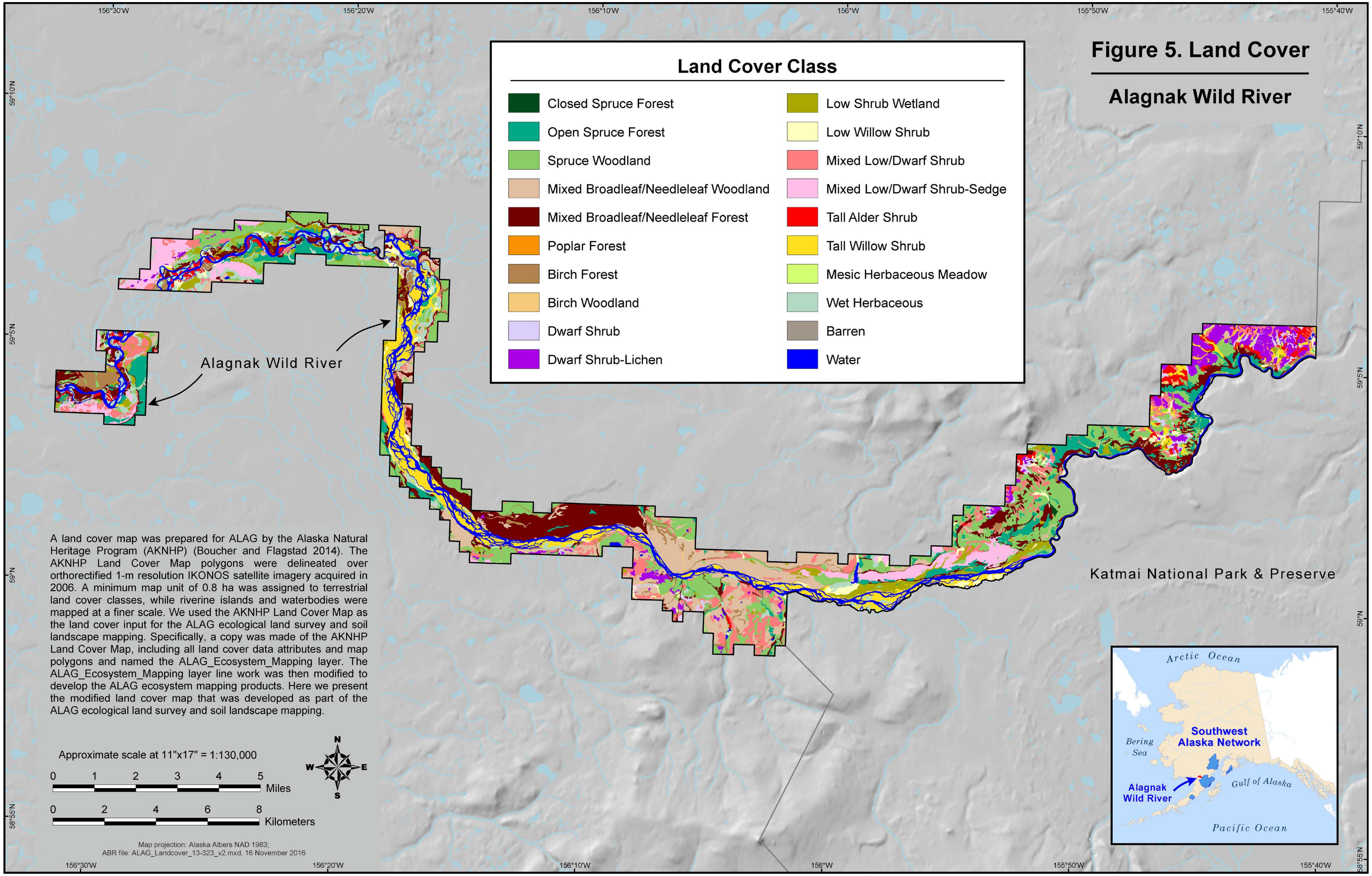

Figure 5. Land cover map for Alagnak Wild River, southwest Alaska, as modified by ABR.

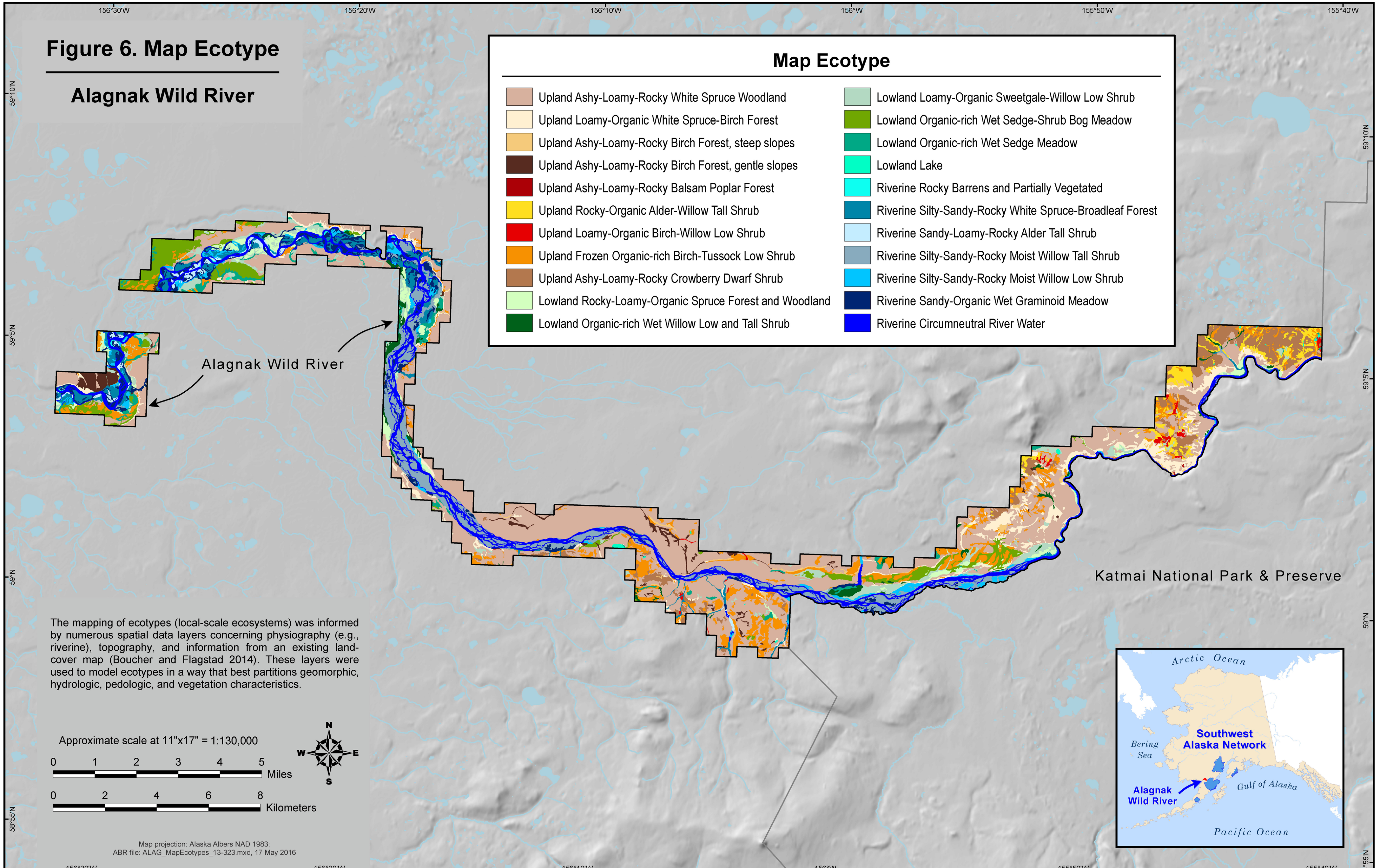

Figure 6. Map ecotypes for Alagnak Wild River, southwest Alaska.

Table 30. Crosswalk of map ecotypes with plot ecotype names, soil landscapes, and disturbance landscapes identified in Alagnak Wild River, southwest Alaska.

Map Ecotype	Ecotype	Soil Landscape	Disturbance Landscape	Great Group Map Class
Lowland Loamy-Organic Sweetgale-Willow Low Shrub	Lowland Loamy-Organic Sweetgale-Willow Low Shrub	Lowland Organic-rich Wet Shrublands and Sedge Meadows	Drying, Paludification	Cryohemists-Hemistels
Lowland Organic-rich Wet Sedge Meadow	Lowland Organic-rich Wet Sedge Meadow	Lowland Organic-rich Wet Shrublands and Sedge Meadows	Drying, Paludification	Cryofibrists-Cryaquepts
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	Lowland Organic-rich Wet Sedge-Shrub Bog Meadows	Thermokarst	Cryohemists-Hemistels
Lowland Organic-rich Wet Willow Low and Tall Shrub	Lowland Organic-rich Wet Willow Low and Tall Shrub	Lowland Organic-rich Wet Shrublands and Sedge Meadows	Drying, Paludification	Cryofibrists-Cryaquepts
Lowland Rocky-Loamy-Organic Spruce Forest and Woodland	Lowland Rocky-Loamy-Organic Spruce Forest and Woodland	Lowland Rocky-Loamy-Organic Forests and Woodlands	Windthrow, Fire, Pests and Pathogens	Haplocryepts-Dystrocryepts
Riverine Circumneutral River Water	Riverine Circumneutral River Water	River	Flooding, Sedimentation, Erosion	Water
Riverine Rocky Barrens and Partially Vegetated	Riverine Rocky Barrens and Partially Vegetated	Riverine Sandy-Rocky Barrens and Wet Meadows	Flooding, Sedimentation, Erosion	Cryaquents
Riverine Sandy-Loamy-Rocky Alder Tall Shrub	Riverine Silty-Sandy-Rocky Alder Tall Shrub	Riverine Silty-Sandy-Rocky Shrublands and Forests	Flooding, Sedimentation, Erosion	Cryofluvents
Riverine Sandy-Organic Wet Graminoid Meadow	Riverine Sandy-Organic Wet Grass Meadow	Riverine Sandy-Rocky Barrens and Wet Meadows	Flooding, Sedimentation, Erosion	Cryaquents
Riverine Sandy-Organic Wet Graminoid Meadow	Riverine Sandy-Organic Wet Sedge Meadow	Riverine Sandy-Rocky Barrens and Wet Meadows	Flooding, Sedimentation, Erosion	Cryaquents
Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	Riverine Silty-Sandy-Rocky Shrublands and Forests	Flooding, Sedimentation, Erosion	Cryofluvents
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	Riverine Silty-Sandy-Rocky Shrublands and Forests	Flooding, Sedimentation, Erosion	Cryofluvents
Riverine Silty-Sandy-Rocky White Spruce-Broadleaf Forest	Riverine Silty-Sandy-Rocky Spruce-Balsam Poplar Forest	Riverine Silty-Sandy-Rocky Shrublands and Forests	Flooding, Sedimentation, Erosion	Cryofluvents
Riverine Silty-Sandy-Rocky White Spruce-Broadleaf Forest	Riverine Silty-Sandy-Rocky Spruce-Birch Forest	Riverine Silty-Sandy-Rocky Shrublands and Forests	Flooding, Sedimentation, Erosion	Cryofluvents
Upland Ashy-Loamy-Rocky Balsam Poplar Forest	Upland Ashy-Loamy-Rocky Balsam Poplar Forest	Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands	Windthrow, Fire, Pests and Pathogens	Haplocryands-Haplocryods-Haplocryalfs
Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes	Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes	Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands	Windthrow, Fire, Pests and Pathogens	Haplocryands-Haplocryods-Haplocryalfs
Upland Ashy-Loamy-Rocky Birch Forest, steep slopes	Upland Ashy-Loamy-Rocky Birch Forest, steep slopes	Upland Rocky-Loamy-Organic Tall Shrublands and Forests	Windthrow, Fire, Pests and Pathogens	Haplocryods-Haplocryepts

Table 30. Continued.

Map Ecotype	Ecotype	Soil Landscape	Disturbance Landscape	Great Group Map Class
Upland Ashy-Loamy-Rocky Crow-berry Dwarf Shrub	Upland Ashy-Loamy-Rocky Crow-berry Dwarf Shrub	Upland Ashy-Loamy-Rocky Dwarf Shrublands	Eolian	Haplocryands-Haplocryods-Hap-locryalfs
Upland Ashy-Loamy-Rocky White Spruce Woodland	Upland Ashy-Loamy-Rocky White Spruce Woodland	Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands	Windthrow, Fire, Pests and Pathogens	Haplocryands-Haplocryods-Hap-locryalfs
Upland Frozen Organic-rich Birch-Tussock Low Shrub	Upland Frozen-Organic-rich Birch-Ericaceous Low Shrub	Upland Frozen Organic-rich Low Shrublands and Tussock Meadow	Thermokarst	Historthels-Histoturbels
Upland Frozen Organic-rich Birch-Tussock Low Shrub	Upland Frozen-Organic-rich Tussock Meadow	Upland Frozen Organic-rich Low Shrublands and Tussock Meadow	Thermokarst	Historthels-Histoturbels
Upland Loamy-Organic Birch-Willow Low Shrub	Upland Loamy-Organic Birch-Willow Low Shrub	Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands	Windthrow, Fire, Pests and Pathogens	Haplocryands-Haplocryods-Hap-locryalfs
Upland Loamy-Organic White Spruce-Birch Forest	Upland Loamy-Organic White Spruce-Birch Forest	Upland Rocky-Loamy-Organic Tall Shrublands and Forests	Windthrow, Fire, Pests and Pathogens	Haplocryods-Haplocryepts
Upland Rocky-Organic Alder-Willow Tall Shrub	Upland Rocky-Organic Alder-Willow Tall Shrub	Upland Rocky-Loamy-Organic Tall Shrublands and Forests	Pests and Pathogens	Haplocryods-Haplocryepts

Table 31. Area (ha) of map ecotypes in Alagnak Wild River, southwest Alaska.

Map Ecotype	Area (ha)	% of Study Area
Lowland Lake	20.8	0.2%
Lowland Loamy-Organic Sweetgale-Willow Low Shrub	423.6	3.4%
Lowland Organic-rich Wet Sedge Meadow	207.8	1.7%
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	574.3	4.6%
Lowland Organic-rich Wet Willow Low and Tall Shrub	167.1	1.3%
Lowland Rocky-Loamy-Organic Spruce Forest and Woodland	296.7	2.4%
Riverine Circumneutral River Water	1056.5	8.4%
Riverine Rocky Barrens and Partially Vegetated	9.4	0.1%
Riverine Sandy-Loamy-Rocky Alder Tall Shrub	94.2	0.8%
Riverine Sandy-Organic Wet Graminoid Meadow	383.2	3.1%
Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	228.1	1.8%
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	898.6	7.2%
Riverine Silty-Sandy-Rocky White Spruce-Broadleaf Forest	429.6	3.4%
Upland Ashy-Loamy-Rocky Balsam Poplar Forest	1.6	0.0%
Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes	219.1	1.8%
Upland Ashy-Loamy-Rocky Birch Forest, steep slopes	108.7	0.9%
Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub	628.6	5.0%
Upland Ashy-Loamy-Rocky White Spruce Woodland	4701.1	37.6%
Upland Frozen Organic-rich Birch-Tussock Low Shrub	1074.6	8.6%
Upland Loamy-Organic Birch-Willow Low Shrub	52.6	0.4%
Upland Loamy-Organic White Spruce-Birch Forest	667.1	5.3%
Upland Rocky-Organic Alder-Willow Tall Shrub	264.1	2.1%
Grand Total	12507.4	100.0%

Soil Landscapes

Summary of Soil Characteristics

Soil Classification

Of the 132 plots included in the ecotype analysis, 100 provided sufficient soils data for classifying soil subgroups. Soils from 7 orders of soil taxonomy were encountered during field sampling: Alfisols, Andisols, Entisols, Gelisols, Histosols, Inceptisols, and Spodosols (Table 36). Thirty-seven soil subgroups were identified, although approximately half of the subgroups (20) were rare (<3 observations).

Alfisols (well-developed, clay-rich soils) accounted for 5% of observations, and included one soil subgroup: Andic Haplocryalfs. Alfisols typically form in cool, humid climates with thick accumulations of translocated clay. Alfisols occurred in uplands on older, stable landforms in ALAG, including gently sloping to flat alluvial terraces, till, and glaciofluvial deposits. Parent materials typically included a thin mantle of volcanic ash over rocky alluvial or glacial deposits.

Andisols were rare, accounting for 4% of observations and including 2 subgroups; Spodic Haplocryands and Typic Haplocryands. Andisols develop in volcanic ejecta (e.g., volcanic ash, pumice, cinders, or lava) and/or volcaniclastic materials (e.g., lahar deposits). They 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 in uplands on older, stable landforms in ALAG, including gently sloping to flat alluvial terraces, till, glaciofluvial deposits, and mountain footslopes. Parent material is predominantly thick accumulations of weathered volcanic ash from historic eruptions of Aleutian Arc volcanoes.

Entisols accounted for 18% of observations and included 6 observed subgroups; the 3 most common were Oxyaquic Cryofluvents, Oxyaquic Cryorthents, and Typic Cryofluvents. Entisols are undeveloped soils with little to no horizon development and minimal translocation and accumulation of materials lower in the soil profile. Surface organic (O-hori-

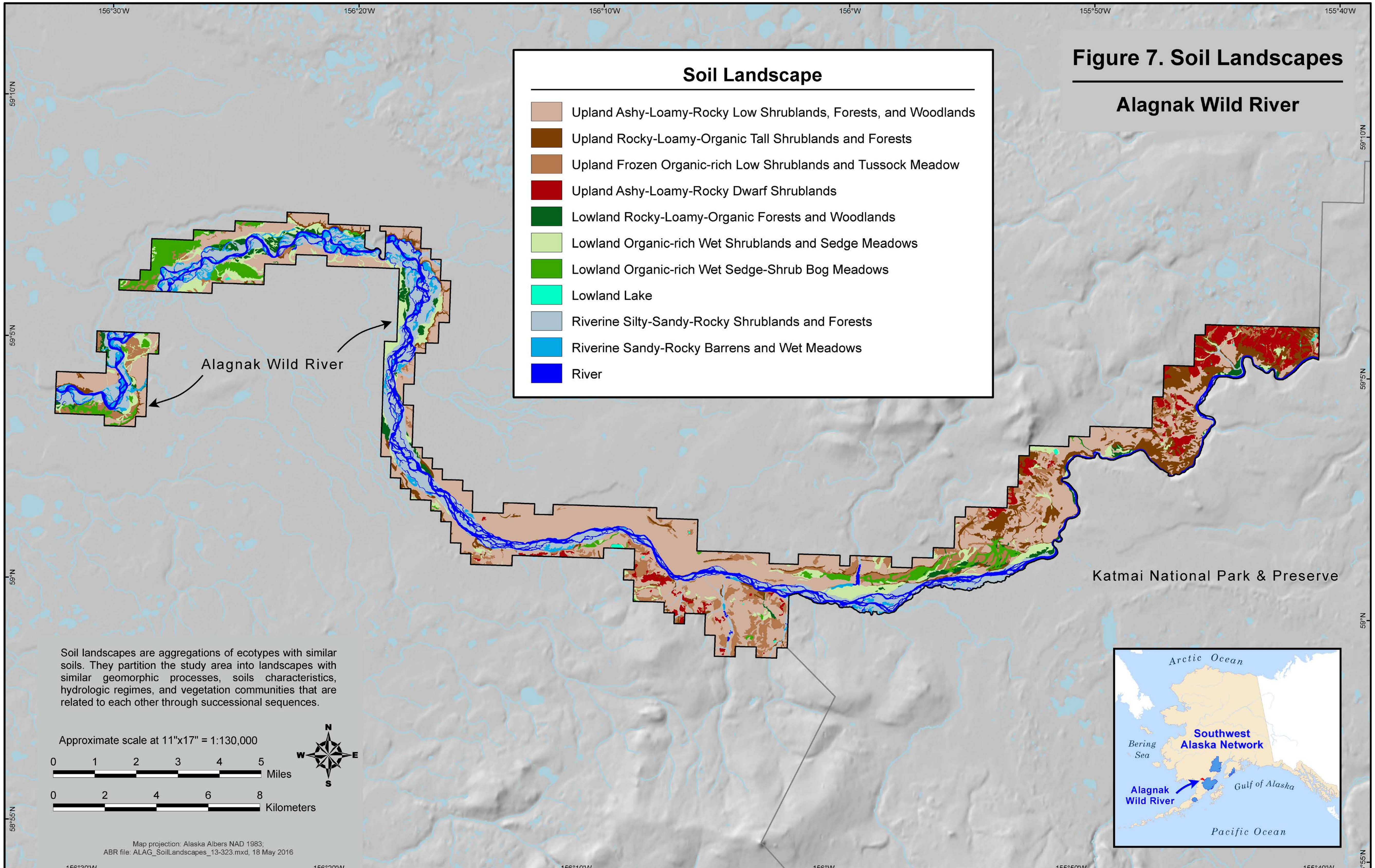

Figure 7. Soil Landscapes Map for Alagnak Wild River, southwest Alaska.

Table 32. Area (ha) of soil landscape classes mapped in Alagnak Wild River, southwest Alaska.

Soil Landscape	Area (ha)	% of Study Area
Lowland Lake	20.8	0.2%
Lowland Organic-rich Wet Sedge-Shrub Bog Meadows	574.3	4.6%
Lowland Organic-rich Wet Shrublands and Sedge Meadows	798.5	6.4%
Lowland Rocky-Loamy-Organic Forests and Woodlands	296.7	2.4%
River	1056.5	8.4%
Riverine Sandy-Rocky Barrens and Wet Meadows	392.6	3.1%
Riverine Silty-Sandy-Rocky Shrublands and Forests	1650.5	13.2%
Upland Ashy-Loamy-Rocky Dwarf Shrublands	628.6	5.0%
Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands	4974.4	39.8%
Upland Frozen Organic-rich Low Shrublands and Tussock Meadow	1074.6	8.6%
Upland Rocky-Loamy-Organic Tall Shrublands and Forests	1039.9	8.3%
Grand Total	12507.4	100.0%

zons) and A-horizons, if present, are typically thin (<14 cm). Entisols have not had sufficient time for soil development to occur, often due to their location in a dynamic environment (e.g., floodplains) or sometimes due to intensive land use practices. In ALAG, Entisols occurred almost exclusively in riverine environments where they were associated with Braided Coarse Active Channel Deposit, Braided Fine Active Channel Deposit, and Meander Active Overbank Deposit.

Gelisols accounted for 12% of observations and included 6 observed subgroups; the three most common were Fluvaquentic Historthels, Terric Hemistels, and Typic Histoturbels. Gelisols are characterized by permafrost (soil materials < 0° C for ≥2 years) within 2 meters of the soil surface. In ALAG they occurred in upland and lowland environments and were associated with organic deposits in bogs and on alluvial terraces.

Histosols accounted for 13% of observations and included 7 observed subgroups; the three most common were Terric Cryohemists, Hydric Cryofibrists, and Fluvaquentic Cryohemists. Histosols are formed in thick (≥20 cm) organic materials that are wet throughout the growing season. Within ALAG they occurred predominantly in lowland environments, and were typically associated with fens, bogs, and abandoned channel deposits.

Inceptisols accounted for 40% of observations and included 12 observed subgroups; the 3 most common were Andic Haplocryepts, Folistic Dystrocryepts, and Fluventic Haplocryepts. 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 in ALAG. Fluventic Haplocryepts were most common in riverine environments on active overbank deposits in soils derived from alluvium. Histic Cryaquepts and Fluventic Haplocryepts were most common in lowland environments on abandoned floodplain deposits and alluvial terraces. In upland environments, Andic Haplocryepts were most common in areas of moderately thick volcanic ash deposits, and Folistic Dystrocryepts were common in areas with moderately thick surface organics.

Spodosols accounted for 8% of observations and included 3 observed subgroups: Andic Haplocryods, Typic Haplocryods, and Typic Humicryods. Spodosols have accumulations of translocated humus and aluminum and/or iron in the mineral subsurface. In ALAG, spodosols occurred exclusively in uplands on older, stable geomorphic landscapes, including white spruce and Kenai paper birch forests on alluvial terrace and glaciofluvial deposits, and on moderate to steeply sloping mountain slopes and terrace risers . They 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 was insufficient to classify these soils into the Andisols soil order, but was sufficient to classify them into Andic subgroups.

Classification and Description of Soil Landscapes

Lowland Lake

This soil landscape corresponds to the Lowland Lake map

Table 33. Area (ha) of disturbance landscape classes mapped in Alagnak Wild River, southwest Alaska.

Disturbance Landscape	Area (ha)	% of Study Area
Drainage, Sedimentation	20.8	0.2%
Drying, Paludification	1372.7	11.0%
Eolian	628.6	5.0%
Flooding, Sedimentation, Erosion	3099.6	24.8%
Pests and Pathogens	264.1	2.1%
Thermokarst	1074.6	8.6%
Windthrow, Fire, Pests and Pathogens	6047.0	48.3%
Grand Total	12507.4	100.0%

ecotype. It is the least extensive soil landscape in ALAG occupying only 0.17% of the study area. Areas mapped as Lowland Lake mapping delineations ranged in size from <0.1 ha to just over 6 ha. This soil landscape is associated with shallow kettle lakes, in drift deposits that flank the riparian corridor on either side. This is an aquatic soil landscape with water chemistry that is expected to be alkaline (>7.3 pH). Hydrophytic vegetation is often present along lake margins. Over time, organic materials may fill in the lakes, a process known as paludification.

Lowland Organic-rich Wet Sedge-Shrub Bog Meadows

This soil landscape corresponds to the Lowland Organic-rich Wet Sedge-Shrub Bog Meadow map ecotype. It may also occur in small, isolated areas of Lacustrine physiography, which were too small to delineate at the scale of mapping. This soil landscape comprises just 4.59% of the study area, primarily near its east and west edges. This soil landscape is confined to very old, abandoned channels of the Alagnak river that are outside the present day floodplain, effectively in young terrace positions. Groundwater hydrology is likely still influenced by the Alagnak River. The old abandoned channel deposits typical of this soil landscape are associated with wet, bog vegetation dominated by low shrubs, sedges and mosses. This soil landscape is spatially associated with the Lowland Organic-rich Wet Shrublands and Sedge Meadows soil landscape, which represents an earlier stage in vegetation succession. Permafrost sometimes occurs in this soil landscape. Soils typically feature a thick organic mat comprised primarily of Sphagnum moss fibers; this insulative layer helps maintain the conditions for permafrost to persist. However, this soil landscape is susceptible to thaw in a warming environment due to the relatively warm permafrost (just below freezing) and the location of ALAG in the zone of isolated permafrost (Jorgenson et al. 2008b). Soil chemistry ranges from acidic to circumacidic (4.5–6.8 pH), largely due to the acidifying effects of *Sphagnum* peat over time. Soils form in saturated, anaerobic conditions, with a shallow depth to water table (≤50 cm). Soils suborders within this soil landscape fall are frozen Histels and unfrozen Fibrists or Hemists. Common soil subgroups are Fluvaquentic Cryohemists, Fluvaquentic Hemistels, Sphagnic Cryofibrists, Sphagnic Fibristels, Terric Cryofibrists, and Terric Cryohemists.

Lowland Organic-rich Wet Shrublands and Sedge Meadows

This soil landscape includes three map ecotypes: Lowland Loamy-Organic Sweetgale-Willow Low Shrub, Lowland Organic-rich Wet Sedge Meadow, and Lowland Organic-rich Wet Willow Low and Tall Shrub. While not extensive, this soil landscape is widely distributed throughout the study area. It is spatially associated with the Lowland Organic-rich Wet Sedge-Shrub Bog Meadows soil landscape. This soil landscape occurs on former riverine, or once channelized glacio-fluvial deposits, that have long since been abandoned and filled with peat, and are outside the present day floodplain. An elevated groundwater table appears to be influenced by the Alagnak River or runoff from adjacent upland areas. This soil landscape represents an earlier stage in landscape evolution and vegetation succession of the Lowland Organic-rich Wet Sedge-Shrub Bog Meadows soil landscape. Soils range from aquatic to wet, with the water table either above or near the soil surface. Soil chemistry is circumneutral, and EC is low (<100 uS/cm). Organic soils or mineral soils with histic epipedons are likely to develop in this flooded or very poorly drained soil landscape. It is possible for permafrost to form in the soil profiles of vegetation communities that have transitioned from meadows to bogs (i.e., ecotones leading towards the Lowland Organic-rich

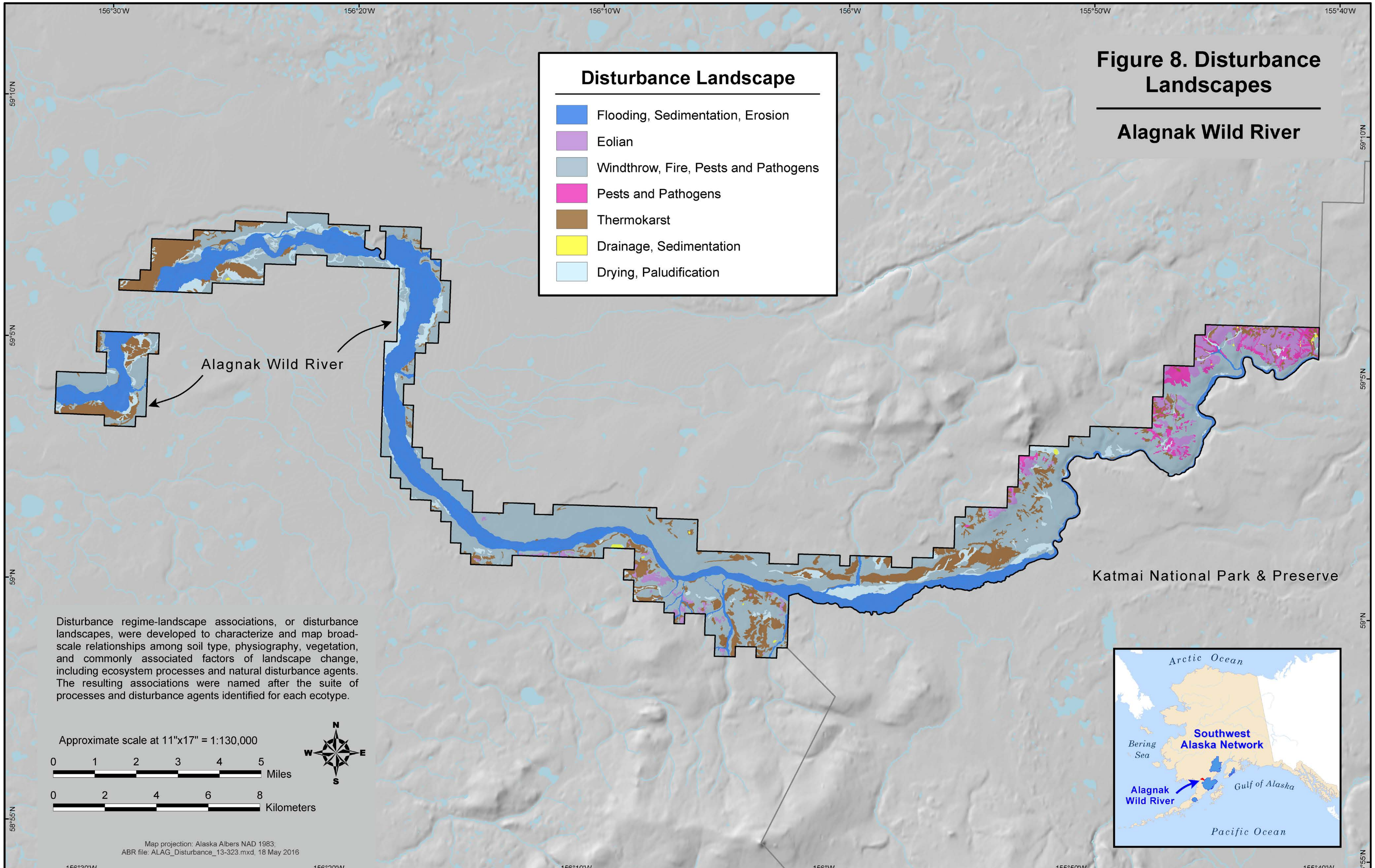

Figure 8. Disturbance landscape map for Alagnak Wild River, southwest Alaska.

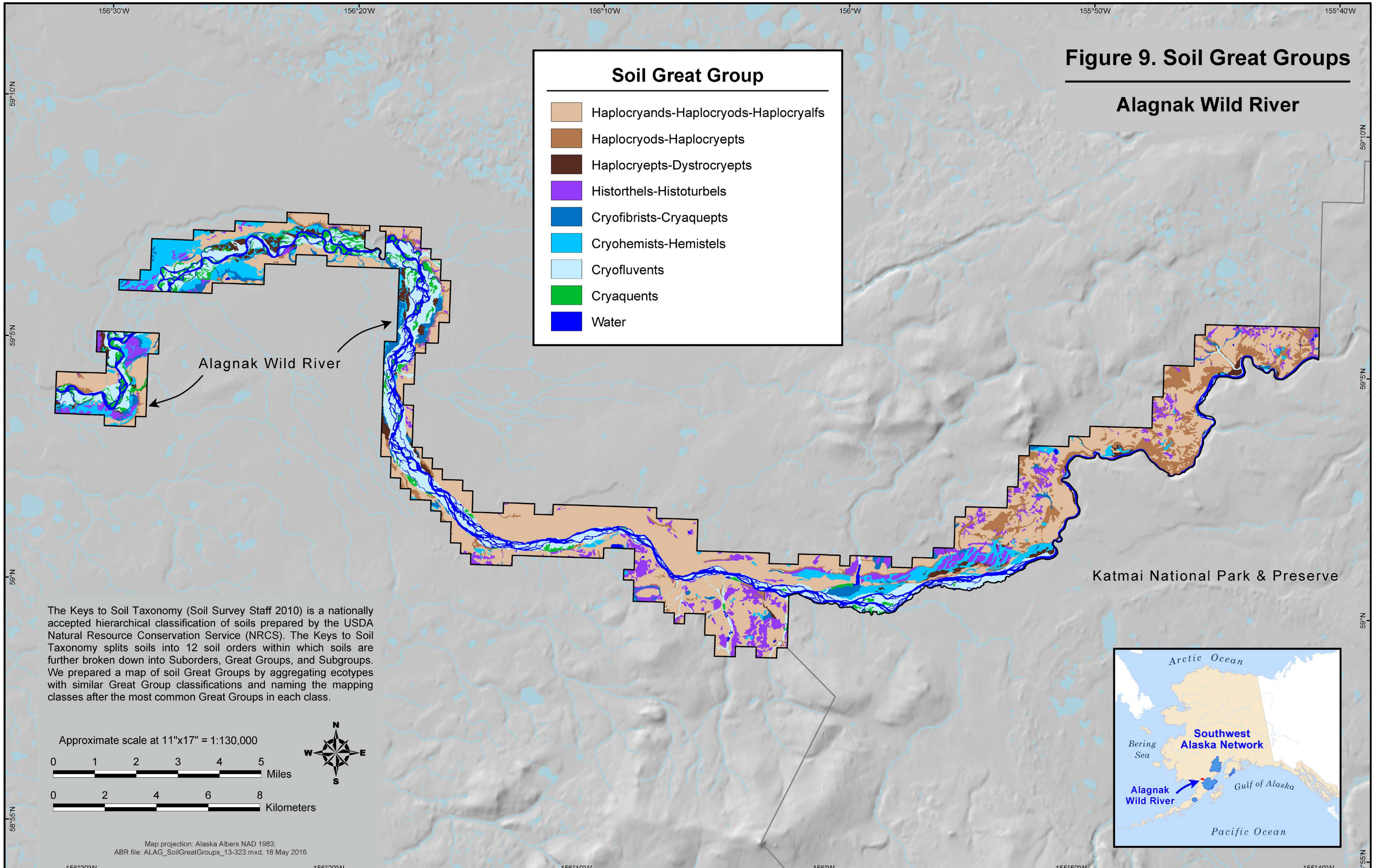

Figure 9. Soil Great Group map for Alagnak Wild River, southwest Alaska.

Table 34. Area (ha) of soil great group mapping classes in Alagnak Wild River, southwest Alaska.

Great Group Class	Area (ha)	% of Study Area
Cryaquents	392.6	3.1%
Cryofibrists-Cryaquepts	798.5	6.4%
Cryofluvents	1650.5	13.2%
Cryohemists-Hemistels	574.3	4.6%
Haplocryands-Haplocryods-Haplocryalfs	5603.0	44.8%
Haplocryepts-Dystrocryepts	296.7	2.4%
Haplocryods-Haplocryepts	1039.9	8.3%
Historthels-Histoturbels	1074.6	8.6%
Water	1077.3	8.6%
Grand Total	12507.4	100.0%

Wet Sedge-Shrub Bog Meadows soil landscape). However, this soil landscape is primarily associated with soil pedogeneis that is not influenced by permafrost. Soil subgroups are Fluvaquentic Cryofibrists, Histic Cryaquepts, Terric Cryohemists, and less commonly, Fluvaquentic Historthels. This soil landscape comprises 6.38% of the study area.

Lowland Rocky-Loamy-Organic Forests and Woodlands

This soil landscape corresponds to the Lowland Rocky-Loamy-Organic Spruce Forest and Woodlands map ecotype. Spatially, this soil landscape is restricted to abandoned overbank deposits, mesic terrace positions of the Alagnak River, or along riparian corridors of tributary streams and rivers. The mounded microtopography of this soil landscape, often caused by remnant scour channels and ridges, promotes spruce recruitment on well-drained mineral soils. Vegetation is characterized by white spruce forests or woodlands with a robust ericaceous shrub community and an abundance of feather mosses in the understory. The moist, well-drained nature of this soil landscape promotes the formation of moderately thick, unsaturated organic horizons, or Folistic epipedons. Accumulations of wind- or water-redistributed tephra in overbank deposits may be present below the surface organic horizon. The influence of tephra accumulations on soil taxonomy vary widely in this soil landscape, as the accumulations of these materials are too thin to meet diagnostic requirements. Soil chemistry ranges from acidic to circumacidic and EC values are often >100 uS/cm. Common soil subgroups include Andic Haplocryepts, Fluventic Dystrocryepts, Fluventic Haplocryepts, and Folistic Dystrocryepts. This soil landscape is rare, comprising 2.37% of the study area.

River

This soil landscape encompasses a single map ecotype, Riverine Circumneutral River Water, and comprises non-glacial rivers and streams in ALAG. It includes both the Alagnak River and small headwater streams that receive their water from non-glacial sources (e.g., snowmelt). The water is clear and mostly silt-free, and water chemistry is circumalkaline to alkaline water chemistry. This soil landscape class comprises 8.45% of the study area.

Riverine Sandy-Rocky Barrens and Wet Meadows

This soil landscape encompasses two map ecotypes: Riverine Rocky Barrens and Partially Vegetated and Riverine Sandy-Organic Wet Graminoid Meadow. The greatest spatial extent of this soil landscape occurs in the western portion of the study area. This soil landscape is associated with gravel and cobble bars on active channel deposits, floodplains in active overbank deposits, and swales and backwater environments in inactive channel deposits. It characterizes primary and early vegetation succession in the Riverine physiography. Vegetation on river bars is absent to sparse; the most common species present are *Calamagrostis canadensis*, *Alopecurus aequalis*, *Mimulus guttatus*, and *Agrostis scabra*. On floodplains, and in swales and backwaters, a dense sward is formed by *Calamagrostis canadensis* and/or *Carex lyngbyaei*. On river bars, soils are very to extremely gravelly and cobbly sands. Surface organic horizons are absent as any organic material deposited at the surface is washed away in the next high water flood event. On floodplains, and in swales and backwaters, the soils typically feature a moderately thick organic cap that is embedded with sands from periodic sedimentation. Below the organic cap interbedded silts, sands, and gravels are common. Soil chemistry is typically circumneutral to alkaline and EC measurements are relatively high (>150 uS/

Table 35. Accuracy assessment for common land cover classes from Boucher and Flagstad (2014) using ABR field plots, Alagnak Wild River, Alaska, 2014.

Landcover Class	AVC Level IV Vegetation Class	Number of ABR Plots	Fuzzy Accuracy Metrics		Fuzzy Accuracy
			Fuzzy Accuracy Score	Adjusted Plot Number	
Open Spruce Forest	Ericaceous–Lichen Dwarf Shrub Tundra	1	0	0	
	Open White Spruce Forest	1	1	1	
	Spruce–Paper Birch Woodland	2	0.5	1	
	White Spruce Woodland	7	0.75	5.25	
Open Spruce Forest Total		11		7.25	65.9%
Spruce Woodland	Dwarf White Spruce Woodland	1	1	1	
	Ericaceous Dwarf Shrub Tundra	1	0	0	
	Open Low Mesic Shrub Birch-Ericaceous Shrub	2	0	0	
	Open Low Shrub Birch-Willow	2	0	0	
	Spruce–Paper Birch Woodland	1	0.75	0.75	
	White Spruce Woodland	5	1	5	
Spruce Woodland Total		12		6.75	56.3%
Mixed Broadleaf/Needleleaf Forest	Open Paper Birch	3	0.5	1.5	
	Open Spruce–Paper Birch	2	1	2	
	Paper Birch Woodland	1	0.5	0.5	
	Subarctic Lowland Sedge-Shrub Wet Meadow	1	0	0	
	White Spruce Woodland	2	0.5	1	
Mixed Broadleaf/Needleleaf Forest Total		9		5	55.6%
Tall Willow Shrub	Barren	1	0	0	
	Bluejoint Meadow	2	0	0	
	Closed Tall Willow	1	1	1	
	Open Low Willow	3	0.75	2.25	
	Open Paper Birch	1	0	0	
	Open Tall Willow	4	1	4	
Tall Willow Shrub Total		12		7.25	60.4%

Table 35. Continued.

Landcover Class	AVC Level IV Vegetation Class	Number of ABR Plots	Fuzzy Accuracy Metrics		Fuzzy Accuracy
			Fuzzy Accuracy Score	Adjusted Plot Number	
Mixed Low/Dwarf Shrub	Ericaceous Dwarf Shrub Tundra	1	1	1	
	Ericaceous–Lichen Dwarf Shrub Tundra	2	1	2	
	Open Low Willow	2	0.75	1.5	
	Open Mixed Low Shrub–Sedge Tussock Tundra	1	0.5	0.5	
Mixed Low/Dwarf Shrub Total		6		5	83.3%
Mixed Low/Dwarf Shrub-Sedge	Ericaceous Dwarf Shrub Tundra	1	0.75	0.75	
	Fresh Sedge Marsh	1	0	0	
	Open Mixed Low Shrub–Sedge Tussock Tundra	3	1	3	
	Subarctic Lowland Sedge-Shrub Wet Meadow	1	1	1	
	Tussock Tundra--Ericaceous	1	1	1	
Mixed Low/Dwarf Shrub-Sedge Total		7		5.75	82.1%
Grand Total		57			64.9%

Table 36. Description of soil subgroups found in Alagnak Wild River, Alaska, 2014.

Soil Class Title	Description
Alfisols	Soils that typically develop in cool, humid climates that demonstrate translocation and appreciation of clay particles in the soil profile.
Cryalfs	Alfisols that occur in a cryic soil temperature regime.
Haplocryalfs	Cryalfs that do not meet the taxonomic requirements for any other great groups.
Andic Haplocryalfs	Haplocryalfs forming in weathered volcanic ejecta or pyroclastic materials and that do not meet the requirements for Andisols.
Andisols	Soils developing in volcanic ejecta (e.g., volcanic ash, pumice, cinders) and/or pyroclastic materials (e.g., lahar, pyroclastic flow). Andisols are characterized by an abundance of volcanic glass and a low bulk density (i.e. a given volume of soil feels lighter than it appears). The volcanic glass weathers into its constituent minerals aluminum and silica which often bind with organic matter (humus) in the soil to form stable organic complexes. These complexes can persist in the soil for significant time periods (>50 years).
Cryands	Andisols that have formed in a cryic soil temperature regime.
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.
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.
Entisols	Undeveloped soils having little to no horizon development or translocation and accumulation of materials lower in the soil profile. Surface organic (O -horizons) and A-horizons if present are typically thin (< 5 cm). Entisols are soils that have not had sufficient time for soil development to occur often due to their location in a dynamic environment (e.g. floodplain, alluvial fan) or sometimes due to intensive land use management practices.
Aquents	Entisols that are saturated with water and have reducing, anaerobic soil conditions within the soil profile throughout the growing season.
Cryaquents	Aquents that occur in a cryic soil temperature regime.
Aquandic Cryaquents	Cryaquents that have thick (≥18 cm) deposits of coarse unweathered volcanic ejecta such as pumice or coarse volcanic cinders, or an abundance (≥5% of soil volume) volcanic glass and accumulations of aluminum and iron in the soil subsurface.
Typic Cryaquents	Cryaquents that are typical for this great group.
Fluvents	Entisols that have buried soil horizon(s) with an appreciation of organic carbon typically resulting from periodic flooding events.
Cryofluvents	Fluvents that have formed in a cryic soil temperature regime.
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.
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.
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.

Table 36. Continued.

Soil Class Title	Description
Gelisols	Soils that have permafrost within 100 cm of the soil surface or within 200 cm of the soil surface if the soil profile has been cryoturbated (showing signs of frost heaving). Permafrost is defined as a thermal condition in which soil material remains below 0° C for two or more years in succession. Cryoturbation is the mixing of soil material, or the sorting of rock fragments, due to annual freezing and thawing cycles.
Histels	Gelisols that have organic soil material at the surface that is greater than 40 cm thick and are saturated throughout the growing season.
Fibristels	Histels that are comprised of fibric soil materials more than any other kind of organic soil material within the upper 50 cm of the soil profile.
Sphagnic Fibristels	Fibristels that have three-fourths or more of the fibric soil materials derived from Sphagnum moss fibers within the upper 50 cm of the soil profile.
Hemistels	Histels that are comprised of hemic soil materials more than any other kind of organic soil material within the upper 50 cm of the mineral soil surface.
Terric Hemistels	Hemistels that have a layer of mineral soil 30 cm or more thick within 100 cm of the soil surface.
Fluvaquentic Hemistels	Hemistels that have one or more thin (≥5 cm) buried mineral soil layers within the upper 100 cm of organic soil material. The buried mineral soils are typically derived from flooding events or volcanic ash.
Sapristels	Histels that are comprised of sapric soil materials more than any other kind of organic soil material within the upper 50 cm of the mineral soil surface.
Fluvaquentic Sapristels	Sapristels 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.
Orthels	Gelisols that do not meet the taxonomic requirements for any other suborder of Gelisols.
Historthels	Orthels with thick surface accumulations (typically >40 cm) of organic matter.
Turbels	Gelisols that have one or more soil horizons showing cryoturbation (frost heaving) in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and oriented rock fragments.
Histoturbels	Turbels that have more than 40% (by volume) organic soil materials in the upper 50 cm and which are saturated throughout the growing season.
Typic Histoturbels	Histoturbels that are typical for this great group.
Histosols	Soils that are saturated throughout the growing season and are comprised primarily of thick accumulations (typically >40 cm) of organic matter.
Fibrists	Histosols that are comprised of fibric soil materials more than any other kind of organic soil materials within a general depth of 0 to 120 cm.
Cryofibrists	Fibrists that have formed in a cryic soil temperature regime.
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.
Fluvaquentic Cryofibrists	Cryofibrists that have one or more thin (≤5 cm) buried mineral soil layers within the upper 100 cm of organic soil material. The buried mineral soils are typically derived from flooding events or volcanic ash.
Hydric Cryofibrists	Cryofibrists that have a layer of water within a depth of 0 to 160 cm from the soil surface (e.g., floating organic mat).
Sphagnic Cryofibrists	Cryofibrists that have three-fourths or more of the fibric soil materials comprised of Sphagnum moss fibers within the depth of 0–60 cm, from the soil surface.
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.

Table 36. Continued.

Soil Class Title	Description
Cryohemists	Hemists that have formed in a cryic soil temperature regime.
Terric Cryohemists	Cryohemists that have a layer of mineral soil 30cm or more thick that has its upper boundary within 60 to 160 cm.
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.
Folists	Histosols that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).
Cryofolists	Folists that occur in a cryic soil temperature regime.
Typic Cryofolists	Cryofolists that are typical for this great group.
Inceptisols	Soils that are moderately developed and include soils that do not meet the requirements for other soil orders. Inceptisols are characterized by distinct horizon development and mild weathering and translocation of materials to lower in the soil profile. Inceptisols also include soils with moderately thick (20–40 cm) surficial organic deposits that do not meet the requirements for Histosols.
Aquepts	Inceptisols that are saturated with water and have reducing, anaerobic soil conditions within the soil profile throughout the growing season.
Cryaquepts	Aquepts that occur in a cryic soil temperature regime.
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.
Cryepts	Inceptisols that occur 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.
Aquic Dystrocryepts	Dystrocryepts that have within 75 cm of the soil surface, redoximorphic depletions resulting from saturated anaerobic soil moisture conditions, for some time in normal years.
Fluvaquentic Dystrocryepts	Dystrocryepts that are 1) located on a landform with a slope of less than 14°, 2) have redoximorphic depletions resulting from anaerobic soil conditions within 75 cm from the soil surface, and 3) have buried organic (O-) horizon(s) at depth. These buried soil horizons are typically associated with flooding disturbances.
Andic Dystrocryepts	Dystrocryepts forming in weathered volcanic ejecta or pyroclastic materials and do not meet the requirement for Andisols.
Fluventic Dystrocryepts	Dystrocryepts that are located on a landform with a slope <14° and have buried organic (O-) horizon(s) between a depth of 25 to 125 cm from the soil surface. These buried soil horizons are typically associated with flooding disturbances.
Folistic Dystrocryepts	Dystrocryepts that have a thick organic surface horizon (15–40 cm) and are not saturated for more than 30 days cumulative in normal years.
Spodic Dystrocryepts	Dystrocryepts that have accumulations of translocated organic matter and Aluminum (Al), or organic matter, Al, and Iron (Fe), in a soil horizon that is 5 cm or more thick.
Haplocryepts	Cryepts that predominantly have higher pH values (>5.5) and do not have thick (>18 cm) accumulations of dark organic-carbon rich soil material at, or near, the soil surface.
Andic Haplocryepts	Haplocryepts forming in weathered volcanic ejecta or pyroclastic materials and do not meet the requirement for Andisols.

Table 36. Continued.

Soil Class Title	Description
Fluventic Haplocryepts	Haplocryepts that are located on a landform with a slope <14° and have buried organic (O-) horizon(s) between a depth of 25 to 125 cm from the soil surface. These buried soil horizons are typically associated with flooding disturbances.
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.
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.
Oxyaquic Humicryepts	Humicryepts that experience periodic saturation within 100 cm of the mineral soil and do not remain saturated throughout the growing season.
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.
Typic Humicryods	Humicryods that are typical for this great group.
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.
Typic Haplocryods	Haplocryods that are typical for this great group.

cm). On barren and partially vegetated river bars common soil subgroups include Oxyaquic Cryorthents. On well vegetated alluvial surfaces common subgroups include Hydric Cryofibrists, Histic Cryaquepts, and Typic Cryaquents. This soil landscape encompasses 3.1% of the study area.

Riverine Silty-Sandy-Rocky Shrublands and Forests

This soil landscape includes four map ecotypes: Riverine Sandy-Loamy-Rocky Alder Tall Shrub, Riverine Silty-Sandy-Rocky Moist Willow Low Shrub, Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub, and Riverine Silty-Sandy-Rocky White Spruce-Broadleaf Forest. It is relatively common in the study area (13.2%), and occurs mainly below the confluence of the Nonvianuk River, where the Alagnak River transitions from a meandering to an anastomosing river. This soil landscape is associated with active and inactive overbank deposits that characterize mid- to late vegetation succession in the Riverine physiography. Vegetation ranges from tall shrub communities dominated by Alder or Willow in the mid-seral state, to White Spruce-Broadleaf forests in the late seral state. The upper 40 cm of the soil profile is consistently moist, yet within 51–100 cm, soils become wet due to an elevated water table. Soil conditions aerobic, despite being saturated at depth, due to the non-static groundwater regulated by the flow of the Alagnak River. Surface organic matter accumulation is generally thin (<10 cm), overlying stratified sandy and rocky alluvial sediments that sometimes include buried organic horizons. Soil chemistry varies from acidic to circumneutral. The coarse alluvial parent material is a defining characteristic of the soils and depth to >15% rock fragments is shallow (≤50 cm) throughout this soil landscape. Common soil subgroups include Fluventic Haplocryepts, Oxyaquic Cryofluvents, Oxyaquic Haplocryepts, and Typic Cryofluvents.

Upland Ashy-Loamy-Rocky Dwarf Shrublands

This soil landscape includes a single map ecotype: Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub. It occurs on summit and shoulder positions of highly weathered volcanic or sedimentary hills in the eastern portion of the study area, and on old glaciofluvial deposits buried by tephra in the western portion of the study area. The dominant species in this ecotype is the dwarf evergreen shrub *Empetrum nigrum*. Lichens, including *Cladonia uncialis*, *Flavocetraria cucullata*, *Cladina rangiferina*, and *Cladina arbuscula*, are common and often abundant. Soils are moist and well-drained, and very to extremely gravelly and cobbly. Soil chemistry ranges from acidic to circumacidic. Common soil subgroups include Andic Haplocryalfs, Andic Haplocryepts, and Typic Humicryods. This soil landscape comprises 8.3% of the study area.

Upland Ashy-Loamy-Rocky Low Shrublands, Forests, and Woodlands

The soil landscape includes four map ecotypes: Upland Ashy-Loamy-Rocky Balsam Poplar Forest, Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes, Upland Ashy-Loamy-Rocky White Spruce Woodland, and Upland Loamy-Organic Birch-Willow Low Shrub. It occurs on alluvial terraces, inactive alluvial fan deposits, and gently sloping backslope and footslopes of mountains and hills. Vegetation ranges from birch-willow dominated low shrub communities in early seral stages to Kenai paper birch forests and white spruce woodlands in older stands. The understory of of broadleaf-dominated forested stands is consistently characterized by the *Calamagrostis canadensis* and feather mosses, including *Pleurozium schreberi* and *Ptilium crista-castrensis*. In white spruce-dominated stands, the understory includes a diversity of ericaceous dwarf shrubs as well as the low shrubs *Betula nana* and *Salix glauca*. On terraces and inactive alluvial fans, soil parent materials includes a moderately thick cap of retransported volcanic ash over very gravelly alluvium or glaciofluvial outwash deposits. On hill and mountain slopes, parent material is very gravelly colluvium often mixed with volcanic ash. At the oldest, most stable sites the weathering of clay minerals over time has led to the formation of Alfisols. Soils typically feature an unsaturated thin to moderately thick organic cap. If sufficient time elapses between disturbance events, the organic cap can become thick enough to form a Folistic epipedon. Soil chemistry is acidic and EC values are commonly greater than 100 uS/cm. Common soil subgroups include Andic Haplocryepts, Spodic Haplocryands, and Andic Haplocryalfs. This soil landscape is the most common in ALAG and comprises 39.8% of the study area.

Upland Frozen Organic-rich Low Shrublands and Tussock Meadow

This soil landscape includes a single map ecotype: Upland Frozen Organic-rich Birch-Tussock Low Shrub. It occurs on nearly level to gently sloping north-facing foot slopes and toe slopes (avg. 3°), on nearly level slopes on ancient terraces, on permafrost plateaus and palsas in bog deposits, and on abandoned alluvial fan deposits. The tussock-forming sedge *Eriophorum vaginatum* is common in this soil landscape, as are dwarf and low shrubs, including *Ledum decumbens*, *Betula nana*, *Vaccinium vitis-idaea*, and *Empetrum nigrum*. Soils are poorly to somewhat poorly drained, range from moist to wet, and are permanently frozen within 1–2 meters of the soil surface. A moderately thick to thick surface organic layer is present over loamy mineral soil. This soil landscape occurs on landforms that are slightly elevated relative to surrounding lowlands. The elevated surfaces are the result of the increase in volume when soil water is frozen. This soil landscape is prone to thermokarst following wildfires or as the result of a warming climate. Following thermokarst the loss in ice volume results in collapse of these landforms and these sites will transition to lowland environments. Soil chemistry ranges from acidic to circumacidic and EC values are always less than 100 uS/cm. Common soil subgroups include Fluvaquentic Historthels and Terric Hemistels. This soil landscape comprises 8.6% of the study area.

Upland Rocky-Loamy-Organic Tall Shrublands and Forests

This soil landscape includes 3 map ecotypes: Upland Ashy-Loamy-Rocky Birch Forest, steep slopes; Upland Loamy-Organic White Spruce-Birch Forest; and Upland Rocky-Organic Alder-Willow Tall Shrub. It occurs on hillslopes and mountain slopes, steep river bluffs, and on terrace risers. The moderately steep to steep slopes and well-drained, rocky soils associated with this soil landscape support open forests and tall shrub vegetation types, often with a rich herbaceous understory dominated by *Calamagrostis canadensis*. Soil parent material includes retransported volcanic ash over colluvium and alluvium. On steeper slopes the ash may be eroded and a thin to moderately thick organic cap sits atop loamy mineral soil. If sufficient time elapses between disturbance events the moist, well-drained nature of this soil landscape promotes the formation of moderately thick, unsaturated organic horizons, or Folistic epipedons. Soil chemistry is acidic and EC values are often greater than 100 uS/cm. Common soil subgroups include Andic Haplocryods, Fluventic Dystrocryepts, and Folistic Dystrocryepts. This soil landscape comprises 5.0% of the study area.

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Appendix 1. List of field data attributes recorded by ABR at Ecological Land Survey field plots, including the plot and soil pit types at which each attribute was recorded, Alagnak Wild River, 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 col-lect 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 high-est 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.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
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.
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.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
ELS	els	Full and Verification Plots	surface_terrain_code	Terrain unit code describing the present the geomorphic deposition and form.
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 30 cm.
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 (< 2 mm) 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., > 2 mm 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 then 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 Clasification (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 (~3–4 m 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 (~3–4 m 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.
VEG	veg_cover	Full Plots Only	veg_cov_field_note	Relevant notes about the vegetation species recorded in the field by the botanist.

Appendix 1. Continued.

Field Form	Dbase Table	Plot Type	Data Attribute	Description
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 Alagnak Wild River, Alaska, including the Alaska Natural Heritage Program (2016) State ranking for rare taxa (all others blank) and the AKEPIC (2016) invasiveness ranking for non-native taxa (all others blank). Rare rankings as follows: S1S2 = Critically imperiled to imperiled within the state; S3 = Rare within the state; and S3S4 = rare to apparently secure, but uncommon within the state. Invasiveness rankings range between 0, representing a taxa posing no threat, and 100 representing a taxa posing a major threat (Nawrocki et al. 2011).

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Deciduous Shrubs	*Alnus fruticosa* Rupr.	alnfru	{abr}		
Deciduous Shrubs	*Alnus sinuata* (Regel ex DC) Rydb.	alnsin	{aknhp}		
Deciduous Shrubs	*Alnus tenuifolia* Nutt.	alnten	{abr,aknhp}		
Deciduous Shrubs	*Arctous alpina* (L.) Nied	arcalp1	{abr}		
Deciduous Shrubs	*Arctous rubra* (Rehder & E.H. Wilson) Nakai	arcrub1	{abr,aknhp}		
Deciduous Shrubs	*Betula glandulosa* Michx.	betgla	{abr}		
Deciduous Shrubs	*Betula nana* L.	betnan	{abr,aknhp}		
Deciduous Shrubs	*Betula occidentalis* Hooker[1]	betocc	{abr}		
Deciduous Shrubs	*Dasiphora fruticosa* (L.) Rydb.	dasfru	{abr,aknhp}		
Deciduous Shrubs	*Myrica gale* L.1	myrgal	{abr,aknhp}		
Deciduous Shrubs	*Oplopanax horridus* (Smith) Miquel	oplhor	{abr}		
Deciduous Shrubs	*Ribes hudsonianum* Richards.	ribhud	{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 bebbiana* Sarg.	salbeb	{abr}		
Deciduous Shrubs	*Salix fuscescens Andersson*	salfus	{abr,aknhp}		
Deciduous Shrubs	*Salix glauca* L.	salgla	{abr,aknhp}		
Deciduous Shrubs	*Salix phlebophylla* Andersson	salphl	{abr}		
Deciduous Shrubs	*Salix pulchra* Cham.	salpul1	{abr,aknhp}		
Deciduous Shrubs	*Salix reticulata* L.	salret	{abr}		
Deciduous Shrubs	*Salix rotundifolia* Trautv.	salrot	{abr}		
Deciduous Shrubs	*Spiraea stevenii* (C.K. Schneid.) Rydb.	spiste	{abr,aknhp}		

[1]As used by Hultén (1968) to represent a hybrid between Betula glandulosa Michx. and Betula papyrifera Marshall subsp. humilis (Regel) Hultén

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Deciduous Shrubs	*Vaccinium ovalifolium* Sm.	vacova	{abr}		
Deciduous Shrubs	*Vaccinium uliginosum* L.	vaculi	{abr,aknhp}		
Deciduous Shrubs	*Viburnum edule* (Michx.) Raf.	vibedu	{abr,aknhp}		
Deciduous Trees	*Betula kenaica* W.H. Evans	betken1	{abr,aknhp}		
Deciduous Trees	*Populus balsamifera* L.	popbal	{abr,aknhp}		
Deciduous Trees	*Populus tremuloides* Michx.	poptre	{abr}		
Evergreen Shrubs	*Andromeda polifolia* L.	andpol	{abr,aknhp}		
Evergreen Shrubs	*Chamaedaphne calyculata* (L.) Moench	chacal	{abr}		
Evergreen Shrubs	*Empetrum nigrum* L.	empnig	{abr,aknhp}		
Evergreen Shrubs	*Ledum decumbens* (Aiton) Lodd. ex Steud.	leddec	{abr,aknhp}		
Evergreen Shrubs	*Ledum groenlandicum* Oeder	ledgro	{abr,aknhp}		
Evergreen Shrubs	*Linnaea borealis* L.	linbor	{abr,aknhp}		
Evergreen Shrubs	*Loiseleuria procumbens (L.) Desv.*	loipro	{abr}		
Evergreen Shrubs	*Oxycoccus microcarpus* Turcz. ex Rupr.	oxymic	{abr,aknhp}		
Evergreen Shrubs	*Vaccinium vitis-idaea* L.	vacvit	{abr,aknhp}		
Evergreen Trees	*Picea glauca* (Moench) Voss	picgla	{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	*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 pratense* L.	equpra	{abr,aknhp}		
Ferns and allies	*Equisetum scirpoides* Michx.	equsci	{abr}		
Ferns and allies	*Equisetum sylvaticum* L.	equsyl	{abr,aknhp}		
Ferns and allies	*Equisetum variegatum* Schleich.	equvar	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Ferns and allies	*Gymnocarpium dryopteris* (L.) Newm.	gymdry	{abr,aknhp}		
Forbs	*Achillea borealis* Bong	achbor	{abr}		
Forbs	*Achillea millefolium* L.	achmil	{aknhp}		
Forbs	*Aconitum delphinifolium* DC.	acodel	{abr,aknhp}		
Forbs	*Anemone narcissiflora* L.	anenar	{abr}		
Forbs	*Anemone parviflora* Michx.	anepar	{abr}		
Forbs	*Angelica genuflexa* Nutt.	anggen	{aknhp}		
Forbs	*Angelica lucida* L.	angluc	{abr}		
Forbs	*Artemisia arctica* Less.	artarc2	{abr}		
Forbs	*Calla palustris* L.	calpal2	{abr}		
Forbs	*Callitriche verna* L. emend. Lonnr.	calver	{abr}		
Forbs	*Caltha palustris* L.	calpal1	{abr,aknhp}		
Forbs	*Campanula lasiocarpa* Cham.	camlas	{abr}		
Forbs	*Cardamine pratensis* L.	carpra3	{aknhp}		
Forbs	*Cardamine pratensis* L. ssp. *angustifolia* (Hook.) O.E. Schultz	carpra1	{abr}		
Forbs	*Cardamine umbellata* Greene	carumb	{abr}		
Forbs	*Castilleja unalaschcensis* (Cham. & Schlecht.) Malte	casuna	{abr}		
Forbs	*Chrysosplenium tetrandrum* (Lund) T. Fries	chrtet	{abr}		
Forbs	*Cicuta mackenzieana* Raup	cicmac	{abr,aknhp}		
Forbs	*Claytonia chamissoi* Esch.	clacha	{abr,aknhp}		
Forbs	*Cornus canadensis* L.	corcan	{aknhp}		
Forbs	*Cornus suecica* L.	corsue	{abr,aknhp}		
Forbs	*Drosera rotundifolia* L.	drorot	{aknhp}		
Forbs	*Epilobium anagallidifolium* Lam.	epiana	{abr}		
Forbs	*Epilobium angustifolium* L.	epiang	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Forbs	*Epilobium glandulosum* Lehm.	epigla	{abr,aknhp}		
Forbs	*Epilobium hornemannii* Rchb.	epihor1	{aknhp}		
Forbs	*Epilobium latifolium* L.	epilat	{abr}		
Forbs	*Epilobium palustre* L.	epipal	{abr,aknhp}		
Forbs	*Galium boreale* L.	galbor	{abr,aknhp}		
Forbs	*Galium trifidum* L.	galtri	{aknhp}		
Forbs	*Galium trifidum* L. ssp. *trifidum*	galtri1	{abr}		
Forbs	*Geranium bicknellii* Britt.	gerbic	{abr}		
Forbs	*Geranium erianthum* DC.	gereri	{abr,aknhp}		
Forbs	*Heracleum lanatum* Michx.	herlan	{aknhp}		
Forbs	*Hippuris vulgaris* L.	hipvul	{abr,aknhp}		
Forbs	*Iris setosa* Pall. ssp. *setosa*	iriset	{abr}		
Forbs	*Lathyrus palustris* L. ssp. *pilosus* (Cham.) Hult.	latpal	{abr,aknhp}		
Forbs	*Limosella aquatica* L.	limaqu	{abr}	S3	
Forbs	*Lupinus nootkatensis* Donn	lupnoo	{abr}		
Forbs	*Mimulus guttatus* DC.	mimgut	{abr}		
Forbs	*Moehringia lateriflora* (L.) Fenzl	moelat	{abr,aknhp}		
Forbs	*Montia fontana* ssp. *fontana* L.	monfon	{abr}		
Forbs	*Oxytropis nigrescens* ssp. *bryophila* (Greene) Hultén	oxybry1	{abr}		
Forbs	*Parnassia kotzebuei* Cham. & Schlecht.	parkot	{abr}		
Forbs	*Parnassia palustris* L.	parpal	{abr}		
Forbs	*Pedicularis labradorica* Wirsing	pedlab	{abr,aknhp}		
Forbs	*Pedicularis langsdorffii* Fisch.	pedlan3	{abr}		
Forbs	*Pedicularis oederi* M. Vahl	pedoed	{abr}		
Forbs	*Pedicularis sudetica* Willd.	pedsud	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Forbs	*Petasites frigidus* (L.) Franchet	petfri	{abr}		
Forbs	*Petasites hyperboreus* Rydb.	pethyp	{abr,aknhp}		
Forbs	*Polemonium acutiflorum* Willd.	polacu	{abr,aknhp}		
Forbs	*Polygonum lapathifolium* L.	pollap	{abr}		47
Forbs	*Polygonum viviparum* L.	polviv	{abr,aknhp}		
Forbs	*Potentilla palustris* (L.) Scop.	potpal	{abr,aknhp}		
Forbs	*Pyrola asarifolia* Michx.	pyrasa	{abr}		
Forbs	*Pyrola grandiflora* Radius	pyrgra	{abr}		
Forbs	*Pyrola secunda* L.	pyrsec1	{abr}		
Forbs	*Ranunculus hyperboreus* Rottb.	ranhyp	{abr,aknhp}		
Forbs	*Ranunculus lapponicus* L.	ranlap	{abr}		
Forbs	*Ranunculus trichophyllus* Chaix	rantri	{abr}		
Forbs	*Rhinanthus minor* ssp. *borealis* (Sterneck) Á. Löve	rhimin	{abr}		
Forbs	*Rorippa hispida (*Desv.) Britt.	rorhis	{abr}		
Forbs	*Rorippa islandica* (Oeder) Borbas	rorisl2	{abr}		
Forbs	*Rorippa palustris* (L.) Besser	rorpal2	{aknhp}		
Forbs	*Rubus arcticus* L.	rubarc1	{abr,aknhp}		
Forbs	*Rubus chamaemorus* L.	rubcha	{abr,aknhp}		
Forbs	*Rumex aquaticus* L.	rumaqu	{aknhp}		
Forbs	*Rumex arcticus* Trautv.	rumarc	{abr,aknhp}		
Forbs	*Rumex fenestratus* Greene	rumfen	{aknhp}		
Forbs	*Sanguisorba officinalis* L.	sanoff	{abr}		
Forbs	*Sanguisorba stipulata* Raf.	sansti	{abr,aknhp}		
Forbs	*Saxifraga hirculis* L.	saxhir	{abr}		
Forbs	*Sedum rosea* (L.) Scop. ssp. integrifolium (Raf.) Hult.	sedros	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Forbs	*Senecio lugens Richardson*	senlug	{abr}		
Forbs	*Spiranthes romanzoffiana* Cham.	spirom	{abr}		
Forbs	*Stellaria borealis* Bigelow	stebor	{abr,aknhp}		
Forbs	*Stellaria calycantha* (Ledeb.) Bong. ssp. interior Hult.	steint1	{aknhp}		
Forbs	*Stellaria calycantha* (Ledeb.) Bong. ssp. *isophylla* (Fern.) Fern.	steiso	{abr}		
Forbs	*Stellaria crassifolia* Ehrh.	stecra	{abr,aknhp}		
Forbs	*Stellaria longifolia* Muhl. ex Willd.	stelon2	{abr}		
Forbs	*Stellaria longipes* Goldie	stelon1	{abr}		
Forbs	*Streptopus amplexifolius* (L.) DC.	stramp	{abr}		
Forbs	*Swertia perennis* L.	sweper	{abr,aknhp}		
Forbs	*Thalictrum sparsiflorum* Turcz.	thaspa	{abr,aknhp}		
Forbs	*Trientalis europaea* L.	trieur3	{abr,aknhp}		
Forbs	*Trientalis europaea* L. ssp. *arctica* (Fisch.) Hult.	trieur1	{abr}		
Forbs	*Veronica americana* Schwein.	verame	{abr}		
Forbs	*Viola epipsila* Ledeb.	vioepi1	{aknhp}		
Forbs	*Viola epipsila* Ledeb. ssp. *repens* (Turcz.) Becker	vioepi	{abr,aknhp}		
Grasses	*Agrostis clavata* Trin.	agrcla	{abr}	S1S2	
Grasses	*Agrostis scabra* Willd.	agrsca	{abr}		
Grasses	*Alopecuris aequalis* Sobol.	aloaeq	{abr}		
Grasses	*Anthoxanthum monticola* ssp. *alpinum* (Sw. ex Willd.) Soreng	antalp1	{abr}		
Grasses	*Arctagrostis latifolia* (R. Br.) Griseb.	arclat	{abr}		
Grasses	*Arctophila fulva* (Trin.) Anderss.	arcful	{abr,aknhp}		
Grasses	*Calamagrostis canadensis* (Michx.) P. Beauv.	calcan	{abr,aknhp}		
Grasses	*Deschampsia cespitosa* (L.) P. Beauv.	desces	{abr}		
Grasses	*Festuca altaica* Trin.	fesalt	{abr}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Grasses	*Festuca rubra* L.	fesrub	{aknhp}		
Grasses	*Poa arctica* R. Br.	poaarc	{abr,aknhp}		
Grasses	*Poa pratensis* ssp. *alpigena* (Lindm.) Hiitonen	poaalp3	{abr,aknhp}		
Grasses	*Poa pratensis* ssp. *irrigata* (Lindm.) Lindb.	poairr	{abr}		52
Grasses	*Trisetum spicatum* (L.) K. Richt.	trispi1	{abr}		
Lichens	*Cetraria islandica* (L.) Ach.	cetisl1	{abr}		
Lichens	*Cetraria islandica* (L.) Ach. ssp. *islandica*	cetisl2	{abr}		
Lichens	*Cetraria laevigata* Rass.	cetlae	{abr}		
Lichens	*Cetrariella fastigiata* (Delise ex Nyl.) Kärnefelt & Thell	cetfas	{abr}		
Lichens	*Cladina arbuscula* (Wallr.) Hale & Culb.	claarb	{abr}		
Lichens	*Cladina mitis* (Sandst.) Hustich	clamit	{abr}		
Lichens	*Cladina rangiferina* (L.) Nyl.	claran	{abr,aknhp}		
Lichens	*Cladina stellaris* (Opiz) Brodo	claste	{abr}		
Lichens	*Cladina stygia* (Fr.) Ahti	clasty	{abr}		
Lichens	*Cladonia amaurocraea* (Flörke) Schaerer	claama	{abr}		
Lichens	*Cladonia bellidiflora* (Ach.) Schaerer	clabel	{abr}		
Lichens	*Cladonia cenotea* (Ach.) Schaer.	clacen	{abr}		
Lichens	*Cladonia coccifera* (L.) Willd. s. lat.	clacoc	{abr}		
Lichens	*Cladonia cornuta* (L.) Hoffm.	clacor	{abr}		
Lichens	*Cladonia crispata* (Ach.) Flot.	clacri	{abr}		
Lichens	*Cladonia deformis* (L.) Hoffm.	cladef	{abr}		
Lichens	Cladonia gracilis (L.) Willd. ssp. *vulnerata* Ahti	clavul	{abr}		
Lichens	*Cladonia macrophylla* (Schaerer) Stenh.	clamac1	{abr}		
Lichens	*Cladonia maxima* (Asahina) Ahti	clamax	{abr}		
Lichens	*Cladonia scabriuscula* (del.) Leight.	clasca2	{abr}		
Lichens	*Cladonia squamosa* Hoffm.	clasqu	{abr}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Lichens	*Cladonia stricta* (Nyl.) Nyl.	clastr	{abr}		
Lichens	*Cladonia subulata* (L.) F.H. Wigg.	clasub1	{abr}		
Lichens	*Cladonia sulphurina* (Michaux) Fr.	clasul	{abr}		
Lichens	*Cladonia thomsonii* Ahti	clatho	{abr}		
Lichens	*Cladonia uncialis* (L.) F. H. Wigg.	claunc	{abr}		
Lichens	*Flavocetraria cucullata* (Bellardi) Kärnefelt & Thell	flacuc	{abr}		
Lichens	*Flavocetraria nivalis* (L.) Kärnefelt & Thell	flaniv	{abr}		
Lichens	*Lobaria linita* (Ach.) Rabenh.	loblin	{abr}		
Lichens	*Nephroma arcticum* (L.) Torss.	neparc	{abr}		
Lichens	*Parmelia sulcata* Taylor	parsul	{abr}		
Lichens	*Peltigera aphthosa* (L.) Willd.	pelaph	{abr}		
Lichens	*Peltigera scabrosa* Th. Fr.	pelsca	{abr}		
Lichens	*Spilonema revertens* Nyl.	spirev	{abr}		
Lichens	*Stereocaulon paschale* (L.) Hoffm.	stepas	{abr}		
Lichens	*Stereocaulon tomentosum* Fr.	stetom	{abr}		
Lichens	*Thamnolia subuliformis* (Ehrh.) Culb.	thasub	{abr}		
Lichens	*Thamnolia vermicularis* (Sw.) Ach. ex Schaerer	thaver	{abr}		
Liverworts	*Ptilidium ciliare* (L.) Hampe	pticil	{abr,aknhp}		
Liverworts	*Ptilidium pulcherrimum* (G. Web.) Vain.	ptipul	{abr}		
Mosses	*Aulacomnium palustre* (Hedw.) Schwaegr.	aulpal	{abr,aknhp}		
Mosses	*Aulacomnium turgidum* (Wahlenb.) Schwaegr.	aultur	{abr,aknhp}		
Mosses	*Brachythecium rivulare* Schimp. in B.S.G.	brariv	{abr}		
Mosses	*Bryum weigelii* Spreng.	brywei	{abr}		
Mosses	*Calliergon giganteum* (Schimp.) Kindb.	calgig	{abr}		
Mosses	*Calliergon stramineum* (Brid.) Kindb.	calstr	{abr}		
Mosses	*Climacium dendroides* (Hedw.) Web. et Mohr.	cliden	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Mosses	*Dicranum elongatum* Schleich. ex Schwaegr.	dicelo	{abr}		
Mosses	*Dicranum flexicaule* Bridel,	dicfle	{abr}		
Mosses	*Dicranum fuscescens* Turner.	dicfus	{abr}		
Mosses	*Dicranum groenlandicum* Brid.	dicgro	{abr}		
Mosses	*Dicranum majus* Sm.	dicmaj	{abr}		
Mosses	*Dicranum polysetum* SW.	dicpol	{abr}		
Mosses	*Dicranum undulatum* Brid.	dicund	{abr}		
Mosses	*Drepanocladus aduncus* (Hedw.) Warnst. s.l.	dreadu	{abr}		
Mosses	*Drepanocladus revolvens* (Sw.) Warnst.	drerev	{abr}		
Mosses	*Helodium blandowii* (Web. & Mohr) Warnst.	helbla	{abr}		
Mosses	*Hylocomium splendens* (Hedw.) B.S.G.	hylspl	{abr,aknhp}		
Mosses	*Hypnum lindbergii* Mitt.	hyplin	{abr}		
Mosses	*Loeskypnum badium* (Hartm.) Paul	loebad	{abr}		
Mosses	*Meesia triquetra* (Richter) Aongstr.	meetri	{aknhp}		
Mosses	*Oncophorus wahlenbergii* Brid.	oncwah	{abr}		
Mosses	*Paludella squarrosa* (Hedw.) Brid.	palsqu	{abr}		
Mosses	*Philonotis fontana* (Hedw.) Brid.	phifon	{abr}		
Mosses	*Plagiomnium insigne* (Mitt.) T. Kop.	plains	{aknhp}		
Mosses	*Pleurozium schreberi* (Brid.) Mitt.	plesch	{abr,aknhp}		
Mosses	*Polytrichum commune* Hedw.	polcom	{abr,aknhp}		
Mosses	*Polytrichum juniperinum* Hedw.	poljun	{abr}		
Mosses	*Polytrichum strictum* Brid.	polstr	{abr}		
Mosses	*Ptilium crista-castrensis* (Hedw.) De Not.	pticri	{abr,aknhp}		
Mosses	*Racomitrium lanuginosum* (Hedw.) Brid.	raclan	{abr}		
Mosses	*Rhizomnium glabrescens* (Kindb.) T. Kop.	rhigla	{aknhp}		
Mosses	*Rhytidiadelphus loreus* (Hedw.) Warnst.	rhylor	{abr}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Mosses	*Rhytidiadelphus squarrosus* (Hedw.) Warnst.	rhysqu	{abr}		
Mosses	*Rhytidiadelphus triquetrus* (Hedw.) Warnst.	rhytri	{aknhp}		
Mosses	*Rhytidium rugosum* (Hedw.) Kindb.	rhyrug	{abr}		
Mosses	*Sanionia uncinata* (Hedw.) Loeske	sanunc	{abr,aknhp}		
Mosses	Sphagnum angustifolium (Russ. ex Russ.) C.Jens	sphang	{abr,aknhp}		
Mosses	*Sphagnum balticum* (Russ.) Russ. ex C.Jens.	sphbal	{abr}		
Mosses	*Sphagnum capillifolium* (Ehrh.) Hedw.	sphcap	{abr}		
Mosses	*Sphagnum fuscum* (Schimp.) Klinggr.	sphfus	{abr,aknhp}		
Mosses	*Sphagnum girgensohnii* Russ.	sphgir	{abr,aknhp}		
Mosses	*Sphagnum lenense* H.Lindb. ex Pohle	sphlen	{abr}		
Mosses	*Sphagnum rubellum* Wils.	sphrub	{abr}		
Mosses	*Sphagnum russowii* Warnst.	sphrus	{aknhp}		
Mosses	*Sphagnum squarrosum* Crome	sphsqu	{abr,aknhp}		
Mosses	*Sphagnum subsecundum* Nees ex Sturm	sphsub	{abr}		
Mosses	*Sphagnum teres* (Schimp.) Ångstr. in Hartm.	sphter	{abr,aknhp}		
Mosses	*Sphagnum warnstorfii* Russ.	sphwar	{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 filiformis* L.	junfil	{abr,aknhp}		
Sedges	*Carex aquatilis* Wahlenb.	caraqu1	{aknhp}		
Sedges	*Carex aquatilis* Wahlenb. ssp. aquatilis	caraqu	{abr}		
Sedges	*Carex bigelowii* Torr.	carbig	{abr,aknhp}		
Sedges	*Carex brunnescens* (Pers.) Poir.	carbru	{aknhp}		
Sedges	*Carex canescens* L.	carcan	{abr,aknhp}		

Appendix 2. Continued.

Lifeform	Scientific Name	ABR Species Code	Data Origin	Alaska Rare Rank	AKEPIC Invasiveness Rank
Sedges	*Carex chordorrhiza* Ehrh.	carcho	{abr}		
Sedges	*Carex lapponica* Lang	carlap	{abr}	S3S4	
Sedges	*Carex limosa* L.	carlim	{abr,aknhp}		
Sedges	*Carex lyngbyaei* Hornem.	carlyn	{abr,aknhp}		
Sedges	*Carex media* R. Br.	carmed	{abr}		
Sedges	*Carex membranacea* Hook.	carmem	{abr}		
Sedges	*Carex nesophila* Holm.	carnes	{abr}		
Sedges	*Carex pluriflora* Hult.	carplu	{abr,aknhp}		
Sedges	*Carex rariflora* (Wahlenb.) Smith	carrar	{abr,aknhp}		
Sedges	*Carex rotundata* Wahlenb.	carrot	{abr}		
Sedges	*Carex saxatilis* L. ssp. *laxa* (Trautv.) Kalela	carsax	{abr}		
Sedges	*Carex stylosa* C. A. Mey	carsty	{abr}		
Sedges	*Carex tenuiflora* Wahlenb.	carten	{abr}		
Sedges	*Carex utriculata* F. Boott	carutr	{abr,aknhp}		
Sedges	*Carex williamsii* Britt.	carwil	{abr}		
Sedges	*Eriophorum angustifolium* Honck.	eriang1	{aknhp}		
Sedges	*Eriophorum angustifolium* Honck. ssp. *subarcticum* (V. Vassiljev) Hult.	eriang	{abr}		
Sedges	*Eriophorum russeolum* Fries	erirus	{abr,aknhp}		
Sedges	*Eriophorum scheuchzeri* Hoppe	erisch	{aknhp}		
Sedges	*Eriophorum vaginatum* L.	erivag	{abr,aknhp}		
Sedges	*Trichophorum caespitosum* (L.) Hartm.	tricae	{aknhp}		

Appendix 3. Integrated Taxonomic Information System (ITIS) synonymy table for ABR taxa that are either not accepted or not recognized by ITIS for plant species found in Alagnak Wild River, Alaska, 2014.

ABR Authority	ABR Code	ABR Taxonomic Serial No.	ITIS Authority	ITIS Taxonomic Serial No.	ABR Taxa Status Code
Achillea borealis Bong	achbor	35424	*Achillea millefolium* L.	35423	Not Accepted
Aconitum delphinifolium DC.	acodel	-999	*Aconitum delphiniifolium* DC.	821196	Not Accepted
Alnus fruticosa Rupr.	alnfru	-999			Not Recognized
Alnus sinuata (Regel ex DC) Rydb.	alnsin	19476	*Alnus viridis* ssp. *sinuata* (Regel) Á. Löve & D. Löve	181895	Not Accepted
Alnus tenuifolia Nutt.	alnten	19477	*Alnus incana* ssp. *tenuifolia* (Nutt.) Breitung	181889	Not Accepted
Artemisia arctica Less.	artarc2	35432	*Artemisia norvegica* ssp. *saxatilis* (Besser) H.M. Hall & Clem.	525294	Not Accepted
Athyrium filix-femina (L.) Roth ssp. *cyclosorum* (Rupr.) C. Chr.	athfil	17416	*Athyrium filix-femina* var. *cyclosorum* (Rupr.) Ledeb.	532449	Not Accepted
Callitriche verna L. emend. Lonnr.	calver	32054	*Callitriche palustris* L.	501143	Not Accepted
Cardamine pratensis L. ssp. *angustifolia* (Hook.) O.E. Schultz	carpra1	525385	*Cardamine nymanii* Gand.	510096	Not Accepted
Carex aquatilis Wahlenb. ssp. *aquatilis*	caraqu	-999			Not Recognized
Carex lyngbyaei Hornem.	carlyn	-999	*Carex lyngbyei* Hornem.	39415	Not Accepted
Carex nesophila Holm.	carnes	39714	*Carex microchaeta* ssp. *nesophila* (T. Holm) D.F. Murray	523775	Not Accepted
Carex saxatilis L. ssp. laxa (Trautv.) Kalela	carsax	525417	*Carex saxatilis* L.	39431	Not Accepted
Cetraria islandica (L.) Ach.	cetisl1	-999			Not Recognized
Cetraria islandica (L.) Ach. ssp. *islandica*	cetisl2	-999			Not Recognized
Cetrariella fastigiata (Delise ex Nyl.) Kärnefelt & Thell	cetfas	-999			Not Recognized
Cicuta mackenzieana Raup	cicmac	29460	*Cicuta virosa* L.	182155	Not Accepted
Cladina arbuscula (Wallr.) Hale & Culb.	claarb	-999			Not Recognized
Cladina mitis (Sandst.) Hustich	clamit	-999			Not Recognized
Cladina rangiferina (L.) Nyl.	claran	-999			Not Recognized
Cladina stellaris (Opiz) Brodo	claste	-999			Not Recognized
Cladina stygia (Fr.) Ahti	clasty	-999			Not Recognized
Cladonia gracilis (L.) Willd. ssp. *vulnerata* Ahti	clavul	-999			Not Recognized

[1]A value of -999 indicates that no taxonomic serial number is available for the ABR taxa because it is not recognized by ITIS.

Appendix 3. Continued.

ABR Authority	ABR Code	ABR Taxonomic Serial No.	ITIS Authority	ITIS Taxonomic Serial No.	ABR Taxa Status Code
Claytonia chamissoi Esch.	clacha	511101	*Montia chamissoi* (Ledeb. ex Spreng.) Greene	20406	Not Accepted
Dicranum flexicaule Bridel,	dicfle	-999			Not Recognized
Dicranum undulatum Brid.	dicund	16765	*Dicranum polysetum* Sw.	16762	Not Accepted
Drepanocladus revolvens (Sw.) Warnst.	drerev	16176	*Limprichtia revolvens* (Sw.) Loeske	547894	Not Accepted
Dryopteris dilatata (Hoffm.) A.Gray ssp. *americana* (Fisch.) Hult.	drydil	525588	*Dryopteris expansa* (C. Presl) Fraser-Jenk. & Jermy	17534	Not Accepted
Epilobium angustifolium L.	epiang	27284	*Chamerion angustifolium* ssp. *angustifolium* (L.) Holub	566019	Not Accepted
Epilobium glandulosum Lehm.	epigla	512918	*Epilobium ciliatum* ssp. *glandulosum* (Lehm.) Hoch & P.H. Raven	27295	Not Accepted
Epilobium latifolium L.	epilat	27281	*Chamerion latifolium* (L.) Holub	510758	Not Accepted
Eriophorum angustifolium Honck. ssp. *subarcticum* (V. Vassiljev) Hult.	eriang	40083	*Eriophorum angustifolium* ssp. *angustifolium* Honck.	40081	Not Accepted
Flavocetraria cucullata (Bellardi) Kärnefelt & Thell	flacuc	-999			Not Recognized
Flavocetraria nivalis (L.) Kärnefelt & Thell	flaniv	-999			Not Recognized
Heracleum lanatum Michx.	herlan	29670	*Heracleum sphondylium* ssp. *montanum* (Schleich. ex Gaudin) Briq.	525943	Not Accepted
Iris setosa Pall. ssp. *setosa*	iriset	-999			Not Recognized
Lathyrus palustris L. ssp. *pilosus* (Cham.) Hult.	latpal	526020	*Lathyrus palustris* L.	25866	Not Accepted
Loiseleuria procumbens (L.) Desv.	loipro	23556	*Kalmia procumbens* (L.) Gift, Kron & P.F. Stevens ex Galasso, Banfi & F. Conti	565766	Not Accepted
Montia fontana ssp. *fontana* L.	monfon	524321	*Montia fontana* L.	20404	Not Accepted
Oxycoccus microcarpus Turcz. ex Rupr.	oxymic	-999	*Vaccinium oxycoccos* L.	505635	Not Accepted
Oxytropis nigrescens ssp. *bryophila* (Greene) Hultén	oxybry1	26160	*Oxytropis nigrescens* var. *nigrescens* (Pall.) Fisch. ex DC.	26159	Not Accepted
Petasites hyperboreus Rydb.	pethyp	518805	*Petasites frigidus* var. *frigidus* (L.) Fr.	529538	Not Accepted
Polemonium acutiflorum Willd.	polacu	30999	*Polemonium caeruleum* ssp. *villosum* (J.H. Rudolph ex Georgi) Brand	526441	Not Accepted
Polygonum lapathifolium L.	pollap	20860	Persicaria lapathifolia (L.) Gray	518735	Not Accepted
Polygonum viviparum L.	polviv	20864	*Bistorta vivipara* (L.) Delarbre	823849	Not Accepted

Appendix 3. Continued.

ABR Authority	ABR Code	ABR Taxonomic Serial No.	ITIS Authority	ITIS Taxonomic Serial No.	ABR Taxa Status Code
Potentilla palustris (L.) Scop.	potpal	24676	*Comarum palustre* L.	501615	Not Accepted
Pyrola secunda L.	pyrsec1	23755	*Orthilia secunda* (L.) House	504066	Not Accepted
Ranunculus trichophyllus Chaix	rantri	18578	*Ranunculus aquatilis* var. *diffusus* With.	566544	Not Accepted
Rhinanthus minor ssp. *borealis* (Sterneck) Á. Löve	rhimin	526545	*Rhinanthus minor* ssp. *groenlandicus* (Chabert) Neuman	524617	Not Accepted
Rorippa hispida (Desv.) Britt.	rorhis	520215	*Rorippa palustris* ssp. *hispida* (Desv.) Jonsell	23009	Not Accepted
Rumex fenestratus Greene	rumfen	520628	*Rumex occidentalis* S. Watson	20947	Not Accepted
Sedum rosea (L.) Scop. ssp. *integrifolium* (Raf.) Hult.	sedros	526670	*Rhodiola integrifolia* ssp. *integrifolia* Raf.	566078	Not Accepted
Stellaria calycantha (Ledeb.) Bong. ssp. *interior* Hult.	steint1	526739	*Stellaria borealis* ssp. *borealis* Bigelow	524717	Not Accepted
Stellaria calycantha (Ledeb.) Bong. var. *isophylla* (Fern.) Fern.	steiso	540941	*Stellaria borealis* ssp. *borealis* Bigelow	524717	Not Accepted
Stereocaulon paschale (L.) Hoffm.	stepas	-999			Not Recognized
Stereocaulon tomentosum Fr.	stetom	-999			Not Recognized
Trichophorum caespitosum (L.) Hartm.	tricae	565577	*Trichophorum cespitosum* (L.) Hartm.	508143	Not Accepted
Trientalis europaea L. ssp. *arctica* (Fisch.) Hult.	trieur1	524771	*Trientalis europaea* L.	24054	Not Accepted
Warnstorfia sarmentosa (Wahlenb.) Hedenaes	warsar	-999			Not Recognized

Appendix 4. Chemical and physical laboratory data for 30 soil horizons across 16 plots, Alagnak Wild River, Alaska, 2014. A value of -999 indicates no data for a given attribute.

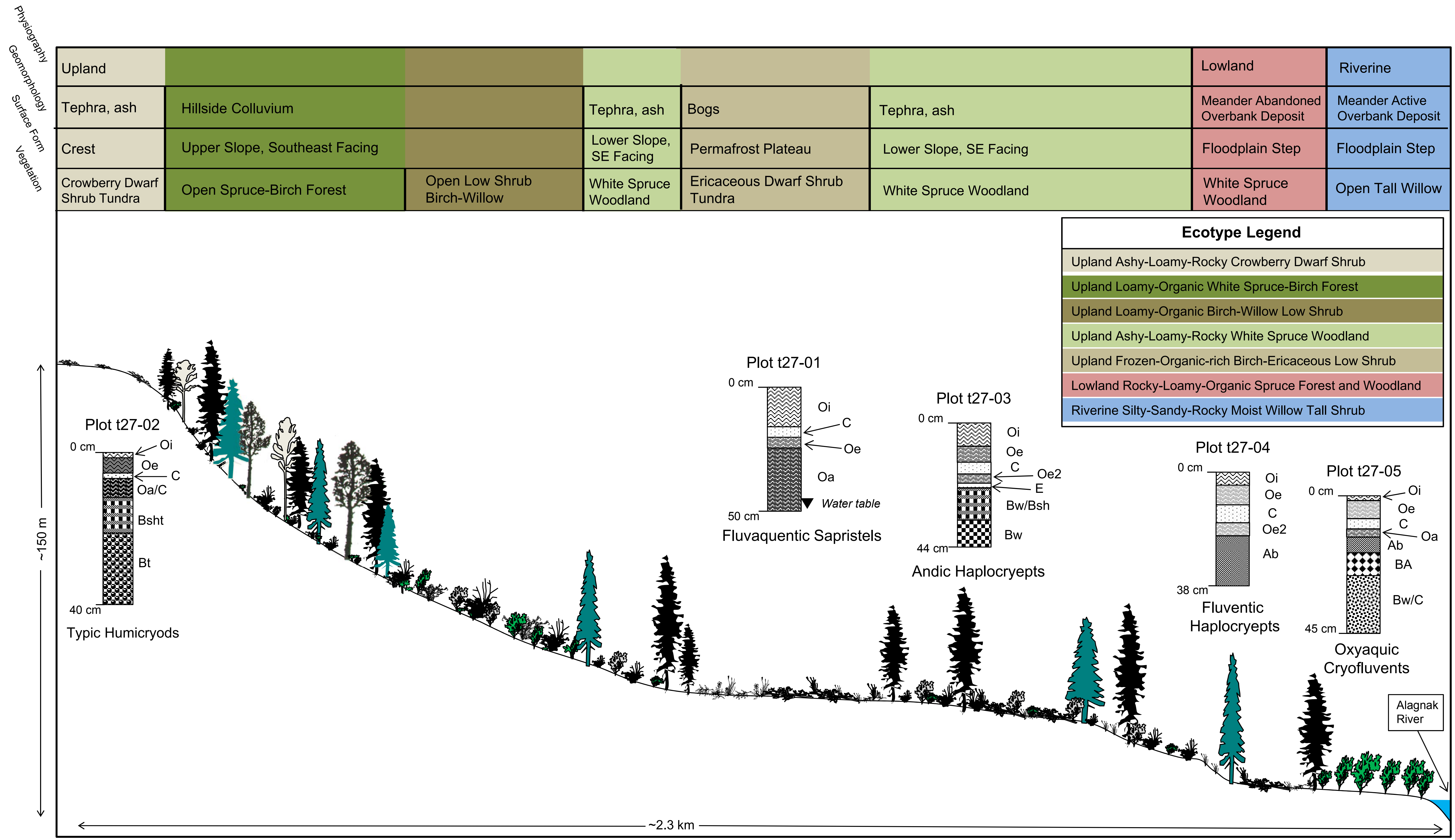
plot_id	Depth cm	Sand %	Silt %	Clay %	Total N %	Total C %	Organic C %	LOI %	BS %	Fe %	Al %	SI %	PO4 %	15 Bar	Glass
alag_t01-01_2014	20–26	42.8	41.2	16	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t01-01_2014	26–37	42.8	39.2	18	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t03-01_2014	18–50	41.8	46.2	12	0.24	7.05	7.04	-999	6.5	0.87	1.97	0.56	97.77	15.5	3
alag_t03-03_2014	11–23	51	39	10	0.38	13.6	13.59	-999	-999	1.23	0.71	0.12	81.85	28.3	74
alag_t03-03_2014	23–44	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	8.8	
alag_t03-04_2014	11–22	-999	-999	-999	-999	-999	-999	43.55	-999	-999	-999	-999	-999		
alag_t03-04_2014	22–25	-999	-999	-999	-999	-999	-999	50.07	-999	-999	-999	-999	-999		
alag_t07-02_2014	10–31	44	40	16	0.26	5.91	5.9	-999	-999	1.22	2.19	0.71	97.97	17.1	5
alag_t07-02_2014	31–38	52	33.6	14.4	0.08	2.12	2.12	-999	-999	1.4	1.63	0.63	95.32		
alag_t07-02_2014	38–47	90	3	7	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t09-06_2014	15–28	40	47	13	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t09-06_2014	28–43	36	47	17	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t11-02_2014	6–9	-999	-999	-999	0.06	2.37	2.37	-999	-999	0.12	0.08	0.01	16.64		
alag_t11-02_2014	9–20	-999	-999	-999	0.84	31.79	31.79	-999	10.29	0.44	0.48	0.02	75.69		
alag_t11-02_2014	28–42	51.4	38.6	10	0.24	7.4	7.39	-999	-999	0.72	1.79	0.43	97.63	21.4	17
alag_t11-04_2014	19–31	49.4	40.4	10.2	0.22	6.06	6.05	-999	8.66	1.54	1.51	0.4	96.45	22.2	6
alag_t11-04_2014	32–42	49.4	35.7	14.9	0.18	5.76	5.75	-999	-999	1.34	1.24	0.22	94.7		
alag_t16-02_2014	21–28	50	34.1	15.9	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t16-02_2014	28–41	46	32.4	21.6	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t22-11_2014	25–33	27	63.5	9.5	0.81	12.37	12.37	-999	42.47	0.84	0.64	0.14	81.69	34	11
alag_t22-11_2014	36–42	42.6	49.8	7.6	0.33	4.73	4.74	-999	-999	0.28	0.47	0.13	50.76		
alag_t23-01_2014	8–12	39.2	49.8	11	0.42	9.58	9.57	-999	5.01	1.85	2.47	0.76	98.82		
alag_t23-01_2014	12–33	35.6	50.8	13.6	0.28	5.93	5.91	-999	12.68	1.79	2.52	0.8	98.2	24.5	22
alag_t23-01_2014	33–52	15.6	63.8	20.6	0.02	0.61	0.61	-999	-999	1.02	0.41	0.16	35.08		
alag_t23-02_2014	10–18	-999	-999	-999	-999	-999	-999	38.49	-999	-999	-999	-999	-999		
alag_t27-02_2014	10v21	41.3	46.7	12.1	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t27-02_2014	21–40	42.6	36.8	20.6	-999	-999	-999	-999	-999	-999	-999	-999	-999		
alag_t27-04_2014	23–38	-999	-999	-999	-999	-999	-999	12.13	-999	-999	-999	-999	-999		
alag_v03-02_2014	26–40	-999	-999	-999	-999	-999	-999	75.66	-999	-999	-999	-999	-999		
alag_v11-04_2014	14–32	-999	-999	-999	-999	-999	-999	15.39	-999	-999	-999	-999	-999		

Appendix 5. Crosswalk between map ecotypes and land cover classes of Boucher and Flagstad (2014) and the total area of each unique combination of ecotypes and classes, Alagnak Wild River, Alaska, 2014.

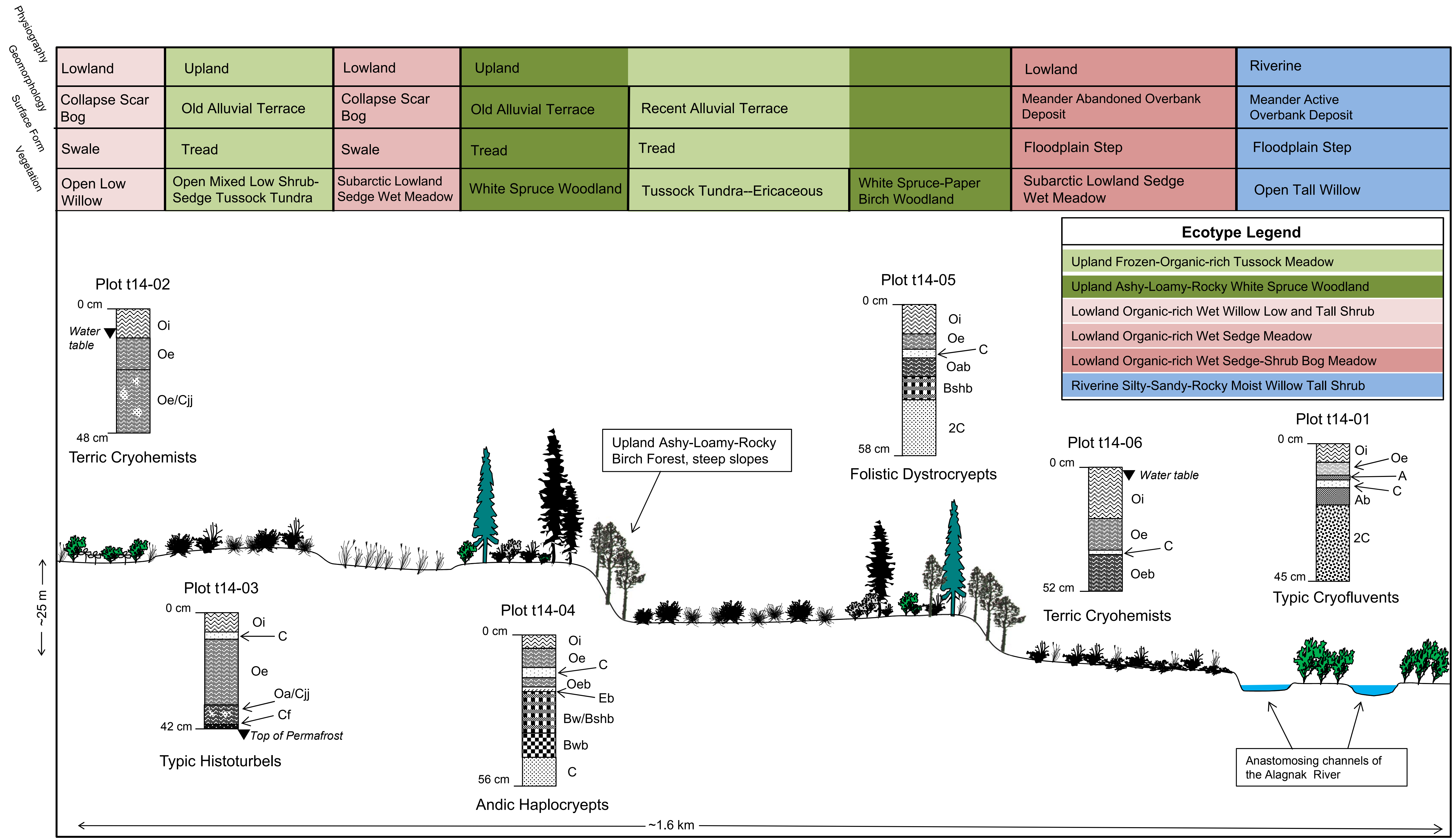
Map Ecotype	Landcover (Primary)	ABR Taxa Status Code
Lowland Lake	Water	20.8
Lowland Loamy-Organic Sweetgale-Willow Low Shrub	Low Shrub Wetland	418.8
	Mixed Low/Dwarf Shrub	4.8
Lowland Organic-rich Wet Sedge Meadow	Mesic Herbaceous Meadow	2.0
	Wet Herbaceous	205.8
Lowland Organic-rich Wet Sedge-Shrub Bog Meadow	Mixed Low/Dwarf Shrub	89.6
	Mixed Low/Dwarf Shrub-Sedge	484.7
Lowland Organic-rich Wet Willow Low and Tall Shrub	Birch Forest	5.1
	Birch Woodland	1.4
	Low Willow Shrub	109.8
	Mixed Broadleaf/Needleleaf Forest	0.9
	Mixed Low/Dwarf Shrub	8.9
	Open Spruce Forest	1.9
	Tall Willow Shrub	39.2
Lowland Rocky-Loamy-Organic Spruce Forest and Woodland	Closed Spruce Forest	0.2
	Mixed Broadleaf/Needleleaf Forest	66.2
	Mixed Broadleaf/Needleleaf Woodland	16.5
	Mixed Low/Dwarf Shrub	0.2
	Open Spruce Forest	115.0
	Spruce Woodland	98.5
Riverine Circumneutral River Water	Water	1056.5
Riverine Rocky Barrens and Partially Vegetated	Barren	9.4
Riverine Sandy-Loamy-Rocky Alder Tall Shrub	Tall Alder Shrub	94.2
Riverine Sandy-Organic Wet Graminoid Meadow	Mesic Herbaceous Meadow	2.6
	Wet Herbaceous	380.6
Riverine Silty-Sandy-Rocky Moist Willow Low Shrub	Birch Woodland	1.3
	Low Shrub Wetland	79.9
	Low Willow Shrub	130.7
	Mixed Broadleaf/Needleleaf Forest	0.3
	Mixed Low/Dwarf Shrub	7.4
	Mixed Low/Dwarf Shrub-Sedge	8.4
Riverine Silty-Sandy-Rocky Moist Willow Tall Shrub	Spruce Woodland	0.5
	Tall Willow Shrub	898.1
Riverine Silty-Sandy-Rocky White Spruce-Broadleaf Forest	Birch Forest	76.4
	Mixed Broadleaf/Needleleaf Forest	231.4
	Mixed Broadleaf/Needleleaf Woodland	0.0

Appendix 5. Continued.

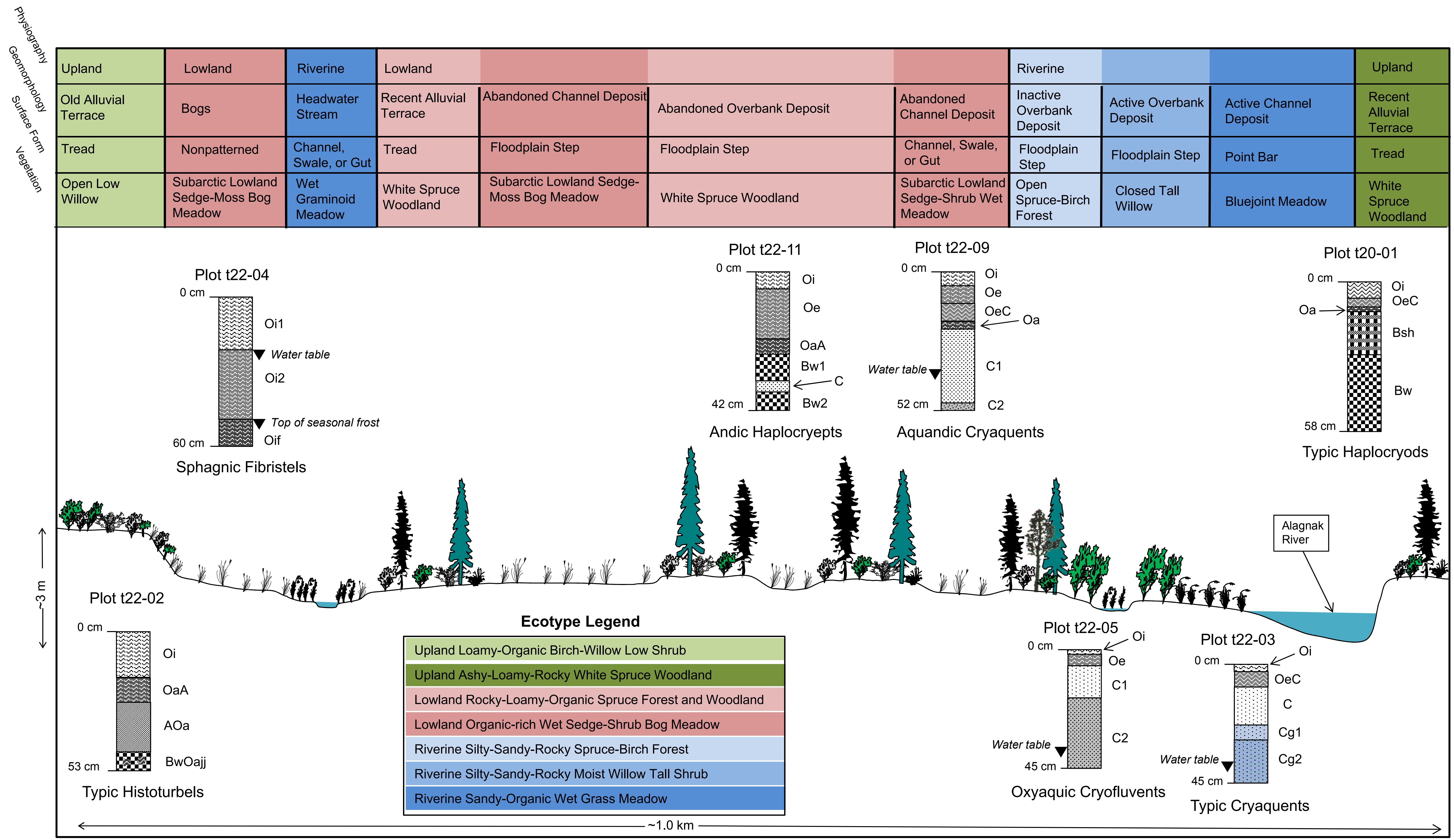
Map Ecotype	Landcover (Primary)	ABR Taxa Status Code
	Open Spruce Forest	81.8
	Poplar Forest	0.9
	Spruce Woodland	39.1
Upland Ashy-Loamy-Rocky Balsam Poplar Forest	Poplar Forest	1.6
Upland Ashy-Loamy-Rocky Birch Forest, gentle slopes	Birch Forest	213.3
	Birch Woodland	5.8
Upland Ashy-Loamy-Rocky Birch Forest, steep slopes	Birch Forest	100.4
	Birch Woodland	8.4
Upland Ashy-Loamy-Rocky Crowberry Dwarf Shrub	Dwarf Shrub	132.0
	Dwarf Shrub-Lichen	485.0
	Mesic Herbaceous Meadow	11.6
Upland Ashy-Loamy-Rocky White Spruce Woodland	Low Willow Shrub	2.1
	Mixed Broadleaf/Needleleaf Forest	665.2
	Mixed Broadleaf/Needleleaf Woodland	1323.9
	Open Spruce Forest	702.1
	Spruce Woodland	2007.7
Upland Frozen Organic-rich Birch-Tussock Low Shrub	Dwarf Shrub-Lichen	18.4
	Low Willow Shrub	2.4
	Mixed Low/Dwarf Shrub	883.4
	Mixed Low/Dwarf Shrub-Sedge	170.4
Upland Loamy-Organic Birch-Willow Low Shrub	Low Willow Shrub	52.6
Upland Loamy-Organic White Spruce-Birch Forest	Closed Spruce Forest	9.4
	Mixed Broadleaf/Needleleaf Forest	657.7
Upland Rocky-Organic Alder-Willow Tall Shrub	Tall Alder Shrub	172.6
	Tall Willow Shrub	91.5
Grand Total		12507.4



Appendix 6. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils in the upper portion of ALAG, Alagnak Wild River, Alaska, 2014.



Appendix 7. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils in the middle portion of ALAG, Alagnak Wild River, Alaska, 2014.



Appendix 8. A generalized toposequence illustrating relationships among physiography, geomorphology, surface form, vegetation, and soils in the lower portion of ALAG, Alagnak Wild River, Alaska, 2014.

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