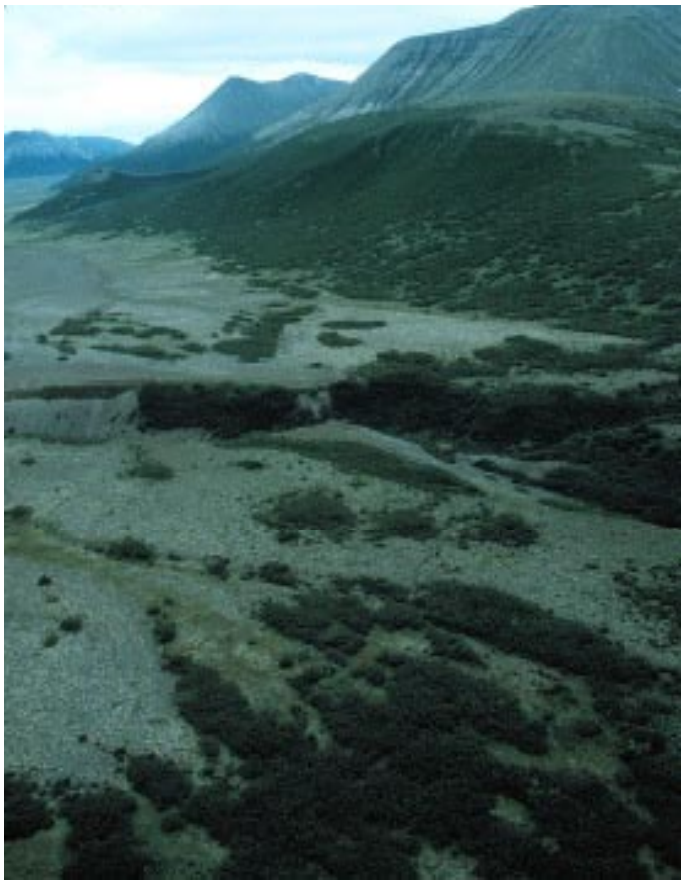
# ECOLOGICAL SUBSECTIONS OF ANIAKCHAK NATIONAL MONUMENT & PRESERVE

**Mapping and Delineation by:**
Gerald F. Tande; Julie Michaelson, AK Natural Heritage Program

**Photographs by:**
Gerald F. Tande



**Alaska Region**
**Inventory and Monitoring Program**
2525 Gambell
Anchorage, Alaska 99503

# Ecological Subsections of Aniakchak National Monument and Preserve, Alaska

**Final Report**

Prepared For:

**U. S. National Park Service**
2525 Gambell Street
Anchorage, Alaska 99503-2892

Prepared By:

Gerald F. Tande
Vegetation Ecologist

Julie Michaelson
Program Data Manager

**Alaska Natural Heritage Program**
Environment and Natural Resources Institute
University of Alaska Anchorage
707 A Street
Anchorage AK 99501

October 2001

# Table of Contents



## *Introduction*

Ecological land classifications are important for evaluating land resources and refining research and management strategies for specific areas. Landscape-level stratification can be used to more efficiently allocate inventory and monitoring efforts; improve landcover classifications developed from remote sensing; partition ecological information for analysis of ecological relationships and development of predictive models; and improve recommendations for ecological restoration (Jorgenson *et al.* 1999, 2000). Accordingly, the National Park Service (NPS) has elected to use landscape-level maps as the basis for stratifying their biological inventory and monitoring programs to insure that their field sampling is distributed across a wide range of environmental gradients.

Ecological land classifications involve organizing ecosystem components at various scales based on the recognition that ecological components and features operate within a hierarchy of differing spatial and temporal scales (Bailey 1996, ECOMAP 1993). This hierarchically linked structure reveals that smaller-scale features, such as vegetation and soils, are related to and nest within larger-scale components such as climate and physiography. Climatic factors, particularly temperature and precipitation, typically account for the largest amount of variation in ecosystem structure and function globally (Walter 1979). Physiography, or broad-scale landforms with a characteristic substrate, surface shape, and relief, are the terrain conditions that control the spatial arrangement and rate of geomorphic processes. These processes, in turn, affect material and energy flows and, ultimately, ecosystem

development (Swanson *et al.* 1988, Bailey 1996). Under the National Hierarchical Framework (ECOMAP 1993), these large-scale factors of climate, physiography, and geology can be used as differentiating criteria for delineating Sections defined as physiographic regions with similar geology and regional climate, and Subsections, more narrowly defined geology with repeating associations of geomorphic units.

The U.S. National Park Service is currently undertaking landscape-level mapping at the Subsection level of the National Hierarchical Framework (ECOMAP 1993) for all its parks and Preserves in Alaska. Landscape-level maps have already been produced for Bering Land Bridge National Preserve (Jorgenson 2000), Cape Krusenstern National Monument (Swanson 2001), Denali National Park and Preserve (Clark 1998), Katmai National Park and Preserve (Shephard 2000), Kobuk Valley National Park (Swanson 2000), and Yukon-Charley Rivers National Preserve (Swanson 1999).
Similar landscape-level mapping in Alaska has been completed outside of the national park system for the Chugach ( Davidson 1996, Davidson and DeVelice 2000) and Tongass National Forests (Nowacki *et al.* 2001); the central Arctic coastal plain (Jorgenson *et al.* 1997); and Fort Wainwright and Fort Greely Military Reservations in central Alaska (Jorgenson *et al.* 1997, 2000).

This report presents the results of the mapping of Ecological Subsections for Aniakchak National Monument and Preserve (ANIA), an area encompassing 586,000 acres (237,146 ha) in southwestern Alaska (Figure 1) that was set aside to protect the unique geological significance of Aniakchak Volcano and its environs. The specific objective of this study was the compilation and review of existing information to identify, map and describe these Ecological Subsections according to the National Hierarchical Framework (ECOMAP 1993).

Ecological Subsection mapping is intended to be used to further understand the coarse-scale ecological units within the Preserve for planning; as a stratification layer for use for species-level inventory and monitoring, and vegetation and cover-type mapping; and to assist with an ongoing water inventory program. Subsection classification was to be constructed in a manner that would lend itself to aggregation upward for the refinement of ongoing efforts to map Ecoregions at the state level (Nowacki *et al.* 2000).

## *Methods*

Data compilation involved reviewing existing field studies for relevant information on the characteristics of the various landscape components; compiling information on the distribution of the various components from hard copy maps; interpreting and mapping ecological units; and integrating digitized map data into a georeferenced GIS database. Multiple factors are used to delineate ecological landscape units in the discipline of ecosystem geography (Cleland *et al.* 1997, Bailey 1996, ECOMAP 1993). For ANIA, these multiple factors included:

Bedrock and surficial geology maps and reports (Burk 1965a, 1965b, Detterman *et al.* 1979, 1981a, 1981b, 1983, 1987a, 1987b, 1996, Karlstrom *et al.* 1964, Knappen 1929, Miller and Smith 1977, 1987, Lyle and Dobey 1973, Muller 1952, Wilson *et al.* 1999);

A composite 1:150,000-scale Landsat satellite image of the Preserve (produced for NPS by Michael Fleming, USGS/EROS Field Office, Anchorage, AK);

USGS 1:250,000 topographic maps for the region (Bristol Bay, Chignik, Sutwik Island, Ugashik);

Digital map data provided by the NPS in GIS databases on CD-ROM. The databases included data at various scales from a variety of sources including: an Ecoregion map of Alaska (1:2.5 million scale, Nowacki *et al.* 2000), digital elevation models developed from 1:250,000-scale USGS quadrangles, digital raster graphics of the USGS topographic maps (1:250,000- and 1:63,360-scale), hydrography from USGS maps (1:63,360 scale), Preserve, and wilderness boundaries (1:63,360 scale), bedrock geology (1:2,500,000 scale, Beikman *et al.* 1980); and

Color infrared aerial photography where available.

Aniakchak Subsection mapping is almost entirely dependent on the USGS/EROS composite image and geologic information listed above. Landform and landcover map information normally employed to assist Ecological Subsection mapping is nearly nonexistent for the Aniakchak region. Descriptive information has been generally limited to the Aniakchak crater (e.g., Bosworth 1987, Hasselbach 1995, Hubbard 1931), and various early geological surveys of the region (e.g., Atwood 1911, Capps 1921, Knappen 1929, Moxham 1951, Smith 1925, Smith and Baker 1922, 1924). Analysis of an early regional Landsat landcover digital database (Wibbenmeyer *et al.* 1982) was beyond the scope of the current project though may be of use in Preserve planning as NPS moves toward ANIA species inventories and landcover mapping in the future.

The USGS/EROS composite image of the Preserve was used as a base layer in conjunction with USGS topographic maps for the area. Ecological units were recognized by qualitative interpretation and synthesis of the available data for the study area; the authors used their experience in southwestern Alaska and the disciplines of geology, plant ecology and landscape ecology to determine what was deemed to be ecologically important. Surficial and bedrock geology maps were carefully examined and interpreted, and the various bedrock and surficial geology reports were reviewed. Boundaries were drawn by mentally synthesizing the base map information and delineating units on a draft 'concept-level' map over the Landsat imagery.

The basis for final line placement was based on interpretation of the Landsat imagery or one of the geology theme maps, whichever best reflected the primary delineating criteria for each line or polygon delineation. Color-infrared aerial photography was consulted when the 1:250,000- or 1:150,000-scale information sources did not provide adequate information. When one or more of the principle delineation factors (gross physiography, lithology, and surficial geology) changed dramatically so that there was a sharp ecotonal boundary, we used the boundary as the delineation between ecological units.

Following the ECOMAP (1993) framework, Sections were defined as physiographic units with similar geology and regional climate that possessed repeating associations of a limited set of closely related geomorphic deposits. Subsections provided further partitioning of geomorphic

or lithologic variability, such as differentiating between volcanic and sedimentary rocks or various surficial deposits.

Although a minimum mapping unit size was not defined for this project, the ECOMAP (1993) recommended size range for Subsection mapping was generally adhered to (between 10's and 1,000's of square miles; 6,000-10,000 A; 40.5 $km^2$). In response to the potential needs of the anticipated users of the maps, ecological units were delineated as finely as the methods would allow. A number of the Subsections could be readily subdivided into more detailed units. However, not all of these more detailed units are fine enough to qualify as the next level down in the National Hierarchical Framework of Ecological Units, the Landtype Association (Cleland *et al.* 1997, ECOMAP 1993). Furthermore, field sampling would be needed to verify the composition of any Landtype Associations. Thus, the finer units are here referred to simply as "Detailed Subsections".

To ensure consistency in NPS's statewide effort, mapping investigators for other Park and Preserve units convened at  workshops in Anchorage on September 26, 2000 and April 17, 2001 to develop a consensus on mapping criteria (Page Spencer, NPS pers. com.). At these meetings, various criteria were discussed and developed including: minimum mapping unit size; differentiating coastal (salt affected) ecosystems and floodplain ecosystems; not differentiating alpine ecosystems (they are problematic because they are part of a continuous toposequence, and are highly patchy and disjunct on mountaintops, which is a pattern that is inconsistent with the principle of broad regionalization (Jorgenson 2000)); colluvial deposit hillslope position; and the standardization of Arcview attribute-table field names.

Nomenclature for classes of the various landscape components followed names used by the individual authors of geological reports; an engineering geology mapping classification system for geomorphic units (ADDGS 1983); a standardized hierarchical arrangement of Subsection names for terrain and physiographic and geologic classes previously developed for southeast Alaska (Nowacki *et al.* 2001); and ecological units of Katmai National Park, the only previously mapped and nearest NPS unit to ANIA in southwest Alaska (Shephard 2000).

Subsections and Detailed Subsections that occurred in the Preserve were extended beyond the ANIA boundary to their natural limits. A few extensive units outside the Preserve were truncated (Aleutian Range-South, Aleutian Range-North). Placement of these boundaries outside of ANIA should be considered tentative.

Following a review by AKNHP and NPS staff, the 'concept-level' map was refined and a final map was prepared on mylar over the mylar 1:250,000 quadrangle maps for the area. Mylar overlay linework was scanned by a contractor, and all lines were edge-matched and smoothed across USGS quadrangle boundaries, and merged into a single, seamless, georeferenced coverage in ARC/INFO (Alaska Albers with NAD27 datum).

The ARC/INFO map polygons were then attributed with the following:

| | |
|---|---|
| PARK_CODE | Four-character NPS abbreviation for the park or preserve unit |
| ECOREGION | From Nowacki *et al.* (2000) |
| SECTION | Full name for tentative Ecological Section |
| SUBSEC_NA | Full name of the Ecological Subsection |
| SUBSEC_CO | Symbol for the Ecological Subsection |
| DETSUB_NA | Full name of Detailed Ecological Subsection |
| DETSUB_CO | Symbol for Detailed Ecological Subsection |
| SS_PHYSIOG | Hierarchical Classification for Alaskan Subsections (Shephard 2000, Nowacki *et al.* 2001) |
| DS_LITHOL | General lithology if bedrock, or otherwise general surficial category |
| ACRES | Total acre amount for individual mapped polygons |
| SS_RATION | A short statement on the rationale for the unit |

Digital metadata meeting Federal Geographic Data Committee standards were prepared for all spatial data products using the metadata generation tools in ArcView 3.2. All final products meet the spatial accuracy of the National Data Information Infrastructure Metadata Standards (NDII).

The total aerial extent of Ecological Subsections and Detailed Subsections were generated using the Arcview AK_Pac module and incorporated into the acreage table provided in this report (Table 3).

A field reconnaissance was attempted on two separate occasions during July 2001 to become familiar with the ANIA landscape and evaluate preliminary concepts of landscape units, and to acquire large-scale photography of Subsections for reference and presentation. Unfortunately, flights could not be completed in the allocated field time due to poor weather. July was reportedly one of the wettest months on record for the State of Alaska and this affected travel from King Salmon to the villages of Chignik and Port Heiden and on to Aniakchak volcano and vicinity. Oblique photography representative of the Preserve was gathered from other sources including Preserve staff and researchers (Page Spencer) or past visitors, and occasionally documents depicting characteristic physiography from known locations.

# *Ecoregion Descriptions*

The map legend for Ecological Subsections of Aniakchak National Monument and Preserve is given in Table 1; criteria used to delineate these Subsections are summarized in Table 2. Table 3 provides a summary of the total landcover area of each Subsection and Detailed subsection. A synoptic summary of ecological units, lithology, physiography, delineation rationale, and a representative photo of units is provided in Table 4.

Simplified maps of Subsections and Detailed Subsections in Aniakchak National Monument and Preserve are provided in Figures 2 and 3. Representative photos of some of the Subsections and Detailed Subsections are provided in Figure 4. All units and their respective attributes are also found in the ARC/INFO coverage that accompanies this report.

## Alaska Peninsula Ecoregion

Gallant *et al.* (1995) divided the Alaska Peninsula into the Bristol Bay-Nusagak Lowlands (west) and Alaska Peninsula Mountains Ecoregions (east) along the spine of the Peninsula. This division has been recently modified by Nowacki *et al.* (2000) resulting in the Bristol Bay Lowlands Ecoregion occurring to the north of Aniakchak National Monument and Preserve. The Preserve occurs in the Alaska Peninsula Ecoregion extending south to Unimak Pass. Further Ecoregion characteristics are found in Nowacki *et al.* (2000), Gallant *et al.* (1995) and Wahrhaftig (1965).

# *Ecological Section Descriptions*

The Alaska Peninsula Ecoregion (Nowacki *et al.* 2000) has been tentatively divided into a Bristol Bay Lowlands and Aleutian Range Mountains Section in the vicinity of Aniakchak National Monument and Preserve (this report). The divisions between the two Sections are based on east/west divisions of climate, topography-physiography and geology (Gallant *et al.* 1995).

## Bristol Bay Lowlands Section

The Bristol Bay Lowland Section occurs outside and west of ANIA along a narrow coastal area of southern Bristol Bay extending southwest from approximately the mouth of the Cinder River. It possesses characteristics similar to Gallant's Bristol Bay-Nushagak Lowlands Ecoregion; however, the area is characterized with a lower density of lakes across a steeper gradient of coastal plain draining the Bristol Bay watershed. It has been more heavily influenced by Pleistocene glaciations of the peaks so characteristic of the Aleutian Range Mountains Section to the east, resulting in more extensive glacial and glacialfluvial deposits and less peatland (I.e., "Swamp" (USGS)) deposits that characterize the Bristol Bay-Nushagak Ecoregion of Gallant *et al.* (1995). *More research will be necessary to clarify the bounds and characteristics of this Section.*

## Aleutian Mountain Range Section

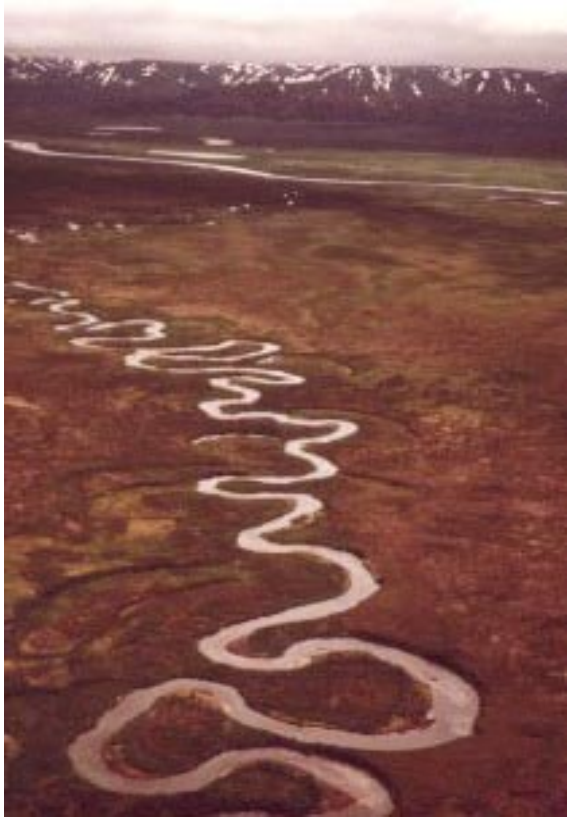
Aniakchak National Monument and Preserve occurs within the Aleutian Range Mountains Section of the Alaska Peninsula Ecoregion. This Section is characterized by rounded ridges, 300 m to 1,200 m high, surmounted at varying intervals by rugged volcanic peaks, 1,400 m to 2,600 m high. The mountains are dissected by many steep drainageways with few coastal lowland areas.

Geological formations consist of stratified Jurassic, Cretaceous, and Tertiary sediments, and undifferentiated Quaternary volcanic rocks. The Section was heavily glaciated during the Pleistocene epoch. Most volcanoes reached their peak activity following Pleistocene glaciations. Streams draining to the Pacific Ocean are short and have steep gradients. Streams draining north and west to the Bering Sea become braided as they reach the rolling to flat lowland plain of the Bristol Bay Lowlands Ecoregion or the Bristol Bay Lowland Section of the Alaska Peninsula Ecoregion.

Aniakchak Volcano and its deposits occur on the area bounding the eastern mountain range and the western coastal plain (Bristol Bay lowlands). The volcano and resultant deposits are considered part of the Aleutian Range Mountains Section due to these volcanic mountain-building processes and subsequent burial of coastal areas and earlier volcanic and sedimentary rock formations.

# *Ecological Subsection Descriptions*

## MRL Meshik River Lowlands Subsection



Geology and Physiography: Low-lying areas of the Meshik River valley extending from near Meshik Lake within the Preserve and nearly to the Meshik River mouth at Port Heiden. Most of the area has saturated peaty soils, mainly an accumulation of sedge and moss peat. The inorganic part of the deposit is largely volcanic ash. The area is dissected by numerous meandering stream channels with active and inactive alluvial deposits.

Elevation: (0 -30 m)

Vegetation/Landcover: Currently not described

## SAL  Aleutian Range Mountains - South Subsection

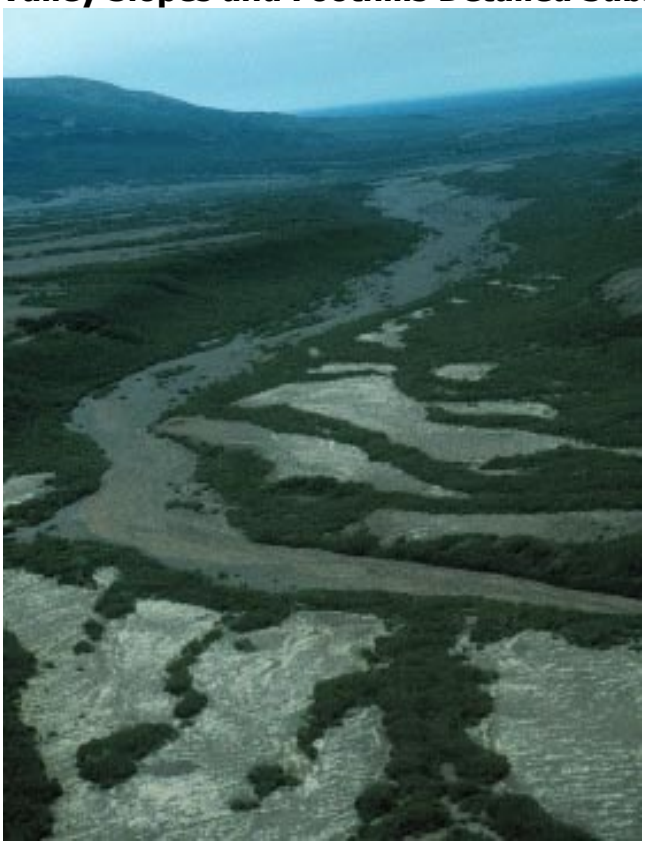
### SAL1 - Highlands and Ridges Detailed Subsection

Geology and Physiography: Rugged mountains  of the southern portion of the Aleutian Range characterized by steep valley walls and precipitous peaks. Formed from early-Tertiary volcanic rocks consisting of course andesitic and basaltic volcanic rubble, lahar and tuff deposits, and andesite and basalt lava flows. The area was glaciated during the Pleistocene. Many exposed headwalls and ridge tops are barren and/or covered by more recent black volcanic ash.

Elevation: 0-887 m

Vegetation/Landcover: Currently not described

### SAL2 - Valley Slopes and Foothills Detailed Subsection



Geology and Physiography: Gently rolling foothills and valley slopes in the Aniakchak and Meshik River valleys, rising abruptly at the base of Aniakchak Volcano and South Aleutian Range Mountains Subsections. Composed of or underlain by Holocene-age andesitic and dacitic ash-flow and ash-fall deposits. Deeply incised by rivers and streams cutting through recent volcanic materials.

Elevation: 30-122 m

Vegetation/Landcover: Currently not described

## SAL3 - Aniakchak River Floodplain Detailed Subsection

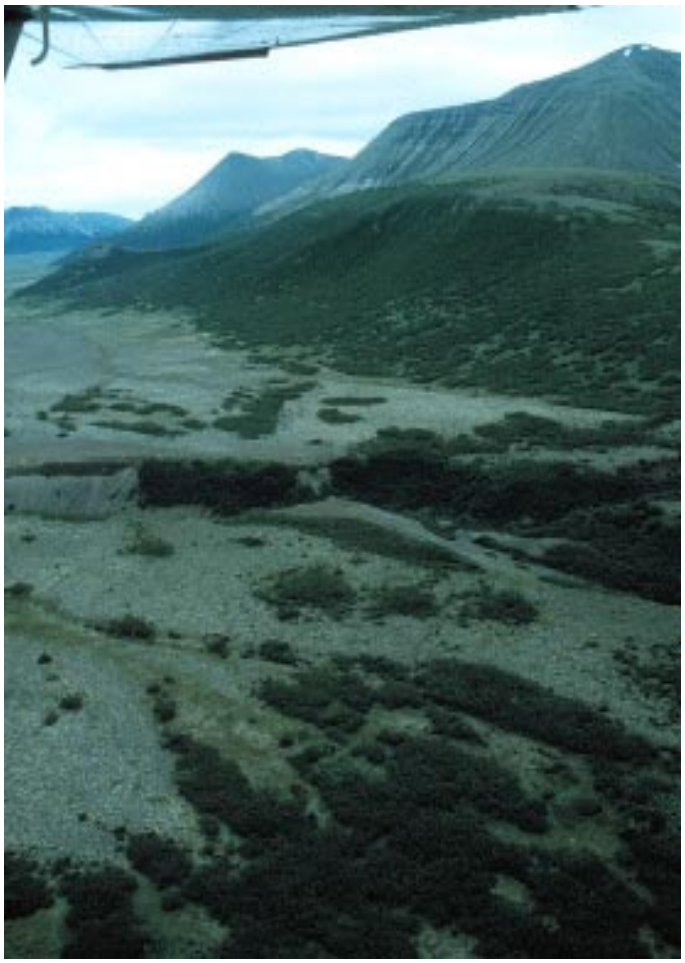
Geology and Physiography: Floodplain and low-lying areas of the upper and lower Aniakchak River valley, draining the east Pacific coastal watersheds of the Preserve. Composed of or underlain by Holocene and Pleistocene surficial deposits of unconsolidated alluvium, alluvial fans, and glacial and landslide deposits near the mountains. Mainly silt, sand, gravel, reworked pumice and volcanic rock fragments.

Elevation: 1-144 m

Vegetation/Landcover: Currently not described

## NAL Aleutian Range Mountains North Subsection

### NAL1 - Highlands and Ridges Detailed Subsection

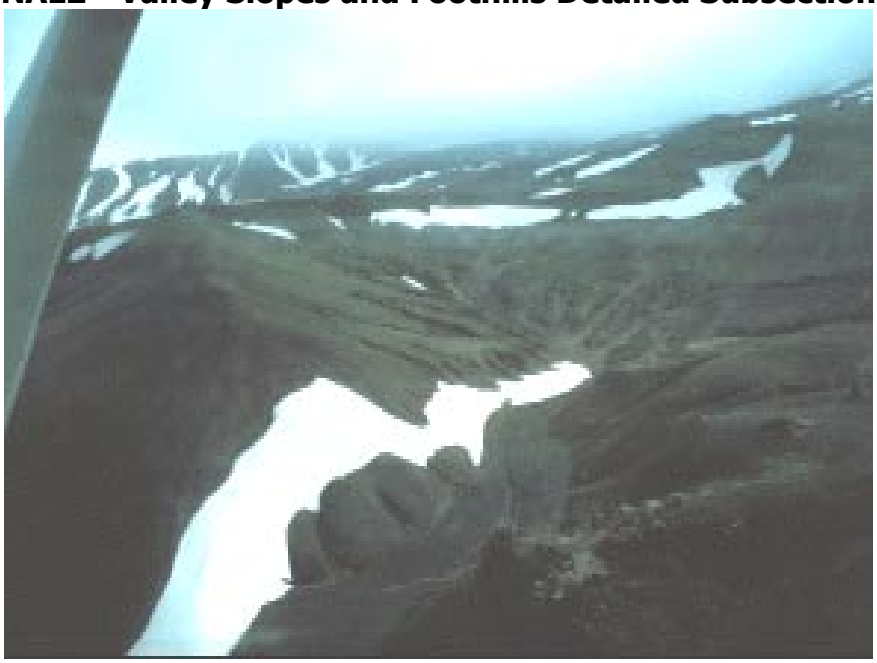


*Geology and Physiography:* Rugged mountains in the northeastern portion of the Aleutian Range composed of or underlain by Jurassic to Cretaceous-aged complex sedimentary rocks, and dissected by past glacial activity. Predominately sandstone, siltstone, conglomerate, and shales of both marine and non-marine origins. The area was glaciated during the Pleistocene. Many exposed headwalls and ridge tops are barren and/or covered by more recent black volcanic ash.

Elevation: 0-1062 m

Vegetation/Landcover: Currently not described

## NAL2 - Valley Slopes and Foothills Detailed Subsection



Geology and Physiography: Flat to gently rolling foothills and valley slopes rising gradually from the Bristol Bay lowlands to the steep northwesterly slopes of the North Aleutian Mountain Range Subsection. Composed of or underlain by Holocene-aged andesitic and dacitic ash-flow and ash-fall deposits. Locally includes glacial drift that forms end, lateral and ground moraine from Pleistocene glaciations originating in the Aleutian Range. Deeply incised by rivers and streams cutting through recent volcanic materials.

Elevation: 30-244 m

Vegetation/Landcover: Currently not described

## NAL3 - Cinder River-Pumice Creek Floodplain Detailed Subsection

Geology and Physiography: Low-gradient floodplain and low-lying areas of the upper reaches of the Cinder River system, Pumice Creek and Old Creek watersheds draining into Bristol Bay. Composed of or underlain by Holocene and Pleistocene surficial deposits of unconsolidated alluvium, alluvial fans, and glacial and landslide deposits near the mountains. Mainly silt, sand, gravel, reworked pumice and volcanic rock fragments. Upper reaches deeply incised, cutting through recent volcanic materials.

Elevation: 30-76 m

Vegetation/Landcover:  Currently not described

## ANV Aniakchak Volcano Subsection

ANV1 - Aniakchak Crater Detailed Subsection

*NPS File Photo*

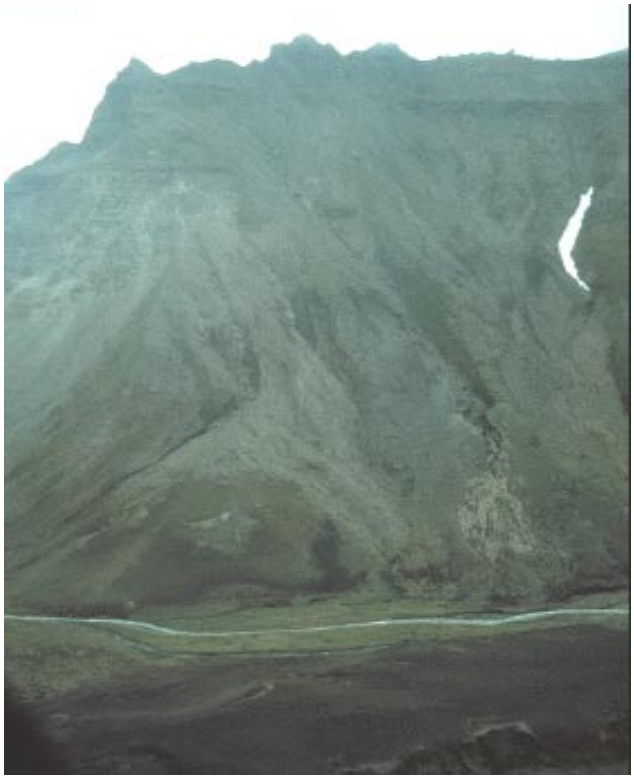
Geology and Physiography: Variable physiography over the 10-km crater radius, including: flat- to gently-sloping cinder fields and flow surfaces on the crater floor; steep slopes of recent cinder cones and vents; and steep walls of the Aniakchak caldera rim. Composed of volcanic ash-flow, ash-fall, cinder and spatter cone, and dacitic-flow deposits. Portions of the steep-sided crater rim not buried by Tertiary-aged volcanic eruptions are Jurassic to Tertiary sedimentary and igneous rocks.

Elevation: Ranges from 322 m on the crater floor at Surprise Lake to 1341 m at Aniakchak Peak on the crater rim

Vegetation/Landcover:

Much of the crater is a vegetatively depauperate area of rugged windswept ashfields. Most of the vegetation is concentrated around Surprise Lake supporting Subarctic Lowland Wet Sedge Meadow (*Carex lyngbyaei*); Lowland Wet Herb Meadow, with areas of Wet Bryophytes (*Philontis fontana*). Lush headlands and terraces support Bluejoint Meadows (*Calamagrostis canadensis*); Open Low Willow Shrub (*Salix alaxensis* and *Salix barclayi*), and Mesic Mixed Herb Communities (*Lupinus nootkatensis*, *Epilobium angustifolium*). Crowberry (*Empetrum nigrum*) Tundra is common on low slopes (Bosworth 1997, Hasselbach 1995).

## ANV2 - Explosion Debris-Lava Flow Slopes and Ridges Detailed Subsection

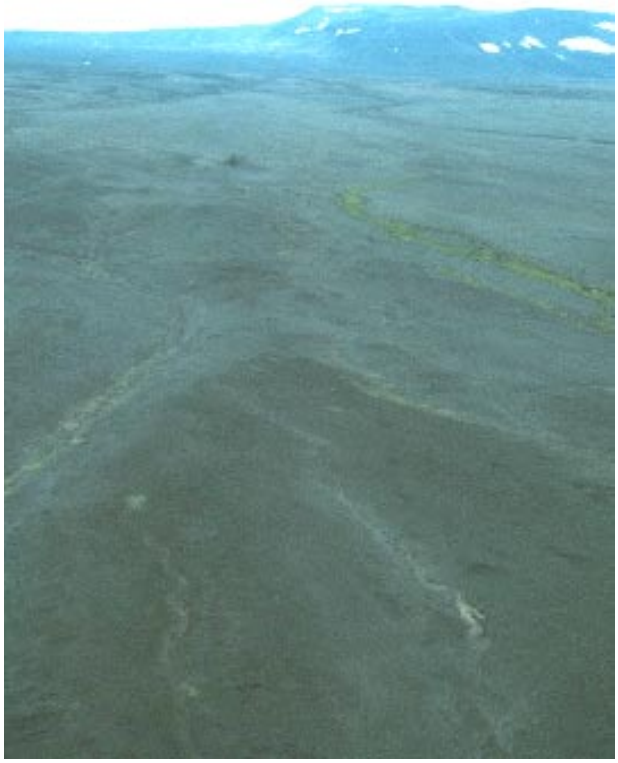


Geology and Physiography: Broad to steeply radiating ridges gradually sloping away from crater rim to the north and west, and rugged, steep, deeply incised outer slopes and old volcanic flows of Aniakchak crater to the south. Composed of or underlain by a complex of Quaternary volcanic explosive debris, dacitic-lava flows, locally including ash-flow and ash-fall deposits, amid outcroppings of Jurassic to Tertiary sedimentary and igneous rocks.

Elevation: 55-1341 m

Vegetation/Landcover: Currently not described

## ANV3 - Ash-Fall and Ash-Flow Plain Detailed Subsection



Geology and Physiography: A vast plain of Quaternary volcanic cinder and ash gradually sloping away from Aniakchak crater to the west and north of the crater rim. Dissected regularly by numerous deeply incised stream channels draining to Bristol Bay.

Elevation: 18-610 m

Vegetation/Landcover: Vegetatively depauperate area of rugged windswept ash fields

## ANV4 - Complex Sedimentary-Volcanic Highlands and Ridges Detailed Subsection

Geology and Physiography: Isolated and disjunct units of low mountains, rounded hills and ridges of the Aleutian Mountain Range Subsections not buried by Quaternary and early-Tertiary eruptions of Aniakchak Volcano. Composed of or underlain by Jurassic to Tertiary sedimentary and igneous rock similar to the Highland and Ridge. Detailed Subsections of the South and North Aleutian Range Subsections (SAL1, NAL1).

Elevation: 30-798 m

Vegetation/Landcover: Currently not described

## ACL Aniakchak Coastal Lowland Subsection

Geology and Physiography: Low-gradient coastal areas and floodplains including hills, gentle slopes and benches along their margins near the mouths of streams and rivers draining into the Pacific Ocean on the eastern side of the Preserve. Coastal lowland complex of beach, estuarine, outwash and alluvial deposits. Associated rivers and streams that transport high sediment loads of volcanic- or glacially-derived materials.

Elevation: 0-122 m

Vegetation/Landcover: Currently not described

Notes: A portion of the peninsula separating Aniakchak and Amber bays possesses the only significant moraines and other glacial deposits on the east side of the Preserve.

# *References*


ADGGS (Alaska Division of Geology and Geophysical Surveys). 1983. Engineering geology mapping classification system. Alaska Division of Geology and Geophysical Surveys. Fairbanks, AK.76 p.

Atwood, W.A. 1911. Geology and mineral resources of parts of the Alaska Peninsula. U.S. Geol. Surv. Bull. 467. 137 p.

Bailey, R. G. 1996. Ecosystem geography. Springer-Verlag, New York, 204 p.

Bailey, R. G. 1997. Ecoregions of North America. U.S. Department of Agriculture, Forest Service, Washington, D. C., Scale 1:15,000,000.

Beikman, H.M. 1980. Geologic map of Alaska. US Geol. Survey, Scale 1:2,500,000.

Bosworth, K. 1987. A vegetation reconnaissance of Aniakchak Caldera, Alaska. Unpubl. Rep. Prep. for U.S. National Park Service. Anchorage, AK. 100 p.

Burk, C. A. 1965a. Geologic map of the Alaska Peninsula southwest of Wide Bay. Geological Society of America, New York, N.Y. 1 map on 2 sheets.

Burk, C.A. 1965b. Geology of the Alaska Peninsula —Island arc and continental margin. Geological Society of America Memoir 99. 250 p., Scales 1:250,000 and 1:500,000, 3 sheets.

Capps, S.R. 1921. The Cold Bay District. U.S. Geol. Surv. Bull. 739: 77-116.

Clark, M. 1998. Hierarchical framework of ecological units to the subsection level for Denali National Park and Preserve. Unpubl. Rep. Prep. for U.S. National Park Service, Anchorage, AK.

Cleland, D.T., P.E. Avers, W.H. McNab , M.E. Jensen, R.G. Bailey, T. King, and W.E. Russell. 1997. National hierarchical framework of ecological units. Pp. 181-200. *In*: M. S. Boyce and A. Haney (eds.). Ecosystem management . Yale University, New Haven, CT. 361 p.

Davidson, D. 1996. Draft ecological hierarchy of the Kenai Peninsula. Draft Manuscript. U.S. Forest Service, Chugach National Forest, Anchorage, AK. 6 p.

Davidson, D. and R. DeVelice. 2000. Ecological subsections of Chugach National Forest, Alaska. Unpubl. Rep. U.S. Forest Service, Chugach National Forest, Anchorage, AK.

Detterman, R.L., J.E. Case, F.H. Wilson, M.E. Yount and W.H. Allaway, Jr. 1983. Generalized geologic map of the Ugashik, Bristol Bay and part of Karluk quadrangles, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map MF-1539-A. 1 sheet, Scale 1:250,000.

Detterman, R.L., J.W. Miller, J.E. Case, F.H. Wilson, and M.E. Yount. 1996. Stratigraphic framework of the Alaska Peninsula. U.S. Geol. Surv. Bull. 1969-A. 74 p.

Detterman, R.L., T.P. Miller, M.E. Yount, and F.H. Wilson. 1979. Generalized geologic map of Chignik and Sutwik Island quadrangles, Alaska. U.S. Geol. Surv. Misc. Field Studies Map MF-1053-A. 1 sheet, Scale 1:250,000.

Detterman, R.L., T.P. Miller, M.E. Yount and F.H. Wilson. 1981a. Geologic map of the Chignik and Sutwik Island quadrangles, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map I-1229. 1 sheet, Scale 1:250,000.

Detterman, R.L., T.P., Miller, M.E. Yount and F.H., Wilson. 1981b. Quaternary Geologic map of the Chignik and Sutwik Island quadrangles, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map I-1292. Scale 1:250,000.

Detterman, R.L., J.E. Case, F.H. Wilson and M.E. Yount. 1987a. Geologic map of the Ugashik, Bristol Bay, and western part of the Karluk quadrangles, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map I-1685. Scale 1:250,000.

Detterman, R.L., F.H. Wilson, M.E. Yount and T.P. Miller. 1987b. Quaternary geologic map of the Ugashik, Bristol Bay, and western part of the Karluk quadrangles, Alaska. U.S. Geol. Surv. Misc. Investigations Series Map I-1801. 1 sheet, Scale 1:250,000.

ECOMAP. 1993. National Hierarchical framework of ecological units. Washington, DC: U.S. Forest Service. 20 p.

Gallant, A.L., E.F. Binnian, J.M. Omernik and M.B. Shasby. 1995. Ecoregions of Alaska. U.S. Geol. Surv. Prof. Paper 1. 73 p. plus map.

Hasselbach, L.M. 1995. Vascular and nonvascular vegetation of Aniakchak Caldera, Alaska. Tech. Rep. NPS/PNROSU/NRTR-95/05. National Biological Service, Forest and Rangeland Ecosystem Science Center, College of Forestry, Oregon State University, Corvallis, OR. 69 p.

Hubbard, B.R. 1931. A world inside a mountain. National Geographic Magazine. 60(3): 319-354.

Jorgenson, M. T., J. E. Roth, E.R. Pullman, R.M. Burgess, M. Raynolds, A.A. Stickney, M.D. Smith and T. Zimmer. 1997. An ecological land survey for the Colville River Delta, Alaska, 1996. Unpubl. Rep., Prep. for ARCO Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK. 160 p.

Jorgenson, M. T., J. E. Roth, M. Raynolds, M.D. Smith, W. Lentz, A. Zusi-Cobb and C.H. Racine. 1999. An ecological land survey for Fort Wainwright, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH. CRREL Rep. 99-9. 83 p.

Jorgenson, M. T., J. E. Roth, M.D. Smith, S. Schlentner, W. Lentz, and E.R. Pullman. 2000. An ecological land survey for Fort Greely, Alaska. U.S. Army Cold Regions Research and Engineering Laboratory. In press.

Jorgenson, M.T. 2000. Landscape-level mapping of ecological units for the Bering Land Bridge National Preserve. Draft Rep. Prep. for U.S. National Park Service, 2525 Gambell St., Anchorage, AK. 42 p.

Karlstom, T.N.V. and others. 1964. Surficial geology of Alaska. U.S. Geol. Survey Misc. Geol. Investigations Map I-357. Scale 1:584,000.

Knappen, R.S. 1929. Geology and mineral resources of the Aniakchak district. U.S. Geol. Surv. Bull. 797: 161-223.

Lyle, W.M. and P.L. Dobey. 1973. Geologic and mineral evaluation of the Aniakchak River drainage, Alaska Peninsula, for wild and scenic river study. Alaska Division of Geology and Geophysical Surveys Open-File Rep. 26. 21 p. 1 sheet, Scale 1:63,360.

Miller, T.P. and R.L. Smith. 1977. Spectacular mobility of ash flows around Aniakchak and Fisher calderas, Alaska. Geology (5): 173-176.

Miller, T.P. and R.L. Smith. 1987. Late Quaternary caldera-forming eruptions in the eastern Aleutian arc. Alaska. Geology (15): 434-438.

Moxham, R.M. 1951. Pumice deposits in the Alaska Peninsula - Cook Inlet region, Alaska. U.S. Geol. Surv. Open File Rep. 52-103.

Muller, E.H. 1952. The glacial geology of the Naknek district, the Bristol Bay region, Alaska: Unpubl. Ph.D. Dissertation. Illinois University, Urbana, IL 98 p.

National Park Service. 1985. Draft general management plan, Aniakchak National Monument and Preserve, Alaska. U.S. National Park Service, Anchorage, AK. 165 p.

Nowacki, G., P. Spencer, T. Brock, M. Fleming and T. Jorgenson. 2000. Narrative descriptions and map for the Ecoregions of Alaska and Neighboring Territories. Draft 6-1-00; Final Rep. in Prep. 16 p. plus map.

Nowacki, G., M. Shephard, P. Krosse, W. Pawuk, G. Fisher, J. Baichtal, D. Brew, E.. Kissinger and T. Brock. 2001. Ecological Subsections of southeast Alaska and neighboring areas of Canada. Draft Rep. U.S. Forest Service, Tongass National Forest, Juneau, AK. 160 p.

Shephard, M. 2000. Ecological units of Katmai National Park and Preserve, Alaska. Limited Copy Report. U.S. National Park Service, Regional Office, Anchorage, AK. 30 p.

Smith, W.R. 1925. Aniakchak Crater, Alaska Peninsula, in W. C. Mendenhall. (ed.). Shorter contributions to general geology: U. S. Geol. Surv. Prof. Pap. 132: 139-149.

Smith, W.R. and A.A. Baker. 1924. The Cold Bay-Chignik district Alaska: U. S. Geol. Surv. Bull. 755-D: 151-218.

Swanson, D.K. 1999. Ecological units of Yukon-Charley Rivers National Preserve, Alaska. U.S National Park Service, Limited Copy Report YUCH-99-001. Yukon-Charley Rivers National Preserve Office, 201 1st Ave, Doyon Bldg., Fairbanks, AK 99701. 29 p.

Swanson, D.K. 2000. Ecological units of Kobuk Valley National Park, Alaska. Draft Rep. Prep. for U.S. National Park Service, 201 1st Ave, Doyon Bldg., Fairbanks, AK 99701. 31 p.

Swanson, D.K. 2001. Ecological units of Cape Krusenstern National Monument, Alaska. Unpubl. draft Rep. Prep. for U.S. National Park Service, Regional Office, Anchorage, AK. 20 p.

Swanson, F.J., T.K. Kratz, N. Caine and R.G. Woodmansee. 1988. Landform effects of ecosystem patterns and processes. Bioscience 38:92-98.

Viereck, L.A., C.T. Dyrness, A.R. Batten and K.J. Wenzlick. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. Pacific Northwest Research Station, U.S. Forest Service, Portland, OR. 278 p.

Walter, H. 1999. Vegetation of the Earth, and Ecological Systems of the Geobiosphere. Springer-Verlag, New York. 274 p.

Wahrhaftig, C. 1965. Physiographic divisions of Alaska: U.S. Geol. Surv. Prof. Paper 482. 52 p. plus map.

Wibbenmeyer, M., J. Grunblatt and L. Shea. 1982. User's guide for Bristol Bay landcover maps. State of Alaska, and U.S. Dept. of the Interior, Anchorage, AK. 120 p.

Wilson, F.H., R.L. Detterman and G.D. DuBois. 1999. Digital data for geologic framework of the Alaska Peninsula, southwest Alaska, and the Alaska Peninsula Terrane. U.S. Geol. Surv. Open File Rep. 99-317. (WWW pdf Eds.). [in press, to be published as U.S. Geol. Surv. Bull. 1969-B; Map at 1:500,000-Scale, but compiled at 1:250,000].

# *Tables*

## Table 1. Index to the ecological units of Aniakchak National Monument and Preserve.

| Ecoregion | Ecological Section | Ecological Subsection Code | Ecological Subsection Name | Detailed Ecological Subsection Code | Detailed Ecological Subsection Name |
|---|---|---|---|---|---|
| Alaska Peninsula | Aleutian Mountain Range (tentative) | MRL | Meshik River Lowlands | | |
| | | SAL | Aleutian Range-South | SAL1 | Highlands and Ridges |
| | | | | SAL2 | Valley Slopes and Foothills |
| | | | | SAL3 | Aniakchak River Floodplain |
| | | NAL | Aleutian Range-North | NAL1 | Highlands and Ridges |
| | | | | NAL2 | Valley Slopes and Foothills |
| | | | | NAL3 | Cinder River-Pumice Creek Floodplain |
| | | ANV | Aniakchak Volcano | ANV1 | Aniakchak Crater |
| | | | | ANV2 | Explosion Debris - Lava Flow Slopes & Ridges |
| | | | | ANV3 | Ash-Fall / Ash-Flow Plain |
| | | | | ANV4 | Complex Sedimentary & Volcanic Highlands and Ridges |
| | Bristol Bay Lowlands | ACL | Aniakchak Coastal Lowlands | | |

## Table 2. Summary of criteria used to delineate Ecological Subsections in Aniakchak National Monument and Preserve

| Ecological Subsection Code | Ecological Subsection Name | SUMMARY OF DELINEATION CRITERIA |
|---|---|---|
| MRL | Meshik River Lowlands | Flat to undulating, poorly-drained lowland of the Meshik River valley characterized by vast peatlands, and dissected by numerous stream channels with active and inactive alluvial deposits. |
| SAL | Aleutian Range-South | Angular mountains of early Tertiary-aged volcanic rock, dissected by past glacial activity. Steep-walled valleys only a few of which exhibit major alluvial deposits (e.g., Aniakchak River ). Valley slopes and foothills of Holocene volcanic ash flow and ash |
| NAL | Aleutian Range-North | Angular mountains of Jurassic to Cretaceous-aged complex sedimentary rocks, dissected by past glacial activity. Steep-walled valleys only a few of which exhibit major alluvial deposits (e.g., Cinder River-Pumice Creek watersheds). Valley slopes and foothills |
| ANV | Aniakchak Volcano | Aniakchak caldera and slopes of Holocene and Pleistocene volcanic rocks consisting of block- and ash-flows, debris flows, volcanic mud flows, cinder cones, and andesitic and dacitic lava flows. Includes isolated low mountains, rounded hills and ridges of sedimentary and igneous rock |
| ACL | Aniakchak Coastal Lowlands | Coastal lowland complex of beach, estuarine, outwash and alluvial deposits. Associated with rivers and streams that transport high sediment loads of volcanic- or glacially-derived materials. |

## Table 3. The landcover area and number of polygons for Subsections and Detailed Subsections associated with Aniakchak National Monument and Preserve.

**Table 3. The landcover area and number of polygons for Subsections and Detailed Subsections associated with**

| Ecological Subsection | | | | Detailed Ecological Subsection | | | |
|---|---|---|---|---|---|---|---|
| **Name** | **Code** | **No. of Polygons** | **Acreage** | **Name** | **Code** | **No. of Polygons** | **Acreage** |
| Meshik River Lowlands | MRL | 1 | 90100 | | | | |
| Aleutian Range-South | SAL | 7 | 268483 | Highlands and Ridges | SAL1 | 3 | 205890 |
| | | | | Valley Slopes and Foothills | SAL2 | 3 | 44187 |
| | | | | Aniakchak River Floodplain | SAL3 | 1 | 18406 |
| Aleutian Range- North | NAL | 6 | 459091 | Highlands and Ridges | NAL1 | 1 | 388889 |
| | | | | Valley Slopes and Foothills | NAL2 | 3 | 30553 |
| | | | | Cinder River-Pumice Creek Floodplain | NAL3 | 2 | 39649 |
| Aniakchak Volcano | ANV | 13 | 356301 | Aniakchak Crater | ANV1 | 1 | 18751 |
| | | | | Explosion Debris - Lava Flow Slopes & Ridges | ANV2 | 1 | 54607 |
| | | | | Ash-Fall / Ash-Flow Plain | ANV3 | 3 | 217618 |
| | | | | Complex Sedimentary & Volcanic Highlands & Ridges | ANV4 | 8 | 65325 |
| Aniakchak Coastal Lowlands | ACL | 1 | 127626 | | | | |
| TOTAL | | 28 | | | | 26 | |

**Table 4. A summary of the ecological units and criteria used to delineate Ecological Subsections of Aniakchak National Monument and Preserve.**

| Ecoregion | Ecological Section | Ecological Subsection | | Detailed Ecological Subsection | | Subsection Physiography | Detailed Subsection Lithology | Subsection Rationale |
|---|---|---|---|---|---|---|---|---|
| | | Code | Name | Code | Name | | | |
| Alaska Peninsula | Bristol Bay Lowlands (tentative) | | | | | | | |
| | | | | | | | | |
| Alaska Peninsula | Aleutian Mountain Range (tentative) | MRL | Meshik River Lowlands | | | Lowlands | Quaternary Peatland & Alluvial Deposits | Flat to undulating, poorly-drained lowland of the Meshik River valley characterized by vast peatlands, and dissected by numerous stream channels with active and inactive alluvial deposits. |
| | | SAL | Aleutian Range-South | SAL1 | Highlands and Ridges | Angular Mountains | Tertiary Volcanic Rock | Angular mountains of early Tertiary-aged volcanic rock, dissected by past glacial activity. Steep-walled valleys only a few of which exhibit major alluvial deposits (e.g., Aniakchak River). Valley slopes and foothills of Holocene volcanic ash-flow and ash- |
| | | | | SAL2 | Valley Slopes and Foothills | | Holocene Volcanic Debris & Flow Deposits | |
| | | | | SAL3 | Aniakchak River Floodplain | | Holocene Alluvial Deposits | |
| | | NAL | Aleutian Range-North | NAL1 | Highlands and Ridges | Angular Mountains | Jurassic to Tertiary Complex Sedimentary Rocks | Angular mountains of Jurassic to Cretaceous-aged, complex sedimentary rocks, dissected by past glacial activity. Steep-walled valleys only a few of which exhibit major alluvial deposits (e.g., Cinder River-Pumice Creek watersheds). Valley slopes and footh |
| | | | | NAL2 | Valley Slopes and Foothills | | Holocene Volcanic Debris & Flow Deposits | |
| | | | | NAL3 | Cinder River-Pumice Creek Floodplain | | Holocene Alluvial Deposits | |
| | | ANV | Aniakchak Volcano | ANV1 | Aniakchak Crater | Rounded Mountains | Complex Quaternary Volcanic Rocks | Aniakchak caldera and slopes of Holocene and Pleistocene volcanic rocks consisting of block- and ash-flows, debris flows, volcanic mud flows, cinder cones, and andesitic and dacitic lava flows. Includes isolated low mountains, rounded hills and ridges of |
| | | | | ANV2 | Explosion Debris - Lava Flow Slopes & Ridges | | Jurassic to Tertiary Sedimentary & Volcanic Rocks | |
| | | | | ANV3 | Ash-Fall / Ash- | | Holocene | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Flow Plain | | Volcanic Cinder Flows | |
| | | | | ANV4 | Complex Sedimentary & Volcanic Highlands and Ridges | | Jurassic-Tertiary Sedimentary & Igneous Rocks | |
| | | ACL | Aniakchak Coastal Lowlands | | | Hills and Plains | Holocene Coastal Deposits | Coastal lowland complex of beach, estuarine, outwash and alluvial deposits. Associated with rivers and streams that transport high sediment loads of volcanic- or glacially-derived materials. |

**Figure 1. Map of the Alaska Peninsula showing the location of Aniakchak National Monument and Preserve (from NPS 1985).**

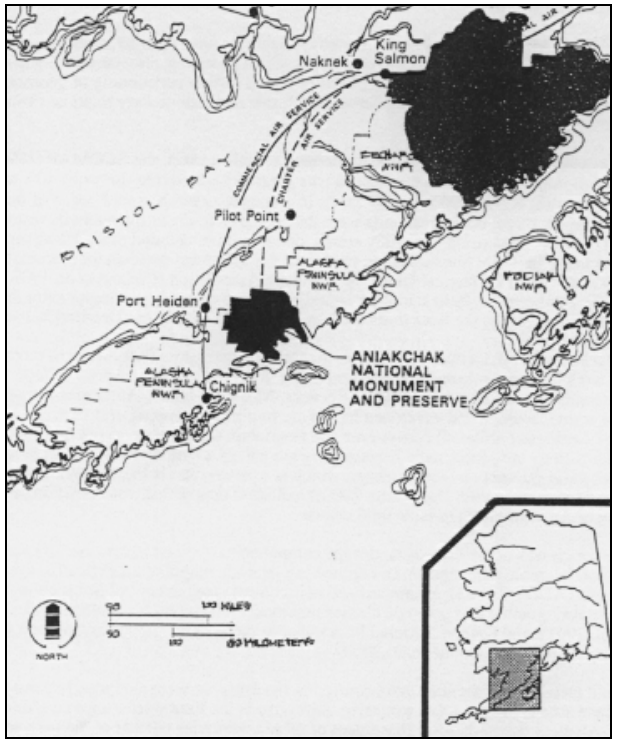



**Figure 2. Map of Subsections within Aniakchak National Monument and Preserve.**

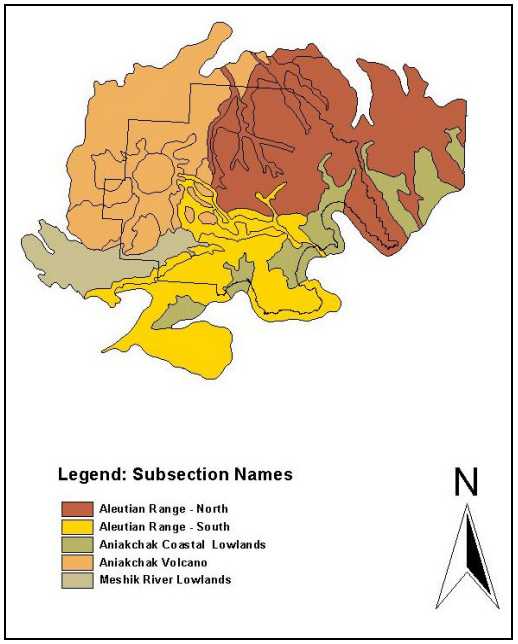



**Figure 3. Map of Detailed Subsections within Aniakchak National Monument and Preserve.**