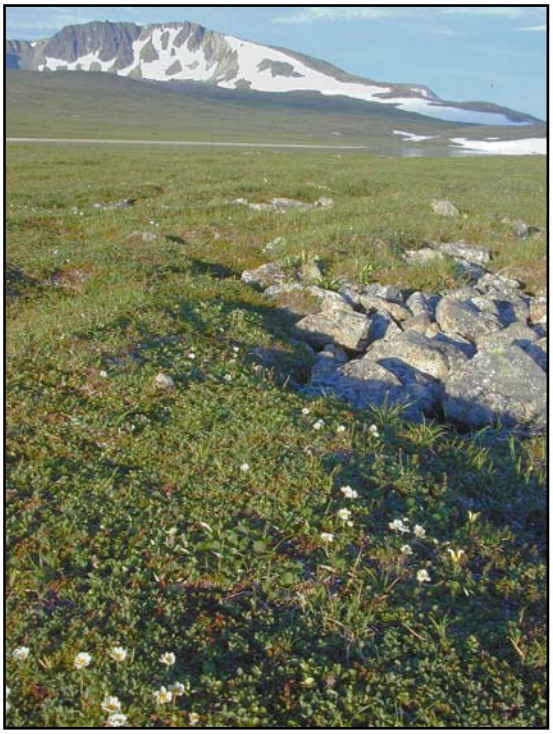
ALAGNAK WILD RIVER & KATMAI NATIONAL PARK
VASCULAR PLANT INVENTORY
ANNUAL TECHNICAL REPORT



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National Park Service Alaska Region
Inventory & Monitoring Program
NPS Report :

June 2003

Cooperative Agreement No. 1443CA991000013

Funding Source: National Park Service, Inventory & Monitoring Program

ABSTRACT

In 2002, the Alaska Natural Heritage Program (AKNHP), conducted vascular plant field inventories in the Alagnak Wild River and Katmai Nation Park units in accordance with a cooperative agreement with the National Park Service. The primary goal was to document ≥ 90% of the vascular plant species expected to occur within the parks and significantly improve our understanding of current species distributions. The inventory targeted diverse habitat types and poorly-sampled areas. The AKNHP visited four diverse eco-geographic regions and sampled intensively within these regions from late June to mid-August, 2002. A total of 530 specimens were collected, recorded, pressed, and curated. For Katmai Park, 317 individual taxa are represented, 146 are new records for the park, and an additional 41 represent verifications of previously unvouchered reports. Of the 133 specimens collected from the Alagnak Wild River, 120 are new records for that unit. A number of finds were significant range extensions or taxa of conservation concern. *Dupontia fisheri* is a tundra grass of northern and western Alaska. We located a population at Swikshak Lagoon, over 300 km east of the other outlying stations, and this site is the first recording from a woodland marsh in Alaska. Additionally, AKNHP collected a number of sedges that were notable range extensions. Last, we located a population of the rare *Primula tschuktschorum* (G3 - S2S3 rank), and *Aphragmus eschscholtzianus* (G3 - S3 rank), near Mirror Lake.

EXECUTIVE SUMMARY

The National Park Service is conducting a vascular plant inventory to document the occurrence, distribution, and relative abundance of plants occurring in the Southwest Alaska Network. The inventory was developed to provide baseline information for future monitoring and management of natural resources within the Park Network. In 2002, the University of Alaska Anchorage, Alaska Natural Heritage Program, conducted field inventories in the Alagnak Wild River and Katmai National Park units in accordance with the Cooperative Agreement No. 1443CA991000013, Modification No. 17. The primary goal is to document ≥ 90% of the vascular plant species expected to occur within the parks and significantly improve our understanding of current species distributions. The inventory targeted diverse habitat types and poorly-sampled areas. Following an analysis of previous floristic surveys, we noted that most collections were from the corridor between Brooks Camp and the Valley of 10,000 Smokes and a few coastal locations. However, the majority of Katmai Park had not been inventoried, and no collecting had occurred along the Alagnak River. Geological maps, aerial photos, and Park personnel were consulted to locate areas of concentrated inventory work. We chose one sampling region (Swikshak Lagoon) on the east coast of Katmai that had a high diversity of habitats, geology, topology, and moisture gradients, and therefore was likely to have high corresponding vascular plant diversity. To capture a large number of alpine taxa and species whose range is more interior, we surveyed the Mirror Lake area of the northeastern portion of Katmai Park. Contact Creek was chosen as a sampling region due to a nearby calcareous outcrop (a determinant of a large group of vascular plants associated with basic soils) and its southwesterly location in the Bristol Bay Lowland eco-region. Last, additional opportunistic collection occurred in the Brooks Camp area, Nonvianuk River, and Dakavak Lake. The Alagnak Wild River was floated and surveys were completed from the confluence of the Nonvianuk Branch to the westerly end of the Wild River boundary.

While at the remote collection regions, techniques of inventory involved hiking to as many habitat types and geographic areas as possible, and collecting specimens that were known to be new records or considered significant. Upon collection of specimens, data were gathered on collection-site characteristics: from latitude and longitude to associated species and soil conditions. Plants were then pressed and dried and catalogued with the Alaska Natural Heritage Program. Last, final taxonomic determinations and herbarium mounting was conducted by the University of Alaska Fairbanks Museum.

A total of 530 specimens were collected, recorded, pressed, and curated. Duplicate or triplicate sheets are present for many of the specimens. 317 separate taxa are represented, and 146 are new records (an additional 41 are taxa that were previously reported but unvouchered) for Katmai Park. All 120 taxa collected from the Alagnak Wild River represent new records. A number of finds were significant range extensions or of taxa of conservation concern. *Dupontia fisheri* is a tundra grass of northern and western Alaska, with outlying stations at Hazen Bay and Cold Bay. We located a population at Swikshak Lagoon, over 320 km east of the other outlying stations. This population is the first recording of *Dupontia* from a woodland marsh in Alaska. *Carex nardina*, *C. rupestris*,

Kobresia myosurioides, and *Ranunculus nivalis* are alpine species that were collected in Katmai Park 160 - 300 km south of their previously known distributions. These four species are more common in the Alaska and Brooks Ranges (*Ranunculus nivalis* is also known from Goodnews Bay to the west and the Lime Hills to the north). A few new exotic species were collected in anthropogenically disturbed sites. Last, we located a population of the rare *Primula tschuktschorum* (G3 - S2S3 rank), and *Aphragmus eschscholtzianus* (G3 - S3 rank), near Mirror Lake.

Key Words
Alagnak Wild River, Katmai National Park, inventory, vascular 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 NPS and the I & M program is to establish baseline information and long-term trends of natural resources in the parks. Currently, biological inventories are being 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 species or exotics)
- Provide information necessary to establish a monitoring strategy, with special reference to special threats and resource issues within each park.

The Alaska Natural Heritage Program (AKNHP) was contracted to conduct the vascular plant inventory component of the I & M program of the Southwest Alaska Network. In 2002, three AKNHP botanists inventoried the vascular flora of Alagnak Wild River and Katmai National Park. The following report outlines pertinent information on the regions inventoried, methods employed, the flora encountered, and a discussion of the importance of those finds.

Alagnak Wild River (ALAG) is the smallest management area in the SWAN at 12,440 hectares. The Wild River status was established in 1980 to protect the river's remarkable scenery, rich wildlife and cultural history, and "free-flowing characteristics." The river flows from Kukaklek Lake to Bristol Bay, a distance of approximately 90 km. The ALAG encompasses a broad range of habitat types, from aquatic and wet-sedge tundra, to boreal forest and dry bluffs. The Alagnak River is renowned for its sport fishing and continues to be essential for subsistence uses as well.

Bordering the Alagnak River to the east, Katmai National Park and Preserve (KATM) is the largest and oldest park in the SWAN. Katmai National Park is 1,655,816 hectares and was established in 1918. The park was created to preserve the geologic features associated with the eruption of Novarupta in 1912. The towering Mount Katmai collapsed in the eruption, leaving a wide crater and an ash-filled valley extending to the

west, known as the Valley of Ten Thousand Smokes. Several active vents remain. Katmai has a great diversity of plant associations and habitats, spanning Shelikof coastal communities in the east, across high mountains and rolling tundra, to extensive wet-sedge tundra of the Bristol Bay Lowlands on the western edge of the park (Boggs et al. 2003). Additionally, the park contains diverse aquatic habitats (including the largest freshwater lake in the National Park System) and the largest population of protected brown bears in North America.

Management Efforts and Issues

Resource managers of SWAN units have had little opportunity to obtain baseline information due to the large size, ruggedness, and remoteness of the units. In addition, earlier scientific research has been stymied by the unavailability of land cover and habitat maps. Clear data gaps exist for vascular plants as well as other taxa. Thus, the I & M Program represents the first step to gather resource information on plant and animal species. The data will assist land managers in developing and improving their management activities and programs.

In addition to documenting greater than 90% of vascular plants, the I & M Program attempts to obtain greater baseline information on the presence, absence, and distribution of species of special concern. For plants, the species of concern relate to threatened, endangered, rare, and exotic species.

To determine the status of previously collected inventory data in SWAN units, the AKNHP was contracted to compile and verify historical and predicted species occurrences for each park. This project involved synthesizing information from a broad range of sources. Ultimately, a list of species verified to be in the units and a list of species, not verified, but expected to occur was compiled.

Overview of Inventory

In an attempt to document 90% or more of the vascular plant diversity in ALAG and KATM, the AKNHP first developed a list of taxa expected to occur in the units (Lenz et al. 2001). Determinations for expected taxa were based on known distributions and collections, and expert opinion of botanists. Second, field sites were chosen prior to arrival that would cover the greatest habitat diversity, and therefore encompass the greatest possible number of species. Third, teams of AKNHP botanists visited the field sites. They collected, identified, and pressed over 500 plant specimens. Identifications were verified and curated at the University of Alaska Museum (ALA) and the collection data was entered into ALA and AKNHP databases.

The compilation of historic collections indicated that for ALAG, virtually no vascular plant taxa were reliably documented prior to AKNHP collections in 2002. The paucity of previous collections is partially an artifact of the small unit size and recent wilderness designation. We estimated that approximately 390 vascular plant taxa ("taxa" in this context refers to classification end units; i.e., either species, subspecies, or varieties) are

possibly present along the corridor. A total of 133 specimens were collected by AKNHP on a float trip during a week-long float trip in late July, 2002. 120 of these represent new records for the unit. No major range extensions or species of special concern were encountered; however, one collection of a grass could not be properly identified and is being reviewed.

Previous plant collections were more thorough from KATM, with over 300 plant taxa documented. Floristic work was initiated soon after the 1912 eruption and continued intermittently to the present. A total of 623 taxa (confirmed + unconfirmed + probably present) were estimated to occur in the unit. Intensive collection by the AKNHP occurred in three main areas with additional collections made sporadically throughout the park. Over 500 specimens, representing 146 new records for the park, were collected by AKNHP botanists. An additional 41 represent confirmations of taxa that were "unconfirmed" from the park - for example, cited in literature but without voucher collections. Therefore, the percentage of documented, confirmed taxa, relative to expected vascular plant taxa rose from 54% to 84% in 2002. Two taxa of special conservation concern were collected, plus three exotic weeds.

The two species of conservation concern are rare both globally and within Alaska (AKNHP Rare Plant Tracking List, see http://www.uaa.alaska.edu/enri/aknhp_web/biodiversity/botanical/vascular_species_concern/species_table/images/AKNHP_Plt_Trking_List_2003%20.pdf). One of the rare species collected in Katmai (*Primula tschuktschorum*) represents a major range extension to the southeast (Fig. 54). This species has a restricted range, occurring only on the tip of the Chukotka Peninsula in Russia, east to Alaska on the Seward Peninsula, and in isolated populations south to Bristol Bay. Population sizes of *P. tschuktschorum* are generally small, but a few are large and threats do not appear imminent (Kelso 1995). We do, however, recommend further survey and monitoring studies on this and the other rare taxon in Katmai.

Methodological details, site descriptions, and discussion of the relevance of 2002 collections and recommendations for future research are outlined below.

METHODS AND MATERIALS

The AKNHP's vascular plant inventory in the Alagnak Wild River and Katmai National Park occurred from late June to mid-August, 2002. Determination of expected taxa, site selection, and sampling design proceeded field work and was initiated in January of 2002.

Expected and Known Taxa

To gauge progress toward achieving 90% documentation of the expected flora, an informed list of known and probable taxa was first required. Plant collections from the Herbarium of the University of Alaska Museum (ALA) and from the herbaria of the various park units (ANCS+) were databased along with selected collections from other herbaria, observations, and floristic lists from published and unpublished literature.

Collections from ALA were verified for both taxonomic identification and geographic location. Collections from ANCS+ were largely unverified for both taxon and geographic location. The records were used by AKNHP to develop lists of taxa known from or expected to occur in the park units. Taxa that were only known from unverified collections or from observations or literature citations were recorded as "Unconfirmed".

Determining the expected species in areas that are poorly known is replete with difficulties. Our method included documented taxa occurring within 50 km of the park units. This is a very rough approximation at best. Even after revisions were made (based on likely habitats and geography) the list undoubtedly omits taxa in the units and includes taxa that are not present. Taxa known from within 50 km of the park boundary, or that were otherwise felt likely to occur in the park, were recorded as "Probably Present".

Using these definitions, we determined that the percentage of the total expected flora known to be present in each park was 0% for ALAG and 54% for KATM.

Floristic History

Alagnak Wild River (ALAG)

Virtually no floristic information exists for this narrow river corridor. We had no records of any collections and only a few unverified observations by park rangers. This park unit is adjacent to KATM and although it is unlikely to contain plant taxa not found in that park, there are very few collections in KATM that were within 50 km of ALAG.

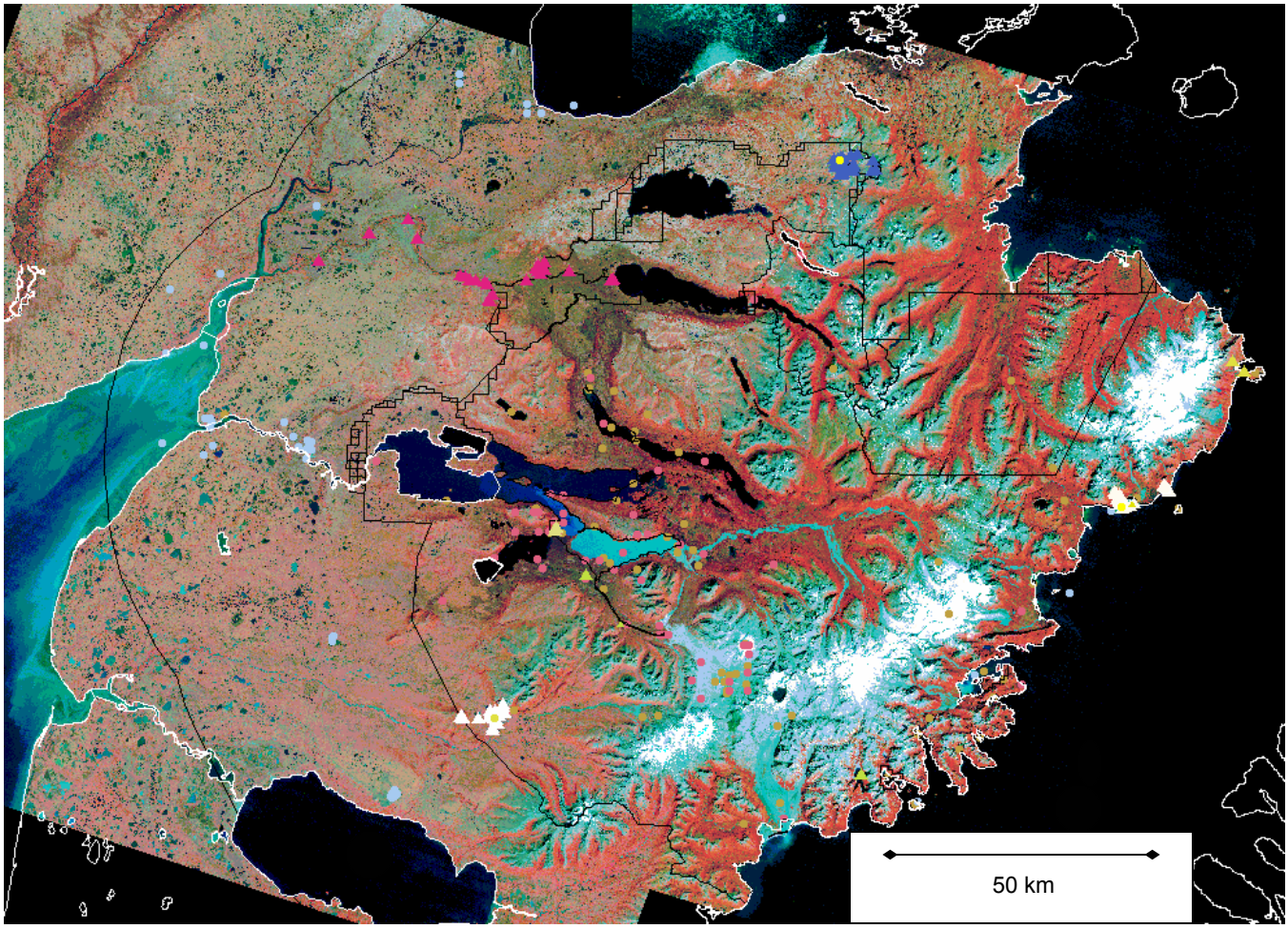
We estimated that approximately 390 vascular plant taxa are possibly present along the corridor. This number was calculated by removing the alpine and coastal species from the list compiled for KATM (discussed below). This estimated number is likely an overestimate since the unit is quite narrow and does not include a wide diversity of habitats, moisture gradients, etc.

Katmai National Park and Preserve (KATM)

Over 330 vascular plant taxa were reliably documented by collections from KATM. Additional taxa are known from unverified collections and observations in literature and field notes. The earliest botanical collections were made from 1915-1930 (Griggs 1918, 1936; Fig. 1), following the 1912 eruption. Cahalane (1954) made collections in 1953-54 as part of a biological survey, though clearly the main focus was not botanical. Collections were made in the 1970's by John Dennis in preparation for a vegetation map (project was unfinished) and by Young and Racine (1976) examining at a proposed park extension. Other significant park collections have been made by NPS personnel (e.g., Rice, Moore) and during studies on bear habitat by Tom Smith. Most recently, collections were made by Boggs et al. (2003) as part of a landcover mapping project for the park. The vast majority of collections are within the corridor between Brooks Camp and the Valley of Ten Thousand Smokes and a few coastal locations (e.g., Hallo Bay). Large areas of the park have had no botanical collecting. Figure 2 shows the collections within the park and surrounding areas.

Figure 1. Robert F. Griggs collecting plants along a *Leymus mollis* beach strand community (above) and a scree slope of 400 m elevation, below (from Griggs 1936).

Figure 2. Katmai National Park and 50 km buffer area, showing areas where plants have been collected. Collections by AKNHP botanists in 2002 are shown as triangles; previous collections are shown as circles.



Sampling Design

In order to attain the goal of documenting 90% of the expected flora, we adopted a reconnaissance method of floristic survey. This method was recommended as the best approach for plant inventories in all Alaska parks by the wide group of botanists at the Alaska Plant Inventory Working Group September 2000 meeting. 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 means, cost)
- potential of certain types of sites to maximize species and communities encountered (e.g., ecotones, high gradient areas)

To maximize species diversity we targeted sampling in ecologically different areas and distributed sampling throughout both units. Targeted sampling has been incorporated into the plant study design to ensure that sampling occurs in unique sites or habitats where species that are expected, but not yet documented, may exist. Logistical feasibility (e.g., access means, cost) and the potential of certain types of sites to maximize species and plant associations encountered (e.g., ecotones, high gradient areas) were incorporated into the study design. The final site selection process for this study required detailed examination of aerial photographs, geology, and landcover maps.

This targeted, judgement-based approach is essential to identify species of special concern and attempt to locate additional populations based on known habitat preferences and patterns of distribution. As surveys progress the lists of species of special concern will be refined as will our knowledge of their habitat and geography.

Site Descriptions

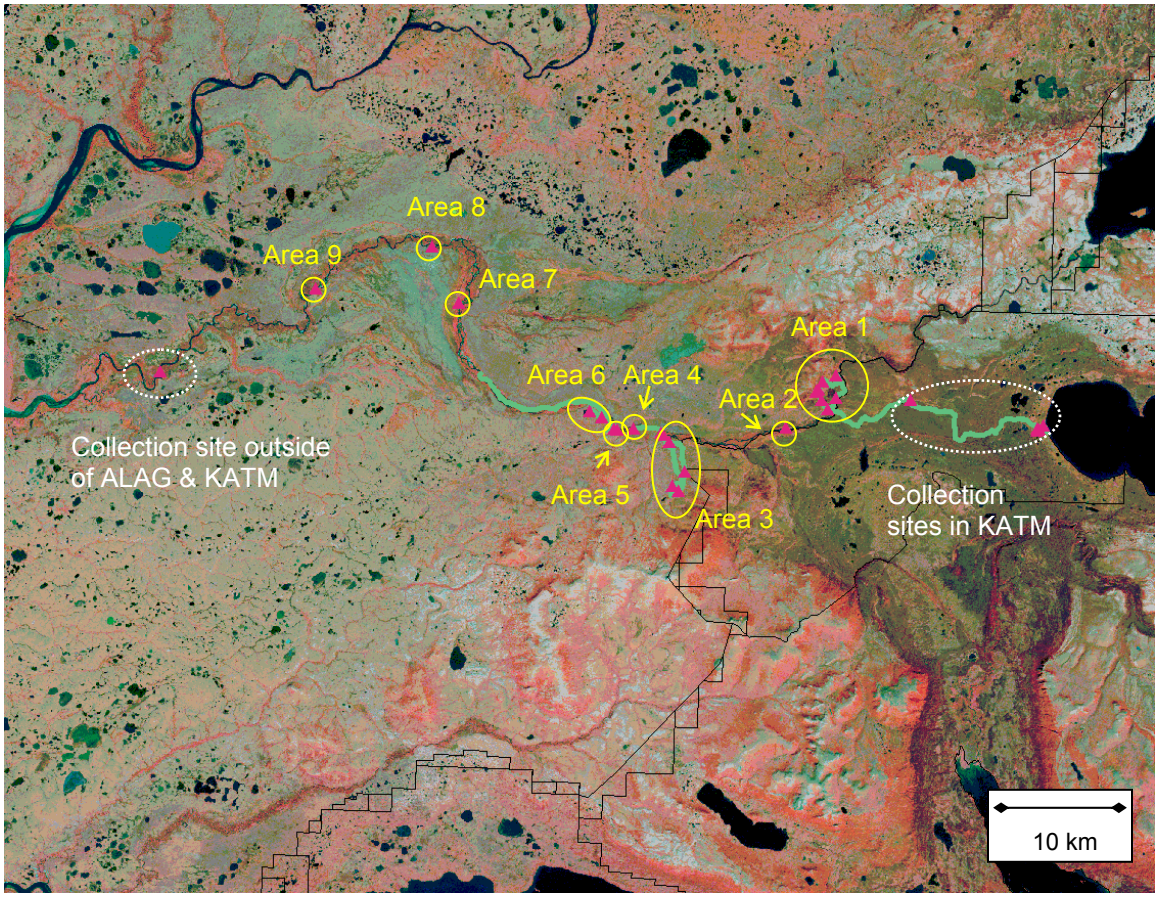
The two units AKNHP inventoried were surveyed differently due to variation in unit size, logistics, and diversity of habitat-types. We therefore present methods, results and discussions of each unit in a somewhat different manner. Sampling in ALAG was conducted on single float trip through a long, narrow corridor of similar wetland habitats. A number of discrete sampling areas were located along this unit and we present findings for each of these areas. In KATM, we visited three distinct eco-geographic regions and sampled a number of different habitat-types within the regions. The total number of collection-sites within regions was 20-30. It is impractical to discuss each of the nearly 100 collection-sites in KATM, and we therefore discuss collections associated with particular habitat-types for each of the three KATM collection regions.

Preferred species names are given based on the Synthesis of North American Flora (BONAP). Names based on Hultén (1968) are given parenthetically when divergent from BONAP

Alagnak Wild River (ALAG)

The ALAG unit was surveyed by a single drift trip from the confluence of the Nonvianuk and Alagnak Rivers to 10 km downstream from Middle River Camp, a distance of roughly 42 km (Fig. 3). Surveys were conducted from 25 July to 29 July 2002 by AKNHP staff and were accompanied by an NPS back-country ranger. Due to dangerous rapids along the upper Alagnak, the field crew was dropped at the upper reaches of Nonvianuk River and rafted down to the Alagnak. Nine major collecting areas, which included from one to eight specific collection-sites, were established along the river. Seven of the nine collection areas were wet-sedge tundra or willow thickets. Additional collecting occurred sporadically. Figure 3 shows the overall area inventoried. The geographic location, topography, and habitats of the areas are discussed below.

Figure 3. Primary collection areas along the Alagnak River. Areas traversed are indicated as the green line and collection-sites are shown as red triangles. Collection-sites outside of the ALAG boundary are also indicated.



ALAG Area 1 -

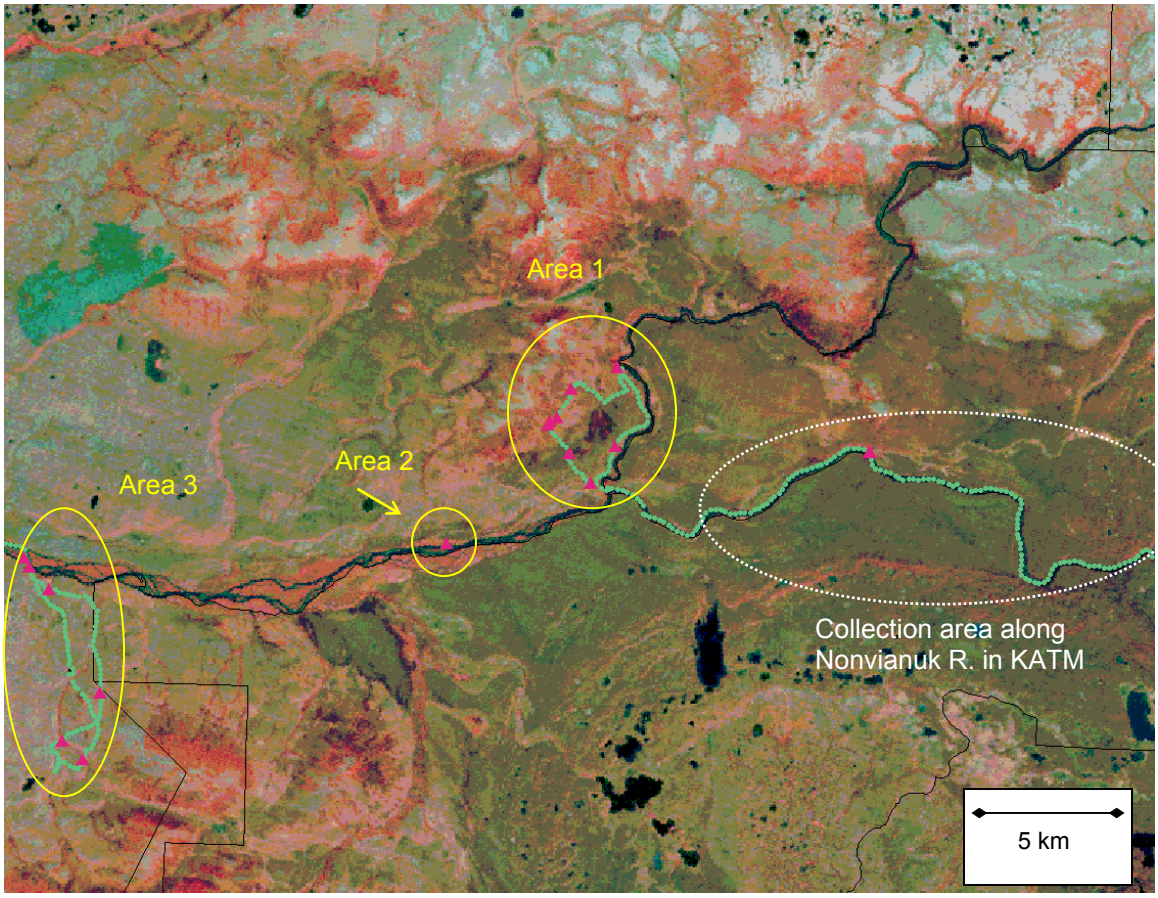
On 25 July 2002, at the Alagnak-Nonvianuk confluence, the crew hiked up the Alagnak River as far as possible (roughly 3.5 km) and surveyed the riparian and higher elevation, bluff habitats. The location was 59.03º N and 155.88º W and ranged from 170 to 210 m (Fig. 3). Habitats within the survey area were diverse. Wet tussock meadow bordered with birch and alder, low shrub-graminoid meadows, and low-shrub tundra were common habitats sampled (Fig. 4). Additionally, the field crew encountered boreal communities with an overstory of Kenai birch and white spruce. Soils ranged from saturated to moist and generally had a well-developed acidic peat component. The major associated species at this site were *Calmagrostis canadensis*, *Ledum palustre*, *Salix barclayi*, *Betula nana*, *B. kenaica*, *Alnus viridis* ssp. *fruticosa* (*crispa* ssp. *sinuata*), and *Picea glauca*.

Figure 4. AKNHP botanist collecting in a wet graminoid meadow at ALAG Area-1. *Mimulus guttatus* is the yellow flower in the foreground. The dominant graminoids are *Calmagrostis canadensis*, *Carex aquatalis*, *Carex canescens,* and *Carex pluriflora*.

ALAG Area 2 -
Collections on 26 July 2002 were confined to a compact area approximately 3 km downstream from confluence of Alagnak and Nonvianuk rivers on the north side of the river (59.01º N, 155.90º W; Fig. 5). This was a moist, low shrub-graminoid meadow at the edge of a small bay with slow moving water. The major associated species of the 11 specimens collected included: *Calamagrostis canadensis*, *Salix barclayi*, and *Comarum* (*Potentilla*) *palustre*.

ALAG Area 3 -
This area was just downstream from Charlie Summerville's lodge where the Katmai National Preserve's northwestern boundary abuts Alagnak Wild River (59.01ºN, 156.05ºW, Fig. 5); collections occurred on 28 July 2002. The elevation was ca. 75 m. The plant habitat was a closed-willow woodland with small graminoid openings. Soils were moist with a large organic component. Dominant associated species were *Salix alaxensis*, *Calamagrostis canadensis*, and *Equisetum arvense*.

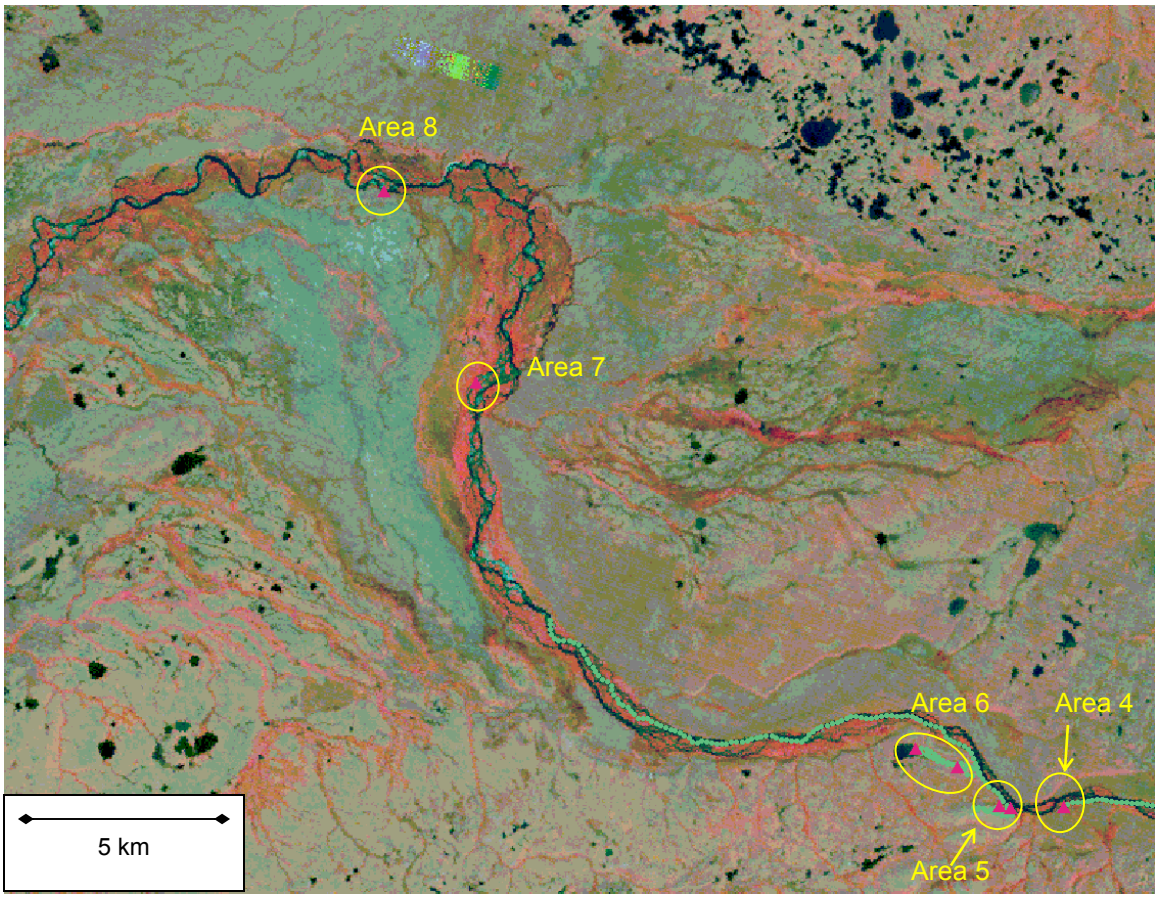
Figure 5. Collection areas along the upper Algnak River. Specific collection-sites are shown as triangles. Areas traversed are in green.



ALAG Area 4 -

Sampling-Area 4 was a low shrub-graminoid meadow that along the south side of the river at 59.01ºN, 156.09ºW (Fig. 6), which was inventoried on 28 July 2002. The area was just along the riverbank, 1 m above the water level. The associated dominants were *Salix barclayi*, *Vaccinium uliginosum*, *Dasiphora* (*Potentilla*) *fruticosa*. Substrates were moist to saturated mud and peat.

Figure 6. Collection areas of the lower Alagnak River. Specific collection-sites are shown as triangles. Areas traversed are in green.



ALAG Area 5 -

Area 5 was a bluff on south side of the river, including rocky outcrops near the river's edge to a 177 m peak, 1 km to the west. The location was 59.01ºN, 156.11ºW with elevation ranging from 160 to over 170 m (Fig. 6). The collection area was inventoried 28 July 2002. The habitat encompassed near vertical rocky outcrops with little vegetative cover (Fig. 7A) to ericaceous low-shrub tundra at the top of the peak (Fig. 7B). The substrates ranged from moist peaty soil to bare mineral outcrops. Major species of the shrub tundra were *Empetrum nigrum*, *Vaccinium uliginosum*, *Ledum palustre*, and lichens (e.g., *Cladina*, *Cladonia*, *Cetraria*, and *Nephroma* spp.).

Figure 7A. Rocky bluff, tall shrub thickets, and ericaceous low-shrub tundra of ALAG Area-5.

Figure 7B. Ericaceous low-shrub tundra of ALAG Area-5. The Alagnak River is visible on the left.

ALAG Area 6 -

Area 6 was a large pond and a smaller pond, 1.5 km northwest of Area 5, which were also inventoried on 28 July 2002. The location of Area 6 was 59.02ºN, 156.14ºW, with an elevation of 110 m (Fig. 6). Five aquatic species were collected in muddy sand under 0.5 m water. Associated species were *Sparganium angustifolium* and *Arctophila fulva* (Fig. 8). Wet-sedge and ericaceous-shrub communities surrounded the ponds.

Figure 8. Wet-sedge and ericaceous-shrub habitat bordering shallow pond of ALAG Area-6.

ALAG Area 7 -

A few collections were made along a sandy gravel bar at 59.08ºN, 156.3ºW along the river at 30 m elevation (Fig. 5). Dominant plant species at this site included *Rorippa palustris*, *Mimulus guttatus*, and *Chamerion* (*Epilobium*) *latifolium*, all species tolerant of soil disturbance (Fig. 9). Substrates were primarily moist mineral soils of small- to medium-sized river cobbles.

Figure 9. ALAG Area-7, a gravel bar along the Alagnak River, bordered by thickets of willows, alders, and bluejoint grass.

ALAG Area 8 -

This collection area was a low-shrub tundra community in an open white spruce forest along the river's edge at the temporary NPS "Middle River Camp" (Fig. 10). The location of the site was 59.12ºN and 156.33ºW, and elevation of 22 m (see Fig. 6). Collections at this site occurred on 29 July 2002. Soils were moist and peaty. The dominant associated species were *Ledum palustre*, *Betula nana*, *Vaccinium uliginosum*, and *Vaccinium vitis-idaea*.

Figure 10. White spruce - low shrub community of ALAG Area-8.

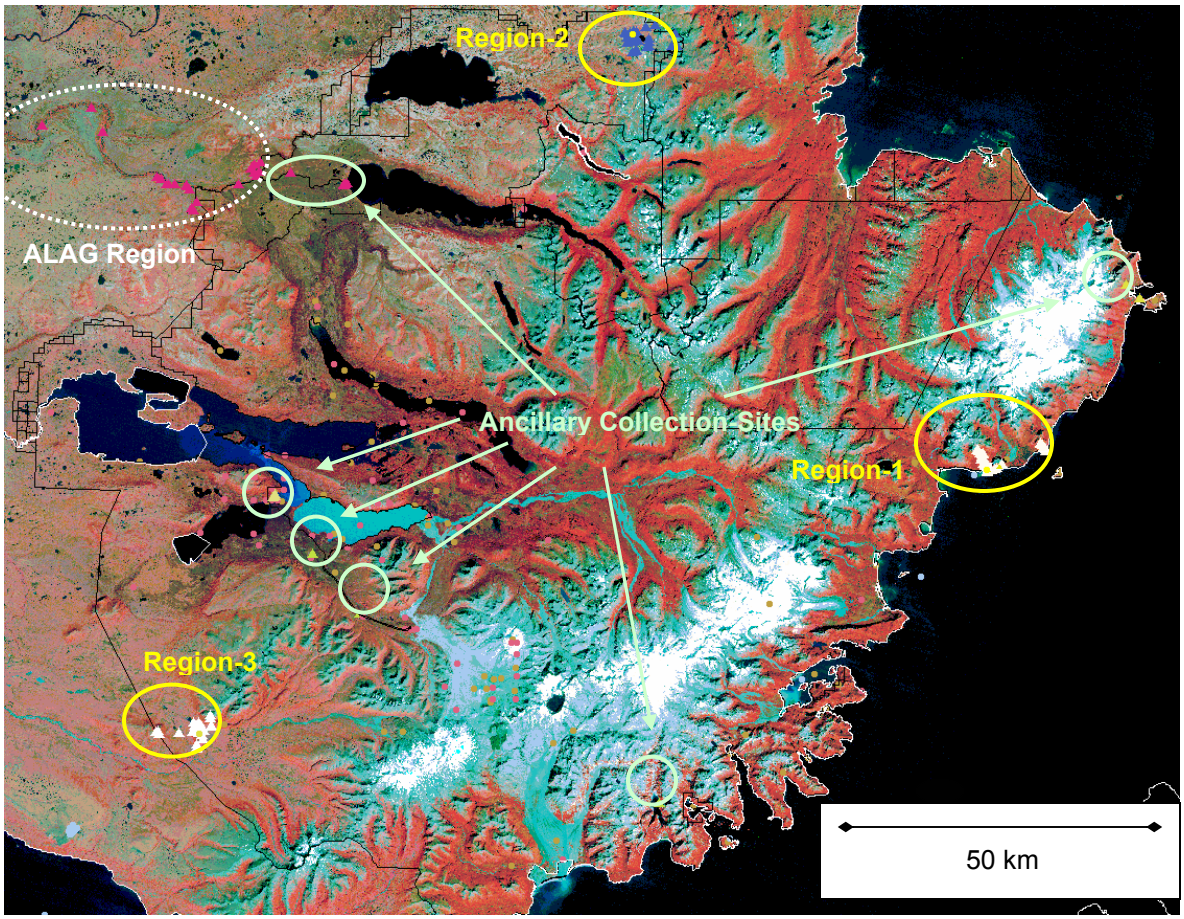
ALAG Area 9 -

The final area was just downstream from Tony Sarp's Katmai Lodge (59.09ºN and 156.47ºW) along a sand bar island. The location of this site in relation to others is shown in Figure 3. This site was sampled on 29 July 2002. The community type was a wet, low shrub-graminoid meadow, recently under spring water flow. The major associates included *Salix barclayi* and *Calmagrostis canadensis*. Substrates were moist to saturated peat.

Katmai National Park and Preserve (KATM)

Based on the sampling design criteria, we concentrated our inventory in three diverse eco-geographic regions of the unit, incorporating very divergent habitat types (Fig. 11). Multiple collection-sites were located within each region. Region-1 was the Swikshak Lagoon area on the east coast of the Alaska Peninsula. This region had salt-marsh, graminoid-umbel meadows, and alpine habitats. Region-2 was an alpine site, located in the northeastern portion of KATM. This region had both tundra, fell field, and aquatic habitats. The third region, largely wet-sedge tundra and higher elevation tundra, was located in the extreme southwestern border of the park. All three regions had a range of bedrock types and topographies. Additional collections occurred near Brooks Camp, Valley of Ten Thousand Smokes, Cape Douglas, and Dakavak Lake. Access to all regions was by fixed-wing aircraft.

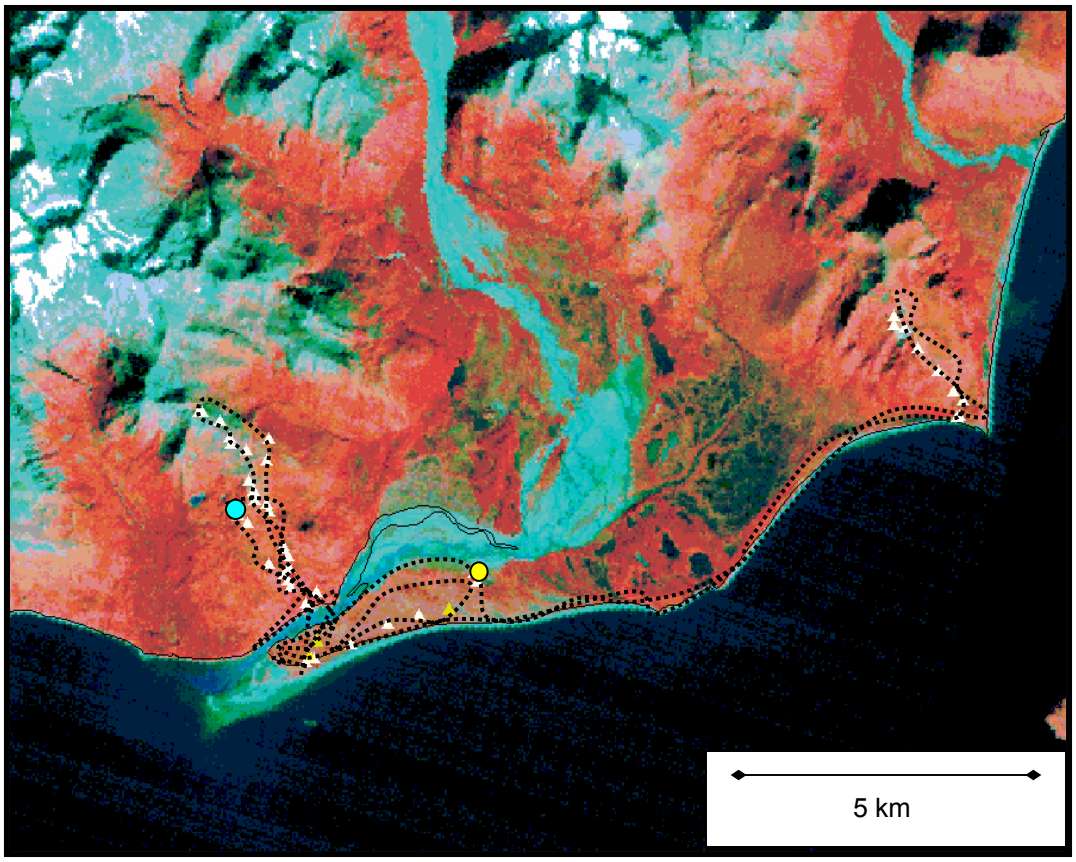
Figure 11. Landsat image of Katmai Park, showing primary and ancillary regions (open ellipses) and specific collection-sites by AKNHP (triangles). Previous collections are shown as small closed circles.



KATM Region 1 -

Areas around Swikshak Lagoon were thoroughly inventoried from 2 - 8 July 2002 and the region was revisited 15 August 2002. A camp was established at the NPS cabin on the end of Swikshak spit (58.61ºN, 153.76ºW). Daily plant-collecting trips by three AKNHP botanists and a Student Conservation Association (SCA) intern radiated from this location. Figure 12 shows the region covered and specific locations of all collection-sites. The primary habitat types encountered at low elevation were intertidal beach and halophytic-sedge habitats, forb-graminoid meadows, freshwater ponds and marshes, and alder and willow thickets. Forb-graminoid meadows and alder/willow thickets extended into higher elevations along with wet, low shrub-sedge meadows and fens. At the highest elevations (450 - 900 m), herbaceous-dwarf shrub tundra, and exposed deflation and scree slopes were dominant. Each of these primary communities is discussed below.

Figure 12. Collection-sites at KATM-1 (Swikshak Lagoon). Areas traversed are shown as the black dashed lines and specific locations where plants were collected are shown as light triangles. Areas revisited 15 August 2002 are shown as yellow triangles. (The collection locality of significant finds are indicated as circles: *Dupontia fisheri* site = yellow circle; *Carex nardina*, *C. rupestris*, and *Kobresia myosurioides* = bright blue circle. These finds are shown and discussed in Results and Discussion sections.)



The topography at KATM Region-1 included extensive sand and gravel beaches and a series of older beach ridges (Fig. 13A) as well as marshes and ponds. Steep headlands were also common as were high mountain peaks and glaciers (Fig 13B). Elevation ranged from sea-level to over 900 m.

Figure 13A. View of Swikshak Lagoon, looking south from a steep headland. Older beach ridges are visible as alder and driftwood bands.

Figure 13B. View of Swikshak Lagoon and Fourpeaked Mountain, looking northeast.

The geology of the region was quite diverse. Marine and riverine deposits were extensive at lower elevations. Schist and shale were common at low and mid-elevations, while more volcanic-derived parent material was present at higher elevations. In one alpine area, we located a small calcareous outcrop.

Intertidal Communities -

In the intertidal-zone, we concentrated collections on salt-marsh ponds and bordering halophytic wet-sedge meadows (Fig. 14). The saturated soil was silty and vegetative cover was nearly 100%. The dominant species were *Carex lyngbyei*, *C. ramenskii*, *Poa eminens*, *Festuca rubra*, *Argentina egedii*, *Plantago maritima*, *Stellaria humifusa*, and *Dendrathemum* (*Chrysanthemum*) *arcticum*. A few additional collections were made on the sandy/gravelly upper beach zone. However, this habitat type had previously been well botanized and we encountered few taxa new to the park. The dominants of this community were *Leymus mollis*, *Honkenya peploides*, and *Senecio pseudoarnica*.

Figure 14. Intertidal salt-marsh community at KATM Region-1 (a bear is present the background).

Figure 15. Forb-graminoid meadow at KATM Region-1.

Forb-Graminoid Meadows -

The intertidal communities transitioned to extensive forb-graminoid meadows of older beach ridges (Fig. 15). The soil in this habitat was generally moist and sandy over coarser gravels. The dominant species were *Calamagrostis canadensis*, *Leymus mollis*, *Chamerion* (*Epilobium*) *angustifolium*, *Lupinus nootkatensis*, *Angelica lucida*, *Conioselinum gmelinii*, *Carex podocarpa*, and *C. gmelinii*. This community-type also extended up the slopes on a number of headlands in the Swikshak area. However, the soil of headland forb-graminoid meadows had a much greater organic component and slopes were as steep as 40º. In these communities the dominant plants were *Calamagrostis canadensis*, *Carex macrochaeta*, *Heracleum lanatum*, *Angelica lucida*, *Geranium erianthum*, *Petasites frigida*, *Sanguisorba canadensis* (*stipulata*), *Equisetum arvense*, and *Athyrium filix-femina*.

Freshwater Marsh -

East of Swikshak Lagoon a series of freshwater ponds and marshes were encountered that had a number of species new to the park. All the collections occurred in saturated soil: wet mud, or in standing water. The dominant plant species were *Carex lyngbyei*, *C. canescens*, *Comarum* (*Potentilla*) *palustre*, *Nuphar polysepalum*, and *Eriophorum russeolum* (Fig. 16).

Figure 16. Freshwater marsh at KATM Region-1.

Figure 17. Wet, low shrub-sedge meadow.

Alder and Willow Thickets -

Occasional stands of cottonwood (*Populus balsamifera* ssp. *trichocarpa*), birch (*Betula kenaica*), alder (*Alnus viridis* ssp. *fruticosa*), and willows (*Salix* spp.) were present at low elevations. The primary species of willows were *Salix alaxensis*, *S. barclayi*, *S. bebbiana*, and *S. pulchra*. These shrub communities often abutted the forb-graminoid meadows and many of the herbaceous species were in common between the two community types. These communities were generally low in diversity and were not heavily sampled.

Wet, Low Shrub - Sedge Meadows and Fens -

Low shrub-sedge meadows and fens were encountered at lower and mid-elevations. These habitats were characterized by poorly drained, subhygric peaty soil with a thick sphagnum layer. *Myrica gale*, *Salix pulchra*, *Deschampsia caespitosa*, *Calamagrostis canadensis*, *Equisetum arvense*, and a number of sedges (*Carex pluriflora*, *C. media*, and *C. loliaceae*) were common in this community (Fig. 17).

Herbaceous - Dwarf Shrub Tundra -

At higher elevations (360 - 900 m) the community transitioned to tundra vegetation with an increasing degree of exposed soil (Fig. 18). Low-ericaceous tundra was common in low-alpine areas with greater organic soil development. *Vaccinium uliginosum*, *V. vitis-idaea*, *Rhododendron camtschaticum, Arctostaphylos alpina*, and *Carex podocarpa* were the common constituents of the low-ericaceous tundra. In more moist, high-elevation snow beds we encountered dense carpets of *Harimanella* (*Cassiope*) *stelleriana* and *Luetkea pectinata*.

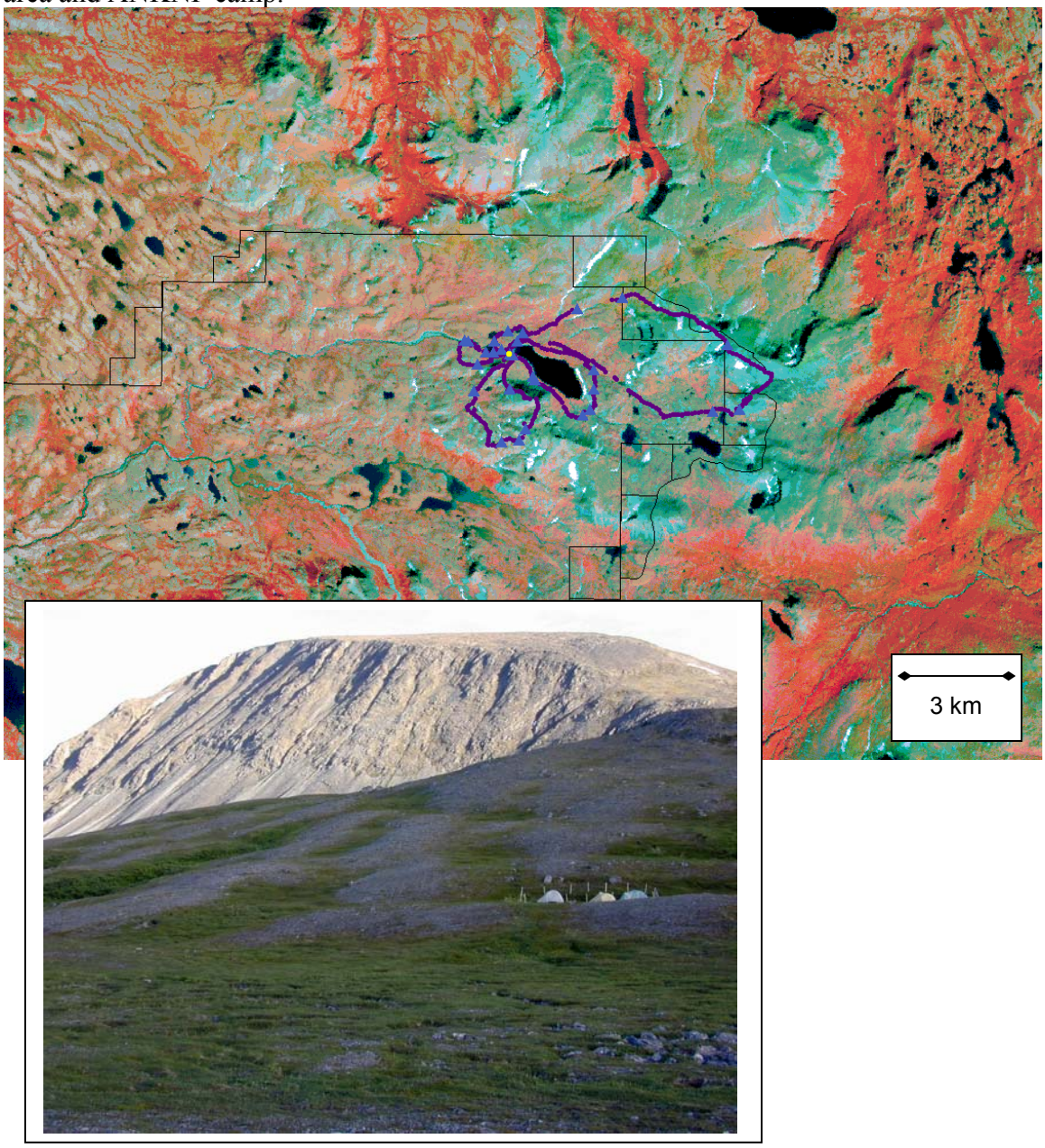
In areas with more rocky, well-drained substrates, the components of the herbaceous-dwarf shrub tundra shifted to include *Dryas alaskensis*, *Oxytropis nigrescens*, *Artemisia arctica*, *Potentilla villosa*, *Saxifraga oppositifolia*, *Saxifraga bronchialis*, *Minuartia obtusiloba*, *Rhodiola integrifolia* (*Sedum roseum*), *Festuca rubra*, *Hierochloe alpina, Carex microchaeta,* and *Luzula* spp. Within the herbaceous-dwarf shrub community a number of exposed deflation areas and scree slopes were also sampled. Soils were extremely well-drained and stony and vegetative cover was minimal. Associated species of these exposed sites were *Lagotis glauca*, *Equisetum arvense*, *Oxytropis varians* (*campestris* ssp. *gracilis*), *O. jordalii* (*campestris* ssp. *jordalii*), *Festuca brachyphylla*, *Achillea borealis*, and *Polemonium boreale* (Fig. 17). A small calcareous knob was located just north of the Swikshak cabin at around 670 m, which had a high diversity of species despite low vegetative cover.

Figure 18. Herbaceous-dwarf shrub tundra. *Rhododendron camtschaticum* is the lavender flower in the foreground. *Arnica frigida* is the yellow flower.

KATM Region 2 -

Areas surrounding Mirror Lake in the northeastern portion of KATM were inventoried from 13 - 18 July 2002 by two AKNHP botanists and an SCA intern. The snow had only recently melted from most of the area and many of the plants had not reached full flower. We were able to seek out more phenologically advanced microsites to capture the more slowly developing taxa. This area was chosen as a collecting locality largely due to its access to higher elevations and northern geographic location within the park. A camp was established on the western end of the lake (59.24ºN, 154.78ºW; 450 m; Fig. 19), and daily plant-collecting trips radiated in all directions from this location. Figure 19 shows the region covered and collection-sites for all plants in the region.

Figure 19. Collection-sites at KATM-2, Mirror Lake. Collection-sites are shown as blue triangles and the area traversed is shown as a purple line. The camp location is shown as a small yellow circle at the west end of the lake. The inset shows the physiognomy of the area and ANKNP camp.



The topography of this region included lakeshores, and ponds, steep-eroded stream banks, rolling low hills, and mountain peaks. Elevations ranged from 400 to 900 m. The geology of the region is largely volcanic, with large basalt slopes, occasional ash and serpentine outcrops, and lesser amounts of lacustrian and riverine deposits.

Primary plant communities were aquatic, associated with shallow ponds and streams; wet-sedge tundra; low shrub - herbaceous tundra; and high alpine fell fields. Each of these primary communities is discussed below.

Aquatic/Semi-Aquatic -

Shallow ponds were numerous to the west of Mirror Lake (see Fig. 20A) and smaller snow-melt ponds were common throughout the region (Fig. 20B). Additionally, we inventoried vegetation along the Mirror Lake outlet, Funnel Creek. In these habitats the saturated soils were stony or silty. Associated dominant plant species of shallow ponds were *Equisetum arvense*, *Eleocharis* spp., *Geum calthifolia*, and *Primula tschuktschorum*. Along the fast-running creek, the primary plant species were *Equisetum arvense*, *Saxifraga nelsoniana*, *Diapensia lapponica*, *Vaccinium uliginosum*, *Carex microchaeta*, *Salix arctica*, *Calamagrostis canadensis*. In the saturated snow-beds *Calamagrostis canadensis*, *Equisetum arvense*, *Polemonium acutifolium*, *Rhodiola integrifolia*, *Saxifraga nelsoniana*, *Salix arctica*, and *Ranunculus nivalis* were common.

Figure 20A. Shallow pond margins in the Mirror Lake area. *Primula tschuktschorum* is present in the foreground.

Figure 20B. Snow-melt pond. Sedges, rushes, and buttercups were the dominants.

Wet-Sedge Tundra -
Poorly drained, wet-sedge tundra were encountered west of Mirror Lake and sporadically throughout the area (Fig. 21). Soils were saturated with a thick peat layer. Low willow shrubs and dwarf birch were also common adjacent to this habitat. Associates include *Sphagnum* spp., *Carex* spp., *Eriophorum* spp., *Betula nana*, *Salix glauca*, and *S. ovalifolium*.

Figure 21. Wet-sedge tundra of KATM Region-2. *Carex* spp. and *Eriophorum* spp. were dominants.

Low Shrub - Herbaceous Tundra -
The most common type of habitat encountered at KATM Region-2 was low shrub-herbaceous tundra, which covered the rolling hills north of the lake and along the lower slopes of the larger peaks (Fig. 22). This habitat was characterized by stony and well-drained substrates, generally with a thick layer of lichens (*Cladonia* spp., *Cladina* spp., *Cetraria* spp., and *Nephroma* spp.) or graminoid turf. The soil was moist in all cases. Graminoid/herbaceous associates included *Festuca altaica*, *Carex microchaeta*, *C. podocarpa*, *Geranium erianthum*, *Geum calthifolium*. The low-shrub component contained *Empetrum nigrum*, *Salix glauca*, and *S. reticulata* at lower elevations. *Leutkea pectinata*, *Harimanella* (*Cassiope*) *stelleriana*, and *Dryas alaskensis* were more common at higher elevations.

Figure 22. Low shrub-herbaceous tundra, common in the Mirror Lake area. *Harimellina stellariana* and *Geum calthifolium* are the dominants shown here.

Alpine Fellfields -

High alpine peaks at elevations of 700 to 1000 m and with little vegetative cover, surrounded Mirror Lake. We sampled vegetation from all of the nearby peaks. Slopes ranged from flat to nearly vertical. The substrates were very rocky, coarse, and well-drained. Most of the parent material was large basalt cobbles; however, we also investigated an ultramafic outcrop 6-8 km east of Mirror Lake and a more basic ash deposit immediately southwest of the lake. Vegetative cover was generally under 10%. The dominant species of alpine fell fields were *Dryas alaskensis*, *Salix arctica*, *Rhododendron camtschaticum*, *Oxytropis nigrescens*, *Festuca richardsonii*, *Trisetum spicatum*, *Luzula multiflora*, *Saxifraga nelsoniana*, and *Minuartia arctica*. Figures 23A and 23B show the habitat and surrounding area.

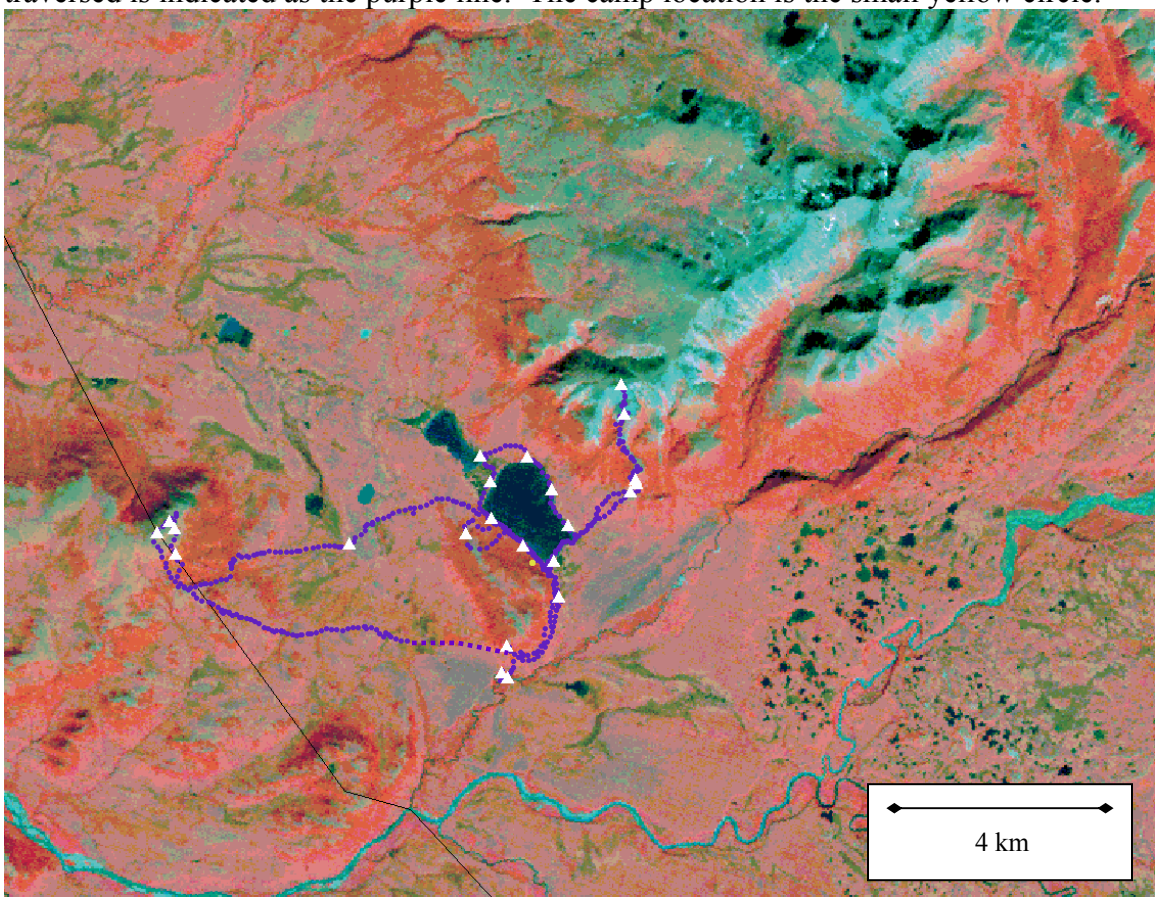
Figure 23A. Alpine fellfields. A low-density mixture of dwarf shrubs and herbs were present at these sites. Mirror Lake is on the right side and Funnel Creek is visible in the middle of the photograph.

Figure 23B. AKNHP crew members on a talus slope above Mirror Lake.

KATM Region 3 -

A region on the southwest border of Katmai Park was inventoried from 5 - 10 August 2002. This area, Contact Creek, was chosen as a study site because little or no collecting had occurred in the Bristol Bay Lowlands eco-region, and the area had a high topographic and geologic diversity. In particular, a large calcareous outcrop was indicated on geologic survey maps at a small peak on the Park and Becharof National Wildlife Refuge boundary. Calcareous substrates often house a very different flora, potentially containing rare taxa, and are uncommon within KATM. A camp was established on the southern end of the unnamed lake north of Contact Creek (58.21ºN, 155.97ºW; 180 m; Fig. 24). Plant-collecting trips radiated from this location westward to the Park boundary, south along Contact Creek, north and east to the nearby peak. Figure 24 shows the region covered and specific locations of all collection sub-sites.

Figure 24. Collection-sites at KATM-3 (Contact Creek), shown as light triangles. Area traversed is indicated as the purple line. The camp location is the small yellow circle.



The topography of this region included lakeshores, streams banks, river-bars, low rolling hills, wetlands, and alpine mountain peaks. Elevations ranged from 180 m to nearly 900 m. Visibility was poor with dense fog, affording limited collecting opportunities at high elevations. The geology of the region is largely volcanic, with large basalt and granite

slopes. Lesser amounts of lacustrian and riverine deposits were also observed. The calcareous deposits on the park boundary were not located.

Primary plant-community types were similar to those encountered at KATM Region-2. However, the dominant species were largely dissimilar. The community types included: aquatic/semi-aquatic, associated with lake margins, shallow ponds, and streams; wet-sedge tundra; low shrub-herbaceous tundra; alder/willow thicket; and alpine fellfields. Each of these primary communities is discussed below.

Aquatic/Semi-Aquatic -

We collected along the lakeshore, in shallow ponds to the north and west of the lake, and along a number of streams (Fig. 25). Soils were saturated and muddy, or peaty in some cases. The lake margin was stony in some areas and thick with mud in others. Along the lake, dominant plants were *Potamogeton* spp., *Arctophila fulva*, and *Hippuris vulgaris*. In the nearby shallow muskeg ponds, *Eriophorum angustifolium, E. russeolum, E. vaginatum* , *Eleocharis* spp., *Comarum* (*Potentilla*) *palustre*, *Carex aquatilis*, and *Betula nana* were common. Small muddy back-waters and exposed gravel bars (Fig. 25) of medium-sized cobbles were sampled along Contact Creek. These contained *Ranunculus hyperboreus* and *Alopecurus aequalis* and were surrounded by *Chamerion* (*Epilobium*) *latifolium* and thick *Calmagrostis canadensis* swards.

Figure 25. Gravel bar along Contact Creek.

Figure 26. Wet-sedge tundra and surrounding willow thickets along the lake margin.

Wet-Sedge Tundra -

Wet-sedge tundra was the most common vegetation type in this region. Soils were completely saturated and peaty, generally with a large *Sphagnum* moss component. The primary sedge species in this habitat were *Carex aquatilis*, *C. membranacea*, *Eriophorum angustifolium*, and *E. russeolum*. The low or dwarf shrubs, *Betula nana*, *Salix reticulata*, *S. glauca*, *Dasiphora* (*Potentilla*) *fruticosa*, were often present. Figure 26 shows this habitat type at Contact Creek.

Low Shrub - Herbaceous Tundra -

At higher elevations (300 - 450 m) that were well drained, the wet-sedge tundra gave way to low shrub-herbaceous tundra. Under a normally thick layer of lichens, the soils were very shallow and rocky. The dominant species of low shrub-herbaceous tundra were *Rhododendron camtschaticum*, *Salix arctica*, *Diapensia lapponica*, *Empetrum nigrum*, and *Carex microchaeta*.

Alder/Willow Thickets and Bluejoint Meadows -

Alder and willow thickets as well as bluejoint meadows were common on most slopes rising from lower wet-sedge tundra. Diversity in these habitats was very low and only modest sampling occurred there. The alder thickets were restricted to moderately well-drained areas with some organic soil development. The dominant species of the alder thickets were *Alnus viridis* ssp. *fruticosa* (*crispa*), *Calmagrostis canadensis*, and *Dryopteris expansa* (see Fig. 27). Willow thickets were common lower on the hill-slopes and where often found in saturated peaty soils (see Fig. 26). The primary willow species were *Salix pulchra* and *S. barclayi*.

Figure 27. SCA intern-botanist collecting in an alder thicket.

Alpine Fellfields -

We encountered fellfields at elevations of 450 - 520 m, 6.5 km west of camp on the KATM Park boundary, and 450 - 820 m, 4 km northwest of camp. Slopes were moderate to nearly vertical. The substrates were very rocky, coarse, and well-drained, with poorly developed soil and often a thick layer of lichens. Most of the parent material was large basalt cobbles. We were unable to locate a calcareous outcrop 6-8 km west of camp, as indicated on geology maps. The parent material at this hill appeared to be neutral to moderately acidic, judging from the species composition and lack of effervescence when dipped in acid. Vegetative cover was generally under 10%. The dominant species of this habitat were *Carex microchaeta*,

Empetrum nigrum, *Rhododendron camtschaticum*, *Salix arctica*, and *Diapensia lapponica*. Figures 28 shows the habitat and surrounding area.

We also collected specimens along a steep rocky outcrop at relatively low elevation (300 m). This location had a similar rocky, well-drained substrate, but largely dissimilar dominant species than the alpine fellfields (Fig. 29). The dominants included: *Bupleurum triradiatum*, *Potentilla villosa*, *Saxifraga bronchialis*, *Salix arctica*, and *Poa glauca*.

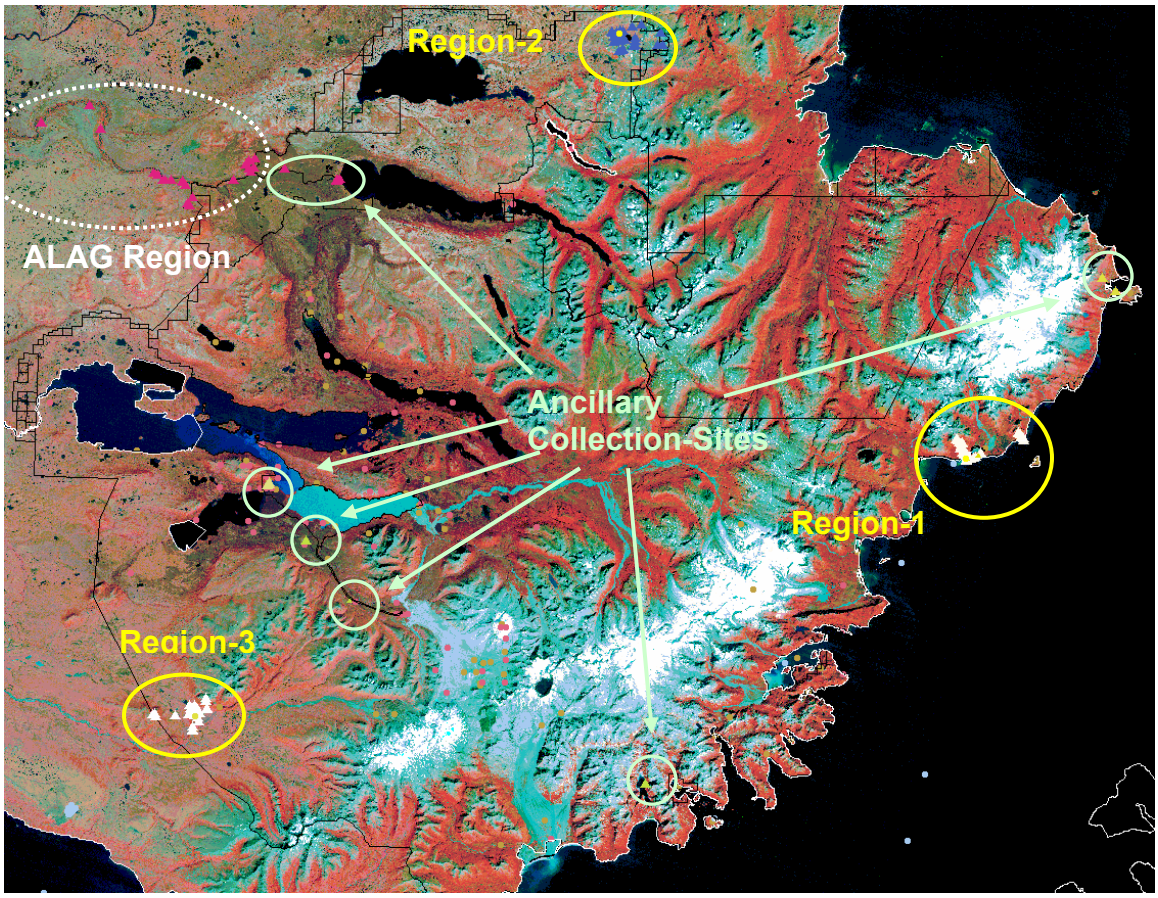
Figure 28. Alpine fellfield north of Contact Creek at 670 m. Note alder thickets and *Calamagrostis canadensis* meadows below.

Figure 29. Rocky outcrop at 300 m, rising above bluejoint meadows and alder thickets.

Ancillary Sites -

The upper Nonvianuk River in KATM was briefly sampled on 23 and 24 July, 2002, by AKNHP. Habitats encountered along the upper Nonvianuk River were largely open white spruce forests and wet-sedge tundra. In mid-August, we briefly visited a number of additional sites. Two botanist sampled in the Brooks Camp area, specifically targeting introduced species around developed areas, such as campgrounds, roads, and buildings. Areas around Dakavak Lake and Sukoi Bay along Shelikof Straights were sampled on the 13 and 14 August, 2002. We returned to Swikshak Lagoon (KATM Region-1) on 15 August and collected a number of additional taxa. Figure 30 shows the location of ancillary sites.

Figure 30. Ancillary vascular plant collection-sites in Katmai Park, highlighted in light green.



Field Methods

Fieldwork was conducted by one or two teams of botanists at each region. At KATM Region-1, three AKNHP botanists and an SCA intern were present. At KATM Regions-2 and 3, two AKNHP botanists and an SCA intern comprised the field-crew. Fieldwork along the Alagnak River was conducted by one AKNHP botanist, an SCA intern, and an NPS ranger. Two AKNHP botanists and an SCA intern conducted the fieldwork at the ancillary sites.

Access to regions was by fixed-wing aircraft and by raft for the ALAG portion. At each region we made a complete floristic inventory using the following methods:

- Each region was mapped on an aerial photo or USGS topographic map and a georeference point was recorded using GPS. The routes surveyed were also mapped. Representative photos were taken of each region including communities, unusual landforms, and notable plants. (However, photographs taken along the upper Alagnak River were destroyed by wet conditions in the field.)
- A description of each region 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.
- A complete species list was made for each region.
- 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.
- An aerial-oblique photo of the region and significant plant associations was taken on departure.
- Vouchers were collected and curated as discussed below.

Vouchers and Curation

Voucher specimens were collected for those species that are new to the park or eco-region, species of concern (rare, endemic, exotic), geographic or ecological range extensions and specimens not identifiable in the field. For species of grapefern (*Botrychium*), above-ground portions of the fern were collected for isozyme analysis at the University of Iowa. Unused portions of the plant will serve as voucher specimens. The following data were collected for each vouchered specimen: date, unique collection number, latitude and longitude (NAD27, decimal degrees); 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, associated photo number, phenology and ecological observations. A "collection-site" is a location in which plants with the same specific latitude, longitude, habitat type, and collection date are collected. Collection-sites can include from just a single vouchered specimen to over 20, and is confined to an area of less than 400 m^2 of similar habitat attributes.

The size of the population and area surveyed was included for species of concern.

Collections were made only if the population was large enough to support removal of individuals and followed the collecting protocol of Murray and Parker (1990). Duplicate or triplicate collections were made when possible, allowing the first set to be archived at the Herbarium of the University of Alaska Museum (ALA) and the second set to be sent to the park.

Specimens were sorted, examined and identified by AKNHP botanists who collected them 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.

A cooperative agreement was initiated with ALA for curation. Specimens to be archived at ALA and those to go to park herbaria were prepared at ALA.

At the park level, specimens will be curated through the import of data into ANCS+. Specimens returned to parks from ALA will be filed and accessioned. In addition, catalog ledgers will be updated and loan forms completed. Rare plant sighting forms (with maps) were completed for taxa with an AKNHP rank of S3 or less.

Products

The AKNHP has agreed to supply the NPS with this Final Technical Report that also includes:

1. An annotated species list describing all taxa and the basic geographic and habitat attributes of each park unit (Appendix 1).
2. Preparation of rare plant species lists for each unit, with notes on conservation status, biogeographic affinities, habitat preferences and related data (Appendix 2).
3. Publication-quality maps for selected species such as species of special concern or major range extensions that result from this project (Discussion).

In addition, the AKNHP has supplied/will supply the following to NPS:

4. A complete set of mounted and curated voucher specimens, to be housed at the Herbarium of the University of Alaska (ALA), with a set of duplicates supplied to the park.
5. Work with NPS to create a fully populated NPSpecies, and ANCS+ databases for each park unit
6. Annual reports describing the results of the inventory in each park unit
7. GIS data layers with links to plant databases (GIS attributes discussed in Appendix 3)

RESULTS

Significant increases in numbers of vascular plant species verified for KATM and ALAG were made in 2002. We collected, recorded, and curated 530 specimens from KATM and 133 from ALAG. 317 separate taxa were represented, and 187 were new records or verifications of unconfirmed taxa for Katmai Park. All 120 taxa collected from ALAG were new records. A number of finds were significant range extensions or of taxa of conservation concern. Significant results from collections are described for each of the primary regions. An annotated species list describing all taxa and the basic topographic and habitat attributes for ALAG and KATM is presented in Appendix 1. Appendix 2 give a list of rare species encountered.

Alagnak Wild River (ALAG)

Prior to this survey, virtually no plants had been collected in the ALAG unit. In a single drift trip from the confluence of the Nonvianuk and Alagnak Rivers to Middle River Camp, a distance of roughly 42 km we collected 133 specimens. Of these, 120 were new records for the unit. Nearly all of the species collected are common in the Bristol Bay Lowlands and are distributed throughout the holarctic region. No species of conservation concern or major range extensions were encountered. However, an unusual grass specimen was collected, and is currently being reviewed.

ALAG Area 1 -

At the Alagnak-Nonvianuk confluence, 66 specimens were collected from riparian and higher elevation, bluff habitats. The location was 59.03º N and 155.88º W and ranged from 170 to 210 m in elevation (see Figs. 3 & 4). Habitats within the survey area were more diverse than most of the other areas along the ALAG. Common habitats were wet tussock meadows bordered by shrub birch and alder, low shrub-graminoid meadows, and low-shrub tundra; additionally, a limited amount of dry-boreal community with an overstory of Kenai birch and white spruce were encountered (Fig. 4).

In the wet tussock meadows many widespread wetland *Carex* species were collected, such as *C. canescens*, *C. loliacea*, *C. pluriflora*, *C. saxatilis*, and *C. utriculata*. Other common wetland species collect included: *Rumex aquaticus*, *Spiranthes romanzoffiana*, and *Drosera rotundifolia*. Kenai birch (*Betula kenaica*) and *Alnus viridis* ssp. *fruticosa* were the small trees and shrubs collected from this site. *Ribes laxiflorum* (trailing black current) is a dry-mesic forest species that is uncommon in western Alaska. This species is more common in dry boreal forest in the Cook Inlet area, and ranges southeast along the Pacific coast and Rocky Mountains. This taxon was also found in Lake Clark in 2001, and these collections represent some of the most westerly known populations of this species. A specimen temporarily referred to as "*Bromus viviparus*" was collected in a small birch and alder stand. This grass looks superficially like the genus *Bromus*, but the awns appear distinctly more subapical, than is characteristic for the genus - in some cases the awns are actually dorsal. This collection is being reviewed. No other taxa from this area are significant range extensions or species of conservation concern.

ALAG Area 2 -
In a low shrub-graminoid community, approximately 3 km downstream from confluence of Alagnak and Nonvianuk rivers, on the north side of the river, 11 specimens were collected (59.01º N, 155.90º W; see Fig. 5). This included the aquatic and semi-aquatic species, *Hippuris vulgaris*, *Juncus filiformis*, and *Iris setosa*. *Agrostis scabra*, *Rhinanthus minor*, *Viola epipsala* were some of the mesic-wet meadow species collected at this site.

ALAG Area 3 -
This moist, closed willow thicket had a low diversity of vascular plants (location: 59.01ºN, 156.05ºW; see Fig. 5). Five taxa, each from separate families were collected. These were *Populus tremuloides*, *Rorippa palustris* var. *palustris*, *Rubus arcticus* ssp. *stellatus*, *Galium trifidum* ssp. *trifidum*, *Cicuta virosa* (*mackenzieana*). All of these are common throughout Alaska. *Populus tremuloides*, which is a dry-boreal species, reaches its southwesterly range limit in this Alagnak River area.

ALAG Area 4 -
Ranunculus trichophyllus, *Petasites frigidus*, *Betula nana*, *Festuca richardsonii*, and *Chrysosplenium tetrandrum* were collected from a low shrub-graminoid location just downstream from Area 3 (59.01ºN, 156.09ºW; see Fig. 6). These five of these species have circumpolar distributions and were expected to occur in the ALAG unit.

ALAG Area 5 -
At this rocky outcrop and bluff on the south side of the river, we collected 17 taxa (location: 59.01ºN, 156.11ºW; see Fig. 6). This was one of the few non-wetland and higher elevation sites encountered, and the species collected reflect the dwarf shrub - herbaceous tundra character. The grass species were *Festuca brachyphylla*, *F. altaica*, and *Hierochloe odorata*. Mesic-tundra herbaceous species collected were *Anemone narcissiflora* (Fig. 31A), *Antennaria monocephala, Arnica frigida, Carex podocarpa, Chamerion (Epilobium) latifolium*, *Pedicularis lanata* (*kanei*) (Fig. 31B), *Pinguicula villosa*, and *Tofieldia coccinea* (Fig. 31C). The woody species were all dwarf shrubs (*Diapensia lapponica*, *Loiseleuria procumbens*, *Salix arctica*, *S. phlebophylla*). All of these species are circumboreal except *Antennaria monocephala, Arnica frigida, Carex podocarpa*, and *Salix*

Figure 31A. *Anemone narcissiflora* - a common species encountered throughtout ALAG & KATM in open mesic sites.

Figure 31B. *Pedicularis lanata* - a species of mesic tundra.

phlebophylla, which are common throughout Beringia.

ALAG Area 6 -
This was a wetland site, of small ponds and adjacent wet-sedge meadows (location: 59.02ºN, 156.14ºW; see Fig. 6). Eleven voucher species were collected including *Eriophorum russeolum*, *E. vaginatum*, *Carex kelloggii*, *C. rotundata*, *C. utriculata*, *Arctophila fulva, Sparganium angustifolium*, and *Subularia aquatica*. All of these species are common over much of Alaska and have a holarctic distribution.

ALAG Area 7 -
In sandy, mesic soil on a gravel bar along the river, *Alopecurus aequalis*, was collected (location: 59.08ºN, 156.3ºW; see Fig. 6). This grass was scattered throughout the site and was also encountered along Contact Creek in southwestern KATM. This species is widespread throughout interior and south coastal Alaska and neighboring regions.

ALAG Area 8 -
The ericaceous shrubs *Vaccinium uliginosum* (Fig. 31D), *V. vitis-idaea*, *Empetrum nigrum* and arctic/subarctic grasses *Calmagrostis canadensis*, *Arctagrostis latifolia* were collected from the white spruce-low shrub community of this site (location: 59.12ºN and 156.33ºW; see Fig. 6).

ALAG Area 9 -
A total of 12 specimens were collected and pressed from the wet, sandbar community of Area 9 (59.09ºN and 156.47ºW; see Fig. 3). The graminoid species were *Juncus arcticus*, *Carex lyngbyei*, *Agrostis scabra*, *Deschampsia caespitosa*, and *Glyceria maxima*. Additional species collected were aquatic or semi-aquatic, including: *Callitriche palustris*, *Caltha natans*, *Ranunculus gmelinii*, and *Limosella aquatica*. *Limosella aquatica* is a widespread species, but has only infrequently been collected in Alaska, probably due to its small stature and aquatic nature.

Figure 31C. Close-up photo of *Tofieldia pusilla* a close relative of *T. coccinea*, found in open rocky tundra.

Figure 31D. *Vaccinium uliginosum*.

Katmai National Park and Preserve (KATM)

Fieldwork at three primary regions and some brief collecting at additional stations resulted in 530 specimens; 146 are new records for the park. New records were obtained from all primary sites and from all major habitat types. Most of the new records were of common species widespread throughout Alaska and/or the holarctic region; however, a number of taxa of conservation significance were also collected. These are discussed below.

KATM Region 1 -

In a targeted search for unknown and under-collected taxa, we collected 153 specimens from around Swikshak Lagoon in early July and again briefly in mid-August. Collecting occurred in all six primary habitat types encountered (i.e., intertidal communities; forb-graminoid meadows; freshwater ponds and marshes; alder and willow thickets; wet, low shrub-sedge meadows and fens; and herbaceous-dwarf shrub tundra, and exposed alpine slopes). A summary of results for each habitat type follows.

Intertidal Communities -

A total of 15 taxa were collected from salt marsh and upper beach strand habitats. In general this habitat was moderately low in diversity. The biomass was dominated by *Honkeya peploides*, *Leymus mollis, Poa eminens*, and *Carex macrocephala* in sandy, beach strand areas, and by *Plantago maritima*, *Carex lyngbei*, *C. ramenskii*, and *Argentia* (*Potentilla*) *egedii* in salt-marsh communities. Most of these dominants had been collected before in the park; however, ten of the specimens had not been confirmed in KATM. These include the common and widespread species: *Carex ramenskii*, *Argentina* (*Potentilla*) *egedii*, and *Stellaria humifusa*. We collected *Cakile edentula* from a sandy site, which is a species restricted to scattered coastal, sandy beaches in Alaska. *Cakile edentula* is quite common along the coastal sand dunes from California to British Columbia, but becomes increasingly rare in the Gulf of Alaska coast. Isolated populations are known from exposed beach sites in southeast Alaska, remote islands in Prince William Sound, on southern Kodiak Island, and at Aniakchak. This population is one of the farthest west collections known from the mainland.

Forb-Graminoid Meadows -

We collected 33 taxa from forb-graminoid meadows. Of these, 26 were new verified records for the park. Many were common species such as *Lupinus nootkatensis*, *Heracleum lanatum*, *Carex gmelinii*, and *Achillea borealis*. The composition of species in this community was typical of the eastern Aleutians and Alaska Peninsula coast, with many umbels (Apiaceae), lupines, geraniums, and large orchids. This included the striking orchids *Dactylorhiza aristata* and *Cypripedium guttatum* (Figs. 32A-B.)

Figure 32A.
Dactylorhiza aristata.

Figure 32B.
Cypripedium guttatum.

Freshwater Marsh -

Twenty-one taxa were collected from freshwater communities in the Swikshak Lagoon area. Many of the collections were of aquatic species such as *Hippuris vulgaris*, *Sparganium angustifolium, Potamageton sp.*, *Menyanthes trifoliata*, and *Utricularia vulgaris*. These habitats tended to be moderately diverse, yet only ten of the taxa were new to the park. The new taxa included two widespread wetland sedges (*Carex chordorrhiza*, and *C. rostrata*) and a number of the new records are often found in wet places, but are not obligate wetland species (e.g., *Prenanthes alata*, *Campanula rotundifolia*, and *Galium trifidum*)

Alder and Willow Thickets -

Vascular plant diversity was low in this habitat-type. Only five specimens were collected in this community; two represent new collections for the park. *Boschniakia rossica* was a new record for KATM. This species is an obligate parasite on *Alnus* and is common throughout Alaska and northeastern Asia. *Oplopanax* (*Echinopanax*) *horridum* was another new collection that was previously unconfirmed record for the park. This collection represents the approximate western limit of this species, whose distribution is centered along the northwestern Pacific Coast Mountains.

Wet, Low Shrub - Sedge Meadows and Fens -

Many taxa new to the park were found in this habitat-type. Thirteen of 23 collections were new to KATM. A collection of the previously unverified, *Picea sitchensis* was made from a small grove on the headland 10.5 km northeast of the Swikshak cabin. According to park rangers, stands of this species are more common from Hallo Bay south to Katmai Bay, but are unknown north of Swikshak Lagoon. Additional collections from wet-sedge meadow that were new or confirmations to the park were three widespread sedges *Carex norvegica* (*media*), *C. pluriflora*, and *C. rotundata*. Collections of *C. rotundata* are generally absent from the Bristol Bay Lowlands; most collections are concentrated in wet places in northern, western, and southcentral Alaska. The collection of *C. rotundata* at Swikshak is the one of the more southerly collections of this sedge;

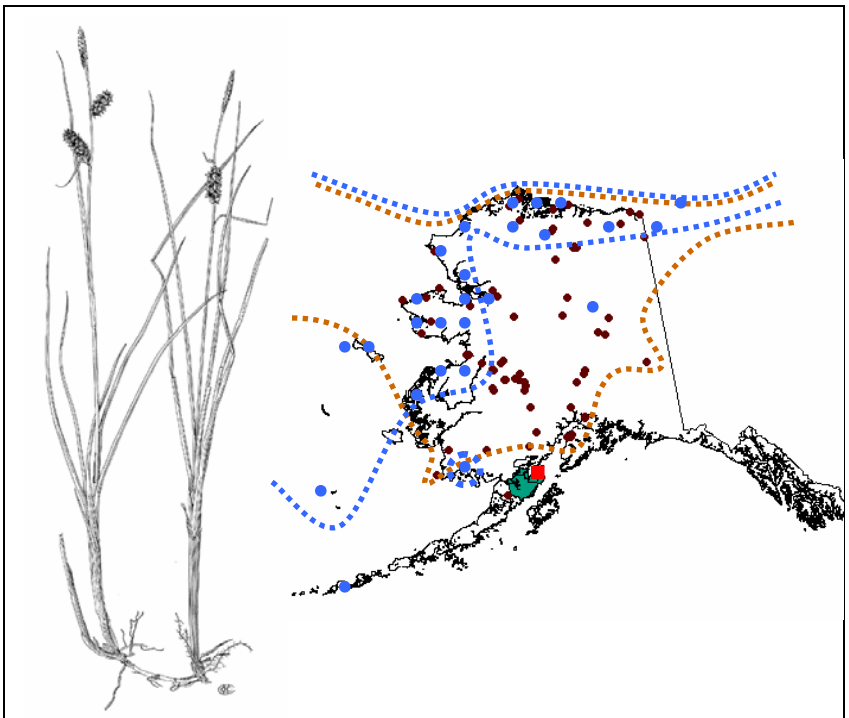


Fig. 33. *Carex rotundata* illustration (Mackenzie 1940) and range in Alaska in brown. *Dupontia fisheri* in blue. The collection in KATM is shown as a red square.

however, it has been collected recently by S. Talbot further south in Becharof NWR (Fig. 33). A more striking range extension and addition to the park is the collection of *Dupontia fisheri* (Fig. 34A-B). The population was found along the edge of a pond in a wet sedge meadow, bordered with alder and willow, cottonwood and birch. This common circumpolar grass is typically found in wet coastal tundra of arctic and western Alaska, and similar regions of Northern Canada, Greenland, and Russia. In Alaska, isolated outlying populations have been found at Cold Bay on the Alaska Peninsula and Cape Pierce in southwest Alaska. This collection of *Dupontia fisheri* at Swikshak is the furthest east location, and the first from a woodland habitat in Alaska. This site is over 320 km from the Cape Pierce location. Individuals of *D. fisheri* were scattered or patchy to numerous; total population size is likely > 5,000. The primary associated species were *Carex lyngbyei*, *Calamagrostis canadensis*, *Eriophorum russeolum*, *Comarum* (*Potentilla*) *palustre*, and *Sphagnum* spp.

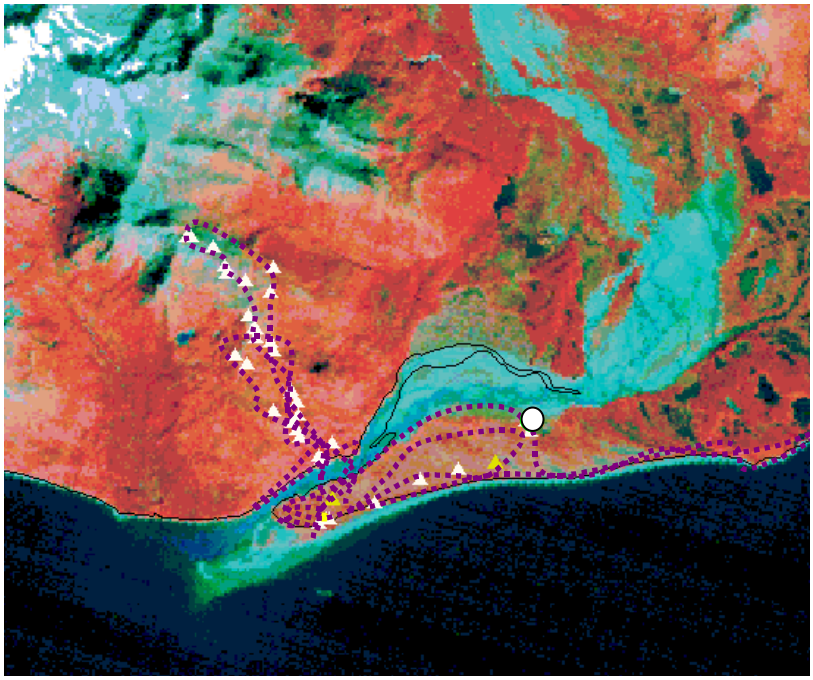


Figure 34A. Collection locality of *Dupontia fisheri* at Swikshak Lagoon, shown as a white circle.

Figure 34B. Photo of *Dupontia fisheri* taken at Swikshak Lagoon.

Herbaceous - Dwarf Shrub Tundra -
Few previous collections were from this habitat-type. Therefore, we spent a large portion of our time surveying tundra communities. A total of 155 specimens were collected, pressed, and catalogued from alpine meadows and tundra habitats around Swikshak. Of the total, 30 taxa were new to the park (or confirmations of "unconfirmed" taxa). Five of the new records were the sedges: *Carex anthoxanthea*, *C. nardina*, *C. podocarpa*, *C. rupestris*, *C. scirpoidea*, and *Kobresia myosuroides*. *Carex anthoxanthea* is an alpine species common on grassy slopes in coastal-southern Alaska. *Carex nardina*, *C. rupestris*, *C. scirpoidea* and *Kobresia myosuroides* are species that had not been collected on the Alaska Peninsula. The *Kobresia myosuroides*, *Carex nardina*, and *C. rupestris* represent range extensions to the southwest approximately 350-500 km (see Figs. 39-41). *Carex scirpoidea* has been widely collected in the Alaska Range and on Kodiak Island, but no records are present for the Alaska Peninsula. The other new records included a variety of widespread species, ranging from the ferns *Botrychium lunaria* and *B. lanceolatum* to more "advanced" (i.e., recently derived) angiosperm families such as Scrophulariaceae s. l. (*Pedicularis lanata*) and Asteraceae (*Arnica lessingii*).

KATM Region 2 -
At this high elevation area (400 - 900 m) in the vicinity of Mirror Lake, we recorded nearly 40 new records for the park, including a number of substantial range extensions and two globally and state, rare taxa (Alaska Natural Heritage Program - Rare Plant Tracking List).

Aquatic/Semi-Aquatic -
Fifteen specimens were collected from aquatic to semi-aquatic habitats. These include six species that are new to the park: *Andromeda polifolia*, *Carex anthoxanthia*, *C. membranacea*, *Juncus biglumis*, *J. drummondii*, and *Primula eximia* (sensu Kelso 1987). Most of these new records are of widespread taxa (e.g., *Andromeda polifolia, Carex membranaceae*, *Juncus biglumis*).

We collected *Primula tschuktschorum* (sensu stricto) in saturated wet tundra along upper Funnel Creek and again in a population mixed with *P. eximia* along a wet pond margin in saturated soil near Mirror Lake. This is not only a significant range extension from known-verified collections, but is a globally rare taxon (Fig. 35). This species may have been collected in KATM in 1978; however, prior taxonomic confusion relating to this species makes the identity of this early collection dubious. The taxon was outlined as *Primula tschuktschorum* var. *tschuktschorum* by Hultén (1968), who loosely distinguished it from

Figure 35. *Primula tschuktschorum* growing along saturated pond margins at KATM Region-2.

P. tschuktschorum var. *arctica* on the basis of plant size. The two varieties were later raised to species status by Kelso (1987), who described a number of clear and consistent traits to separate the rare, *P. tschuktschorum* (s.s.) from the larger and more widespread *P. eximia*. Bud Rice with NPS made a collection of "*P. tschuktschorum* var. *arctica*" at Murray Lake, Katmai in 1978. He would not have been using the currently accepted treatment of these two taxa, and since they are poorly delineated in Hultén (1968), it is difficult to say with certainty which taxon was collected in the park in 1978. A careful examination of his collection is clearly warranted along with the recent *Primula* collections by AKNHP botanists. AKNHP assumed they had collected *P. tschuktschorum* (s.s.) from two populations; however, determinations by ALA indicated that both *P. tschuktschorum* and *P. eximia* had been collected. Duplicate sheets from the "*P. eximia*" site suggest *P. tschuktschorum* is also present. The morphology of *Primula* at Mirror Lake appears to be intermediate in many traits and a closer evaluation is needed.

The specific collection locality of *P. tschuktschorum* (s.s.) by AKNHP is shown in Fig. 36. This species is restricted to the Bering Strait Region with an outlying populations south to the northern coast of Bristol Bay. The KATM Region-2 population is located nearly 320 km to the east of the northern Bristol Bay populations (see Fig. 54). At KATM Region-2, *P. tschuktschorum*, was relatively common along the banks of shallow ponds and snowmelt areas at around 400 to 450 m and into wet-sedge tundra communities with noticeable water flow (see Fig. 35). Many patches of 50 - 200 plants were encountered, with a total population size estimated at 5,000 individuals. This species was always associated with heavy saturated soils, generally with a shallow layer of peat. The associated species of the rare primrose were: *Calamagrostis canadensis, Carex podocarpa, Sanguisorba sitchensis, Salix glauca, Rumex spp. Eriophorum spp., Salix reticulata, Vaccinium uliginosum, Festuca altaica*.

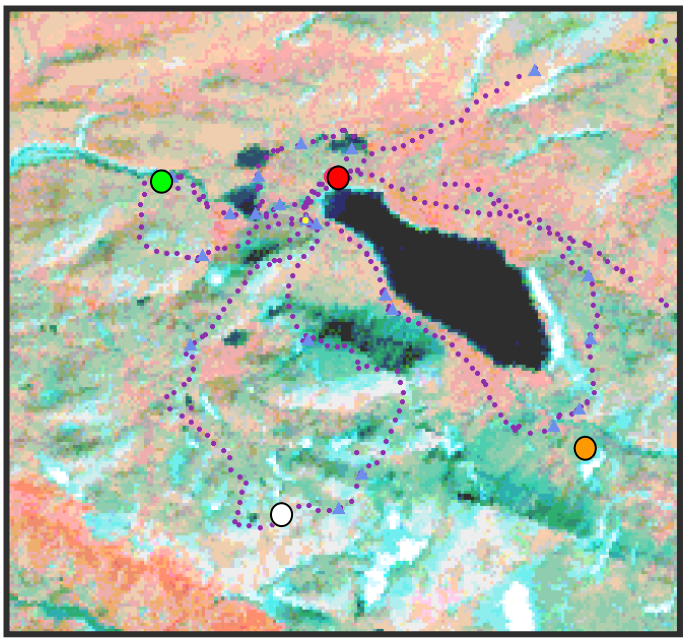


Figure 36. Collection-sites of KATM Region-2, as blue triangles. *Primula tschuktschorum* site is highlighted in green and the potentially mixed *P. tschuktschorum-P. eximia* site in red. *Aphragmus eschscholtzianus* site is shown in white, and *Ranunculus nivalis* in orange.

Wet-Sedge Tundra -

Poorly drained, wet-sedge tundra was encountered west of Mirror Lake and 18 specimens were collected from this habitat. Of the 18 specimens, ten were new to the park: *Anemone narcissiflora* ssp. *monantha* (*alaskana*), *Carex bigelowii*, *C. rariflora*, *Eriophorum angustifolium* ssp. *scabriusculum*, *E. russeolum*,

Lagotis glauca, *Ranunculus nivalis*, *Rumex arcticus*, *Salix fuscescens*, and *Saxifraga hirculus*. The new records included a range extension of the sedge, *Carex rariflora*, which is more common in wet peaty soils in southcentral and central Alaska but was not known from the Alaska Peninsula. *Ranunculus nivalis* was collected on the southern end of Mirror Lake (Fig. 36). This taxon, which is a circumpolar species of wet meadows in mountains or tundra, was previously unrecorded from southwestern Alaska. The nearest collections are ca. 160 km north in the Chigmit Mountains of Lake Clark National Park and Lime Hills, and ca. 500 km northwest at Hooper Bay on the Bering Sea.

Low Shrub - Herbaceous Tundra -

The most common type of habitat encountered at KATM Region-2 was low shrub-herbaceous tundra and 38 specimens were collected. Of these, 15 were new park records: *Agrostis mertensii*, *Arnica latifolia* (Fig. 37), *Campanula uniflora*, *Carex bigelowii*, *Carex lachenalii*, *Draba stenoloba*, *Equisetum scirpoides*, *Lupinus nootkatensis*, *Pedicularis albolabiata* (*sudetica* ssp. *albolabiata*), *Pedicularis labradorica*, *Saxifraga lyallii*, *Thalictrum alpinum*, *Tofieldia pusilla*, *Vaccinium ovalifolium*, *Veronica wormskjoldii*. The new record, *Arnica latifolia*, is well known from Kodiak Island and Kenai Peninsula-Susitna Valley and to the southeast; however, no records are known from the Alaska Peninsula. *Equisetum scirpoides* is a new park record and a moderate range extension south (the species is generally collected much farther to the north). *Campanula uniflora* is a widespread circumboreal alpine species with populations from Norway to the Rocky and Sierra Mountains. This taxon is found on arctic and alpine tundra in northern Alaska, through the Alaska Ranges and in the Aleutians. No records were known from the northern portion of the Alaska Peninsula.

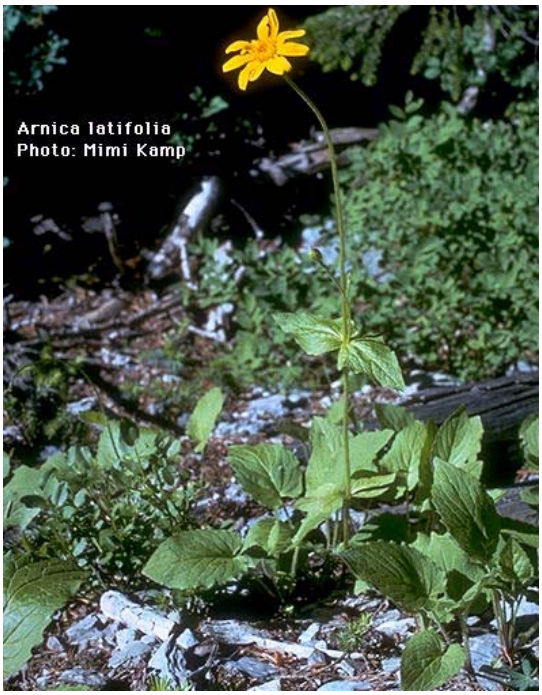


Figure 37. Photo of *Arnica latifolia* (http://www.swsbm.com/Images/A/Arnica_latifolia-3.jpg)

Figure 38. Photo of *Eritrichium chamissonis* from KATM Region-2 (Mirror Lake).

Alpine Fellfields -

Eight of 19 collections in the alpine communities, surrounding Mirror Lake, were newly verified park records *Aphragmus eschscholtzianus*, *Carex micropoda*, *Cryptogramma sitchensis*, *Draba fladniznesis*, *Festuca brevissima*, *Ranunculus nivalis*, *Saxifraga flagellaris*, *Saxifraga serpyllifolia*. Nearly all of these collections were of very widespread species. Two collections were of more

restricted species. We collected *Eritrichium chamissonis* (see Fig. 38) that is a species restricted to rocky or sandy soil in the Bering Sea area, from the upper Colville River in the western Brooks Range to the Chukotka Peninsula in Russia and south to the Pribilof Islands, Alaska Peninsula, and east to Kodiak Island. Despite a narrow geographic range, this species is relatively common and has been collected in a number of areas near Katmai Park and was listed by Young et al. (1978) as present in the park, although not vouchered until recent collections by T. Smith. *Aphragmus eschscholtzianus* (Fig 39A) on the other hand, is listed as a G3, S3 (rare or uncommon globally and within the state) and is known from scattered alpine sites in 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 (see Fig. 53). This rare mustard is restricted to solifluction soil and rocky melt-ponds at high elevations. We located the *Aphragmus eschscholtzianus* population on a rocky, sparsely vegetated, former melt-pond along an alpine bench just south of Mirror Lake (Fig. 39B). The population size was between 100 and 200 individuals. Nearby associated species included *Carex microchaeta*, *Ranunculus eschscholtzii*, and *Lagotis glauca*.

Figure 39A. *Aphragmus eschscholtzianus* photographed from a different site in southcentral Alaska.

Figure 39B. Collection locality of *Aphragmus eschscholtzianus* at KATM Region-2 (Mirror Lake).

KATM Region 3 -

Aquatic/Semi-Aquatic -
We collected 24 specimens along the lakeshore, in shallow ponds to the north and west of the lake, and along a number of streams in the vacinity of Contact Creek. This included obligate aquatic species such as four *Potamageton* species (*P. filiformis*, *P. gramineus*, *P. praelongus*, *P. pusillus*) *Sparganium angustifolia*, and *Subularia aquatica*, and wetland species such as *Carex lyngbyei*, *C. chordorrhiza*, and *Comarum palustre*. Additionally, we collected a number of taxa from wet sand and gravel bars such as *Rorippa palustris* ssp. *palustris*, *Barbarea orthoceras*, and even an isolated *Papaver radicatum* ssp. *alaskanum* that likely was washed down from higher elevations. Nine taxa from aquatic/semi-aquatic habitats were new records for KATM. This included: *Aster sibericus*, *Callitriche heterophylla*, *Poa glauca*, *Poa pratensis*, *Polygonum fowleri*, *Potamogeton gramineus*, *Sagina saginoides*, *Sparganium angustifolium*, *Utricularia vulgaris*. *Polygonum fowleri* has been collected along the Gulf Coast from British Columbia through Alaska as far as Kodiak Island, but no collections are known from the mainland west of Homer.

Wet-Sedge Tundra -
Twenty specimens were collected from wet-sedge tundra. *Carex bigelowii*, *Carex media*, *Carex membranacea*, *Carex sitchensis, Epilobium palustre*, *Eriophorum russeolum*, *Eriophorum vaginatum* (Fig. 40), *Juncus triglumis*, *Pedicularis parviflora* ssp. *parviflora*, and *Saxifraga hirculus* were new park records. These species are widespread in wet areas of southwestern Alaska.

Figure 40. *Eriophorum vaginatum*. Photo from Robert W. Freckmann, Wisconsin State Herbarium.

Low Shrub - Herbaceous Tundra -
At mid elevations, low shrub-herbaceous tundra was commonly encountered. We recorded 26 taxa; nine are new park records. The new taxa were *Betula glandulosa, Isoetes echinospora*, *Lycopodium alpinum*, *Poa glauca*, *Draba nivalis*, *Prenanthes alata*, *Carex bigelowii*, *Arnica chamissonis*. Two species, *Artemesia globularia* and *Stellaria laeta*, were found on more open, rocky microsites within the to low shrub-herbaceous tundra.

Alder and Willow Thickets and Bluejoint Meadows -
Alder and willow thickets and adjacent bluejoint meadows were very low in diversity, and we collected just six taxa in this habitat. *Cicuta douglasii*, widespread in southern Alaska and western North America, was the only taxa new for the park.

Alpine Fellfields -

Five specimens were collected from higher elevation, fellfield sites. None of the collections are new to the park. However, *Claytonia scammaniana* (see Fig. 40) is endemic to Alaska and western Yukon Territory, with most populations clustered in the Alaska Range, Tanana Uplands, and scattered locations southwest to Goodnews Bay. One population has been recorded just south of Katmai Park on the Alaska Peninsula and recently Tom Smith has collected the taxon in the park.

Figure 40. *Claytonia sarmentosa*, a close relative of *C. scammaniana*, which is found in moist, mossy microsites. *Claytonia scammaniana* is generally found on talus slopes in the mountains.

Ancillary Sites -

A total of 66 taxa were collected and recorded from additional sites scattered throughout the park. The majority of collections were from the upper Nonvianuk River in the northwestern region of KATM. This included 34 mostly wetland specimens, 14 of which were new park records: *Aster sibericus*, *Carex brunnescens* (Fig. 41A) *Carex pluriflora*, *Carex rotundata*, *Carex tenuiflora*, *Carex williamsii*, *Epilobium palustre*, *Eriophorum vaginatum*, *Isoetes echinospora*, *Poa pratensis*, *Ranunculus lapponicus*, *Rumex arcticus*, *Salix fuscescens*, and *Trichophorum caespitosum*. *Carex williamsii* is a new park record, whose distribution is generally confined to the northern half of Alaska. However, within the last ten years populations have been located at Ugashik on the Alaska Peninsula, just south of KATM, and on Kodiak Island.

Fourteen specimens were collected from areas around Brooks camp. *Carex media*, *Juncus arcticus* ssp. *sitchensis*, *Juncus alpinus*, *Matricaria matricarioides*, and *Taraxacum trigonolobum* were new to the park. Our collections included three introduced species: *Capsella rubella* and *Plantago major* var. *major*, along with the previously

unknown, *Matricaria matricarioides*. All of these collections of exotics were around developed areas such as buildings, roads, and campgrounds.

Seven species were collected from Dakavak Lake the southeastern part of KATM. *Aruncus dioicus* (*sylvester*), *Poa pratensis*, and *Romanzoffia sitchensis* were new records for the park and *Salix sitchensis* was formerly unconfirmed.

At Sukoi Bay, on Cape Douglas, 11 voucher specimens were collected. This site, visited in mid-August, had all new or previously uncomfirmed park records. The taxa new to the park at this location were: *Arnica amplexicaulis*, *Campanula rotundifolia* (41B), *Dendranthemum arcticum* ssp. *arcticum*, *Gentiana douglasiana*, *Gentiana platypetala*, *Juncus supiniformis*, *Plantago macrocarpa*, *Prenanthes alata*, and *Vaccinium ovalifolium*.

Figure 41A. *Carex brunnescens*, photo from Emmet J. Judziewicz, Wisconsin State Herbarium.

Figure 41B. *Campanula rotundifolia*, photo from Robert R. Kowal, Wisconsin State Herbarium.

DISCUSSION

A vascular plant inventory was conducted by the Alaska Natural Heritage Program in agreement with NPS to provide baseline information for future monitoring and management of natural resources for Katmai National Park and Alagnak Wild River Units. The AKNHP documented the occurrence, distribution, and relative abundance of plants occurring in these units with the primary goal of documenting ≥ 90% vascular plant taxa expected to occur within the parks and improve our understanding of current species distributions.

Significant increases in the number of vascular plant species verified for KATM and ALAG were made in 2002. Prior to 2002, no plants were reliably known from the ALAG and 54% of the 623 expected taxa were known from KATM. Following the 2002 field season, 120 new taxa were recorded for ALAG. An estimated total of 390 taxa are possible within ALAG, based on an analysis of the distribution and habitat requirements of southwestern Alaskan plants. However, this is likely a severe overestimate, since the ALAG unit is quite small and narrow, excluding a broad range of substrate and habitat types. Based on this broad interpretation of expected taxa, we collected 31% of the potential vascular plant species. Additional, targeted collecting would likely add 60 -100 taxa to the 120 collected in 2002.

The percent of documented and vouchered taxa in KATM jumped from 54% prior to 2002 to 84% after the field season. This included documenting previously unconfirmed taxa, collecting many well-known and widely distributed taxa, but also a number of conservation significance. It is likely that an additional 20-40 taxa can be added to the 523 now verified in the park with a single field season of future collecting in novel habitat types and geographic regions. This would closely approximate the goal of NPS in documenting ≥ 90% vascular plant taxa expected to occur within the park (ca. 40 new taxa are required to achieve 90%).

A number of important finds were made in KATM in 2002. AKNHP collected six species that are major range extensions, three species that are exotic weeds, and two species that are globally and regionally rare. The relevance and importance of the finds are discussed below.

Major Range Extensions -

Dupontia fisheri R. Br. ssp. *psilosantha* (Rupr.) Hult.:
Tundra grass (*Dupontia fisheri*. ssp. *psilosantha*, Fig. 42) is a circumpolar grass of wet meadows in coastal tundra. In Alaska it is found across the North Slope and extending south across the coastal tundra of the Seward Peninsula to the Yukon-Kuskokwim Delta, with outlying, disjunct populations at Cape Pierce and Cold Bay (Fig. 33).

The population at Swikshak (KATM Region-1) is a range extension to the east of 320 km from the Cape Pierce population and is unusual in being surrounded by open deciduous woodland. (Typically, this tundra species is not found near wooded habitats). Figure 43 (top) shows the more typical habitat of the species relative to the habitat it was found in at Swikshak (Fig. 43: bottom). The total population size was likely ≥ 5,000 individuals.

As with nearly all populations of *Dupontia* in western and southwestern Alaska, this population was quite uniform in morphology and typical of subspecies *psilosantha*. No individuals were suggestive of, or intermediate to, subspecies *fisheri*. This supports the maintenance of the two forms as distinct taxa (see discussion in Aiken et al. in prep).

The two disjunct populations in south-western Alaska are likely the result of long-distance dispersal by waterfowl. The grass is an important food source for migrating ducks and geese (Gauthier et al. 1995) and the locations of these southerly, disjunct populations are along migration routes. It is unlikely that is a relictual population as the region was heavily glaciated during the Pleistocene.

Figure 42. Photo of *Dupontia fisheri* from Swikshak Lagoon.

While the KATM population is relatively large and secure, it is still a conservation concern. Disjunct populations are not genetically linked to other populations and are often under divergent natural selection. This creates an opportunity for the population to develop novel genetic-morphological-ecological attributes, via genetic drift and selection, not found in other, more contiguous populations. We therefore stress the importance of this population (and of the other range extensions discussed below) and suggest that modest population monitoring occurs in the future. This is discussed further in the "Recommendations" section below.

Figure 43: Top. Typical coastal north-slope habitat of *Dupontia fisheri*. Photo is from A. T. L. A. S. (Arctic Transistions in the Land-Atmosphere System: http://www.geobotany.uaf.edu/atlas/atlas_sites.html)

"**Barrow, Arctic Coastal Plain (coastal acidic tundra)** The site is located in Subzone 3 (N 71 19 17.6, W 156 36 29.3) on a fairly homogenous flat residual surface (unaffected by thaw-lake processes). Most of the surface is either featureless or has flat-centered ice-wedge polygons. The primary plant community is Saxifraga cernua–Carex aquatilis. This type commonly occurs on moderately drained, zonal sites near the coast and is dominated by graminoids (*Alopecurus alpinus, Carex aquatilis, Dupontia fisheri, Eriophorum angustifolium, Poa arctica*), forbs (*Cardamine pratensis, Cerastium jenisejense, Chrysosplenium tetrandrum, Petasites frigidus, Saxifraga cernua, S. hirculis, S. hieracifolia, S. nelsoniana, Stellaria laeta and mosses (Oncophorus wahlenbergii, Polytrichastrum alpinum, Polytrichum strictum,* and *Sarmentypnum sarmentosum*). Prostrate and semi-erect willows (*Salix rotundifolia, S. planifolia* ssp. *pulchra*) are common in some areas." - A .T .L .A. S. (2002)

Figure 43: Bottom. Woodland marsh at Swikshak Lagoon, where *Dupontia fisheri* was found.

Carex nardina Fries:
On an exposed alpine knob at 450 m, just north of Swikshak Lagoon (KATM Region-1; Fig. 44) three significant range extensions of sedge species were noted. The substrate was dry and rocky and likely moderately calcareous. However, the material did not effervesce when acid was applied, so it was likely only modestly basic. The associated species were *Saxifraga oppositifolia*, *Saxifraga bronchialis*, *Minuartia obtusiloba*, *Rhodiola integrifolia* (*Sedum rosea*), *Festuca rubra*, *Artemisia arctica*, and *Silene acaulis*. Although, none of these species are obligate calciphiles, *Saxifraga oppositifolia*, and *Silene acaulis* are tolerant of high pH substrates and are common on calcareous sites; these two species were not fount elsewhere in the area. The densely tufted, terminally spiked sedge, *Carex nardina* (Figs. 45, 46) was found in very limited numbers; perhaps less than 20 individuals were located. In general, this taxon is found on exposed, rocky arctic and alpine tundra, usually on calcareous parent material (Murray 2002). *Carex nardina* is common throughout mountainous and northern regions of the state but has not been observed on the Alaska Peninsula. However, a population was collected in 1996 by P. Caswell in the mountains of Lake Clark National Park, approximately 160 km to the north. Additionally, a collection is known about 160 km to the northeast, from a scree slope in Kachemak Bay on the southern tip of the Kenai Peninsula. The collection in KATM represents a moderate range extension to the southwest; however, it is not surprising since mountainous habitat is continuous from the Alaskan Range to the Aleutian Range.

Figure 44. Exposed alpine knob at Swikshak where *Carex nardina* and *C. rupestris* were collected. *Kobresia myosuroides* was collected from a site nearby.

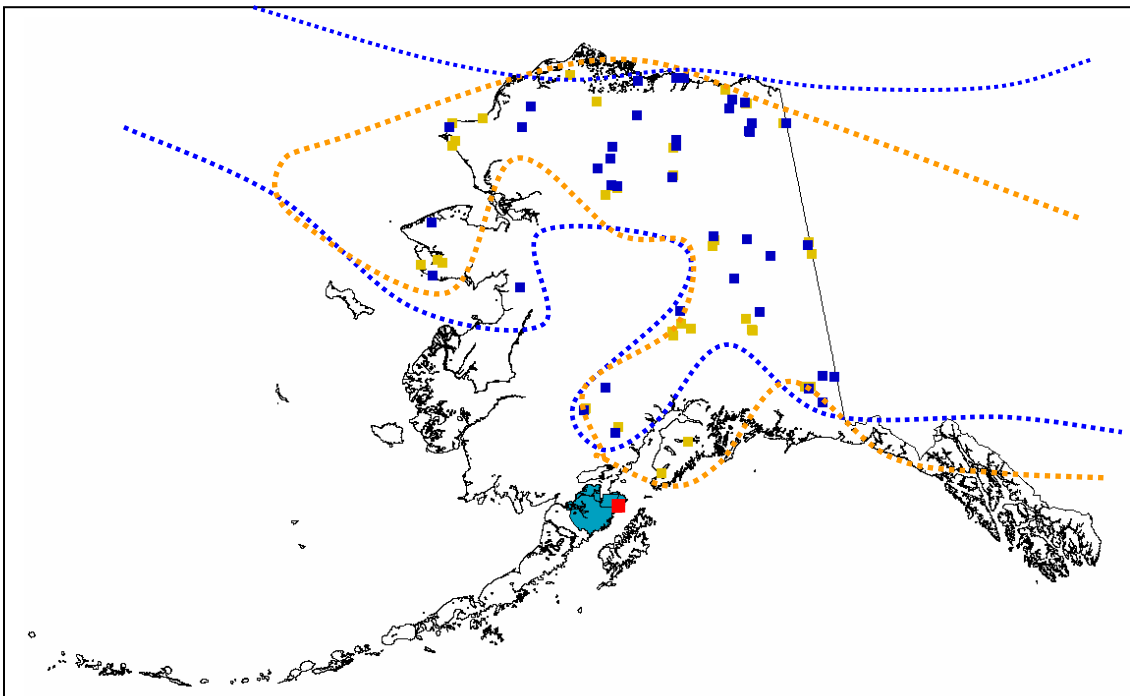


Figure 45. Range of *Carex nardina* in yellow-orange and *C. rupestris* in blue. The range of *Kobresia myosurioides* follows that of *C. rupestris*. The collection in KATM is shown as a red square.

Carex rupestris Allion:
We located another single-spiked, androgynous sedge, *Carex rupestris* (Figs. 44, 45, 47) that was growing together with *C. nardina* near Swikshak Lagoon (KATM Region-1). Thus, the substrate and associated species are identical to those described above. *Carex rupestris* is found on dry to mesic heaths and rocky outcrops; it has a very widespread holarctic distribution with populations in the Alps, Scandinavia, Siberia, East Asia, and throughout northern North America, including disjunct populations in the Rocky Mountains (Ball 2002a). In Alaska, this taxon is confined to the Alaska Range, Wrangell Mountains, Tanana Uplands, and Brooks Range (Fig. 45). A number of populations are also known from the Lime Hills. In 1997, P. Caswell located a population at Falls Mountain in Lake Clark National Park, roughly 160 km to the north of the population found at Swikshak. This range extension farther south along the Aleutian Range is not surprising. Only a narrow, 15-30 km low elevation "barrier", separates the high elevation sites of the Chigmit Mountains (Lake Clark and Lime Hills) with the continuous mountains of Katmai National Park. More extensive survey work would likely reveal more *C. rupestris* sites along the Walakta Mountains in KATM.

Figure 46. *Carex nardina*. Photo is from Nilsson 1995.

Figure 47. *Carex rupestris*. Photo is from Nilsson 1995.

Kobresia myosuroides (Villars) Fiori et al.:
At 450 m, in moist rocky soil at KATM Region-1, we collected *Kobresia myosuroides*. This voucher was made from a patch of ca. 100 individuals within ericaceous low-shrub tundra with a thick *Cladina* spp. and *Cladonia* spp. lichen component. The associated species were *Empetrum nigrum*, *Artemisia arctica*, *Carex podocarpa*, *Gymnocarpium dryopteris*, *Rubus arcticus*, *Vaccinium uliginosum*, and *Salix arctica*. The global and Alaskan distribution of this species is almost identical to that of *C. ruprestris* (Fig. 45) and this collection near Swikshak Lagoon represents a 160-300 km range extension to the southwest. According to Hultén (1968), this species is associated with calcareous slopes and gravel bars. However, Ball (2002b) describes the habitat more broadly: "tundra, grasslands, heaths, bare rocky, dry to wet ground." The Swikshak population did not appear to be on a calcareous substrate with such a large ericaceous shrub component. However, this site is not far from the weakly calcareous site of *C. nardina* and *C. ruprestris* and may, in fact, have a more basic pH.

Ranunculus nivalis L.:
At Mirror Lake (KATM Region-2), in a saturated snow bed we found a population of 500 to 1000 individuals of snow buttercup, *Ranunculus nivalis* (see Fig. 48). The snow buttercup is found in wet meadows and along brooks in the mountains and in snow beds, and blooms quickly after the snow has melted (Nilsson 1995). This is a common holarctic species found throughout the mountains of Alaska and near sea level in the Arctic (Fig. 49; Benson 1948), but according to Hultén (1968) has not been collected from the southwestern portion of the state. However, in 2001 the AKNHP collected the taxon near a moutain lake in Lake Clark National Park. The collection in KATM is a ca. 160 km range extension to the southwest.

Figure 48. *Ranunculus nivalis*. This photo was taken in Satteviera, Artfjället, Sweden. (www.quark.lu.se/~jum/hiking/vindelfjallen/1991/frame3.htm)

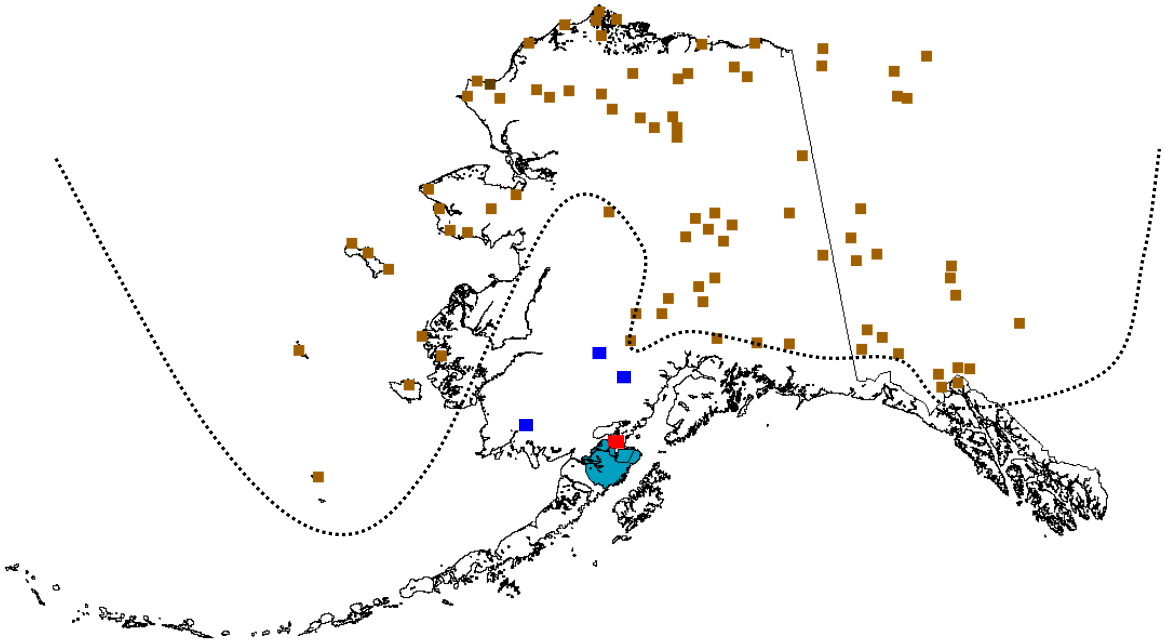


Figure 49. Distribution of *Ranunculus nivalis*, based on Hultén (1968). Individual collections are shown as brown squares and general distribution indicated above the dashed line. The recent collections in LACL, Lime Hills, and Goodnews Bay are shown in blue, and KATM is shown as a red square.

Exotic Species -

At Brooks Camp three introduced species were found. The camp receives thousands of visitors each year and it is surprising that only three exotic 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.

Figure 50A. *Capsella rubella*. Photo is from: http://www.inra.fr/hyppa/hyppa-a/capru_ah.htm#Adult plant

Figure 50B. *Matricaria matricarioides*. Photo is from: http://www.missouriplants.com/Greenalt/Matricaria_matricarioides_page.html

Capsella rubella Reut.:
The introduced weed, *Capsella rubella* (Fig 50A) was rare (fewer than 200 individuals) and confined to disturbed ground near buildings at Brooks Camp. Associated species were *Equisetum arvense*, *Achillea millefolium*, and *Calamagrostis canadensis*. This weed is capable of establishing in areas with disturbed substrates, but is not considered a serious threat to native communities. However, destruction of this population and further monitoring is recommended (see below).

Matricaria matricarioides (Less.) Porter:
At the same collection site as *Capsella rubella*, the small composite, *Matricaria matricarioides* (Fig. 50B) was collected. Few individuals were found scattered around buildings and roads. This species is believed to be native to northwestern North America (as well as Asia), but is not native to Alaska (Hultén 1968, McClintock 1996). Like *C.*

rubella, this species is restricted to waste places and does not appear to successfully compete with intact communities.

Plantago major var. *major*:
Another introduced species was located at the Brooks Camp campground. *Plantago major* var. *major* (Fig. 51) was more common than *Capsella rubella*, but was also restricted to disturbed sites. The community associates included *Calamagrostis canadensis*, *Betula papyrifera*, *Chamerion* (*Epilobium*) *angustifolium*, and the weed *Matricaria matricarioides*. This species is not a particularly aggressive invader and is not cause for serious concern. Although it can become dense under high nutrient and disturbance conditions, it is a weak competitor in moderately intact plant communities.

Figure 51. *Plantago major*. Photo is from: http://www.wsu.edu:8080/~wsherb/images/Plantaginaceae/plantago.html

Species of Conservation Concern -

Aphragmus eschscholtzianus Andrz.:

We identified a small population of the rare species, *Aphragmus eschscholtzianus* (Fig. 52) at an alpine site just south of Mirror Lake (KATM Region-2). This species is listed by the AKNHP as a 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. 53). We found a population of between 100 and 200 individuals in a former melt-pond along an alpine bench at approximately 600 m. 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. Because of its rarity, small population sizes, and narrow habitat specificity, we recommend more targeted inventory for this taxon and demographic monitoring of the Mirror Lake population.

Figure 52. *Aphragmus eschscholtzianus.*

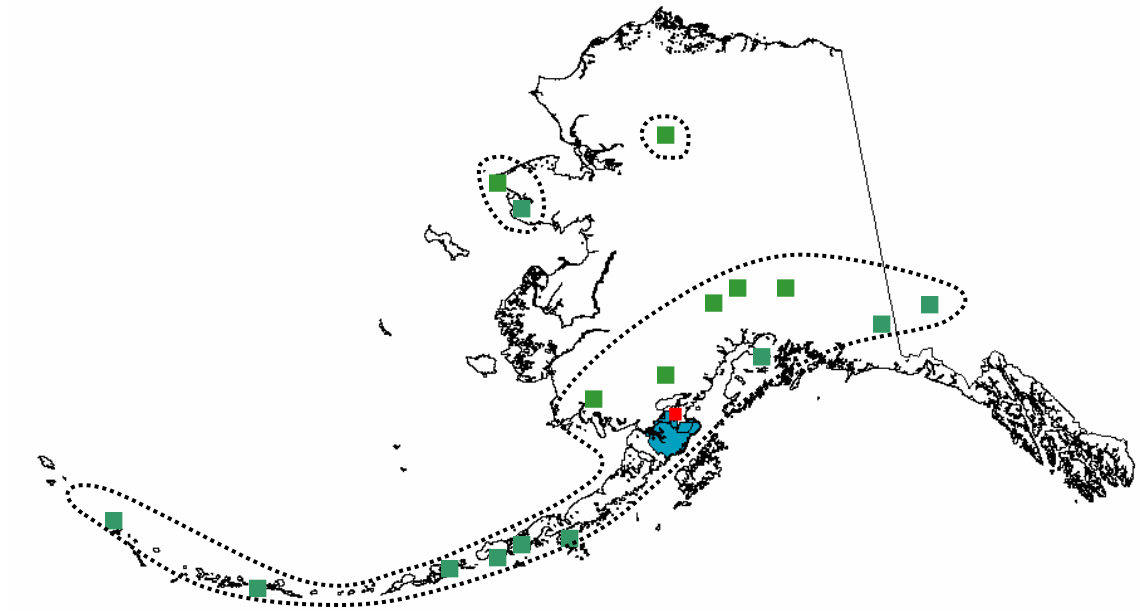


Figure 53. Global range of *Aphragmus eschscholtzianus* shown as dotted line. Previous collection localities are indicated as green squares. The collection in KATM is indicated by the red square.

Primula tschuktschorum Kjellm.:

An additional species, which is not only a significant range extension, but globally rare was also collected near Mirror Lake (KATM Region-2). *Primula tschuktschorum* is a taxon restricted to the Bering Strait Region with a few outlying populations south in the Akhlun and Kilbuck Mountains near Bristol Bay (Kelso 1995; Fig. 54). The species is considered a G3 - S2S3 (i.e., uncommon to rare globally and within Alaska). The KATM population is located nearly 320 km to the east of the Bristol Bay populations, which are concentrated around alpine lakes and seeps near Tikchik Lake and Goodnews Bay. At the KATM site, plants were relatively common along the banks of shallow ponds and snowmelt areas at around 400 to 450 m and into wet-sedge tundra communities. Many patches of 50 - 200 plants were encountered, with a total population size estimated at 5,000 individuals.

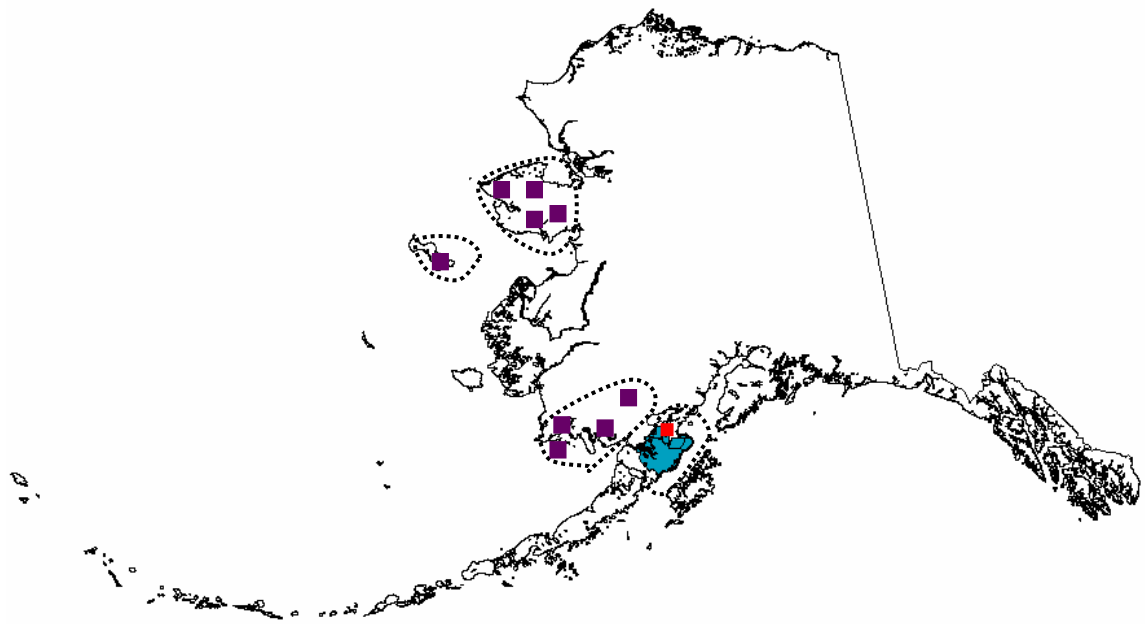


Figure 54. Range of *Primula tschuktschorum* in Alaska shown as dotted lines. Previous collection localities are indicated as purple squares. The collection in KATM is indicated by the red square. Outside of Alaska, this taxon is only known from the extreme eastern tip of the Chukotka Peninsula in Russia.

Kelso, in her 1995 USFWS status report, indicated that the taxon is not in eminent danger of extirpation, since more populations of large size had been located on the Seward Peninsula and south, near Goodnews Bay. However, Kelso (1995) noted a number of concerns and potential threats to the species. At some populations on the Seward Peninsula grazing by geese and reindeer is quite severe, with almost all fruits and flowers removed from a population numbering in the thousands. If grazing of this intensity is consistent across years as the geese migrate through, reproduction by this rare plant could

be severely curtailed or eliminated. Thus, the viability of individual populations and the species as a whole could be threatened.

Additionally, this species has an unusual reproductive system, distyly, which may limit its ability to reproduce by seed. Distyly is a genetic polymorphism in which populations are composed of two morphs: one with long styles and short stamens and another with short styles and long stamens (Fig. 55). The style/stamen dimorphism is normally accompanied with a self- and intra-morph physiological incompatibility, such that only pollinations between *different* morphological types results in seed set. Under conditions in which pollinators are common, this reproductive system may function well. However, when pollinators become rare, seed production can become nearly non-existent. Distylous species should produce less than half the seeds as species with normal self-incompatibilities as pollinators become limiting, because only half the members of the distylous population/species are available as compatible mates.

Figure 55. Closeup photograph of both morphological forms of *Primula tschuktschorum*. Notice the stigma is obvious in the upper flower ("pin" morph) and the stigma is below the anther-level in the lower flower ("thrum" morph).

More often than is generally acknowledged, distylous systems are not as complete as suggested (Carlson and Meinke, in prep.). Often, the intra-morph physiological incompatibility is only weak, allowing moderate seed set even when pollinators are rare. Further, it has been suggested that distyly functions only with a very limited suite of pollinators, such that pollen from each morph-type is deposited on specific locations on the bodies of the pollinators (Ganders, 1979). However, this may not always be true (Carlson and Meinke, in prep.).

The reproductive status and health of the KATM *P. tschuktschorum* population is unknown. During the six days we were at this site the weather was poor, no pollinators were observed visiting the flowers. This species flowers very early when conditions for pollinators are meager, even for bumblebees, which can function at nearly freezing temperatures (Heinrich 1979). We did observe fruits with apparently viable seeds were maturing. We therefore suggest, that more ecological information is needed to determine the status of this rare and disjunct species in the park.

Additionally, we collected the very closely related species, *P. eximia* that was co-occurring and flowering with *P. tschuktschorum*. Kelso (1987) considers *P. eximia* a homostylous (just a single morph with a consistent style length) derivative of the distylous *P. tschuktschorum*, and she noted that presence/absence of farina (powdery or mealy wax exudate) and plant size are additional characters that are useful in separating the two taxa. It is very curious to have two such closely related species flowering together in the same location. This raises further questions and concerns for the security of the rare species. If pollinators move freely between the two, then a loss of fitness of both taxa will likely occur via a number of mechanisms, including pollen wastage, hybrid inviability or sterility, or genetic swamping (see Waser 1978, Armbruster et al. 1994). It is also interesting that specimens identified as *P. eximia* by UAF Herbarium lacked the characteristic white farina, and some of the *P. tschuktschorum* individuals were of a size more typical of *P. eximia*. The apparent mosaic of traits in this mixed population may be evidence of past or present hybridization (see Harrison and Rand 1989, Young 1996). AKNHP is currently reviewing the material and conducting a preliminary morphological analysis. However, revisiting the site may be necessary to resolve the systematic and ecological questions.

Suggestions for further research are outlined in the Recommendations section below.

PLANS FOR COMING YEAR

The AKNHP will be concentrating floristic inventories for the Southwest Alaska Network Parks in Kenai Fjords National Park in 2003. Targeted sampling in KATM and ALAG will likely occur in 2004 or 2005.

Recommendations

To achieve a more complete list of species in ALAG and KATM, we recommend the following locations and habitats be inventoried (also shown in Fig. 58):

- Old Savonoski Village Site. This location is one of only two known in Alaska for the grass *Catabrosa aquatica* (Fig. 56, listed as "Critically Imperiled" within Alaska, although not rare globally: AKNHP Vascular Plant Tracking List). This grass has a broad distribution (Eurasia and in North America from New Brunswick to New Mexico), but populations are often small and isolated (e.g., State listed as "Endangered" in Wisconsin). The populations in Alaska are disjunct from the other North American and Asian populations by thousands of kilometers. Additionally, the village site was a location of early European influence and it is possible that introductions of exotic species have become established. Further, wetland and white spruce woodland habitats would likely result in additional new taxa to the park as these habitat types were not exhaustively surveyed in 2002.

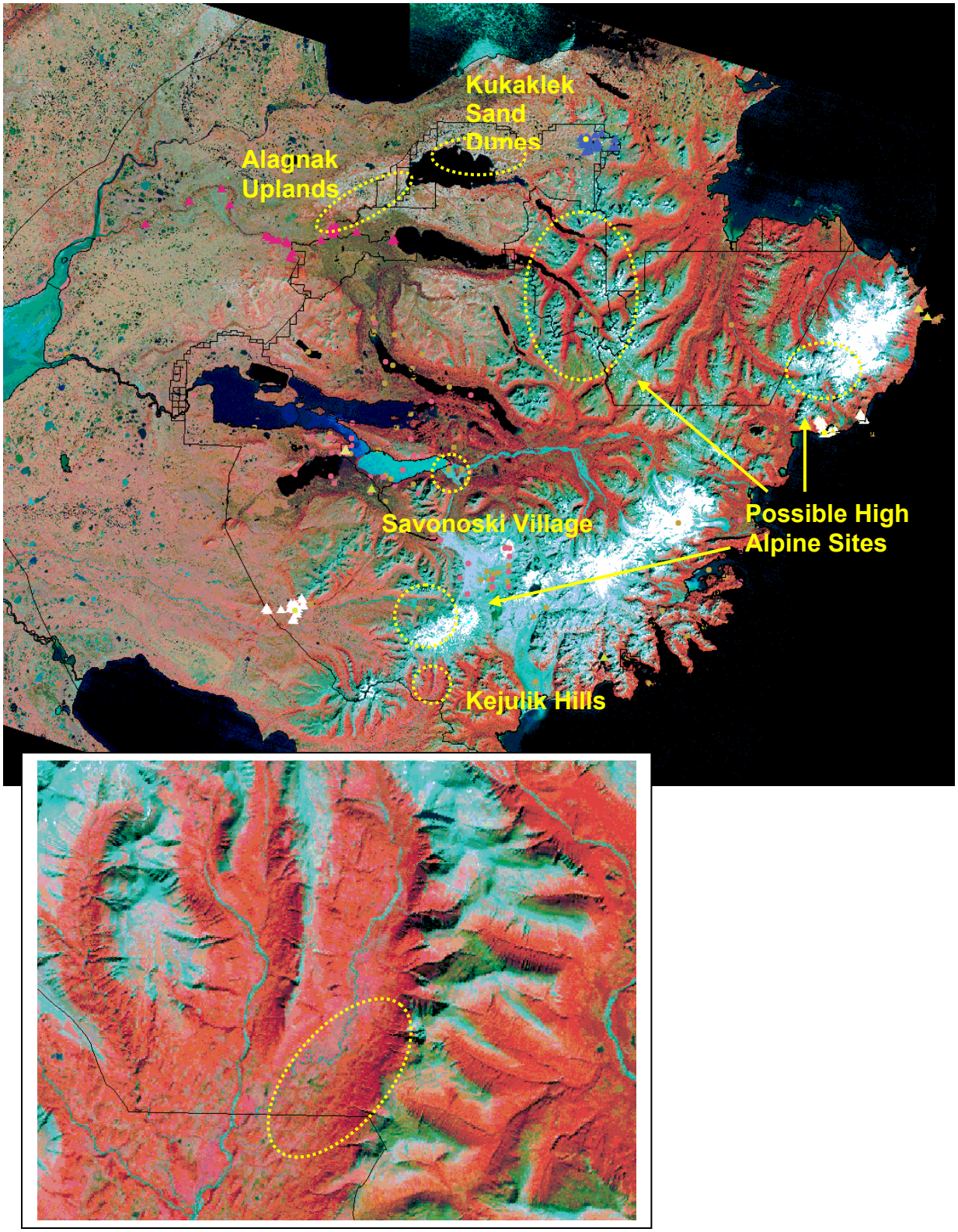
Figure 56. *Catabrosa aquatica* (photo from http://www.toyen.uio.no/botanisk/nbf/plantefoto/catabrosa_aquatica_Dag_Fosse01.jpg).

- Sand dunes along the northern edge of Kukaklek Lake and outlet of Moraine Creek into Kukaklek Lake (Fig. 57). We did not encounter any inland sand dunes in the 2002 field season and it is likely that a small number of taxa new to the park would be located in such habitats.

Figure 57. Oblique view of sand dunes at the confluence of Moraine Creek and Kukaklek Lake. Extensive dunes are also located along the northern portion of Kukaklek Lake.

- Elevations above 1000 m. No inventories were conducted at the highest elevations, which often have unique, high-alpine habitat specialists. Suggested locations include: Kejulik Mountains, Walatka Mountains, and ice-free peaks near Fourpeaked Mountain. These areas appear to be only helicopter accessible.
- Areas with calcareous outcrops. We were only able to access one site with merely moderately basic soils. A large component of the KATM taxa listed as probably present are widespread calciphiles and would likely be added as confirmed if an appropriate substrate was identified and visited.
- 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.
- Upper Alagnak River. The upper portion of this unit was not sampled due to rapids and this portion includes higher elevation sites, with apparently dry and stony tundra that was not sampled along ALAG in 2002.

Figure 58. Suggested future sampling sites in ALAG and KATM units, shown as labeled yellow circles. The inset is a close-up of the Kejulik Hills. Known plant collection sites are shown as triangles (AKNHP 2002) or circles (previous collections).



Recommendations for monitoring or other action include the following:

- *Dupontia fisheri* - We recommend casual monitoring of this major range (and habitat) extension at Swikshak Lagoon to observe any changes in abundance. Further, botanists working in the park should pay special attention for this species in other locations, especially at coastal marshes, meadows, and lake shores. This taxon is very abundant in the high arctic and is not of conservation concern, but because of the nature of the range extension, opportunistic observations are recommended.
- Exotic species - We suggest that efforts be made to eliminate the introduced plants at Brooks Camp. This includes three species: *Capsella rubella*, *Matricaria matricarioides*, and *Plantago major* var. *major*. None of these species are known to be aggressive in undistrubed sites; however, weeds that were not problems have been known to become particularly invasive after many years as benign species in novel communities (Cronk and Fuller 2001). Because the weeds seem to be isolated and not of large population sizes, control by spot-applied herbicide over a couple of years seems manageable.
- *Aphragmus eschscholtzianus* - This rare species would benefit from a better understanding of its distribution within KATM and knowledge of its population dynamics. We only located one site of relatively few individuals, but it is possible that that this taxon is more common in the park. More extensive surveys in the mountains to the south may reveal additional populations and of larger sizes. 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 (see discussion in Schemske et al. 1994). Additionally, ancillary data on ecology and reproductive ecology can be taken while collecting population data.
- *Primula tschuktschorum* - We recommend the same monitoring procedures for this species, also located at Mirror Lake. A careful survey and estimation of population sizes in KATM is necessary, as well as documenting the biological status of populations within the park. Additionally, because of the unusual reproductive system and potential limitations imposed by it, we suggested that a study be conducted on its reproductive biology. Last, we believe it is essential to determine what are the evolutionary (thus, taxonomic) differences 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.

ACKNOWLEDGEMENTS

The AKNHP is grateful for the logistical and financial support of the NPS, and in particular of the SWAN coordinators, Susan Kedzie-Webb and William Leacock. The NPS staff at Katmai was invaluable in identification of appropriate collecting sites, securing housing, and general logistical support. Tom Smith from USGS BRD offered helpful advice on the electric bear fence, and access to plant collections from bear habitat studies. Botanical support and enthusiasm of Ian Pierce, the SCA intern, was greatly appreciated. Anna Jansen was an invaluable addition to the botany crew, with an excellent eye for new plant taxa, great organizational and managerial skills, and tireless work in the field.

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