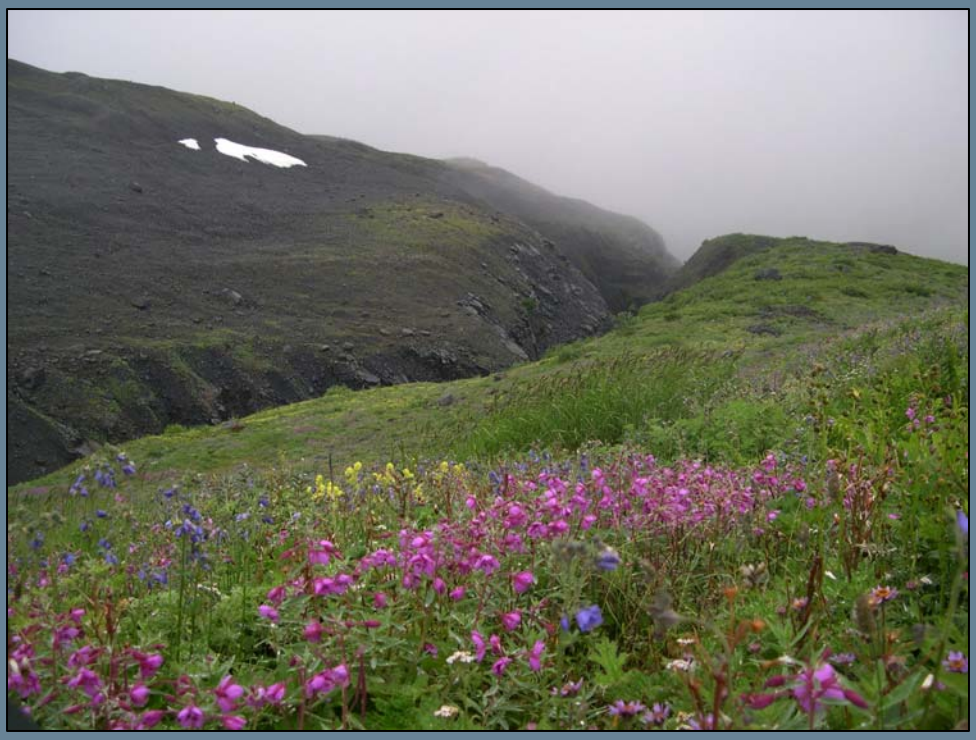
SOUTHWEST ALASKA NETWORK
VASCULAR PLANT INVENTORY
SUMMARY REPORT



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ACRONYMS:

I&M	Inventory & Monitoring
SWAN	Southwest Alaska Network
AKNHP	Alaska Natural Heritage Program
ANIA	Aniakchak National Monument & Preserve
ALAG	Alagnak Wild River
KATM	Katmai National Park & Preserve
KEFJ	Kenai Fjords National Park
LACL	Lake Clark National Park & Preserve

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ABSTRACT

From 2001 to 2005 the Alaska Natural Heritage Program (AKNHP), University of Alaska Anchorage, conducted vascular plant field inventories in Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), Katmai National Park and Preserve (KATM), Kenai Fjords National Park (KEFJ), and Lake Clark National Park and Preserve (LACL), in accordance with a cooperative agreement with the National Park Service. The primary goal was to document greater than 90% of the vascular plant species expected to occur within each of the park units and to significantly improve our understanding of the distribution of species of the region. The inventory targeted diverse habitat types and under-sampled areas. The AKNHP staff visited the primary ecogeographic regions in each park and sampled intensively each summer from early July to early August. A total of 2,307 specimens were collected, recorded, and pressed. Five hundred fifty-seven of these collections represent taxa previously undocumented in the parks. The known, documented flora increased by roughly 30% for each of the five units, yielding collections that represent 74 – 96% of the species expected to occur. A total of 21 species of conservation concern were collected from four of the parks (ANIA, KATM, KEFJ, LACL). Small populations of non-native species were found in three of the park units (KATM, KEFJ, LACL). Significant range extensions and globally and regionally rare plants were encountered in all units. One collection from ANIA, *Botrychium pedunculosum*, is a new record for Alaska. Here, we summarize our findings and discuss the significance of the non-native species, range extensions, and rare species. We put these findings into a regional context and make recommendations for future scientific inquiry.

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EXECUTIVE SUMMARY

The Inventory and Monitoring Program (I&M) of the National Park Service supported vascular plant inventories to document the occurrence, distribution, and relative abundance of plants occurring in the Southwest Alaska Network (SWAN). The Southwest Alaska Network includes Lake Clark National Park and Preserve (LACL), Katmai National Park and Preserve (KATM), Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), and Kenai Fjords National Park (KEFJ). The inventories were developed to provide baseline information for future monitoring and management of natural resources within the SWAN. From 2001 to 2005 the University of Alaska Anchorage (UAA), Alaska Natural Heritage Program (AKNHP) conducted field inventories in LACL, KATM, ALAG, KEFJ, and ANIA under Cooperative Agreement No. 1443CA991000013, Modification numbers 10, 13, 17, and 30. In addition to gaining a better understanding of the distribution of species in the region, the major goal was to document 90% or more of the vascular plant species that would be expected to occur within each unit. We focused our efforts on diverse habitat types and areas that were historically underrepresented in botanical surveys. Here we summarize our findings from five years of inventory work in these units. For a more complete description of work completed in each park unit, see the final technical reports: Lipkin 2002 (LACL), Carlson et al. 2003 (KATM/ALAG), Carlson et al. 2004 (KEFJ), and Lipkin 2005 (ANIA).

Our research was initiated by an analysis of previous floristic surveys. Very large gaps in our floristic knowledge were noted for each park unit. A number of units had sites that had been previously surveyed or had received some attention from botanists, such as Brooks Camp (KATM) and Exit Glacier (KEFJ). Virtually no collections were known from ALAG or from most of ANIA. Nearly all previous collections were concentrated at low elevations and close to park headquarters or other easily accessible sites. Following discussions with NPS personnel and the Alaska Plant Inventory Working Group, gaps were identified and floristic sampling areas targeted. AKNHP inventory sites encompassed most geographic regions and plant community types. Nunataks on the Harding Icefield (KEFJ) and in the Chigmit Mountains (LACL) had not been sampled in the initial inventory and were subsequently visited in July and August 2005.

While in remote collection areas, we hiked to as many habitat types and geographic areas as possible and collected specimens that were known to be new records or that were considered significant in some way (e.g., range extensions, species of conservation concern). Access to sites was by rotary and fixed-wing aircraft, and by boat. At each collection site, data were gathered on site characteristics, associated species, habitat conditions, etc. Final taxonomic determinations and herbarium mounting of specimens were done by AKNHP and staff of the University of Alaska Fairbanks Museum.

A total of 2,307 specimens were collected, recorded, pressed, and curated by AKNHP. Duplicate or triplicate collections exist for many of the specimens. A total of 1,487 individual taxa are represented and 557 are new records for SWAN. Following our fieldwork, the percentage of known, verified taxa expected to occur increased from 0 to 31% for ALAG, 74 to 96% for ANIA, 54 to 84% for KATM, 40 to 77% for KEFJ, and 52 to 74% for LACL.

Invasive plants were encountered at KATM, LACL, and KEFJ, but not at ALAG or ANIA. Three invasive species were collected at Brooks Camp in KATM. Five invasive species were collected in LACL, at Port Alsworth and Silver Salmon Creek. Two invasive were collected in KEFJ at a relatively remote cabin site. Populations of all of these species appear to be restricted to

the areas of highest human density and generally do not show signs of invading natural ecosystems. However, we recommend removal of these populations.

The SWAN units comprise an important floristic center, combining Arctic, Aleutian, Boreal, and Pacific Northwest maritime floras. The region also contains a high diversity of vascular plants and harbors very important rare and disjunct species. Range extensions and range-filling collections were made in all SWAN units. These collections represent range-fillers for species with Aleutian-Gulf Coast distributions, and modest to significant range extensions for interior-montane species to the south and west, and disjunct arctic species to the southeast of their known distributions.

Twenty-one rare taxa were collected within the park units. This represents roughly 6% of the 370 taxa tracked by the AKNHP. Four of these taxa are critically imperiled in Alaska; most of the other taxa are widely distributed but very uncommonly collected in the state. A collection of stalked moonwort (*Botrychium pedunculosum*) from the Meshik River Lowlands (ANIA) is a new record for Alaska. A white-flowered jacob's ladder (*Polemonium*) collected in Aniakchak Caldera (ANIA) remains under study but appears to be a local variant of *Polemonium boreale* var. *villosissimum*. A collection of Lemmon's rockcress (*Arabis lemmonii*) from Saddle Mountain (LACL) appears to be morphologically distinct from other collections in Alaska and the Yukon. In Beauty Bay (KEFJ) we found the very rare and poorly delineated species *Cochlearia sessilifolia*, or sessile-leaved scurvy grass.

Additional, opportunistic surveys of areas missed in the original inventory may yield additional park records, including additional rare taxa. These areas include, but are not limited to, calcareous outcrops, ultramafic intrusions, and high elevation sites near the park boundaries. A number of taxonomic problems persist for rare species found in the units, and additional study may be required for final determination. Additionally, the phylogeography of the region requires a much more detailed investigation; we found assemblages of species on nunataks that are disjunct from their range by 1,000 km (620 mi.) to the west. It is unknown if this region has served as a center from which plants dispersed, or if its diversity is due to recent migrations into the region. Last, we recommend the use of rare plants as bioindicators of current and future ecological change.

Key Words –
Southwest Alaska Network, Alagnak Wild River, Aniakchak National Monument and Preserve, Katmai National Park and Preserve, Kenai Fjords National Park, Lake Clark National Park and Preserve, inventory, vascular plants, rare plants, non-native plants, invasive plants

INTRODUCTION

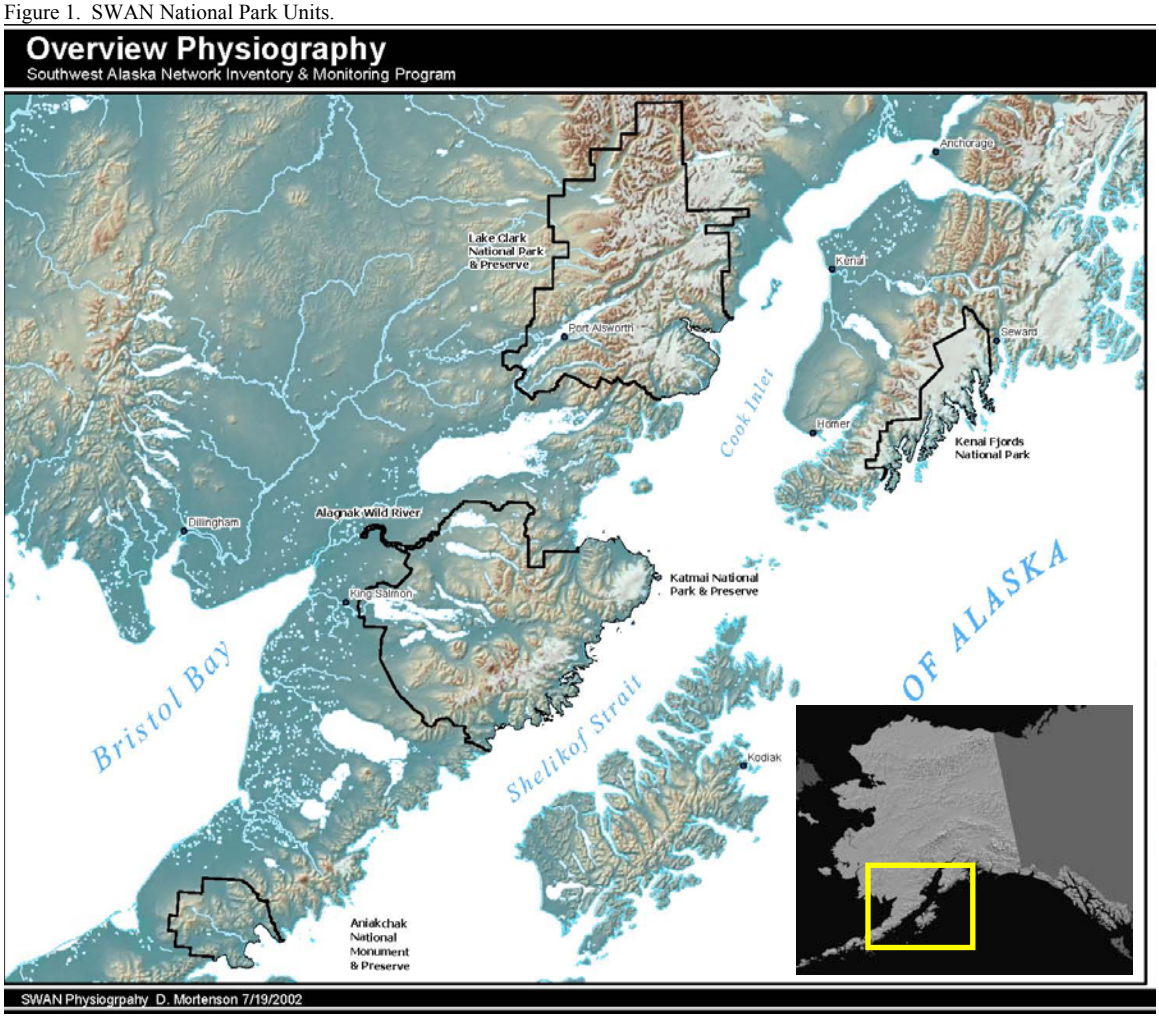
An Inventory and Monitoring (I&M) Program for the National Park Service (NPS) was established by the US Congress in 1992. The goal of the I&M program is to establish baseline information on, and monitor long-term trends in, natural resources in the parks. Biological inventories were conducted to establish data to be used in future monitoring programs, make management decisions, conduct research, and educate the public. To meet these objectives, NPS established three program goals:

- Document at least 90 percent of the species of vertebrates and vascular plants expected to occur in the park,

- Describe the distribution and abundance of species of special concern (e.g., rare or invasive species), and
- Provide information necessary to establish a monitoring strategy, with special reference to particular threats and resource issues within each park.

The SWAN includes five units, encompassing 9.4 million acres or 11.6% of all NPS park lands and 2% of Alaska's lands. The units are concentrated along the western Gulf Coast of Alaska, from the Alaska Peninsula northwest to the outer coast of the Kenai Peninsula (Fig. 1.).

Figure 1. SWAN National Park Units.



Alaska Natural Heritage Program (AKNHP) botanists inventoried the vascular flora of LACL (2001), KATM and ALAG (2002), KEFJ (2003) and ANIA (2004). Nunataks (ice-free mountains) in extensive glacial regions were surveyed in a separate inventory in KEFJ and LACL (2005). This report summarizes highlights from each of the inventory efforts, including a brief discussion of the regions inventoried, methods employed, the flora encountered, and recommendations for future work.

Physiographical and Ecological Background

The florisitic elements encountered in our inventories should be viewed in light of the physical, ecological, and historical-geological context. Here we give a brief overview of the SWAN. For more detailed descriptions, see Shephard and Spencer (2000), Tande and Michaelson (2001), Tande et al. (2001), and Spencer (2001, 2002a, 2002b).

The region circumscribed by the SWAN parks is characterized by an extremely dynamic landscape and climate. The Aleutian-Alaska Range and Kenai Mountains are a parallel series of mountains running southwest-northeast that are the result of tectonic activity as the Pacific Plate is subducted under the North American Plate. These ranges abut the Gulf of Alaska, which brings relatively warm, moisture-bearing air to the southern flanks of the mountains. The northern and western slopes of the mountains are characterized by much drier conditions, warmer summers and cooler winters. Parks on the Alaska Peninsula are also influenced by the cool waters of the Bering Sea to the west, where discontinuous permafrost is not uncommon along the Bristol Bay Lowlands (Ferrians 1965). The mean summer temperature in western LACL is 12.8ºC, with a winter temperature of -8.9ºC and just 37 cm of precipitation annually, while the eastern portion of KEFJ has a similar mean summer temperature of 12.6ºC, a milder mean winter temperature of -3.1ºC, and over 170 cm of precipitation (Western Regional Climate Center 2005).

The physiography of the SWAN ranges from sea-level coastal forelands and beaches to volcanic peaks over 3,000 m (9850 ft.) in elevation. Large lakes and long, low-gradient rivers are common features in KATM and LACL; short, high-gradient rivers and streams are a common feature to all SWAN units. A large portion of KATM, KEFJ, and LACL are covered by glaciers. KEFJ, in particular, is characterized by an extensive, geologically young and dynamic glacial fjord system. It is backed by the Kenai Mountains and possesses the largest ice sheet entirely in Alaska (see Mann 1998 for a discussion of geology and ecological context).

Volcanism is an important force in ANIA, KATM, and LACL. A massive eruption of the ancestral Aniakchak Volcano occurred 3,400 years BP. This left a large caldera and blanketed the region with pyroclastic flows. Minor eruptions have continued into the last century. Catastrophic eruptions also have occurred in KATM; most notable was the 1912 eruption of Novarupta that left extremely thick tuffaceous ash deposits in the Valley of Ten Thousand Smokes. Three volcanic piles are active in LACL and are responsible for a series of ash and pumice deposits.

The lithology of the region is quite diverse, including multi-aged plutonic and volcanic, sedimentary, and metamorphic rocks. KATM and LACL, in particular, are characterized by a range of parent materials that strongly influence plant distributions (Kruckeberg 2002), from highly acidic granites and neutral shales, to basic limestone outcrops, and even ultramafic intrusions.

The biota of southwestern Alaska is also strongly influenced by glacial history. At the height of the Illinoian (ca. 200,000 years BP), all of southern Alaska and the Aleutians were under extensive glaciers (Fig. 2). At this time Alaska was connected with Siberia by a large unglaciated subcontinent (Beringia) and isolated from the rest of North America by extensive ice sheets. This allowed for considerable migration of Asian taxa (e.g., *Sausseria*) into the North American continent. Many of these Asian-affiliated taxa have not since migrated to the east or south, making Alaska and Yukon as floristically similar to Siberia as to other northern portions of North America (Hultén 1937, Hultén 1968). Climatic conditions were ameliorated 100,000 years BP, with the climate becoming much warmer and wetter and the continents being separated by a

shallow sea again. The forests were little different from their current composition and expanded throughout interior and southern Alaska (Hopkins et al. 1982, Hultén 1968). The climate began to cool again after the interglacial period, reaching another glacial maximum at 20,000 years BP (Wisconsin Glaciation, Fig. 2).

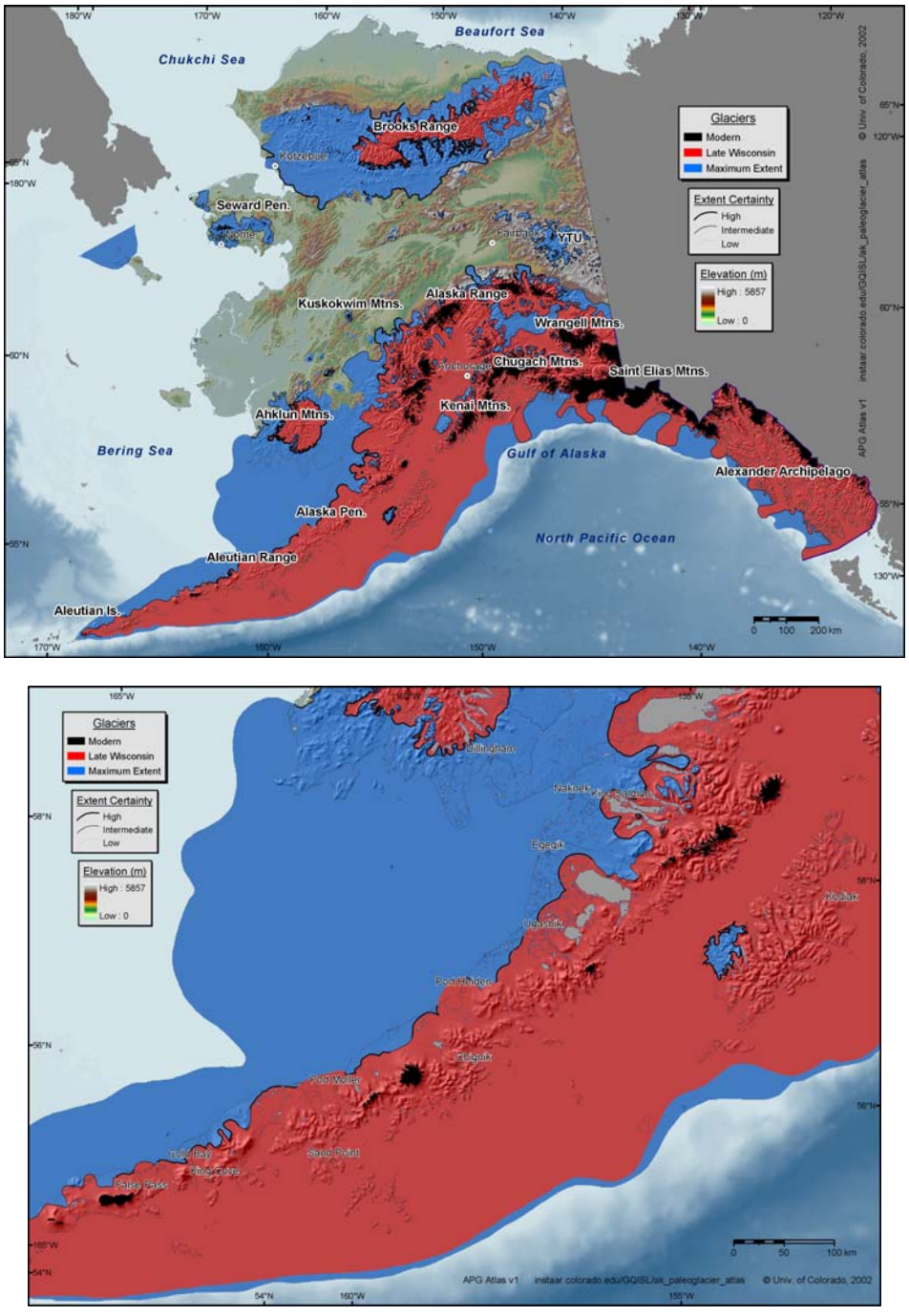


Figure 2. Alaska Paleoglacial Extents (Manley and Kaufman 2002)

Glaciation was not as extensive during the Wisconsin as in the Illinoian, and many ice-free regions were present in areas now circumscribed by the SWAN parks. The Bristol Bay lowlands, Caribou Hills on the Kenai Peninsula, and numerous smaller nunataks in the Aleutian and Alaska Range remained unglaciated until the present time (Manley and Kauffman 2002).

The landscape-level plant assemblages of SWAN are extensive and diverse, and are covered elsewhere (Shephard and Spencer 2000; Tande and Michaelson 2001; Tande et al. 2001; Spencer 2001, 2002a, 2002b). It is critical to note, however, that these environments include such diverse elements as halophytic coastal meadows, moist lowland tundra underlain by permafrost, white spruce-birch forests, cottonwood and willow-dominated alluvial floodplains, herbaceous subalpine meadows, and barren fellfields.

METHODS AND MATERIALS

The AKNHP's vascular plant inventory effort was initiated in 1999 with the compilation of an expected species list, site selections, and development of a sampling design (AKNHP 2000). Fieldwork was conducted from 2001- 2005.

Expected and Known Taxa

To achieve 90% documentation of the expected flora, a list of known and probable taxa was compiled by AKNHP. Plant collections from the herbarium of the University of Alaska Museum (ALA) and from the herbaria of the various park units (ANCS+ database) were compiled in a database, along with selected collections from other herbaria, additional observations, and floristic lists from published and unpublished literature. Collections from ALA had been verified for both taxonomic identification and geographic location, while collections from ANCS+ were largely unverified. Taxa that were known only from unverified collections or from observations or literature citations were recorded as "Unconfirmed."

Compiling the expected species list for areas that are so poorly known botanically is replete with difficulties. We included taxa that had been documented within 50 km of the park units, or that were expected to occur in the unit for other reasons, as "Probably Present" (Fig. 3). This is a very rough approximation of taxa actually present in the units. Even after revisions were made based on likely habitats and geography, the list undoubtedly omitted some existing taxa and included others that were not present. Using these criteria, we initially determined that the percentage of the total expected flora known to be present in each unit ranged from ca. 40% to 55% (with the exception of ALAG, in which no prior collections were present). This initial analysis did not fully account for species duplicated due to taxonomic synonymy.

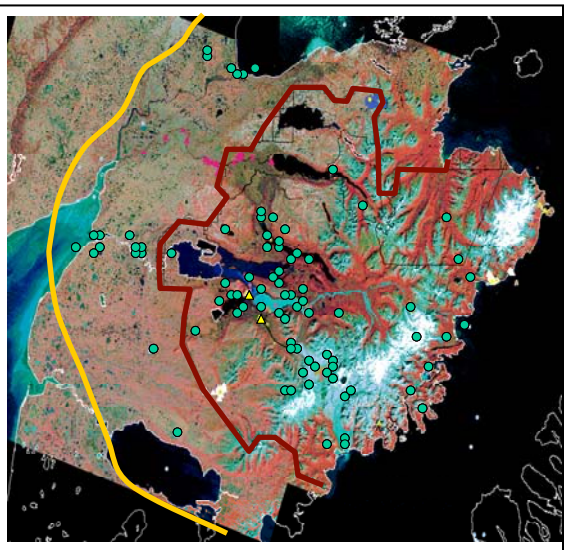


Fig. 3. Katmai National Park and Preserve, showing previous collection localities (green dots) within the unit (red line) and within the 50 km buffer (yellow line).

Taxonomic designations are in a constant state of flux, despite efforts to create a natural and stable classification system. Taxa are often ascribed different names by different authors who are unfamiliar with one another's work, or an author may split a single species into one or more species, subspecies, or varieties. This nomenclatural confusion has been identified as a research priority that is fundamental to ecosystem management and biodiversity conservation. This primary need, noted by the White House on Biodiversity and Ecosystem Dynamics Subcommittee, requires improvements in the organization of, and access to, standardized nomenclature. ITIS (originally referred to as the Interagency Taxonomic Information System: http://www.itis.usda.gov/) was designed to fulfill these requirements.

We used the standardized nomenclature of ITIS to eliminate all taxa that were recorded more than once. We reanalyzed the expected species list to remove the large number of synonyms that artificially inflate the diversity in each unit. Synonyms were eliminated from the "Probably Present" list if found on the "Unconfirmed" list. If synonyms were found on the "Present" list, then synonyms were removed from both the "Probably Present" and "Unconfirmed" lists.

After synonym removal, the number of taxa expected to occur in most units dropped by about 5%. For example, the number of expected taxa in KEFJ dropped from 573 to 543. Of the 543 taxa, 127 were listed as "Present." A total of 326 were listed as "Probably Present," and 90 were listed as "Unconfirmed." This indicates that 40% of the expected flora was documented prior to AKNHP fieldwork. ITIS names are used in this document, with names used in Hultén (1968) included parenthetically for commonly encountered species.

Floristic History of SWAN

Early botanical collections in the SWAN region are quite limited and the paucity of information has translated into large gaps in our understanding of the floristics and ecology. The earliest collections on the Alaska Peninsula are from Georg Heinrich von Langsdorff and Wihelm Tilesius, who accompanied Krusenstern on his voyages in 1803-1806 (Hultén 1968). More focused collecting occurred in what is now KATM by Griggs in 1915-1930, following the 1912 eruption of Novarupta, and in the KEFJ area by G. W. Gasser and E. Hultén in 1932. Collection intensities slowly increased in the 1940's and 1950's by individuals such as Cahalane and Jacob Anderson, and additional botanical work increased again in the 1970's to 1980's following the establishment of the park units (NPSpecies 2004).

Figure 4. Early Alaskan botanist Robert F. Griggs collecting plants from a *Leymus mollis* beach meadow (from Griggs 1936).

In general, previous collections were concentrated in a few locations of greatest accessibility, near settlements (e.g., Brooks Camp, Port Alsworth) and at low elevations (e.g., Fig. 3.). For all units historic collection sites were few and separated by large distances. Additionally, historic collection sites often included only a few species, making mapping of previous collection intensity difficult.

Sampling Design

In order to attain the goal of documenting 90% of the expected flora, we used the reconnaissance method of floristic survey. This method was recommended as the best approach for plant inventories in all Alaska parks by the Alaska Plant Inventory Working Group in September 2000; the general methodology is also supported by Catling and Reznicek (2003). The reconnaissance method involves identifying survey areas within landscape units via spatial analysis using the following key criteria:

- regionally unique geological or geomorphologic features
- communities or habitats of biological concern
- likely habitats of expected species, as indicated by regional floras and Park collections
- under-represented plant communities in existing inventories
- logistical feasibility (e.g., access, cost)
- potential of certain types of sites to maximize species and communities encountered (e.g., ecotones, high environmental gradient areas)

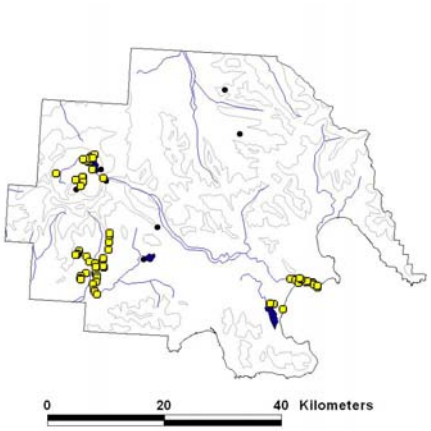
We selected collection sites to represent the range in variability of ecological subsections, landcover types, wetlands, plant associations, and vascular plant species diversity. Collection sites were explored by covering the region by foot and by carefully examining all the plant species to identify those that were new or noteworthy. Greater time and effort was expended in high diversity and high environmental gradient areas.

This targeted, judgment-based approach is an efficient way to locate populations of species of special concern based on known habitat preferences and patterns of distribution. As surveys progressed, the list of species of special concern was refined, as well as knowledge of species' habitat and geography.

Collection Locations

Based on the sampling design criteria, we concentrated our inventory efforts in LACL on the northwest corner, mountains and nunataks of the eastern interior, and the southeast coastal region. In KATM we focused on tundra communities in the northeast corner, coastal and montane communities, and the southern border of the park in the Bristol Bay lowlands. Since no collections were known from ALAG and the unit is small, we surveyed the extent of the Wild River boundary from Nonvianuk Lake. In KEFJ, collections were focused on the coastline, Nuka River Pass, the Resurrection River, and nunataks on the Harding Icefield. Relatively few collections were known from ANIA outside of the caldera, and we focused our collecting along the lower Aniakchak and Meshik Rivers, and on the coast at Aniakchak Bay. Figure 4 shows the collection locations for each park unit. Detailed descriptions of the collection locations and habitats are given in the individual park reports.

Figure 5. SWAN park units, showing specific collection sites by AKNHP (yellow circles) and previous collections (black circles) for A) ANIA, B) KATM and ALAG, C) KEFJ, and D) LACL.



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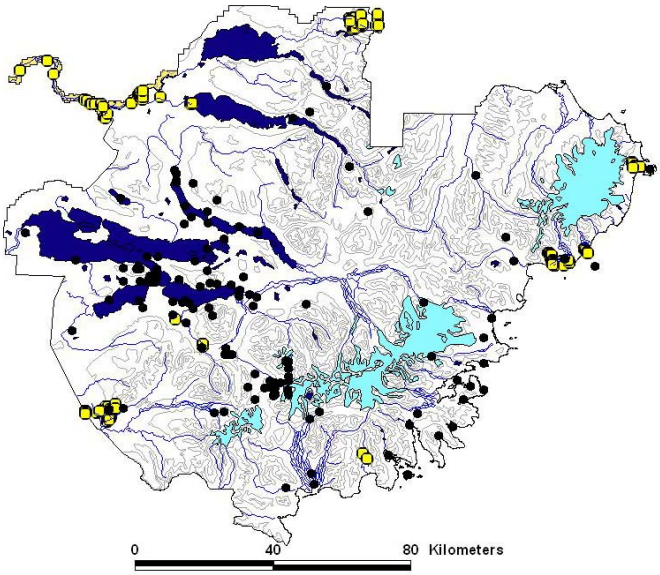

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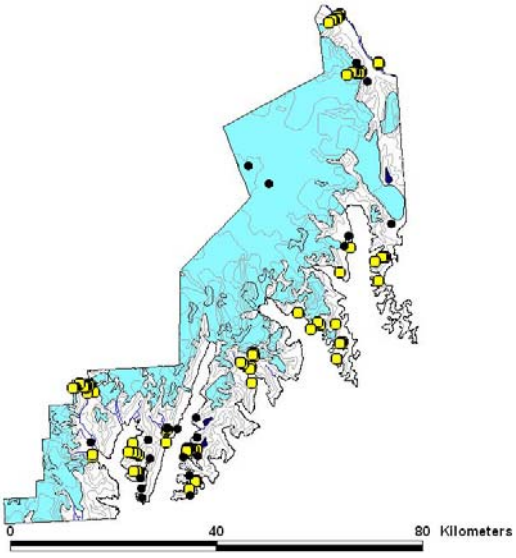

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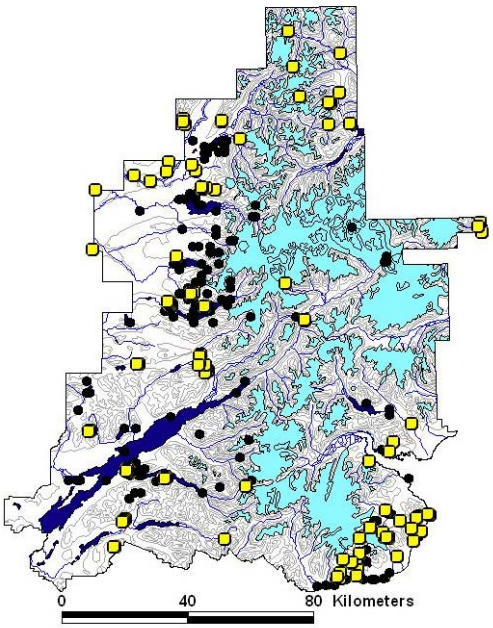


D.

Field Methods

The field personnel consisted of teams of two to four people. This included AKNHP botanists (Matt Carlson, Rob Lipkin, Michelle Sturdy, Anna Jansen, Mike Duffy, Koren Bosworth, Bruce Bennett, Phil Caswell, and Eve Laeger) and NPS ecologists and support staff (Amy Miller, Page Spencer, Penny Knuckles, Bud Rice, Eric Groth, Lucretia Fairchild, Ian Pierce, and Evelyn Martin).

Transportation to most areas within the units was by fixed-wing aircraft. Helicopters were used to access high elevation sites at KEFJ and LACL. River rafts were used in ALAG and ANIA. Access to much of the coastal region in KEFJ was facilitated by the NPS vessel *Serac*. Collections were made by daily forays on foot from central base camps. Site data and specimens were collected during 20- to 30-day field seasons each summer.

At each site we conducted a complete floristic inventory using the following methods:

- Each area was mapped on an aerial photo or USGS topographic map and collection sites were georeferenced using a GPS. Survey routes were also mapped. Representative photos were taken of each area including the plant communities, unusual landforms, and notable plants present.
- A description of each area was recorded and significant landforms and plant associations described.
- As new communities were encountered, the following data were recorded: vegetation type, slope, aspect, elevation, topographic position, moisture, soil types, parent material, cover classes of growth forms and bare ground, and dominant species by growth form.
- Additional data were gathered specific to the location, habitat, etc. in which plants were collected (these collection localities are referred to as "collection sites"). The nature of data collected is discussed in the following section.
- Vouchers were collected and curated as discussed below.

Collections were made only if the population was large enough to support removal of individuals, following the collecting protocols of Murray and Parker (1990) and Parker and Murray (1992). Rare plant sighting forms with maps were completed for species with an AKNHP state rank of less than 3 (i.e., “rare or uncommon,”).

Vouchers and Curation

The following data were recorded with each vouchered specimen: date, unique collection number, latitude and longitude (NAD27, decimal degrees, taken from a handheld GPS unit); slope, aspect, elevation, topographic position, associated landforms, associated species, vegetation class, substrate, soil moisture, soil type, drainage, parent material, cover class and frequency class, notes on characters not preserved well (e.g., flower color), associated photo number, phenology, and ecological observations. Each voucher specimen is referenced to a specific geographic locality, generally less than 1,000 m^2 (10,760 ft^2), having a uniform habitat. Collections at each site ranged from single specimens to ≥ 20 individuals. In general we would collect one or two representatives of each taxon for each park unit. Multiple collections of the same taxon occurred if the taxon was found in a significantly different location or habitat type, if the taxon was of conservation significance, or if it was not easily identifiable in the field (e.g., the same species of bluegrasses and sedges were often collected multiple times).

The size of the population and area surveyed was included for species of conservation concern. Population is defined here as a group of individuals of the same species (or subspecies) that occupy the same locality separated from other such groups by more than 1 km (0.6 mi.). This follows from the definition that NatureServe uses to define "element occurrences."

The first set of collection sheets were archived at the Herbarium of the University of Alaska Museum (ALA). A second, duplicate, set was sent to NPS if enough material was present for a second sheet. If a third sheet was present it was archived at the University of Alaska Anchorage herbarium.

Specimens were given conditional names in the field by AKNHP and NPS staff. The plants were later sorted, examined and identified by AKNHP botanists and the collections were then sent to ALA where notable finds and difficult taxa were reviewed by the museum staff. As needed, specimens were sent out to authorities by ALA for determination. Specimens to be archived at ALA and those to go to park herbaria were prepared at ALA.

RESULTS

Following fieldwork from 2001 to 2005, the number of vascular plant species verified for each park unit increased signficantly. The percentage of known taxa was improved dramatically for all units, but we documented 90% or greater of the expected number of taxa only in ANIA. Summaries for each unit follow. The broader relevance and importance of the findings are covered in the Discussion section.

Park Unit Summaries

Lake Clark National Park and Preserve (LACL)

LACL was relatively well known prior to our fieldwork, with 52% of the 571 expected species known from verified collections and an additional 21% known from unconfirmed reports in the literature. The percentage of known taxa increased to 80% following intensive sampling in 2001 and limited sampling on nunataks in 2005. The total number of collections for this unit was 827, representing 386 separate taxa. Twenty-four (24) were collections of taxa previously unrecorded, but expected to occur ("Probably Present") and 15 were of taxa not expected to occur in LACL. The 15 unexpected taxa represent range-filling collections and significant range extensions. In one case, the taxon was found more than 600 km (375 mi.) to the west of previously known collections.

Twelve (12) species collected in the inventories are tracked by the AKNHP (Table 1). A number of these species are quite widespread in North America, but are only known from a handful of locations in Alaska, and the majority of them are endemic to Alaska and the Yukon and are known from 30 or fewer locations.

Five (5) collections from LACL are of invasive species. These were *Amaranthus retroflexus* (not ranked), *Chenopodium album* (AKNHP invasiveness = 35), *Leucanthemum vulgare* (AKNHP invasiveness = 61), *Rumex acetosella* (not ranked), *Stellaria media* (not ranked). All of these collections were from developed areas at either Port Alsworth or Silver Salmon Creek.

Table 1. Rare species collected at Lake Clark National Park and Preserve by AKNHP

Scientific Name	Global Rank*	State Rank*	Habitat	Number of Sites in LACL taxon was collected
Aphragmus eschscholtzianus	G3	S3	Alpine	2
Arabis cf. *lemmonii*	G5	S1	Alpine	3
Arnica diversifolia	G5	S1	Alpine	1
Botrychium alaskense	G2G3	S2S3	Alpine	1
Carex phaeocephala	G4	S1S2	Alpine	3
Douglasia alaskana	G3	S3	Alpine	1
Eleocharis kamtschatica	G4	S2S3	Estuary/Wetland	2
Papaver alboroseum	G3G4	S3	Alpine	1
Potentilla drummondii	G5	S2	Alpine	2
Rumex beringensis	G3	S3	Alpine	4
Taraxacum carneocoloratum	G3Q3	S3	Alpine	1
Thlaspi arcticum	G3	S3	Alpine	2

* 1 = Critically imperiled (globally or within the state), 2 = Imperiled, 3= rare or uncommon, 4 = Apparently secure, but cause for long-term concern, 5 = Demonstrably secure. Q = taxonomically questionable.

Alagnak Wild River (ALAG)

Prior to our surveys, virtually no plants had been collected from ALAG. In a single drift trip of 42 km from the confluence of Nonvianuk and Alagnak Rivers to Middle River Camp we collected 133 specimens. Of these, 120 were new records for the unit and they represent 31% of the total expected 390 vascular plant taxa. No invasive or rare species were encountered and nearly all are common species of the Bristol Bay lowlands.

Katmai National Park and Preserve (KATM)

Our verification of taxa known for KATM increased from 54% to 84% following fieldwork in 2002. We collected over 500 specimens; 146 were new records for the park. Two species were rare globally and within the state: *Primula tschuktschorum* (G3 S3) and *Aphragmus eschscholtzianus* (G3 S3). Three invasive species were collected: *Capsella rubella* (not ranked) *Matricaria discoidea* (AKNHP invasiveness score = 34) and *Plantago major* (AKNHP invasiveness score = 44).

Table 2. Rare species collected at Lake Clark National Park and Preserve by AKNHP

Scientific Name	Global Rank*	State Rank*	Habitat	Number of Sites in KATM taxon was collected
Aphragmus eschscholtzianus	G3	S3	Alpine	1
Primula tschuktschorum	G3	S3	Alpine	1

* 1 = Critically imperiled (globally or within the state), 2 = Imperiled, 3= rare or uncommon, 4 = Apparently secure, but cause for long-term concern, 5 = Demonstrably secure. Q = taxonomically questionable.

Kenai Fjords National Park (KEFJ)

Prior to our efforts, 40% of the 543 expected taxa were known from KEFJ. Following the 2003 field season, 131 collections were made of taxa considered "Probably Present" but not vouchered, 70 new taxa were collected that were not originally predicted to occur in the Park, and 34

collections represented vouchered collections of previously "Unconfirmed" taxa. Thus, the percentage of documented vascular plant taxa relative to the 2003 expected list rose to 77%. This indicates significant progress toward the goal of documenting greater than 90% of vascular plant taxa in KEFJ.

Collections were made of five globally or regionally restricted species (Table 3). Two invasive species (*Poa annua* – invasiveness rank = 51 and *Cerastium fontanum* – not ranked) were collected from remote cabin sites along the coast. Eight species represent new collections for the Kenai Peninsula. Most of these range extensions were of species common to the Interior, and three were range-filling collections of Gulf Coast Species.

Table 3. Rare species collected at Kenai Fjords National Park by AKNHP

Scientific Name	Global Rank*	State Rank*	Habitat	Number of Sites in KEFJ taxon was collected
Carex lenticularis var. *dolia*	G5T3Q	S3	Wetland	4
Carex phaeocephala	G4	S1S2	Alpine	2
Cochlearia sessilifolia	G1Q	S1	Tidal Zone	1
Douglasia alaskana	G3	S3	Alpine	1
Papaver alboroseum	G3G4	S2	Alpine	1
Platanthera chorisiana	G3	S3	Wetland	2
Thlaspi arcticum	G3	S3	Alpine	1

* 1 = Critically imperiled (globally or within the state), 2 = Imperiled, 3= rare or uncommon, 4 = Apparently secure, but cause for long-term concern, 5 = Demonstrably secure. Q = taxonomically questionable. T = rank described to the variety or subspecies.

Aniakchak National Monument and Preserve (ANIA)

Very few botanical collections were known from ANIA prior to fieldwork by AKNHP. The percent of known vascular plant taxa increased from 74% to 96% in 2004. We collected 388 specimens, which represent 247 individual taxa. One hundred seventy (170) are new park records, 67 of these were expected to occur in the unit, and 103 were unexpected taxa.

Eight collections were of rare species (Table 4) and nine additional collections represented significant range extensions. A white-flowered *Polenomium* collected from the Caldera appeared to be a local variant of *P. boreale* var. *villossissimum*. No invasive species were encountered in ANIA.

Table 4. Rare species collected at Aniakchak National Monument and Preserve by AKNHP

Scientific Name	Global Rank*	State Rank*	Habitat	Number of Sites in ANIA taxon was collected
Aphragmus eschscholtzianus	G3	S3	Alpine	1
Botrychium alaskense	G2G3	S2S3	Alpine	4
Botrychium pedunculosum	G2G3	S1?	Herbaceous Meadow	1
Carex lenticularis var. *dolia*	G5T3Q	S3	Wetland	1
Douglasia alaskana	G3	S3	Alpine	1
Eleocharis kamtschatica	G4	S2S3	Wetland	3
Orobanche uniflora	G5	S1	Herbaceous Meadow	3
Plagiobothrys orientalis	G3G4	S3	Sand Bar	1
Phyllospadix serrulatus	G4	S2	Tidal Zone	1
Viola selkirkii	G5?	S3	Alder Scrubland	2

* 1 = Critically imperiled (globally or within the state), 2 = Imperiled, 3= rare or uncommon, 4 = Apparently secure, but cause for long-term concern, 5 = Demonstrably secure. Q = taxonomically questionable. T = rank described to the variety or subspecies.

Range Extensions

Range extensions and significant range filling collections were made in nearly all of the SWAN park units. These are summarized in Table 5. Greater detail and summaries are given in the Discussion.

Table 5. Range extensions and range filling collections made by AKNHP. When a species name appears more than once it was a range extension in multiple parks.

Scientific Name	Collection Type	Distance From Previous Known Distribution	Park Unit	Habitat
Agrostis trinii	Extension	380 km	ANIA	Wetland
Allium schoenoprasum	Extension	400 km	ANIA	Herbaceous Meadow
Antennaria alpina ssp. *alaskana*	Extension	150 km	KEFJ	Alpine
Aphragmus eschscholtzianus	Range Filling	NA	ANIA	Alpine
Arabis hirsuta	Range Filling	NA	ANIA	Herbaceous Meadow
Arabis lemmonii	Extension	1,300 km	LACL	Alpine
Arabis cf. *media*	Extension	1,300 km	ANIA	Tundra Meadow
Arnica angustifolia	Range Filling	NA	KEFJ	Herbaceous Meadow
Arnica diversifolia	Extension	600 km	LACL	Alpine
Boschniakia rossica	Extension	380 km	ANIA	Alder Shrubland
Botrychium alaskense	Extension	520 km	LACL	Alpine
Botrychium minganense	Range Filler	NA	ANIA	Herbaceous Meadow
Botrychium pinnatum	Range Filler	NA	ANIA	Herbaceous Meadow
Calamagrostis cf. *neglecta*	Extension	780 km	ANIA	Rock Outcrop
Callitriche anceps	Extension	370 km	ANIA	Wetland
Carex bicolor	Range Filler	NA	ANIA	Wet Meadow
Carex bicolor	Range Filling	NA	KEFJ	Wetland
Carex brunnescens	Extension	280 km	ANIA	Wetland
Carex gynocrates	Extension	700 km	ANIA	Wet Tundra
Carex cf. *krausei*	Extension	630 km	ANIA	Rock Outcrop
Carex laeviculmis	Extension	700 km	ANIA	Herbaceous Meadow
Carex magellanica	Extension	530 km	ANIA	Wet Meadow
Carex nardina	Extension	160 km	KATM	Alpine
Carex nigricans	Range Filling	NA	LACL	Alpine
Carex phyllomanica	Extension	850 km	LACL	Wetland
Carex podocarpa	Range Filling	NA	LACL	Alpine
Carex ramenskii	Range Filler	NA	ANIA	Wet Meadow
Carex rupestris	Extension	160 km	KATM	Alpine
Carex spectabilis	Extension	350 km	ANIA	Wet Tundra
Carex stylosa	Extension	370 km	ANIA	Wet Tundra
Claytonia sarmentosa	Extension	350 km	ANIA	Herbaceous Meadow
Crassula aquatica	Range Filling	NA	KEFJ	Tidal Marsh
Douglasia alaskana	Extension	350 km	ANIA	Rock Outcrop
Dupontia fisheri ssp. *psilosantha*	Extension	400 km	ANIA	Wet Meadow
Dupontia fisheri ssp. *psilosantha*	Extension	320 km	KATM	Wetland
Draba fladnizensis	Range Filling	NA	KEFJ	Alpine
Draba glabella	Range Filling	NA	KEFJ	Alpine
Draba cinerea	Range Filling	NA	LACL	Barren Slope
Eleocharis palustris	Range Filler	NA	ANIA	Wetland
Erigeron compositus	Extension	370 km	LACL	Alpine
Euphrasia disjuncta	Range Filling	NA	KEFJ	Alpine
Festuca richardsonii	Extension	360	ANIA	Herbaceous Meadow
Gentianella propinqua ssp. *aleutica*	Range Filling	NA	KEFJ	Alpine
Gentiana prostrata	Range Filler	NA	ANIA	Rock Outcrop
Gentianella tenella	Extension	250 km	KEFJ	Alpine
Gentianella tenella	Range Filler	NA	ANIA	Rock Outcrop
Hierochloe pauciflora	Extension	370	ANIA	Wet Meadow
Juncus bifonius	Range Filler	NA	ANIA	Tidal Zone
Limosella aquatica	Extension	440 km	ANIA	Wetland
Kobresia myosurioides	Extension	160-300 km	KATM	Alpine
Kumlienia cooleyae	Extension	560 km	LACL	Alpine
Luzula spicata	Extension	630 km	ANIA	Rock Outcrop
Minuartia biflora	Range Filling	NA	KEFJ	Alpine
Minuartia biflora	Extension	370 km	ANIA	Alpine
Orobanche uniflora	Extension	150 km	ANIA	Herbaceous Meadow
Phyllospadix scouleri	Extension	2,600 km	ANIA	Tidal Zone
Pedicularis arctoeuropaea	Extension	900 km	LACL	Alpine
Pedicularis sudetica ssp. *interior*	Extension	250 km	KEFJ	Alpine
Polemonium pulcherrimum	Extension	640 km	ANIA	Alpine

Table 5 (continued). Range extensions and range filling collections made by AKNHP. When a species name appears more than once it was a range extension in multiple parks.

Scientific Name	Collection Type	Distance From Previous Known Distribution	Park Unit	Habitat
Polypodium vulgare	Range Filler	NA	ANIA	Rock Outcrop
Potentilla drummondii	Extension	600 km	LACL	Alpine
Prenanthes alata	Range Filler	NA	ANIA	Alder Scrubland
Primula tschuktschorum	Extension	320 km	KATM	Alpine-Wetland
Puccinellia langeana	Range Filler	NA	ANIA	Tidal Zone
Puccinellia nutkaensis	Range Filler	NA	ANIA	Tidal Zone
Ranunculus cf. *arborvitus*	Extension	300 km	ANIA	Herbaceous Meadow
Ranunculus gelidus	Extension	340 km	ANIA	Alpine
Ranunculus nivalis	Extension	160 km	KATM	Alpine
Ruppia maritima	Range Filling	NA	KEFJ	Alpine
Salix pseudomyrsinites	Extension	380 km	LACL	Barren Slope
Saxifraga tricuspidata	Range Filling	NA	LACL	Alpine
Solidago canadensis var. salebrosa	Range Filling	NA	LACL	Herbaceous Meadow
Stellaria humifusa	Extension	230 km	ANIA	Tidal Zone
Taraxacum kamtschaticum	Extension	230 km	ANIA	Herbaceous Meadow
Taraxacum trigonolobum	Range Filler	NA	ANIA	Herbaceous meadow
Utrica dioica	Extension	300 km	ANIA	Alder Scrubland
Viola selkirkii	Extension	400 km	ANIA	Alder Scrubland
Zostera marina	Range Filler	NA	ANIA	Tidal Zone

DISCUSSION

Range Extensions

The vascular plant inventory effort supported by NPS in the southwestern region of Alaska has significantly improved our understanding of the Alaskan flora. This region of the state has long suffered from a lack of systematic botanical collections, making our understanding of many species' distributions rudimentary. Sporadic collecting had occurred in most units, and more focused collecting had occurred in LACL. Major range extensions (≥ 100 km/62 mi.) and significant range filling collections were recorded for all SWAN units except ALAG, approximately 80 in all (Table 5).

Montane-Interior Disjuncts –
The majority of range extensions encountered are characterized by montane interior-boreal species being found south or southwest of their known distributions. *Carex nardina*, *C. rupestris*, *Kobresia myosuroides*, and *Ranunculus nivalis* are examples of species that are well known from the alpine in the Alaska and Brooks Ranges and Interior Uplands, but that were unknown south of the Chigmit Mountains on the Alaska Peninsula (Fig. 6). Fairly wide and low passes and Iliamna Lake bisect the Aleutian Range and it is unclear if these disjuncts moved to the south by long-distance dispersal events, or if they moved across the low passes when the habitat was sufficiently different to support slow, yearly local migration (see Sauer 1988). In general, plants display a surprising ability to migrate across large barriers much more quickly than would be predicted from their measured dispersal velocities (Pitelka 1997). However, other geographic-habitat barriers have been responsible for dramatically affecting the genetic structure of plants, if not their distributions (DeChaine and Martin 2005).

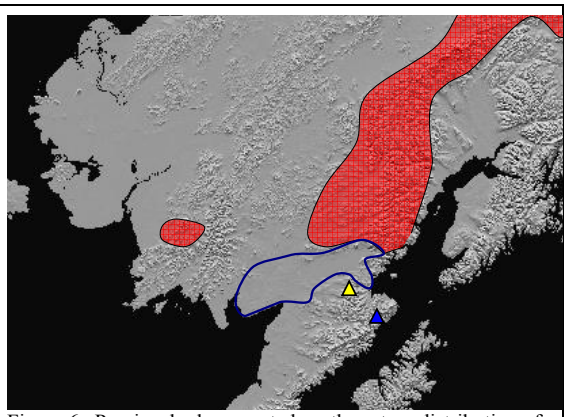


Figure 6. Previously documented southwestern distribution of *Carex rupestris*, *Kobresia myosurioides*, and *Ranunculus nivalis*, shown as red polygons. New collections in KATM of *C. rupestris* and *K. myosuroides* are displayed as a blue triangle and *R. nivalis* is shown as a yellow triangle. The blue polygon delineates a low elevation barrier to alpine plant dispersal.

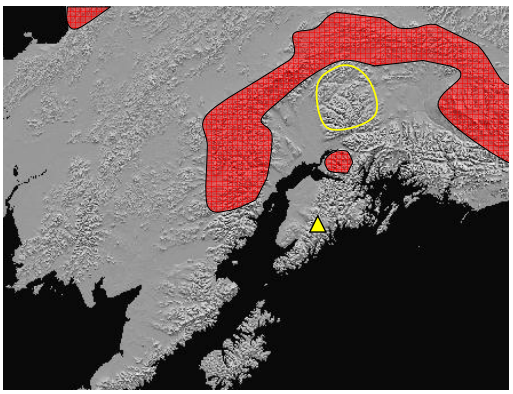


Figure 7. Approximate southwestern distribution of *Arnica angustifolia*, *Carex bicolor*, *Draba glabella*, *Euphrasia disjuncta*, *Gentianella tenella*, shown as red polygons. New collections in KEFJ of are shown as a yellow triangle. The yellow polygon indicates the relatively poorly sampled Talkeetna Mountains, which may house populations of these species.

Numerous interior-associates, previously unknown from the Kenai Peninsula, were found in KEFJ along the north and western border of the park (Resurrection River and Nuka River Valley) (Fig. 7). These range extensions included such Interior species as *Arnica angustifolia*, *Carex bicolor*, *Draba glabella*, *Euphrasia disjuncta*, *Gentianella tenella*). Most of these species are

quite widespread and it is somewhat surprising that they have not been collected elsewhere on the Kenai Peninsula. High elevation surveys in the northern portion of the Kenai Peninsula would likely reveal additional populations. The gap in distribution in the Talkeetna Mountains in Figs. 6 and 7 is probably due to a paucity of botanical collections in those mountains.

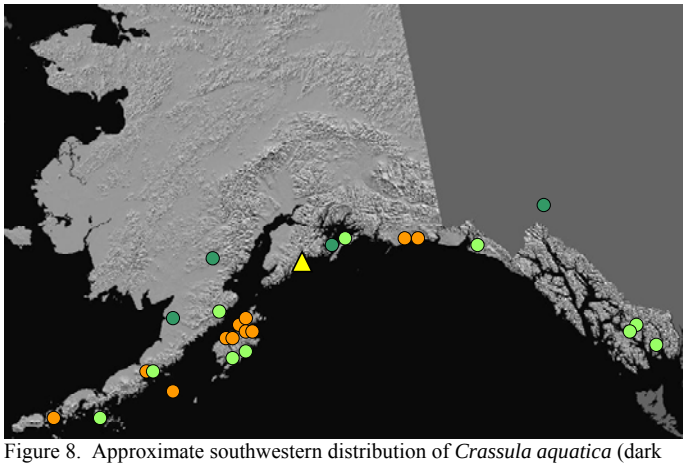


Figure 8. Approximate southwestern distribution of *Crassula aquatica* (dark green circles), *Gentianella propinqua* ssp. *aleutica* (orange circles), and *Ruppia maritima* (light green circles). New collections in KEFJ of are shown as a yellow triangle.

Gulf Coast Range Filling Collections –
We made collections of a few species in KEFJ of widely distributed species throughout the Gulf of Alaska (Fig. 8). However, taxa such as *Crassula aquatica*, *Gentianella propinqua* ssp. *aleutica*, and *Ruppia maritima* are rarely collected and no specimens were known within 100 km (62 mi.) of sites in KEFJ. These species are probably reasonably common throughout the Gulf region, and it is important to know that they have colonized the most recently deglaciated terrains of the Gulf of Alaska in Kenai Fjords.

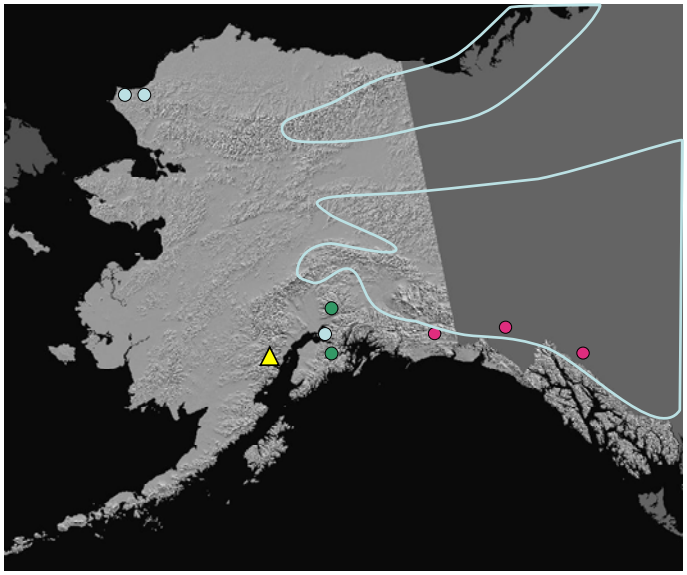


Figure 9. Previously known locations of *Arabis lemmonii* (pink circles), *Potentilla drummondii* (green circles), and range of *Erigeron compositus* (light blue polygon and blue circles) (Hultén 1968, Cody 1996, AKNHP Database 2005). New records for these 3 species in LACL are indicated by the yellow triangle.

Rocky Mountain Disjuncts –
A number of more extreme range extensions were revealed in surveys in LACL. Interestingly, a number of species that were widely disjunct were collected at high elevation, unglaciated sites together. This suggests that these species may have been found throughout the Alaska Range during the interglacial period and were since lost from most sites throughout the mountains as the glaciers advanced and remained stranded on ice free peaks and ridges until the present time.

Arnica diversifolia and *Potentilla drummondii* are widespread montane species, found throughout the Cascades and western Rockies from California and Utah north to British Columbia and Yukon Territory. In Alaska, they are known only from a limited number of sites in the Talkeetna Mountains. *Erigeron compositus* (mountain fleabane) is found from Arizona and California northeast through the intermountain west and throughout the

high latitudes of Canada. In Alaska, *E. compositus* is found in the Copper River, Tanana and upper Yukon basins, as well as a couple of western arctic sites and outlying sites along Turnagain Arm. The collection of this taxon on a nunatak in LACL is an extension of the species range by over 170 km (110 mi.) west from sites in Turnagain Arm (Miller et al. 2006). Most striking is the collection of *Arabis lemmonii* from two sites in LACL. The *Arabis* collection from Saddle Mountain was difficult to key out and has a number of characteristics that differentiate it from other collections from Wrangell-St. Elias and the Yukon. It appears to fall within the range of variation of the widespread and polymorphic species, *A. lemmonii* (sensu lato). It is found from the southern Cascades to the Rocky Mountains and North to the Yukon. In Alaska, it is known only from a single population in the southern Wrangell-St. Elias Range, a distance of 555 km (345 mi.) east of the site in LACL (Miller et al. 2006). One population of *A. lemmonii* was growing with *Arnica diversifolia* on an exposed, eroding ridge on Saddle Mountain and the other population of *A. lemmonii* was found growing with *Erigeron compositus* on a steep eroding granite slope on a nunatak. It is noteworthy that these species were found growing together in such isolated and westerly montane sites and suggests that the distribution of many plant species, such as these, were dramatically altered following the Wisconsin Glaciation. It is likely that many other species with more Rocky Mountain distributions were found throughout the Alaska Range during the Interglacial and were since lost during the ice advances. We collected material of widespread western montane plants for a genetic analysis by scientists at the Royal British Columbia Museum (Ken Marr) and Univeristy of Victoria (Geraldine Allen). They are attempting to determine historic migrations and the influence of glaciation on current genetic diversity

Arctic Disjuncts –
Dupontia fisheri ssp. *psilosantha* and *Primula tschuktschorum* are two species, restricted to arctic regions of Alaska that were found in KATM (both species) and ANIA (*Dupontia fisheri* ssp. *psilosantha*) (Fig. 10).

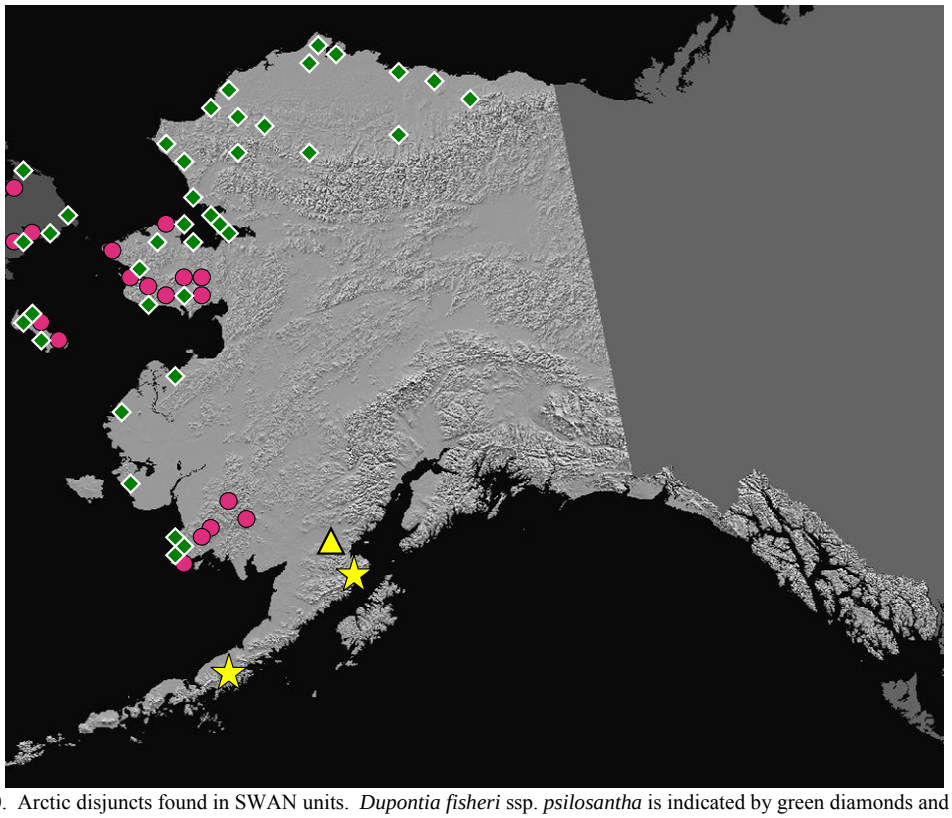


Figure 10. Arctic disjuncts found in SWAN units. *Dupontia fisheri* ssp. *psilosantha* is indicated by green diamonds and yellow stars in KATM and ANIA. *Primula tschuktschorum* is shown as rose circles and a yellow triangle in KATM.

Dupontia fisheri ssp. *psilosantha* is a circumpolar grass of wet meadows and coastal tundra that is commonly encountered in the Bering Strait region, south to Goodnews Bay. The population encountered in KATM was in an open deciduous woodland at Swikshak Lagoon, a habitat very unlike most of its tundra habitat. Two collections of *D. fisheri* ssp. *psilosantha* were made in wet meadows north of the Meshik River in ANIA, and one at the east end of the lagoon on Aniakchak Bay.

Because these populations are located well outside the normal range for this taxon and have been found in at least one novel habitat, the populations are of conservation concern. Disjunct populations are not genetically linked to other populations and are often under divergent natural selection. This creates opportunities for such populations to develop novel genetic-morphological-ecological attributes not found in other populations.

Primula tschuktschorum is a rare globally and within the state (G3 S3), restricted to the Bering Strait region (Fig. 10). More recently, populations have been located in the Ahklun and Kilbuck Mountains, northeast of Goodnews Bay. This species was probably more widespread throughout the western arctic zone in Alaska following the last glacial cycle and since retreated to higher wet meadows and gelifuction-dominated substrates in the region. We observed many patches of 50 – 200 plants *Primula tschuktschorum* at a number of sites in the Mirror Lake area in the northwest corner of KATM, with a total number of individuals estimated at 5,000.

This rare arctic primrose is not in eminent danger of extirpation; however, Kelso (1995) noted a number of concerns and potential threats to the species, including extensive herbivory. We did not observe evidence of herbivory on the Mirror Lake sub-populations, but the unusual reproductive system (distyly) it possesses may limit its ability to reproduce and there may be reproductive interference from closely related *Primula* species (Carlson and Lipkin 2003, Carlson unpublished). Greater ecological information is needed to determine the status of this rare and disjunct species in KATM.

Invasive Species

Ten non-native species vascular plant species were collected in the SWAN units (Table 6). Here we adopt the National Park Service terminology of "invasive" to describe non-native species, regardless of their potential to establish and alter communities and ecosystem function. Overall, very few non-native species were encountered in our surveys and nearly all of those encountered were in areas of very high human use. SWAN currently does not suffer from the negative ecological impacts of invasive plants like most National Parks outside of Alaska. However, while the remoteness of most areas in SWAN is a natural protection against unwanted invasive species introductions, if invasive species are able to establish it may take many years for the infestation to be observed and control measures may be particularly expensive. We recommend a proactive approach to remove all incipient populations before the negative impacts are realized. For more specific information about the invasive plant sites see the Annual Technical Reports for each unit.

Gardens and the landing strip in Port Alsworth, and developed areas of Silver Salmon Creek in LACL, contained the greatest number of invasive species. Most of these plants are confined to areas with disturbed soil and are unlikely to spread. However, *Leucanthemum vulgare* (oxeye daisy) is moderately invasive (AKNHP Invasiveness Rank = 61) and can affect soil erosion, herbivory regimes, and reduce the cover of native plants (AKNHP 2004).

Table 6. Non-native plants collected in SWAN Units.

Scientific Name	Common Name	Invasiveness Rank	SWAN Unit	Site Location
Amaranthus retroflexus	Redroot amaranth	Not Ranked	LACL	Port Alsworth
Capsella bursa-pastoris	Shephard's purse	Not Ranked	KATM	Brooks Camp
Cerastium fontanum	Mouse-ear chickweed	Not Ranked	KEFJ	McCarty Fjord
Chenopodium album	Lamb's quarters	35	LACL	Port Alsworth
Leucanthemum vulgare	Ox-eye daisy	61	LACL	Silver Salmon Creek
Matricaria discoidea	Pineapple weed	34	KATM	Brooks Camp
Plantago major var. *major*	Common plantain	44	KATM	Brooks Camp
Poa annua	Annual bluegrass	51	KEFJ	Aialik Bay
Rumex acetosella	Common sheep sorrel	Not Ranked	LACL	Port Alsworth
Stellaria media	Common chickweed	Not Ranked	LACL	Port Alsworth

The roadside weeds, *Capsella bursa-pastoris* (= *C. rubella*), *Matricaria discoidea* (= *M. matricarioides*), and *Plantago major* var. *major* were all encountered around buildings at Brooks Camp, KATM on disturbed soils. The camp receives thousands of visitors each year and it is surprising that only three invasive species were collected. However, AKNHP sampling intensity was restricted to a single collecting day. The species were restricted to highly disturbed sites and did not appear to be establishing in more native habitats.

Two species of invasive plants (*Cerastium fontanum* and *Poa annua*) were located on a beach and at a coastal cabin site in KEFJ. The introduced mouse-ear chickweed *Cerastium fontanum* was confined to a single site in McCarty Fjord, James Lagoon at sea-level. The location was a sparsely vegetated depression in moist graminoid meadow, associated with *Leymus mollis*, *Carex lyngbyei*, and *Argentina egedii*. In Alaska this species is normally associated with heavily used areas, with disturbed soils, such as along roads, ATV trails, and gardens. It is somewhat surprising to find this species in a relatively remote location, especially without collections in more frequently used parts of the Park, such as Aialik Bay. However, its occurrence in such a site highlights the importance of inventory and monitoring efforts.

The introduced annual blue grass *Poa annua* (Fig. 11) was found at a single site at Aialik Bay, lining the trail and surrounding a cabin. This site receives a significant number of visitors. Open, high nutrient conditions, with coarse soils around remote cabins elsewhere in south coastal Alaska often have small populations of this grass; despite persisting in these areas it does not appear to invade undisturbed habitats.

Figure 11. *Poa annua*.

Most remote regions of the unit showed no signs of invasive species establishment and habitat alteration. Densmore et al. (2001) summarized the occurrences of additional invasive species found near Exit Glacier and the ranger station.

Species of Conservation Concern

Species rare in Alaska but globally widespread –

Figure 12. *Orobanche uniflora* (photo courtesy of Jan Anderson).

Rare species were encountered in all SWAN units with the exception of ALAG. Some of these taxa are very widespread outside of Alaska, but are only known from very few sites in Alaska. *Arabis lemmonii*, *Potentilla drummondii*, *Arnica diversifolia*, and *Orobanche uniflora* (Fig. 12) are examples of species widespread in western North America, but very rarely encountered in Alaska.

Even though these species are not in danger of extinction, they are of critical conservation concern in Alaska and deserve special attention by NPS. These populations are certainly under very different natural selective regimes and are genetically isolated from core populations. Populations in Alaska do not have the homogenizing effects of genetic exchange with populations outside of Alaska, and Alaskan populations face different environments, herbivores, and pollinators, which exert different selective pressures. These conditions set the stage for greater ecological, morphological, and evolutionary divergence, and therefore represent an essential source of future speciation and biodiversity for SWAN and the greater region. Additionally, peripheral populations are more likely to suffer from inbreeding depression and low levels of additive genetic variation, making them much more susceptible to extinction (Newman and Pilson 1997).

Orobanche is a parasitic genus, completely lacking chlorophyll. These plants most often parasitize members of the Fabaceae (legumes), but are believed to be generalists on other groups as well. While *Orobanche* as a genus is most often associated with arid grasslands, *Orobanche uniflora* was found in mesic forb meadows on the coast of ANIA, in association with *Solidago* (goldenrod).

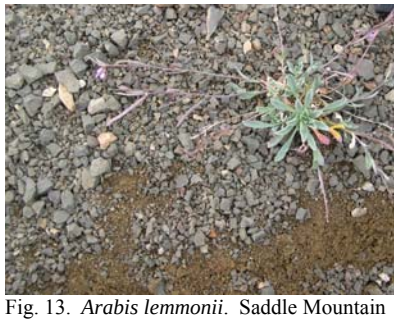


Fig. 13. *Arabis lemmonii*. Saddle Mountain LACL.

Rare species of questionable taxonomic status –

We made a special effort to revisit, and collect many more specimens of *Arabis lemmonii* at a barren alpine site in LACL (Saddle Mountain, Fig. 13). We had not been able to key out specimens collected in the 2001 inventory; i.e., while it superficially resembled *Arabis lemmonii*, known only from a single site in Alaska in the eastern Chugach Mountains (Cook and Roland 2002), it lacked clasping stem leaves. After collecting numerous new specimens at different phenological stages at Saddle Mountian in 2006, and locating a new site on a granite nunatak on Double Glacier, it appears that the morphology of this rockcress falls within the broad concept of this species. However, the weakly clasping leaves and presence of other characters, as well as its extreme isolation, suggest that greater taxonomic work is required. This *Arabis* was found on exposed, eroding gravels of granite at the Double Glacier nunatak and mudstone at Saddle Mountain (Fig. 14). Both of these sites appear to have escaped glacial advances 20,000 years BP (Fig. 2), leaving the LACL populations widely disjunct from the nearest populations on the Alaska-Yukon border (Cook and Roland 2002).

Figure 14. Saddle Mountain (left) and Double Glacier Nunatak (right) *Arabis* sites.

Figure 15. *Aphragmus eschscholtzianus*.

A second major group of rare plants encountered in SWAN are those that are endemic to Alaska (or Alaska and Yukon Territory), but are known from enough populations and from a large enough region to not be in immediate danger of extirpation. This includes species such as *Aphragmus eschscholtzianus*, *Botrychium alaskense*, *Douglasia alaskana*, *Rumex beringensis*, and *Thlaspi arcticum*. These five species were found in LACL and all but *Thlaspi* were also recorded from ANIA. Most of these species were collected from high elevation sites, and they appeared to be restricted to particular microhabitats that are not ubiquitous in the alpine zone. For example *Aphragmus eschscholtzianus* (Fig. 15) was observed at an alpine site just south of Mirror Lake (KATM), as well as in ANIA and LACL. This species is listed by the AKNHP as G3 - S3 (rare globally and within the state). It is known primarily from scattered alpine sites from the Aleutians, east across the Alaska Range, Chugach and Wrangell Mountains to Northern B.C., with disjunct populations on the Seward Peninsula and Central Brooks Range (Fig. 16). We found a population of between 100 and 200 individuals in a former melt-pond along an alpine bench at approximately 600 m (1970 ft.). Many of the high elevation areas around Mirror Lake were inventoried, but only this isolated patch of plants was located. Further, the habitat-type of where it was found (drying melt-ponds with large cobbles at high elevations) was not observed elsewhere.

It is important to note that the SWAN vascular plant surveys have been very important in re-evaluating the rarity ranks of many species. *Carex lenticularis* var. *dolia* was considered to be rare to uncommon in the state, but it was collected from enough sites in KEFJ and ANIA to warrant reducing its state rank from S3 (rare to uncommon) to S4 (apparently secure, but cause for long-term concern). Similarly, *Carex phaeocephala* is an alpine sedge that was considered to be imperiled in the state, but this species was collected from a number of small populations on talus slopes and glacial moraines in KEFJ and LACL, indicating that a state rank of S2S3 (imperiled to rare) is more appropriate. Last, *Platanthera chorisiana*, a small wetland orchid, has been collected in KEFJ, and more recently from Glacier Bay National Park and Preserve and Prince William Sound. This species should be downgraded in its global and state rank to apparently secure, but cause for long-term concern (G4 S4).

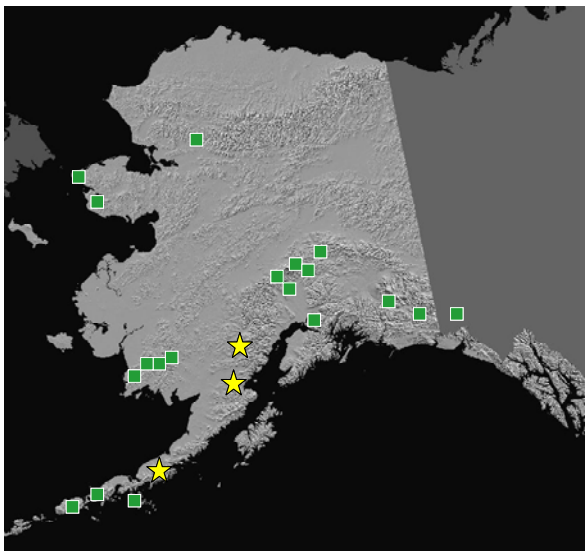


Figure 16. Global distribution of *Aphragmus eschscholtzianus*. Populations in ANIA, KATM, and LACL are shown as yellow stars; other documented populations are indicated by green squares. Additional populations in the Aleutians are not shown.

We observed two species that are both globally and locally imperiled. *Cochlearia sessilifolia* (G1Q S1) is a very narrow endemic, known only from a handful of sites along the south-central Gulf of Alaska. A few individuals were collected at a beach at Beauty Bay on the west side of Ferum Creek (KEFJ). The site was a combination of mud flats and shingle beach in the upper intertidal zone, with a sparsely vegetated, halophytic grass-forb meadow of *Puccinellia nutkaensis*, *Honckenya peploides*, and *Argentina egedii*. We visited this site in early July in 2003 before fruits were present, making positive identification of this annual species difficult. We revisited the site in August of 2004 and collections were clearly different than the common *C. officinalis*, and most likely *C. sessilifolia*. We estimated that several thousand individuals were present. Questions remain as to the validity of this taxon and the AKNHP is currently conducting a taxonomic investigation (Lipkin unpublished data).

The putative sister species of *C. sessilifolia* is *C. officinalis (sensu* Rollins), which was collected in a nearby flooded mining road in Beauty Bay (as well as other coastal sites in KEFJ). *Cochlearia officinalis* is a widespread coastal circumboreal species that has significantly smaller fruits and seeds, and lacks sessile leaves. The rare species, *C. sessilifolia*, is known from a handful of sites on Kodiak and adjacent mainland beaches. We recommend ecological studies to determine habitat differentiation, potential for competition, and hybridization with its common congener.

The other critically imperiled taxon we encountered was *Botrychium pedunculosum*, which has 30 known populations in North America, scattered over seven northwestern states and provinces, but has never been collected in Alaska. Despite being widely distributed, and probably often overlooked, this species is quite rare globally (G2G3) and always treated as regionally imperiled (NatureServe 2005). A single population of this taxon was found in a mesic forb meadow north of the Meshik River in ANIA.

We made a number of collections of an unknown *Polemonium* in the caldera of Aniakchak Crater (Figs. 17 and 18). This plant was previously collected from the crater and had caused UAF taxonomists trouble since it does not appear to fit descriptions of known taxa. This plant appears to be related to *Polemonium boreale* ssp. *villosissimum*, but appears to be a local variant. The plants collected in ANIA are unique in possessing bright white corollas and densely glandular pubescence. More thorough taxonomic study is required to delineate this taxon and understand its ecology and conservation status.

The *Polemonium* was collected from low angle (≤ 25°), gravelly slopes on several of the volcanic cones within the Aniakchak caldera. No other vascular plants were found growing with it.

Figure 17. *Polemonium* cf. *boreale* var. *villossimum* from ANIA.

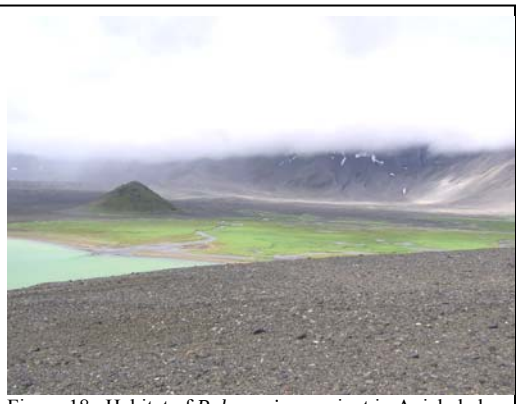


Figure 18. Habitat of *Polemonium* variant in Aniakchak Caldera.

Floristic Patterns

Regional Biogeography –

Following these inventory efforts it is possible to reflect on broader patterns of floristic diversity. The SWAN units are located in a botanically rich region of the state that encompasses a number of floristic zones (Fig. 19). Hultén (1937) described the Aleutian Islands, Alaska Peninsula, plus Bering Strait as one of a few 'elemental areas' in the Northern Hemisphere. These elemental areas are described as partially isolated in the past and harboring a large number of endemic species.

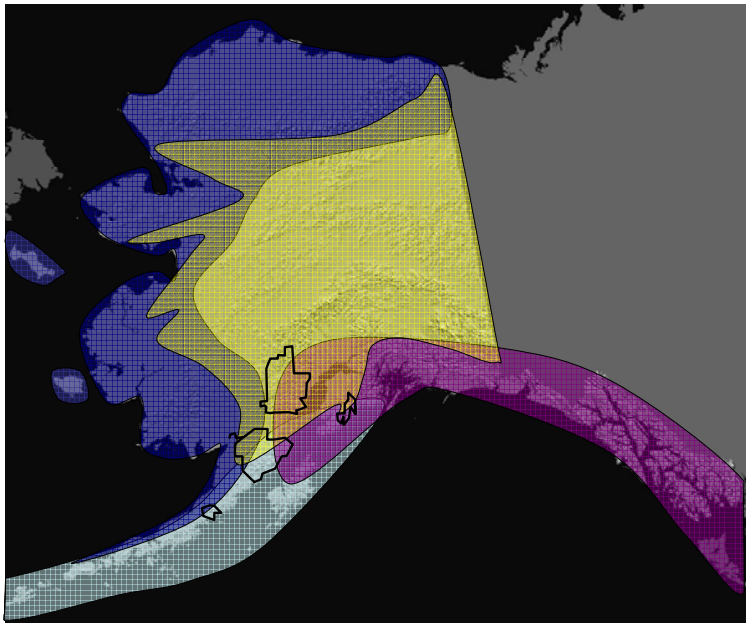


Figure 19. Floristic zones of Alaska. Arctic = blue, Boreal = yellow, Aleutian = white, and Pacific Coastal = purple. Broad zones of overlap in floristic elements are also indicated.

Figure 20. *Plagiobothrys orientalis*, a species restricted to the Aleutian Islands and Kamchatka, collected in ANIA.

Figure 21. Spruce forest community in KEFJ, with an *Oplopanax horridus* understory.

Aleutian Island-associates (e.g., *Dactylorhiza aristata*, *Draba borealis*, *Plagiobothrys orientalis* (Fig. 20), *Rhododendron camtschaticum*) are relatively common through ANIA to KATM. Coastal Pacific-associates such as *Picea sitchensis*, *Menziesia ferruginea*, *Nephrophyllidium crista-galli*, and *Kumliena cooleyae*) comprise the majority of the flora in KEFJ and are often the dominant species in various habitats (Fig. 21); many of the coastal Pacific-associates and extend westward to LACL and KATM, and to a much lesser extent, ANIA. Boreal-associates were found in all units with the exception of ANIA. These species (e.g., *Populus tremuloides*, *Shepherdia canadensis*, *Geocaulon lividum*) are relatively common on the western slopes of the Alaska Range in LACL and KATM and not observed in ANIA. A smaller subset of boreal-associates were observed along the northern border of KEFJ. Arctic-associates were primarily encountered in the southwestern portion of KATM in the Bristol Bay Lowlands, but were also occasionally seen in LACL and ANIA. Tundra grass (*Dupontia fisheri* ssp. *psilosantha*) and Chukchi primrose (*Primula tschuktschorum*) are two obligately-arctic examples that have been discussed above. Broadly distributed arctic species (also found in areas of permafrost outside of arctic Alaska) such as *Eriophorum vaginatum* and *Carex bigelowii* were relatively common in LACL and KATM.

Patterns for Habitat Associated Species –

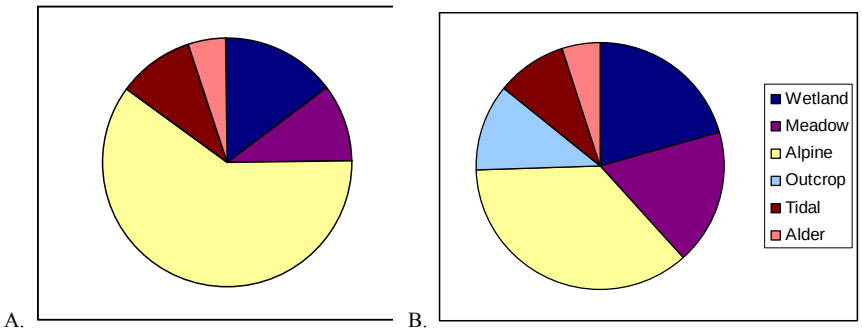
Northern alpine species (e.g., *Carex phaeocephala*, *Draba nivalis*, *Minuartia macrocarpa*, and *Silene acaulis*: Fig. 22) collectively composed a large component of the biodiversity in each SWAN unit. These species were often associated with particular substrates, for example higher pH, unstable granitic moraines, saturated or well-drained soils and there is clearly a much higher species turnover (β diversity) in alpine habitats relative to sideslopes or lower elevation habitats, although this was not quantified. It is quite common to have an assemblage of species in one local alpine area and a short distance away have a different assemblage of species with very few plants in common between the sites. Plant assemblages tend to be significantly more homogenous at lower elevations.

Figure 22. *Silene acaulis* a common northern alpine species of barren slopes, tolerant of more basic substrates.

The majority of rare species encountered were alpine specialists (60%) and 38% of all range extension and range filling collections were of

alpine species (Fig. 23). The high representation of alpine species as those of conservation significance is due to a number of reasons. First, alpine habitat in general is rare, and therefore its associates are more likely to be rare. Second, alpine areas are difficult to access and are generally poorly sampled, so that the taxa may appear more rare, due to undersampling. These species are then more likely to have large gaps in their known distributions, which would tend to lead to a greater likelihood of finding range extensions. Third, alpine habitats tend to have a much greater diversity of microhabitats that can support an overall greater diversity of species (see discussion above). This emphasizes that alpine habitats are differentially a more important resource for

Figure 23. Frequency diagram of rare species (A.) and range extensions (B.) collected in SWAN park units from 2001-2005 for six habitat categories



plant biodiversity.

Coastal-halophytic species are likewise an important contingent of the biodiversity in all SWAN units, except ALAG. These species tend to be quite widespread in Alaska and the Pacific Rim; they are generally not species of conservation concern (Fig. 24), but they compose over 10% of SWAN's florisitic diversity. Coastal species include those associated with gravel and sand beaches (e.g., *Cochlearia officinalis*, *Glaux maritima*, *Honkenya peploides*, *Senecio pseudoarnica*), intertidal-and halophytic sedge meadows (e.g., *Argentina egedii*, *Carex lyngbyei*, *Carex ramenskii*, *Dendranthema arcticum* ssp. *arcticum*, *Stellaria humifusa*). In ANIA, KATM, KEFJ, and LACL these intertidal-halophytic meadows often transitioned to supratidal forb-graminoid meadows that had a high diversity of widespread and unique species. For example, in KATM and LACL *Carex gmelinii*, *Ligusticum scoticum*, and *Poa eminens* are common species encountered in the supratidal zone, and less commonly encountered plants such as a number of species of *Botrychium*, *Cicuta douglasii*, and *Eleocharis kamtschatica*.

Freshwater wetlands were generally not particularly species rich, but they often contained important sources of unique species (those not found in other habitats) for each of the SWAN units and of rare species (Fig. 24). For example plants such as *Utricularia vulgaris*, *Potamogeton* species, *Sparganium* species, and *Subularia aquatica* were often nearly the only species present in small ponds in KATM. Aquatic and many wetland species often have large range sizes and are distributed across much of the state, so in general they are not of critical conservation concern. However, we did make collections of *Eleocharis kamtschatica* and *Limosella aquatica*, which are rare aquatic or wetland species in the state, although widely distributed globally.

The habitat that was very species poor and lacking in unique plants was alder thickets. Alder habitats are found from 0-1,000 m (0-3280 ft.) in elevation and comprise 10-20% of land cover in the larger SWAN parks. These habitats were extremely species poor, often including only *Calamagrostis canadensis*, *Boschniakia rossica*, and *Athyrium felix-femina*. As alder scrublands expand, vascular plant diversity will certainly decline.

Noteworthy areas

Occasionally while surveying the park units we encountered particular areas that harbored a surprisingly high diversity of species or of unique species. We suggest that these noteworthy areas receive greater attention from biologists in the future and that they are buffered from undue human impacts.

Lake Clark –

LACL had a number of noteworthy locations. Nunataks in the western side of the park (Double Glacier and Tuxedni Glacier) were found to have a surprisingly high diversity of vascular plants (e.g., 28 species in a 50 × 50 m area on an exposed bench at Double Glacier). These nunataks also had a number of very significant range extensions (*Arabis lemmonii*, *Potentilla drummondii*, *Erigeron compositus*). A high elevation site east of Turquoise Lake harbored a large number of new records for the park and of rare alpine species. We made collections of range extensions and new park records at East Glacier Creek in Chinitna Bay, at a low elevation beaver pond. Coastal estuary sites, such as Silver Salmon Creek and Tuxedni Bay, are important sources of coastal-halophytic species.

Katmai –

In KATM the most floristically interesting location was Swikshak Lagoon and the surrounding area, which ranged from coastal meadows to alpine fellfields. In particular, a pair of small partially calcareous outcrops at 450 m, directly north of the NPS cabin, was floristically quite rich and harbored species not seen elsewhere in KATM, and rarely on the Alaska Peninsula. Additionally, a diversity of unusual plants was encountered in the alpine habitats around Mirror Lake in the northeast corner of KATM. This area had a mixture of wetland, mesic uplands, and alpine fellfield habitats.

Alagnak –

Most of ALAG habitat is riparian and wetland or white spruce-birch open forests that were not particularly noteworthy floristically. At the confluence of the Alagnak and Nonvianuk Rivers, there is a diversity of habitats that include higher elevation dwarf shrub habitats and rocky outcrops. Half of all the taxa collected in ALAG were collected in this area. Greater attention to the upper portion of the Alagnak River would increase the proportion of known taxa for that unit.

Kenai Fjords –

Nuka River Pass (Fig. 24) in KEFJ was botanically rich. In just a few days we made collections of 70 taxa, half of which were new records for the park. Seven of the 12 range extensions for KEFJ were from this area. A steep eroding slope of metasediments across from the Nuka Glacier was the most floristically interesting feature, supporting five unexpected species and the rare sedge, *Carex phaeocephala*.

Figure 24. Nuka River Pass in KEFJ, dwarf shrub community.


Figure 25. Ephemeral wetlands of ANIA.

Aniakchak –

Some of the most species-rich environments in ANIA were fens and ephemeral wetlands north of the Meshik River, between Cub Creek and Waterfall Creek, and along the coast of Aniakchak Bay (Fig. 25). These sites were characterized by diverse microtopographic features (e.g., hummocks, frost boils) that supported a high number of species; for example, a total of 36 species were collected from two small, neighboring fens north of the Meshik River. Rock outcrops and mesic forb meadows, such as those near Waterfall Creek, also harbored high species diversity and supported rare species such as *Douglasia alaskana*, *Orobanche uniflora*, *Botrychium alaskense*, *B. virginanum*, and *B. pedunculosum*.

Recommendations

While this effort to make a more complete inventory of the SWAN units has resulted in significant increases in the numbers of species known in the region and for each unit, there are still a number of areas and habitats that have been poorly sampled and would benefit from targeted sampling. Additionally, we identify a series of outstanding botanical questions and highlight the need for greater ecological and evolutionary investigations into these floristic resources.

Areas requiring surveys

LACL

- ***Calcareous Outcrops near Kontrashibuna, Martha's Mountain, Portage Lake, and Calcareous Sedimentary Outcrops Near the Coast***
  We were able to visit some calcareous sites in 2001, but it was too late in the year for many plants and we did not have enough time for a thorough inventory. Surveying these calcareous substrates will be very important in documenting additional species new to the unit and may also uncover rare species.
- ***Northern Border of LACL***
  Little sampling has occurred along the northern and northwest regions of LACL. In our surveys we did not encounter species of particular interest, but greater efforts may reveal species new to the unit.

ALAG

- ***Upper Alagnak River***
  The upper stretches of ALAG were not sampled due to difficult access. This region includes higher elevation sites, with apparently dry and stony tundra that were rarely if ever encountered on the survey from the Nonvianuk confluence westward. While it is unlikely that many rare or unexpected species would be encountered, it is likely that a much greater number of species considered "probably present" would be located.

KATM

- ***Calcareous Outcrops in Western KATM***

We surveyed just one site with only moderately basic soils. A large component of the KATM taxa listed as probably present are of widespread calciphiles and would likely be added as confirmed if an appropriate substrate was identified and visited.

- ***Sand Dunes along the Northern Edge of Kukaklek Lake***
  No inland sand dunes were encountered in our surveys of SWAN. The moderately extensive dunes present on the northern and western shores of Kukaklek Lake in northern KATM may house a handful of species that are new to the park.
- ***Hills along Upper Kejulik River***
  No collections are known from this southerly border of KATM and there are a series of drumlins (streamlined glacial depositions) that may harbor unique taxa.

KEFJ

- ***High elevation regions above Resurrection River***
  The extreme northern border of KEFJ above Resurrection River has received only cursory visitation by botanists. A reasonable number of collections are known from the Exit Glacier area, but few exist to the west. Due to the difficult terrain, we were only able to access the alpine zone on a single day, but collected over 25 new records for the Park, including species not expected to occur in KEFJ and important range extensions. The alpine zone from Placer Creek to Moose Creek is the area with the greatest likelihood of harboring boreal species common to the rest of the Kenai Peninsula, but unknown in KEFJ.
- ***High elevation regions east of Bear Glacier***
  The alpine zone from Paradise Creek to the headwaters of Tonsina Creek deserves attention, as this region has not been thoroughly surveyed botanically. Additionally, it represents a transition from a coastal to interior zone, where a high diversity of alpine species is likely. Further, a number of nunataks are present, which may be sources of unusual species that have been present during much of the last glacial period.
- ***Upper Nuka River***
  The most productive area we visited was the Upper Nuka River. This was a region with a high proportion of species that are generally associated with more interior-boreal habitats, as well as unusual and rare alpine species. We collected 55 species that were new to the Park at this location. Twenty of these were not expected to occur in KEFJ, and they represent most of the range extensions and rare species of our collections. While we conducted a thorough survey of the western portion of the river valley, we were unable to access the eastern valley and area around Storm Mountain.

ANIA

- ***Wetlands and floodplains along the Cinder River and Lava Creek***

Collections from the northern portion of ANIA are unknown. The wetlands associated with the Cinder River system, and the cinder flats and ridge systems may harbor additional species typical of the Bristol Bay lowlands and those transitional between the lowlands and Northern Aleutian Mountains.

- ***Upper Aniakchak River (e.g., the Gates to Hidden Cr.), particularly mesic meadows, bluffs and rock outcrops***

The area along the Aniakchak River, between the caldera rim and Hidden Creek, has not been explored. Sedimentary outcrops grading into more recent volcanic deposits could yield additional taxa.

Recommendations for monitoring or other action

- Taxonomic investigations are critically necessary for three rare plants in the SWAN:

- *Cochlearia* cf. *sessilifolia*
- *Arabis* cf. *lemmonii*
- *Polemonium* cf. *boreale* var. *villosissimum*

We have collected specimens of *Cochlearia* and of *Arabis* that do not clearly fit descriptions of these taxa and it is unclear if the specimens from SWAN units fit within the limits of variation for the species described by previous authorities. The *Arabis* was initially thought to be a new species, but specimens from a second population appear to be *Arabis lemmonii* in the broad sense (it is a polymorphic taxon with numerous subspecies) and form a clear link to the plants from Saddle Mountain. *Cochlearia sessilifolia* is a very narrow endemic from the central coast of the Gulf of Alaska that seems to have populations in KEFJ. Very little is known about this species and taxonomic treatments poorly distinguish this from *Cochlearia officinalis*. The unusual *Polemonium* collected in the Aniakchak Caldera has received a preliminary determination of *P. boreale* aff. *villosissimum* (ALA, 2006), but requires more in-depth morphological and genetic study.

- First, we recommend studies that improve our understanding of the distribution of rare taxa such as *Botrychium pedunculosum*, *Cochlearia* cf. *sessilifolia*, *Primula tschuktschorum* and *Aphragmus eschscholtzianus*. We located only a few populations of relatively few individuals for each of these species in the SWAN, but it is possible that that these taxa are more common than our surveys suggest. More extensive surveys in alpine areas may reveal additional populations of *Primula tschuktschorum* and *Aphragmus eschscholtzianus*. *Botrychium* individuals are often overlooked and are not able to be keyed out in the field, so we recommend additional surveys in herbaceous meadows in the Meshik River area. Directed surveys in coastal estuary sites in KEFJ are necessary to delineate the distribution of *Cochlearia sessilifolia* and *C. groenlandica* (common congener).

- Second, most management decisions of rare plants are made without a good understanding of the biological status of the species (Schemske et al. 1994), and we therefore recommend that explicit stage-specific matrix population modeling be employed. Matrix population models are a powerful tool to identify population growth parameters and the particular stages (or age-classes) most important to population growth (Schemske et al. 1994). Studying the trends in populations of the most critical species within the park units also offers a unique opportunity to protect the unit's most sensitive species and to gauge the effects of broader changes that may be occurring within the parks, but are obscured by an overly coarse scale or by a large number of variables. For example, because of its unusual reproductive system and potential for reproductive limitations, we suggested that the reproductive biology of *Primula tschuktschorum* be studied.

Figure 26. *Papaver alboroseum*, photo from Saddle Mountin, LACL.

- Last, we believe it is essential to determine whether evolutionary (and thus taxonomic) differences occur between the more widespread, homostylous entity, *P. eximia*, and rare, *P. tschuktschorum*, both of which co-occur at Mirror Lake in KATM. This investigation would involve isozyme or DNA-based methods in addition to a morphological analysis and examination of reproductive interactions between the two entities. Studies investigating the reproductive ecology of rare species and their common relatives offer an extremely valuable opportunity to inform managers of the mechanisms influencing population decline or growth and to understand broader patterns of

the ecology of rare species. We are often able to observe changes in populations, but rarely do biologists understand what mechanisms are behind those changes.

- We recommend casual monitoring (revisit easily accessed populations every few years and record the approximate number of individuals and other notes) of the following rare taxa: *Botrychium alaskense, Douglasia alaskana, Papaver alboroseum* (Fig. 27)*, Rumex beringensis,* and *Thalspi arcticum*. These species were all located in apparently secure populations with no observable threats. However, NPS employees and botanists working in the units should pay special attention to these species in known and in potential habitats to determine the number, extent, and status of the populations.

- Alpine habitats are clearly the most important floristically for the SWAN. Alpine areas disproportionately housed rare species and plants not found in other areas of the units and many of these high-elevation habitats were similar across the units. Any changes in the area or nature of this ecological community-type will have major impacts on the floristic diversity of southwestern Alaska. We recommend that community-level monitoring be undertaken for barren alpine habitats in each SWAN unit. The barren habitats are much more important in providing areas for critically rare plants than are snow-beds, ericaceous tundra, or herbaceous tundra. The barren areas are also the most sensitive to environmental alterations and therefore studies are more likely to observe changes in the plant community, which has important implications to the floristic diversity of the units. Monitoring a number of these sites across the SWAN should be successful in informing us about larger scale changes, such as conversion of barren habitats to snowbeds.

- Invasive species – Elimination of the weedy introduced species, *Amaranthus retroflexus, Capsella bursa-pastoris, Cerastium fontanum*, *Chenopodium album, Leucanthemum vulgare, Matricaria discoidea, Poa annua*, *Plantago major* var. *major*, *Rumex acetocella,* and of *Stellaria media* is recommended. Additionally, an evaluation of the effectiveness of eradication efforts is needed, and attempts should be made to minimize soil disturbance in areas with the greatest number of visitors (e.g., Brooks Camp, KATM).

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