The Vascular Plant Floristics of Denali National Park and Preserve

A Summary, Including the Results of Plant Inventory Fieldwork 1998-2001

National Park Service
Inventory and Monitoring Program
Central Alaska Network

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ABSTRACT

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A reconnaissance inventory of the vascular plant flora of Denali National Park and Preserve was conducted during the period 1998-2001. The primary goal of this project was to synthesize existing floristic information with the results of targeted original inventory field work in order to produce a voucher-based list of the vascular plant species that occur within the Park. In order to accomplish this fundamental goal of documenting the flora of Denali National Park and Preserve there were five major objectives that needed to be met:

1) to assemble all available pre-existing floristic data into a highly functional database;
2) to assess the strengths and weaknesses of this existing data set and identify geographic and taxonomic gaps in our knowledge of Denali National Park and Preserve's flora;
3) to perform targeted vascular plant inventory fieldwork in order to effectively fill the existing data gaps and to assemble a complete, voucher-based vascular plant flora for Denali National Park and Preserve;
4) to create a GIS data layer delineating the floristic regions of Denali National Park and Preserve, and to summarize and present all existing floristic information available for the Park in this context;
5) to synthesize the results of both existing and new floristic investigations from original field work into a report describing the state of our knowledge concerning the vascular plant floristics of Denali National Park and Preserve.

Vascular plant inventories were performed documenting the flora of 197 sites across the landscape of Denali National Park and Preserve. This set of sites included a broad cross-section of habitats from aquatic communities in large boreal lakes to high alpine scree slopes. I estimate that approximately 1,358 hours of actual survey time were spent in the field recording plant species occurrences and making voucher collections. Over 4,000 plant specimens were collected as a part of this study, and a total of 3,793 permanent voucher specimens were prepared from these collections.

The set of specimens collected during this inventory documents the occurrence of about 622 separate vascular plant species within the Park (which represents approximately 83 percent of all of the species presently known to occur there). This collection represents an addition of 224 plant species and 246 separate taxa (including subspecies and varieties) to the vouchered vascular flora of the Park, as compared to the list of taxa known to occur in the Park that was prepared in 1996-7. In addition, this set of new taxa represents 52 genera and 14 families of plants that were not known to occur in the Park prior to 1998. Two hundred and thirty-five specimens of forty-six different taxa considered rare in Alaska by the Alaska Natural Heritage Program (AKNHP) were collected during this inventory. Eight of these taxa had an AKNHP State-level rarity rank of S2 or lower.

EXECUTIVE SUMMARY

Chapter One: Introduction

- The subject of this report is the results of a vascular plant inventory project that occurred in Denali National Park and Preserve, Alaska, from 1998 to 2001.

- This document summarizes the current state of knowledge of the distribution and composition of the vascular flora of Denali National Park and Preserve.

- The principal goal of this project was to compile a complete, voucher-based list of the vascular plant taxa that occur in the Park through examination of existing data and targeted field inventory work.

- The total project-specific cost of this work (excluding the Principal Investigator's salary) was approximately $130,000 over a four year period, including all aspects of the work.

- The steps that were completed in preparation for conducting the new field inventories that would complete the Floristic Inventory Project were to:
    - create a relational database for storing, analyzing and presenting floristic data;
    - review the existing literature and collection data to develop an "expected" species list for the Park, and integrate this list into the floristic database;
    - identify geographic, taxonomic and habitat gaps in existing floristic data for the Park;
    - develop a strategy for efficient allocation of fieldwork and accomplishing the goals of this project.

- Fieldwork for the project was performed each summer during the period 1998-2001.

Chapter Two: Overview and Description of the Study Area

- Denali National Park and Preserve is located within the south central section of mainland Alaska. It occupies the area spanning roughly 62° 18' and 64° 04' North latitude and between 148° 48' and 152° 52' West longitude.

- The Park preserves 2.4 million ha of intact subarctic ecosystems; the maximum latitudinal extent of the Park spans about 200 km north to south, and similarly the longitudinal extent of the Park spans about 200 km from east to west.

- Physiography varies dramatically across the Park landscape from ice-covered alpine peaks, to several ancient, weathered low ranges of hills, to lowland boreal basins.

- The Alaska Range mountains are the central element of the Park landscape, both aesthetically (they dominate the horizon, even from the deep lowlands of the Minchumina Basin), and through their crucial role in dominant landscape processes.

- The Alaska Range alpine landscape is characterized by steep, barren rock escarpments and thick sheets of glacial ice. Permanent ice occupies most surfaces above 2,300 meters elevation throughout the range.

- There are three primary lowland regions of the Park, two are north of the Alaska Range – the Toklat Basin and the Yukon-Kuskokwim lowlands, and one is south of the Range – the Cook Inlet lowlands.

- Whereas the core of the Alaska Range was formed by igneous intrusions of granitic rock, much of the accessible terrain in the alpine region, and that hospitable to plant life, is composed of rock that is sedimentary, or meta-sedimentary in origin. Significantly for plant life, small areas of calcareous sedimentary rock, including limestone and marbleized limestone, crop up on both the southern and northern parts of the range.

- The primary macroclimatic gradient in the Park is the interface between the relatively warm and moist maritime air masses that are generated in the Gulf of Alaska and the dry, highly continental air masses that occur north of the Alaska Range. Moist maritime air masses move onshore with atmospheric currents and collide with southern flanks of the Alaska Range, where they cool and cause high precipitation and considerable cloudiness south of the Alaska Range crest. Climate conditions north of the crest, conversely, are highly continental.

- Vegetation patterns in the subarctic are strongly controlled by environmental factors that vary with topographic variables such as slope, aspect and elevation.

- The ecological history of the Denali National Park and Preserve region during the past two million years is characterized by repeated advances and subsequent retreats of massive sheets of glacial ice throughout the Pleistocene Epoch. These repeated and enormous ecological upheavals have had profound influences on the nature of the biota resident in the Park and the very nature and shape of the Park landscape itself.

- Twenty three different ecological units at the level of the ecoregion subsection were defined for Denali National Park and Preserve.

Chapter Three: History of Plant Collecting in Denali National Park and Preserve

- The flora of the Park road corridor area of Denali National Park and Preserve has been collected more intensively than most regions of Alaska.

- The history of plant collecting in the Park includes work by many of the leading botanists in the history of the botanical exploration of Alaska, such as Lawrence J. Palmer, A. Erling

Porsild, Jacob P. Anderson, Eric Hultén, Olav Gjaerevoll, Stanley L. Welsh, Leslie A. Viereck, and David F. Murray.

- The focus of this summary is on broad-spectrum vascular plant collections that contributed substantial information about the composition of the vascular plant flora of this area.

Chapter Four: Methods

- This inventory was a targeted reconnaissance survey of the vascular plant flora. The size of the study area, in combination with strict budget constraints, meant that a premium was put on efficient site selection for this project (relative to acquiring new records of plant species for the Park).

- The starting point for this project was the development of a *bona fide* vouchered vascular plant species list for the Park. This task was performed during 1996-7 by Joe Van Horn and Dr. John Kartesz who assembled and verified (along with help from Alan Batten and Carolyn Parker from the University of Alaska Herbarium) specimens from the principal herbaria containing specimens collected from Denali National Park and Preserve.

- A floristic database for the Park was constructed, containing the following three primary elements:

    - a taxon database, containing information on each taxon that occurs in the Park, and those species "expected", but not documented to occur there;

    - a specimen database, containing records of each specimen collected in the vicinity of the Park;

    - a site database that stores information about specific sites where plant inventory work has occurred.

- I performed gap analyses in order to determine the geographic, ecological and taxonomic gaps in Denali's floristic data set.

- I sought to intensively survey a set of sites that provided plant occurrence data across the entire spectrum of vegetation types, landscape positions, site moisture characteristics, lithologies, and edaphic conditions that occur in Denali National Park and Preserve. Potential field sites were identified prior to field work using satellite imagery, aerial photos, bedrock geology maps, and topographic maps of the Park landscape.

- The primary unit of data resulting from this work is the voucher specimen, which records the occurrence of a particular taxon at a specific place and time with a physical record.

- A comprehensive floristic reconnaissance of each survey site was completed. The objective of the reconnaissance was to survey the range of communities and habitats available within the time allocated for the site, starting with the highest priority areas.

- Specimens were collected for all noteworthy taxa at each site, including species new to the Park flora, ecological or geographic range extensions, rare or endemic species, species of management concern, or specimens reflecting other noteworthy characteristics such as atypical morphology for the taxon. In instances when sufficient time was available, we made a more exhaustive set of specimens that documented the majority of the vascular taxa resident at the site.

- Specimens were pressed in the field and allowed to dry. They were removed from presses upon drying and transferred to the University of Alaska Museum, where they passed through a -50° C fumigation freezer. Determination work occurred in the University of Alaska Herbarium.

- Specimens were initially identified by principal N.P.S. project botanists (Carl Roland, Amy Larsen, and Mary Beth Cook). Specimens were then further reviewed by staff at ALA including Carolyn Parker and Alan Batten. Problematic specimens, or particularly difficult taxa, were sent to specialists in particular genera for determination, including George Argus (*Salix*), David Murray (*Cyperaceae*), Robert Soreng (*Poa*), Donald Farrar and Mary Stensvold (*Botrychium*), and John L. Strother (*Bidens*).

- Collection and site data were entered into the database for the project. Accession and catalog numbers were assigned to each specimen and labels were printed on archival paper. Specimens were then mounted onto archival herbarium paper by staff at ALA.

- Nine floristic regions were defined for the Park, based on the results of the Soils Inventory project and this vascular plant inventory.

- All current and preexisting specimens for which electronic records were available were attributed to a floristic region of origin within the Park, based upon where they were collected. This process made it possible to assess the distribution of past botanical collecting work in each floristic region of the Park.

- We used several GIS coverages to analyze and describe the biophysical characteristics of the floristic regions. The goal of these analyses was to examine the available GIS data in order to understand broad-scale similarities and difference in the landscape characteristics among the floristic regions of the Park.

- I compared plant collections made during this inventory to the published plant distribution literature in order to document any range extensions for plant taxa resulting from Floristic Inventory collections.

Chapter Five: Overall Summary of Inventory Results

- Vascular plant inventories were conducted at 197 sites spanning the extent of Denali National Park and Preserve during this study.

- I estimate that approximately 1,358 hours of survey time were spent in the field recording plant species occurrences and making voucher collections. Over 4,000 plant specimens were collected as a part of this study, and 3,793 permanent voucher specimens were prepared from these collections.

- Inventory work was performed across the Park landscape. However, the large majority of effort was focused outside of the Park Road corridor, in areas not surveyed by botanists prior to this study.

- Five taxa that did not appear in the primary references for Alaska's vascular plant flora (Hultén 1968, Welch 1974) were collected during this inventory: *Bidens tripartita*, *Botrychium alaskaense*, *B. minganense*, *Najas flexilis*, and *Potamogeton obtusifolius*.

- The set of specimens collected during this inventory documented the occurrence of about 622 separate vascular plant species within the Park (about 83 percent of the 753 species known to occur there).

- This collection added 224 plant species and 246 separate taxa (including subspecies and varieties) to the vouchered vascular flora of the Park, as compared to the list of taxa known to occur in the Park that was prepared in 1996-7. In addition, this set of taxa represented 52 genera and 14 families of plants unknown in the Park prior to 1998, when this study was begun.

- Two hundred and thirty-nine specimens of 48 taxa considered rare in Alaska by the Alaska Natural Heritage Program were collected during this inventory. Eight of these species had a state-level rarity rank of S1 *Agrostis clavata, Arnica diversifolia, Carex echinata* ssp. *echinata, Carex incurviformis, Carex interior, Cicuta bulbifera, Najas flexilis,* and *Potamogeton obtusifolius*.

- In general, the plant species from the AKNHP vascular plant tracking list that occurred in Denali National Park and Preserve fit into one of two broad categories: 1) Alaska –Yukon or Amphiberingian endemic species; or 2) wetland or aquatic plants that have wide-ranging geographic distributions that are nevertheless very interrupted and spotty within Alaska.

- Collections made during the floristic inventory of Denali National Park and Preserve documented major range extensions for 32 taxa of vascular plants. Seventy-three voucher specimens were made of this suite of taxa during this study. Simple range extensions for an additional 78 plant taxa were documented by collections made during this inventory.

- The southern slopes of the Alaska Range and the Cook Inlet lowlands represent the northern range limit for numerous species limited to maritime-influenced climate zones, including *Polystichum braunii, Cinna latifolia, Carex echinata, Carex mertensii, Salix sitchensis,* and *Viola glabella* to name just a few.

- The northern flanks of the Alaska Range and the adjacent boreal lowlands represent a southern range limit in Alaska for a set of plant species with essentially arctic or arctic/alpine distributions for which major range extension were made during this project such as *Draba corymbosa*, *Halimolobos mollis*, *Phlox richardsonii* and *Smelowskia calycina*.

- Two other important contributions to our knowledge of the flora of Denali National Park and Preserve were made during the period that this inventory was being conducted: the Denali National Park and Preserve Soils Inventory conducted by the Natural Resources Conservation Service during the period 1997 through 2002; and an exotic plant survey of the Park Road corridor undertaken jointly by the National Park Service and Roseann Densmore of the Alaska Science Center (U.S.G.S.-B.R.D.).

- If we include all of the floristic data now available for the Park, I believe that at least 95 percent of the total number of vascular plant species that occur in Denali National Park and Preserve have been documented with voucher specimens. In fact, the actual percentage is probably closer to 98 percent.

Chapter Six: Detailed Summaries of Inventory Results by Floristic Region

- We performed reconnaissance floristic inventories of 23 sites within the Interior Boreal Floodplain and Alluvial Fan Floristic Region of Denali National Park and Preserve. These inventories required 82 hours of field survey time during which we collected 270 voucher specimens. These collections included new vouchers for 35 taxa that were not known to occur in the Park prior to 1998.

- The Interior Boreal Lowland Floristic Region within Denali National Park and Preserve was very poorly known from a botanical perspective prior to this inventory due to its large size and the considerable difficulties of access into these vast lowland basins. We inventoried a total of 33 sites within this floristic region, which was the highest number of sites visited in any single floristic region during this study. We made 421 specimen collections in the Interior Boreal Lowland Floristic Region, which documented the occurrence of 70 species that were not known to occur within Denali National Park and Preserve prior to 1998.

- We surveyed 15 sites within the Interior Boreal Upland Floristic Region and spent a total of 95 survey hours in the field there. The results of these surveys included the collection and preparation of 276 voucher specimens that documented eight element occurrences for taxa tracked by the Alaska Natural Heritage program. Thirty-five taxa that were not documented in the Park prior to 1998 were collected in the Interior Boreal Upland Floristic Region.

- We spent 203 hours performing field surveys of 22 sites in the Interior Alpine Outer Range Floristic Region of the Park. During these surveys, we made 455 specimen collections, which resulted in the documentation of major range extensions for nine taxa into this region, including the following: *Athyrium alpestre*, *Cassiope lycopodioides*, *Draba borealis*, *Epilobium leptocarpum*, *Phlox richardsonii*, *Primula mistassinica*, *Ranunculus occidentalis*, *Rhododendron camtschaticum*, and *Smelowskia calycina.*

- We performed vascular plant inventories of 27 sites in the Interior Alpine Alaska Range Floristic Region of the Park. These surveys required 249 hours of field survey time and resulted in the collection of 707 vascular plant specimens. This region of the Park was the most thoroughly collected area of the Park prior to this inventory. Nevertheless, our collections resulted in the documentation of 18 taxa that were not known to occur in the Park prior to 1998.

- We performed surveys of 19 sites within the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region of the Park. These surveys required 67 hours of field survey time and 174 voucher specimens were collected during this work. This set of collections documented 52 taxa new to the Park as well as 15 element occurrences for eight taxa considered rare by the AKNHP.

- We spent 34 hours performing field surveys of 11 sites in the Southcentral Boreal Lowland Floristic Region of the Park. We collected 165 voucher specimens at this set of sites. These collections documented the addition of 61 taxa new to the Park as compared to the pre-1998 flora.

- We performed floristic inventories at 17 sites within the Southcentral Boreal Subalpine Floristic Region of the Park, which required 72 hours of actual field survey time. A total of 242 voucher specimens were collected in this region of the Park, which documented 62 taxa that were not known to occur in the Park prior to 1998. This set of 62 new taxa represented the third highest total of taxa new to the Park for a floristic region, behind the Southcentral Alpine Mountains (95 species) and Interior Boreal Lowlands (70 species) regions.

- The Southcentral Alpine Floristic Region was the largest botanically unsurveyed region of the Park prior to this study. Accordingly, this region received the greatest amount of survey effort during this project. We spent 420 hours of field survey time completing vascular plant inventories of 30 sites in this region. Almost 1,200 specimens were collected in the southcentral mountains, which documented the addition of 95 taxa new to the Park, as compared to the species list for the Park developed in 1998.

Chapter Seven: The Floristics and Phytogeography of Denali National Park and Preserve

- There are 753 species (816 taxa including subspecies and varieties) of vascular plants that have been vouchered within Denali National Park and Preserve. This represents about 49 percent of the total number of species in the vascular flora of Alaska. The 753 resident species are members of 250 separate genera, representing 74 families of vascular plants.

- The Park flora includes representatives of the following major divisions of vascular plants: flowering plants (**Magnoliophyta**; 706 species), ferns and fern allies (**Pteridophyta**; 25 species), lycopods (**Lycopodiophyta**; 11 species), horsetails (**Equisetophyta**; 7 species) and conifers (**Coniferophyta**; 4 species). The set of flowering plants (**Magnoliophyta**) that occurs in the Park includes 214 monocots (class **Liliopsida**) and 492 dicots (class **Magnoliopsida**.

- For comparison, the vascular plant flora of Wrangell-St. Elias National Park and Preserve, which is also located in the southern mainland of Alaska (about 200 kilometers to the east of Denali National Park and Preserve), includes 832 species (887 taxa including subspecies and varieties). The four most species-rich families in the Denali National Park and Preserve flora are also the most species rich in the flora of Wrangell-St. Elias National Park and Preserve.

- Only 11 percent of the vascular plant species have woody growth forms (85 species, including trees, shrubs and dwarf shrubs).

- The largest growth-form class in the Park flora is herbaceous forbs, almost all of which are perennial species. Sixty percent of the vascular plant species that occur in the Park are forbs. Graminoids (or grass-like plants) represent about a quarter of the Park's vascular plant species (24 percent, or 178 species). The remaining five percent of the vascular plant species that occur in the Park are ferns and fern allies (25 species, or 3 percent of the total), club-mosses (11 species) and horsetails (7 species).

- I recognize six major floristic elements within the Park flora:

    - Circumpolar species, 31 percent of the flora (**233 species**)
    - Incompletely circumpolar species, 16 percent of the flora (**119 species**)
    - North American species – 25 percent of the flora (**186 species**)
    - Amphiberingian species – 23 percent of the flora (**176 species**)
    - Amphiatlantic species – 1 percent of the flora (**8 species**)
    - Alaska-Yukon endemic species – 4 percent of the flora (**32 species**).

- This set of state-level rare vascular plant taxa was found to be unevenly distributed across the Park landscape; certain regions harbored relatively large numbers of these taxa whereas other regions contained relatively few rare species. At the largest spatial scale, the north side of the Alaska Range harbored higher numbers of rare species. Of the 53 state-level rare species that occurred in the Park, only eight were entirely absent from floristic regions north of the Alaska Range crest. In contrast, 21 of these rare state-level rare species were absent from regions south of the Alaska Range crest.

- My examination of the distribution of state-level rare plant species richness and composition among the Park's nine floristic regions showed the following:

    - The Interior Alpine – Alaska Range Region contained the highest number of rare taxa (24 taxa), followed by the Southcentral Alpine Region and the two Interior

Boreal Lowlands regions (15 taxa each). The fewest rare taxa were observed in the Southcentral Boreal Lowland Region (5 taxa);

- There was a highly significant relationship between floristic region size and the number of rare vascular plant taxa that occurred in a region;
- Cluster analysis of the species occurrence matrix for rare plants showed a strong clustering of the regions based on life zone (boreal versus alpine) regardless of geographic location; the Southcentral Boreal Subalpine Region was identified as a conspicuous outlier for rare plant composition because of the large number of taxa unique to that region (primarily Cordilleran taxa of lush subalpine meadows).

- I observed striking patterns in the distribution and abundance of the two classes of endemic species among the nine floristic regions of the park. To summarize, I concluded the following:
  - The patterns in species richness of two sets of endemic species (Alaska-Yukon and Amphiberingian) among the floristic regions of the park are essentially identical (correlation coefficient of species numbers per region: $r = 0.96$);
  - Alpine areas, in general, contain the highest numbers of endemic plant species in the Park. Interior alpine regions of the Park, in particular, contain by far the highest numbers of both sets of endemic taxa;
  - The relationship between the number of endemic species and region size is not significant for both Amphiberingian species and narrowly-distributed Alaska-Yukon endemic species (this is in contrast to similar analyses for AKNHP rare taxa, which returned highly significant species richness : area size relationship);
  - The endemic flora that was observed south of the Alaska Range crest was essentially a subset of that observed north of the crest, and furthermore the geographic occurrence of these endemic taxa is markedly clustered in two areas close to low passes into interior Alaska;
  - Cluster analyses of the endemic species occurrence matrices indicated a strong geographic similarity among interior regions, and marked dissimilarity of this cluster from the southcentral boreal regions.

Chapter Eight: Synthesis and Recommendations for Conservation

- It is critical that the information we have gathered be used to effect the conservation of the precious botanical heritage in our trust and to educate and inspire those interested in the Park and in Alaska's biota (amateurs and professionals alike).

- In addition to providing managers with a nearly complete inventory of the vascular flora of the Park, and extensive data regarding the distribution of these species, the results of this inventory delivers the following information for management:

- This inventory provided an extensive, coarse-scale status report on the extent of exotic plant invasions in undisturbed vegetation on Park lands;
- I identified a list of rare and sensitive vascular plant taxa, crafted specifically for Denali National Park and Preserve, based on a review of all available plant occurrence data;
- I identified lists of sets of geographic areas, habitats and individual sites of particular botanical significance or sensitivity on the Park landscape (thus of high priority for protection).

- A remarkable fact confirmed by this inventory is the absence of an invasive exotic plant problem in natural areas of Denali National Park and Preserve. Whereas more than 20 exotic vascular plant taxa have become established in developed areas and in the road shoulders within the Park, these exotic taxa were never observed in native plant communities (even those adjacent to the Park Road).

- In my view, the absence of exotic taxa from these expansive landscapes should be one of the most closely and strenuously protected facets of the natural heritage that has been placed in our trust.

- The list of rare vascular plants for Denali includes the following (often overlapping) sets of taxa: 1) plants ranked S1, S2, or S3 on the AKNHP tracking list; 2) plant taxa known from fewer than 10 localities within the Park (***and*** judged to be genuinely rare, not simply under-collected).

- An important result of the project for conservation is an improved ability to identify geographic areas, habitats or plant associations and individual sites of particular botanical significance or sensitivity on the Park landscape. These areas include the following:

  - Biogeographically unique areas of the landscape with botanical significance – one example is the Broad Pass region, which represents the northern range limit for a relatively large number of plant species and a dispersal corridor for species between maritime and interior climate zones;
  - Notable habitats and plant associations that support multiple species that are rare either in the Park or statewide;
  - Notable individual sites of botanical significance due to a concentration of multiple species and/or communities of interest in a single area.

- There are three key components remaining to accomplish in order to for the Park to have a comprehensive set of data and the tools necessary to understand and effectively safeguard the Park's flora on the appropriate scale for a 2.4 million hectare World Biosphere Reserve and major National Park. These components include the following:

- A complete cryptogam inventory of Park lands (including mosses, lichens and hepatics). This is a major missing data set for understanding and managing biological diversity of the Park;
- We have begun installing a network of permanent monitoring plots that allow us to quantify the primary landscape-ecosystem gradient relationships, and thus to understand the factors causing the distribution of biological diversity (both of communities and species), on the Park landscape. This plot network will allow us to monitor fundamental ecosystem attributes through time on a landscape scale;
- An operational and active adaptive monitoring program for exotic plant species in the Park.

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Chapter 1 Introduction

This report describes the results of vascular plant inventory work that occurred in Denali National Park and Preserve from 1998 through 2001. As a result of this work, the number of vascular plant species known to occur in the Park increased from 490 to more than 750, an increase of 263 species (54 percent of the total flora). The goal of this document is to provide the reader with an understanding of the results of this project and, more importantly, a full overview of our current state of knowledge of the Park's rich botanical resources.

Mount McKinley National Park was established in 1917 for "…the preservation of animals, birds, and fish and for the preservation of the natural curiosities and scenic beauties thereof…." (39 Stat. 938). At the time, much of the huge landmass encompassed by the Territory of Alaska was inaccessible to all outsiders save the most intrepid of wilderness travelers. By 1922, however, the "entrance" to the new Mount McKinley National Park was situated directly on the Alaska Railroad line that connected the seaport at Seward with the interior mining hub of Fairbanks, 190 kilometers to the north of the new park.

The combination of a national park designation with relative ease of access by means of the Alaska Railroad insured that tourists, nature enthusiasts, and biologists visiting Alaska frequently made Mount McKinley National Park a principal destination. In addition, the construction of the 90-mile long McKinley Park Road, which was begun in 1922 and completed to Kantishna in 1938, provided unparalleled ease of access into the subalpine and alpine zones of the central Alaska Range. As a result of these factors, and a flurry of interest by some avid botanists, the flora of accessible areas within Mount McKinley National Park was quickly collected as thoroughly as any region of Alaska had been, with the exception of the immediate vicinities of major population centers, Point Barrow, and some areas of the north slope of the Brooks Range. (A history of botanical collecting in Denali National Park and Preserve is provided in Chapter 3 of this report.)

In contrast, the flora of areas outside of the immediate road corridor remained largely unstudied due to the remote and rugged nature of the terrain. In 1980, 1.5 million hectares were added to the newly renamed Denali National Park and Preserve through ANILCA (Alaska National Interest Lands Conservation Act, Public Law 96-487). The flora of these new additions to the Park was also essentially unknown at the time. As a consequence, although certain areas within the Park had been collected quite extensively, the composition of the flora of Denali National Park and Preserve in its entirety was poorly known from its inception. There was virtually no floristic information about major ecological regions of the Park, such as the extensive wetlands north of the Alaska Range and all areas south of the Alaska Range crest.

Sporadic plant collecting efforts continued within Denali National Park and Preserve during the decades of the 1980's and 90's. However, these collections were made for a variety of purposes and largely during the course of other activities such as studying vegetation succession, mapping projects, or wildlife browse studies. There was no sustained, systematic effort to thoroughly document the composition and distribution of the Park vascular plant flora. However, a popular picture-book was published during this period, which provided a field guide to the wildflowers of the Park Road corridor area (Pratt 1986).

From a scientific point of view, then, the considerable floristic data that existed for the Park from a long history of botanical collecting had not been comprehensively summarized and synthesized. These data existed primarily in the form of numerous specimens deposited in disparate herbaria, as diverse species lists scattered in the published literature, and in grey literature reports. In short, park managers and others interested in the botany of this fascinating region had no access to a systematic and comprehensive accounting, or inventory, of the rich botanical resources of Denali National Park and Preserve. The principal goal of this project was to correct that situation.

A. Objectives of the Denali National Park and Preserve Floristic Inventory Project

The principal goal of the Floristic Inventory of Denali National Park and Preserve project was to compile a complete, voucher-based list of the vascular plant taxa that occur in the Park through examination of existing data and targeted field inventory work. In addition, I (serving as principal investigator for the project) sought to collect more detailed information concerning the occurrence and distribution of the flora of the Park, particularly plants of management concern, such as rare and sensitive plant species. This goal required that inventory fieldwork encompass a cross section of all habitats and landscape units throughout each of the ecological regions of the Park, from the Minchumina Basin north of the Alaska Range, to alpine sites in the Alaska Range and forested lowlands in the Cook Inlet basin.

1) to assemble all existing floristic data into a database;

2) to assess the strengths and weaknesses of this existing data set and identify geographic and taxonomic gaps in our knowledge of Denali National Park and Preserve’s flora;

3) to target vascular plant inventory fieldwork to effectively fill the data gaps and to assemble a complete, voucher-based vascular plant flora for Denali National Park and Preserve;

4) to create a GIS data layer delineating the floristic regions of Denali National Park and Preserve, and to summarize and present all existing floristic information available for the Park in this context;

5) to synthesize the results of both existing and new floristic investigations from original field work into a report describing the state of our knowledge concerning the vascular plant floristics of Denali National Park and Preserve (this document)!

B. Background and development of Denali National Park and Preserve Floristic Inventory

A crucial antecedent of the Floristic Inventory of Denali National Park and Preserve project occurred in 1996-7, when the Park contracted with Dr. John Kartesz to develop a voucher-based list of the vascular plant taxa that occur in Denali National Park and Preserve. Dr. Kartesz and his assistant Amy Farstad reviewed specimens in the Park Herbarium (DENA) and University of Alaska Museum Herbarium (ALA) to assemble a voucher-based species list for the Park. Dr. Kartesz's methodology consisted of reviewing specimens and designating a single specimen as a taxon voucher for each species that was documented for the Park. By the spring of 1998, the documented vascular flora of Park lands included 490 species of plants from 192 genera, representing 50 families of vascular plants. This vouchered plant list for Denali National Park and Preserve was then incorporated into Dr. Kartesz's Synthesis of the North American Flora computer program, making it widely available to botanical researchers (Kartesz and Meecham 1999).

A second key precursor to the Floristic Inventory project was provided by Joe Van Horn, (Denali Division of Research and Resource Preservation), who worked with Jon Paynter (Denali GIS specialist) to assemble a geo-referenced set of collection records based on existing specimen locality data from available electronic records. This data set allowed us to plot the majority of known collection localities for vascular plants in the Park within the Park GIS, which allowed us to visualize the distribution of past plant collection efforts on the Park landscape.

The final steps in preparation for conducting the new field inventories that would complete the Floristic Inventory Project were to:

1) create a relational database for storing, analyzing and presenting floristic data;

2) review the existing literature and collection data to develop an "expected" species list for the Park, and integrate this list into the floristic database;

3) identify geographic, taxonomic and habitat gaps in existing floristic data for the Park;

4) develop a strategy for efficient allocation of field work and accomplishing the stated goals of this project.

These steps were first accomplished in the spring of 1998 and refined during subsequent years. Fieldwork for the project was performed each summer during the period 1998-2001.

C. Funding sources for Floristic Inventory of Denali National Park and Preserve

This project was accomplished on a very modest budget during its first three years (1998-2000). The National Park Service (N.P.S.) Servicewide Inventory and Monitoring Program provided money for logistical support of vascular plant inventory fieldwork in the amount of $10,000 for each of the fiscal years of 1998 and 1999, and in the amount of $15,000 for fiscal year 2000. These funds were used solely for logistical support for vascular plant inventory fieldwork. The salary of the principal investigator during this period of time was borne by a combination of

Park-based, U. S. Geological Survey – Biological Research Division (USGS-BRD), and Long Term Ecological Monitoring program funds. During 2001, the work on this project was accomplished under the auspices of the Central Alaska Network vascular plant inventory project, which was funded in the amount of $90,700. This facet of the Denali plant inventory work was part of the N.P.S. Inventory and Monitoring program's Biological Inventories initiative, which was formalized in a study plan for inventory of the flora of the three Central Alaska Network park units (Cook and Roland 2000). The total project-related costs of the new inventory fieldwork, then (excluding the salary of the Principal Investigator), was approximately $130,000, which was spent over the course of four years.

D. Overview of this report

The goal of this report is to present, as completely as possible, the results of this project and to summarize the current state of knowledge of the distribution and composition of the vascular flora of Denali National Park and Preserve. Therefore, I treat information from preexisting plant collections as well as the results from fieldwork accomplished during this study. I have included a section of this report that describes the history of collections in the Denali National Park and Preserve region, going back to the earliest known botanical explorations of the area. In order to provide the biogeographic and ecological contexts for the set of data presented here, I have included sections broadly summarizing the climate, physiography, geology, vegetation, and ecological history of the Denali National Park and Preserve area.

Following the descriptions of the study area and the history of vascular plant collecting in the area, I describe the methods that were used during this reconnaissance floristic inventory. This includes site selection, field methods, curation of specimens and, and analysis of the resulting data, including GIS analyses that were performed to describe the floristic regions of the Park.

The goals of this study were essentially descriptive in nature and not aimed at testing a particular set of hypotheses. For this reason, I have chosen to integrate the presentation and discussion of the results together rather than keeping them separate. There are three chapters dedicated to the presentation and discussion of the results of this project: Chapter 5 is an overall summary of the results of this project from a parkwide perspective; Chapter 6 contains detailed treatments of the results of our work organized by the nine floristic regions defined for Denali; and Chapter 7 is a discussion of the floristics and phytogeography of Denali based on our current knowledge of the Park vascular plant flora.

I begin the results and discussion with a summary of the overall, park-wide results of this work (Chapter 5). This chapter includes the numbers of new records for plant species, the numbers of range extensions for vascular plant taxa and the documentation of previously unknown populations of rare plant species within the Park. An annotated list of particularly significant collections made during the course of this study is provided in this Chapter. Chapter 5 concludes with an assessment of the degree of completeness of our current vascular plant inventory.

The results of the work accomplished during this study are best understood in the context of the major phytogeographic regions of Denali National Park and Preserve. Chapter 6 of this document enumerates more detailed, specific results of this study organized by a set of nine floristic regions that were defined for the Park based on the results of a Soil Survey and this project (Clark and Duffy 2004).

I conclude the presentation and discussion of results with Chapter 7, which describes the vascular floristics of Denali National Park and Preserve. In this chapter, I discuss the composition of the vascular flora and the distribution of its rare and endemic elements on the Park landscape. I begin this section by describing the taxonomic and growth-form composition of the Park flora. I then treat the biogeographic affinities of the vascular plant flora of Denali National Park and Preserve. The final elements of the floristics section are discussions of the broader geographic patterns in the patterns of distribution of three significant classes of vascular plants on the landscape of the Park: 1) taxa considered rare at the statewide level by the Alaska Natural Heritage Program (AKNHP), 2) Alaska-Yukon endemic species, and 3) Amphiberingian endemic species.

In Chapter 8 of this report I present a brief synthesis of what we have learned relevant to conservation of the flora and management of the Park. This includes enumeration of a rare plant list crafted specifically for Denali National Park and Preserve. I also describe geographic areas and habitats that were found to contain relatively high numbers of rare or sensitive taxa. Finally, this report closes with an appraisal of the directions for future work needed to better understand and protect the precious botanical diversity of Denali National Park and Preserve.

Chapter 2 Overview and Description of Study Area

Denali National Park and Preserve is located within the south central section of mainland Alaska (Figure 2.1). It occupies the area spanning roughly 62° 18' and 64° 04' North latitude and between 148° 48' and 152° 52' West longitude. The maximum latitudinal extent of the Park spans about 200 km north to south, and similarly the maximum longitudinal extent of the Park spans about 200 km from east to west. In the following sections, I briefly describe the landscape and ecological context of the Park. The nature and shape of the landscape exerts strong influences on the character of the resident flora. Different sets of species occur in more or less predictable patterns, depending on the landscape context, including physiography, geology and their interactions with local and regional climates in the area. These interactions among physical drivers of the biotic systems, in combination with the ecological history of the place, order the mosaic of vegetation that covers the Park landscape.

In this chapter, I review the major physiographic, geologic, and climatic patterns in Denali, and what is known of the ecological history of the region. In addition, I summarize the results of a recent study (Soil Survey of Denali National Park and Preserve, Clark and Duffy 2004) that has generated a new ecoregion map (to the subsection level) for Denali. These major physical attributes and landscape context of the Park are treated here because of their strong influence on the composition and distribution of the flora.

A. Physiography

The shape of the land (its physiography) exerts important influences on habitat attributes for plants – slope, aspect, elevation, and how they vary and interact, affect all of the major physical drivers for plant growth, including temperature, amount and distribution of solar energy, moisture and many of the important attributes of the substrate. Physiography varies dramatically across the Park landscape from ice-covered high alpine peaks, to several ancient, weathered low ranges of hills to lowland boreal basins filled with forests, ponds and wetlands. I describe the major physiographic elements of Denali in the following sections.

1. Mountains and hills

a. Alaska Range

The Alaska Range mountains are the central element of the Park landscape, both aesthetically (they dominate the horizon, even from the deep lowlands of the Minchumina Basin), and through their crucial role in dominant landscape processes such as tectonic activity, glaciation, and erosion and sedimentation. In addition, the Alaska Range exerts strong influences on temperature, precipitation and wind patterns (and other climatic factors) throughout the region, all of which then strongly affect the physical environment for plants and the processes of mineral weathering that provide the substrate for plant life.

The Alaska Range is oriented in a northeasterly to southwesterly direction in the Denali region and occupies virtually the entire southern half of Denali National Park and Preserve (Figure 2.1). The Park is located at the inflection point in the great arc formed by this mountain range: to the east of the Park, the range trends east to west, and to the south, the Alaska Range is oriented primarily in a north to south direction. The Mount McKinley massif is the highest and most massive section of the Alaska Range. This massif contains both the highest point in North America (Mount McKinley at 6,194 m) and the greatest area of terrain above 2,500 meters in the entire extent of the Alaska Range, based on an analysis of digital elevation data in the GIS database.

The Alaska Range alpine landscape is characterized by steep, barren rock escarpments and thick sheets of glacial ice. Permanent ice occupies most surfaces above 2,300 meters elevation throughout the range. There are, however, substantial differences in the character of both the glaciers and the landscape that contains them, between areas on the north versus the south sides of the Alaska Range crest. The south side of the crest receives considerably more snow than the north side due to the moisture generated in the Gulf of Alaska and deposited on the southern flanks of the range. The colder, more continental air masses that reach the mountain slopes north of the crest contain considerably less moisture, and thus a much thinner mantle of snow blankets these slopes during a typical winter.

The difference in the amount of snow that accumulates in areas south of the Alaska Range crest versus the north side has important consequences. For example, glaciers on the south side are, on average, much larger, generally steeper and often reach considerably lower elevations than north side glaciers, which are generally small in comparison to huge ice fields such as the Eldridge, Kahiltna, and Ruth glaciers that flow south from the crest of the range (Figure 2.1). As a result, south side glaciers move up to twice the amount of material as the glaciers on the north side of the range do, thus affecting much higher rates of material transport down slope in these areas. This dynamic results in a more profound sculpting of the landscape in areas on the south side of the Alaska Range as compared to the north side (see Plate 2.1).

Landscape surfaces south of the Alaska Range crest are also, on average, more recently deglaciated than equivalent areas north of the Range. As a result, these surfaces tend to be of a steeper and more jagged nature because erosion and other mass movement of material have had less time to operate on the newly-exposed, ice-gouged landscape (see Plate 2.2). As a result, soils in mountainous regions on the south side are often younger and less weathered than in equivalent areas of the landscape on the north side of the range (personal observation).

One striking similarity between the landscapes on the north and south sides of the range is the predominance of large, braided glacial streams in both areas. These rivers are heavily laden with silt and cobbles and as a result form very large and active floodplains within which river channels are constantly shifting and changing. The braided and active nature of these floodplains results in the creation of large open expanses of bare cobbles and silt available for colonization by plants. Large open terraces of alluvium occur in mountain valleys and extend out into the lowlands on both sides of the Alaska Range crest.

Plate 2.1. The alpine landscape south of the Alaska Range crest is steep and rugged, as shown in this photograph taken between the Kahiltna Glacier and Chelatna Lake, looking toward Mt Foraker.

Plate 2.2. The northern slopes of the Alaska Range in the vicinity of Heart Mountain.

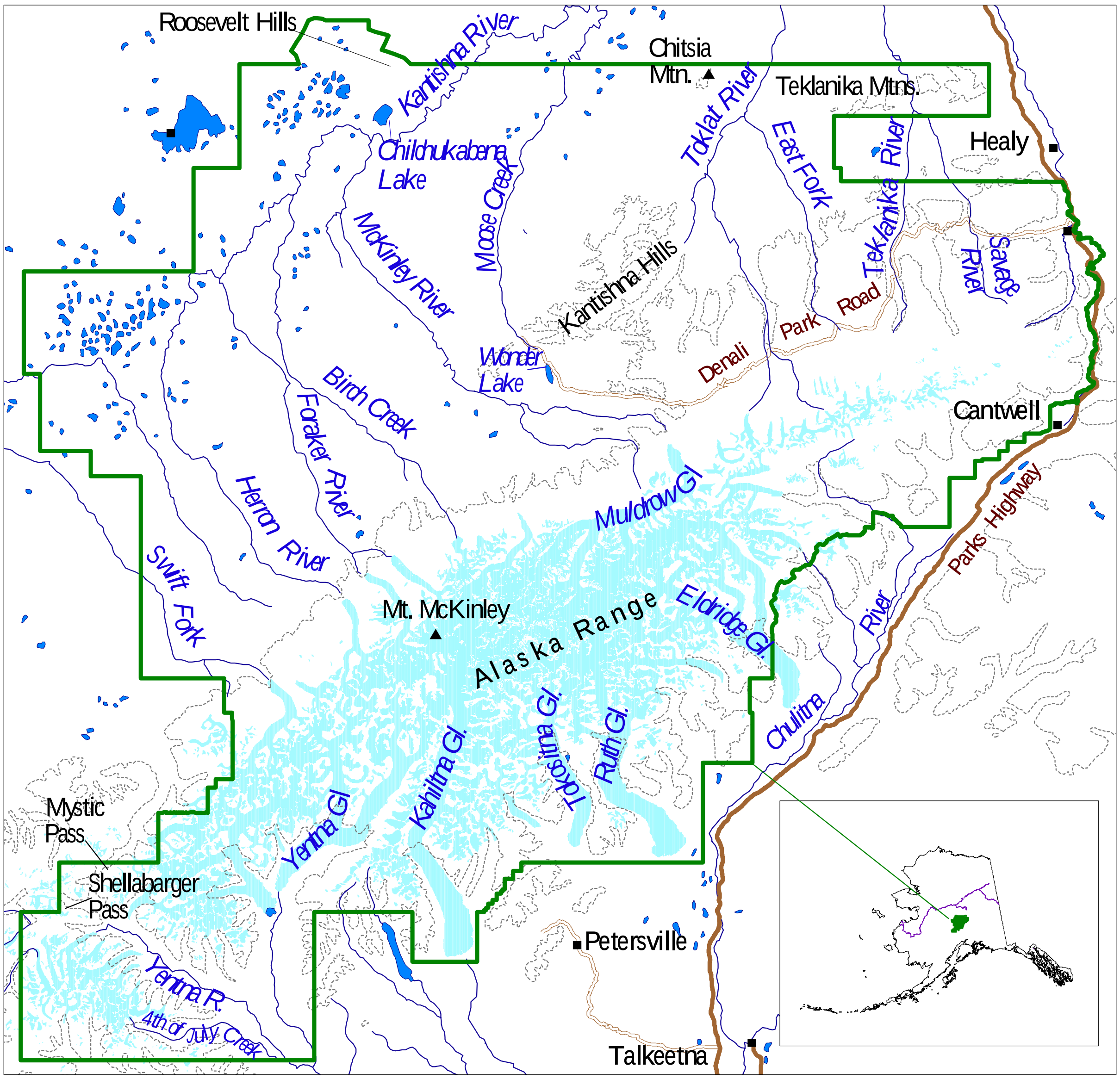


Figure 2.1 Major features of the landscape of Denali National Park and Preserve, located in Southcentral Alaska, U.S.A. (Mercator Projection, NAD 1927). Dotted line shows the 3000 foot elevation contour.

Examples of these large glacial rivers in the Park are the Chulitna, Kahiltna and Yentna rivers on the south side and the Toklat and McKinley rivers on the north side.

b. Kantishna Hills

The Kantishna Hills form a peninsula of mountainous terrain that extends out from the Alaska Range to the northwest from approximately longitude 150° 30’ (Figure 2.1). The crest of the Kantishna Hills runs roughly north-south between Mt. Chitsia, the Hills northern terminus, and Eagle Gorge on the McKinley River. These mountains are considerably lower and less precipitous than the high Alaska Range summits to the south, but they nevertheless reach elevations of more than 1,500 meters and constitute a large area of alpine habitat within the Park (see Plate 2.3). While glaciers are absent from the current landscape of the Kantishna Hills, there are several cirques and U-shaped valleys surrounding the major peaks that attest to the past existence of glaciers in the area. Due to the absence of glaciers, streams draining the area are different in character from the silt-laden glacial streams of the Alaska Range. Stream channels in the Kantishna Hills are similar to other interior clear-water streams, without the characteristic high sediment loads and braided appearance of glacial streams in the Alaska Range. Several streams in the Kantishna Hills bear the scars of the history of mining activity in the area, and have heavily modified stream courses, damaged by the numerous excavations for placer mines.

c. Teklanika Mountains

In addition to the Kantishna Hills, there is another small range of hills set off from the Alaska Range to the north that is within the Park, known as the Teklanika Mountains (Figure 2.1). These hills are formed by a series of relatively low domes of Birch Creek schist and related metamorphic rock units that rise east of the Toklat River and north of the Stampede Trail (see Plate 2.4). The Teklanika Mountains are more similar in structure and origin to the numerous low ranges of hills dotting interior Alaska (such as the domes around Fairbanks, 80 km to the north) than to the high mountains of the Alaska Range. This range of hills is dissected by the Teklanika and Sushanna rivers, which flow north out of the Alaska Range to join the Toklat and Nenana rivers, respectively. The canyons through the hills formed by these streams are geomorphically active and contain numerous outcrops and steep rubble slopes, resulting in an open alpine environment, although at fairly low elevations. The physical environment of this set of hills is distinctive, due to the fact that they are physically separate from the Alaska Range proper and have a more strongly continental climate than the Kantishna Hills. Another distinctive facet of the environment of this range of hills is the considerable windiness that occurs across the summits and canyons there. This windiness affects the resident flora in many ways, including redistribution of the snowpack and causing intense winter desiccation stress resulting from the scouring effects of cold winter winds.

2. Lowland basins

There are three primary lowland regions of the Park, two are north of the range – the Toklat Basin and Yukon-Kuskokwim lowlands, and one is south of the Range – the Cook Inlet lowlands. By far the most extensive lowland areas within the Park lie north of the Alaska Range.

Plate 2.3. Alpine tundra in the Canyon Creek drainage, in the open, rolling alpine landscape of the central Kantishna Hills.

Plate 2.4 Ridgetop granitic rock outcrop in the alpine zone of the Teklanika Mountain, west of the Teklanika River; note the proximity of tree line to the ridgeline in this area.

South of the Alaska Range, the Park boundary runs very close to the base of the Alaska Range escarpment, and thus only widely separated fragments of lowland ecosystems occur within the Park boundary in this region. North of the range, on the other hand, there are huge expanses of lowlands, comprising nearly a third of the Park's total land surface.

The surface of the lowland basins in the Park is dominated by sediments, including eolian silt, glacial deposits (including glacial drift, outwash, and morainal deposits of varying ages), and alluvium. Most of these sediments were originally derived from the weathering of Alaska Range rock. These surficial deposits are of quaternary origin (i.e. they were deposited within the past 1.6 million years). The widely scattered sets of low hills that occur in these basins represent the few areas of bedrock emerging through the heavy mantle of the weathered remains of the Alaska Range that blankets the lowlands of the Denali region. These old, weathered satellite ranges of granitic hills are part of the ancient, mostly unglaciated heart of interior Alaska. This ancient landscape, having persisted through geologic time, has witnessed major upheavals surrounding the Alaska Range Mountains to the south, including the periodic expansions and contractions of the huge cloaks of glacial ice and the successive transformations of the landscape resulting from these events. This landscape, now unmistakably boreal in character, has fluctuated between open tundra-like environments near the continental ice margins during glacial maxima and the mosaic of boreal forest and wetlands we observe there today.

a. Toklat Basin

The Toklat Basin is the lowland region surrounding the Toklat River immediately north of the Alaska Range, east of the Kantishna Hills, and west of the Teklanika River. This distinctive lowland basin was recognized as a discrete subsection of the Alaska Range ecological region in the Natural Resource Conservation Service (N. R. C. S.) Ecoregions of Denali National Park and Preserve map (see Plate 2.5).

The terrain of the Toklat Basin is inclined to the north on a gentle slope, except where rivers and minor escarpments have shaped the landscape and interrupt this prevailing ti1t of the land surface. The generally north-inclined aspect of the land in this region, along with the topographic shading of the southern horizon by the Alaska Range and the hyper-continentality of the climate, combine to make permafrost the defining element of this lowland area. This is due to the fact that solar radiation receipts are very low on north aspects in the subarctic, and mean annual temperatures in the area hover at or below about -3 degrees Celsius. Only relatively narrow thaw bands along rivers and small areas of south-facing terrain are free of permanently frozen ground in this area, and the active layer is generally shallow throughout much of the Toklat Basin.

The landscape of the Toklat Basin is low-relief, with an undulating topography formed by periglacial processes and the action of flowing water reworking alluvial and glacial sediments. The southern edge of the basin abuts the Alaska Range which is formed, in this area, by granitic rocks of the Wyoming Hills pluton. Low ridges emanating from the Wyoming Hills section of the Alaska Range extend into the Toklat Basin, forming higher topographic relief in this section. In addition, a low hill that rises south of the confluence of the East and Main forks of the Toklat River interrupts the low relief of the basin.

Plate 2.5 The boreal landscape of the Toklat Basin is characterized by widely-spaced rolling forested ridges and low relief tussock plains bisected by river corridors. The Toklat River corridor is barely visible in the distance.

Plate 2.6 The Minchumina Basin landscape is a mosaic of ponds, wetlands and forested lowlands. This photo is looking west into the basin from the ridge above Lake Chilchukabena.

This formation is underlain by schistose and phyllite metamorphic rocks of the Keevy Peak formation (Csejtey et al.1992). The floodplains of the East and Main forks of the Toklat River are the most conspicuous facets of this basin, and the rivers were largely responsible for reshaping the local landscape into its current appearance once the glaciers receded after the end of the Wisconsin glaciation.

b. Yukon-Kuskokwim rivers lowland drainage basins

The largest area of lowlands in the Park, by far, occurs north of the Alaska Range and west of the Kantishna Hills, within the watersheds of the Kantishna and the upper Kuskokwim rivers (see Plate 2.6). This area includes lowland sections of such major drainages as the McKinley, Foraker, and Herron rivers; Moose Creek; and numerous smaller streams (Figure 2.1). The surficial geology of this area consists almost exclusively of unconsolidated cobble, gravel, sand, and silt deriving from three different depositional processes: 1) eolian sediments (primarily silt); 2) glacially-deposited drift including outwash, moraines and lacustrine sediments; and 3) alluvium deposited by the erosion and redeposition of sediments including cobbles, gravel, sand and silt. The majority of these sediments have likely been reworked by the action of flowing water since they were originally deposited, because streams flowing off of the mountains crisscross the entire area. This is an area of low relief that drains generally to the northwest (Kuskokwim River drainage) or due north (Kantishna River and its tributaries).

Numerous small and shallow subarctic ponds dot the landscape of this vast lowland basin. These ponds were formed as a result of four primary processes: 1) topographic depressions (kettles) in glacial drift left behind by retreating glaciers; 2) thermokarst thaw ponds resulting from the melting of permafrost in localized areas; 3) ponding of stream courses that occurs due to the intrepid activity of beavers (*Castor canadensis*); and 4) instances where former stream meanders are cut off from the current stream-course as the channels shifts (oxbow lakes).

c. Cook Inlet lowlands

Most of the area within the Park boundary and south of the crest of the Alaska Range is very mountainous. However, there are fragmentary areas of lowlands within the Park boundary in the Yentna and Chulitna river drainages (see Plate 2.8). These areas are flat or gently rolling and are underlain by unconsolidated sediments of glacial till, outwash, and layers of volcanic ash deposited by periodic eruptions of the volcanoes on the Alaska Peninsula. These lowland areas are dotted with wetlands and small lakes in kettles and other depressional features and old oxbows of rivers (see Plate 2.7).

B. Geology

Lithology, or the mineral type and texture of the parent rock, has numerous important influences on habitat traits for plant life. These include influences on the texture, reaction, porosity and mineral nutrient status of soils (see review in Kruckeberg 2002). In sparsely vegetated and rocky areas, even the color of the parent rock affects the characteristics of plant habitat due to

Plate 2.7 The Cook Inlet boreal lowlands are a mosaic of wet depressions with numerous ponds and open wet meadows interspersed with terraces and hillocks supporting lush mixed forest with dense understory.

Plate 2.8 The open floodplains and terraces formed by the action of large, braided glacial rivers are an important facet of the landscape on both sides of the Alaska Range. The West Fork of the Yentna River is shown in the photograph.

differences in the albedo of the soil surface, which affects the soil temperature regime. In Denali, two important attributes of the parent rock are the pH and texture of the soil that results from the weathering of parent materials.

Areas of the Park formed by igneous rock with high quartz and feldspar content, such as granite, which weather into relatively acidic soil conditions, often support plant communities with different species composition than landscapes formed by basic rock types high in calcium and other cations. In addition, moisture stress is higher in soils formed from minerals that are highly resistant to weathering (including quartz and feldspar). Highly calcareous sites, such as limestone and marble, support characteristic suites of species, which occur much less frequently, or not at all, in sites with acidic soil reaction.

In addition to affecting the chemical and textural aspects of the soil, the geomorphology of the landscape is different in areas of differing lithology. For example, areas of the landscape formed by granitic rock tend to have massive, domelike appearance, with numerous outcrops and cliffs due to the resistant nature of the rock. In contrast, landscapes formed by less resistant rock types such as phyllite tend to form complex, highly eroded landforms with sharp ridges. This in turn affects the habitat attributes of different landscapes for the resident flora.

Whereas the core of the Alaska Range was formed by igneous intrusions of granitic rock (see Plate 2.9), much of the accessible terrain in the alpine region, and that hospitable to plant life, is composed of rock that is sedimentary, or meta-sedimentary in origin (Reed and Nelson 1980, Jones et al. 1983, Csejtey et al. 1992). These older, preexisting rock units have been uplifted and deformed from below during the building of this massive mountain range during the past 60 million years. Most of the bedrock north of the range is sedimentary in origin (see Plate 2.11), although large areas at high elevations and south of the range are formed by granitic intrusive igneous rock. Significantly for plants, small areas of calcareous sedimentary rock, including limestone and marbleized limestone crop up on both the southern and northern parts of the range (see Plate 2.12). I have observed limestone outcrops in the following areas of the Park:

1) Shellabarger Pass
2) Mystic Pass and the upper West Fork of the Yentna River
3) The upper West Fork of the Chulitna River
4) Windy Creek vicinity near Cantwell
5) “Ram Canyon” and vicinity in the upper Toklat drainage south of the Park Road
6) Areas of the Wyoming Hills

Perhaps the most homogeneous and consistent geologic province in the Park is the northern range of hills and mountains set off from the Alaska Range proper. This province includes the Kantishna Hills and the domes and plateaus north of the Park Road, as well the hills north of the Stampede Trail and the satellite ranges of outcrops and promontories in the northwestern lowlands such as Castle Rocks, the Roosevelt Hills and the ridges surrounding Chilchukabena Lake. The bedrock of this entire region is underlain by altered igneous rock such as schist, phyllite and related rock types (see Plate 2.10; Reed and Nelson 1980, Jones et al. 1983, Csejtey et al. 1992).

Plate 2.9 The core of the Alaska Range is formed by intrusive igneous rock, such as this massive granitic outcrop near Augustin Peak in the upper Kichatna River drainage.

Plate 2.10 Many of the low mountains and hills in the northeastern part of the Park are formed by domes of schist bedrock, such as this area in the “outer canyon” of the Teklanika River north of the Alaska Range.

Plate 2.11 Metamorphosed sedimentary rock units such as those shown in this photograph from the Wyoming Hills, are common in the alpine zone of the Alaska Range in Denali National Park and Preserve.

Plate 2.12 Outcroppings of limestone, and marbleized limestone occur in widely separated sites in Denali. This photograph shows a limestone outcrop in Shellabarger Pass in the southwestern corner of Denali National Park.

C. Climate

Major climate parameters vary considerably across the landscape of the Park due to both macro-climatic and microclimatic phenomena. The primary macroclimatic gradient in the Park is the interface between the relatively warm and moist maritime air masses that are generated in the Gulf of Alaska and the dry, highly continental air masses that occur north of the Alaska Range. Moist maritime air masses move onshore with atmospheric currents and collide with southern flanks of the Alaska Range, where they cool and cause high precipitation and considerable cloudiness south of the Alaska Range crest.

The moderating influence of the oceanic air results in warmer winter temperatures and cooler summer temperatures on the south side as compared to the highly continental interior climate zone. Temperatures in the interior are extreme in comparison, with short, intense summers and long, bitterly cold winter seasons. An examination of the mean monthly temperature for five stations in the vicinity of Denali National Park and Preserve that represent a transect across this climatic gradient shows this quite clearly (Figure 2.2). The station at Minchumina represents the highly continental climate zone in the Park, and the Skwentna and Talkeetna stations represent the most maritime end of this climatic gradient. McKinley Park is the sole station in the mountains represented by these climate monitoring sites. Mean annual temperatures are considerably higher on the Cook Inlet side of the Alaska Range as compared to the interior side (Figure 2.3)

Variation in the amount of precipitation across the landscape of the Park is strongly correlated with the variation in temperature gradients discussed above. The driest localities in the Park lie within the rainshadow north of the Alaska Range. Interior lowland localities such as Minchumina receive less than half the amount of total annual precipitation, on average, as southern localities such as Skwentna and Talkeetna (Figure 2.4). The timing of precipitation also varies across this gradient. The precipitation peak for the maritime localities of Skwentna and Talkeetna is not only considerably higher in amplitude (reflecting more precipitation) but generally comes somewhat later in the year (Figure 2.5). Whereas the three more interior stations experience a precipitation peak in July, Skwentna generally receives its highest precipitation total in September.

The timing of vegetation green-up is also different across this macroclimatic gradient. Although areas lying south of the Alaska Range have a relatively moderate climate due to the proximity of the ocean, alpine areas in this zone tend to green up later in the year as compared to subarctic sites north of the Alaska Range. This is due to the much higher accumulation of snow on the southern flanks of the range. In order for green-up to occur, the snow must first melt, and thus the large southern snow pack results in delayed phenology on the south side (see Plate 2.14).

There are also strong microclimatic gradients within the Park due to its dramatic and diverse topography and the interaction of topography with macroclimatic variables and patterns in prevailing winds. For example, areas in close proximity to the low elevation passes across the Alaska Range (Broad Pass in the east and Mystic Pass in the west) are frequently subject to extreme windiness. This results in scouring of the snow layer; cold, desiccating winter winds; and wind-pruning of trees and shrubs as well as other wind-related stresses to plant life.

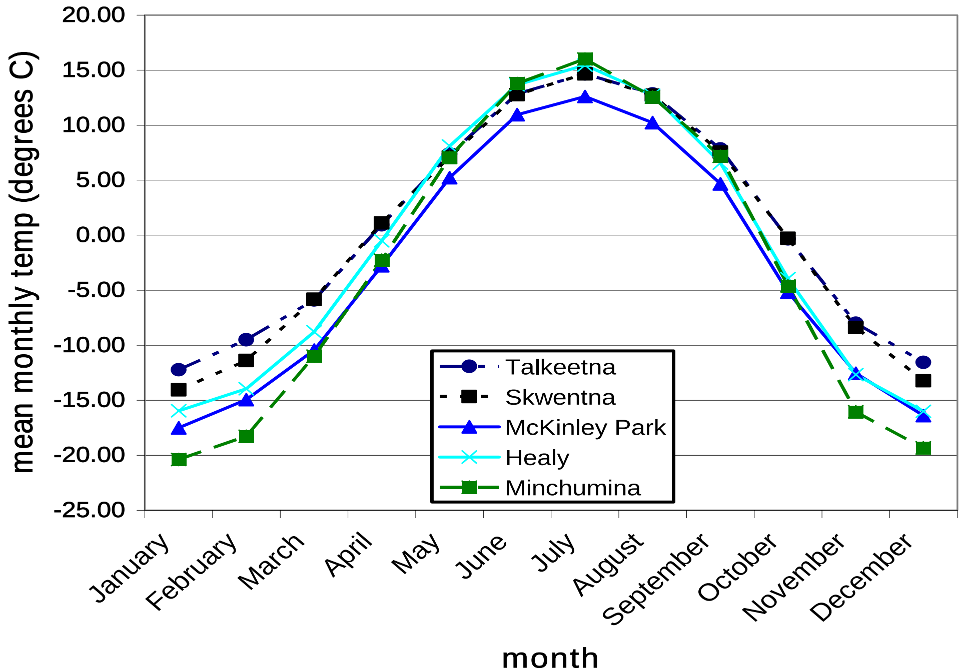


Figure 2.2 Mean monthly temperatures for five climate monitoring stations in the vicinity of Denali National Park and Preserve.

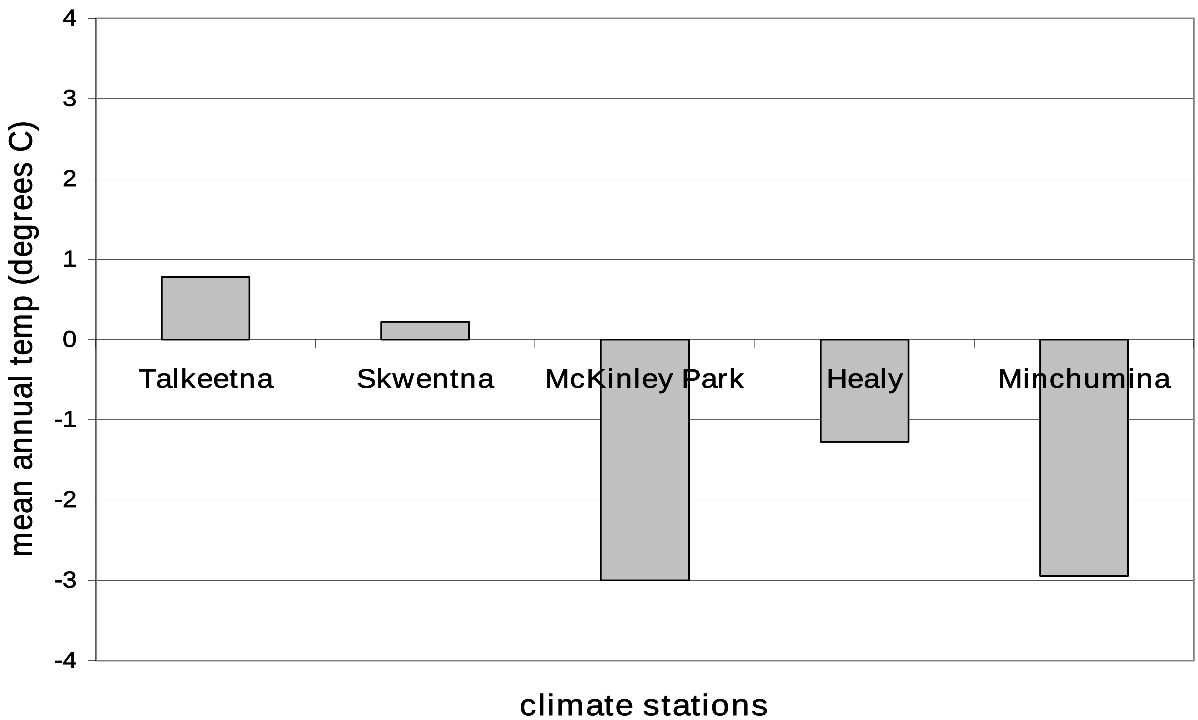


Figure 2.3 Mean annual temperatures measured at five climate monitoring stations in the vicinity of Denali National Park and Preserve.

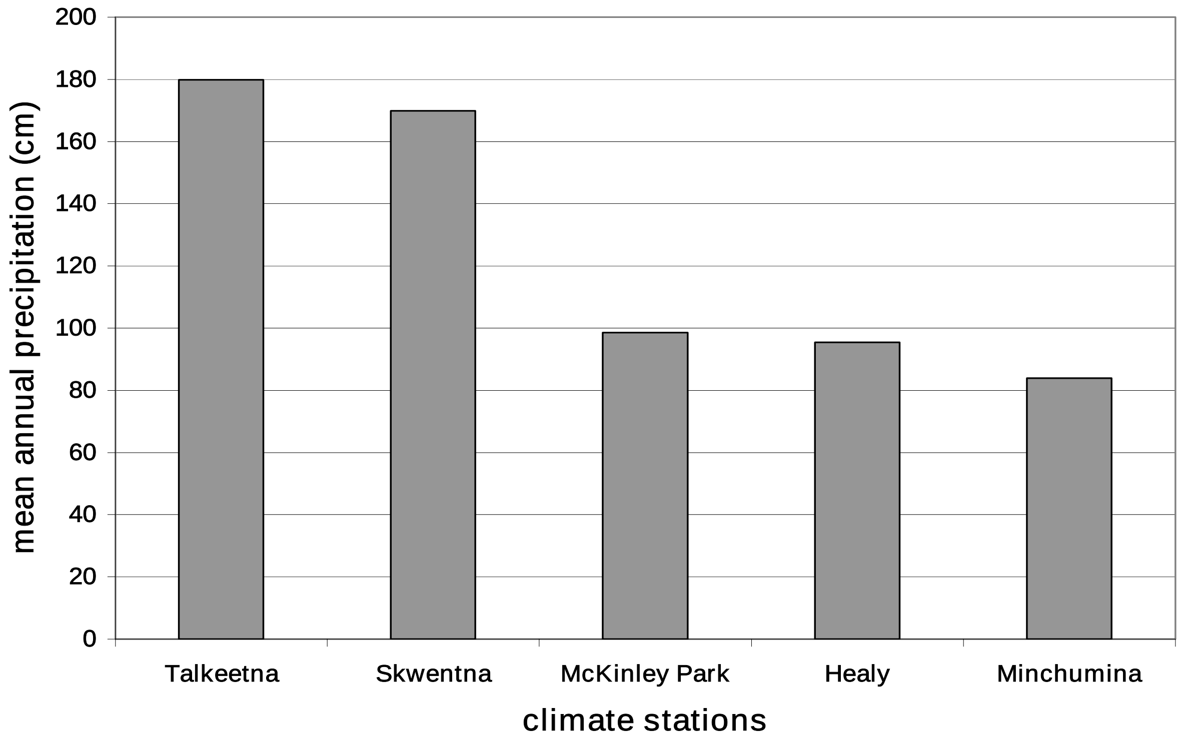


Figure 2.4 Mean annual precipitation measured at 5 climate monitoring stations in the vicinity of Denali National Park and Preserve.

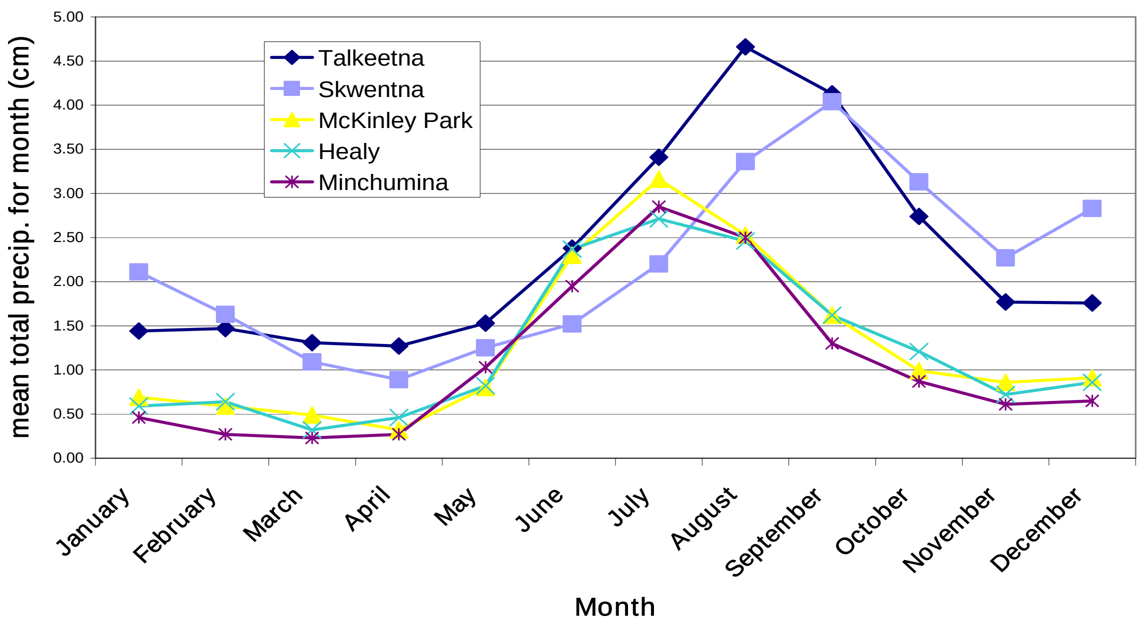


Figure 2.5 Mean monthly precipitation measured at 5 climate monitoring stations in the vicinity of Denali National Park and Preserve.

Plate 2.13 The Alaska Range profoundly influences regional weather patterns. This picture shows the Alaska Range shrouded in clouds while the interior lowlands are experiencing a hot, clear summer day.

Plate 2.14 The deep snowpack on the south side of the Alaska Range results in delayed green up in this region as compared to areas on the north side. This photograph shows considerable snow cover remaining in a subalpine basin on July 1st 1999. The toe of the Kahiltna Glacier is visible to the north in this photograph.

Vegetation patterns in the subarctic are strongly controlled by environmental factors that vary with topographic variables such as slope, aspect and elevation. Because of the low solar angle in the far north, variation in solar radiation among sites within a particular region is largely a function of the azimuth and angle of slope. Solar radiation, in turn, affects a variety of important attributes of the physical environment including soil and air temperature, potential evapo-transpiration rate, soil moisture content, snow-free date and growing season length. These physical variables also affect a myriad of other biotic processes such as element mineralization and other microbial activity rates that then also have important consequences for the vegetation.

Similarly, the elevation of a site interacts with regional climate to fundamentally affect the properties of the physical environment, such as temperature, precipitation, and humidity, in ways that determine the patterns of vegetation on the landscape. For example, high elevation sites in the Park tend to receive substantially more precipitation than low elevation areas, and this affects the vegetation, including causing shorter growing seasons and less extreme summer drought stress in the mountains (see Plate 2.13). Patterns in the alpine vegetation are controlled by the timing of snowmelt much more than in areas in the lowlands. This is particularly true in areas of very high snow accumulation south of the range where we see the development of heath-dominated plant communities characteristic of areas with very late-lying snow.

D. Ecological history

The ecological history of the Denali National Park and Preserve region during the past two million years is characterized by repeated advances and subsequent retreats of massive sheets of glacial ice throughout the Pleistocene Epoch. These repeated and enormous ecological upheavals have had profound influences on the nature of the biota resident in the Park and the very nature and shape of the Park landscape itself. In fact, at least half of the Park was intermittently covered by the Cordilleran Ice Sheet during glacial maxima (see Figure 2.6).

As a result of the formation of the Cordilleran Ice Sheet, only the areas well north of the Alaska Range proper were habitable during the periods of maximum glacial advance. This northern section of the Park was a part of Beringia, the vast refugium for plants and animal life that formed during the Pleistocene glaciations (Hopkins 1982). This biotic refugium was connected to northeastern Asia by the formation of the Bering Land Bridge, and cut off from North America east of the Yukon Territory by the Cordilleran Ice Sheets (Hamilton and Thorsen 1983). The Beringian refugium almost certainly had a hyper-continental climate due to the recession of any maritime climatic influences far to the south and the climatic barriers formed by the massive ice sheets in the mountains. The climate during glacial advances was probably colder and much drier than the present climate (Edwards and Barker 1994). The landscape of full-glacial Beringia is known to have been quite different from the boreal landscape that we know today. For example, trees were essentially absent from the area during glacial maxima, and pollen spectra indicate that the vegetation was considerably more open and tundra-like in nature than what occurs in the region today (Giterman et al 1982, Matthews 1982, Ritchie and Cwynar 1982, Eisner and Colinvaux 1990).

Pleistocene sediments in the Denali region indicate that even areas in the lowlands and foothills north of the Alaska Range supported graminoid-tundra vegetation during the last glacial

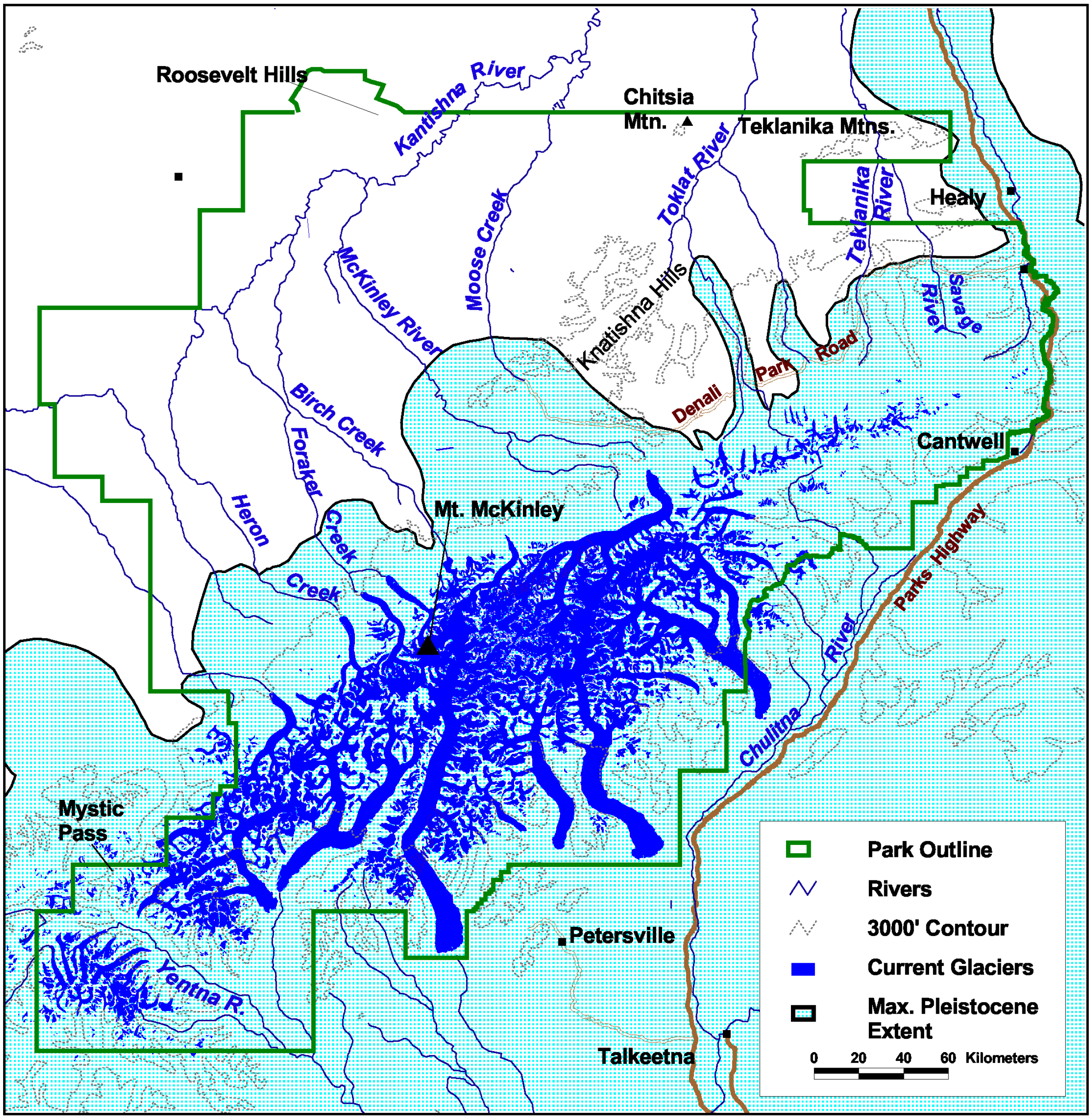


Figure 2.6 Generalized map of the maximum extent of Cordilleran Ice Sheet in Denali National Park and Preserve during last peak glacial advance, (Mercator Projection, NAD 1927).

maximum (Elias et al. 1996). Holocene sediments within Denali National Park show that the northern lowlands were dominated by dwarf birch low scrub tundra types (similar to what occurs in the subalpine and lower alpine regions of the Park currently), and that coniferous forest only became established in these areas after 6,500 years before the present (Elias et al. 1996). This suggests that the vegetation zonation that occurs on the current Park landscape is actually of very recent origin (in geologic terms), and the forest types that dominate the lowland basins, in particular, are relatively new elements on the landscape of this region. However, it also appears that during the previous interglacial warm interval (the Boutellier interval, approximately 60,000 to 30,000 years before the present) the vegetation was at least broadly similar to the boreal taiga vegetation that occurs there at present (Elias et al. 1996).

The fossil evidence from interior Alaska indicates that the Pleistocene epoch has seen repeated major shifts in the vegetation patterns on the landscape, which correlate with the advance and retreat of glaciers in response to major shifts in climate (specifically temperature and precipitation). It is this dynamic of change that has profoundly shaped the composition of the endemic flora of this region. Plants whose evolutionary histories are confined to Beringia are disproportionately plants of dry and open areas of the landscape including tundra, rubble slopes and dry meadow areas devoid of trees. Conversely, few of Alaska's endemic plant species occur in forested habitats. Even those endemic species that occur in the lowlands on the current landscape usually occur around rock outcrops, floodplains or other open areas of the boreal landscape.

The repeated formation of a land connection to northern Eurasia and the simultaneous separation from the mass of the North American continent that occurred during this Epoch also has had important influences on the character and composition of the Alaskan flora. Many plant species that occur in Alaska have their evolutionary roots in Eurasia. A common distribution pattern for species in our flora is "Amphiberingean" – which means that the range is centered on what was formerly Beringia and the species occurs on both sides of the Bering Strait. The repeated interchange of plants and animals that occurred during periods when the Land Bridge was exposed has resulted in a degree of similarity between the flora of North Asia and Alaska, particularly in the unglaciated portions of these areas.

E. Ecological subsections of Denali National Park and Preserve

Ecoregion mapping is an attempt to integrate descriptive data about a landscape from a variety of sources including observations of climate, geology, topography, soils, hydrology, and vegetation in order to delineate a hierarchical set of meaningful biophysical units. It is intended that this mapping exercise will allow for a better understanding of how ecological patterns and processes co-vary across a given landscape. Often, however, this process is performed using disparate data sets collected over long and/or varying lengths of time at different spatial scales for a variety of different purposes. In such cases, the product of the ecoregion mapping exercise may be of poor quality due to problems with mismatched data sets. Fortunately, this potential problem is not the case for Denali National Park and Preserve. There has been a very intensive, six-year field effort to create a soils inventory and ecological site map in the Park, which has also provided managers and biologists with a high quality ecoregion map from a high-quality and internally consistent set of data (Clark and Duffy 2004).

Twenty three different ecological units at the level of the ecoregion subsection were defined for Denali National Park and Preserve (for definitions of units see Clark and Duffy 2004). The ecological subsections that occur in Denali National Park and Preserve are shown in Figure 2.7. These subsections are divided among the five ecological sections: Alaska Range, Cook Inlet lowlands, Kuskokwim Mountains, Yukon-Kuskokwim bottomlands, and water (Clark and Duffy 2003). A primary dividing line among these units is the boundary between the interior climate zone, which occurs north of the Alaska Range, and the maritime-influenced climate zone of Cook Inlet that lies to the south. Other major factors separating these ecological units are elevation, landform and dominant general landcover types.

Five ecological subsections occur in the Park south of the Alaska Range. The boundaries among these subsections appear to be separated primarily by variation in biophysical attributes related to elevation (alpine, subalpine and boreal life zones) and secondarily by three different landform types (colluvial slopes; floodplains, alluvial fans and terraces; and glaciated lowland plains). There are three mountainous subsections in this area: *Alaska Range-Southcentral Alpine Mountains, Alaska Range-Southcentral Non-vegetated Alpine Mountains*, and *Alaska Range-Southcentral Boreal and Subalpine Mountains*. The lowland subsections south of the range are separated into areas underlain by surfaces recently deposited by running water (*Cook Inlet Lowlands-Lowland Flood Plains, Terraces and Fans*) and areas underlain by glacial drift of varying ages (*Cook Inlet Lowlands-Glaciated Lowlands*).

There is considerably more diversity in ecological types in the Park north of the range. There are 20 different ecological subsections that occur in this area of the Park (four times as many as are found south of the range within the Park). The ecoregions that are represented on the north side of the Alaska Range in the Park are the *Alaska Range – Interior, Kuskokwim Mountains*, and *Yukon-Kuskokwim Bottomlands*. These broad ecoregion sections are further divided into subsections based on lifezone (boreal, subalpine and alpine) and landform (alluvial fans, alluvial plains, eolian plains, floodplains and terraces, low mountains, alpine mountains and plateaus, glacial hills and plains). Detailed descriptions of these ecological subsections and the factors that define them are presented in Clark and Duffy (2004).

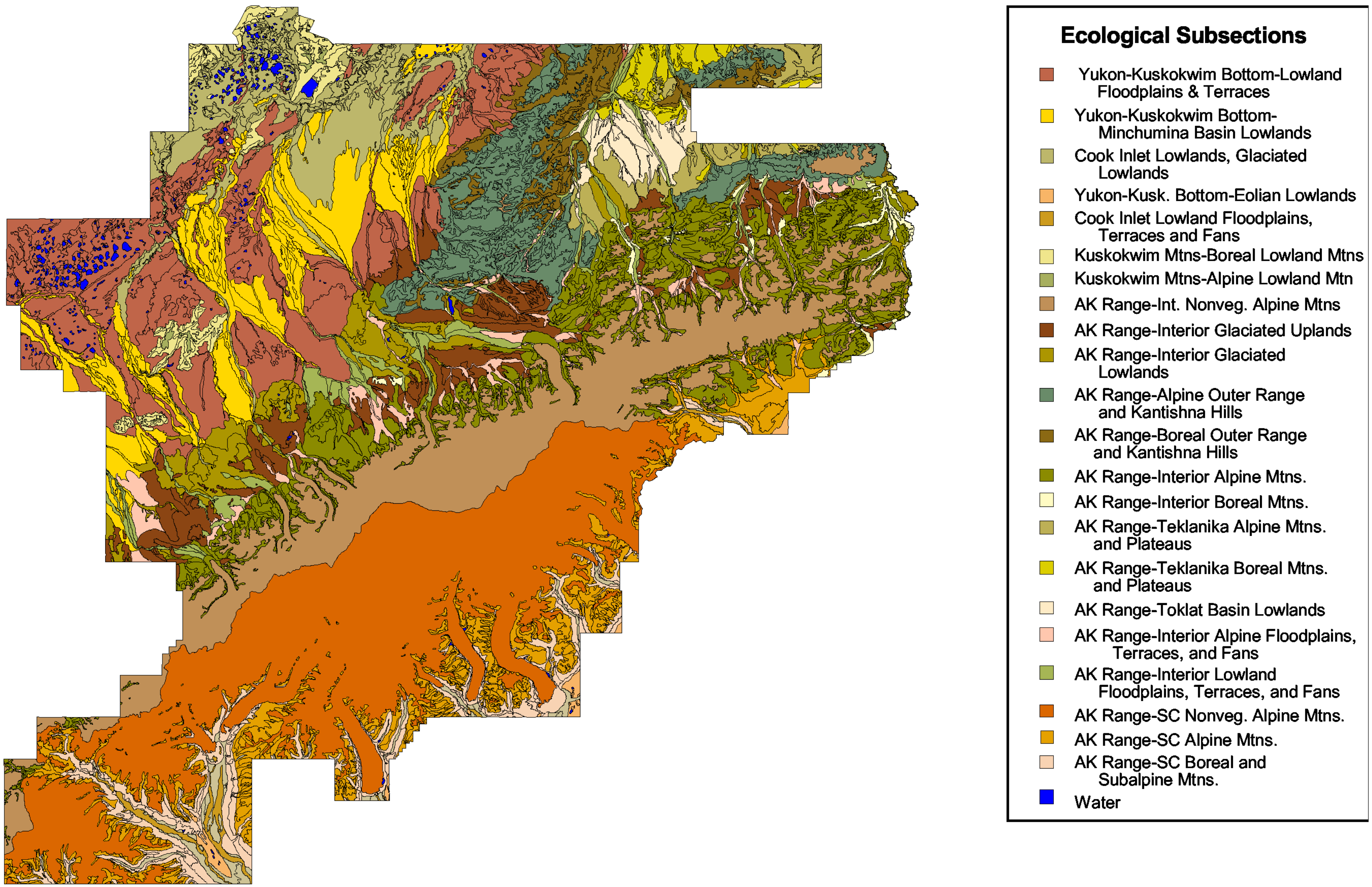


Figure 2.7 Map showing the ecological subsections that have been defined for Denali National Park and Preserve, Mercator Projection, NAD 1927, from Clark and Duffy (2004).

Chapter 3 History of Plant Collecting in Denali National Park and Preserve

The flora of the Park Road corridor area of Denali National Park and Preserve has been collected more intensively than most regions of Alaska. Only a handful of other areas, including the immediate vicinities of Anchorage, Fairbanks, Juneau, and Pt. Barrow; certain southern coastal sites; and areas of the North Slope of the Brooks Range, have as long and thorough a history of botanical collecting. The goal of this chapter is to provide an overview of that long history of botanical collecting in the Park, which includes work by many of the leading botanists in the history of the botanical exploration of Alaska, such as Lawrence J. Palmer, A. Erling Porsild, Jacob P. Anderson, Eric Hultén, Olav Gjaerevoll, Stanley L. Welsh, Leslie A. Viereck, and David F. Murray. This history also includes cameo appearances by a few of the most eminent botanists and plant ecologists of our century, including G. Ledyard Stebbins of the University of California, and W. Dwight Billings of Duke University.

In compiling this history, I had the benefit of access to several sources of information prepared by others. First of all, Dr. Les Viereck made available to me a review of botanical work in the Park that he made in the early 1970's. This useful file of information included correspondences with Adolph Murie and others, as well as helpful references to collecting activity during the middle of the twentieth century and before. Secondly, Hultén's History of Botanical Exploration of Alaska contains several useful references relevant to collections made in the area (Hultén 1940). Thirdly, a review of vegetation studies in Denali National Park and Preserve, made by Joe Van Horn and Jim Thorne (1997), yielded several valuable references. And finally, the record of collecting permits maintained by the Park was a valuable reference for documenting plant collecting activities that have occurred there over the years.

The focus of this summary is on broad-spectrum vascular plant collections that contributed substantial information about the composition of the vascular plant flora of this area. Of necessity, small collections and those made during the course of narrow studies (such as of pollination biology) focused on a single species are generally omitted from this account. It should also be noted that I have omitted numerous important nonvascular plant collections that were made in the Park, in the interest of space, and in keeping with the focus of the current project on vascular plants.

1902 - The first documented reference to scientific collecting of plant specimens in the region of what is now Denali National Park and Preserve is the description of the collection made by L.M. Prindle, a geologist with the A.H. Brooks expedition in 1902 (Brooks and Prindle 1911, p. 201-207). This expedition traveled from Cook Inlet via Skwentna, then continued across the Alaska Range through Rainy Pass. After crossing the mountains, Brooks and company traversed the northern slopes of the Alaska Range across the upper Kuskokwim River drainages and eastward across the broad flanks north of Mt. McKinley. East of Mt. McKinley, the expedition turned northeastward, and reached the Tanana River, where they continued to the confluence with the Nenana River. During this journey, Prindle collected more than 130 specimens, which were sent to F.V. Colville for determination. A list of these collections is contained in the account of Brooks expeditions work (Brooks and Prindle 1911, p. 208-211).

1903 - Ralph Sheinwald, a botanist on Cook's expedition to Mt. McKinley, was also thought to have made a few collections in the area of what is now the Park during the expedition to Mt. McKinley of 1903, although the extent of this work is not known (Les Viereck, personal communication).

1908/9 – Charles Sheldon spent this period of time in the Toklat River region of what is now the Park traveling and observing Dall sheep. He reportedly made a few plant collections and general descriptions of the vegetation (Sheldon 1930).

1923 - Olaus and Margaret Murie collected plants near the Savage River in the Park in July and August of 1923, six years after Mt. McKinley National Park was established (Hultén 1940). These eminent conservationists and natural historians were primarily focused on zoology, however, and so this collection was not a large or comprehensive one.

1926 - L.J. Palmer of the U.S. Biological Survey and the eminent northern botanist A.E. Porsild traveled from Anchorage across to Fairbanks (and later on overland to Nome). During this trip they made several collections in the vicinity of both Cantwell, just east of the Park, and Healy, just north of the Park. The results of their extensive collecting during this entire trip were published by the National Museum of Canada (Porsild 1939).

Also in 1926, Hultén reported that a Mrs. R.P. Mackie collected a few specimens in the vicinity of Mt. McKinley Park during August. The identity and disposition of these specimens are not known (Hultén 1940).

1927 – Ruth Fisher published a short account of plant species that she observed in McKinley Park in the Joint Bulletin of the Vermont Botanical and Bird Clubs (Fisher 1927). This brief account includes several intriguing species references (including to two rather rare species of gentian in the Park, *Gentianella tenella*, and *Gentiana amarella*). Unfortunately, there are no actual botanical specimens referenced, or documentation of how the species were identified. Also in 1927, Hultén reported that a John and Paula Anderson collected a few plants at Mt. McKinley Park in June and July. The identity and disposition of these specimens are not known (Hultén 1940).

1928 - The first large and systematic plant collection effort made within the boundary of the Park itself was accomplished by Ynez Mexia, a Mexican general's daughter living in Washington D.C., who spent the summer of 1928 traveling and collecting plants in the Park. Mexia made about 365 species collections in Mt. McKinley National Park, of which there were as many as 6,100 total duplicate sheets prepared. Because of the large number of duplicates, these specimens were distributed to many herbaria, including the University of California Herbarium, the National Herbarium in Washington D.C., and the Riks Museum in Stockholm (Hultén 1940). She collected plants in numerous sites throughout the road corridor of the Park, from the headquarters area, Savage River, and Polychrome Pass to Wonder Lake (Hultén 1940). The results of this work were published in the journal Rhodora (Mexia 1939).

1931 – J.P. Anderson (author of the Flora of Alaska and Adjacent Parts of Canada, Anderson 1959) made collections in the vicinity of Healy, Lignite and Cantwell outside of the Park boundary and a few collections in the vicinity of Mt. McKinley Park headquarters. Anderson, a prolific collector and key figure in the history of botanical exploration of Alaska, also made collections in the vicinity of the Park in 1939, including a very few collection localities within the Park Road corridor.

1932 – In the summer of 1932, monographer of the genus *Salix*, W.A. Setchell, along with David Kaye and F.W. Morand, collected plants in the Park. Walter Setchell's work on willows was published in the botanical journal Madroňo (Ball 1940).

1934 – Dr. Fritz Went collected plants in the Park. These collections are housed in the University of California Herbarium and at Lund, Sweden (L. Viereck, personal communication).

1936 – Edith Scamman of Harvard's Gray Herbarium spent about two weeks collecting plants in Mt. McKinley Park. She also collected extensively elsewhere in Alaska during the same summer, and the results of these studies were published in Rhodora (Scamman 1940). Two new plant species, *Claytonia scammaniana* and *Oxytropis scammaniana*, were named from among the important set of specimens Scamman collected on her trip to Alaska (Hultén 1940, 1968). In addition, during the summer of 1936, Elizabeth Kol studied the algae on glaciers in the Park and also made a handful of vascular plant collections (Kol 1942).

1939 – Dr. Aven Nelson, a professor of botany from the University of Wyoming, and his wife Ruth A. Nelson made a large collection of plants in the Park consisting of about 930 specimens (excluding duplicates). This collection represented a significant contribution to the knowledge of the Park's flora. The Nelsons collected extensively throughout the Park Road corridor, from the Park headquarters in the east to Wonder Lake in the west. Duplicate sets of specimens from the Nelsons' collection are deposited at ALA, the herbarium of Denali National Park and Preserve (hereafter referred to as DENA), and the Rocky Mountain Herbarium at the University of Wyoming, Laramie. The Nelsons described the results of their project in a file report to the National Park Service (Nelson and Nelson 1946).

Adolph Murie, who was supervisory biologist for Mt. McKinley National Park from 1939 until 1943 and was involved in numerous important wildlife studies in the Park during the period from 1946 until 1966, with his wife Louise, made their first accessioned plant collections in the Park in 1939. The Muries' collections were made as a part of Adolph Murie's investigations of wolf, grizzly bear, and Dall sheep ecology in the Park. Over the years, the Muries continued to make collections of vascular plant specimens in the Park and Louise Murie eventually prepared a manuscript describing the common flora of the Park Road corridor (Murie 1975). We have records of 350 specimens made by the Muries over the years in the Park. These collections are now housed in ALA and DENA).

Early 1940's - There was a relative hiatus in collecting activity and botanical studies in the Park during this period, no doubt related to the fact that the Second World War was in progress. The records of collections made by the Park biologist, Adolph Murie, are the primary additions to the collecting record of the Park during this period of time.

1949-1950 – Herbert C. Hanson, with botanists Earnest LePage and Ethan D. Churchill, studied soil profiles and vegetation composition as part of an analysis of potential reindeer range and forage characteristics using aerial photographs, 8/20-8/27, 1949, and 07/19-07/26, 1950 (Hanson 1951). Any collections made for this study would be housed at the Catholic University of America in Washington, D.C. The research team included botanist Earnest LePage, who published the results of his investigations in Alaska in a note in the American Midland Naturalist (LePage 1951).

1950 – Harold and Virginia Bailey, prolific botanical collectors for the University of California Berkeley Herbarium, collected nearly 550 specimens in Mt. McKinley National Park. This was apparently the most significant plant collection made since the Nelsons collected in the Park in 1939. The Baileys' collection localities also spanned the Park Road corridor from headquarters to Wonder Lake. Specimens were deposited in the University of California at Berkeley Herbarium with a duplicate set going to DENA. The Baileys also made significant collections at other major western national parks.

Les Viereck, the most prolific plant collector in the history of botanical collecting of the Denali National Park and Preserve area, made his first collections in the Park proper during the summer of 1950 when he worked there as a seasonal park ranger. He made additional small collections in the Park during the summers of 1951 and 1952.

1952 – Winslow R. Briggs made a collection of high alpine plants in the region around McGonagall Pass as a member of the Harvard Mountaineering Club expedition to Mt. McKinley. Some of their results were published in the journal Rhodora (Briggs 1953).

1953 – Botanist Dr. Galen Smith, monographer of the genus *Eleocharis*, made a collection of more than 60 specimens in the Park during 1953 and 1954, primarily in alpine areas of the Park Road corridor. Most of these collections are housed at DENA and ALA.

Dr. Olav Gjaerevoll, the eminent Norwegian botanist, made a few collections in Mt. McKinley National Park in both 1953 and 1959. The results of this work, including a species new to the Park, are described in the scientific literature (Gjaerevoll 1953, 1958, 1963 and 1967; Persson and Gjaerevoll 1957).

Dr. Duis Bollinger apparently made collections of plant specimens for Oregon State University Herbarium and the Natural History Museum from June 30 through August 31st.

Adolph and Louise Murie made collections for a project entitled "The Common Flora of Mount McKinley National Park" during 1953 (and many subsequent years, as previously mentioned). Louise Murie eventually produced a manuscript of a McKinley Park Flora - an annotated list of the common plants of the Park Road corridor (Murie 1975) which was, however, never published.
Elton Thayer, a park ranger, also made some collections for addition to DENA in 1953 and 1954.

1954 – Gertrude M. Frohne of Alaska Pacific University made a collection of at least 155 specimens in the Denali vicinity (of which 69 were in the Park proper). This collection was deposited at Alaska Methodist University. Many of these specimens are now housed at ALA.

Park collection permit records also indicate that a Stanley G. Smith made collections in the Park for a study of edible plants of Alaska.

1955 - Mary C. Anderson, of the Anchorage Botanical Society, made a collection of plants during 14 days in July, in order to "obtain material for publication". The results of her work and disposition of specimens for this project are not known.

1956 – There was a considerable amount of new activity related to the botany and vegetation of Mt. McKinley National Park in 1956. Les Viereck made extensive plant collections in the Park, particularly in the region of the Muldrow Glacier and other glacier termini as part of the preliminary reconnaissance work for his Ph.D. research (Viereck 1962). This collection included 526 specimens and the specimens are housed at ALA and DENA.

George Argus, author of The Genus Salix in Alaska and the Yukon (Argus 1973), made numerous collections in interior Alaska in 1956. There are 75 of these herbarium specimens from the Denali vicinity (58 from the Park proper), all of which are housed at ALA. (Note: in July of 2001, we were fortunate to have Dr. Argus return to Denali for a collecting trip in the alpine zone south of the Alaska Range crest under the auspices of the current inventory effort).

Also in 1956, Park permit records show that Philip H. Pope of Whitman College in Walla Walla, Washington; Jean Langenheim of the University of California, Berkeley; Donald McBeth of Ohio University and the N.Y. Botanical Garden; Haukur Jorundsson of the College of Agriculture at Borgafjordar, Iceland; and R. Maurice Myers of West Illinois State College all obtained collecting permits for various studies of the subarctic flora of Mt. McKinley National Park.

1957 – Dr. Fred Dean, professor of wildlife at the University of Alaska Fairbanks (U. A. F.), began his long tenure working in Mt. McKinley National Park in 1957. During the summer, Dean made plant and animal collections in the Yanert Fork and in the vicinity of the Toklat River as part of his mammal studies. In subsequent years, Dr. Dean also made plant collections in 1958 and 1980, and supervised the first landcover map prepared using remotely-sensed data for the Park in the 1980's.

1958 – Les Viereck performed extensive botanical fieldwork focused on a chronosequence of outwash terraces at the base of the Muldrow Glacier, during which he made numerous collections of both vascular plants and mosses and lichens (Viereck 1962).

1959 – Celia Hunter and Anore Bucknell, two founders of Camp Denali in Kantishna, made a plant collection of more than 81 specimens in the area; 14 specimens were collected near Minchumina west of the Park and 67 specimens were collected in what is now the Park, primarily in the Kantishna Hills. These specimens are deposited at DENA.

Louis Schene made a collection of more than 100 specimens in the Park, primarily from alpine localities along the Park Road, such as Cathedral Mountain, Sable Pass and Igloo Mountain. These specimens are housed at DENA. Ernest H. Renzel of the Dudley Herbarium of Stanford University collected plants in the Park during the period between June 30th and September 15th in order to assemble a representative collection from this region. Dr. Edward F. Webb from the Chicago Museum of Natural History collected plants and insects for classification on June 20, 1959. Lyman Benson of Pomona College also received a permit to collect plants in the Park during the summer of 1959.

1960 – Dr. Albert Johnson (ALA) made a few collections of vascular plants which are housed at ALA and DENA. Dr. James G. Dickson from the Palmer Experiment Station made collections in the Park from August 10 to September 15th for a study of subarctic grasses (including collections of seeds from sheep range near Polychrome Pass).

1961 – Dr. Les Viereck made a large collection of plants in the upper Tonzona River drainage just west of Mystic Pass, outside of the present Park boundary. These collections include numerous quite significant specimens that document range extensions and rare taxa for this region, including the only specimen of the very rare endemic *Smelowskia pyriformis* known from the vicinity of Denali National Park and Preserve; this plant collection is housed at ALA.

Napier Shelton, graduate student from Duke University, made several collections of alpine plants at Cathedral Mountain for study of vegetation patterns related to slope and aspect.

Elbert Little, of U.S. Forest Service Herbarium in Washington D.C., made collections of tree and shrub species for a prospective update of his Pocket Guide to Alaska Trees (Taylor and Little 1950). The work performed in the Park for this project also informed the later, more substantial work entitled Alaska Trees and Shrubs (Viereck and Little 1972).

1962 – Les Viereck made a large collection north of the Park in the Dry Creek drainage of the Alaska Range near Healy; specimens from this collection are housed at ALA. Robert A. Richey, a student at the U. A. F., made a collection of nearly 100 specimens in the Park in order to fulfill the requirements for college systematic botany course. Richey's specimens are housed at ALA.

Maxine Williams of the Juneau Botanical Club made collections for the club herbarium. Duplicate specimens from this collection were sent to Eric Hultén in Stockholm. J.P. Anderson also received a collection permit in support of his preparation of his Flora of Alaska and Adjacent Parts of Canada (Anderson 1959).

Charles Travers, from the University of Idaho received a permit to obtain vascular plant specimens for the University of Idaho Herbarium.

1963 – Richard H. Russell from the Herbarium of the University of British Columbia made a collection of at least 150 specimens in the Park.

W.D. Billings, Duke University, obtained a permit to collect plants for research on the distribution of arctic-alpine vascular plant species.

1964 – Eric Hultén, preeminent botanist of the North from Sweden, and author of Flora of Alaska and Neighboring Territories (Hultén 1968), among other volumes, collected plants in the Park under a permit from the N.P.S. Hultén had help in this work from Adolph Murie, who remembered the marathon plant-pressing sessions with Hultén fondly in a letter to Henry Warren, Park Naturalist, in 1974 (Murie 1974). We currently have information for only nine specimens from this collection, which are duplicate specimens that are housed at ALA. The bulk of Hultén's collection is housed in the Herbarium at Stockholm, along with most of his other extensive Alaska collections.

Also in 1964, Les Viereck revisited sites near the Muldrow Glacier and made some more vascular plant collections.

Stanley Welsh, then of the Iowa State University, collected specimens in Denali National Park and Preserve in support of his work on Anderson's Flora of Alaska (Welsh 1974).

1965 – Adolph and Louise Murie continued plant collection activities for the preparation of a manual of common plants of Mt. McKinley National Park. Dr. Stanley Welsh, from Iowa State University, collected plants in the Park during late July for the preparation of his revision of Anderson's Flora of Alaska (Welsh 1974).

Maxcine Williams again obtained a permit to collect plants in Mt. McKinley National Park for the Herbarium of Oregon State University and the Anderson collection at Iowa State University.

1967 – Les Viereck made collections of shrub species in the Park in preparation of Alaska Trees and Shrubs (Viereck and Little 1972).

John P. Bryant made collections for Colorado State University Herbarium and DENA for preparation of Park species list and alpine plant community classification.

Fred J. Herman of the U.S. Forest Service collected plant specimens for taxonomic studies in the genus *Carex.*

Herbert K. Kobayashi collected plant specimens for developing comparisons between tundra areas of Hawaii and Alaska. (Note: These are perhaps specimens that have resulted in the peculiar assignation of the name *Huperzia haleakalae* to Alaskan specimens from the group *Huperzia selago*?)

1968 – S. Jones made collection of more than 50 specimens in the Park, including localities in road corridor area and in the vicinity of Windy Pass. Specimens are housed at DENA and ALA. William C. Frohne of Alaska Methodist University also collected a handful of plant and insect specimens for scientific study.

Maxcine Williams was back in McKinley Park. She made plant collections for Brigham Young University (where Stanley Welsh, for whom she collected, moved upon finishing at Iowa State University).

1975 – Dave Densmore, who was associated with Dr. Les Viereck at the Institute of Northern Forestry in Fairbanks, made some plant collections in the Park in support of a project that re-examined the successional vegetation stands on the Muldrow Glacier studied by Dr. Viereck during his Ph.D. research (Viereck 1962).

1976 – Deborah Heebner, a graduate student of Dr. Fred Dean at U.A.F., collected specimens as part of plant community classification and remotely-sensed vegetation map of the Park; 44 specimens from this work are housed at ALA and DENA. Bud Rice, N.P.S. employee, collected almost 50 specimens in the Park during 1976 and 1977, which are also housed at DENA. This project was the first comprehensive map of the vegetation patterns prepared for the Park (Heebner 1982).

1977 – Steve Carwile, an N.P.S employee in various capacities over the years (presently Compliance Officer for the Park), made numerous plant collections in alpine areas of the Park during the period 1977-1987. His collection localities included the upper Toklat River drainage and the Kantishna Hills. Some of these collections were made as part of a study of high alpine plants in the Park. The collections document several significant localities for plant taxa, including the surprising *Rhododendron camtschaticum* locality in the Kantishna Hills, 500 km distant from its primarily coastal range.

1979 – Gretchen Pederson made plant collections in the Park for the development of the herbarium of Camp Denali in Kantishna. Numerous collections by various individuals over the years have contributed to the Camp Denali herbarium, a source of information about the local flora for visitors and guests at the camp.

1980 –An important collection of vascular plants consisting of 172 specimens, (albeit outside of the Park boundary), was made by Dr. Vladimir Siplivinsky in the area of Kroto Lake on the Petersville Road. This collection is housed at ALA, and provided a strong indication of the potential elements of the flora that would be expected to occur within the Park south of the Alaska Range crest. Dr. Siplivinsky was a Russian ex-patriot, trained at the Academy in Leningrad, but in trouble with the K.G.B., who became an itinerant botanist in North America, working in Colorado with Dr. William Weber and in New York.

1981 - Ms. Alix Wennekens and Bjartmar Sveinbjornsson (University of Alaska, Anchorage) received a permit to make a plant collection for the Herbarium of the University of Alaska at Anchorage. Carl Sharsmith also collected specimens in the Park for deposit in the herbarium of the San Jose State University.

1983 – The eminent botanist from the University of California, G. Ledyard Stebbins, made a plant collection in the Park for a study whose aim was to compare the differences of the floras of unglaciated, glaciated and marginal regions. Dr. Jack Major was co-Principal Investigator on the project, according to the collection permit.

1984 – 1992 - Carolyn Parker, a University of Alaska graduate student and later a prolific botanical collector as a research associate at ALA, made collections of vascular plants in the

Park in the years 1984, 1985, 1990, 1991, and 1992. Her collections in the Denali National Park and Preserve vicinity during this period totaled almost 140 specimens, 96 of which were in the Park. Primary collection localities included alpine screes in the Park Road corridor, and the Kantishna Hills. These specimens are housed at ALA. A specimen from this collection was referenced in the naming of *Botrychium alaskense*, a newly named species of moonwort (Wagner and Grant 2002).

Joan Foote, a researcher with the Institute of Northern Forestry in Fairbanks, collected plants in Denali National Park and Preserve during her studies of vegetation succession in 1984 and 1985, including 109 specimens from the area, of which 78 specimens were made within the boundaries of the Park itself. Foote's collection localities included a site near the Foraker River in the large area of lowlands north of the Alaska Range and west of Kantishna, where very few collections had been made.

1997-2002 – Soils Map and Ecological Site Inventory of Denali performed by Mark Clark and Mike Duffy of the Natural Resources Conservation Service (Clark and Duffy 2004). This was perhaps the most intensive single field investigation focused on soil and vegetation that has occurred in Denali to date. Sites all across the Park and Preserve were surveyed and described. Plant species lists were prepared for each site and entered into a Microsoft Access database. This project represented a major contribution to our knowledge of the vegetation patterns in the Park. For each of the years during the period 1999 through 2002, Mike Duffy made large plant collections, which added a great deal to the floristic data for the Park.

1998-2001 – Floristic inventory of Denali National Park and Preserve (the project described herein). This study focused on compiling a complete, voucher-based vascular plant flora for Denali National Park and Preserve in its entirety. We compiled all available floristic information and performed targeted field inventories aimed at documenting the flora of Denali. More than 3,900 specimens were collected from 197 sites across Denali.

2000 – An exotic plant species assessment was performed and collections were made documenting the presence of 18 exotic plant species in Denali National Park and Preserve (Densmore, McKee and Roland 2001). Field work was performed in the road corridor area to assess the composition of the exotic plant flora of the Park Road corridor.

We have assembled a database containing electronic specimen data for 5,161 separate specimens in Denali National Park and Preserve and areas within the four U.S.G.S. Quadrangles surrounding it. Using either specific coordinate data or locality statements, I attributed 3,455 of these specimens to a floristic region of origin within the Park, based on where the collection was made. The table below shows the most prolific plant collectors in the Denali National Park and Preserve vicinity as reflected in this database. There are certainly a few collections missing from this list, including a few quite important ones, such as Eric Hultén's, Stanley Welsh's and perhaps others. This is evident because we only have a handful of electronic records of these men's collections, both of whom likely collected numerous specimens. Given the large amount of collecting effort that has occurred in the same geographic areas that these collections were made, however, it is unlikely that a large number of taxa would be added to the Park flora, even if we had access to these additional specimen records.

Table 3.1 A chronological list of the significant vascular plant collections for Denali National Park and Preserve for which we have electronic specimen records.

Collectors	# of records	# in Park	Principal years of collection	Principal Localities
L.F. Palmer	106	4	1926, 1927	Cantwell, McKinley Park
Ynez Mexia	109	109	1928	Park Road area, upper Savage R.
J.P. Anderson	59	0	1931, 1939	Healy, Lignite, Talkeetna
Aven and Ruth Nelson	930	797	1939	Alpine areas of Park Road, and Park HQ area
Adolph and Louise Murie	350	349	1939, 1940-50's	Throughout accessible portions of Mt. McKinley National Park.
Harold and Virginia Bailey	539	539	1950	Throughout Park Road corridor, vicinity of Curry on Susitna R.
Galen Smith	67	49	1953, 1954	Alpine areas of Park Road
G.M. Frohne	115	69	1954	Cantwell, Park Road corridor
Leslie Viereck	1130	566	1956, 1957, 1958, 1961, 1962, 1964, 1967, 1969, 1971, 1972, 1974, 1981	Muldrow Glacier, Mt. Eielson, Tonzona Valley, Windy Creek, McKinley Bar
George Argus	75	58	1956, 1989 (outside park)	Park Road corridor, Denali Highway
Fred Dean	63	25	1957, 1958, 1980	Yanert Fork, vicinity of Toklat and East Fork Toklat
Anore Bucknell & Celia Hunter	81	67	1959	Kantishna Hills and vicinity, Minchumina
Louis Schene	107	107	1959	Park Road – Cathedral Mountain, Sable, Igloo
R. Richey	98	98	1962, 1963	Park Road corridor, Thorofare, Eielson, out west mostly
Eric Hultén	10	10	1964	Park Road corridor
Joan Foote	109	78	1967, 1972, 1976, 1977, 1982, 1984, 1985	Lowlands including Foraker R., Kantishna Hills, Susitna R.
Steve Jones	51	51	1968	Alpine – Windy Cr., Refuge Valley, Sable, Igloo, Toklat
Carolyn Parker	136	96	1984, 1985, 1990, 1991, 1992	Alpine areas on Park Road corridor, Kantishna Hills
Steve Carwile	99	99	1977, 1979, 1980, 1986, 1987	Alpine areas, particularly in upper Toklat R. and Kantishna Hills
Deborah Heebner	44	44	1976	North side of Alaska Range, and areas in vicinity of Windy Cr.
Bud Rice	64	46	1976, 1977	Park road area, windy, HQ, Petersville Rd.
V. Siplivinsky	172	0	1980	Kroto Lake – Petersville Road
Roland et al.	3,904	3,904	1998 - 2001	Park-wide
M. Duffy	~ 1,200	~ 1,200	1999 - 2002	Park-wide
R. Densmore and C. McKee	32	32	2000	Exotic species along the Park Road

Chapter 4 Methods

This inventory was a targeted reconnaissance survey of the vascular plant flora of Denali. The primary objective of this study was to obtain a complete, voucher-based flora for the entire 2.45 million ha extent of the Park. The size of the study area, in combination with strict budget constraints, meant that a premium was put on efficient site selection for this project (relative to acquiring new records of plant species for Denali). Thus to meet the goals for this project, I needed to carefully allocate field work in order to maximize the number of new taxa collected for each day spent in the field. These factors also meant that I needed to rely on existing information to the maximum extent possible, in developing the plan for this project.

In this chapter, I describe how this project was accomplished. The methods that were used may be separated into four general categories:

- Methods for the preparatory steps leading up to field work
- Field methods and personnel
- Herbarium, specimen curation and data management procedures
- Analytical methods – interpreting and utilizing the field data

The preparatory methods included developing a verified list of taxa already known to occur in the Park, creating a floristic database to evaluate these data, the development of an "expected' species list for the area, completing a set of gap analyses to identify where existing information was weakest, and finally, making targeted site selections for fieldwork. The field methods included what activities were performed in the field during the inventory and the personnel who accomplished this work. Herbarium and curation procedures consisted of how the specimens were handled and determinations made, and the process for mounting and storage of the specimens. The analytical methods included how the floristic regions of Denali were delineated, GIS methods for analyzing the biophysical properties of these floristic regions, and the process for defining range extensions for vascular plant taxa collected during this study.

A. Development of a vouchered vascular flora for Denali National Park and Preserve

The starting point for this project was the development of a *bona fide* vouchered vascular plant species list for the Park. This task was performed during 1996-7 by Joe Van Horn and Dr. John Kartesz who assembled and verified (along with help from Alan Batten and Carolyn Parker from the University of Alaska Museum Herbarium) specimens from the principal herbaria containing specimens collected from Denali National Park and Preserve. They compiled this information to produce a specimen-based database that documented the Park plant list using a standardized nomenclature (the same nomenclature accepted in USDA's PLANTS database). Dr. Kartesz then integrated this information into the very useful Synthesis of the North American Flora computer software program (Kartesz and Meecham 1999). In addition, Denali National Park and Preserve resource staff (Joe Van Horn and Jon Paynter) produced a georeferenced database of the collection localities documented within the Park, which made possible an initial examination of the distribution of plant collecting effort in the Park.

B. Database system for tracking and analyzing floristic data in Denali National Park and Preserve

The specimen-based database files that were created by Van Horn and Kartesz were integrated into a database system for floristic data that was created for a vascular plant inventory of Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002). This system is composed of three interrelated databases:

1. Taxon database – each record of this database is an individual plant taxon with fields that contain information on the conservation status and taxonomic, anatomical, and biogeographic attributes of each taxon.

2. Site database – each record of this database represents a locality where plant occurrence data have been collected. Fields in this database describe this locality, including coordinate data and related precision information, elevation and other physical attributes, the amount and type of work done at the site, ecoregion attributes, and significant floristic information recorded there. A ”site” in this context is not a fixed size because of the variability in how locality data have been recorded over time. A site may represent a very specific collection locality (with associated latitude and longitude coordinates). A site may also be a more general area, such as “Primrose Ridge, Denali National Park”. Thus the general term “site” is used for an area where plant collections are made, from the scale of a single small wetland to a particular valley that was traversed during the course of a day’s inventory work. Because the particular spot where a specimen is collected represents only one of the many places that the species may occur in an area, this level of precision associated with an inventory site is generally adequate and appropriate for this scale of inquiry.

3. Specimen database – each record of this database represents an individual plant specimen that was collected at a particular site (thus this database relates fields of the taxon database with the site database, using a unique collection number). This database contains information about the specific habitat and location of the plant population from which the collection was made. In addition, this database contains a set of fields for curation information for each specimen (such as collector name, collection number, and accession and catalog numbers). This database also reflects a specimen’s determination history (who initially identified it and any changes to its identification over the years).

During 1998, the first year of this project, numerous new taxa were added to the taxon database to reflect species that occur in Denali National Park and Preserve. In addition, the specimen database was populated for Denali National Park and Preserve using the available electronic specimen records from ALA and the work of Van Horn and Kartesz. Specimen records from neighboring areas outside of the Park were also acquired from ALA in order to help identify a list of species that would likely occur in the Park, even if they had not yet been collected there, (i.e., an “expected” plant species list).

C. Preparation of an expected species list for Denali National Park and Preserve; Gap analyses

I created an ‘expected" species list for Denali National Park and Preserve that consisted of vascular plant taxa that could reasonably be expected to occur in the Park, but were as yet not documented by vouchers within the Park boundary. I used two primary lines of evidence to create this list of taxa: 1) specimen information from the Northern Plant Documentation Center database (ALA) of specimens; and 2) published distribution maps from various sources including Hultén 1968 and Cody 1996, among others. Thus plant taxa were added to the expected species list using two criteria. First, if a taxon had been collected on any of the five USGS 1:250,000 quadrangles that surround or intersect the Park boundary (according to *bona fide* ALA collection localities) it was added to the expected list because it was known from the geographic vicinity of the Park. Secondly, if a species geographic and ecological range suggested that it might possibly occur in the Park, it was also added to the list. The idea was to create as complete as possible a watch list for vascular plant species for the Park. This list would then be used to maximize the efficiency in targeting of field work. The expected list also provided a comprehensive list of taxa that should be collected, if encountered within the Park, which was distributed to scientists and field staff to assist in the accumulation of vouchers for these taxa.

1. Taxonomic and habitat gap analyses

The list of expected species for Denali that was generated included 409 vascular plant taxa. These taxa were entered into a database, whereupon their habitat preferences and geographic range characteristics were attributed into a set of habitat preference fields. The set of fields that were used to store these data included: site moisture preferences (aquatic, hygric, mesic, xeric), likely landscape position of occurrence (alpine, subalpine, upland, lowland), and geographic region of the Park in which the species would be expected to occur (south side of Alaska Range, northeastern region north of the Alaska Range crest, and northwestern region north of the crest). In addition, the expected species database contained information on the growth form and other attributes of each taxon. Thus the “expected” species list, with attributed habitat and geographic preferences, constituted a fourth cluster of records in the database system (forming a subset of the records in the taxon database).

I queried this database in order to identify patterns and obvious gaps represented by the set of species expected to occur, but not yet documented, in the Park. Briefly, the results of these analyses showed that lowlands areas, particularly wetlands and aquatic habitats across the Park, contributed a large number of species to this list. In addition, species that would be expected to occur in areas south of the Alaska Range crest, (including in the alpine zone in this region), also represented a large fraction of the expected species list. Although these analyses helped to identify the highest priority areas, they also showed that there was a distinct need for a broad spectrum inventory approach across the Park because there were numerous taxa in all of the habitat and landscape categories investigated indicating that much remained to be learned about the flora even in relatively well-studied regions of the Park.

Additionally, the taxonomic gap analyses indicated the expected list was relatively high in numbers of graminoids and lower-vascular plants (such as ferns and fern-allies) as compared to other types of plants (trees, shrubs, forbs). These percentages reflected a potential bias toward the collection of more “apparent” taxa in previous plant collecting work within the Park, and thus the need to collect even in habitats already well-collected within the Park. This perception was borne out during the first year of this inventory when a tiny native species of *Draba* that was new to the Park flora was collected just below the Polychrome Pass rest stop on the Park Road, where many thousands of people stop each summer.

2. Geographic gap analysis

The distribution of existing collection localities was examined in the Park GIS using Arcview software. This simple analysis clearly demonstrated that more than 95 percent of the actual collections in the Park were from the immediate vicinity of the Denali Park Road corridor. Only a very few widely-scattered collections were located outside of this zone. As a result, major floristic regions of the Park, such as areas south of the Alaska Range crest, the vast lowlands north of the range, the Kantishna Hills and other satellite outer ranges of hills north of the Stampede Trail, and the region of the Alaska Range proper west of McKinley River, were very poorly represented in past plant collection efforts within the Park.

D. Study site selection

General focus areas for this study were identified using the gap analyses outlined above. The overall objective, however, was to intensively survey a set of sites that provided plant occurrence data across the entire spectrum of vegetation types, landscape positions, site moisture characteristics, lithologies, and edaphic conditions that occur in Denali National Park and Preserve. Therefore, potential sites were identified prior to field work using aerial photos, bedrock geology maps, and topographic maps of the Park landscape. Prospective sites were identified that allowed us to visit the greatest cross-section of different kinds of plant habitat areas in the shortest period of time. We then chose specific survey sites in the field following aerial reconnaissance of the selected areas. We also took advantage of opportunistic chances to survey new areas in a cost-effective manner. For example, Floristic Inventory botanists accompanied the Soils Inventory crew on numerous occasions when their survey sites were located in high priority areas of the Park that were logistically challenging and expensive to visit separately.

E. Field methods and collections

The primary unit of data resulting from this work is the voucher specimen, which records the occurrence of a particular taxon at a specific place and time with a physical record. The great advantage of this record compared to other forms of occurrence data is that it stands the test of time and changing concepts of plant nomenclature and taxonomy. New names can be attributed to a specimen, as taxonomy changes, which is not the case with a simple species list in the absence of a voucher. Thus the primary emphasis of field work for this study was on the collection of well-documented, representative voucher specimens.

A comprehensive floristic reconnaissance of each survey site was completed. The objective of the reconnaissance was to survey the range of communities and habitats available within the time allocated for the site, starting with the highest priority areas. Specimens were collected for all noteworthy taxa at each site, including species new to the Park flora, ecological or geographic range extensions, rare or endemic species, species of management concern, or specimens reflecting other noteworthy characteristics such as atypical morphology for the taxon. In instances when sufficient time was available, we made a more exhaustive set of specimens that documented the majority of the vascular taxa resident at the site. In addition, we made complete lists of the plant species observed at each site. We also recorded the amount of time spent performing actual surveys there.

Specimens were pressed in the field and allowed to dry. They were removed from presses upon drying and transferred to ALA, where they passed through a -50° C fumigation freezer to kill any potential pests. Determination work occurred in the University of Alaska Herbarium, where botanists had access to a large collection of carefully determined specimens for comparative purposes.

F. Field personnel

The following people were instrumental in the success of this project by performing substantial work in the field under a variety of conditions, and making numerous important collections:

Alan Batten, Collections Manager for ALA, participated in field work each year of the project 1998-2001. Alan also reviewed specimens, provided electronic data, and helped with curation and specimen transfer among institutions.
Carolyn Parker, Research Assistant for ALA, participated in field work on the project in 1998-9. Carolyn also reviewed hundreds of determinations each year and facilitated additional expert reviews.
Amy Larsen, Botanist for Central Alaska vascular plant inventory project in 2001, made large collection in sites across the Park.
Mary Beth Cook, Botanist for Wrangell-St. Elias NP, participated in field work in 1998, and in 2001, collaborated in the development of the database system that formed the basis for the one used for this project.

In addition the following individuals provided valuable assistance on one or more individual plant collecting trips:

George Argus, eminent botanist and monographer of genus *Salix*, collected willows
Jean Balay, Revegetation Technician, Denali National Park and Preserve
Andrea Blakesley, Environmental Quality Specialist, Denali National Park and Preserve
Jedediah Brodie, Biological Technician, Denali National Park and Preserve
Shan Burson, Ecologist, Denali National Park and Preserve
Steve Carwile, Compliance Officer, Denali National Park and Preserve
Cedar Drake, Biological Technician, Denali National Park and Preserve
Mike Duffy, Plant Ecologist, USDA Natural Resource Conservation Service
Sara Goeking, Biological Technician, Denali National Park and Preserve

Wendy Mahovlic, Revegetation Technician, Denali National Park and Preserve
James Walton, Biological Technician, Denali National Park and Preserve

G. Herbarium methods and review of specimens

Specimens were initially identified by principal N.P.S. project botanists (Carl Roland, Amy Larsen, and Mary Beth Cook). Specimens were then further reviewed by staff at ALA including Carolyn Parker and Alan Batten. Problematic specimens, or particularly difficult taxa, were sent to specialists in particular genera for determination, including George Argus (*Salix*), David Murray (*Cyperaceae*), Robert Soreng (*Poa*), Donald Farrar and Mary Stensvold (*Botrychium*), and John L. Strother (*Bidens*).

H. Data storage and management: curation of specimens – storage, mounting and housing

Collection and site data were entered into the database for the project that is described above. Accession and catalog numbers were assigned to each specimen and labels were printed on archival paper. Specimens were then mounted onto archival herbarium paper by staff at ALA. Specimens are housed both at the Park Herbarium in Denali National Park and Preserve (DENA), and at ALA in Fairbanks, Alaska.

I. Delineation of floristic regions of Denali National Park and Preserve

The boundary of Denali National Park and Preserve was imposed on the natural landscape through a set of economic and political negotiations. These boundaries were not created along natural "fault lines" in the biogeography of the area. Because of this fact, it makes little biological sense to analyze the flora of the Park as a whole for anything other than summary purposes. Consequently in order to facilitate understanding of plant distribution patterns within the Park, I have divided the Park up into nine separate floristic regions by grouping together areas with relatively similar ecological and floristic attributes (Figure 4.1). The basis for this delineation was the very valuable Soils Inventory map and database provided to me by Mark Clark, N.R.C.S. soils scientist (Clark and Duffy 2004). I used the ecological subsection, life zone, and landform data layers in order to construct a set of floristic region boundaries encompassing the entire Park and Preserve. The nine floristic regions of Denali National Park and Preserve that were defined, and the ecological subsections that were merged to form them are shown in Table 4.1.

The floristic regions represent a hierarchical grouping of nine individual floristic regions among four very general categories that represent a condensation of the "life zone" values in the Soils Inventory database. These general categories of floristic regions are: 1) interior boreal, 2) interior alpine, 3) southcentral boreal, and 4) southcentral alpine. Floristic regions were defined through a process of assigning each of the individual soil units delineated within the Park a single value in a new field called "floristic region". This process primarily consisted of condensing sets of ecological subsections into a smaller set of floristic regions. In addition to this simple process of

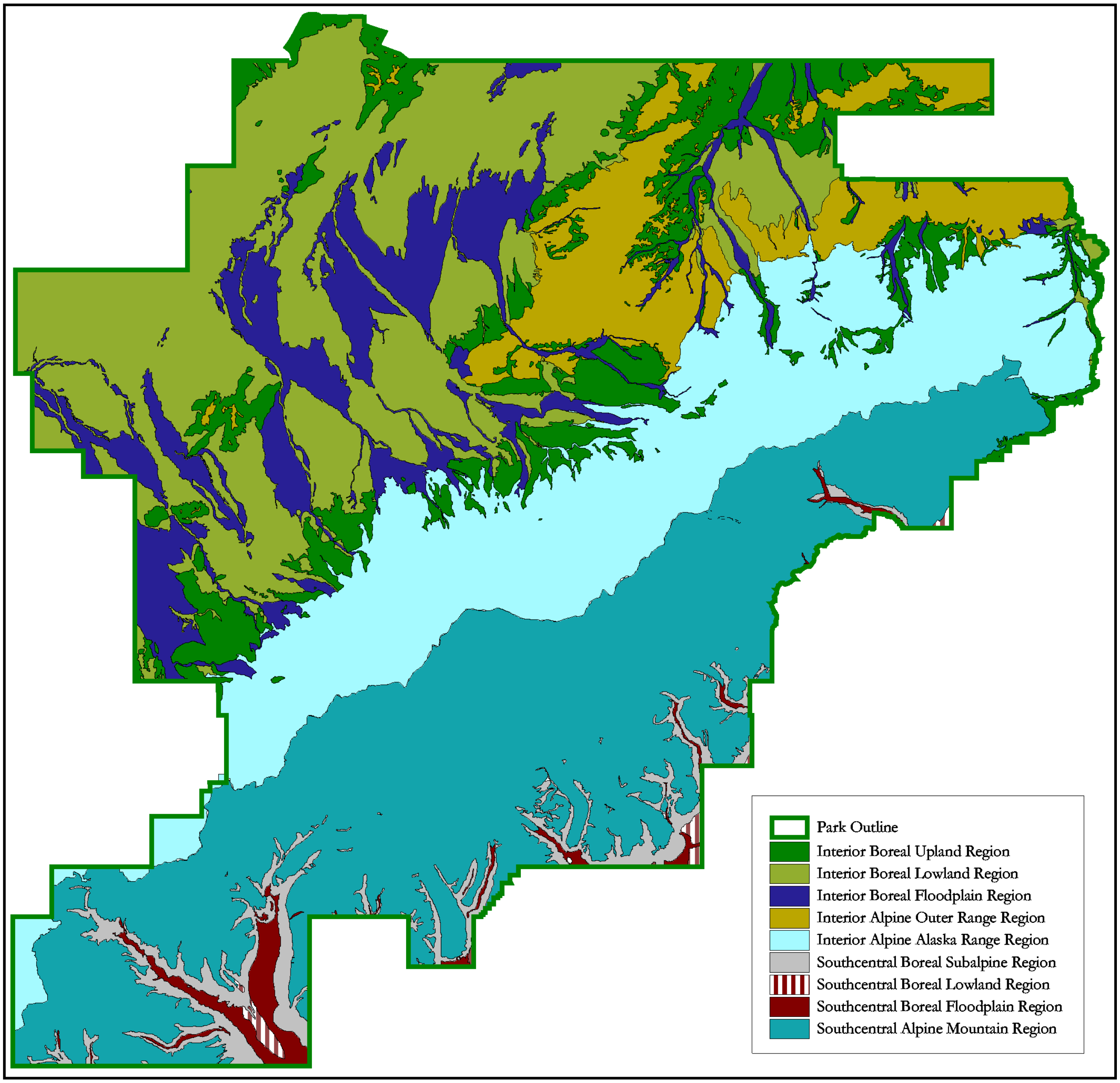


Figure 4.1 Map showing the nine floristic regions that were identified for Denali National Park and Preserve, 1998-2001 (Mercator Projection, NAD 1927).

Table 4.1: The nine floristic regions of Denali National Park and Preserve, and the sets of ecological region subsections that were merged to form these regions:

Interior Boreal Floristic Regions:
Interior Boreal Floodplain and Alluvial Fan Region
Yukon-Kuskokwim Bottomlands-Lowland Flood Plains & Terraces
Alaska Range-Interior Lowland Flood Plains & Terraces & Fans
Interior Boreal Lowland Floristic Region
Yukon-Kuskokwim Bottomlands-Eolian Lowlands
Yukon-Kuskokwim Bottomlands-Minchumina Basin Lowlands
Alaska Range-Interior Glaciated Lowlands
Alaska Range-Toklat Basin Lowlands
Interior Boreal Upland Floristic Region
Kuskokwim Mountains-Boreal Low Mountains
Alaska Range-Interior Glaciated Uplands
Alaska Range-Boreal Outer Range & Kantishna Hills
Alaska Range-Interior Boreal Mountains
Alaska Range-Teklanika Boreal Mountains & Plateaus
Interior Alpine Floristic Regions:
Interior Alpine Outer Range Region
Kuskokwim Mountains-Alpine Low Mountains
Alaska Range-Alpine Outer Range & Kantishna Hills
Alaska Range-Teklanika Alpine Mountains & Plateaus
Alaska Range-Interior Alpine Flood Plains & Terraces & Fans (in part)
Interior Alpine Alaska Range Region
Alaska Range-Interior Nonvegetated Alpine Mountains
Alaska Range-Interior Alpine Mountains
Alaska Range-Interior Alpine Flood Plains & Terraces & Fans (in part)
Southcentral Boreal Floristic Regions:
Southcentral Boreal Floodplain and Alluvial Fan Region
Cook Inlet Lowlands-Lowland Flood Plains & Terraces & Fans
Southcentral Boreal Lowland Region
Cook Inlet Lowlands-Glaciated Lowlands
Southcentral Boreal Subalpine Region
Alaska Range-Southcentral Boreal & Subalpine Mountains
Southcentral Alpine Floristic Regions:
Southcentral Alpine Mountain Region
Alaska Range-Southcentral Nonvegetated Alpine Mountains
Alaska Range-Southcentral Alpine Mountains

merging subsections, however, there were three additional primary changes that were made to the soils inventory delineations, based on my judgment:

1. I changed the original "life zone" assignment for all of the polygons from "interior alpine" to "southcentral alpine" in two small regions of the Park:
    a. I reclassified all areas south of the Alaska Range crest and southwest of the main fork of Windy Creek near Cantwell as "southcentral" as opposed to "interior", and
    b. I similarly reclassified all areas south of the Alaska Range crest and in the drainage basin of the Yentna River (which flows into Cook Inlet) as "southcentral" as opposed to "interior"

2. I parsed individual polygons within the "Interior Alpine Floodplains and Terraces and Fans" subsection into either the "Interior Alpine Outer Range" or "Interior Alpine Alaska Range" depending on their geographic location:

3. Finally, I eliminated "water" as a distinct unit by subsuming all of the polygons identified as "water" into the floristic region delineation that surrounded them. For example, the myriad of lowland subarctic ponds in the Minchumina Basin were generally subsumed into the "Interior Boreal Lowlands" thus eliminating "water" as a separate life zone within those lowlands.

J. Assignment of all existing specimens (pre-1998) to floristic regions

Once the delineation of the floristic regions for Denali National Park and Preserve was completed in winter 2003, all current and preexisting specimens for which electronic records were available were attributed to a floristic region of origin within the Park, based upon where they were collected. This process made it possible to assess the distribution of past botanical collecting work in each floristic region of the Park. It also allowed me to more fully describe and analyze the distribution of rare and endemic plant taxa among the Park's floristic regions, based upon the large number of plant specimens collected as far back as the 1920's.

The assignment of existing specimens to floristic regions was accomplished in two ways:

1. For those specimens that had georeferenced collection data (latitude/longitude) the locations were imported into the GIS and each specimen was then assigned a floristic region based upon its location (using Arcview 'select by theme' query);

2. for older specimens lacking coordinate-based location data, I used the locality statements from the specimen labels in order to assign each specimen to a floristic region (for example "Mount Eielson" lies completely within the Interior Alpine Alaska Range Floristic Region, so specimens from this locality were assigned to that region based on the label data).

In some cases, point data and specimen label information were not specific enough to warrant a decision as to which region the collection should be attributed to. In the instances where data were not sufficiently clear, no region was assigned, and the specimens were excluded from any analyses. Using this process, I was able to assign a floristic region to 3,269 separate preexisting plant specimens for which electronic data were available. This batch of records includes a majority of the available specimens collected in the Park over the years. All plant collections from the current inventory were also assigned to floristic region of origin, based on precise location data acquired using GPS receivers in the field.

K. GIS analyses of the physical and landcover characteristics of the floristic regions

We used several GIS coverages to analyze and describe the biophysical characteristics of the floristic regions. The goal of these analyses was to examine the available GIS data in order to understand broad-scale similarities and difference in the landscape characteristics among the floristic regions of the Park. We used the following GIS coverages to perform these analyses: 1) 60 meter digital elevation model from the National Elevation Dataset for elevation, slope and aspect analyses; 2) Soils Inventory coverages for permafrost distribution, general potential vegetation types (a coverage provided by Soils Inventory that identifies "the biotic community that would become established if all successional sequences were completed without interferences under the present environmental conditions" (Clark and Duffy 2004)) and lithology (substrate origin); 3) a coverage outlining the perimeter of all fires in the Park over the past 50 years; and 4) the Denali National Park and Preserve Landcover map for satellite-interpreted landcover types.

For the continuous variables of slope angle, aspect, and elevation, the range of values that occur on the Park landscape was divided into discrete categories for purposes of this set of analyses (Table 4.2). The amount of terrain in each of these discrete categories for these topographic attributes was then calculated for each floristic region. These values were then expressed as a percentage of the planimetric area for each floristic region. For categorical variables such as landcover and lithology, the amount of area in each unique category was calculated, and these values were then presented as percentage of the planimetric area encompassed by the different types (such as "closed alder scrub" or "schist bedrock", for example).

Table 4.2. Discrete categories for GIS landcover analysis of floristic regions in Denali National Park and Preserve.

Continuous Variable	Discrete Categories
Slope	0-5, 6-10, 11-15, 16-20, 21-25, 26-30, 31-35, 36-40, 41-45, 46-50, >51
Aspect	North, South, East, West
Elevation	0-200, >200-400,>400-600, >600-800, >800-1000, >1000-1200, >1200-1400, >1400-1600, >1600-1800, >1800-2000, >2000-2200, >2200-2400, >2400-2600, >2600-2800, >2800

Because the topography of the Park is extremely heterogeneous, the amount of *surface area* was also calculated for each of the GIS variables described above. This was done because calculating area in strictly planimetric terms significantly underestimates the extent of certain types of habitats on the Park landscape. Areas of the landscape with steeply sloping terrain are significantly under-represented in calculations based upon planimetric area alone. This is readily observable in the sharp differences between percent of a region for planimetric versus surface area for certain landscape categories. For example, high elevation terrain, which tends to be very steep, occupies a much lower percent of the planimetric area than it does of total surface area for the Alaska Range floristic regions (for an example, see Figure 6.16B). The amount of surface area more accurately describes the amount of actual plant habitat in such an area than does the simple amount of planimetric area.

In order to accomplish the surface area analyses, each floristic region was converted into a Grid data layer in ArcInfo, a Triangular Irregular Network (TIN) of each region was then created using the 60 m DEM, and the TIN was converted into a polygon coverage, thus adding a surface area field in the attribute table in ArcInfo. The amount of surface area in each category of slope, aspect or other variable thus calculated was finally summed for each region, and these values are expressed as percent of the entire surface area of the region in the figures that I prepared for this document (see Figure 6.2 for an example). Thus the graphs simultaneously show the amount of planimetric area and the amount of surface area in any given landscape category. Large differences in percentages for an individual category highlight areas of the landscape where slopes tend to be steeper.

L. Determination of range extensions for plant taxa

I compared plant collections made during this inventory to the published plant distribution literature in order to document any range extensions for plant taxa resulting from Floristic Inventory collections. Range extension distances were measured using digitized locality information (with Arcview GIS software). For purposes of summarizing the results of this project, I defined two categories of range extensions for vascular plant taxa:

1. Major range extension – a new locality was 250 km or more from known, published locations and the taxon is new to the drainage basin where it was discovered. For Denali National Park and Preserve, then, a species had to be new to the Cook Inlet, Kantishna River or Kuskokwim River basins in order to be considered a major range extension;

2. Range extension – a new locality was more than 100 km, but less than 250 km, from existing published localities, or if new locality was more than 250 km, the taxon in question was already known from within the drainage basin where the new collection was made.

The primary reference for published plant distribution information in Alaska is Hultén’s Flora of Alaska and Neighboring Territories (Hultén 1968). This reference is thirty years old, however, so it is important to investigate all other available sources of published range information in order to assess species ranges. Important published collections that are relevant to the Denali National Park and Preserve area include the recent botanical surveys of Fort Richardson near Anchorage and Fort Wainwright near Fairbanks, both of which are published on the worldwide web at (**http://www.uaa.alaska.edu/enri/aknhp_web/biodiversity/akbiodiv.html**). It is also important to use other published distribution information, where possible, including range maps published in genus monographs that cover Alaskan plants. Examples of other references pertinent to Denali National Park and Preserve are Aiken and Darbyshire 1990 (*Festuca*), Bayer 1993 (*Antennaria*), Cook and Roland 2002 (Floristics of Wrangell-St. Elias National Park region) and Kelso 1992 (*Douglasia*). New floras covering areas that are contiguous to, or contain, Alaska such as William Cody's Flora of Yukon Territory (Cody 1996), Vascular Plants of the Continental Northwest Territories (Porsild and Cody 1980) or the available volumes of the Flora of North America (Flora of North America Editorial Committee 1993+) are other critical sources of information for published plant distribution information.

An additional significant source of plant distribution information is the University of Alaska Herbarium (ALA), located in Fairbanks, where the majority of scientific plant collections made in Alaska are deposited. We requested all specimen data for taxa of interest (rare species and range extensions) from ALA's Northern Plant Documentation Center database. Many of these specimens have not been published, however, so whereas these data were used to describe a species distribution and to create new distribution maps, they were not always used for calculation of range extensions.

Chapter 5 Overall Summary of Inventory Results

Vascular plant inventories were conducted at 197 sites spanning the extent of Denali National Park and Preserve during this study (Figure 5.1). I estimate that approximately 1,358 hours of survey time were spent in the field recording plant species occurrences and making voucher collections. Over 4,000 plant specimens were collected as a part of this study, and 3,793 permanent voucher specimens were prepared from these collections. Although this work occurred throughout the Park landscape, the majority of the effort was focused outside of the Park Road corridor, in areas not surveyed by botanists prior to this study. The region of the Park south of the Alaska Range crest and the large lowland regions north of the Alaska Range crest were major foci of this inventory work. Areas in the “outer ranges” of hills and mountains north of the main body of the Alaska Range were also the targets of considerable field effort. Descriptions of the specific results from inventory effort in each of the nine floristic regions of the Park are presented in Chapter 6 of this report. This Chapter provides an overall summary of the results of the project on a Park wide basis.

A. Taxa new to the flora of Alaska

Five taxa that did not appear in the primary references for Alaska’s vascular plant flora (Hultén 1968, Welch 1974) were collected during this inventory: *Bidens tripartita*, *Botrychium alaskaense*, *B. minganense*, *Najas flexilis*, and *Potamogeton obtusifolius*. These taxa were either unknown from Alaska when these works were published (*B. tripartita*, *B. minganense*, *N. flexilis* and *P. obtusifolius*) or had not yet been described in the scientific literature at that time (*B. alaskaense*). A sixth species, the rare wetland umbel *Cicuta bulbifera*, was absent from Welsh (1974), and was cited from a single locality outside of Alaska in eastern Northwest Territory in Hultén (1968). In the intervening years, *C. bulbifera* had been collected in three localities within Alaska. Similarly, *Botrychium alaskaense, B. minganense, Najas flexilis,* and *Potamogeton obtusifolius* had each been collected in a handful of localities within Alaska since these primary works were published. The collection of *Bidens tripartita* made in Denali National Park and Preserve during this study, however, represented the addition of this taxon to the known flora of Alaska.

B. Taxa new to the flora of Denali National Park and Preserve

The set of specimens collected during this inventory documented the occurrence of about 622 separate vascular plant species within the Park (about 83 percent of the 753 species known to occur there). This collection added 224 plant species and 246 separate taxa (including subspecies and varieties) to the vouchered vascular flora of the Park, as compared to the list of taxa known to occur in the Park that was prepared in 1996-7. In addition, this set of taxa represented 52 genera and 14 families of plants unknown in the Park prior to 1998, when this study was begun. A list of the taxa that were added to the Park flora since 1998 is provided in Appendix A of this document.

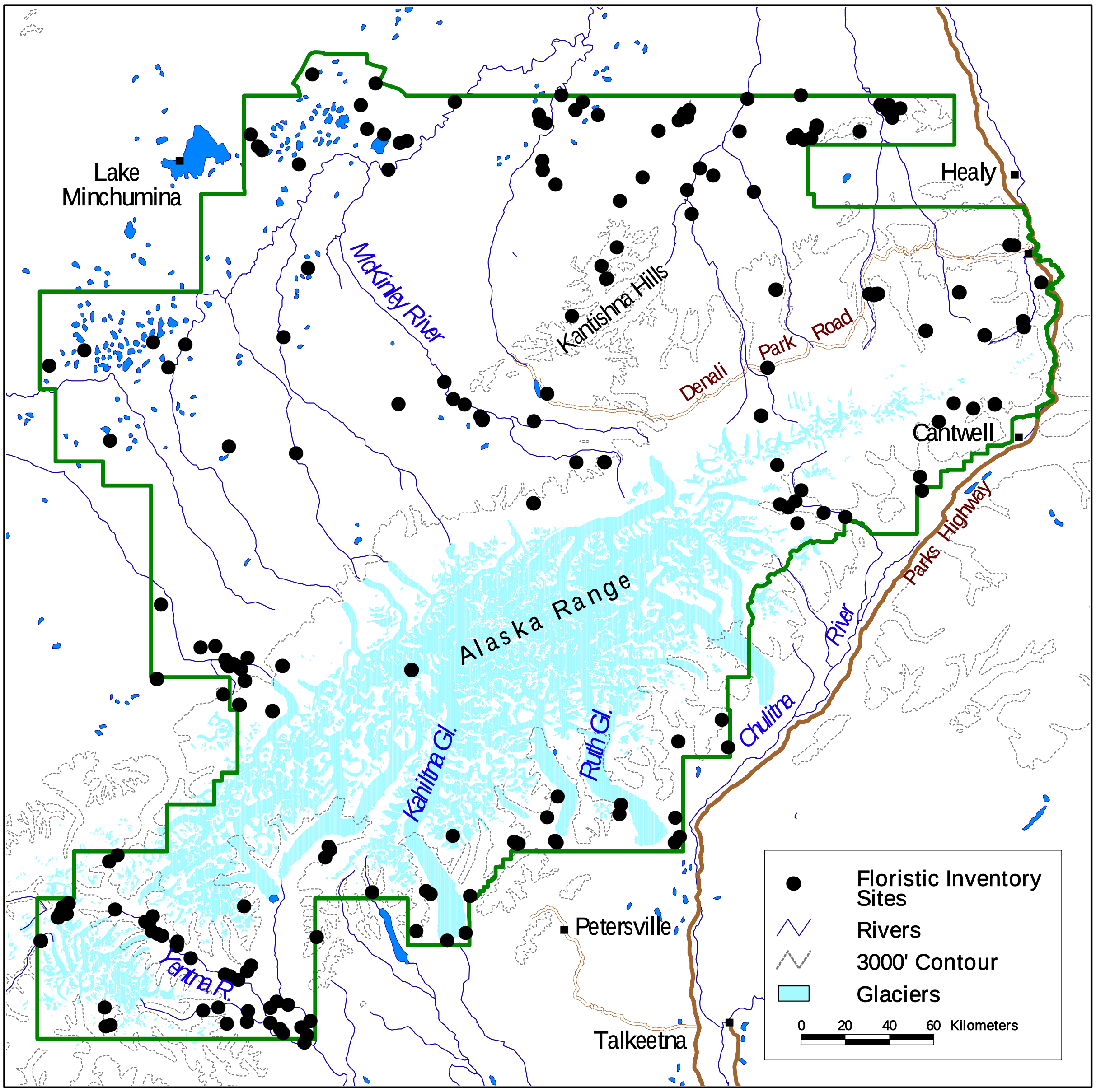


Figure 5.1 Map of Denali National Park and Preserve showing 197 sites surveyed in the Denali Floristic Inventory Project, 1998-2001 (Mercator Projection, NAD 1927).

Among the set of taxa new to the Park and Preserve were a variety of plant species of particular interest from conservation and biogeographic perspectives. These included taxa considered rare at a state and/or global level by the Alaska Natural Heritage Program, Alaska-Yukon endemic species, and Amphiberingian endemic species. A final class of vascular plant taxa presented here includes those taxa for which our collections represented a substantial extension of the known geographic range for the taxon.

C. Annotated list of particularly noteworthy taxa documented during this study

This list of noteworthy collections includes taxa in the following categories: 1) species new to the state from our collections, 2) major range extensions (see Chapter 4 for definition), and 3) species with a state rarity rank of S1 or S2 on the Alaska Natural Heritage Program vascular plant tracking list. An annotated list of these collections follows, in alphabetical order by family: genus: species. I briefly describe the plant's distribution, the reason(s) for the taxon's inclusion on this list of significant collections, and collection data for specimens collected within Denali National Park and Preserve. Each reference to an individual specimen is indicated with a symbol (►). All of the coordinates are in the North American 1927 Datum (NAD27).

Apiaceae:

***Cicuta bulbifera* L., "Bulbous Water-hemlock"**

This is a wetland species known from across boreal North America, with disjunct populations reaching as far south as Florida (Kartesz and Meecham 1999). *C. bulbifera* is considered "critically imperiled" in Alaska by AKNHP with a state-level rarity rank of S1, and is also considered rare in the Yukon Territory by Douglas (Douglas et al. 1981). *C. bulbifera* was not documented for Alaska in Hultén (1968) or Welsh (1974). However, the species was collected at Threemile Lake, at Knik, near Anchorage in 1993 by Verna Pratt (►*Pratt s.n. ALA V0116477*). *C. bulbifera* was also collected in 1995 at three different ponds during an inventory of Ft. Wainwright near Fairbanks (►Fairbanks Quad: Duck Pond #3; 140 m, 64.858°N, 147.600°W, *M. Duffy & J. Tande 95-792, V0120726,* 31 July 1995; ►Fairbanks Quad: beaver pond; 150 m, 64.528°N, 148.019°W, *J. Tande 95-852*, *V0120776,* 31 August 1995; and ►Fairbanks Quad: Salchaket Slough; 130 m, 64.741°N, 147.780°W; *M. Duffy & M. Raynolds 95-871*, *V0120784,* 31 August 1995*)*; all specimens are at ALA.

The collection site in the Yentna River watershed (see Plate 5.1) was approximately 180 km northwest of the Anchorage-area collection made in 1993, and the collection made by Michael Duffy near Chilchukabena Lake extended the range of this species into the western interior from the localities near Fairbanks. Thus populations of this rare umbel occurred in wetlands on both sides of the Alaska Range crest within Denali National Park and Preserve. The habitat in both *C. bulbifera* localities in the Park was wet sedge meadow in boreal pond margins, where it was growing as an emergent. Map 1.

<u>Floristic Inventory collections:</u>

Southcentral Boreal Floodplains:

►Talkeetna Quad: rare in wet sedge meadow around small pond, on W side of East Fork of Yentna R.; 73 m, 62º 18.001'N, 151º 48.113'W, *C. Roland and C. Parker 4274*, 17 August 1999.

Plate 5.1 Wetland and pond complex in the southwest corner of the Park. ***Cicuta bulbifera*** was collected in the shoreline vegetation and ***Najas flexilis*** occurred as a submerged aquatic in the small pond. The floodplain of the East Fork of the Yentna River is visible in the background.

Plate 5.2 Lush tall forb-herbaceous meadow of *Veratrum* and *Athyrium*; habitat of ***Arnica diversifolia*** on south slopes of Alaska Range near the Kahiltna Glacier terminus

Other Park collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: water horsetail-beaked sedge wet meadow pond margin; Lower Kantishna R. E of Chilchukabena L.; 181 m, 63.877°N, 151.400°W, *M. Duffy 00-264*, 14 August 2000.

Asteraceae:

***Anaphalis margaritacea* (L.) Benth. & Hook, "Pearly Everlasting"**

Anaphalis margaritacea occurs in northeastern Asia and across North America from Newfoundland to Alaska (Cody 1996). However, it is considered rare in the Yukon Territory, where it is known from a single locality in the extreme southern part of the territory (Cody 1996). In Alaska, *A. margaritacea* is restricted to coastal locations from the southeastern panhandle to the western tip of the Aleutian chain. The collection made near Mt. Goldie extended the range of this species 250 km to the northwest from a locale in Prince William Sound shown in Hultén (1968). This represents the northernmost documented locality for the species in North America. The habitat was an open, sandy patch on a subalpine moraine dominated by *Alnus viridis*. Map 2.

Floristic Inventory collections:
Southcentral Alpine:
►Talkeetna Quad: scattered on sandy slope among alders; Mt. Goldie, AK Range, AK; 853 m, 62° 42.100'N, 150° 50.440'W, *A. Larsen and M. Duffy 01-0302B*, 9 July 2001.

Other Park collections:
Southcentral Boreal Subalpine:
►Talkeetna Quad: open tall Sitka alder/shield fern scrub; Kanikula Glacier area; 585 m, 62.693°N, 150.842°W, *M. Duffy 01-053*, 9 July 2001.

***Arnica diversifolia* Greene (=*Arnica ovata* Greene)**

This species is restricted to the Cordillera of western North America from California to Southcentral Alaska (Kartesz and Meecham 1999). It is considered critically imperiled in both Alaska (AKNHP rank of S1) and the Yukon Territory (Douglas et al. 1981). The species is taxonomically problematic, and some authors have suggested that it is of hybrid origin (a cross between *A. latifolia* and *A. amplexicaulis*; Cody 1996). Hultén called its taxonomic status "somewhat doubtful", also citing the possibility that it is of hybrid origin. *A. diversifolia* is known from only a handful of sites in Alaska, including the two new localities documented during this inventory. Hultén showed a single locality for the species in Alaska, in the Chitina River drainage in Wrangell-St. Elias National Park and Preserve, although the species was not collected during a four-year inventory of that region. There are seven specimens of this taxon deposited at ALA. The localities from east to west include: near Thompson Pass on Richardson Hwy (►Valdez Quad: moist; 61.133°N, 145.733°W, *B. Cumby 282, ALA 071646*; 18 August 1974), Tangle Lakes (►Mt Hayes Quad: ridge north of Tangle Lakes; 1158 m, 63.050°N, 146.016°W, *G. Smith 2049, ALA 10626*, 20 August 1953), mi 25 Denali Highway (►Mt Hayes Quad: alpine tundra; 63.083°N, 146.111°W, *R. Backer 85, ALA 95393* 6 August 1976), Spencer Glacier near Seward (►Seward Quad: rocks; 274 m, 60.667°N, 149.0667°W, *L.A. Viereck 2069 ALA 8506*, 8 July 1957), and three localities near Anchorage (►Anchorage Quad: Lower

Snowhawk; 650 m, 61.200°N, 149.583°W; *M. Duffy 803 ALA V0119111*, 19 July 1994; ►Anchorage Quad: gravelly; Nike Road; 930 m, 61.254°N, 149.539°W, *M. Duffy and Tande 1076*, *ALA V0119255*, 18 August 1994 and ►Anchorage Quad: Willow Road; 61.750°N, 149.500°W, *G.M. Frohne s.n. ALA 21808*, 12 August 1950).

Arnica diversifolia grows in lush subalpine forb-herbaceous meadows in the mountains (see Plate 5.2) where it occurs with tall forbs such as *Geranium erianthum*, *Actaea rubra*, and *Veratrum viride*, among others. The specimens collected in the Chelatna Lake and Wild Horse Creek sites represented the western-most known localities for this species, 170 km northwest of the collection's nearest published localities in Fort Richardson near Anchorage collected by Mike Duffy (**www.uaa.alaska.edu/ enri/aknhp_web/biodiversity/akbiodiv.html**). Map 3.

Floristic Inventory collections:
Southcentral Alpine:
►Talkeetna Quad: occasional in lush herbaceous vegetation on well-drained SW-slope; AK Range E of Chelatna L.; 732 m, 62º 29.517'N, 151º 21.860'W, *C. Roland 3938*, 30 June 1999.
►Talkeetna Quad: scattered in lush meadow, vicinity of upper Wildhorse Cr., AK Range, AK; 930 m, 62º 39.190'N, 150º 57.640'W, *M.B. Cook and A. Larsen 3765*, 3 July 2001.

***Aster subspicatus* Nees, "Douglas' Aster"**
Aster subspicatus is endemic to the western Cordillera of North America where it occurs in open wet meadows and woodlands from the lowlands into the subalpine zone. It is known as far south as Oregon and as far east as Montana (Kartesz and Meecham 1999). In Alaska, *A. subspicatus* occurs along the southern coast westward to Unalaska (Hultén 1968). *Aster subspicatus* occurs in open wet meadows in the subalpine zone (see Plate 5.3). This species was collected in an open wet meadow in Cascade Creek in Denali National Park and Preserve (see Plate 5.3). This collection extended the range of this species 260 km to the northwest from a locality in Prince William Sound shown in Hultén (1968). There is also an unpublished specimen of this plant from Hatcher Pass, in the Talkeetna Mountains east of Denali National Park and Preserve (►Anchorage Quad: alpine, Independence; 1067 m, 61.783°N, 149.283°W, *C.L. Williams 89-138, ALA V0105003*, 23 September 1989). Map 4.

Floristic Inventory collections:
Southcentral Boreal Lowlands:
►Talkeetna Quad: occasional in wet *Trichophorum-Sphagnum* fen in valley bottom; valley of Cascade Cr., AK Range; 329 m, 62º 25.748'N, 152º 01.515'W, *C. Roland and C. Parker 4254B*, 16 August 1999.
►Talkeetna Quad: scattered in sloping wet meadow-fen above creek; valley of Cascade Cr., AK Range; 1070 m, 62º 25.748'N, 152º 01.515'W, *C. Roland and C. Parker 4259A,* 16 Aug 1999.

***Bidens tripartita* L., "Bur-marigold"**
Bidens tripartita was not recorded from Alaska prior to this inventory. Similarly, it is not known to occur in the flora of the Yukon Territory (Cody 1996). *B. tripartita* is a species of open soil in very wet areas and lakeshore vegetation. This species was first collected in July 2000, growing in abundance in deep, rich organic muck lining the northeast shore of Chilchukabena Lake in the western lowlands of the Park (see Plates 5.4 and 5.5). This is a large, exceptionally productive

Plate 5.3 The habitat of ***Aster subspicatus***, a wet sedge meadow on Cascade Creek in the Yentna River drainage.

Plate 5.4 ***Bidens tripartita***, an Aster family species new to the flora of Alaska, growing in lakeshore vegetation of Lake Chilchukabena.

boreal lake with dense aquatic vegetation and large numbers of resident waterfowl. In late August of 2000, a second locality was discovered nearby by Mike Duffy during field work for the Soils Inventory. The closest documented locality to these locations is in British Columbia, where there are voucher specimens at the University of British Columbia Herbarium (Kartesz and Meecham 1999). Thus this collection is a substantial northwestward expansion of the known range of this species. The specimens collected in Denali were determined by John L. Strother of the Jepson herbarium (JEPS), a specialist in this group. *Bidens tripartita* is a circumpolar boreal species absent from Greenland. Map 5.

Floristic Inventory collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: common in lush lakeshore vegetation on organic muck; Chilchukabena Lake, E of Lake Minchumina, AK; 192 m, 63º 55.702'N, 151º 29.634'W, *C. Roland and W. Mahovlic 4618*, 24 July 2000.

Other Park collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: bluejoint-beaked sedge wet meadow pond margin; north of Castle Rocks in Minchumina Basin; 201 m, 63.928°N, 51.490°W, *M. Duffy 00-290,* 27 August 2000.

Brassicaceae:
***Halimolobos mollis* (Hook.) Rollins, "Soft Fissurewort"**
This mustard is native to arctic-alpine areas of North America and Greenland, where it has a peculiar interrupted distribution (Cody 1996). It is often associated with rodent burrows, and Cody reported that it is a "dung-loving calciphilous species". It occurs on river bluffs and other open habitats in interior and arctic Alaska from the lowlands into the subalpine region. The collection on the Toklat River drainage extended the range of this species 400 km to the south of the Hultén station in the Brooks Range, and represented the southwestern edge of the species range in Alaska (see Cook and Roland 2002). There are 14 specimens of this taxon deposited in ALA including the closest localities to this one from near Fairbanks: Wood R. Buttes (►Fairbanks Quad: steep slope (24°-45°), E Bluff, Wood R. Buttes; 300 m, 64° 47.00'N, 148° 05.57'W, *M. Duffy, R. Lipkin and J. Tande, 95-056, ALA V0120227,* 15 June 1995), and from Bluff on the Seward Peninsula (►Solomon Quad: VABM Bluff at coast near Koyana; 38 m, 64° 34.00' N, 163° 43.00'W, *Dean Kildaw s.n., ALA# V0090555,* July 1987; ►Solomon Quad: unstable, rocky, dry; vicinity of Bluff; 30 m, 64° 32.00'N, 163° 45.00'W, *Dean Kildaw s.n. ALA# V0097869*, 24 May 1988). *H. mollis* was also collected at several locations in the Mentasta and Wrangell mountains during the plant inventory of Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002). Map 6.

Floristic Inventory collections:
Interior Boreal Floodplains:
►Mt. McKinley Quad: locally common in sand on open floodplain and slopes of eroding silt bluff; E bank of Toklat R., N of AK Range; 335 m, 63º 59.470'N, 150º 02.274'W, *C. Roland and A. Batten 3779*, 17 June 1999.

Plate 5.5 The habitat of ***Bidens tripartita***, a wet lakeshore meadow on northeast shore of Lake Chilckukabena, in the Minchumina Basin in the northwest part of the Park.

Plate 5.6 ***Smelowskia calycina***, a small white flowered mustard, occurs in exposed alpine fellfields in the northern mountains of Denali National Park and Preserve.

***Smelowskia calycina* (Stephan) C.A. Meyer sensu lat., "False Candytuft "**
Smelowskia calycina, a low-growing mustard with white flowers (see Plate 5.6), is a xerophyte that grows in rocky, exposed tundra, fellfields and scree. This species has an Amphiberingian distribution that stretches from the Rocky Mountains of Colorado at its eastern terminus, through the western Cordillera of North America, west into Eurasia nearly to the Ural Mountains (Hultén 1968). Several subspecies have been described within this variable species complex, based on leaf shape and dissection. I prefer Cody's broad approach to the taxon for our area, where individuals with a variety of leaf shapes from narrowly linear to broad and dissected co-occur (Cody 1996). The identity of the specimens collected in Denali National Park and Preserve were determined according to this broad species concept.

The distribution of *S. calycina* in Alaska includes the Brooks Range, the Seward Peninsula, and scattered localities in the interior mountain ranges (Hultén 1968; Cook and Roland 2002). It was collected in numerous locales in the northern reaches of Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002). The collection locality at Triple Lakes Bluff is 250 km southeast of the middle Yukon River locality cited by Hultén (1968). However, there is a specimen of this taxon that was collected by Carolyn Parker at a site in the western Alaska Range, south of Denali National Park and Preserve in the Farewell area, that is deposited at ALA (►McGrath Quad: s-facing scree, vicinity Farewell Mtn.; 750 m, 62.31°N, 153.43°W, *C. Parker 900, ALA V0076739*, 11 July 1983). Map 7.

<u>Floristic Inventory collections:</u>
Thirteen specimens of this taxon were collected during this inventory – all collections were made in sites in the northern ranges of hills in the Park in the Interior Alpine Outer Range Region, including in the hills north of the Stampede Trail, at Chitsia Mountain at the northern terminus of the Kantishna Hills, and in the Roosevelt Hills west of the Minchumina area. I report here only the specimen that represented the largest range extension, which was a locality near Triple Lakes in the vicinity of McKinley Village in the Alaska Range.

Interior Boreal Uplands:
►Healy Quad: scattered in dry rubble on outcrop on steep S-slope; bluffs above Triple Lakes, near McKinley Village, AK; 914 m, 63º 40.001'N, 148º 51.782'W, *C. Roland, A. Larsen and J. Brodie 4978*, 20 June 2001.

<u>Caryophyllaceae:</u>
***Minuartia biflora* (L.) Schinzl. & Thell., "Mountain Stitchwort"**
Minuartia biflora is a circumpolar arctic-alpine species, which is considered rare in Alaska by AKNHP (S2), but is found more commonly in the Yukon Territory (Cody 1996). It is likely a frequently overlooked species because of its small stature and very small, inconspicuous flowers (Plate 5.7). *M. biflora* occurs in moist alpine tundra, snowbeds and seepage areas high in the mountains. The distribution of *M. biflora* in Alaska is arctic-alpine and it is known from scattered localities north of the Brooks Range, the Yukon-Tanana Uplands, and the mountains of the southern interior, including the Alaska Range and the Wrangell Mountains (Cook and Roland 2002). Six collections of this species were made during the inventory project; in addition, there was one specimen from the Park collected by Adolph Murie in the Sable Pass area in 1964.

Plate 5.7 ***Minuartia biflora***, an alpine species with a circumpolar distribution that is rare in Alaska, occurs in high alpine seeps, rivulets and often in calcareous substrate.

Plate 5.8 An alpine rivulet in limestone area in Shellabarger Pass; habitat of ***Stellaria umbellata*** and ***Phippsia algida***.

Three collections of the species were also made in the Park by Mike Duffy during the Soils Inventory. Map 8.

Floristic Inventory collections:
Southcentral Alpine:
►Healy Quad: rare in mesic snowbed tundra in gully on E slope; Windy Cr. valley, AK Range, AK; 1311 m, 63º 26.533'N, 149º 07.967'W, *C. Roland 3250*, 9 July 1998.
►Healy Quad: growing in forb-herbaceous tundra disturbed by marmots; ridge S of W. Fork of Chulitna R., AK Range; 1402 m, 63º 14.184'N, 149º 50.246'W, *C. Roland and S. Carwile 4603A*, 18 July 2000.
►Healy Quad: scattered in *Dryas* tundra on limestone knob; ridge E of upper Cantwell Cr., AK Range, AK; 1396 m, 63º 25.110'N, 149º 16.291'W, *C. Roland and S. Carwile 4606*, 7/18/2000.
►Talkeetna Quad: vicinity of Wildhorse Cr., AK Range, AK; 960 m, 62° 39.460'N, 150° 58.360'W, *A. Larsen and MB Cook 01-0161B*, 4 July 2001.
Interior Alpine Alaska Range:
►Healy Quad: rare in saturated soil in protected alpine swale; Wyoming Hills, AK Range, AK; 1372 m, 63º 39.256'N, 149º 55.391'W, *C. Roland 3291A*, 14 July 1998.
►Talkeetna Quad: growing in turfy, mesic tundra in saddle on W-slope; vicinity Chedotlothna Glacier, AK Range; 1524 m, 62º 58.709'N, 151º 53.987'W, *C. Roland 004*, 10 July 1999.

Other Park collections:
Interior Alpine Alaska Range:
►Healy Quad: tundra in Sable Pass area, AK Range, AK; 63° 38’N, 149°40’W, *A. Murie s.n.*, 7/19/1964.
►Talkeetna Quad: white mountain avens-polar willow dwarf alpine scrub ridge east of the terminus of the Chedotlothna Glacier; 1629 m, 62.976°N, 151.897°W, *M. Duffy 99-068*, 10 July 1999.
Southcentral Alpine:
►Healy Quad: crowberry-Alaska mountain avens dwarf alpine scrub, W side of Easy Pass; 1029 m, 63.349°N, 49.801°W, *M. Duffy MD00-098*, 12 July 2000.
►Talkeetna Quad: scree slope Upper Eldridge Glacier; 1472 m, 63.0515°N, 150.1179°W, *M. Duffy 00-203*, 26 July 2000.

***Stellaria umbellata* Turcz., “Umbrella Starwort”**
This plant occurs in the western Cordillera of North America and in the mountains of northern Eurasia (Hultén 1968). It only occurs in widely scattered sites in both Alaska, where it is considered rare (S2S3), and the Yukon, where it is known from only three locations (Cody 1996). It was first collected in the Park by Galen Smith in 1954 along a small alpine creek just east of Sable Pass. I collected *S. umbellata* in a wet seepage area on limestone bedrock in Shellabarger Pass, 180 km SW of the Smith collection locality (see Plate 5.8). This species is often found in moist to wet sand near alpine rivulets. The highest concentration of collection localities for this species in Alaska is in the high mountains of eastern Alaska, in the Wrangell-St. Elias National Park (Cook and Roland 2002). Outside of this area, it is known from very scattered sites in the arctic, and from the localities cited below. *Stellaria umbellata* is another diminutive alpine plant that is likely overlooked, having inconspicuous inflorescences. Map 9.

Floristic Inventory collections:
Interior Alpine Alaska Range:
►Talkeetna Quad: rare in stony area in wet alpine rivulet draining limestone knoll; vicinity of Shellabarger Pass, AK Range; 1097 m, 62º 31.890'N, 152º 146.674'W, *C. Roland and A. Batten 4727*, 16 August 2000.

Other Park collections:
Interior Alpine Alaska Range:
►Healy Quad: snowbed above creek, just E of Sable Pass; 1097 m, 63° 33'N, 149° 40'W, *G. Smith 2580A*, 19 August 1954.

Ceratophyllaceae:
***Ceratophyllum demersum* L., "Coon's Tail"**
This aquatic plant has a wide-ranging, circumpolar distribution that includes all 50 United States (Kartesz and Meecham 1999). It often forms dense mats in shallow water of small lakes and ponds. *C. demersum* is considered rare in Alaska (S2) where it was known from six sites in the eastern interior (Cook and Roland 2002). It is also considered rare in Yukon Territory, where it is known from only three sites (Cody 1996).

The specimen collected at Chilchukabena Lake (see Plate 5.9) extends the range of this species 150 km west from the Healy Quad location (►Healy Quad: vicinity Cantwell, 63°24.0'N 148°56.0'W, *G. Smith 2243*, 6 September 1953 (ALA)). Map 10.

Floristic Inventory collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: abundant in 1.5 meters of water in highly productive lowland lake; Chilchukabena L., E of Lake Minchumina, AK; 192 m, 63º 55.702'N, 151º 29.634'W, *C. Roland and W. Mahovlic 4615*, 24 July 2000.

Other Park collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: beaked sedge-water horsetail wet meadow pond margin; Beaverlog Lakes, in northwestern corner of Preserve; 206 m, 64.019°N, 151.733°W, *M. Duffy 01-278*, 2 September 2001.

Cyperaceae:
***Carex crawfordii* Fern., "Crawford's Sedge"**
This sedge occurs across boreal North America and reaches its southern range limit in Missouri (Kartesz and Meecham 1999). Prior to this inventory, *C. crawfordii* was known from Alaska from several sites in the eastern interior, between the Yukon and Tanana rivers, three locations in the Cook inlet basin, and one site on the Chitina River in Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002). It is considered rare in Alaska (AKNHP rank of S2S3) and in the Yukon Territory (Douglas et al. 1981). *C. crawfordii* was collected at three separate locations during this inventory project, ranging from the vicinity of the Toklat River in the north, to the Yentna River lowlands in the south. This species occurs in open, moist soil in shorelines

Plate 5.9 Lake Chilchukabena an extremely productive large, shallow boreal lake where numerous noteworthy collections of aquatic species were made, including ***Ceratophyllum demersum,*** a rare aquatic species in Alaska.

Plate 5.10 Aerial view of wetland and pond mosaic in boreal lowlands west of the Kantishna Hills. ***Carex diandra*** occurred in open meadow vegetation along shore of pond shown in photograph.

and drying lake beds and in mesic meadows in the lowlands to the subalpine region in Denali. It was not known to occur in the Park prior to this study. Map 11.

Floristic Inventory collections:
Southcentral Boreal Lowlands:
►Talkeetna Quad: scattered in *Carex utriculata* meadow; east of Ruth Glacier terminus, Chulitna R. valley; 226 m, 62º 42.045'N, 150º 19.697'W, *C. Roland 3531*, 18 August 1998.
Southcentral Boreal Subalpine:
►Talkeetna Quad: occasional in wet meadow on alluvium; upper W. Fork of Yentna R. valley, AK Range; 134 m, 62º 24.527'N, 152º 06.569'W, *C. Roland and W. Mahovlic 4184*, 2 August 1999.
Interior Boreal Lowlands:
►Mt. McKinley Quad: co-dominant in depressions and open muddy shores in wetland; pond on bench, E side of Toklat R, N of AK Range; 421 m, 63º 56.027'N, 150º 04.178'W, *C. Roland and A. Batten 3783*, 17 June 1999.

***Carex diandra* Schrank, "Lesser Tussock Sedge"**
This boreal wetland sedge species has a wide-ranging, nearly circumpolar distribution (it is known from Iceland, but not Greenland; Hultén 1968). In North America, *C. diandra* occurs across the boreal regions of the continent, reaching as far south as Colorado, where it is rare (Flora of North American Editorial Committee 1993+). This plant often forms dense, nearly floating swards around the margins of subarctic ponds (see an example of its habitat in Plate 5.10). *Carex diandra* is included here because the collection at Spectacle Lake extended the range of this species 250 km to the southwest from the location at Fairbanks, and 250 km northwest from Anchorage area locality published in Hultén (1968). There are two unpublished collections of *C. diandra* from Alaska that are deposited at ALA that document its range west of the Denali localities cited below: these specimens are from the Great Kobuk sand dunes (►Baird Mountains Quad: Great Kobuk Sand Dune; 60 m, 67.000°N, 159.017°W, *D.R. Hunt 9635, ALA V0123879*, 15 July 1996) and from the vicinity of Beverley Lake (►Dillingham Quad: east end Beverley Lake, Wood Tikchik State Park; 59.667°N, 158.750°W, *P. Caswell 106, ALA V0108453,* 31 July 1990). *C. diandra* was not known from our area prior to this inventory. Map 12.

Floristic Inventory collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: common around large lake; small lake near Spectacle Lake, upper Herron R. area, AK; 259 m, 63º 33.668'N, 152º 25.078'W, *A. Larsen and C. Roland 01-0927*, 5 August 2001.
►Mt. McKinley Quad: occasional in margin of lake; vicinity pond E of Sandless Lake in lowlands W of Kantishna Hills, AK; 172 m, 63º 57.746'N, 150º 38.115'W, *A. Larsen, C. Roland and A. Batten 01-0985*, 6 August 2001.
►Mt. McKinley Quad: patchy around margin of old slough pond on river terrace; 4.8 km S of John Hansen Lake, Kantishna R. lowlands, AK; 175 m, 63º 59.156'N, 151º 12.636'W, *C. Roland 5134*, 4 August 2001.

Interior Boreal Floodplains:
►Mt. McKinley Quad: scattered in muddy banks and margins of drained beaver pond; E bank of upper Birch Cr., W of Foraker R., AK; 280 m, 63º 34.199'N, 151º 53.711'W, *C. Roland 5165*, 5 August 2001.
Southcentral Boreal Floodplains:
►Talkeetna Quad: patchy in wet sedge meadow; pond on W side of E. Fork of Yentna R.; 73 m, 62º 18.001'N, 151º 48.113'W, *C. Roland and C. Parker 4275J*, 17 August 1999.

***Carex eburnea* Boott, "Bristleleaf Sedge"**
The Alaskan portion of the range of *Carex eburnea* is disjunct from the southerly part of its range in the Great Basin and prairie states (Hultén 1968). This sedge is mostly absent in the lower 48 states west of the Rocky Mountains (Kartesz and Meecham 1999). It is known from a single locality in Yukon Territory (Cody 1996), and is also rare in Alaska (S2S3). Prior to this inventory, the known distribution of this species in Alaska was restricted to interior stations in the central part of the state (Cook and Roland 2002). Our collection of *C. eburnea* in the Yentna River drainage in Denali extended the range of this species to include the Cook Inlet drainage. In Denali National Park and Preserve, this dry land sedge occurred in sandy sites on the floodplains of large glacial rivers on both sides of the Alaska Range (its habitat is shown in Plate 5.11). This species was not known from our area prior to this inventory. Map 13.

<u>Floristic Inventory collections:</u>
Southcentral Boreal Subalpine:
►Talkeetna Quad: rare in moist spruce woods on river terrace; upper W. Fork of Yentna R., AK Range, AK; 259 m, 62º 29.567'N, 152º 25.398'W, *C. Roland, M. Duffy and A. Blakesley 4145*, 30 July 1999.
Interior Boreal Floodplains:
►Mt. McKinley Quad: rare in open alluvium on stabilized river bar; W bank of Toklat R., AK Range, AK; 460 m, 63º 49.853'N, 150º 16.743'W, *C. Roland 5002*, 25 June 2001.

<u>Other Park Collections</u>:
Interior Boreal Floodplains:
►Mt. McKinley Quad: white spruce-poplar woodland east of McKinley River, approximately 10 km north of Eagle Gorge; 365 m, 63.580°N, 151.386°W, *M. Duffy 99-147*, 18 August 1999.

Carex echinata* Murr. ssp. *echinata
Carex echinata spp. *echinata* occurs across boreal North America from the Aleutian Islands to Newfoundland (Flora of North American Editorial Committee 1993+). This sedge reaches as far south as California and Nevada in the west and North Carolina in the east. This species occurs in wet meadows and peatlands in the lowlands. Prior to this inventory, this species was known only from a single Alaska locality near Unalaska in the Aleutian islands (►Unalaska Quad: valley above Unalaska Village, 100 m, 53.867° N, 166.533° W, C. Parker 6941, 8 August 1996). The collections in Denali extend the Alaska Range for this taxon almost 1,400 km to the northeast to two stations in the Southcentral Boreal Lowlands. In both of these sites, *C. echinata* occurred in well-developed sphagnum peatlands in saturated soils (see habitat photo in Plate 5.12).

Plate 5.11 Site on first terrace of the Toklat River north of the Alaska Range where the rare sedge ***Carex eburnea*** occurred in open silt and cobbles. Associated species at the site included scattered balsam poplars and *Elaeagnus commutata*, *Leymus innovatus*, *Epilobium latifolium* and *Lupinus arcticus*.

Plate 5.12 Well-developed peatland bog at the base of the south side of the Alaska Range, near the confluence of the Fountain and Chulitna rivers, where ***Carex echinata* ssp**. ***echinata*** was collected in 1998.

C. echinata ssp. *echinata* was collected in two sites within Denali during this study both of which were in well-developed peatlands on the south side of the Alaska Range. It was collected near the confluence of the Fountain and Chulitna rivers in 1998 and in the Cascade Creek drainage in 1999. Map 14.

Floristic Inventory collections:
Southcentral Boreal Lowlands:
►Talkeetna Quad: rare in pond within fen; valley of Cascade Cr., AK Range, AK; 329 m, 62º 25.748'N, 152º 01.515'W, *C. Roland and C. Parker 4255B*, 16 August 1999.
►Talkeetna Quad: rare in wet meadow margin; wet meadow near confluence of Fountain and Chulitna rivers; 311 m, 62º 49.785'N, 150º 06.907'W, *C. Roland and M.B. Cook 3476A*, 13 August 1998.

***Carex echinata* Murr. ssp. *phyllomanica* (W. Boott.) Reznicek (=*C. phyllomanica* Boott.)**
The subspecies *phyllomanica* of *Carex echinata* is narrowly endemic to the Pacific coastal states of North America, although the species complex (including *C. echinata* ssp. *echinata*) occurs more broadly across boreal North America (Kartesz and Meecham 1999). *C. echinata* ssp. *phyllomanica* is apparently absent from the Yukon Territory, but is not currently considered rare in Alaska, where there are numerous localities along the southern coast. This plant grows in sphagnum bogs and fens in lowland areas with maritime climates. The collection near the Kahiltna Glacier extended the range of this taxon 320 km to the northwest from a locality in Prince William Sound shown on Hultén's distribution map for this taxon (Hultén 1968). This locality in the Park represented the northwestern edge of this species range in North America, except for a single unpublished specimen deposited at ALA from the Norton Bay quadrangle (►Norton Bay Quad: North Fork; 60 m, 64°N, 160°W, *B. Parker 7985 A, V0125057*, July 1998). Map 15.

Floristic Inventory collections:
Southcentral Boreal Subalpine:
►Talkeetna Quad: scattered in heath-rich meadow area on W-facing slope; vicinity of confluence of Granite Cr. with Kahiltna Glacier, AK Range, AK; 509 m, 62º 33.458'N, 151º 08.938'W, *C. Roland and A. Batten 4925*, 18 August 2000.

***Carex incurviformis* Mackenzie in Rydb.**
Carex incurviformis is a segregate of the widespread *Carex maritima* species complex that occurs in high alpine sites in western North America (Reznicek 2002). This taxon is a Cordilleran endemic that occurs in the Rocky Mountains, Sierra Nevada and isolated stations in the mountains of Alaska (Reznicek 2002). In Alaska and Yukon, specimens of this taxon were previously assigned to *Carex maritima* sensu lat. (Hultén 1968, Cody 1996). The treatment in the Flora of North America separated this taxon from the typical *C. maritima* of lowlands based on differences in the pistillate scales and perigynia venation (Reznicek 2002).

In Alaska, this species is considered rare (S2) and is known from only two areas - the upper Chitina River drainage in Wrangell-St. Elias National Park and Preserve and the collection site in Healy quadrangle made during this inventory project (see habitat photo in Plate 5.13). Our collection of this species in "Ram Canyon" in the upper Toklat River drainage represents a range

Plate 5.13 Photograph of upper Ram Canyon, near Divide peak, in the Toklat River drainage. ***Carex incurviformis***, a rare alpine sedge with a Cordilleran distribution, was collected on a spur ridge in this area.

Plate 5.14 Very wet depression in *Tricophorum*-sedge wetland on bench above Fourth of July Creek in the Yentna River drainage where ***Eriophorum viridi-carinatum***, a rare species of cotton grass, was collected in 1999.

extension for the species of 525 km to the northwest from the locality in the Chitina River drainage. Map 16.

Floristic Inventory collections:
Interior Alpine Alaska Range:
►Healy Quad: Rare, growing in small patches on alpine ridge; alpine valley 7 km S of Divide Mt, AK Range, AK; 1737 m,63º 25.737' N,149º 59.065' W, C. Roland 5030, 6/28/2001.

***Carex interior* Bailey, "Inland Sedge"**
Carex interior is restricted to North America, where it grows in wetlands and wooded lowlands in northern temperate areas across the continent (Hultén 1968). *Carex interior* has a widespread distribution in North America, which includes all of the lower 48 states except the southeastern corner of the continent from Texas east to North Carolina and southward (Kartesz and Meecham 1999). *C. interior* is considered very rare in Alaska (S1) and rare in the Yukon Territory, where it is known from only three localities in the southern portion of the territory (Douglas et al. 1981; Cody 1996). *Carex interior* was known from three localities in Alaska prior to this inventory, all of which were in southcentral Alaska: the Tana River drainage in Wrangell-St. Elias National Park; Baxter Bog in Anchorage, and another site in the Anchorage vicinity cited in Hultén (Cook and Roland 2002).

The specimens collected in Denali National Park and Preserve during this inventory extended the range of *C. interior* 200 km northwest from Baxter Bog in the Cook Inlet lowlands in the Anchorage Quad (►Anchorage Quad: Baxter Bog; 61°13.0' N, 149°54.0' W, *E. F. Layser 3275*, July 1984 (ALA)). The specimens collected by Mike Duffy in the Minchumina Basin near the northern boundary of Denali, further extended the range of this species 175 km to the north into the interior of Alaska, where it was not previously known to occur. Map 17.

Floristic Inventory collections:

Southcentral Boreal Floodplains:
►Talkeetna Quad: common in saturated sphagnum-rich *Menyanthes-Carex-Equisetum* bog; W side of E. Fork of Yentna R., S of Midway Lakes, AK; 207 m, 62º 18.854'N, 151º 49.494'W, *C. Roland and A. Batten 4870*, 18 August 2000.

Other Park collections:
Interior Boreal Lowlands:
►McKinley River Quad: tufted bulrush-mud sedge wet meadow fen; large terrace along lower Kantishna River near north border of Park; 201 m, 63.832°N, 151.210°W, *M. Duffy, MD00-288*, 16 August 2000.
►Mt. McKinley Quad: tufted bulrush-water sedge wet meadow fen; about 5 miles south of Chilchukabena Lake in Minchumina Basin; 217 m, 63.784°N, 151.464°W, *M. Duffy, MD00-341*, 11 September 2000.
Southcentral Boreal Floodplains:
►Talkeetna Quad: water horsetail-buckbean wet meadow fen Yentna River, south of the confluence, near Preserve boundary; 80 m, 62.295°N, 151.818°W, *M. Duffy MD01-205*, 7 August 2001.

***Carex lapponica* O.F. Lang, "Silvery Sedge"**
Carex lapponica has a wide-ranging, incompletely circumpolar distribution with large gaps (Cody 1996). This sedge is rare in both Alaska (S2) and the Yukon Territory (Douglas et al. 1981). C. *lapponica* occurs in woodland bogs and wet areas in the lowlands into subalpine region. Hultén showed only two localities for this species within Alaska, and commented that the range of the species was "very incompletely known, probably throughout northern part of North America" (Hultén 1968). At present, *C. lapponica* is known to occur in all of the Canadian Provinces, as well as Washington, Idaho and Wyoming in the west, and most of the northern border states of the United States in the upper Midwest and New England (Kartesz and Meecham 1999).

The first collection of this species in the vicinity of Denali National Park and Preserve (although outside of the Park boundary) was made by Dave Densmore in the Broad Pass area in 1975 (►Healy Quad: moist; Broad Pass; 702 m, 63.267°N, 149.250° W, *D. Densmore JF3317, ALA#86831*, 30 July 1975). *Carex lapponica* was collected in five separate locations during this inventory, all in wetlands on the north side of the Alaska Range crest. These collections extended the range of the species 240 km south from the locality on the Tanana River shown in Hultén (1968). Only three localities for the species in Alaska were known west of the localities cited below, based on a review of specimens at ALA. These specimens were from the Ishtalitna Creek Hot Springs on the Tanana Quad (►Tanana Quad: Ishtalitna Creek Hot Springs; 65.867°N, 151.163°W, *G. P. Juday, s.n. ALA V0096069*, 27 June 1983), from the Iditarod River on the Ophir Quad (►Ophir Quad: shallow water, Iditarod River, Innoko NWR; 63.083°N, 157.917°W, *J. DeLapp 690, ALA V0105058*, 28 July 1987), and from the Bear River on the Solomon Quad (►Solomon Quad: Bear River; 45 m, 64.867°N, 163.700°W, *D. Murray 11827, ALA V0114535,* 25 July 1993). Map 18.

Floristic Inventory collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: occasional in open wet silt in margin of beaver pond; Chilchukabena Lake, E of Lake Minchumina, AK; 198 m, 63º 55.702'N, 151º 29.634'W, *C. Roland and W. Mahovlic 4663*, 26 July 2000.
►Mt. McKinley Quad: abundant in floating bog; vicinity Slippery Cr., AK Range, AK; 588 m, 63º 27.040'N, 151º 26.180'W, *C. Roland and A. Batten 5284*, 10 August 2001.
►Mt. McKinley Quad: rare in wet sedge-*Menyanthes* meadow; vicinity VABM Diamond, lowlands W of Kantishna Hills, AK; 176 m, 63º 51.955'N, 150º 51.455'W, *A. Larsen and C. Roland 01-0895*, 4 August 2001.
►Mt. McKinley Quad: scattered in meadow around vegetated lake; vicinity Slippery Cr., AK Range, AK; 588 m, 63º 27.040'N, 151º 26.180'W, *A. Larsen, C. Roland and A. Batten 01-1051*, 10 August 2001.
Interior Alpine Alaska Range:
►Talkeetna Quad: confined to small riparian corridor and pond on bench; vicinity Chedotlothna Glacier, AK Range; 975 m, 62º 58.709'N, 151º 53.987'W, *C. Roland 4049*, 10 July 1999.

***Eriophorum viridi-carinatum* (Engelm.) Fern., "Tassel Cotton-grass"**
This species of cotton-grass occurs only in North America, where its primary range is in the northeastern boreal region, including Ontario, Quebec and New England (Hultén 1968). The

distribution of *E. viridi-carinatum* is apparently spotty outside of this region, and it is considered rare in both Alaska (S2) and the Yukon, where it is only known from four localities in the extreme southern part of the territory (Cody 1996). The distribution of *E. viridi-carinatum* in Alaska is apparently restricted to the southcentral portion of the state, and isolated locations in the southeast panhandle (Cook and Roland 2002). Our collections represented the northern and westernmost stations for this taxon in Alaska.

The station in the Yentna River drainage represented the northwestern most extent of the species range, and extends its range approximately 150 km northwest from stations near Anchorage (see photo of the site in Plate 5.14). There is a specimen collected near Talkeetna deposited in ALA (►Tyonek Quad: muddy spot, Sheep Creek, Road to Talkeetna; 61° 59.00’N, 150° 04.00’W, *M. Williams 953, ALA V0101430*, 27 June 1965). *E. viridi-carinatum* occurs in bogs and fens, often in the subalpine region. It was not known from our area prior to this inventory. Map 19.

<u>Floristic Inventory collections:</u>
Southcentral Boreal Subalpine:
►Talkeetna Quad: scattered in wet *Trichophorum-Sphagnum* meadow on bench between lower Fourth of July Cr. and W. Fork of Yentna R., AK Range, AK; 305 m, 62º 20.617'N, 152º 02.327'W, *C. Roland and C. Parker 4278A*, 17 August 1999.

<u>Dryopteridaceae:</u>
***Athyrium alpestre* (Hoppe) Clairville (=*A. distentifolium* Tausch.), “Alpine Lady Fern”**
Athyrium alpestre has a wide geographic distribution that is essentially circumpolar, although there are large gaps within this range (Cody 1996). The subspecies *americanum*, which occurs in Alaska, has an essentially bicoastal distribution in North America, where it occurs in Newfoundland, Quebec and Ontario in the east, is unknown from the Midwestern U.S. and the Prairie provinces, and then occurs in the western Cordilleran region (Kartesz and Meecham 1999). This fern is known from just a single locality in the Yukon Territory (Cody 1996), and only a few coastal locations within Alaska (Hultén 1968). *A. alpestre* occurs in moist subalpine to alpine meadows with lush herbaceous vegetation, frequently in regions with acidic bedrock.

The collections made during this inventory represented a major northwestward extension of the species range. The Kantishna Hills location, in particular, is 340 km northwest of stations in Prince William Sound cited by Hultén (1968). The species has been documented in areas on both sides of the Alaska Range crest within the Park (A photo of the alpine basin where it was collected in 1998 is shown in Plate 5.15). Map 20.

<u>Floristic Inventory collections</u>:
Interior Alpine Outer Range:
►Mt. McKinley Quad: growing in lush graminoid-forb meadow in steep gully; vicinity upper Canyon Cr., Kantishna Hills, AK; 1067 m, 63º 40.480'N, 150º 36.000'W, *C. Roland and A. Batten 5177*, 6 August 2001.
Southcentral Alpine:
►Talkeetna Quad: cirque basin on granitic bedrock between Skihi Cr. and Hidden R.; 1097 m, 62º 52.819'N, 150º 08.518'W, *C. Roland and M.B. Cook 3450*, 13 August 1998.

Plate 5.15 Photograph of the alpine cirque basin (on granitic bedrock) between Skihi Creek and Hidden River where ***Athyrium alpestre*** was collected in 1998.

Plate 5.16 ***Polystichum lonchitis***, a fern that occurs in rocky slopes and meadows, was collected four times during the floristic inventory project; it was previously not known to occur in the Park.

►Talkeetna Quad: herbaceous meadow on SE slope; W of Kahiltna Glacier terminus, AK Range, AK; 701 m, 62º 30.260'N, 151º 18.250'W, *A. Larsen and M. Duffy 01-0498*, 19 July 2001.

***Polystichum braunii* (Spenn.) Fee [=*P. braunii* (Spenn.) Fee var. *alaskense* (Maxon) Hult.]**
This fern species has a bicoastal distribution in North America, where it occurs narrowly along the northwest coast and more broadly in the northeastern quadrant of the continent (Kartesz and Meecham 1999). It is apparently absent from areas with a strongly continental climate. The species consists of numerous subspecies that, in sum, have a nearly circumboreal distribution, albeit with very large gaps (Hultén 1968). In Alaska, this fern was only known to reach as far north as the Valdez area in Prince William Sound until this inventory. It was not collected in an extensive inventory of Eielson Air Force base near Anchorage, where there is presumably suitable habitat (**www.uaa.alaska.edu/enri/aknhp_web/biodiversity/ akbiodiv.html**). The locality in the Yentna River drainage represented the northwest extent of the species range, and is approximately 340 km northwest of the Valdez locality cited in Hultén (1968). Map 21.

Floristic Inventory collections:
Southcentral Boreal Subalpine:
►Talkeetna Quad: scattered in very moist, shady area underneath alders on toe of slope; upper W. Fork of Yentna R. valley, AK Range; 280 m, 62º 29.245'N, 152º 23.986'W, *C. Roland, M. Duffy, and A. Blakesley 4153*, 30 July 1999.

Polystichum lonchitis (L.) Roth, "Holly Fern"
This fern is circumpolar but with major gaps in regions with continental climates (Hultén 1968). In North America, it is apparently more prevalent in maritime floristic provinces, and is mostly absent from the central states (Kartesz and Meecham 1999). *P. lonchitis* is considered rare in the Yukon Territory (Douglas et al. 1981). This species is relatively common along the Gulf of Alaska coast, however, where it occurs in rocky areas and talus meadows from the subalpine into the lower alpine region (see Plate 5.16; Cook and Roland 2002).

The collections made in the Park extended the range of *P. lonchitis* 340 km to the northwest from Valdez-area station cited in Hultén (1968). Collections made by Mike Duffy during the Soils Inventory represented the northwest extent of the species range in the Alaska Range (see below). There is a single unpublished specimen of this species from well north of these localities from a spring in the Kobuk River drainage in northern Alaska (►Ambler River Quad: spring, Upper Akillik River, Kobuk Valley NP; 244 m, *M.W. Britton, ALA 103947*, 2 September 1984). Map 22.

Floristic Inventory collections:
Southcentral Alpine:
►Talkeetna Quad: rare in talus meadow on steep SE-slope; AK Range E of Chelatna L.; 1219 m, 62º 29.517'N, 151º 21.860'W, *C. Roland 3903*, 29 June 1999.
►Talkeetna Quad: growing in open, rocky slope vicinity of Wildhorse Cr., AK Range, AK; 930 m, 62° 39.240'N, 150° 57.280'W, *A. Larsen and M.B. Cook 01-0154*, 3 July 2001.
►Talkeetna Quad: growing in mountain saddle near pond; Kahiltna Glacier, AK Range, AK; 853 m, 62° 33.590'N, 151°19.280'W, *A. Larsen and M. Duffy 01-0427*, 18 July 2001.

►Talkeetna Quad: Patchy in ericaceous lichen rock heath vicinity of Granite Cr., AK Range, AK; 1189 m, 62º 40.080'N, 151º 03.090'W, *M.B. Cook and A. Larsen 3882*, 10 July 2001.

Other Park collections:

Southcentral Alpine:

►Mt. McKinley Quad: mixed forb meadow, head of Ohio Creek SW of Dunkle Mine; 905 m, 63.174°N, 149.908°W, *M. Duffy 00-144*, 16 July 2000.

►Talkeetna Quad: open low Barclay willow scrub, Tokositna Glacier area; 1190 m, 62.839°N, 150.808°W, *M. Duffy 01-016*, 6 July 2001.

►Mt. McKinley Quad: closed medium Barclay willow scrub; Easy Pass on upper Bull River; 1093 m, 63.376°N, 149.633°W, *M. Duffy 00-035*, 24 June 2000.

Ericaceae:

***Cassiope lycopodioides* (Pall.) D. Don, "Club-moss Mountain-heather"**

This distinctive, diminutive *Cassiope* only occurs along the northern Pacific coastal areas of North America and Eurasia, including southeast Alaska and the Aleutian Islands, Kamchatka and the Kurile Islands (Hultén 1968; see photo in Plate 5.17). In North America it is restricted to Washington, British Columbia and southern Alaska (Kartesz and Meecham 1999). It occurs in snowbeds and tundra, primarily in the coastal mountains. The stations for this taxon discovered in Denali National Park and Preserve, represented a significant northward extension of the species range to include interior stations for the species in central Alaska. The locality in the Kantishna Hills, in particular, extended the range of this species approximately 330 km northwest of a station near Whittier in Prince William Sound cited in Hultén (1968). One additional locality north of the Alaska Range crest (in the vicinity of the Chedotlothna Glacier) was documented by Mike Duffy during the Soils Inventory. In addition, the species was found in three localities in the Southcentral Mountains in the Park. Map 23.

Floristic Inventory collections:

Interior Alpine Outer Range:

►Mt. McKinley Quad: vicinity upper Canyon Cr., Kantishna Hills, AK; 1280 m, 63º 40.480'N, 150º 36.000'W, *C. Roland and A. Batten 5172*, 6 August 2001.

Southcentral Alpine:

►Talkeetna Quad: vicinity of Granite Cr., AK Range, AK; 1189 m, 62º 40.080'N, 151º 03.090'W, *A. Larsen, M.B. Cook and M. Duffy 01-0328*, 10 July 2001.

►Talkeetna Quad: Kahiltna Glacier, AK Range, AK; 853 m, 62°33.590'N, 151°19.280'W, *A. Larsen and M. Duffy 01-0413*, 18 July 2001.

Other Park collections:

Interior Alpine Alaska Range:

►Talkeetna Quad: Cassiope-Alaska mountain avens dwarf alpine scrub ridge east of the terminus of the Chedotlothna Glacier; 1486 m, 62.975°N, 151.893°W, *M. Duffy 99-069*, 10 July 1999.

Southcentral Alpine:

►Talkeetna Quad: Roundleaf willow-mixed ericaceous dwarf alpine scrub; Lower Buckskin Glacier; 1023 m, 62.915°N, 150.235°W, *M. Duffy 00-194*, 25 July 2000.

Plate 5.17 ***Cassiope lycopodioides***, a dwarf alpine Cassiope, was found in sites on both sides of the Alaska Range during this inventory.

Plate 5.18 ***Rhododendron camtschaticum***, a dwarf tundra species, was found in one locality in the Kantishna Hills during the floristic inventory. This species is known only from coastal locations in Alaska prior to this collection.

Rhododendron camtschaticum **Pall. “Kamtchatka Rhododendron”**
R. camtschaticum occurs in alpine meadows and heath tundra (photo of species is shown in Plate 5.18). This species is endemic to coastal areas of the North Pacific region in North America and Eurasia. It does not occur outside of Alaska in North America, where it is generally restricted to coastal stations on the southern and western coasts of the state. The subspecies *glandulosum* that occurs in the Park is characteristic of populations on the west coast of Alaska (Hultén 1968). The type subspecies of *R. camtschaticum* occurs along the southern coast of Alaska. The station documented in the Kantishna Hills within Denali National Park and Preserve is the sole interior station known for this species. This locality extended the range of the species 500 kilometers east (inland) from coastal stations cited in Hultén (1968) and collections at ALA. This plant occurs in alpine meadows and mesic tundra.

This significant locality for the species was first documented by Steve Carwile, who collected a specimen at the same site in 1987 during a hike from Chitsia Mountain to Kantishna (►Mt. McKinley Quad: 914 m, *S. Carwile 87-8, DENA5692*, 25 June 1987). Map 24.

<u>Floristic Inventory collections</u>:
Interior Alpine Outer Range:
►Mt. McKinley Quad: ridge between upper Marten Cr. and Flume Cr., Kantishna Hills; 899 m, 63º 51.194'N, 150º 27.498'W, *C. Roland and S. Carwile 3756*, 16 June 1999.

<u>Fabacaeae</u>:
Oxytropis huddelsonii **Pors., “Huddelson's Locoweed”**
This alpine legume is endemic to the hills and mountains of interior and central Alaska and mountains of southwestern Yukon Territory. It is considered rare in Alaska (S2S3) as well as globally (G3). The core of this species range is the region that includes Wrangell-St. Elias National Park and Preserve in Alaska and the Kluane region of Yukon Territory (see map in Cook and Roland 2002). *O. huddelsonii* was collected in numerous localities during an inventory of the Wrangell-St. Elias National Park and Preserve, and the species appears to be reasonably abundant in the Kluane region, based on the distribution map of Cody (1996). Curiously, however, *O. huddelsonii* is known from only two localized areas in Denali National Park and Preserve discovered during this inventory – alpine slopes in the vicinity of Windy Creek valley near Cantwell, and somewhat further south in the vicinity of the West Fork of the Chulitna River drainage. These are both isolated areas of calcareous sedimentary rock, which is a lithology that is much more common in the Wrangell Mountains area where this species occurs much more commonly. Map 25.

<u>Floristic Inventory collections</u>:
Interior Alpine Alaska Range:
►Healy Quad: scattered in loose rubble and patchy tundra on S-facing slope; Windy Cr. valley, AK Range, AK; 1219 m, 63º 27.057'N, 149º 02.780'W, *C. Roland 3239*, 9 July 1998.
►Healy Quad: scree on SW-slope; S bank of W. Fork of Chulitna R., AK Range; 1300 m, 63º 17.790’N, 149º 49.342'W, *C. Parker 8234B*, 14 August 1998.

Other Park collections:
Interior Alpine Alaska Range:
►Healy Quad: scree slope Windy Creek near Cantwell; 63.459°N, 149.007°W, *M. Duffy 00-016*, 21 June 2000.

Najadaceae:
***Najas flexilis* (Willdenow) Rostkov. & Schmidt, "Wavy Water Nymph"**
This is an aquatic plant species that was recently reported as new to the flora of Alaska based on a specimen collected in Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002). Two specimens of this species had also been collected in 1986 in the Fort Yukon Quad (►Fort Yukon Quad: near Preacher Creek, 66º 01'N 144º 42'W, *P. Heglund 86-351*, *86-363*, 16 & 17 July 1986 (ALA)). *N. flexilis* was also collected from a third locality in Alaska in the Anchorage Quad (►Anchorage Quad: Little Kiowa Lake, 61º 15.48'N, 149º 39.38'W, *M. Duffy & J. Tande 1030*, 4 August 1994). *N. flexilis* is rare in Alaska (S1S2), and has not been documented in the Yukon Territory, although it is likely frequently overlooked due to its aquatic habitat, which is under-collected in most plant inventories. A photograph of this species habitat is shown in Plate 5.1.

Najas flexilis has an Amphiatlantic distribution and, like many aquatic species found in the far north, occurs broadly across North America: it is known from all of the 50 United States (Kartesz and Meecham 1999). The collections of this species made in Denali National Park and Preserve included sites in the boreal lowlands on both sides of the Alaska Range crest. The northern localities in the Park represented the western range extent for this species in North America (Cook and Roland 2002). Map 26.

Floristic Inventory collections:
Southcentral Boreal Floodplains:
►Talkeetna Quad: growing in small shallow pond on mineral substrate; pond on W side of East Fork of Yentna R.; 73 m, 62º 18.001'N, 151º 48.113'W, *C. Roland and C. Parker 4272*, 17 August 1999.
Interior Boreal Lowlands:
►Mt. McKinley Quad: occasional in shallow water; vicinity VABM Diamond, lowlands W of Kantishna Hills, AK; 199 m, 63º 50.420'N, 150º 48.410'W, *C. Roland and A. Batten 5202A*, 6 August 2001.

Other Park collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: water horsetail-beaked sedge wet meadow pond margin; Lower Kantishna River, east of Chilchukabena Lake; 181 m, 63.886°N, 151.399°W, *M. Duffy 00-269,* 14 August 2000.

Ophioglossaceae:
***Botrychium alaskaense* W.H. Wagner & J.R. Grant, "Alaska Moonwort"**
This species was recently described in the scientific literature (Wagner and Grant 2002). A specimen collected by Carolyn Parker in the Kantishna Hills in Denali National Park and Preserve was cited as a paratype in the description of this species (►Mt. McKinley Quad,

Kantishna, Wickersham Dome, 900 m, 63.525°N, 150° 57.5'W, *C. Parker 2294*, *ALA V0105834*, 26 June 1990). This species is only known to occur in Alaska at present. We collected *Botrychium alaskaense* in two widely separated locations in the Park, both south of the Alaska Range crest. One site was a subalpine meadow on calcareous slopes in the upper West Fork of the Yentna River, and the second site was a grassy alpine meadow area, also on calcareous sedimentary bedrock above the upper West Fork of the Chulitna River. Map 27.

Floristic Inventory collections:
Southcentral Alpine mountains:
►Healy Quad: mesic meadow in swale; S bank of W Fork of Chulitna R., AK Range; 1219 m, 63º 17.790'N, 149º 49.342'W, *C. Roland and M.B. Cook 3493B*, 14 August 1998.
Southcentral Boreal Subalpine:
►Talkeetna Quad: upper W Fork of Yentna R. valley, AK. Range; 792 m, 62º 31.212'N, 152º 25.150'W, *C. Roland and S. Burson 4083*, 27 July 1999.

Other Park Collections:
Interior Alpine Outer Ranges:
►Mt. McKinley Quad: moist, herbaceous, meadow; Wickersham Dome, Kantishna Mining District; 900 m, *C. Parker 2290*, 26 June 1990.

***Botrychium minganense* Victorin, "Mingan Moonwort"**
This moonwort occurs in scattered localities across boreal North America and as far south as Arizona in the western Cordillera, but because of a peculiar, interrupted range it is rare in many areas (Kartesz and Meecham 1999). This apparent rarity may also be due to the taxon being overlooked and the taxonomic difficulties presented by this group. Based on the published literature, *B. minganense* is known from only a few localities in Alaska, in the Yakutat Quad (►Yakutat Quad:, 59°19.35'N, 138°40.14' W, *M. Stensvold 7313*, 16 July 1998 (ALA)) and several locations well to the east in Wrangell-St. Elias National Park and Preserve (see Cook and Roland 2002). However, a recent review of the specimens deposited at ALA revealed that recent collections have added numerous new localities for this species across Alaska. The localities span the state, from the Bristol Bay quad in the west to the Atka quad in the south, and northward to the Chandler Lake and Killik quads on the north slope of the Brooks Range.

We made four collections of *B. minganense* in the Park: three in a small drainage off of the upper Savage River in the Interior Alpine Alaska Range (see Plate 5.19) and one near the Kahiltna Glacier south of the Alaska Range crest. These collections represented the westernmost published localities for this species in North America, and represented a westward range extension of approximately 405 km to the west from the nearest published localities for this taxon in Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002). Map 28.

Floristic Inventory collections**:**
Interior Alpine Alaska Range:
►Healy Quad: drainage of small tributary that enters upper Savage R. from E, AK Range, AK.; 1202 m, 63º 39.741'N,149º 11.836'W, *J. Brodie and C. Roland 01-300*, 1 Aug 2001.
►Healy Quad: drainage of small tributary that enters upper Savage R. from E, AK Range, AK; 1120 m, 63º 39.800'N,149º 13.654'W, *J. Brodie and C. Roland 01-328*, 3 Aug 2001.

Plate 5.19 A subalpine slope in side canyon of the Savage River, a collection locality for ***Botrychium minganense***.

Plate 5.20 A wet silt flat on the floodplain of the Tokositna River where ***Agrostis exarata*** was collected in 1998.

►Healy Quad: drainage of small tributary that enters upper Savage R. from E, AK Range, AK; 1203 m,63º 38.920'N,149º 11.369'W, *J. Brodie and C. Roland 01-422*, 7 July 2001.
Southcentral Alpine Mountains Floristic region:
►Talkeetna Quad: among willows along creek; W of Kahiltna Gl. terminus, AK Range, AK; 701 m, 62° 30.260'N,151° 18.250'W, *A. Larsen and M. Duffy 01-0505*, 19 July 2001.

<u>Orchidaceae:</u>
***Malaxis monophylla* (L.) Sw. "Adder's-mouth Orchid"**
This circumboreal orchid of wet sphagnum bogs and lowland wetlands occurs across boreal North America, although with wide gaps which make it rare throughout a large portion of its northern range (Hultén 1968, Kartesz and Meecham 1999). *M. monophylla* occurs in scattered localities in coastal Alaska including Cook Inlet lowlands, Kodiak Island and northern southeast Alaska (Hultén 1968). This species is apparently absent from the flora of the Yukon Territory (Cody 1996), and was not collected during a floristic inventory of Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002). Thirty-two specimens of this taxon are deposited in ALA, all of which come from southern coastal stations, from near Petersburg in the southeast Alaska Panhandle to Attu Island in the western Aleutian Islands.

The collection of *M. monophylla* near Sandless Lake west of the Kantishna Hills was the first documented occurrence of the species in interior Alaska and represented a major extension of the species range. This station represented an extension of its range 260 km to the northwest from a station near Anchorage cited in Hultén (1968). This locality represents the northern range limit for the species in North America (Hultén 1968). Map 29.

<u>Floristic Inventory collections:</u>
Interior Boreal Lowlands:
►Mt. McKinley Quad: rare in wet sedge-*Menyanthes* meadow; vicinity pond E of Sandless Lake in lowlands W of Kantishna Hills, AK; 172 m, 63º 57.746'N, 150º 38.115'W, *A. Larsen, C. Roland and A. Batten 01-0971*, 6 August 2001.

***Malaxis paludosa* (L.) Sw. [=*Hammarbya paludosa* (L.) Ktze.]**
This tiny orchid occurs in wet sphagnum bogs and other lowland wetlands. *M. paludosa* has a circumboreal distribution (but does not occur in Greenland). It is rare throughout its North American range, which includes all of boreal Canada except Quebec, New Brunswick, and Newfoundland (Kartesz and Meecham 1999). It is considered rare in Alaska (S2S3) where it occurs in scattered localities in the interior and coastal areas. Hultén (1968) shows only two stations for the taxon in mainland Alaska. Examination of specimen records at ALA showed that this species was collected at three localities in the Fairbanks Quad (►Fairbanks Quad: hummocky site, Birch Hill ski lift, Ft. Wainwright; 140 m, 64.854°N, 147.610°W, *M. Duffy 95-514, ALA V0120546*, 8 July 1995, ►Fairbanks Quad: on hummock; Birch Island, Ft. Wainwright; 130 M, 64.720°N, 147.960°W, *M. Duffy and Reynolds 95-735, ALA V0120693*, 20 July 1995), ►Fairbanks Quad: wet sphagnum, Farmers Loop Road; 140 m, 64.867°N, 147.767°W, *M.A. Calmes 246, ALA 75280*, 26 June 1974) and a single locality in the Big Delta Quad (►Big Delta Quad: wet site, French Creek; 275 m, 64.600°N, 146.830°W, *M. Duffy and J. Tande 95-883*, 7 August 1995).

During this study, this orchid was collected in four localities in the boreal lowlands on both sides of the Alaska Range. It was collected in two additional localities in Denali during the Soils Inventory. These localities represent the northwestern range limit for the species in North America (Hultén 1968). Map 30.

Floristic Inventory collections:
Southcentral Boreal Lowlands:
►Talkeetna Quad: rare in wet *Trichophorum-Sphagnum* fen in valley bottom; valley of Cascade Cr., AK Range; 329 m, 62º 25.748'N, 152º 01.515'W, *C. Roland and C. Parker 4250B*, 16 August 1999.
Interior Boreal Lowlands:
►Mt. McKinley Quad: rare in wet sedge-*Menyanthes* meadow; vicinity VABM Diamond, lowlands W of Kantishna Hills, AK; 176 m, 63º 51.955'N, 150º 51.455'W, *A. Larsen and C. Roland 01-0894*, 4 August 2001.
►Mt. McKinley Quad: growing on wet sphagnum hummock with *Trichophorum caespitosum*; Corner Lake, AK Range, AK; 229 m, 63º 41.560'N, 151º 47.910'W, *A. Larsen and A. Batten 01-1042*, 9 August 2001.
►Mt. McKinley Quad: scattered around small muskeg pond in slough; pond in vicinity of Bearpaw R., AK Range, AK; 122 m, 63º 56.930'N, 150º 50.740'W, *A. Larsen and J. Brodie 01-1064*, 11 August 2001.

Other Park collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: mud sedge/sphagnum moss wet meadow bog east of McKinley River, approximately 10 km north of Eagle Gorge; 374 m, 63.587°N, 151.310°W, *M. Duffy 9943*, 18 August 1999.
Southcentral Boreal Lowlands:
►Talkeetna Quad: marsh five finger-water sedge wet meadow pond margin Lower Buckskin Glacier; 479 m, 62.922°N, 150.197°W, *M. Duffy MD00-186*, 25 July 2000.

Poaceae:
***Agrostis exarata* Trin. "Spiked Bentgrass"**
This grass of open sites in the lowlands occurs across western North America, reaching as far south as Mexico, and from there continuously eastward to Nebraska (Kartesz and Meecham 1999). In addition, it has been reported from widely disjunct stations in Kentucky and Vermont (Kartesz and Meecham 1999). *A. exarata* is not uncommon along the southern coast of Alaska from southeastern panhandle through the Aleutian Islands (Hultén 1968) but is considered rare in the Yukon Territory (Douglas et al. 1981). The collections of this species in the Yentna and Chulitna river drainages made during this study extended the range of this species approximately 300 km northwest from localities in northern Prince William Sound cited in Hultén (1968), and represent the northern terminus of the species continuous range in North America (see a habitat photo for this species in Plate 5.20). There is, however, a single specimen of *Agrostis exarata* collected from a site at Sadlerochit Springs in the arctic, deposited in ALA, which represented a considerable disjunction of the species range to the north (►Mt. Michelson Quad: moist site, Sadlerochit Spring; 305 m, 66.667°N, 144.333°W, *D.A. Walker 82-46, ALA V0090794*, 23 August 1982). Map 31.

Floristic Inventory collections:
Southcentral Boreal Lowlands:
►Talkeetna Quad: *Carex utriculata*-dominated area below beaver dam; E of Ruth Glacier terminus, Chulitna R. valley; 226 m, 62º 42.045'N, 150º 19.697'W, *C. Roland 3548*, 18 August 1998.
►Talkeetna Quad: rare in open wet silt and sedge meadow; vicinity Tokositna Glacier terminus, AK Range, AK; 247 m, 62º 39.318'N, 150º 48.111'W, *C. Roland and A. Batten 4954*, 19 August 2000.
Southcentral Boreal Floodplains:
►Talkeetna Quad: common in open wet silt of stream bank and riparian meadows; Fourth of July Cr., W of Yentna R., AK Range; 329 m, 62º 20.578'N, 152º 13.126'W, *C. Roland and A. Batten 4850*, 17 August 2000.

***Agrostis thurberiana* A. S. Hitchc. [=*Podagrostis thurberiana* (Hitchc.) Hult.], "Thurber's Bentgrass"**
This western North American species of bentgrass occurs in scattered wetland localities along the southern coast of Alaska where it is considered rare (S2). A recent distribution map for the species in Alaska shows that it occurs only as far northwest as the vicinity of Anchorage (Cook and Roland 2002). The Alaska populations of *A. thurberiana* are apparently disjunct from the primary range of the species in the temperate zone mountains of North America (Hultén 1968). It is not known to occur in the Yukon Territory (Cody 1996). A single collection of this species was made in Denali National Park and Preserve, in the vicinity of the Coffee River, on the south side of the Alaska Range, which represented the northwestern edge of this species known range (Cook and Roland 2002). Map 32.

Floristic Inventory collections:

Southcentral Boreal Subalpine:
►Talkeetna Quad: alpine basin on W side of Coffee R. drainage, AK Range; 808 m, 62º 50.404'N, 150º 18.975'W, *C. Roland and M.B. Cook 3424a*, 13 August 1998.

***Festuca lenensis* Drobov (=*F. ovina* L. ssp. *alaskensis* Holmen), "Tundra Fescue"**
Festuca lenensis occurs in dry, open habitats in hills and mountains on both sides of the Bering Strait (Cody 1996; see habitat photo in Plate 5.21). In both Eurasia and North America, this grass is generally restricted to Beringia, thus it is considered an Amphiberingian endemic species. This arctic-alpine fescue is considered rare in Alaska (S2S3) where it grows occurs in northern and central parts of the state (see map in Cook and Roland 2002). In the Yukon Territory *F. lenensis* is known from numerous stations in the arctic but only a single locality in the southwest corner of the territory (Cody 1996).

F. lenensis was first collected in Denali National Park and Preserve by Aven and Ruth Nelson in 1960 near Polychrome Pass on the Park Road (although the specimen was initially referred to *Festuca ovina*). The taxon was subsequently collected in the same area by Adolph Murie (in 1960) and Dave Densmore (in 1970). During this study, *F. lenensis* was found growing in numerous localities throughout the northern ranges of hills in Denali National Park and Preserve, including the Kantishna Hills, the range of hills north of the Stampede Trail, and "Outer Range"

Plate 5.21 Open, exposed alpine fellfield habitat (in the hills north of the Stampede Trail) of the Amphiberingian grass species ***Festuca lenensis***, which occurs in scattered xeric areas across the northern mountains of the Park.

Plate 5.22 An aerial view of the collection locality of the wetland grass species ***Glyceria pulchella*** in a slough of the Muddy River in the northwestern lowlands of Denali National Park and Preserve. *G. pulchella* was collected in the open meadow on the left bank of the water body pictured.

just north of the Park Road. It was also found in scattered locations in the northern flanks of the Alaska Range proper. In all, 13 specimens of this endemic species were collected during this study; only the southernmost locations are cited here, in the interests of space. Map 33.

Floristic Inventory collections:
Interior Alpine Alaska Range:
►Healy Quad: scattered in gravelly patch on W-facing hillside; hills N of Double Mountain, AK Range, AK; 945 m, 63º 38.691'N, 149º 31.980'W, *C. Roland 3015*, 19 June 1998.
►Healy Quad: barren S-slope near ridgetop with *Dryas* stringers; drainage of small tributary that enters upper Savage R. from E, AK Range, AK; 1162 m, 63º 38.954'N,149º 12.570'W, *J. Brodie and C. Roland 01-270*, 30 July 2001.

Other Park collections:
Interior Alpine Alaska Range:
►Healy Quad: stony slopes, Polychrome Pass area, 63°31'N, 140° 56'W, *A. Nelson and R. Nelson 3787*, 14 July 1939.
►Healy Quad: alpine slopes, Polychrome Pass area, 63°31'N, 140° 56'W, *A. Murie s.n.*, 13 July 1960.
►Healy Quad: talus slopes, Polychrome Pass area, 63°31'N, 140° 56'W, *D. Densmore 39*, 4 July 1977.

***Glyceria pulchella* (Nash) K. Schum., "MacKenzie Valley Manna Grass"**
This grass of wetlands and floodplain meadows in the lowlands occurs only in Canada from Manitoba westward, and in Alaska (Kartesz and Meecham 1999). It is rare throughout most of its range including Alaska (S2S3). In Alaska it is known only from the greater Yukon River drainage basin in the interior (see Cook and Roland 2002). It was collected at a single locality (in a flooded slough of the Muddy River – see Plate 5.22) during this inventory, which is the first record for the species in Denali. Map 34.

Floristic Inventory collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: rare in slowly moving water in flooded slough and riparian meadows on floodplain; slough on NE side of Muddy R., Kantishna R. lowlands, AK; 193 m, 63º 58.816'N, 151º 35.216'W*, C. Roland and A. Batten 5216*, 7 August 2001.

***Glyceria striata* (Lam.) Hitchcock var. *stricta* (Scribn.) Fern., "Fowl Manna Grass"**
This taxon occurs in floodplain meadows and marshes. *G. striata* var. *stricta* is restricted to North America, where it is found throughout the lower 48 states and Canada except Keewatin in the eastern arctic (Kartesz and Meecham 1999). *G. striata* ssp. *stricta* is considered rare in Alaska (S2S3) and the Yukon Territory (Douglas et al. 1981). In Alaska the species is known from the vicinity of Anchorage and scattered northern localities including Munson's Slough on the Tanana River near Fairbanks (►Big Delta Quad: Munson's Slough; 240 m, 64.466°N, 146.983°W, *C. Parker N-3032, V0122942*, 10 August 1997), and Kanuti Hot Springs on the Bettles Quadrangle (►Bettles Quad: Kanuti Hot Springs; 66.350°N, 150.850°W, *S. Keller 1365, V0096480*, 29 June 1987).

During this study, this species was collected at five localities in the boreal zone of the Yentna River drainage south of the Alaska Range crest. Map 35.

Floristic Inventory collections:
Southcentral Boreal Floodplains:
►Talkeetna Quad: growing in open moist silt of river bar; NE side of W Fork of Yentna R., AK Range; 67 m, 62º 18.210'N, 151º 53.795'W, *C. Roland and W. Mahovlic 4220*, 3 August 1999.
►Talkeetna Quad: scattered in moist area on gravel bar; SW bank of East Fork of Yentna R., AK Range; 122 m, 62º 21.760'N, 151º 55.341'W, *C. Roland and C. Parker 4265*, 16 August 1999.
►Talkeetna Quad: rare in saturated soil in tall alder scrub; E side of E. Fork of Yentna R., E of Midway Lakes, AK; 207 m, 62º 21.348'N, 151º 52.666'W, *C. Roland and A. Batten 4906*, 18 August 2000.
Southcentral Boreal Subalpine:
►Talkeetna Quad: scattered in wet sedge meadow on margins of beaver pond; upper W Fork of Yentna R., AK Range, AK; 259 m, 62º 29.567'N,152º 25.398'W, *C. Roland, M. Duffy, and A. Blakesley 4141*, 30 July 1999.
►Talkeetna Quad: occasional in meadow area in silt around small beaver pond; upper W Fork of Yentna R. valley, AK Range; 134 m, 62º 24.527'N, 152º 06.569'W, *C. Roland and W. Mahovlic 4185*, 2 August 1999.

Other Park collections:
Southcentral Boreal Floodplains:
►Talkeetna Quad: cottonwood woodland Ruth glacier terminus; 202 m, 62.542°N, 152.071°W, *M. Duffy 00-225*, 31 July 2000.
►Talkeetna Quad: open black cottonwood/thinleaf alder forest Lower West Fork of Yentna River; 134 m, 62.412°N,152.134°W, *M. Duffy 01-215*, 8 August 2001.

Polemoniaceae:
***Phlox richardsonii* Hook. [=*P. sibirica* L. ssp. *richardsonii* (Hook.) Hult.], "Siberian Phlox"**
This species of subalpine to alpine barrens, talus slopes and dry tundra is endemic to Alaska and neighboring areas of the Canadian arctic (Kartesz and Meecham 1999). It is rare in Alaska (S2) where it is known from several localities in the northern section of Wrangell-St. Elias National Park and Preserve (Cook and Roland 2002) and the Yukon-Tanana Uplands (Hultén 1968). *Phlox richardsonii* is known from one site on the arctic coast in the Yukon Territory (Cody 1996). Some taxonomists argue that the specimens referred to this taxon should be included in the broad concept of *Phlox hoodii*, a Cordilleran species of the Rocky Mountains and prairies (David Murray, personal communication).

Phlox richardsonii was collected in four separate stations north of the Alaska Range crest in Denali National Park and Preserve during this study (see photo of taxon in Plate 5.23). The collection in the vicinity of Triple Lakes extended the range of this species 400 km to the southwest from a station in the Yukon-Tanana Uplands cited by Hultén (1968). Map 36.

Plate 5.23 ***Phlox richardsonii***, an Alaska-Yukon endemic species, occurs in scattered localities in open, dry areas across the northern section of the Park.

Plate 5.24 ***Douglasia alaskana***, an Alaska-Yukon endemic species, occurs in high alpine slide rock (often on calcareous sedimentary rock) in the Alaska Range.

Floristic Inventory collections:
Interior Boreal Uplands:
►Healy Quad: rare in dry rubble, rock outcrops and forb-herbaceous tundra; bluffs above Triple Lakes, near McKinley Village, AK; 939 m, 63º 40.001'N, 148º 51.782'W, *C. Roland, A. Larsen and J. Brodie 4967*, 20 June 2001.
Interior Alpine Outer Range:
►Mt. McKinley Quad: scattered in rock crevices and steep, loose scree on SE-slope; spur ridge of Mt. Chitsia, Kantishna Hills; 884 m, 63º 57.166'N, 150º 18.770'W, *C. Roland, A. Batten and S. Carwile 3651,* 15 June 1999.
►Talkeetna Quad: rare in limited area of gravelly slope on crystalline rock; ridge 8 km S of Heart Mountain, AK Range; 1070 m, 62º 57.111'N, 152º 03.003'W, *C. Roland 4409*, 30 June 2000.
►Healy Quad: scattered on SE side of rock outcrop in lichen-forb herbaceous vegetation; Plateau E of Teklanika R, AK Range, AK; 1036 m, 63° 57.520'N, 149°27.440'W, *M.B. Cook and A. Larsen 3629*, 23 June 2001.
►Healy Quad: rock outcrop; Plateau E of Teklanika R., AK Range, AK; 991 m, 63°57.520'N, 149°27.440'W, *A. Larsen and M.B. Cook 01-0014B*, 23 June 2001.

Polygonaceae:
***Rumex maritimus* L., "Golden Dock"**
This wetland species of dock is widespread in North America, occurring from coast to coast, and apparently absent only from the southeastern United States and from eastern arctic provinces in Canada (Kartesz and Meecham 1999). Hultén (1968) believed that this was an introduced species, although no evidence was given for the assertion. Cody's 1996 treatment did not refer to the species as being non-native. Cody stated that its habitat is "marshy, sometimes alkaline margins of lakes and ponds". Given the localities and landscape context in which this species was found in Denali National Park and Preserve, I am inclined to believe, with Cody, that *R. maritimus* is a native element of the flora, although it is not possible to say for sure without more detailed study of the problem.

This taxon was collected twice during this inventory. Both localities for *R. maritimus* were in the general vicinity of Chilchukabena Lake east of Lake Minchumina. These collections extended the range of this plant species 360 km west of the station in the Copper River basin cited in Hultén (1968). Mike Duffy also collected one specimen of *R. maritimus* during the Soil Inventory, also in the interior boreal lowlands of the Park, north of Castle Rocks. Map 37.

Floristic Inventory collections:
Interior Boreal Lowlands:
►Mt. McKinley Quad: common is lush lakeshore vegetation on organic muck; Chilchukabena L., E of L. Minchumina, AK; 192 m, 63º 55.702'N, 151º 29.634'W, *C. Roland and W. Mahovlic 4617*, 24 July 2000.
►Mt. McKinley Quad: occasional in slowly moving water in flooded slough and riparian meadows on floodplain; slough on NE side of Muddy R., Kantishna R. lowlands, AK; 193 m, 63º 58.816'N, 151º 35.216'W, *C. Roland and A. Batten 5214*, 7 August 2001.

<u>Other Park collections:</u>
Interior Boreal Lowlands:
►Mt. McKinley Quad: bluejoint meadow, North of Castle Rocks in Minchumina Basin; 188 m, 63.927°N,151.492°W, *M. Duffy 00-300*, 27 August 2000.

<u>Potamogetonaceae:</u>
***Potamogeton obtusifolius* Mert. & Koch**
The aquatic pondweed *Potamogeton obtusifolius* has an Amphiatlantic distribution, and occurs across boreal North America, although it is rare throughout much of its northern range (Cody 1996, Kartesz and Meecham 1999). This aquatic species had not been collected in Alaska or neighboring regions at the time the two primary floras covering this region were published (Hultén 1968, Welch 1974). It was known from a single locality in Yukon Territory when the <u>Flora of the Yukon Territory</u> was published (Cody 1996). There are two specimens of *P. obtusifolius* deposited at ALA from Alaska. One of these specimens is from the Yukon Flats National Wildlife Refuge in northern interior Alaska (►Fort Yukon Quad: Heglund Plot M, Lake 24, Yukon Flats NWR, 66.367°N, 144.250°W, *P. Heglund 86-420*, 27 July 1986) and the other is from the Palmer area (►Anchorage Quad: in .25 m of water, Palmer, Matanuska-Susitna Borough, 61.600°N, 149.108°W, *L. Fuller s.n.*, 22 July 1991). This species is considered rare in Alaska (S1) and the Yukon Territory (Douglas et al. 1981).

This species was collected growing in boreal ponds in the lowlands on both sides of the Alaska Range. This included ponds in the Yentna River drainage in the Cook Inlet lowlands in Denali and ponds near Chilchukabena Lake in the Minchumina Basin. *P. obtusifolius* was growing in approximately one meter of water in Midway Lake between the lower reaches of the East and West Forks of the Yentna River. It also occurred in a slough pond of the Kantishna River near the northern boundary of the Park. Map 38.

<u>Floristic Inventory collections:</u>
Southcentral Boreal Lowlands:
►Talkeetna Quad: common in one meter of water in lower Midway Lake, Yenta R. lowlands; 137 m, 62º 21.030'N, 151º 56.881'W, *C. Roland and C. Parker 4287*, 17 August 1999.

Interior Boreal Lowlands:
McKinley Quad: pond on old slough; vicinity of Kantishna R. near Chilchukabena Lake, Ak.; 122 m, 63º 55.210' N, 151º 23.340' W, A. Larsen Jedediah Brodie 01-1075, 8/11/01.

<u>Primulaceae:</u>
***Douglasia alaskana* (Coville & Standley ex Hultén) S. Kelso (=*Androsace alaskana* Cov. & Standl.), "Alaskan Douglasia"**
This distinctive alpine *Douglasia* occurs only in the mountains of central Alaska (see Plate 5.24), the Yukon Territory and northern British Columbia, with disjunct populations on the Seward Peninsula (Cook and Roland 2002). *D. alaskana* is considered rare in Alaska (S2S3) and globally (G2G3). It occurs in high alpine slide rock, often on calcareous substrates.

This species was first collected in the region of Denali National Park and Preserve by Les Viereck, who collected it in 1961 in the upper Tonzona River valley, just outside of what is now the boundary of the Park (►Talkeetna Quad: high ridges and talus slopes, upper Tonzona R. area W of Mystic Pass, 1219 m, 62° 40'N, 152° 30'W, *L. Viereck 5378*, 12 August 1961). Two prior collections of *D. alaskana* were made in the Park (by Steve Carwile and Barb O'Donnell, see species cited below) both in the vicinity of Divide Mountain, in the upper Toklat River drainage south of the Park Road. Six new localities for this endemic species were documented during this study. All of the new stations were in the alpine zone of the Alaska Range, including sites on both sides of the crest of the range. Map 39.

<u>Floristic Inventory collections:</u>
Southcentral Alpine:
►Healy Quad: scattered in scree on SW-facing slope; S bank of W. Fork of Chulitna R., AK Range; 1219 m, 63º 17.790'N, 149º 49.342'W, *C. Roland and M.B. Cook 3500*, 14 August 1998.
►Talkeetna Quad: scree on S-slope; vicinity of W. Fork Yentna R., AK Range, AK; 1067 m, 62º 31.970'N, 152º 34.260'W, *A. Larsen and A. Batten 01-0819*, 1 August 2001.
Interior Alpine Alaska Range:
►Talkeetna Quad: occasional in very loose slide-rock on steep E-slope; vicinity Chedotlothna Glacier, AK Range; 1554 m, 62º 58.709'N, 151º 53.987'W, *C. Roland 3992*, 10 July 1999.
►Talkeetna Quad: growing in loose scree on SW-slope; ridge 8 km S of Heart Mountain, AK Range; 1219 m, 62º 57.111'N, 152º 03.003'W, *C. Roland 4451*, 30 June 2000.
►Talkeetna Quad: Rare in barren limestone scree on S-facing slope; vicinity of Shellabarger Pass, AK Range; 1433 m, 62º 32.21'N, 152º 46.73'W, *C. Roland and A. Batten 4749*, 16 August 2000.
►Talkeetna Quad: scree slope; vicinity of Chedotlothna Glacier, AK Range, AK; 1768 m, 62º 53.760'N, 151º 56.400'W, *A. Larsen and M. Duffy 01-1163*, 20 August 2001.

<u>Other Park collections</u>:
Interior Alpine Alaska Range:
►Healy Quad: scree on E-facing saddle slope, vicinity Divide Mountain, AK Range, AK; 1737 m, 63° 26'N, 149° 59'W, *S. Carwile 79-188*, 2 August 1979.
►Healy Quad: scree top of Divide Mountain, AK Range, AK; *B. O'Donnell s.n.*, 6 May 1984.

<u>Pteridaceae</u>:
***Cryptogramma stelleri* (S.G. Gmel.) Prantl. "Fragile Rock-brake"**
This fern has a circumpolar distribution, but is rare throughout much of its range, with localized, widely scattered populations (Hultén 1968, Kartesz and Meecham 1999). It generally grows in shaded, protected microsites, but may also be encountered growing in the protected lee of boulders in exposed alpine situations. It is considered rare in both Alaska (S2S3) and the Yukon Territory (Douglas et al. 1981). In Alaska, this species was previously known only from northern and interior stations (see map in Cook and Roland 2002). The collections in the Yentna River drainage made during this study were the first reports of this fern from the Cook Inlet watershed. The species was not known from Denali prior to this inventory. Map 40.

<u>Floristic Inventory collections:</u>
Southcentral Boreal Floodplains:
►Talkeetna Quad: rare, growing on mossy log in forest, upper W. Fork of Yentna R. valley, AK Range; 293 m, 62º 30.559'N, 152º 26.957'W, *C. Roland and S. Burson 4103*, 27 July 1999.

Southcentral Boreal Subalpine:
►Talkeetna Quad: growing in moist organic soil in rock crevices on shaded rock outcrop; upper W. Fork of Yentna R. valley, AK Range; 283 m, 62º 29.245'N, 152º 23.986'W, *C. Roland, M. Duffy, and A. Blakesley 4150*, 30 July 1999.
Interior Boreal Uplands:
►Mt. McKinley Quad: rare, growing in deep shade at base of outcrop; N side of McKinley R. in Eagle Gorge, Kantishna Hills, AK; 472 m, 63º 26.964'N, 151º 10.249'W, *C. Roland and A. Batten 5084*, 12 July 2001.

<u>Ranunculaceae:</u>
***Coptis trifolia* (L.) Salisb., "Trifoliate Goldthread"**
This species occurs widely in North America and reaches its western range limit along the west coast of the Russian Far East, including stations in the far western Aleutian Islands and the coast of Kamtchatka (Hultén 1968). This species occurs across Canada (except it is not known from Yukon Territory or the District of Mackenzie), but is generally absent from the western continental U.S., (Kartesz and Meecham 1998). *C. trifolia* grows in fens and wetlands as well as thickets along the southern coast of Alaska (Cody 1996). This species is not uncommon along the southern coastal regions of Alaska and is known from a disjunct station on the coast of the Seward Peninsula (see map in Cook and Roland 2002).

The collection made in the Tokosha Mountains on the south side of the Alaska Range in Denali National Park and Preserve extended the range of this species almost 300 km to the northwest from the nearest published locality in western Prince William Sound (Hultén 1968). Map 41.

<u>Floristic Inventory collections</u>:
Southcentral Alpine:
►Talkeetna Quad: occasional in fen, Tokosha Mountains, AK Range, AK; 1052 m, 62º 42.420'N, 150º 33.030'W, *A. Larsen and M.B. Cook and M. Duffy 01-0398*, 11 July 2001.

<u>Other Park collections:</u>
Southcentral Alpine:
►Talkeetna Quad: tufted bulrush-few flowered sedge meadow; south slope of Tokosha Mountains; 608 m, 62.696°N, 150.517°W, *M. Duffy 01-079*, 11 July 2001.

***Ranunculus occidentalis* Nutt. "Western Buttercup"**
This species of buttercup is endemic to the western mountains of North America, and it primarily occurs in the maritime-influenced coastal ranges, with mostly isolated stations inland, except in the southern part of its range, where it occurs as far east as Wyoming (Hultén 1968, Kartesz and Meecham 1999). In Alaska this species is a common member of lush subalpine meadow communities in the Chugach and southern Wrangell mountain ranges, reaching as far west as the Kenai Peninsula (Cook and Roland 2002). It was collected in nine different sites south of the Alaska Range in the Park, where it was expected to occur, based on nearby collections of the species in the Peter's Hills. The locality in the Kantishna Hills, well north of the Alaska Range crest, on the other hand, was not expected. This was the first record of the species occurring north of the range in Alaska (see Cook and Roland 2002) and represented an extension of this

species range 250 km to the northwest from a station in the Talkeetna Mountains shown in Hultén. In the interest of space, I reference only the Kantishna Hills specimen below. Map 42.

Floristic Inventory collections:
Interior Alpine Outer Range:
►McKinley Quad: 4 km SW of VABM Antim, Kantishna Hills, AK; 1000 m, 63º 41.770'N, 150º 37.380'W, *J. Brodie and A. Larsen 01-390*, 8 August 2001.

Saxifragaceae:
***Saxifraga adscendens* L. ssp. *oregonensis* (Raf.) Baciagalupi, "Small Saxifrage"**
This tiny alpine saxifrage is endemic to the Cordillera of western North America (Kartesz and Meecham 1999) where it occurs in widely scattered localities, often on calcareous substrate such as limestone (Hultén 1968). *S. adscendens* ssp. *oregonensis* is rare in Alaska (S2), where it is known from localities in the Wrangell-St. Elias National Park and Preserve, the Kenai Peninsula, and scattered sites elsewhere (Cook and Roland 2002). This taxon is not considered rare in the Yukon Territory, where it is known from numerous localities across the territory (Cody 1996). The type subspecies of *S. adscendens* occurs in the mountains of Europe (Hultén 1968).

This tiny saxifrage was first collected in Denali National Park and Preserve by Aven and Ruth Nelson near Stony Creek on the Park Road in 1939. It was also collected by Adolph Murie in Sable Pass and Steve Carwile near Thoroughfare Pass prior to this study (see specimen references below). Two new stations for this alpine endemic species were documented during this study – one on each side of the Alaska Range crest, and both on calcareous sedimentary rock. The first specimen was in the Windy Creek drainage near Cantwell, the second new locality was near Divide Mountain in the upper Toklat River area. Map 43.

Floristic Inventory collections:
Southcentral Alpine:
►Healy Quad: rare in mesic snowbed tundra in gully on E-slope; Windy Cr. valley, AK Range, AK; 1311 m, 63º 26.533'N, 149º 07.967'W, *C. Roland 3252*, 9 July 1998.
Interior Alpine Alaska Range:
►Healy Quad: rare on moist, rocky NW-facing calcareous alpine slope, 7 km S of Divide Mt., AK Range, AK; 1676 m, 63º 26.059'N, 149º 58.659'W, *C. Roland and A. Batten 5234*, 8 August 2001.

Other Park collections:
Interior Alpine Alaska Range:
►Healy Quad: Stony Creek area, *A. and R. Nelson 2163*, 16 July 1939.
►Healy Quad: pinnacles northwest of Sable Mountain, 63° 38' N, 149° 40' W, *A. Murie 24.*
►Healy Quad: vicinity Thoroughfare Pass area, Denali Park Road, 1200 m, *S. Carwile 79-145*, 30 June 1979.

Violaceae:
***Viola selkirkii* Pursh., "Great-spurred Violet"**
This violet has a circumpolar distribution, although its range is interrupted and spotty in North America, and it has been considered rare in Alaska (S3) and the Yukon Territory where it is

known from a single locality (Cody 1996). Hultén's range map for the species shows stations in the Cook Inlet area, in Southwestern Alaska, and in the northern southeast panhandle of the state (Hultén 1968). More recent distribution data shows that this species has been collected near Fairbanks and in isolated locations west of the Alaska Range and the Alaska Peninsula (Cook and Roland 2002). The collection of this species in the Rock Creek watershed near Denali National Park and Preserve headquarters connects the range of the species 250 km north of a locality in the lower Susitna River watershed cited by Hultén 1968, to the location near Fairbanks cited in Cook and Roland (2002).

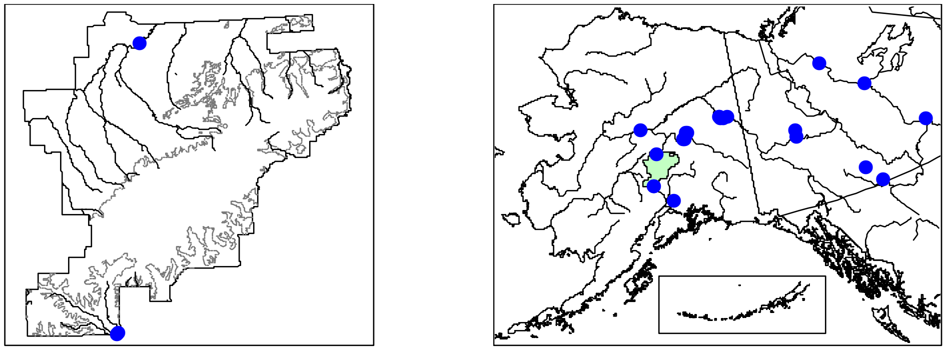
The presence of this small violet in the Rock Creek watershed was first documented by Mike Duffy who made a collection of it there in May 1990. I collected a specimen of the plant in the same watershed in 1998, and during this inventory two additional collections of the species were made, both south of the Alaska Range crest. In addition, Mike Duffy documented four additional locations of the species during field work for the Soils Inventory. In the interest of brevity, I reference only the collections in Rock Creek below (which represent a major range extension for the species).

It seems likely that this species is considerably more common than once thought. This species flowers quite early and often occurs in dense underbrush with alder thickets. For both of these reasons, it is not a particularly apparent plant and hence is probably under-represented in collections. Map 44.

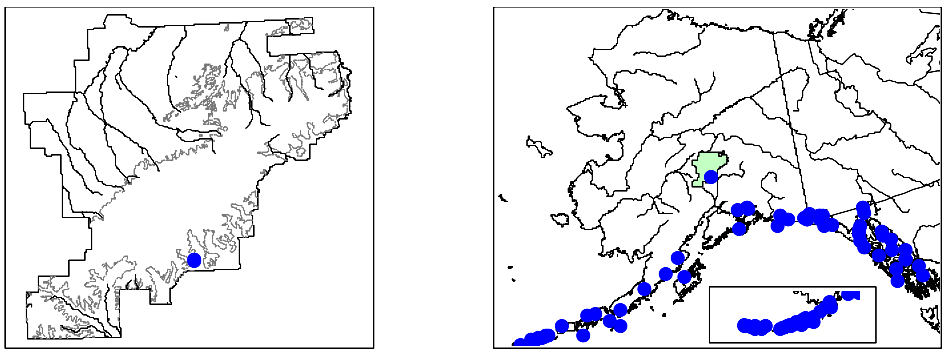
<u>Floristic Inventory collections:</u>
Interior Boreal Floodplain:
►Healy Quad: scattered in mossy area in spruce woods, floodplain of Rock Cr. valley, AK Range, AK; 701 m, 63º 44.002'N, 148º 59.358'W, *C. Roland 3001*, 1 June 1998.
►Healy Quad: growing in dense alder with lush understory; Rock Cr. drainage near Park HQ, AK Range, AK; 927 m, 63º 44.714'N, 148º 59.398'W*, J. Brodie 01-085*, 26 June 2001.

<u>Other Park collections</u>:
Interior Boreal Floodplain:
►Healy Quad: riparian zone, Rock Creek drainage near Park Headquarters, 620 m, *M. Duffy, s.n*, 25 May 1990.

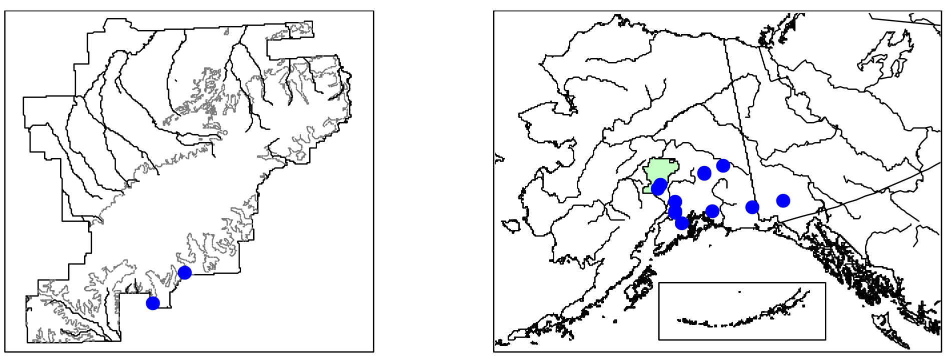
Distribution maps for noteworthy taxa documented during this study



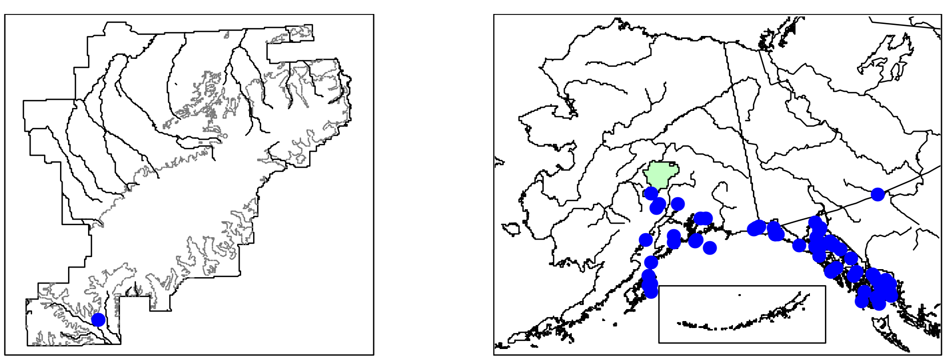
1. ***Cicuta bulbifera*** **L.**



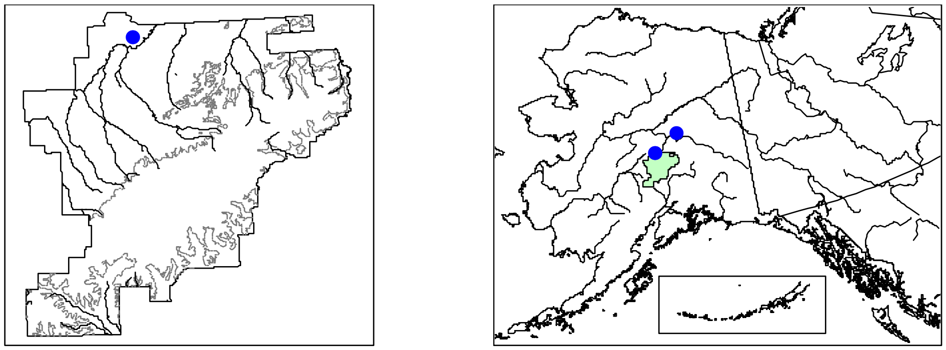
2. ***Anaphalis margaritacea*** **(L.) Benth. & Hook**



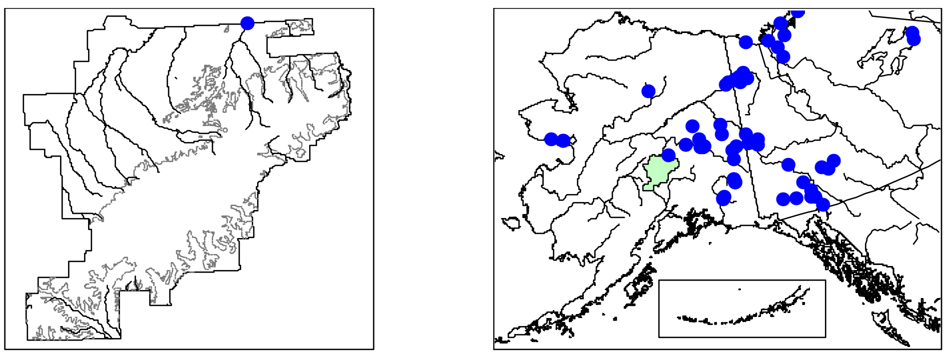
3. ***Arnica diversifolia*** **Greene**



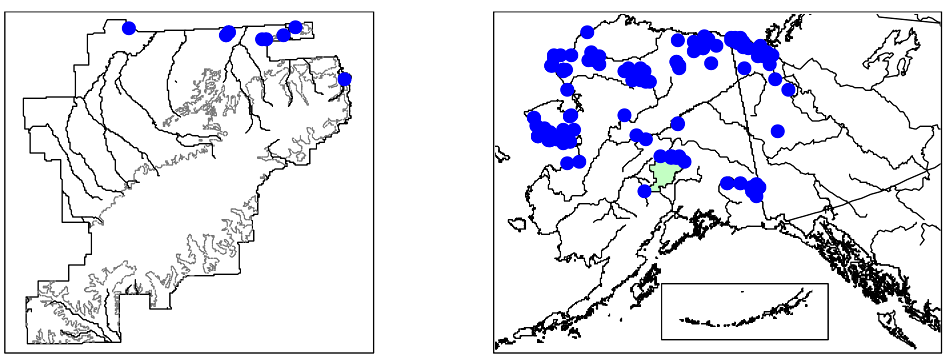
4. ***Aster subspicatus*** **Nees**



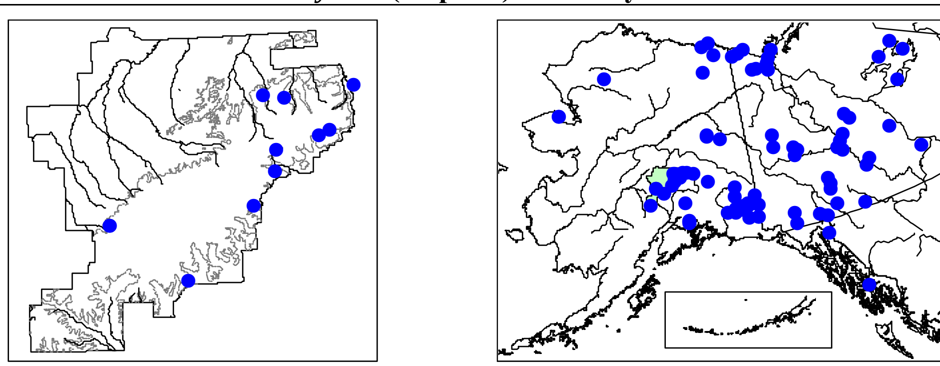
5. ***Bidens tripartita*** **L.**



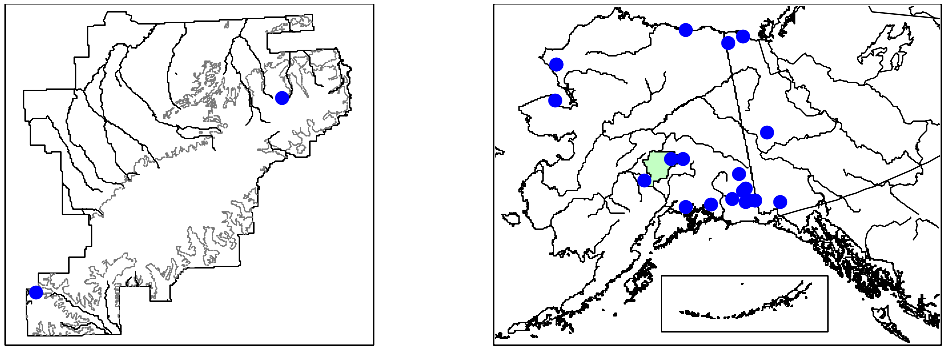
6. ***Halimolobos mollis*** **(Hook.) Rollins**



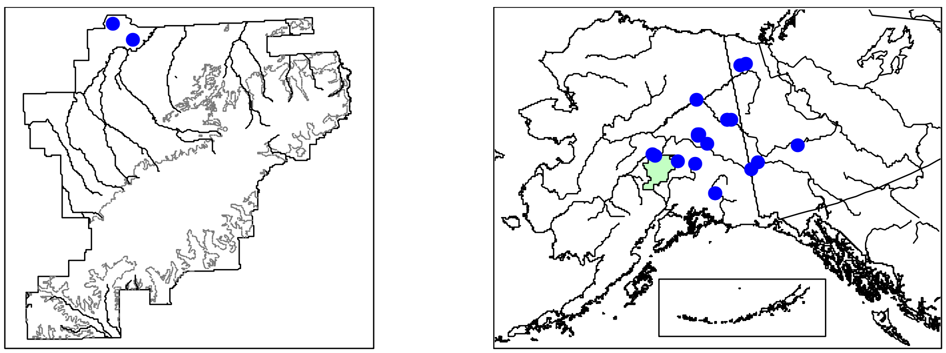
7. ***Smelowskia calycina*** **(Stephan) C.A. Meyer sensu lat.**



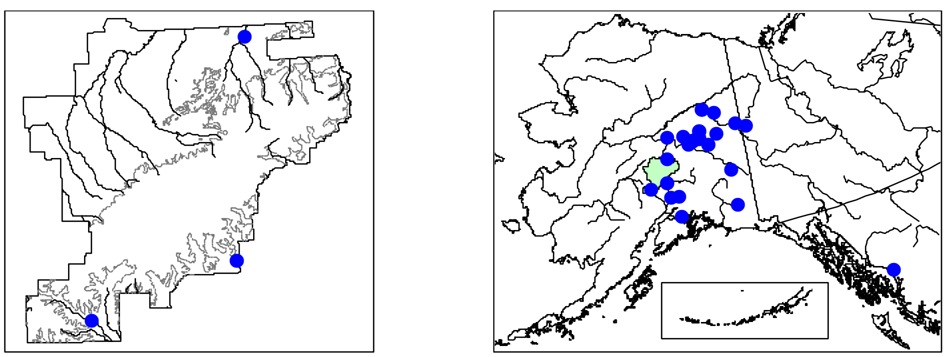
8. ***Minuartia biflora*** **(L.) Schinzl. & Thell.**



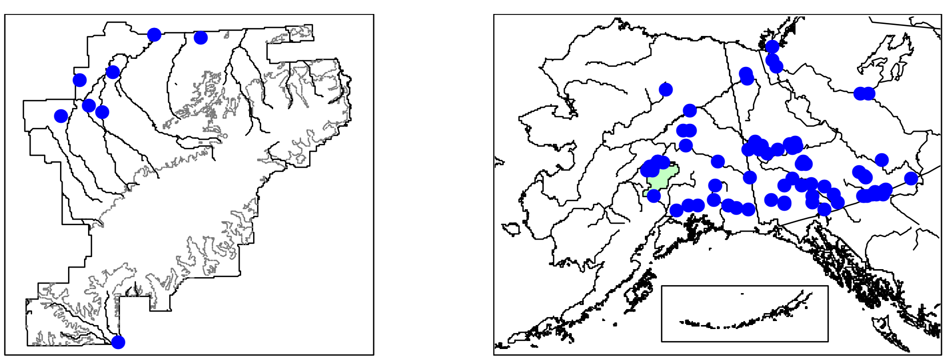
9. ***Stellaria umbellata*** **Turcz.**



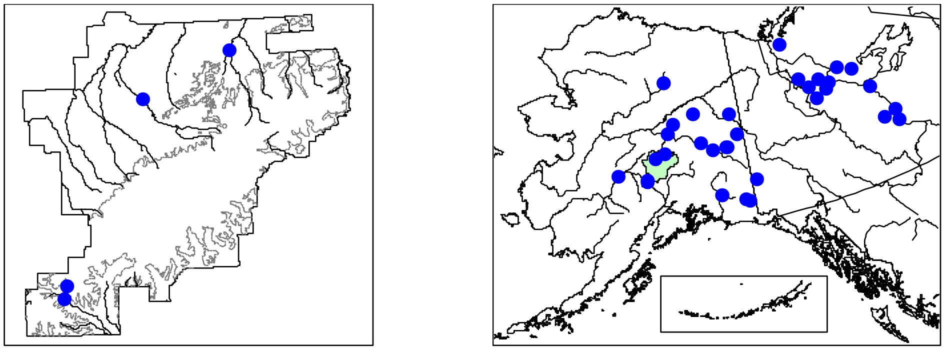
10. ***Ceratophyllum demersum*** **L.**



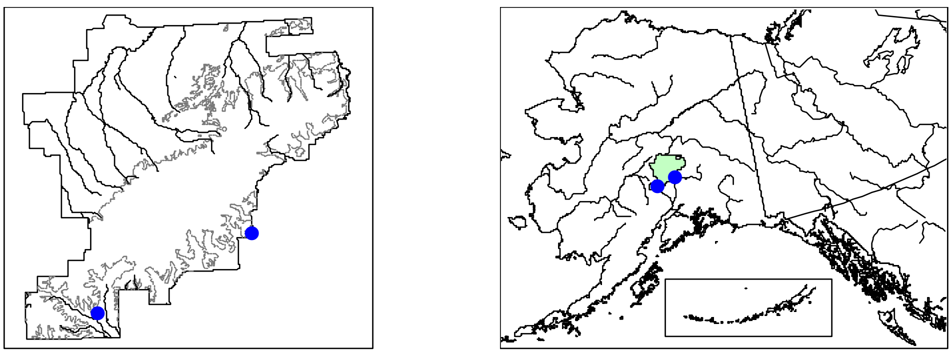
11. ***Carex crawfordii*** **Fern.**



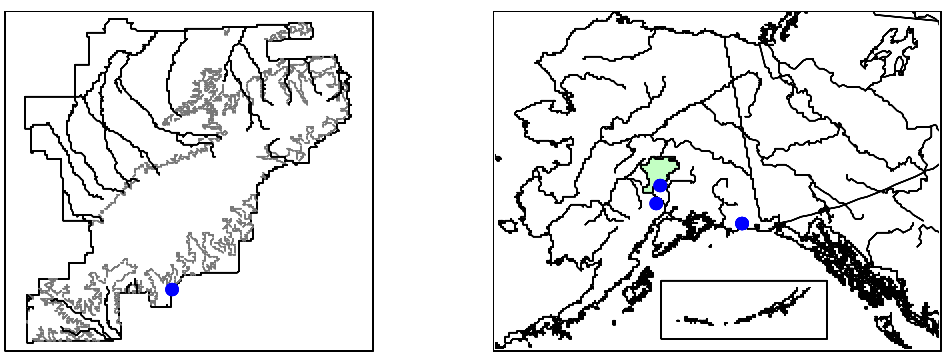
12. ***Carex diandra*** **Schrank**



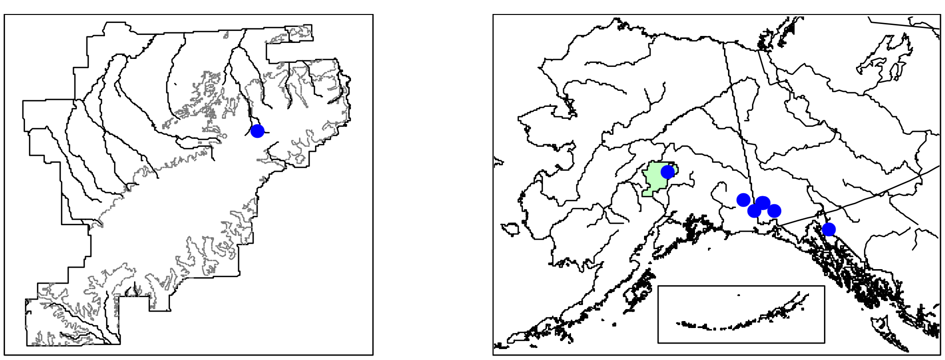
13. *Carex eburnea* Boott



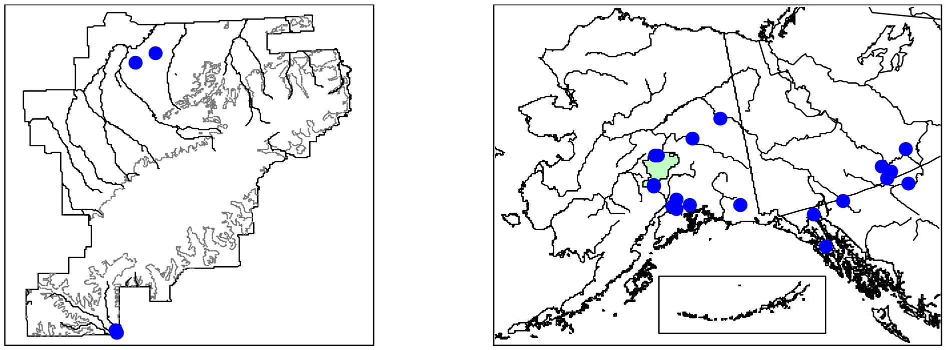
14. *Carex echinata* Murr. ssp. *echinata*



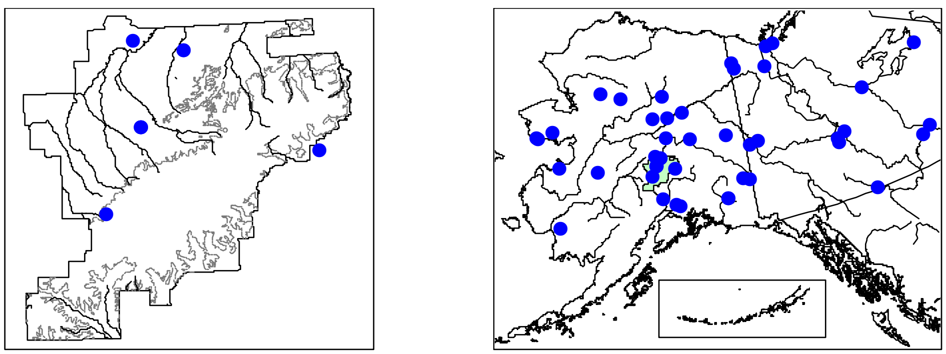
15. *Carex echinata* Murr. ssp. *phyllomanica* (W. Boott.) Reznicek



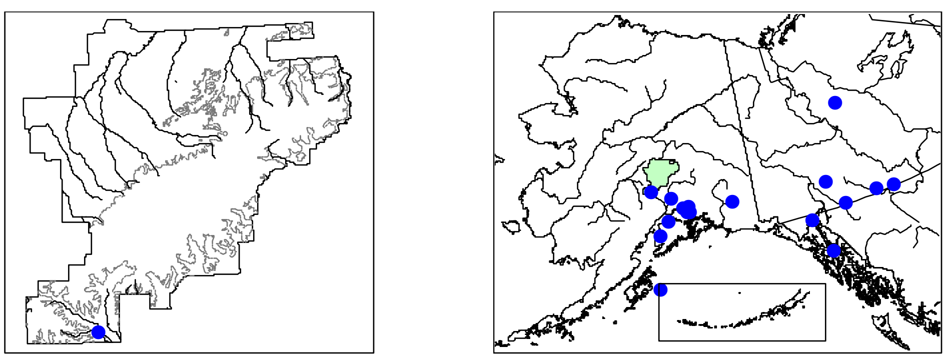
16. *Carex incurviformis* Mackenzie in Rydb.



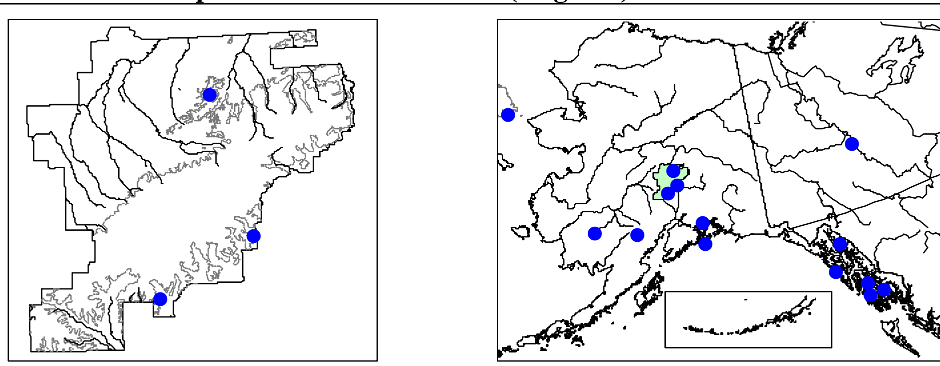
17. ***Carex interior*** **Bailey**



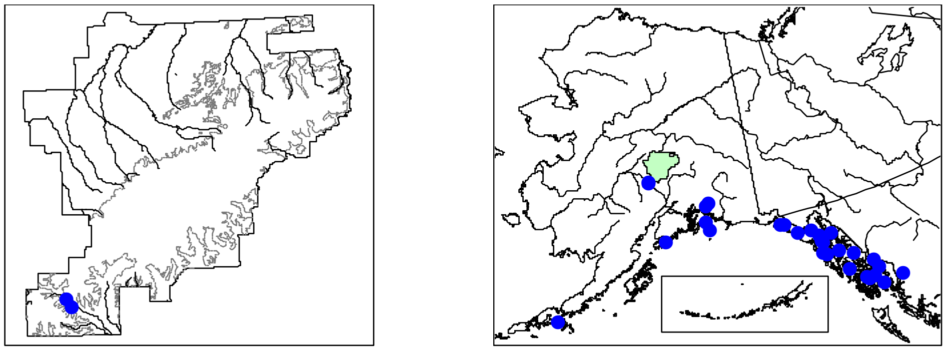
18. ***Carex lapponica*** **O.F. Lang**



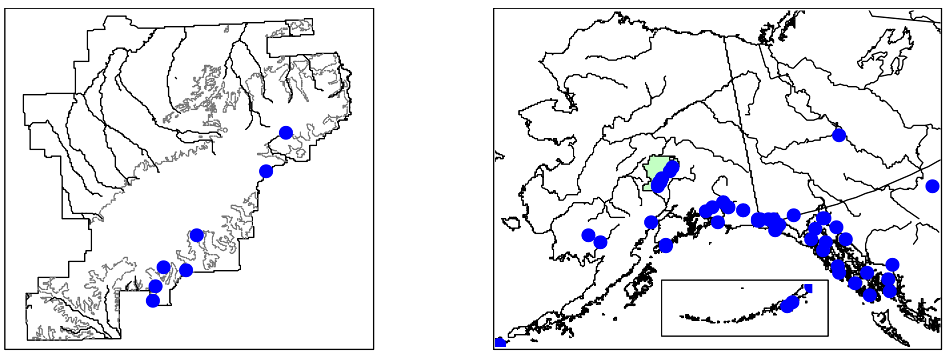
19. ***Eriophorum viridi-carinatum*** **(Engelm.) Fern.**



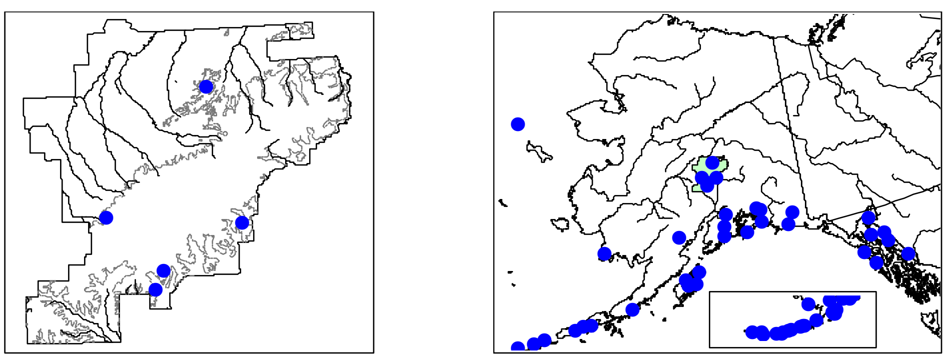
20. ***Athyrium alpestre*** **(Hoppe) Clairville**



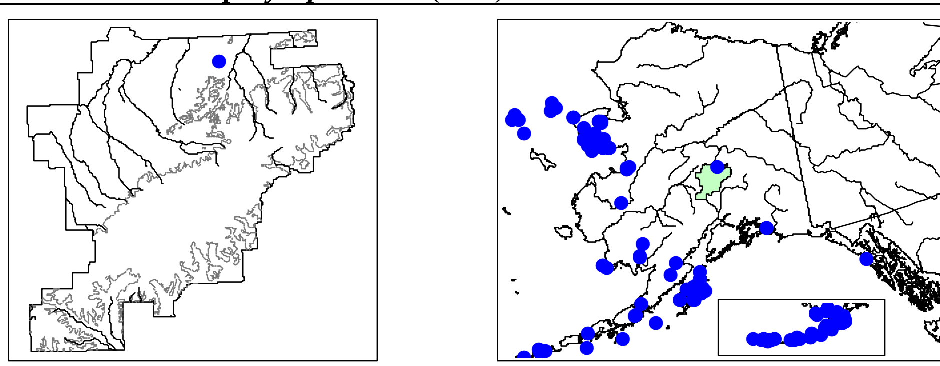
21. *Polystichum braunii* (Spenn.) Fee



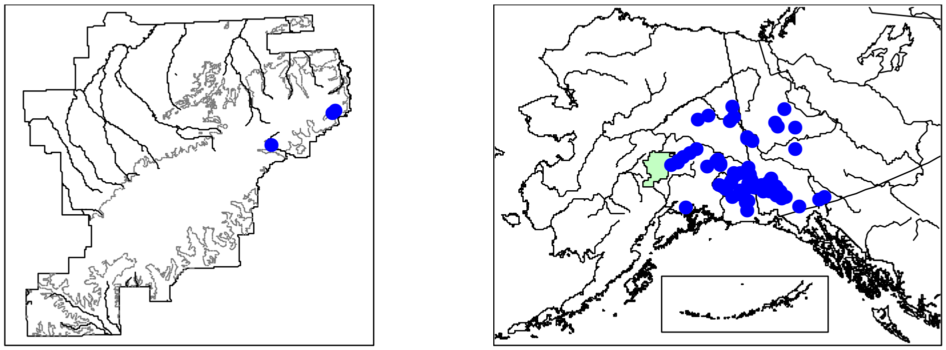
22. *Polystichum lonchitis* (L.) Roth



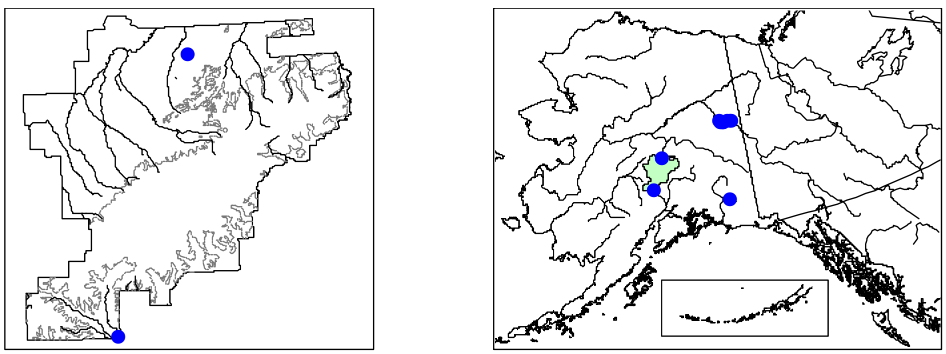
23. *Cassiope lycopodioides* (Pall.) D. Don



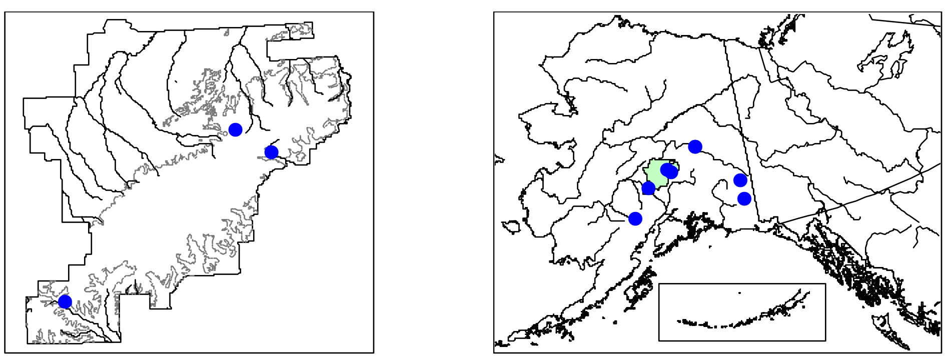
24. *Rhododendron camtschaticum* Pall.



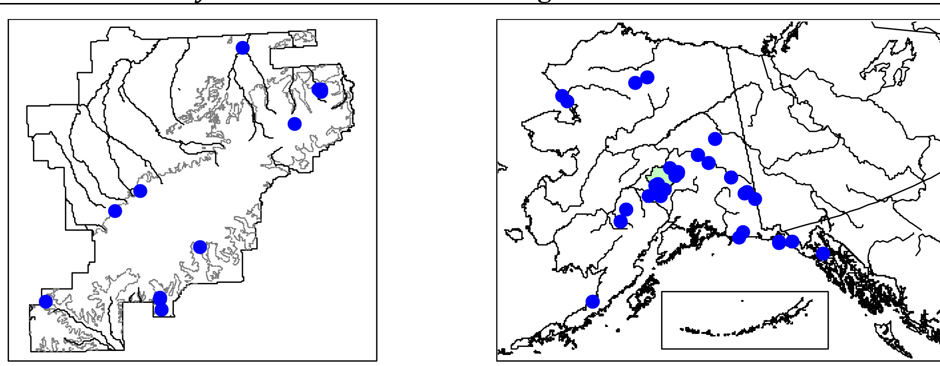
25. ***Oxytropis huddelsonii*** **Pors.**



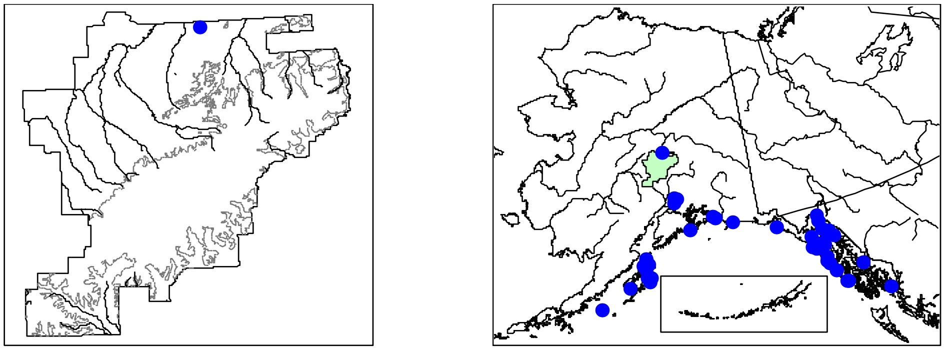
26. ***Najas flexilis*** **(Willdenow) Rostkov. & Schmidt**



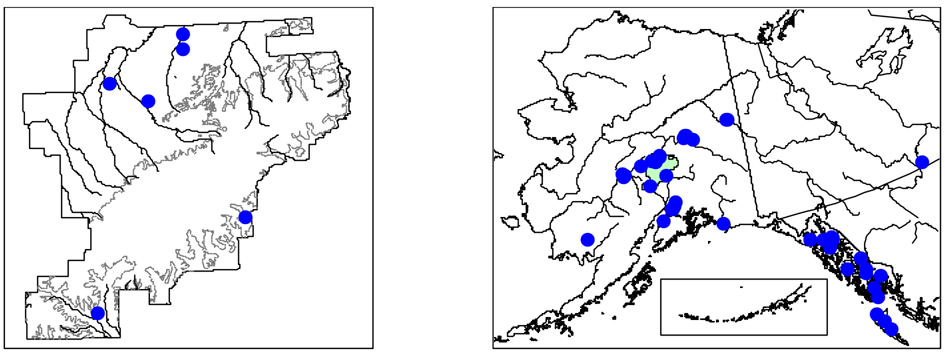
27. ***Botrychium alaskense*** **W.H. Wagner & J.R. Grant**



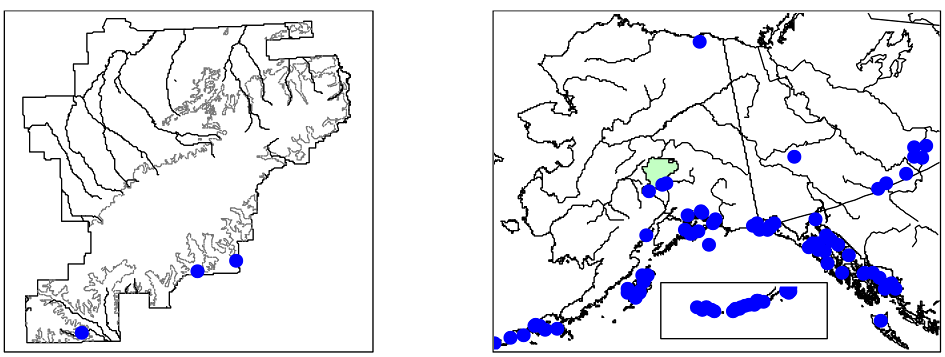
28. ***Botrychium minganense*** **Victorin**



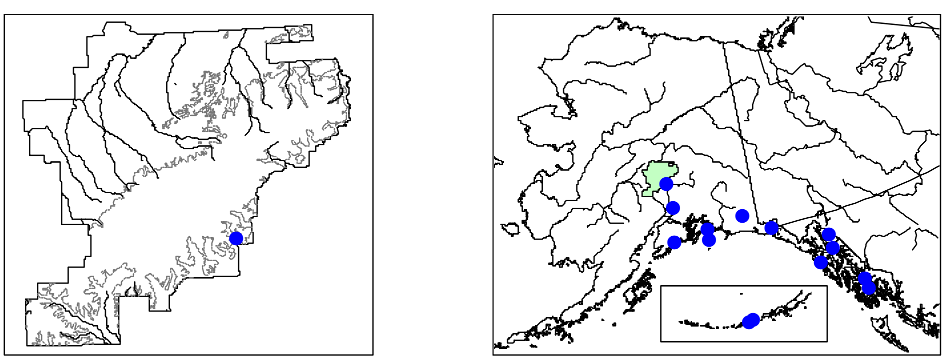
29. *Malaxis monophylla* (L.) Sw.



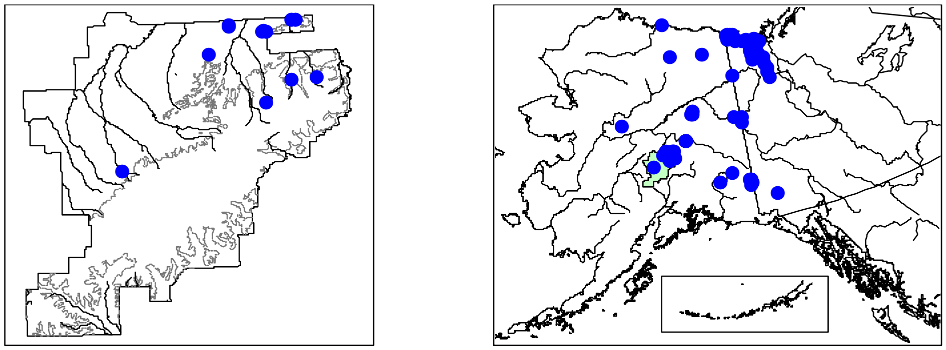
30. *Malaxis paludosa* (L.) Sw.



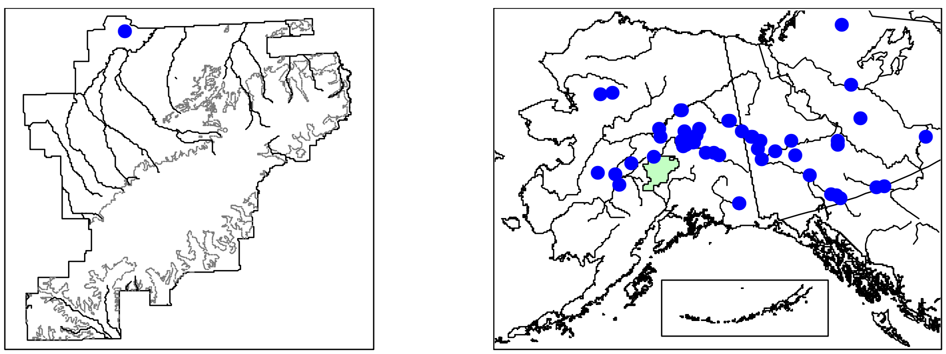
31. *Agrostis exarata* Trin.



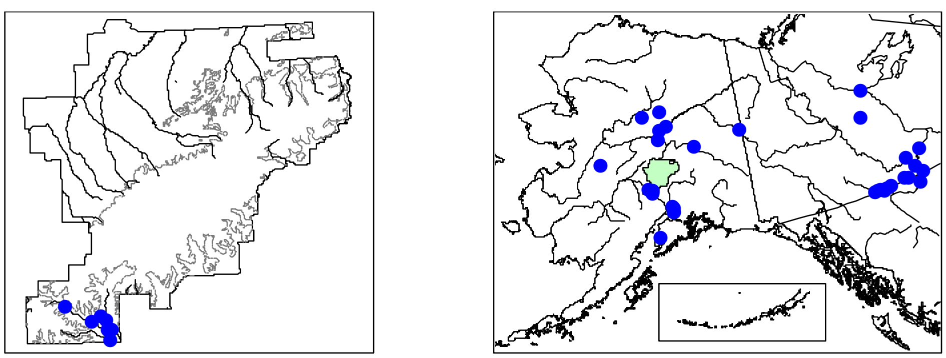
32. *Agrostis thurberiana* A. S. Hitchc.



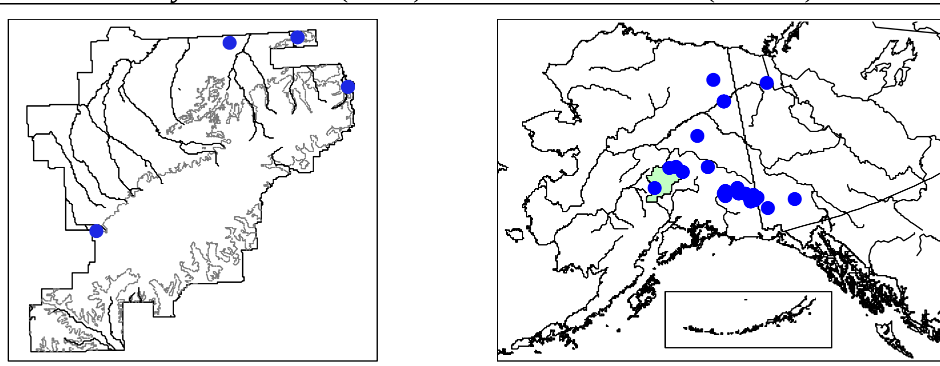
33. *Festuca lenensis* Drobov



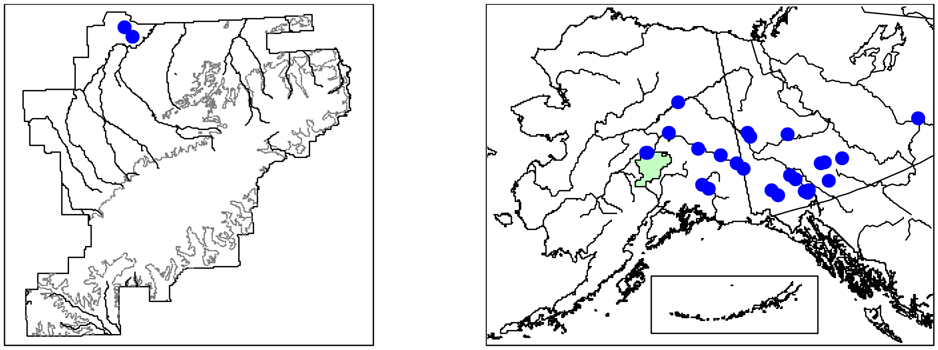
34. *Glyceria pulchella* (Nash) K. Schum.



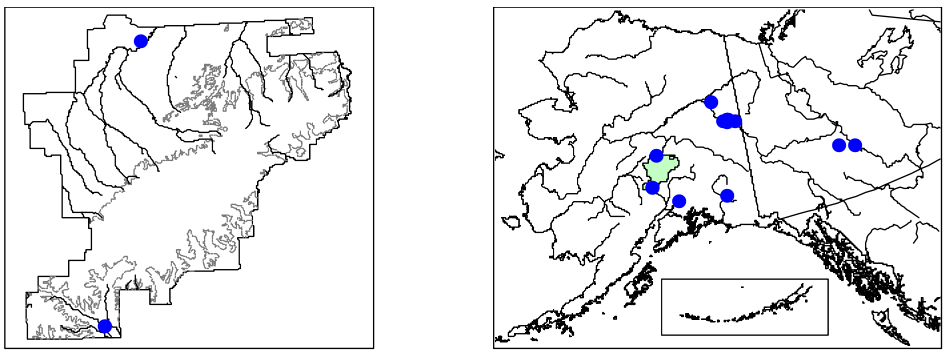
35. *Glyceria striata* (Lam.) Hitchcock var. *stricta* (Scribn.) Fern.



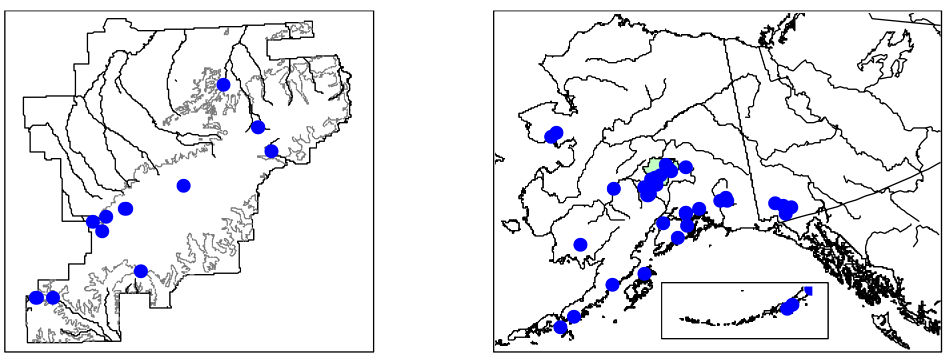
36. *Phlox richardsonii* Hook.



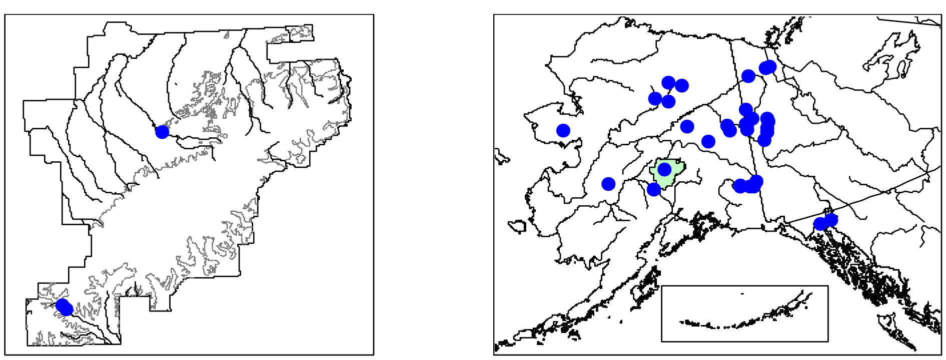
37. ***Rumex maritimus*** **L.**



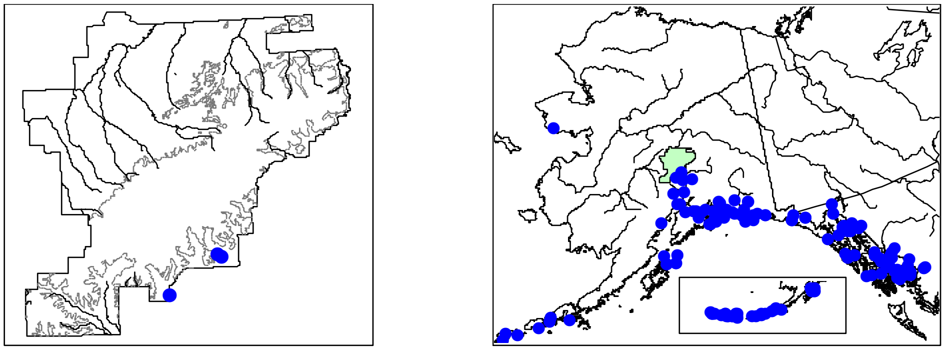
38. ***Potamogeton obtusifolius*** **Mert. & Koch**



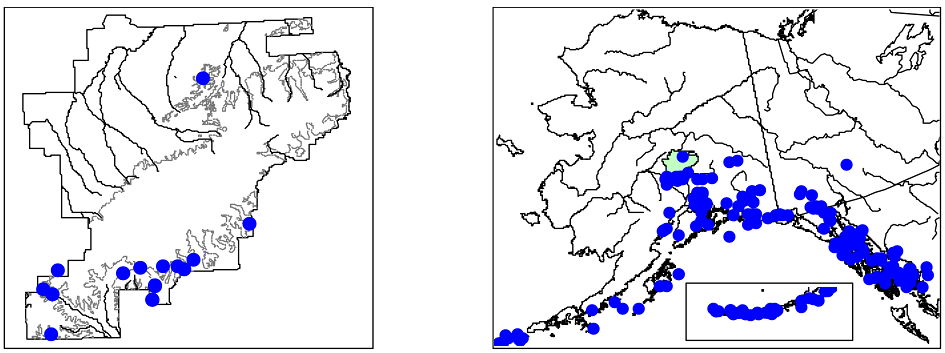
39. ***Douglasia alaskana*** **(Coville & Standley ex Hultén) S. Kelso**



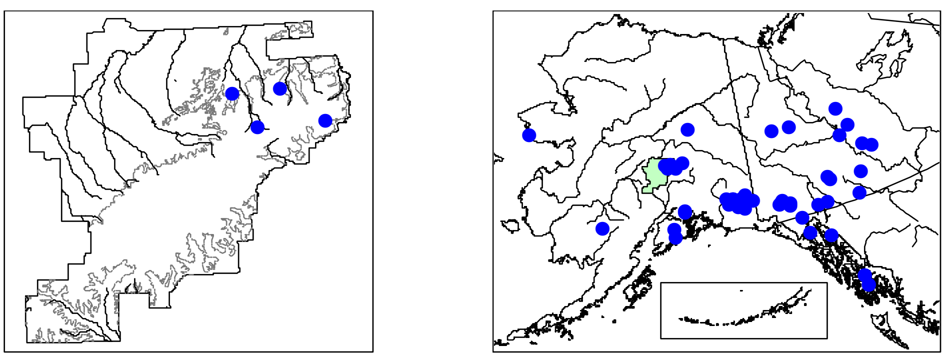
40. ***Cryptogramma stelleri*** **(S.G. Gmel.) Prantl.**



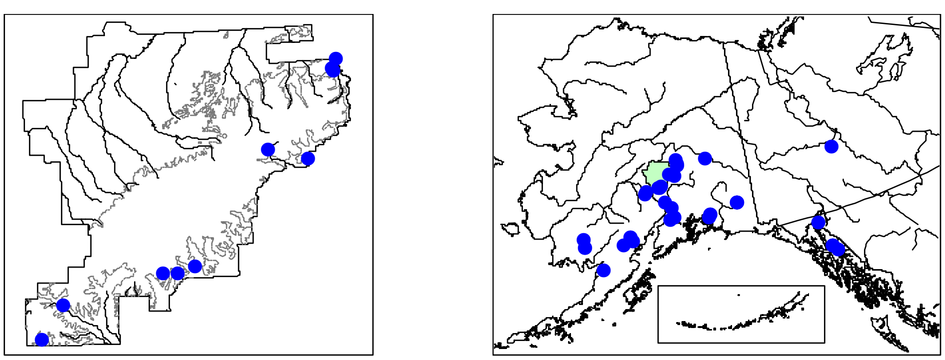
41. ***Coptis trifolia*** **(L.) Salisb.**



42. ***Ranunculus occidentalis*** **Nutt.**



43. ***Saxifraga adscendens*** **L. ssp.** ***oregonensis*** **(Raf.) Baciagalupi**



44. ***Viola selkirkii*** **Pursh.**

D. Occurrences of plant species tracked by the Alaska Natural Heritage Program

The State of Alaska does not maintain a list of rare or sensitive plant species. As a result, agencies and groups interested in the conservation of botanical diversity rely on the Alaska Natural Heritage Program (AKNHP) vascular plant tracking list for rare and potentially sensitive species. The list of species with a state rank of S1, S2 or S3 is generally considered to be the list of rare plants for the State of Alaska (**www.uaa.alaska.edu/enri/aknhp_web/biodiversity /akbiodiv.html**).

Two hundred and thirty-eight specimens of 47 taxa considered rare in Alaska by the Alaska Natural Heritage Program were collected during this inventory (see Table 7.1). Six of these species had a state-level rarity rank of S1 *Agrostis clavata, Arnica diversifolia, Carex interior*, *Cicuta bulbifera*, *Najas flexilis,* and *Potamogeton obtusifolius*.

None of these very rare species were known to occur in the Park prior to this inventory. An additional 20 taxa documented in the Park by this inventory had a state rarity rank of S1 or S2. Of these 18 taxa, 14 were new to the Park based on collections made during this inventory. The remaining 21 tracked vascular plant taxa were ranked S3 (see Table 7.1), and five of these S3 species were new to Park flora from this inventory project.

In general, the plant species from the AKNHP vascular plant tracking list that occurred in Denali National Park and Preserve fit into one of two broad categories: 1) Alaska –Yukon or Amphiberingian endemic species that have restricted and compact geographic ranges that are generally limited to alpine sites or other treeless, well-drained habitats such as dry slopes in Alaska and neighboring areas (examples of this set of rare taxa include *Douglasia gormanii*, *Papaver alboroseum*, and *Stellaria dicranoides*); or 2) wetland or aquatic plants that have wide-ranging geographic distributions that are nevertheless very interrupted and spotty within Alaska. Many of these wetland plants are thus regionally quite rare with few documented localities in Alaska. Examples of these rare wetland and aquatic plants that occurred in the Park included: *Ceratophyllum demersum*, *Cicuta bulbifera*, and *Najas flexilis*. A smaller subset of the AKNHP-tracked taxa was composed of plants that occurred in meadows in the western Cordillera whose ranges just reach Alaska, which is their western distribution limit. These taxa generally occurred in lush sloping meadows south of the Alaska Range crest and included species such as *Arnica diversifolia* and *Agrostis thurberiana*.

E. Range extensions for vascular plant taxa

The current knowledge of the distribution of the flora of Alaska is highly uneven. Whereas some areas are very well known and the flora is documented with complete collections from numerous localities, the floras of other areas are essentially unknown or only poorly known from only a few widely scattered collection localities. As a result, new collections in previously unsurveyed territory in Alaska (such as much of Denali National Park and Preserve was prior to 1998) can result in major extensions for the known ranges of plant species. This study was no exception in this regard.

Collections made during the floristic inventory of Denali National Park and Preserve documented major range extensions for 32 taxa of vascular plants (Table 5.1; for a list of these species see Table 5.2). Seventy-three voucher specimens were made of this suite of taxa during this study. Simple range extensions for an additional 78 plant taxa were documented by collections made during this inventory. Two hundred and ten individual specimens were collected of these taxa (Table 5.2; for a list of these species see Table 5.3). For the definitions of range extension employed during this study, please consult Chapter 4 of this report.

Table 5.1. Number of species in each of two range extension classes resulting from Denali National Park and Preserve Floristic Inventory Project (1998-2001)

Range Extension category	# of taxa for which range extended	# collections of these taxa within Park
Major range extension	34	76
Range extension	78	210

As would be expected, the biogeographic characteristics of the sets of taxa for which range extensions were documented were quite different between floristic regions of the Park. Of the 34 taxa for which major range extensions were documented, 11 occurred only on the south side of the range, 11 occurred only on the north side of the range, and the remaining 12 taxa were found in sites on both sides of the Alaska Range crest.

The major range extensions that were documented in this study fell into three basic categories: 1) plants of coastal and Cordilleran distribution that reach their northern and/or western range limits in the Park; 2) plants of primarily arctic and interior distribution for which the Denali National Park and Preserve region represented a southern range limit; and finally 3) plants with wide-ranging, but spotty, distributions that were only found in widely separated localities in the Alaska portion of their range.

The southern slopes of the Alaska Range and the Cook Inlet lowlands represents the northern range limit for numerous species limited to maritime-influenced climate zones, including *Polystichum braunii*, *Cinna latifolia*, *Carex echinata*, *Carex mertensii*, *Salix sitchensis,* and *Viola glabella* to name just a few. This is due to the fact that the Cook Inlet drainage basin, (and its associated maritime-influenced climate), penetrates farther north into mainland Alaska in this region than anywhere else. This region of *relatively* moderate climate represents the northern edge of the distribution of numerous taxa of more temperate distribution, including numerous lowland taxa (such as those cited above), as well as several Cordilleran montane and alpine taxa that do not occur north of the Alaska Range such as *Aster subspicatus*, *Juncus mertensianus*, and *Senecio triangularis*, among others. Biogeographically, then, this section of the Park is an important region because it represented the northern range limit for a large suite of vascular plant species, and thus a major floristic “fault-line” within Alaska.

A similar (but more surprising) result of this inventory was the documentation of a set of alpine taxa of generally coastal (and mostly southern) distribution growing together in a relatively small area of the central Kantishna Hills. Major northward range extensions for *Athyrium alpestre*, *Cassiope lycopodioides*, *Epilobium leptocarpum, Ranunculus occidentalis,* and *Rhododendron camtschaticum* were documented within this relatively small interior region during this

Table 5.2: Major range extensions for vascular plant taxa documented by collections made during Floristic Inventory of Denali National Park and Preserve Project (1998-2001).

Taxon	Floristic regions	Description of maximum range extension documented for taxon in Denali National Park and Preserve
Agrostis clavata	SC Boreal Subalpine	Southernmost locality in AK, 350 km SW from Fairbanks-area locality in Hultén
Agrostis exarata	SC Boreal Lowland SC Boreal Floodplain	Farthest N locality in N Am., 300 km NW of Prince William Sound locality in Hultén
Anaphalis margaritacea	SC Alpine Mtn	Northernmost locality for species, 250 km NW from Prince William Sound locality
Aster subspicatus	SC Boreal Lowland	260 km NW from Hultén map; 160 km NW from unpublished locality at Hatcher Pass
Athyrium alpestre* var. *americanum	SC Alpine Mtn Int Alpine Outer Range	First locality N of AK Range, south-side locality is 250 km NW of Hultén locality on Prince William Sound, Kantishna Hills locality is 340 km NW of Prince William Sound locality in Hultén
Bidens tripartita	Int Boreal Lowland	New to the flora of Alaska, closest record in British Columbia
Botrychium alaskaense	SC Alpine Mtn SC Boreal Subalpine	New localities for new taxon described in 2002.
Botrychium minganense	Int Alpine Alaska Range SC Alpine Mtn	405 km SE from localities in Wrangell-St. Elias NP (see Cook and Roland 2002)
Carex echinata* ssp. *echinata	SC Boreal Lowland	1,400 km NE from locality near Unalaska in the Aleutian Islands in Hultén
Carex echinata* ssp. *phyllomanica	SC Boreal Subalpine	320 km NW from Prince William Sound locality in Hultén
Carex incurviformis	Int Alpine Alaska Range	525 km NW from locality in Chitina R. drainage in eastern Alaska
Cassiope lycopodioides	Int Alpine Outer Range	Farthest N locality in N Am., first locality N of AK Range, 330 km NW of Whittier locality in Hultén
Coptis trifolia	SC Alpine Mtn	300 km NW from Hultén locality in western Prince William Sound
Cryptogramma stelleri	SC Boreal Subalpine Int Boreal Lowland	Southernmost Alaska locality, only one S of AK Range, 300 km SE of Hultén locality
Draba corymbosa	Int Alpine Alaska Range	Species primarily arctic; 400 km NE from Wood-Tikchik locale in Cook and Roland 2002
Epilobium leptocarpum	Int Alpine Outer Range	First locality N of AK Range, 350 km N of Kenai Peninsula locality in Hultén
Halimolobos mollis	Interior Boreal Floodplain	Farthest W locality except for disjunct location at Bluff on Seward Peninsula, 400 km S of Hultén locality in Brooks Range; 400 km W of Chitina locality
Lycopodium clavatum* ssp. *clavatum	SC Boreal Subalpine	250 km NW of Portage-area Hultén map locality
Malaxis monophylla	Int Boreal Lowland	260 km N of Cook Inlet lowlands locality in Hultén
Minuartia yukonensis	SC Boreal Subalpine	Farthest S known locality; 325 km S from Hultén map
Najas flexilis	Int Boreal Lowland	250 km NW of Fort Richardson locality near Anchorage
Oxytropis campestris* ssp. *jordallii	SC Boreal Subalpine	350 km SW from Hultén locality in White Mtns area
Papaver lapponicum	SC Boreal Subalpine	Only locality S of AK range, 300 km SW from Hultén's southernmost locality
Pedicularis macrodonta	Int Boreal Lowland	Only published report N of AK Range; 275 km NW of Cook Inlet lowland locality in Hultén

Table 5.2 (continued): Major range extensions for vascular plant taxa documented by collections made during Floristic Inventory of Denali National Park and Preserve Project (1998-2001).

Phlox richardsonii	Int Alpine Outer Range Int Alpine Alaska Range	Westernmost locality, 400 km SW of Yukon-Tanana uplands locality in Hultén
Polystichum braunii	SC Boreal Subalpine	330 km WNW of Valdez-area locality in Hultén
Polystichum lonchitis	SC Alpine Mtn	Northern limit of range in N. Am.; 350 km NW of Valdez-area locality in Hultén
Potamogeton obtusifolius	SC Boreal Lowland Int Boreal Lowland	Species not listed for Alaska in Hultén, Park locality is 1000 km W of Cody locality
Primula mistassinica	Int Boreal Upland	Few published localities, 550 km SW from Hultén locality in Ogilvie Mtns
Ranunculus occidentalis* ssp. *occidentalis	Int Alpine Outer Range	230 km NW of Talkeetna Mtns locality in Hultén
Rhododendron camtschaticum	Int Alpine Outer Range	Farthest inland collection for otherwise coastal taxon, 500 km E (inland) from locality on lower Yukon R. in Hultén
Rumex maritimus	Int Boreal Lowland	360 km WNW of Hultén locality in the Copper R. drainage
Smelowskia calycina	Int Alpine Outer Range Int Boreal Upland	Farthest SW published locality in AK, one ALA specimen from Farewell area to SW of the Park, 250 km SE from Yukon R. locality in Hultén
Viola selkirkii	Int Boreal Floodplain	250 km N of Hultén locality in Susitna R. Valley

Table 5.3: List of vascular plant taxa for which range extensions were documented during Floristic Inventory Project (1998-2001).

Taxon	Floristic regions	Description of maximum range extension documented for taxon in Denali National Park and Preserve
Agrostis alaskana	SC Boreal Subalpine, SC Alpine Mtn	320 km N from Kachemak Bay locality in Hultén; 150 km SE from Kuskokwim locality
Agrostis thurberiana	SC Boreal Subalpine	170 km NW of locality near Anchorage from Cook and Roland 2002 map
Angelica genuflexa	SC Boreal Subalpine, SC Boreal Floodplain	Northernmost locality in AK.; 125 km NW from Hultén Susitna R. lowlands locality
Aphragmus eschscholtzianus	Int Alpine Alaska Range	225 km NW from Fort Richardson locality
Arabis drummondii	SC Alpine Mtn	175 km N from Chugach Mtns locality
Arnica diversifolia	SC Alpine Mtn	Westernmost locality for taxon; 170 km WNW from Fort Richardson locality
Bidens cernua	Int Boreal Lowland	Southernmost collection in AK; 130 km S of Tanana R. locality in Hultén
Botrychium lanceolatum	SC Boreal Subalpine	400 km N of southern Kenai Peninsula locality in Hultén
Carex anthoxanthea	SC Alpine Mtn	120 km W of Hultén locality in Chugach Mtns
Carex bonanzensis	Int Boreal Floodplain	240 km NW from Hultén locality near Fairbanks
Carex diandra	SC Boreal Floodplain, Int Boreal Floodplain	Connects Anchorage locality with interior localities; 150 km NW from Anchorage locality
Carex enanderi	SC Boreal Subalpine, SC Alpine Mtn	170 km NW from Anchorage locality in Hultén
Carex interior	SC Boreal Lowland, SC Boreal Floodplain	220 km NW from Cook Inlet lowlands locality on Hultén map
Carex lapponica	Int Boreal Lowland, Int Alpine Alaska Range	240 km S of Tanana River locality in Hultén
Carex lyngbyaei	SC Boreal Lowland	150 km NW of Cook Inlet lowlands locality in Hultén
Carex mertensii	SC Boreal Lowland, SC Alpine Mtn	100 km NW from Susitna Valley locality in Hultén
Carex nigricans	SC Alpine Mtn	130 km NW from Hatcher Pass locality in Hultén
Carex oederi* ssp. *viridula	SC Boreal Lowland	Western limit of range, 230 km NW from Fort Richardson locality
Carex pachystachya	SC Alpine Mtn, SC Boreal Subalpine, SC Boreal Lowland	160 km W of Hultén localities
Carex petricosa	SC Boreal Subalpine	Only collection S of AK Range; 220 km S from Healy locality; in W Yentna Notch
Carex phaecocephala	SC Alpine Mtn	160 km NW from Chugach Mtns locality in Hultén
Carex sitchensis	SC Alpine Mtn	180 km N of Cook Inlet locality in Hultén
Carex spectabilis	SC Alpine Mt, SC Boreal Subalpine	250 km N from Kenai locality in Hultén
Ceratophyllum demersum	Int Boreal Lowland	150 km W of Hultén locality near Denali Hwy
Cicuta bulbifera	SC Boreal Floodplain	200 km NW from locality near Anchorage in Cook Inlet lowlands
Cinna latifolia	SC Boreal Lowland	Northernmost limit of range, 100 km W from Talkeetna locality in Hultén
Draba crassifolia	Int Alpine Alaska Range, SC Alpine Mtn	100 km WSW from Hultén locality
Draba stenoloba	SC Alpine Mtn, SC Boreal Subalpine	210 km NW from Fort Richardson locality

Table 5.3 (cont'd): List of vascular plant taxa for which range extensions were documented during Floristic Inventory Project (1998-2001).

Danthonia intermedia	SC Boreal Subalpine, SC Alpine Mtn	150 km NW from Talkeetna Mtns locality in Hultén
Deschampsia beringensis	SC Boreal Lowland	110 km NW from Cook Inlet lowland locality in Hultén
Diphasiastrum sitchense	SC Alpine Mtn	Northernmost locality; 175 km NW of Glenn Highway locality on Hultén map
Epilobium leptocarpum	Int Alpine Outer Range, Int Alpine AK Range	200 km NW of Kenai locality in Hultén
Epilobium luteum	SC Alpine Mtn	150 km N of Cook Inlet lowlands locality in Hultén
Eriophorum viridi-carinatum	SC Boreal Subalpine	Farthest N locality; NW extension of taxon; 150 km NW of Cook Inlet locality
Euphrasia mollis	SC Boreal Subalpine	225 km N from coastal locality in Hultén
Gentiana douglasiana	SC Boreal Lowland	150 km N from Cook Inlet locality in Hultén
Gentianella amarella* ssp. *acuta	SC Alpine Mtn	Farthest NW locality in N Am; 200 km NW of Chugach Mtns locality in Hultén
Glyceria striata* ssp. *stricta	SC Boreal Subalpine	200 km NW from Ft. Richardson locality near Anchorage
Geum macrophyllum* ssp. *macrophyllum	SC Boreal Subalpine	Northernmost locality; 200 km NW from Fort Richardson locality
Hippuris montana	SC Alpine Mtn	180 km W of AK Range locality in Hultén
Isoetes echinospora	Int Boreal Lowland	230 km W of Hultén localities
Juncus drummondii	Int Alpine Outer Range	NW extent of taxon range; 120 km NW from localities above Susitna River in Hultén
Kobresia sibirica	SC Alpine Mtn, Int Alpine Alaska Range	200 km SW from Hultén locality near McKinley Park
Lemna minor	Int Boreal Lowland	125 km SW of Tanana River stations mapped in Hultén
Listera cordata	SC Alpine Mtn	Near N extent of range as reflected in ALA; 150 km NNW from Hultén map locality
Matteuccia struthiopteris	SC Boreal Floodplain	115 km W from Susitna River locality in Hultén
Melandrium taylorae	SC Boreal Subalpine	400 km E from Hultén locality, 225 km NW from map locality near Anchorage in Hultén
Minuartia biflora	Int Alpine Alaska Range, SC Alpine Mtn	Western limit of range, 250 km NW of Forth Richardson locality
Mitella pentandra	SC Alpine Mtn	At northern range limit; 150 km NW from locality near Anchorage in Hultén
Myriophyllum verticillatum	Int Boreal Lowland	210 km SW of Fairbanks-locality in Hultén
Osmorhiza depauperata	SC Boreal Floodplain	150 km NW from locality near Anchorage
Oplopanax horridus	SC Boreal Lowland	150 km NW from locality near Anchorage
Oxytropis campestris* ssp. *jordallii	Int Boreal Upland, SC Boreal Subalpine	Southwestern-most station in AK; 350 Km SW from Hultén locality in White Mts area
Papaver lapponicum	Int Alpine Outer Range	Southern limit of range, 110 km SW from Hultén locality
Phippsia algida	Int Alpine Alaska Range	150 km SW of AK Range locality in Hultén
Phyllodoce aleutica* ssp. *glanduliflora	Int Alpine Outer Range, SC Alpine Mtn	150 km W of AK Range collection locality in Hultén
Phyllodoce caerulea	SC Alpine Mtn	New to Cook Inlet drainage; 125 km E of Farewell-locality in Hultén

Table 5.3 (cont'd): List of vascular plant taxa for which range extensions were documented during Floristic Inventory Project (1998-2001).

Platanthera dilatata	SC Boreal Floodplain, SC Alpine Mtn	200 km NW from Fort Richardson locality
Platanthera stricta	SC Alpine Mtn	Northernmost locality; NW range extension; 150 km NW from Palmer locality in Hultén
Platanthera dilatata	Int Boreal Lowland	200 km SW of Fairbanks-area locality in Hultén
Platanthera stricta	SC Boreal Subalpine	Only locality S of AK Range; 70 km E from Kuskokwim locality in Hultén
Potamogeton foliosus	Int Boreal Floodplain, Int Boreal Lowland	220 km SW of Tanana Valley locality in Hultén
Potamogeton friesii	Int Boreal Lowland	Locality at Ft. Wainwright; 240 km SW of Tanana Valley locality in Hultén
Ranunculus macounii	SC Boreal Subalpine	Westernmost published locality; 175 km NW of Anchorage locality in Hultén
Rubus spectabilis	SC Alpine Mtn	150 km NW from Cook Inlet lowlands locality in Hultén
Salix interior	Int Boreal Lowland	150 km S of Yukon River locality in Argus
Salix sitchensis	SC Boreal Subalpine	At northern range limit; 200 km NW of Ft. Richardson locality
Salix stolonifera	SC Boreal Subalpine	Northernmost locality;175 km NW of Anchorage locality in Hultén
Scirpus validus	SC Boreal Floodplain	160 km NW of Cook Inlet lowlands locality in Hultén
Senecio fuscatus	Int Alpine Alaska Range	No collections farther south in AK Range; 100 km SW of collections along Park Road
Solidago lepida	SC Alpine Mtn	150 km NW from Anchorage locality
Stellaria longifolia	Int Boreal Lowland	150 km WNW from Cantwell locality on Parks Hwy.
Stellaria umbellata	Int Alpine Alaska Range	180 km SW of Hultén locality in Park; 230 km WNW
Vaccinium alaskensis	SC Boreal Lowland	300 km N of Kenai locality in Hultén
Viola glabella	SC Boreal Lowland, SC Alpine Mtn	150 km NNW from Cook Inlet lowlands locality in Hultén
Viola selkirkii	SC Boreal Lowland, SC Alpine Mtn, Int Boreal Upland	100 km W from locality in Hultén

inventory. These taxa were known from numerous localities south of the Alaska Range but were not commonly found in areas north of the Alaska Range crest. This observation suggested that conditions in this region are perhaps similar to certain alpine coastal stations. The fact that the Kantishna Hills are the first prominent mountains east of the Bering Sea Coast may have resulted in increased precipitation from the air masses that move across western Alaska from the Bering Sea and thus have created a more temperate moisture climate in this localized area. The clouds do often appear to be collect along the higher peaks of this range during storms.

The northern flanks of the Alaska Range and the adjacent boreal lowlands represent a southern range limit in Alaska for a set of plant species with essentially arctic or arctic/alpine distributions for which major range extension were made during this project such as *Draba corymbosa*, *Halimolobos mollis, Phlox richardsonii* and *Smelowskia calycina*. These species were collected in northern regions of the Alaska Range area of the Park for the first time during this project. This area was probably close to the southwestern range limit for these species and others, although additional collecting in remote areas to the south of the Park would be required to confirm this. For example, *S. calycina* has been collected in a locality near the Farewell south and west of the Park (Carolyn Parker, personal communication).

Another interesting geographic cluster of range extensions that were documented during this inventory was located in the upper West Fork of the Yentna River drainage, where several northern and/or interior taxa that occur almost exclusively north of the Alaska Range were found growing in this area south of the Alaska Range crest. We documented major range extensions in this area with collections of *Carex eburnea*, *Cryptogramma stelleri*, *Minuartia yukonensis*, *Oxytropis campestris* ssp. *jordallii*, and *Papaver lapponicum*. None of these taxa were known from the Cook Inlet drainage or other maritime regions of Alaska prior to this study. This area is apparently a dispersal corridor across the Alaska Range that has allowed passage of several of these taxa. Mystic Pass is a low elevation pass over the Range with only 25 km separating the 2000 foot elevation contours on either side of the pass.

A third set of taxa for which range extensions were documented during this study were species with spotty distribution patterns in the Alaska portion of their range. These taxa were mostly aquatic and wetland plants including *Najas flexilis*, *Potamogeton obtusifolius*, and *Rumex maritimus* (taxa for which major range extensions were documented during this study) that either occurred only very sporadically in Alaska, or had been under collected because of their watery habitat. Several of these wetland taxa with spotty known ranges in Alaska were collected in sites on both sides of the Alaska Range crest in the Park, suggesting that they may be more common than what is suggested by current collections (see Table 5.2).

F. Completeness of vouchered vascular flora of Denali National Park and Preserve - 2003

Two other important contributions to our knowledge of the flora of Denali National Park and Preserve were made during the period that this inventory was being conducted: the Denali National Park and Preserve Soils Inventory conducted by the Natural Resources Conservation Service during the period 1997 through 2002; and an exotic plant survey of the Park Road corridor undertaken jointly by the National Park Service and Roseann Densmore of the Alaska Science Center (U.S.G.S.-B.R.D.). Mike Duffy, the Botanist for the Soils Inventory, made a significant collection of more than eight hundred vascular plant specimens during this period of time, which document 30 vascular plant species and 38 taxa (including subspecies and varieties) that are new to the Park vascular flora and that were not collected during the Park Floristic Inventory study. In addition to adding these taxa to the Park flora, Mike Duffy’s plant collections also contribute a wealth of information about plant distribution within the Park. The exotic plant survey added an additional nine exotic vascular plant species to the plant list that were not documented prior to 1998. If the results of all of the botanical studies (including the Floristic Inventory) are tallied, the documented vascular flora of Denali National Park and Preserve totals 753 species, an increase of 263 species (54 percent) over the 490 vascular plant species that were documented within the Park as of 1998.

In the following chapters that present the results of this inventory, I will only reference collections made as a part of the current study when presenting the documentation of numbers and identity of new taxa, range extensions, and occurrences of rare and sensitive plant taxa and endemic species. However, in summarizing the floristic composition of the Park, or particular sub-regions thereof, I will include all of the plant occurrence data that are available including the following sources: preexisting Park and University of Alaska plant collections and the two botanical studies cited above (Clark and Duffy 2004, Densmore, McKee and Roland 2001).

If we include all of the floristic data now available for the Park, I believe that at least 95 percent of the total number of vascular plant species that occur in Denali National Park and Preserve at this time have been documented with voucher specimens. In fact, the actual percentage is probably closer to 98 percent. One strong measure of support for this estimate is that two intensive botany-related field projects took place in Denali National Park and Preserve during the summer of 2002 (a landscape-scale vegetation monitoring project and the last year of the Soils Inventory). During the numerous weeks of sampling for these projects by three separate field crews, only four new species were added to the vouchered Park flora. In contrast, during just eleven days of fieldwork in 1998, I collected vouchers documenting the occurrence of almost eighty species new to the Park list. I believe that at this point in time it is unlikely that more than 40 vascular plant species remain to be documented within the Park boundary.

Chapter 6 Detailed Summaries of Inventory Results by Floristic Region

In the previous chapter, I summarized the noteworthy overall results of this project at the park-wide level. However, an important goal of this project was to identify and describe the patterns of plant distribution and floristic composition *within* the Park. The results of this project, in combination with large amount of ecological and vegetation data from the recent Soil Inventory Project, have provided us with sufficient data to define a set of nine broad floristic regions for the Park. Regions that supported similar floras and vegetation patterns were grouped together, forming a discrete set of nine floristic regions within the Park (for a description of how this was accomplished, see Chapter 4). The floristic region delineations allow us to better examine covariation in floristic composition and landscape variables at large spatial scales within the Park. The nine floristic regions defined for the Park are shown in Table 6.1.

The goal of this chapter is to provide the reader with an accurate description of the Park landscape and the important floristic patterns that were observed in this landscape. To meet this goal, I present the results of a variety of analyses of the physiography, surficial geology, landcover patterns, and fire history of each floristic region. These analyses were performed using the Park GIS, with Digital Elevation Model data, fire perimeter maps, the Denali Landcover Map (Boggs et al. 2001) and data from the Soils Inventory (Clark and Duffy 2004). I also describe the specific results of our inventory work in each of these nine regions. This presentation includes the amount of survey effort that was expended, the number of new taxa discovered and the rare and endemic plant species that occurred in the region. In addition, the range extensions for vascular plant taxa that were documented in each region are discussed in this section of the report. The notable plant associations that were observed in each floristic region are discussed following the summary of the inventory results. I hope that the information presented here will allow managers and others interested in plant conservation and biogeography to better identify sensitive areas and issues and how these issues vary across this large and diverse landscape. In addition, these data will allow us to better understand the ecological and biogeographic patterns that were observed on the park landscape, and to grasp the contribution of the current study to our knowledge of plant distribution in Denali.

Table 6.1. Nine floristic regions of Denali National Park and Preserve

Floristic Regions of Denali National Park and Preserve
Interior Boreal Floristic Regions:
Interior Boreal Floodplain and Alluvial Fan Floristic Region
Interior Boreal Lowland Floristic Region
Interior Boreal Upland Floristic Region
Interior Alpine Floristic Regions
Interior Alpine Outer Range Floristic Region
Interior Alpine Alaska Range Floristic Region
Southcentral Boreal Floristic Regions:
Southcentral Boreal Floodplain and Alluvial Fan Floristic Region
Southcentral Boreal Lowland Floristic Region
Southcentral Boreal Subalpine Floristic Region
Southcentral Alpine Floristic Region:
Southcentral Alpine Mountain Floristic Region

A. Summary of results for Interior Boreal Floodplain and Alluvial Fan Floristic Region

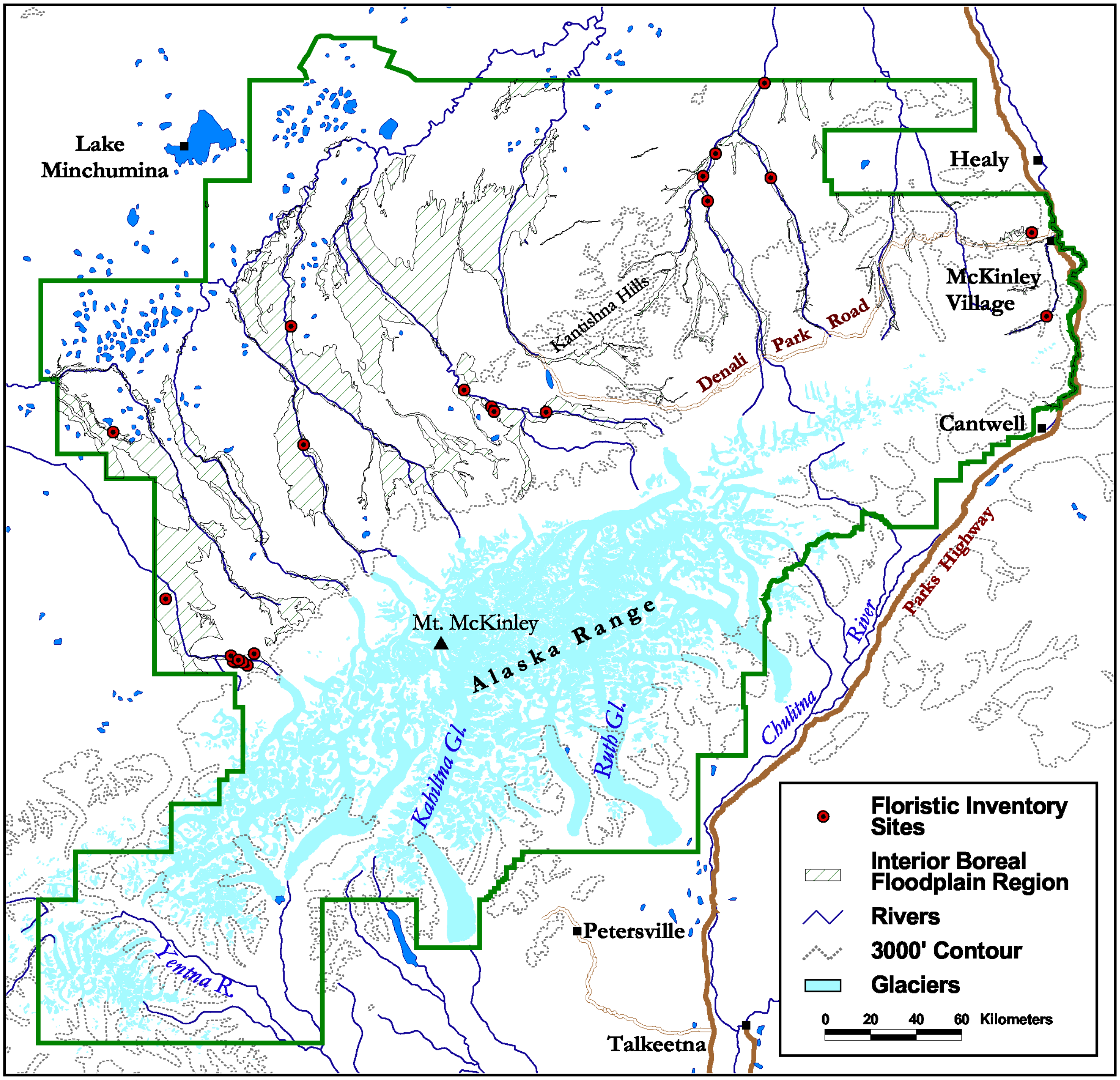


Figure 6.1 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Interior Boreal Floodplain and Alluvial Fan Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.2 General summary of Floristic Inventory effort and results for the Interior Boreal Floodplain and Alluvial Fan Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	No. of specimens
Number of sites surveyed in region:	23	N/A
Total number of hours in surveys:	81.5	N/A
Average number of survey hours per site:	3.7	N/A
Average number of surveyors per site:	2.0	N/A
Total number of collections in region:	270	270
Number of taxa new to the Park (pre-1998) found in region:	35	44
Number of taxa with major range extension into region:	2	2
Number of taxa with range extension into region:	3	3
Number of AKNHP-tracked taxa found in region:	3	7
Number of AKNHP element occurrences:	7	7
Number of Alaska - Yukon endemic taxa collected in region:	(5) 6	16
Number of Amphiberingian endemic taxa collected in region:	4	5

Plate 6.1 Aerial view of the floodplain of the Foraker River in the northern Interior Boreal Floodplain and Alluvial Fan Floristic Region of Denali National Park and Preserve.

1. Physiography

The Interior Boreal Floodplain and Alluvial Fan Floristic Region covered approximately 2,283 km^2 in the northern lowlands of Denali National Park and Preserve (for map see Figure 6.1; representative photo in Plate 6.1). This region consists of areas on the large alluvial fans and terraces deposited by the McKinley, Foraker, Herron, and upper Kuskokwim rivers. These deposits occurred adjacent to the current floodplain and in a set of deltas formed where stream gradients decrease rapidly upon leaving the escarpment of the Alaska Range. These sediments form a set of more or less triangular deltas of alluvium at the base of the Alaska Range. The Interior Boreal Floodplain and Alluvial Fan Floristic Region was geographically intertwined with the Interior Boreal Lowlands Floristic Region. The primary difference between the two regions was the preponderance of *recently deposited* alluvial landforms such as active channels and floodplains, alluvial fans and river terraces in the Floodplain and Alluvial Fan region as compared to the Interior Boreal Lowland Floristic Region, which was underlain by older surfaces and a high percentage of eolian sediments.

The elevation signature of the terrain in this region was similar to other lowland areas of the Park, with 84 percent of the terrain lying at elevations below 600 meters (Figure 6.2). Slopes were predominantly low-angle in the boreal floodplain region, with nearly 90 percent of the terrain lying at slope angles of less than five degrees (Figure 6.2). The rivers in this region all flowed either north or northwest as the terrain sloped in these two primary directions in this region of the Park. An analysis of aspects showed that surfaces in the region were skewed heavily in these directions, and only 13 percent of this floristic region was occupied by slopes facing either south or east (Figure 6.2).

2. Surficial geology

Predictably, unconsolidated alluvial sediments were the primary surficial deposit on the landscape of the Interior Boreal Floodplain and Alluvial Fan Floristic Region, covering 98 percent of its surface area (Figure 6.2; calculated from Clark and Duffy 2004). Soils containing permafrost were also prevalent in this floristic region, an estimated 37 percent of the land area in this floristic region was occupied by soils units that were classified as containing continuous permafrost, and 42 percent of the area was occupied by soil units with discontinuous permafrost (Figure 6.4). This relative reduction in the prevalence of permafrost in the floodplain region was likely due to the more recent sediment deposition there as compared to the Interior Boreal Lowland Floristic Region. Newly deposited sediments require time and insulation in order to develop permanently frozen ground.

3. Landcover patterns

Three open boreal forest types, stunted spruce, open woodland spruce, and recently burned areas, occupied 73 percent of the area of the Interior Boreal Floodplain Floristic Region (Figure 6.3; calculated from Boggs et al. 2001). The remaining 27 percent of the land area of this floristic region was divided relatively evenly among eleven other landcover types, including spruce-broadleaf, low shrub birch-ericaceous and unvegetated cover types (Figure 6.3). The major general potential vegetation types (as defined by Soil Inventory, Clark and Duffy 2003) that.

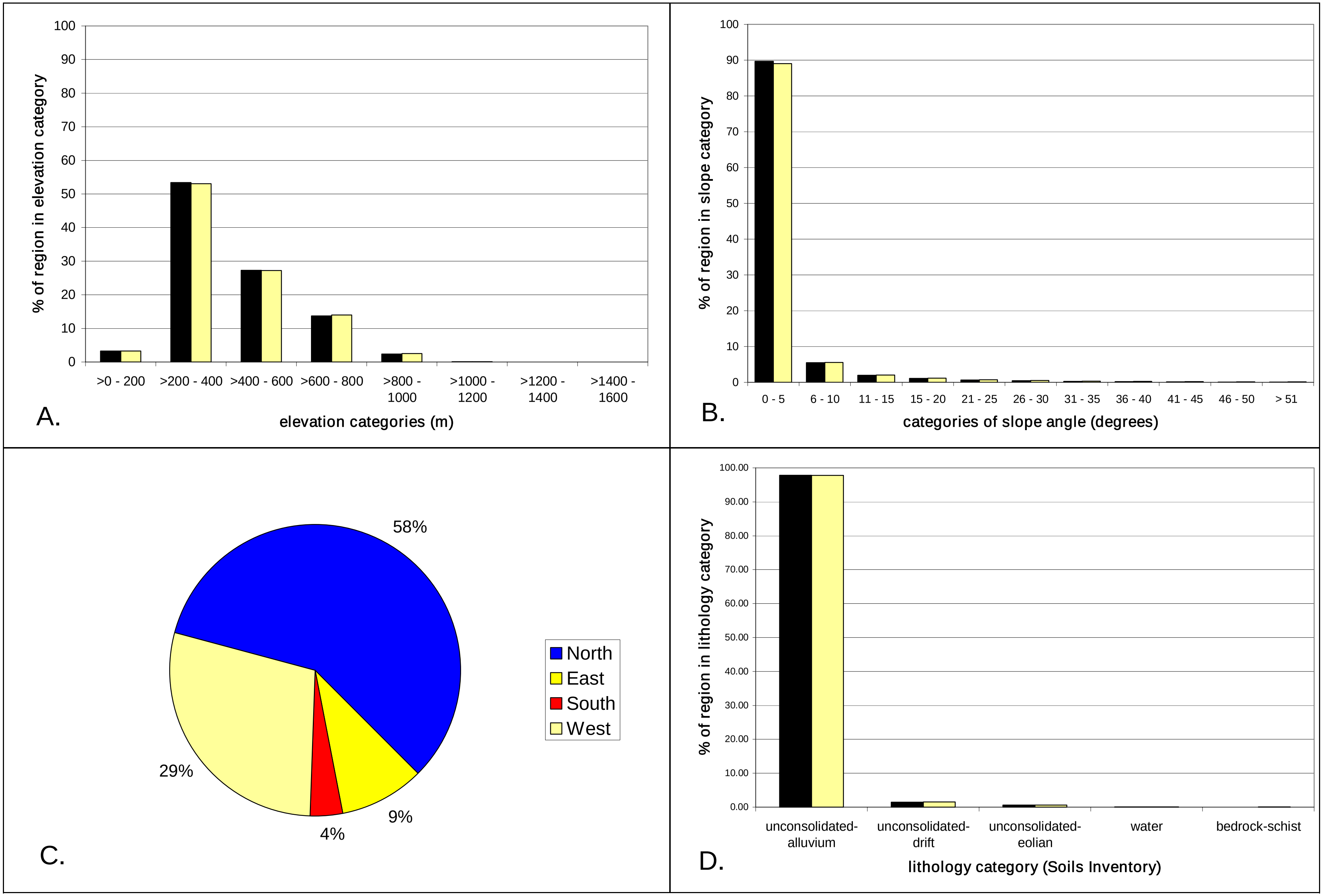


Figure 6.2 Four graphs showing the percentage of the landscape of the Interior Boreal Floodplain and Alluvial Fan Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.

occurred in this floristic region included black spruce permafrost woodland (63 percent of the area), riparian white spruce and hardwoods (30 percent), and tussock and shrub birch scrub (four percent; see Figure 6.3).

4. Fire on the landscape

The vegetation of an estimated 17.4 percent of the Interior Boreal Floodplain Floristic Region has burned during the past fifty years based on our analysis of the fire perimeter GIS coverage (Figure 6.5). This was the largest percentage of area affected by fire for any of the floristic regions in the Park. It suggests a fire rotation of approximately 290 years for this region, under current conditions and assuming that the fire coverage is accurate. By fire rotation, I mean that it will take an average of 290 years for the entire area to be affected by fire, if current trends continue.

5. Summary of inventory results in region

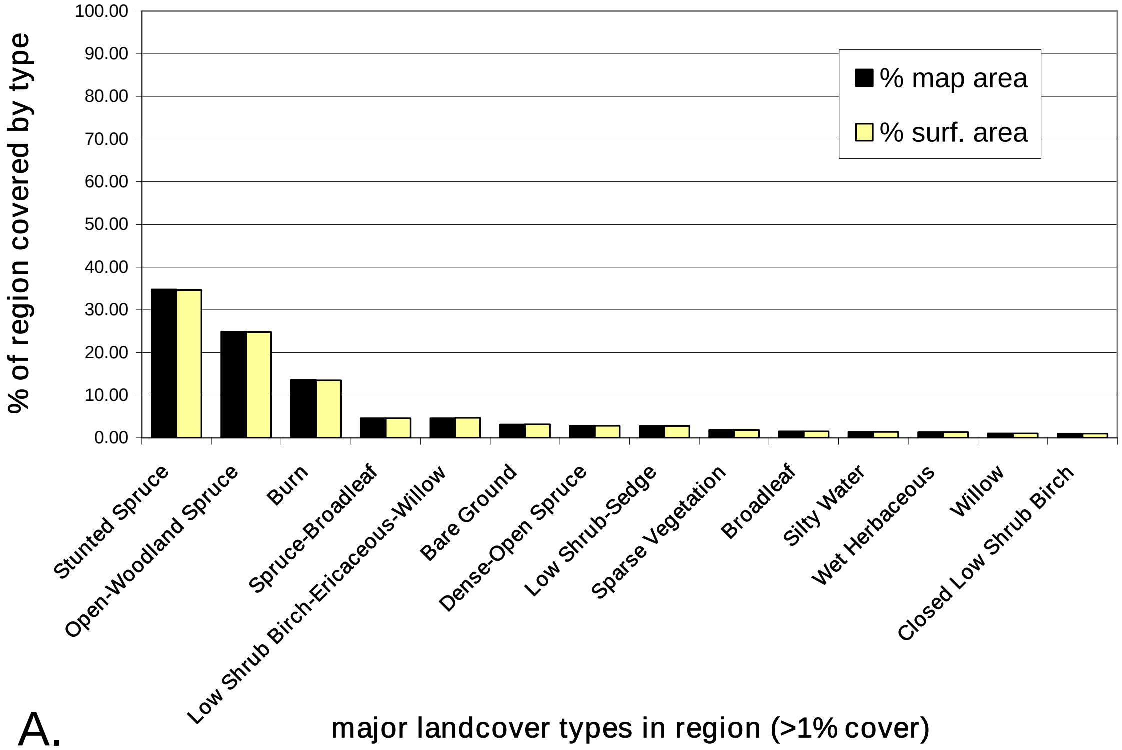
We performed reconnaissance floristic inventories of 23 sites within the Interior Boreal Floodplain and Alluvial Fan Floristic Region of Denali National Park and Preserve. These surveys required 82 hours of field survey time during which we collected 270 voucher specimens (see Table 6.2). These collections included new vouchers for 35 taxa that were not known to occur in the Park prior to 1998. We documented major range extensions for *Halimolobos mollis* and *Viola selkirkii* from sites within the Interior Boreal Floodplain and Alluvial Fan Floristic Region (see Table 5.2). In addition, our collections documented range extensions for *Carex bonanzensis*, *Carex diandra* and *Potamogeton foliosus* from sites in this region. Seven element occurrences of three taxa considered rare by AKNHP were documented by our work in this region (including *Carex eburnea*, *Salix setchelliana*, and *Viola selkirkii*; (see Table 7.1). The foci of inventory work in this floristic region were floodplains and alluvial fans in areas that were previously unsurveyed, including sites in the upper Kuskokwim River drainage and the lower section of the Toklat River. We also surveyed sites on the rivers that drain the western section of the Alaska Range in the Park including the Foraker, Herron and McKinley rivers.

6. Notable plant associations surveyed in region

Although the majority of the landscape of this floristic region was dominated by boreal forest vegetation (see Plate 6.2) , the noteworthy collections made at inventory sites in this region were made in only two types of plant associations: 1) open floodplain sediments and low river bluffs composed of floodplain sediments, and 2) open wetland areas on river terraces. In fact, only two of the species that were new to the Park flora from this project were collected in zonal boreal forest types within this region: *Ranunculus lapponicus* and *Pyrola minor*. The flora of zonal boreal forest communities varied little across wide expanses of terrain. It is only in openings in this relatively unvarying mantle of boreal vegetation that pockets of plant diversity occur. A mosaic of plant communities form in response to the disturbance caused by large, shifting glacial rivers, which frequently shift channels, creating a patchwork of wetlands and different-aged surfaces in close proximity. Plate 6.3 portrays an abandoned channel of the Kantishna River in which the results of this dynamic process are clearly visible.

Plate 6.2 The majority of the Interior Boreal Floodplain and Alluvial Fan Floristic Region is forested with zonal vegetation of spruce and mixed spruce-birch forest.

Plate 6.3 A complex mosaic of plant communities of varying ages that results from succession following erosion and deposition of sediments along large glacial rivers is visible in this photograph of an abandoned channel of the Kantishna River.



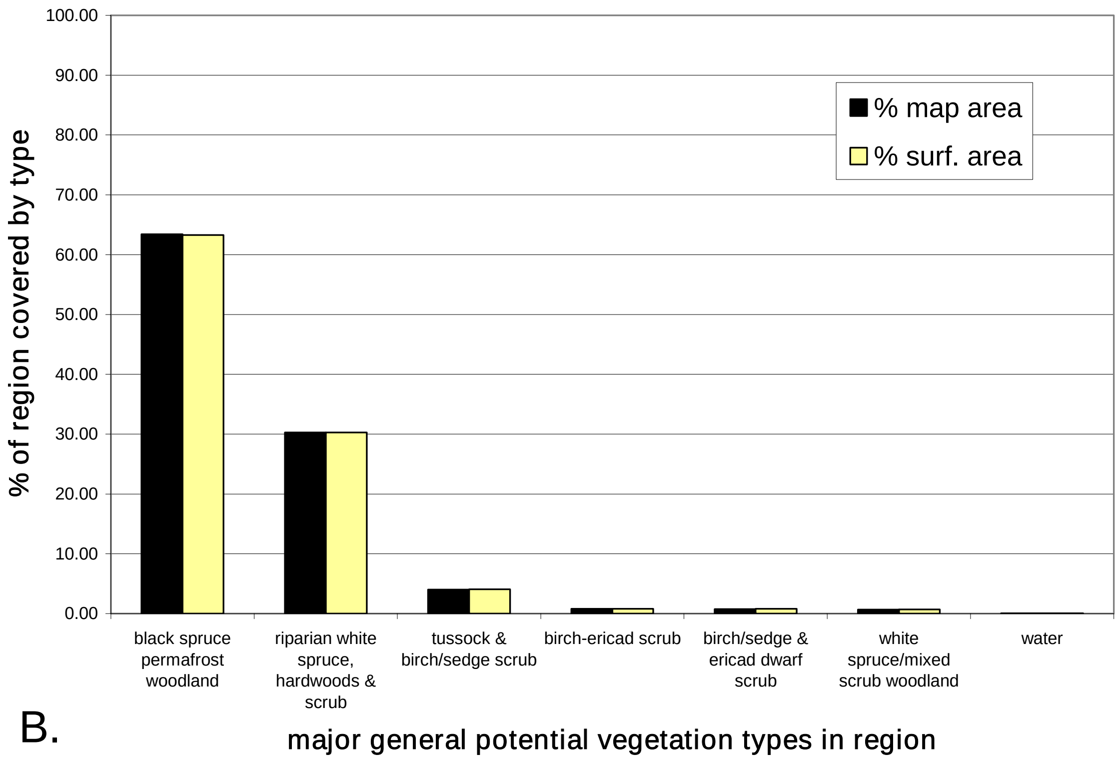


Figure 6.3 Histograms showing the percentage of the landscape of the Interior Boreal Floodplain and Alluvial Fan Floristic Region distributed among categories of landcover type and general potential vegetation classes.

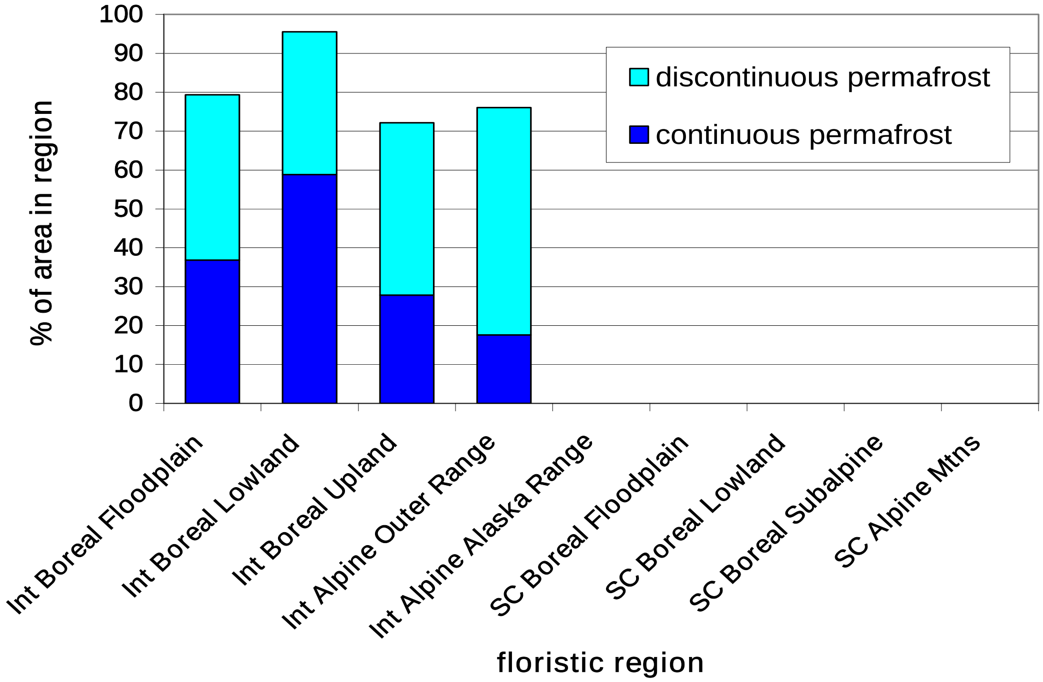


Figure 6.4 The percentage of the area of each of the nine floristic regions of Denali National Park and Preserve underlain by soil units with A) discontinuous and B) continuous permafrost. These quantities were derived from a GIS analysis of the Soils Inventory coverages.

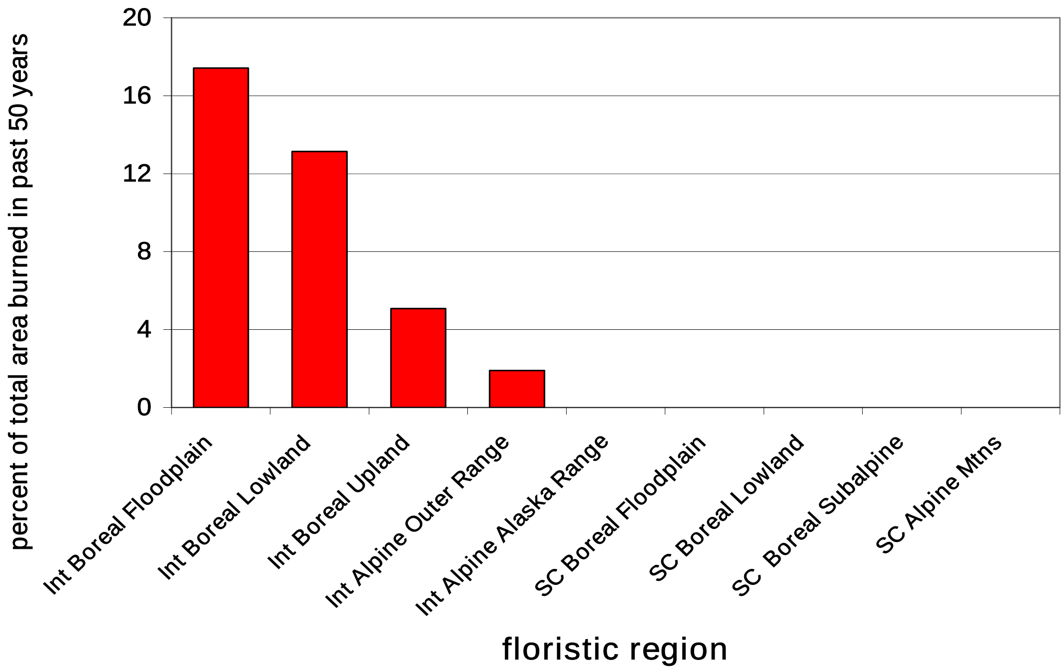


Figure 6.5 The percentage of the area of each of the nine floristic regions of Denali National Park and Preserve burned by fire in the last 50 years. These quantities were derived from a GIS analysis of the fire perimeters mapped in the Park during this period of time.

- **Open floodplain sediments and low river bluffs composed of floodplain sediments**

  The large bands of open floodplain sediments associated with major braided glacial rivers presented a very different set of edaphic conditions from those that occurred in the vast majority of the lowland landscape of the Park. These were areas of well-drained, open soils that were free of permafrost and not covered by dominant woody taxa and mosses. These areas represent "windows" of open, thawed soils within an otherwise heavily vegetated landscape largely underlain by permafrost. The frequent disturbance of floodplain areas by the action of running water has acted to keep them free of zonal dominants within the vegetation. This dynamic disturbance regime has allowed for the establishment of a series of successional vegetation types that contained sets of species very different from those that occupied the dominant "climax" boreal vegetation that occurred in this region of the Park.

  Both of the major range extensions (*Halimolobos mollis* and *Viola selkirkii*) and all three of the state-level rare plant taxa (*Carex eburnea*, *Salix setchelliana*, and *Viola selkirkii*) documented within this region were collected in floodplain sediments. In addition, all 16 collections of the 6 plant taxa endemic to Alaska and the Yukon that were made in the Interior Boreal Floodplains Floristic Region were collected in open floodplain habitats within this region (see Table 6.2). The primary boreal vegetation types that occurred in this region were relatively species-poor and were dominated by widely-distributed taxa (with a few exceptions).

- **Wetlands on river terraces**

  Open meadow and marsh vegetation in wetland areas located on river terraces also yielded significant novel floristic information for the Park during this inventory (see an example in Plate 6.4). Seventeen taxa new to the Park flora were documented from these areas within the Interior Boreal Lowland Floodplain Floristic Region, including range extensions for *Carex bonanzensis*, *Carex diandra*, and *Potamogeton foliosus*. One wetland type of particular note that occurred in this region was open meadows adjacent to clear water springs and streams on open silt on river terraces (see Plate 6.5). The combination of periodic flooding and silt deposition with saturated substrate has resulted in open, fen-like plant communities. A rich and characteristic herbaceous flora including orchids (*Coeloglossum viride* and *Platanthera hyperborea*), and a variety of other forbs such as *Antennaria pulcherima*, *Pinguicula vulgaris*, *Primula egaliksensis*, and *Mimulus guttatus* occurred in these sites (see Plate 6.6). A suite of small cyperaceous species, including *Carex bicolor*, *Carex microglochin*, and *Kobresia simpliciuscula*, also occurred in these open floodplain meadow sites.

Plate 6.4 An example of a diverse marsh plant community growing along an old slough of the Muddy River in the Minchumina Basin. *Caltha natans* is growing as an emergent in foreground.

Plate 6.5 Open floodplain meadow in old channel on recently-deposited silt dominated *by Equisetum variegatum* and characteristic assemblage of forbs, including *Platanthera hyperborea* and graminoids such as *Hierochloe odorata* and *Carex microglochin*.

Plate 6.6 Four vascular plant species characteristic of rich floodplain meadows on in the Interior Boreal Floodplain and Alluvial Fan Floristic Region, clockwise from top right: A) *Carex microglochin*, B) *Pinguicula vulgaris*, C) *Primula egaliksensis* and D) *Kobresia simpliciuscula*.

B. Summary of Results for Interior Boreal Lowland Floristic Region

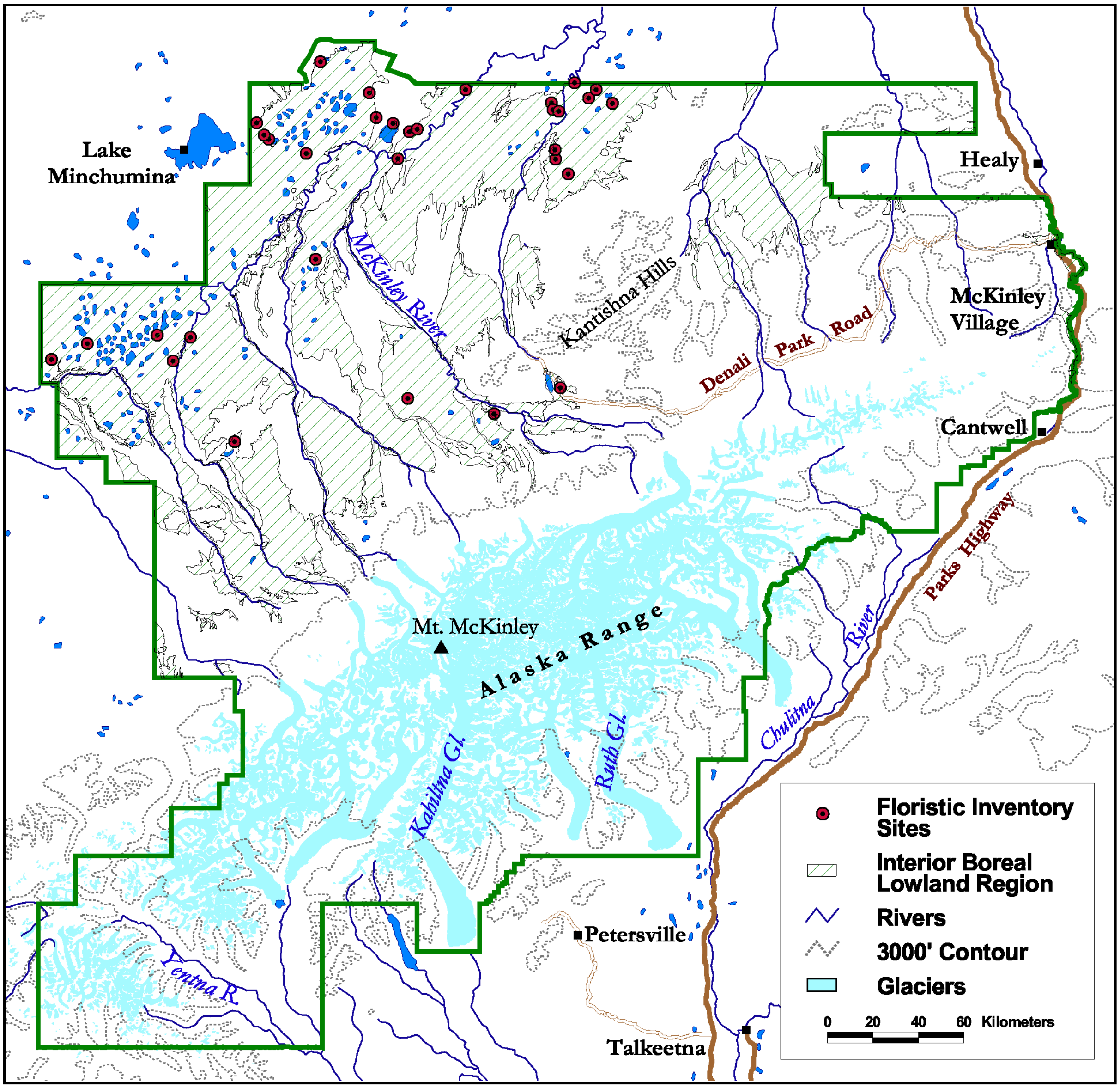


Figure 6.6 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Interior Boreal Lowland Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.3 General summary of Floristic Inventory effort and results for the Interior Boreal Lowland Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	No. of specimens
Number of sites surveyed in region:	33	N/A
Total number of hours in surveys:	137.6	N/A
Average number of survey hours per site:	4.2	N/A
Average number of surveyors per site:	2.2	N/A
Total number of collections in region:	421	421
Number of taxa new to the Park (pre-1998) found in region:	70	211
Number of taxa with major range extension into region:	3	16
Number of taxa with range extension into region:	13	17
Number of AKNHP-tracked taxa found in region:	9	21
Number of AKNHP element occurrences:	22	22
Number of Alaska - Yukon endemic taxa collected in region:	1	1
Number of Amphiberingian endemic taxa collected in region:	3	7

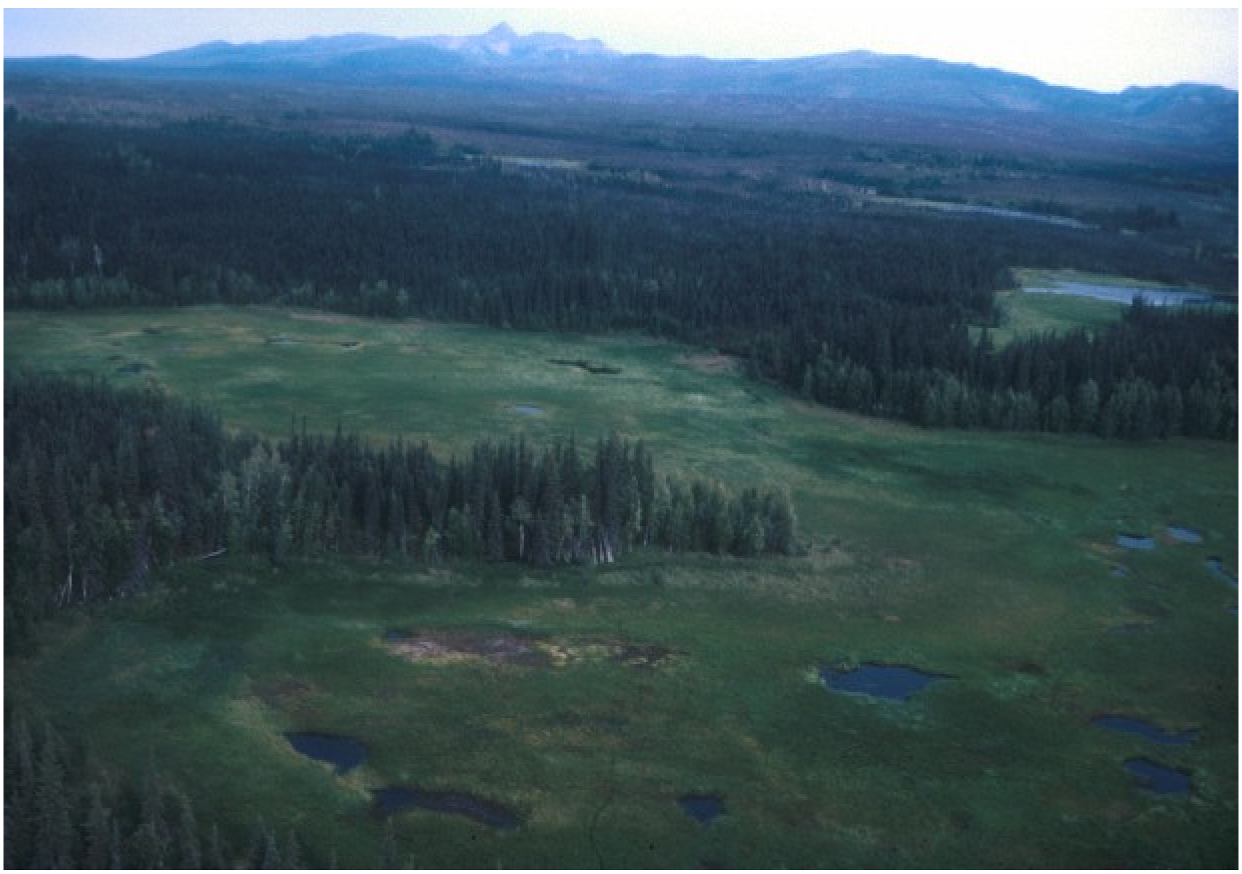


Plate 6.7 An aerial view of a site near the Bear River in the Interior Boreal Lowlands of Denali National Park and Preserve. The mosaic of spruce forest, wet meadows and ponds is characteristic of much of this floristic region; the Kantishna Hills are visible to the east in the background.

1. Physiography

The Interior Boreal Lowland Floristic Region occupied about 5,900 km^2 in the lowlands north of the Alaska Range crest (for map, see Figure 6.6). The majority of this region lay west of the Kantishna Hills in the Yukon-Kuskokwim bottomlands ecoregion (see photo in Plate 6.7). The Toklat Basin lowland, just east of the Kantishna Hills in the Alaska Range ecoregion, formed the remainder of this floristic region. Terrain elevations within the Interior Boreal Lowland Floristic Region ranged between about 150 m to almost 800 m elevation (Figure 6.7). However, 90 percent of the terrain lay at elevations below 600 m. This was a vast area of lowland plains, so it was predictable that slopes would be almost uniformly low-angle. In fact, an estimated 78 percent of the slopes in this region were less than five degrees (Figure 6.7). This region drained the northern flanks of the Alaska Range, which has been uplifted by tectonic forces along an axis that is oriented from northeast to southwest. As a result, aspects of the low angle slopes in this region were overwhelmingly north and west-facing (50 and 25 percent of the area respectively; Figure 6.7). Slopes with south and east aspects combined represented only one quarter of the area in the Interior Boreal Lowland Floristic Region.

2. Surficial geology

The surface of the Interior Boreal Lowland Floristic Region was covered with a mantle of unconsolidated surficial deposits of varying origins (Figure 6.7). Silty eolian sediments that were likely deposited during glacial periods were estimated to underlie 46 percent of this region (Clark and Duffy 2004). An additional 39 percent of the surficial sediments in the region were estimated to be of alluvial origin, having been deposited by the numerous large glacial streams that flow across the area (Figure 6.7). Unconsolidated glacial drift underlies another approximately 12 percent of this floristic region. Surface waters were more abundant in the Interior Boreal Lowlands than in any other floristic region of the Park. Four percent of the surface area of this very large region lay under clear surface waters, mostly in the form of the myriad boreal ponds and lakes that predominated in the Minchumina Basin subsection. Another one percent of the region was covered by silty waters, in the form of the braided glacial streams that have emanated from the Alaska Range.

The landscape of the Interior Boreal Lowland Floristic Region was strongly affected by permafrost, to a greater degree than any of the other regions of the Park. Soil units characterized as containing continuous permafrost occupied 59 percent of the area, and another 37 percent of the area was occupied by soil units with discontinuous permafrost (Figure 6.4; Clark and Duffy 2004).

3. Landcover patterns

Open black-spruce dominated boreal forest types were the most abundant landcover types in the interior lowlands of Denali National Park and Preserve (Figure 6.8: calculated from Boggs et al. 2001). In fact, the landcover map for the Park indicated that an estimated 75 percent of the area of this region was occupied by three classes: stunted spruce, open woodland spruce, and burn (which is primarily recently burned stunted spruce). There were numerous additional landcover types that covered relatively small areas of this region, but were nevertheless floristically

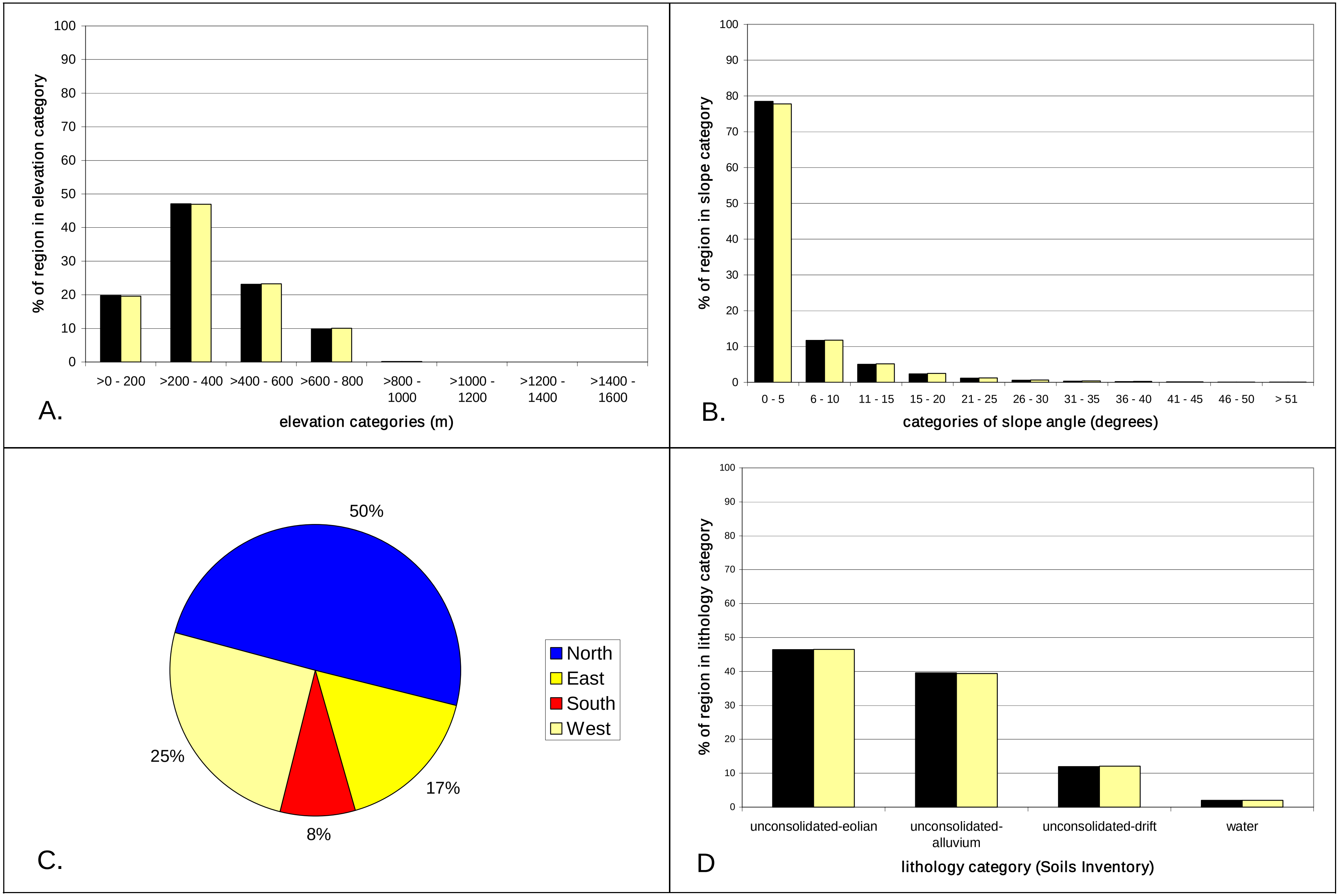


Figure 6.7 Four graphs showing the percentage of the landscape of the Interior Boreal Lowland Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.

significant. For example, wet herbaceous meadows and low shrub-sedge boggy areas represented two and five percent of the land area of this region respectively, but contributed the majority of the range extensions, new species, and rare plants that were collected in this region during the current study. In general, vegetation types other than the primary boreal forest classes occurred only in areas where the existence of the predominant continuous ice-rich permafrost has been disrupted. For example, relatively productive mixed white spruce forest have developed in the thaw bands along the rivers, and the wet meadows form in the riparian corridors and thermokarst ponds that dot the landscape of the interior lowlands.

The general potential vegetation classification performed for the Soils Inventory indicated that 85 percent of the terrain was estimated to have a potential vegetation type of permafrost black spruce woodland (Figure 6.8; Clark and Duffy 2004). Other general potential vegetation types that occurred in the Interior Boreal Lowland Floristic Region included the following: riparian white spruce forest (seven percent of the area) and tussock - shrub birch (five percent of the area) (see Figure 6.8).

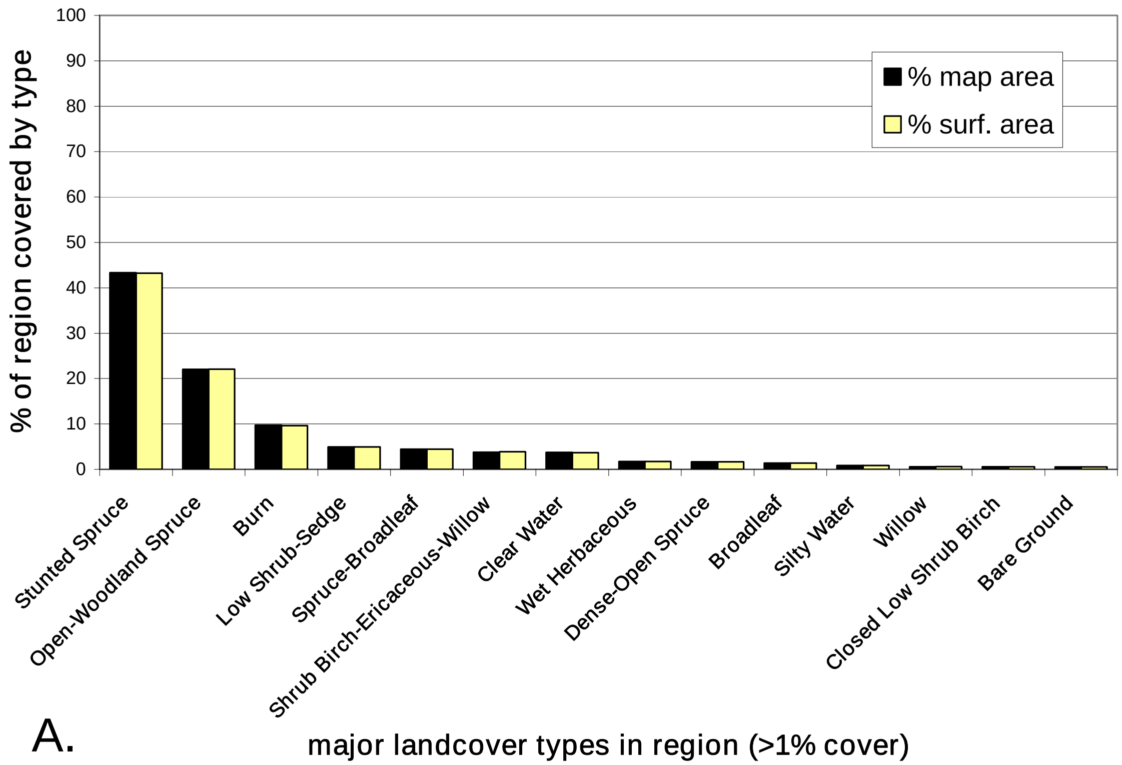
4. Fire on the landscape

An analysis of the available GIS data for fire perimeters in Denali National Park and Preserve over the past 50 years showed that an estimated 13.1 percent of the Interior Boreal Lowland Floristic Region had burned during the past 50 years (Figure 6.5.) Fire certainly has been an important factor in determining vegetation patterns and processes in this floristic region which had the highest total acreage of burned area of any of the floristic regions. The Interior Boreal Floodplain Floristic Region had a slightly higher percentage of its area burned over the previous 50 years, but the overall acreage burned was considerably lower there, due to its smaller size.

5. Summary of inventory results in region

The Interior Boreal Lowland Floristic Region within Denali National Park and Preserve was very poorly known from a botanical perspective prior to this inventory due to its large size and the considerable difficulties of access into these vast lowland basins. A significant portion of this area was occupied by wetlands which have frequently been under-represented in floristic collections. We inventoried a total of 33 sites within this floristic region, which was the highest number of sites visited in any single floristic region during this study. Many of the targeted sites were wetlands and aquatic areas that could be surveyed quite thoroughly in a relatively short period of time. We spent a total of 138 hours in actual field surveys in this Park region, which was less time than was spent in the large alpine floristic regions. This is due to the fact that alpine areas offer extensive amounts of terrain accessible on foot at each inventory site and because total diversity was also considerably higher in the alpine regions as compared to Park lowlands, which required that, on average, more time needed to be spent surveying an individual site.

We made 421 specimen collections in the Interior Boreal Lowland Floristic Region, which documented the occurrence of 70 species that were not known to occur within Denali National Park and Preserve prior to 1998 (Table 6.3). This was the second highest total of new species found in a single floristic region during this study. *Bidens tripartita,* a member of the



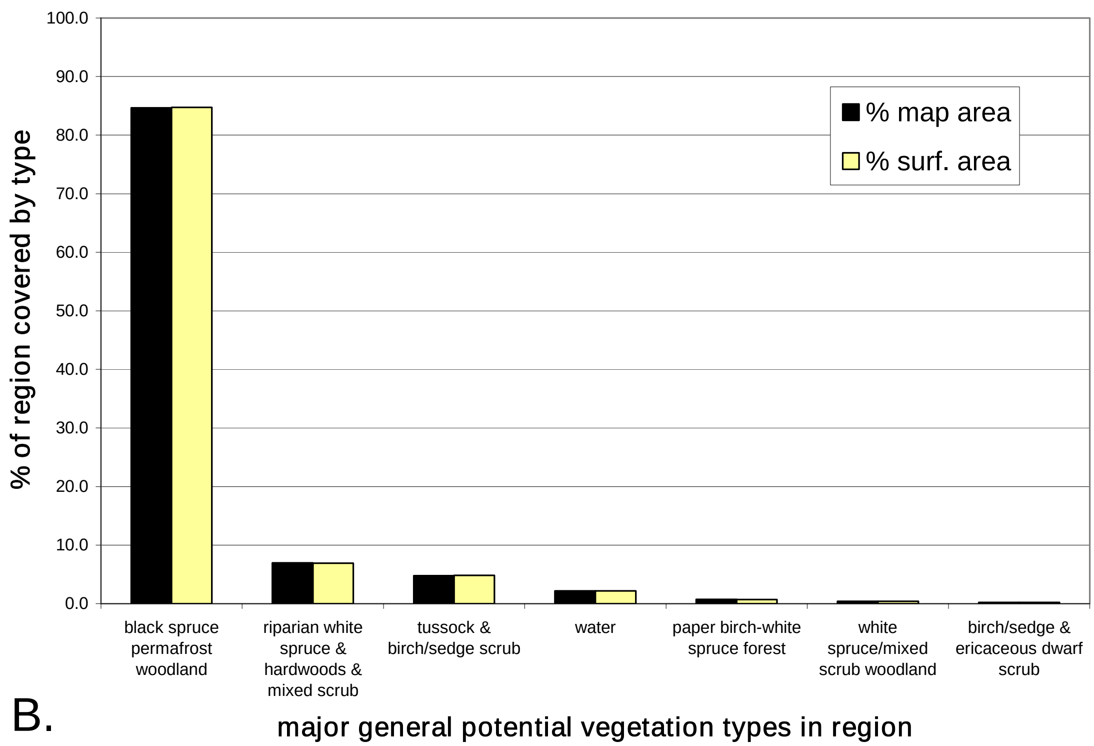


Figure 6.8 Histograms showing the percentage of the landscape in Interior Boreal Lowland Floristic Region distributed among categories of landcover type and general potential vegetation classes.

Asteraceae, was not known to occur in Alaska prior to our collection of it at Lake Chilchukabena in the interior lowlands of Denali National Park and Preserve. In addition, collections in this region resulted in three major range extensions and thirteen range extensions for vascular plant species. Major range extensions were documented for *Malaxis monophylla, Najas flexilis,* and *Rumex maritimus* in the Interior Boreal Lowlands Floristic Region (Table 5.2). Our inventory in the Interior Boreal Lowlands resulted in the documentation of 22 element occurrences for ten rare vascular plant species tracked by the AKNHP for Alaska (see Table 7.1).

6. Notable plant associations surveyed in region

The focus of inventory work in the Interior Boreal Lowland Floristic Region was on aquatic plant communities growing in ponds and lakes and the wet herbaceous vegetation that was often associated with these features, including fens, bogs, and meadows in old sloughs of streams. Lowland permafrost woodland and forest types (the predominant vegetation in this floristic region of the Park) were notably species-poor and, in the main, contained species that had already been documented in the Park prior to the inception of this inventory effort. There were only three species new to the Park flora that were collected in forested habitats in the Interior Boreal Lowland Floristic Region during this inventory: *Goodyera repens, Larix laricina* and *Lycopodium dendroideum* (see Plate 6.8). Significant collections were made in aquatic plant communities and three wetland types in this region, which are described below.

- **Aquatic plant communities; emergent and submerged**

  The Interior Boreal Lowland Floristic Region contained the largest amount of area covered by surface waters of any region of the Park. As a result, there were a wide variety of aquatic habitats available in this region of the Park, from small thermokarst ponds to beaver ponds to large lakes formed by geologic processes. Many significant collections of aquatic vascular plant species were made in this region of the Park. These collections included new localities for the following state-level rare aquatic plant species: *Ceratophyllum demersum*, *Myriophyllum verticillatum*, and *Potamogeton subsibiricus*. In addition, numerous localities for 24 species of aquatic plants that were not known to occur in the Park prior to 1998 were documented in the Interior Boreal Lowlands during this inventory, including: *Bidens cernua* (Plate 6.11), *Callitriche hermaphroditica*, *Caltha natans* (Plate 6.9), *Isoetes echinospora*, *Lemna minor*, *Lemna trisulca, Nymphaea tetragona, Potamogeton epihydrus, P. foliosus*, *P. friesii*, *P. natans*, *P. praelongus, P. zosteriformis, Senecio congestus* (Plate 6.10), *Utricularia intermedia* (Plate 6.10), *U. minor*, and *U. vulgaris*.

- **Bogs, Fens and Marshes**

  Another target of inventory work in the Interior Boreal Lowlands was wet meadow plant associations, which included fens, bogs, and herbaceous meadows associated with old sloughs. These habitats were indeed profitable areas for contributing new floristic information about the Park although, on an area basis, they represented a very small fraction of the lowland landscape of the Park. In this respect, the pattern of floristic diversity observed within this floristic region was similar to the other boreal floristic

Plate 6.8 Two plant species new to the Park from this inventory that occurred in zonal dominant boreal forest vegetation in Denali National Park and Preserve: *Lycopodium dendroideum* (left) and *Larix laricina* (right). Both of these taxa were collected in the vicinity of Lake Chilchukabena in the Minchumina Basin.

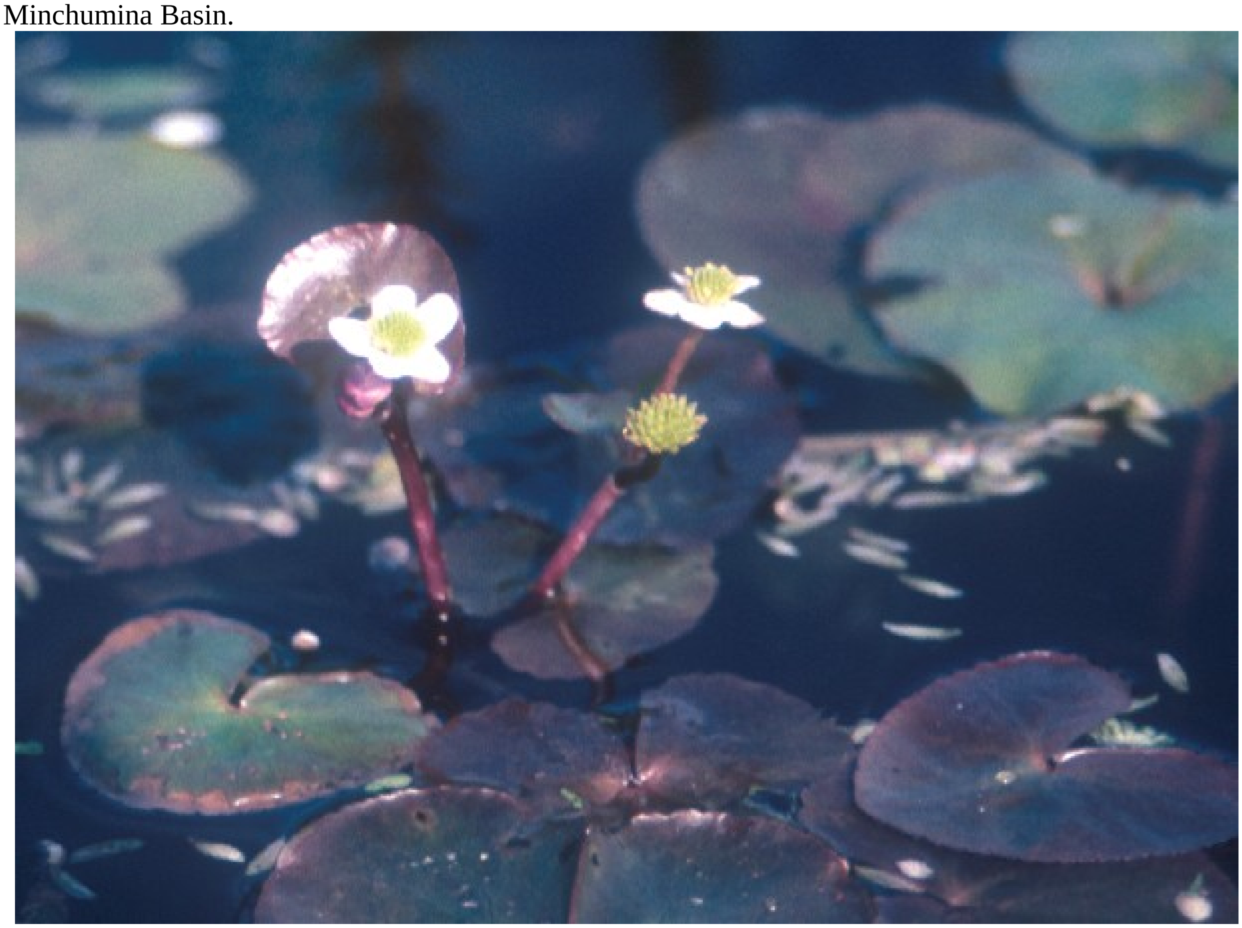


Plate 6.9 *Caltha natans*, an aquatic buttercup new to the Park flora that occurred in several boreal ponds in the Interior Boreal Lowlands Floristic Region.

regions of the Park in that the dominant plant communities were relatively species-poor, and floristically unremarkable, whereas small, isolated areas of the landscape apparently contributed a disproportionate fraction of the vascular plant diversity resident in the region.

For purposes of summarizing the results of inventory efforts in this region, I separated three primary classes of wetland plant associations surveyed during this inventory in the Interior Boreal Lowlands of the Park:

1) **bogs** – had a dense layer of peat, acidic soils with low nutrient content, and the water table at or near the soil surface; bogs were usually covered with *Sphagnum* mosses, shrubs and sedges; and trees were sometimes present
2) **fens** – were also covered with peat and had the water table at or near the surface, but generally had higher nutrient content than bogs, with a supply of cations moving through the system (thus higher pH values); the vegetation of fens was usually characterized by richer and more productive association of sedges, grasses and forbs than bogs, although trees and shrubs were sometimes also present
3) **marshes** (and herbaceous "strand" vegetation) – marshes were periodically or permanently flooded habitats characterized by an absence of trees and dominance by relatively lush swards of sedges, grasses and forbs, including emergent vegetation; marshes generally occurred in areas of high nutrient content and thus were quite productive. Periodic disturbance may have been a factor in maintaining open communities in these areas (such as by seasonal flooding).

Bogs were by far the most common wetland type in the interior region of the Park, and fens and marshes were confined to smaller segments of the landscape. Bogs occurred across the Interior Boreal Lowlands of the Park, interspersed with thermokarst ponds and with open black spruce forest. Fens occurred in a particular landscape position in the interior region of the Park, which was at the base of the apron of glacial sediments that lines the base of the Alaska Range. Water has percolated through the deep mantle of glacial sediments and emerged at the surface near the base of these sediments in isolated areas. The result of these nutrient rich waters bubbling to the surface has been the development of several distinctive fens along the base of the northern apron of the Alaska Range. Marshes occurred as more or less linear strands of vegetation along slough margins and in nutrient-rich areas on the downwind shores of certain lakes where nutrient-rich organic materials have been deposited through wave action.

Collections made in marshy strand vegetation yielded the largest number of noteworthy plant taxa of any of these wetland types, including *Bidens tripartita*, which was new to the flora of Alaska with this study. Twenty-five species of plants that were not known to occur in the Park were found in marsh vegetation in the Interior Boreal Lowlands (see Table 6.4). Nineteen species that were new to the Park were collected in bogs within the interior lowlands and ten species new to the Park were collected in fens within the region (Table 6.4).

Plate 6.10 Two emergent aquatic species new to the Park flora from our collections in the Interior Boreal Lowland Floristic Region were (left) *Utricularia intermedia* and (right) *Senecio congestus*.

Plate 6.11 *Bidens cernua*, a facultative aquatic member of the Aster family, was another new species for the Park that occurred in wetlands near Lake Chilchukabena.

Table 6.4 List of taxa new to Denali National Park and Preserve observed in four wetland habitats within the Interior Boreal Lowland Floristic Region of Denali National Park and Preserve, 1998-2001.

Taxon	Wetland habitats observed in:
Bidens cernua	marsh/strand
Bidens tripartita	marsh/strand
Calla palustris	marsh/strand
Callitriche hermaphroditic	aquatic
Caltha natans	aquatic
Carex chordorrhiza	bog, fen
Carex diandra	marsh/strand
Carex lapponica	bog
Carex lasiocarpa* ssp. *americana	bog, marsh/strand
Carex livida	bog, fen
Carex magellanica*. ssp. *irrigua	bog, fen
Carex rostrata	bog
Carex tenuiflora	bog
Chamaedaphne calyculata	bog
Ceratophyllum demersum	aquatic
Cicuta virosa	marsh/strand, fen
Eleocharis acicularis	marsh/strand
Eleocharis palustris	marsh/strand, bog, fen
Epilobium adenocaulon	marsh/strand
Eriophorum gracile	bog
Glyceria borealis	marsh/strand
Glyceria grandis	marsh/strand
Glyceria pulchella	marsh/strand
Iris setosa	marsh/strand
Isoetes echinospora	aquatic
Juncus alpinus	marsh/strand
Juncus bufonius	marsh/strand
Juncus stygius	bog, fen
Lemna minor	aquatic
Lemna trisulca	aquatic
Lysimachia thrysiflora	bog, marsh/strand
Malaxis monophylla	bog
Malaxis paludosa	bog
Myrica gale* var. *tomentosa	bog
Myriophyllum sibiricum	aquatic
Myriophyllum verticillatum	aquatic
Najas flexilis	aquatic
Nymphaea tetragona	aquatic
Pedicularis macrodonta	bog, fen
Polygonum lapathifolium	marsh/strand
Polygonum pennsylvanicum	aquatic
Potamogeton foliosus	aquatic
Potamogeton friesii	aquatic
Potamogeton gramineus	aquatic
Potamogeton natans	aquatic
Potamogeton praelongus	aquatic
Potamogeton pusillus	aquatic
Potamogeton subsibiricus	aquatic

Table 6.4 (continued) List of taxa new to Denali National Park and Preserve observed in four wetland habitats within the Interior Boreal Lowland Floristic Region of Denali National Park and Preserve, 1998-2001.

Potamogeton xosteriformis	aquatic
Ranunculus lapponicus	bog, fen
Ranunculus pensylvanicus	marsh/strand
Ranunculus sceleratus* ssp. *multifidus	marsh/strand
Rumex maritimus	marsh/strand
Scirpus validus	marsh/strand
Senecio congestus	marsh/strand
Sparganium minimum	aquatic
Stellaria crassifolia	marsh/strand
Stellaria longifolia	marsh/strand
Tofieldia glutinosa* ssp. *brevistyla	bog, fen
Trichophorum alpinum	bog, fen
Typha latifolia	aquatic, marsh/strand
Utricularia intermedia	aquatic
Utricularia minor	aquatic
Utricularia vulgaris	aquatic

C. Summary of Results for Interior Boreal Upland Floristic Region

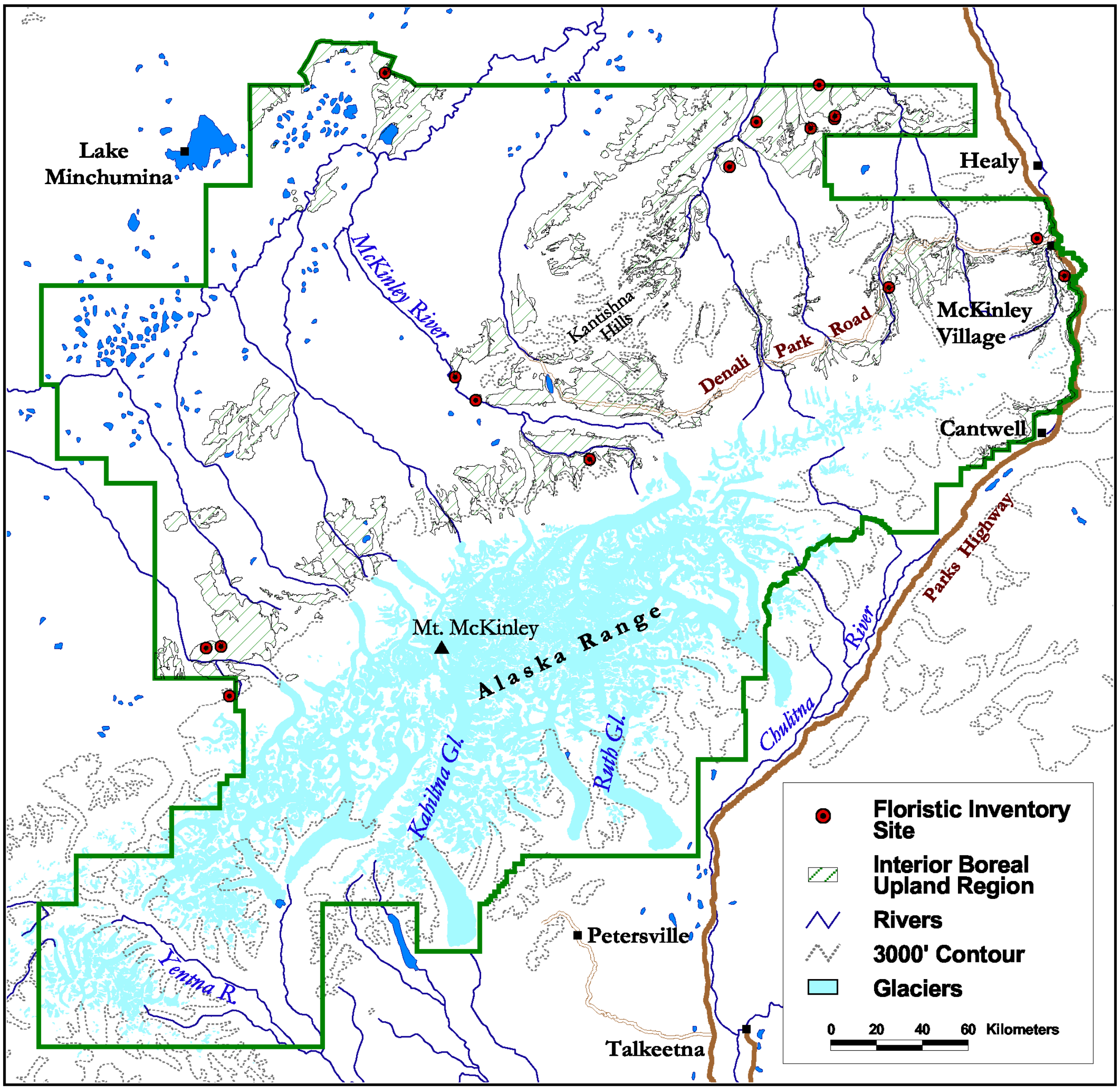


Figure 6.9 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Interior Boreal Upland Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.5 General summary of Floristic Inventory effort and results for the Interior Boreal Upland Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	No. of specimens
Number of sites surveyed in region:	15	N/A
Total number of hours in surveys:	95	N/A
Average number of survey hours per site:	6.3	N/A
Average number of surveyors per site:	2.0	N/A
Total number of collections in region:	276	276
Number of taxa new to the Park (pre-1998) found in region:	35	45
Number of taxa with major range extension into region:	3	5
Number of taxa with range extension into region:	5	5
Number of AKNHP-tracked taxa found in region:	8	8
Number of AKNHP element occurrences:	8	8
Number of Alaska - Yukon endemic taxa collected in region:	6	10
Number of Amphiberingian endemic taxa collected in region:	12	13

Plate 6.12 The Interior Boreal Uplands Floristic Region of Denali National Park and Preserve is characterized by boreal forest and scrub vegetation. This photograph is looking southeast into this region from the ridge separating the Teklanika and Sushanna rivers.

1. Physiography

The Interior Boreal Upland Floristic Region occupied almost 2,420 km^2, primarily in the central area of the Park, north of the Alaska Range crest (for map, see Figure 6.9, a representative photo is shown in Plate 6.12). This floristic region occurred along the northern flanks of the Alaska Range, and it encircled the alpine areas in the outer ranges of mountains between the mostly forested boreal lowlands and the largely treeless alpine zone. The interior uplands region occupied elevations between 120 m and 1300 m, but 84 percent of the area of this region occurred on terrain at elevations lying between 400 and 1000 m above sea level (Figure 6.10). Slope angles within the region were generally moderate, with only 25 percent of the area occupied by terrain with slope angles of 30 degrees or steeper, and just 5 percent in the steepest slope category above 50 degrees (Figure 6.10). Overall, west facing slopes were most prevalent in this region (31 percent), followed by north facing slopes (26 percent), at the expense of east and south facing slopes, which each occupy less than a quarter of the terrain in this region (Figure 6.10). Again, this uneven distribution of terrain among aspects was due to the fact that much of this region lay on the northwestern flanks of the Alaska Range, which drained to the northwest.

2. Surficial geology

The predominant surficial geology type in this region was unconsolidated glacial drift deposits, which occupied about 40 percent of the terrain surface in the Interior Boreal Upland Floristic Region (Figure 6.10; calculated from Clark and Duffy 2004). This mantle of sediments occurred along the northern apron of the Alaska Range. These unconsolidated drift sediments were derived from bedrock in the Alaska Range and were deposited upon retreat of Alaska Range glaciers. Colluvium derived from schistose bedrock was the second most abundant lithology type in the interior subalpine region, and this type occurred in the outer ranges of hills north of the Alaska Range proper, such as the Kantishna Hills. Nenana gravels deposits (also glacial in origin) and eolian deposits each occupied about 10 percent of the area within the region (Figure 6.10). There were no current glaciers within the region, and a negligible amount of area was occupied by water (0.4 percent).

In total, approximately 51 percent of the soils in the region were derived from drift, 36 percent from bedrock colluvium, 11 percent from eolian sediments, and just over 2 percent were derived from alluvium (Clark and Duffy 2004).

An analysis of the permafrost coverage for the Park indicated that the landscape of the Interior Boreal Upland Floristic Region was strongly affected by permafrost (Figure 6.4; Clark and Duffy 2004). An estimated 28 percent of the area of this region was occupied by soils units with continuous permafrost (Figure 6.4). Forty-four percent of the soils units were characterized as containing discontinuous permafrost, and the remaining 28 percent contained sporadic permafrost.

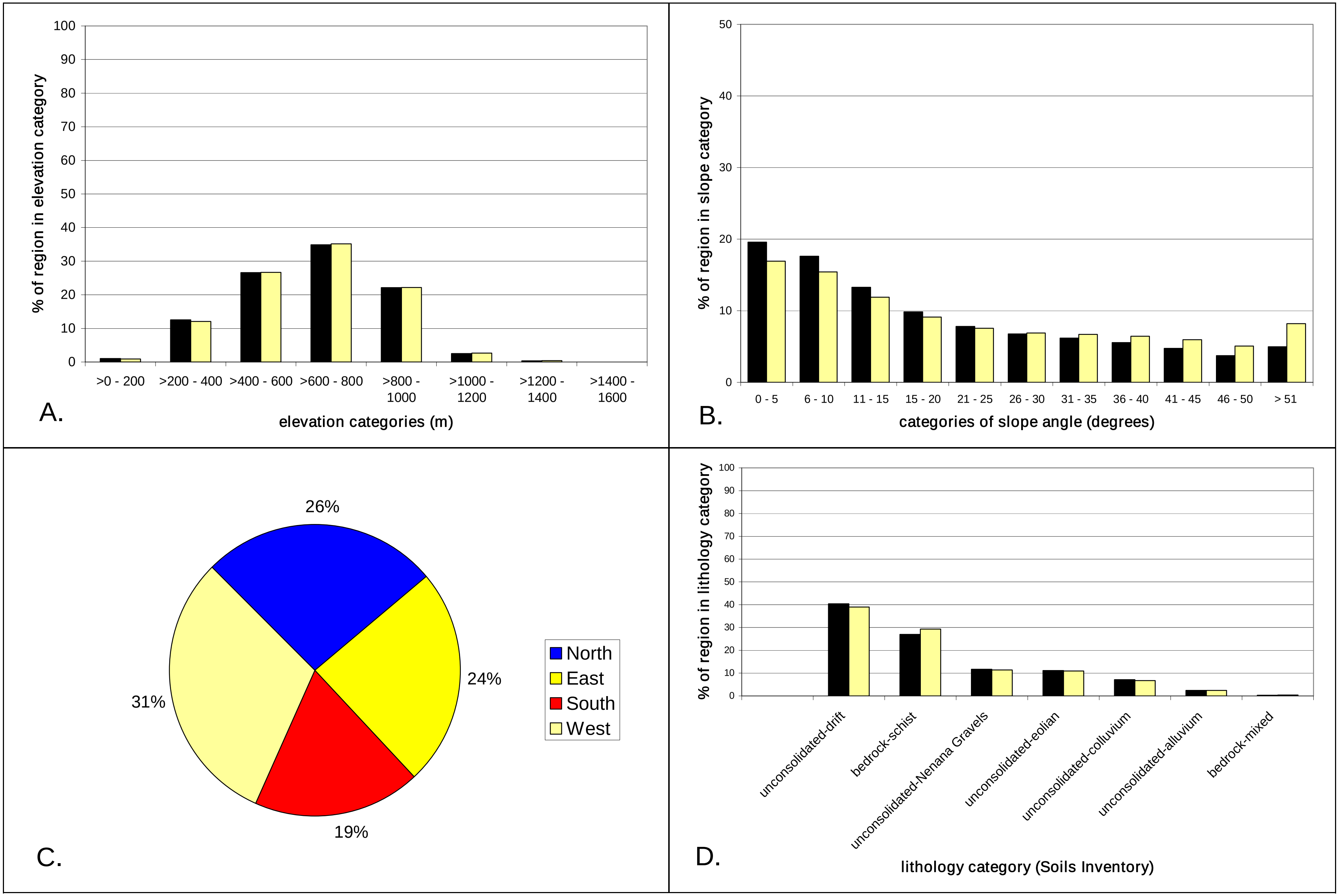


Figure 6.10 Four graphs showing the percentage of the landscape of the Interior Boreal Uplands Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.

3. Landcover patterns

Scrub landcover types were abundant in the landscape of the Interior Boreal Upland Floristic Region (Boggs et al. 2001). The total percentage of the region's land area covered by five major scrub landcover types was 56 percent (Figure 6.11). The most common scrub landcover types in the region were low shrub birch-ericaceous-willow and low shrub-sedge, which covered 31 and 13 percent of the area of this region respectively (Figure 6.11; Boggs et al. 2001). By contrast, woodland and forest landcover types occupied a total of 39 percent and tundra types covered slightly more than 2 percent of the area of this floristic region. Much of the area that was assigned to forested landcover types within the Interior Boreal Uplands was actually quite open with scattered trees occurring within a mosaic of shrub birch and ericaceous shrub vegetation. The dominant forested landcover types observed in the Interior Boreal Upland Floristic Region were open woodland spruce (13 percent of the area) and stunted spruce (12 percent of the area).

The general potential vegetation cover in the region identified by the Soils Inventory was more equally divided between scrub and forest types, reflecting the potential of areas currently supporting scrub to eventually become forested through time with the process of succession (Figure 6.11; Clark and Duffy 2004).

4. Summary of inventory results in region

We surveyed 15 sites within the Interior Boreal Upland Floristic Region and spent a total of 95 survey hours in the field there (Table 6.5). The results of these surveys included the collection and preparation of 276 voucher specimens that documented eight element occurrences for taxa tracked by the Alaska Natural Heritage program (see Table 7.1). In addition, 35 taxa that were not documented in the Park prior to 1998 were collected in the Interior Boreal Upland Floristic Region (Table 6.5). Major range extensions for the following species were documented within this region: *Phlox richardsonii*, *Primula mistassinica* and *Smelowskia calycina*. Range extensions for *Cryptogramma stelleri*, *Carex pachystachya*, *Isoetes echinospora*, *Oxytropis campestris* ssp. *jordalii*, and *Viola selkirkii* were also documented in the Interior Boreal Upland sites.

5. Notable plant associations surveyed in region

The dominant vegetation types within this floristic region were not particularly noteworthy from a floristic perspective. In fact, the blanket of dwarf birch scrub, open white spruce forest, and alder scrub types (see Plate 6.13), that predominated in upland and subalpine areas of the landscape within the interior of the Park, were generally species-poor, and contain few of the rarer elements of our flora. Plant communities of higher vascular floristic diversity and floristic interest within the interior upland zone occurred in sites where the development of the dominant shrub canopy and thick moss cover was curtailed or absent. Absence or disruption of the dominant vegetation cover occurred either by frequent disturbance of the substrate by geomorphic processes, or because edaphic conditions in a site were outside of the tolerances for the dominant shrubs species such as *Betula glandulosa*, *Alnus viridis* and *Salix pulchra*, among others. There were two primary examples of sites in the Interior Boreal Uplands where the

Plate 6.13 The uplands and subalpine zones north of the Alaska Range crest are dominated by a mosaic of scrub and forest vegetation types. This photo shows dwarf birch scrub on permafrosted terrace and open white spruce forest on hill slope in background in the vicinity of lower Stony Creek in the Interior Boreal Upland Floristic Region of Denali.

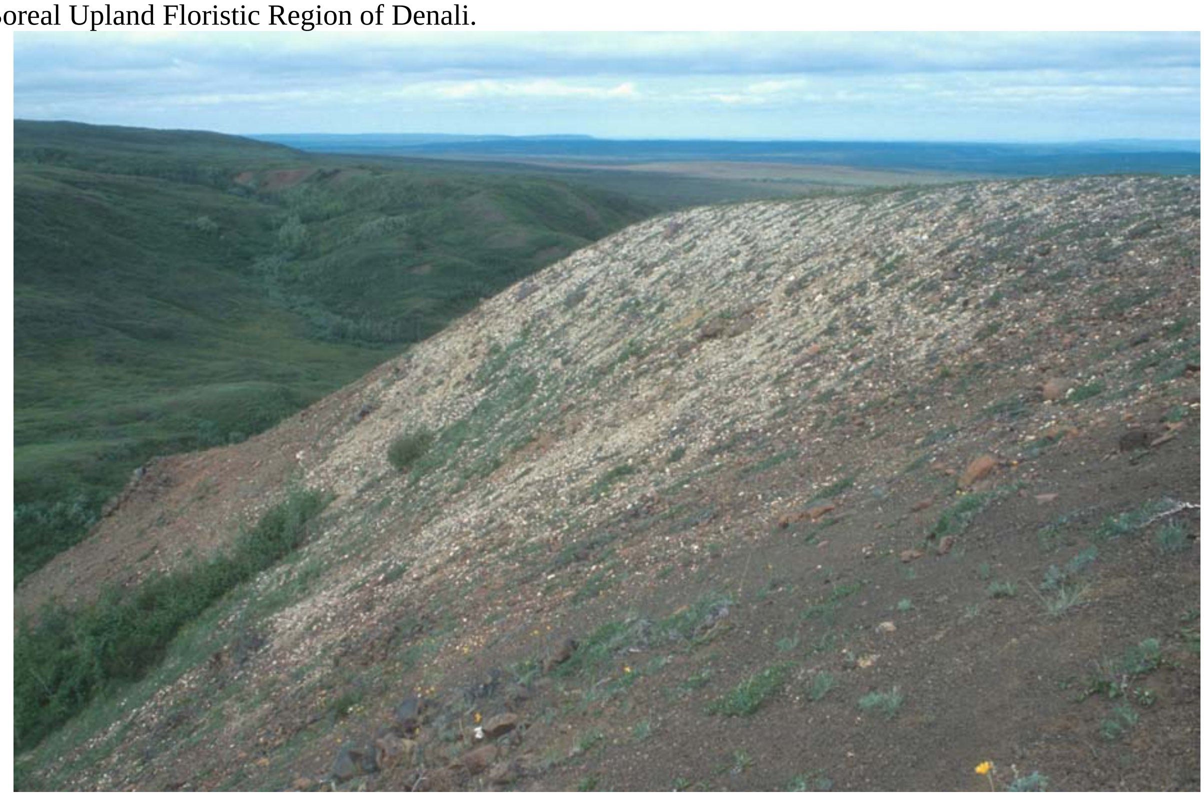
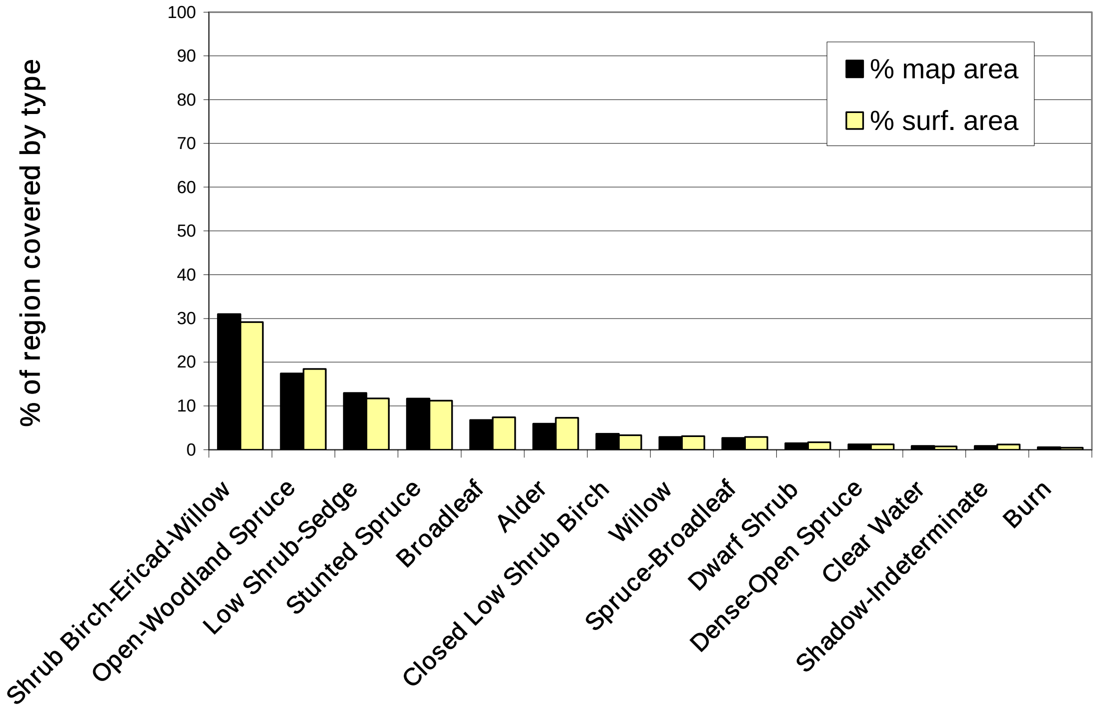
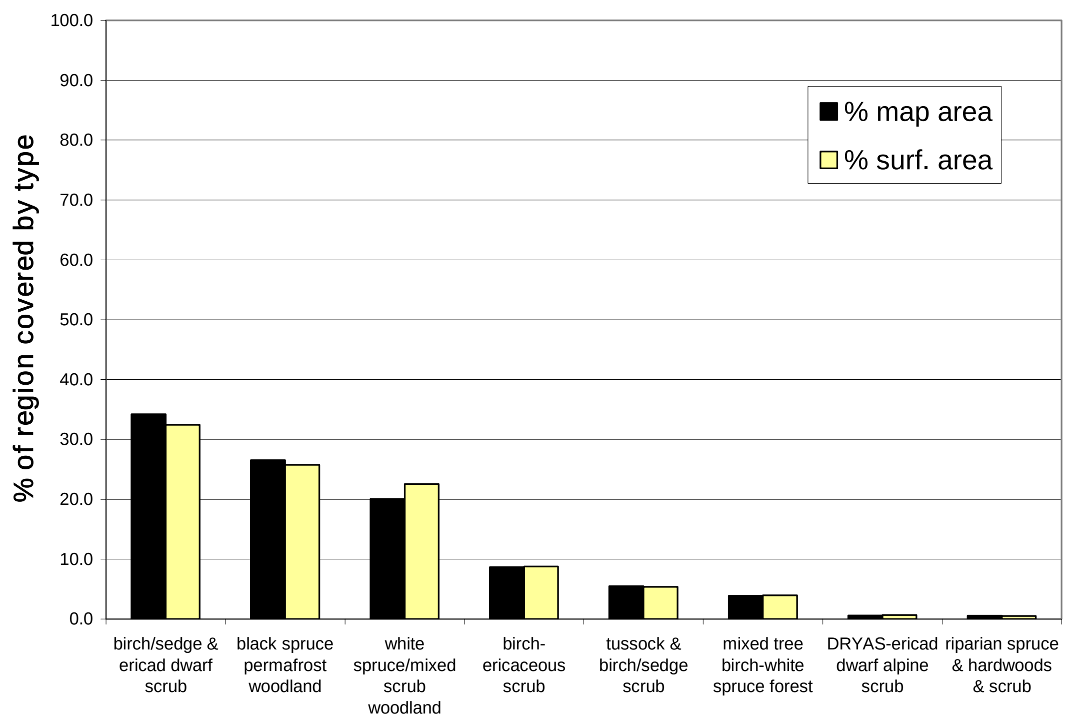


Plate 6.14 Openings in the zonal vegetation of the Interior Boreal Upland Floristic Region, such as this subalpine bluff between the Sushanna and Teklanika Rivers, contain relatively high numbers of rare and biogeographically noteworthy vascular plant taxa.



A. major landcover types in region (>1% cover)



B. major general potential vegetation types in region

Figure 6.11 Histograms showing the percentage of the landscape in Interior Boreal Upland Floristic Region distributed among categories of landcover type and general potential vegetation classes.

dominant woody taxa were less prevalent and a broader diversity of plant species occurred: 1) Open subalpine herbaceous plant communities on open bluffs and steep hillslopes (Plates 6.14 and 6.15); and 2) open wet graminoid-herbaceous meadows and aquatic sites (Plate 6.16).

The sites that were intensively inventoried in this floristic region were focused on areas in one of the categories listed above, although surveys of the dominant vegetation were also made in adjacent areas. Seven of the sites in the Interior Boreal Upland Floristic Region were focused on dry rocky bluffs, rock outcrops and their associated plant communities, and eight of the sites were focused on ponds and associated wet meadow habitats or associated riparian areas.

- **Open subalpine herbaceous plant communities on open bluffs and steep hillslopes**

  These areas generally had relatively thin, rocky soils and were very xeric in character (see Plate 6.14). In these dry, windswept upland sites, drought stress precludes the establishment of the dominant plant species and moss layer, and/or geomorphic activity periodically removes the dominant taxa, thus allowing a broader array of herbaceous plant species to persist. Two of the sites that were surveyed in this region stood out as the most significant: a subalpine bluff at Triple Lakes near McKinley Village and a site in the Roosevelt Hills, located in the far northwestern corner of Denali National Park and Preserve. Both of these sites supported xeric, open plant communities on steep, south-facing slopes associated with rock outcrops and rubble slopes.

  These sites were unusually rich in taxa whose ranges are endemic to Beringia and the Alaska-Yukon Territory region, in comparison to most of the plant communities that occurred in the boreal uplands within the interior of the Park. The following endemic taxa were collected at the above sites: *Cnidium cnidiifolium*, *Douglasia gormanii*, *Festuca lenensis*, *Eritrichium splendens*, *Lupinus arcticus*, *Luzula rufescens*, *Phlox richardsonii*, *Polygonum alaskanum*, and *Silene williamsii*. The increase in the numbers of endemic taxa in these open sites likely reflected the ecological history of this region, where periodic cold, very dry glacial intervals have resulted in the expansion of open landscapes as compared to today's predominant boreal ecosystems. Endemic plants whose evolutionary history is rooted in this landscape are generally plants that have an affinity for open habitats and drier soil conditions because those are attributes that have been most prevalent over recent geologic time in this part of Alaska, imparting a strong selection pressure for adaptation to these environments. It is reasonable to assume that the ranges of these endemic species were expanded considerably during glacial intervals, followed by contractions into small refugia of open space during times when boreal taxa were favored by climatic norms (such as the present).

- **Open, wet graminoid-herbaceous meadow vegetation and aquatic sites**

  We performed inventories in eight wetland sites in this floristic region. These sites were focused on areas too wet to support the development of dominant vegetation types, generally with standing water at the ground surface (see photo in Plate 6.16). Large sedge species such as *Carex utriculata* and *Carex rostrata* were abundant in these sites. Because wetlands were generally under-represented in plant collection efforts within

Plate 6.15 Two species that were new to the Park that occurred in the Interior Boreal Upland Floristic Region: *Cypripedium guttatum*, left and *Carex albo-nigra*, right.

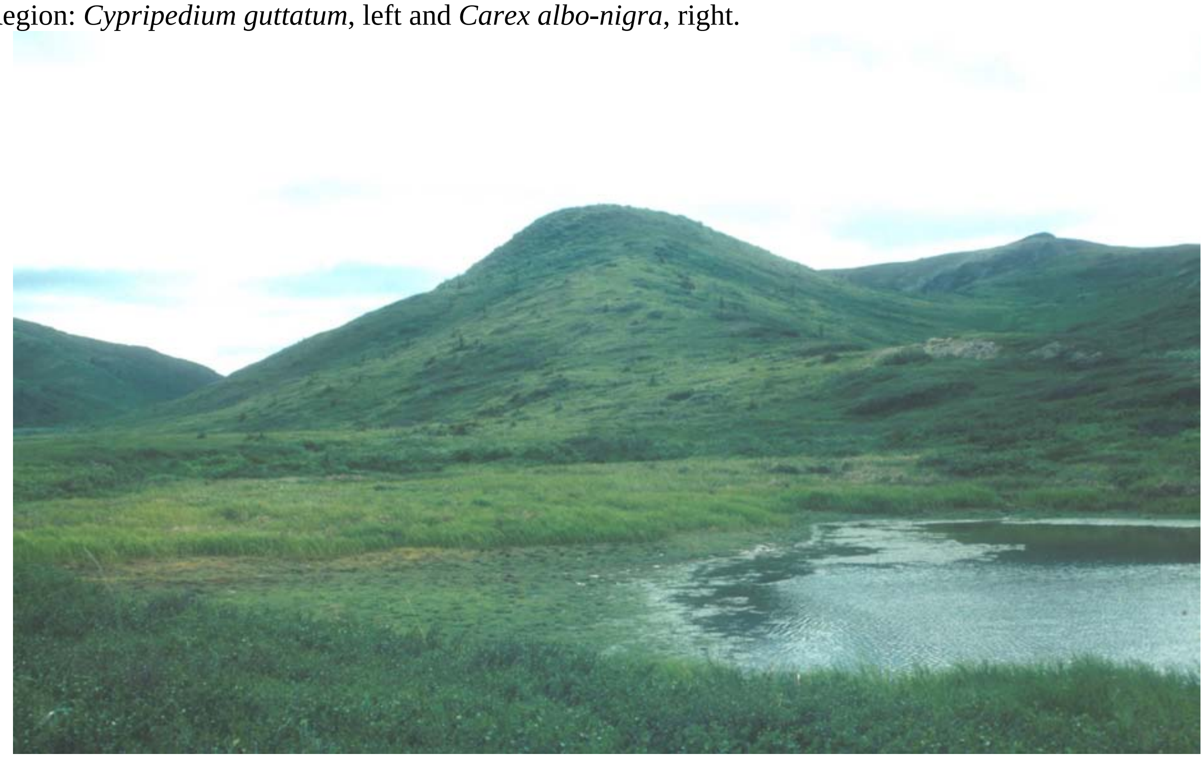


Plate 6.16 A photograph of an open subalpine wetland surrounding a small pond in the Interior Boreal Uplands Floristic Region of the Park (in the range of hills east of the Sushanna River).

Denali National Park and Preserve in the past, numerous plants new the Park were collected in these sites, including: *Callitriche anceps, Carex brunnescens, Carex chordorrhiza*, *Carex crawfordii*, *Carex magellanica*, *Carex tenuiflora*, *Cicuta virosa*, *Isoetes echinospora*, *Myriophyllum sibiricum*, *Ranunculus scleratus,* and *Selaginella selaginoides*.

D. Summary of Results for Interior Alpine Outer Range Floristic Region

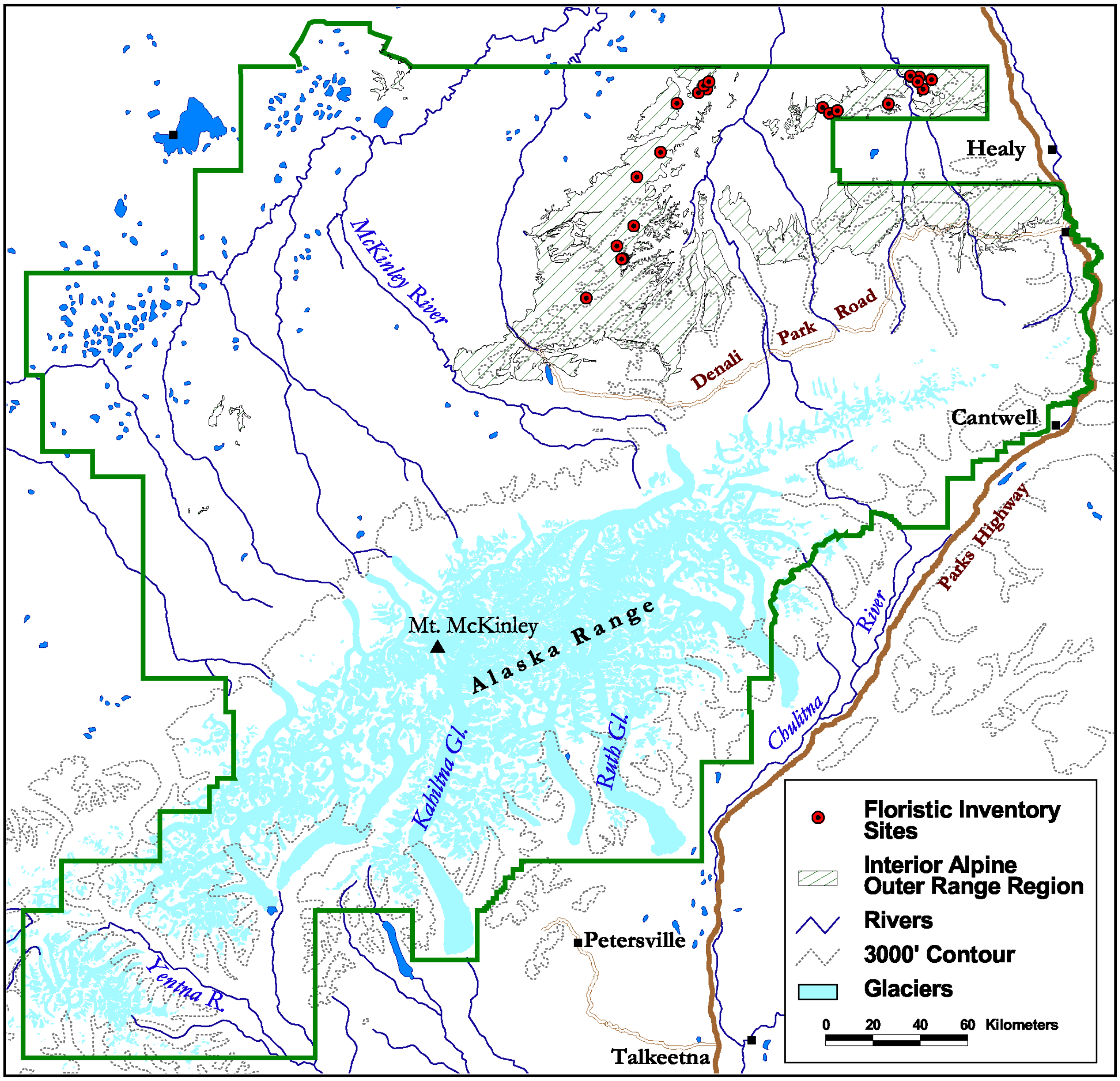


Figure 6.12 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Interior Alpine Outer Range Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.6 General summary of Floristic Inventory effort and results for the Interior Alpine Outer Ranges Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	No. of specimens
Number of sites surveyed in region:	22	N/A
Total number of hours in surveys:	202.5	N/A
Average number of survey hours per site:	9.2	N/A
Average number of surveyors per site:	2.2	N/A
Total number of collections in region:	455	455
Number of taxa new to the Park (pre-1998) found in region:	25	58
Number of taxa with major range extension into region:	8	23
Number of taxa with range extension into region:	3	5
Number of AKNHP-tracked taxa collected in region:	10	39
Number of AKNHP element occurrences:	39	39
Number of Alaska - Yukon endemic taxa collected in region:	18	56
Number of Amphiberingian endemic taxa collected in region:	33	78

Plate 6.17 A representative view of the Interior Alpine Outer Range Floristic Region of Denali National Park and Preserve, taken near Mount Chitsia in the northern Kantishna Hills.

1. Physiography

The Interior Alpine Outer Range Floristic Region occupied approximately 1,907 km^2 north of the Alaska Range crest (for map, see Figure 6.12). A representative photo of this floristic region is shown in Plate 6.17. This region was formed by alpine areas that were set off from the Alaska Range proper and included the Kantishna Hills, the domes north of the Stampede Trail, and portions of the Outer Range north of the Park Road as well as isolated islands of alpine habitat further north and west. The Outer Range mountains are considerably lower, on average, than the peaks of the Alaska Range proper, and elevations in this floristic region ranged between about 300 and almost 1800 m (Figure 6.13). Approximately a third of the terrain lay at elevations between 800 and 1000 m, and 92 percent lay between the elevations of 600 and 1200 m (Figure 6.13).

The terrain within this region was generally much less steep than the landscape of the Alaska Range regions of the Park, (although considerably steeper, on average, than either the Interior Boreal Uplands or Lowlands regions). For example, an estimated 20 percent of the terrain in the outer ranges region was inclined at slope angles steeper than 50 degrees, as opposed to 45 percent of slopes being in this category in the interior region of the Alaska Range (Figure 6.13). The remaining 80 percent of the terrain in the Interior Alpine Outer Ranges Floristic Region was split fairly evenly among the slope classes between 0 and 50 degrees, although only four percent of the area was estimated to be 0 to 5 degrees in slope, in sharp contrast to the boreal regions which were dominated by level terrain. Thirty-one percent of the terrain in this region was westerly in aspect and 27 percent was inclined to the north (Figure 6.13). Slopes with an easterly aspect occupied 22 percent of the area and south facing slopes represented just 20 percent of the area in this floristic region.

2. Surficial geology

The bedrock geology of the Interior Alpine Outer Ranges region was dominated by schistose rock types, which underlay 61 percent of the Interior Alpine Outer Ranges Floristic Region (Figure 6.13). Both the Kantishna Hills and the domes north of the Stampede Trail were formed by schist (Clark and Duffy 2004). The other two major surficial geology types in this region were unconsolidated sedimentary deposits. Nenana gravels deposits of glacial origin covered 19 percent of this region and wind-deposited loess covered approximately 14 percent of its area (Figure 6.13; Clark and Duffy 2004).

3. Landcover patterns

Low shrub types were the most abundant landcover classes in the Interior Alpine Outer Range Floristic Region (Figure 6.14). Low shrub birch-ericaceous-willow was the most abundant single landcover class and covered an estimated almost 31 percent of the area in this region. The other two low shrub types that occurred in this region, low shrub-sedge and closed low shrub birch, covered about ten and two percent of this region respectively. The low shrub landcover types were mostly dominated by dwarf birch (*Betula nana*) and ericaceous shrubs such as *Ledum* spp. and *Vaccinium* spp. (for descriptions of types see Boggs et al. 2001). Alpine dwarf scrub tundra was the second most widespread landcover type in the region, covering 15 percent of its

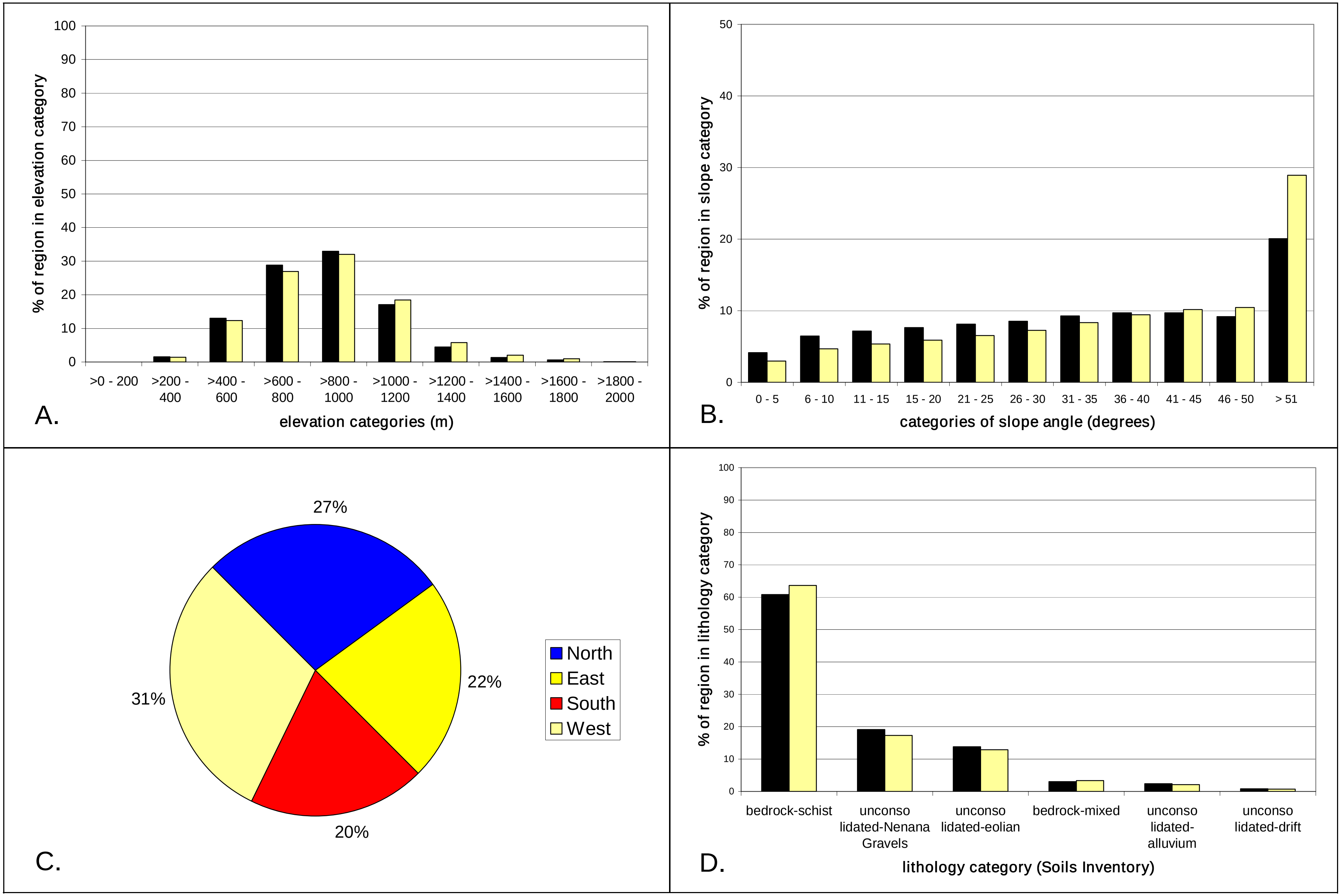


Figure 6.13 Four graphs showing the percentage of the landscape of the Interior Alpine Outer Range Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.

area. Dwarf scrub was primarily represented by well-drained *Dryas* and *Dryas* – ericaceous tundra on alpine ridges and slopes in this floristic region. Alder scrub, which occurred in gullies, riparian areas and steep, moist slopes, covered about 14 percent of the area in the Interior Alpine Outer Range Floristic Region. Most of the remainder of the landscape in this region was covered by a mix of willow scrub (four percent of the area) and several woodland and forested types, which together accounted for about 12 percent of the area of the region (Figure 6.14).

The Soils Inventory data indicated that the shrub birch – ericaceous shrub type was the dominant general potential vegetation for the area, covering almost 64 percent of the region (Figure 6.14; calculated from Clark and Duffy 2004). An estimated 15 percent of this area would support tussock-shrub birch vegetation and another almost 9 percent would support *Dryas* dwarf scrub tundra (Clark and Duffy 2004).

An estimated 59 percent of the land surface of this region was occupied by soil units with discontinuous permafrost (Figure 6.4; Clark and Duffy 2004). Soils units rated as containing continuous permafrost covered an estimated 18 percent of the area in this region, and were generally restricted to north aspects in the lower parts of the Kantishna Hills, in areas contiguous to heavily permafrosted lowlands.

4. Fire on the landscape

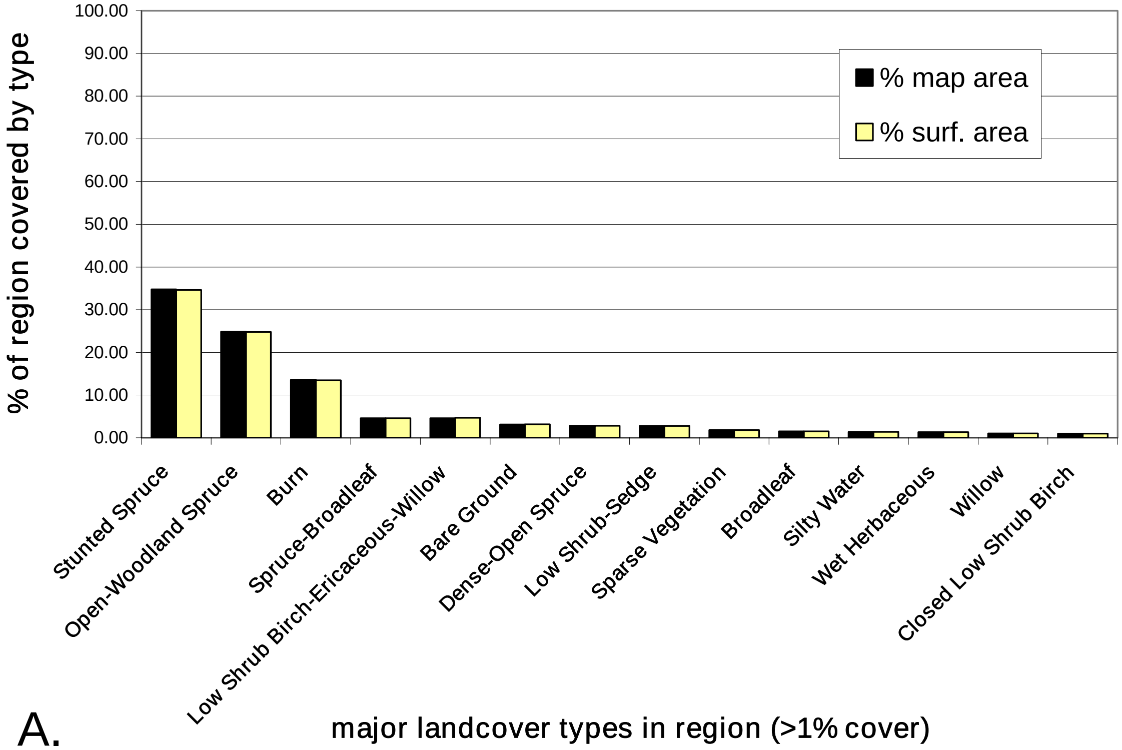
Although this floristic region was alpine in character, a small amount of woodland and open forested vegetation did occur there, and these vegetation types are susceptible to fire. An analysis of fire perimeters for the past fifty years suggests that about two percent of the area of the Interior Alpine Outer Range Floristic Region has been burned during this period of time (Figure 6.5). The terrain that falls into this region was surrounded by boreal lowlands that undergo considerable disturbance by fire, which can spread up hill slopes and thus enter the alpine region.

5. Summary of inventory results in region

We spent 203 hours performing field surveys of 22 sites in the Interior Alpine Outer Range Floristic Region of the Park (for map, see Figure 6.12). During these surveys, we made 455 specimen collections (Table 6.6), which resulted in the documentation of major range extensions for nine taxa into this region, including the following: *Athyrium alpestre*, *Cassiope lycopodioides*, *Draba borealis*, *Epilobium leptocarpum*, *Phlox richardsonii*, *Primula mistassinica*, *Ranunculus occidentalis, Rhododendron camtschaticum*, and *Smelowskia calycina*. Range extensions were documented for three additional taxa: *Hieracium triste*, *Juncus drummondii*, and *Phyllodoce aleutica* (see Tables 5.2 and 5.3). Thirty-nine element occurrences of ten species considered rare by the AKNHP were documented in this floristic region (see Table 7.1).

6. Notable plant associations surveyed in region

There were two primary ranges of mountains that form the Interior Alpine Outer Ranges Floristic Region: 1) the Teklanika Mountains, which are the low range of domes and ridges north of the



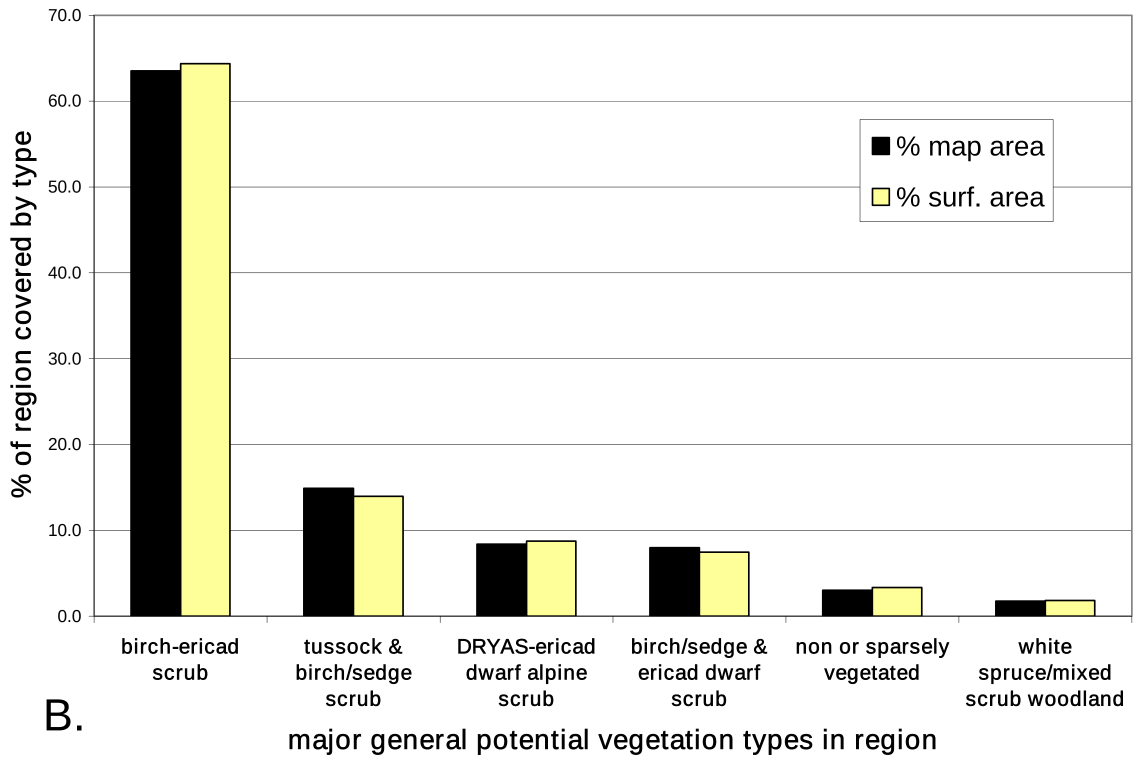


Figure 6.14 Histograms showing the percentage of the landscape in Interior Alpine Outer Range Floristic Region distributed among categories of landcover type and general potential vegetation classes.

Stampede Trail and 2) the Kantishna Hills. Work in both of these areas produced noteworthy collections and novel floristic information for the Park, although the floristic character of each of these two regions was very distinctive from each other. Noteworthy collections in the high peaks of the central Kantishna Hills documented the presence of a distinctive coastal floristic element in this region, whereas noteworthy collections in the Teklanika Mountains (and the far northern Kantishna Hills, including Chitsia Mountain) documented new localities of species endemic to interior and arctic regions of Alaska and Beringia.

The significant plant collections that were made in the Interior Alpine Outer Ranges Floristic Region were of species that fell into two general categories: 1) species of coastal distribution that were found in mesic heath tundra and snowbed-meadow mosaic in the central Kantishna Hills; and 2) plants of generally interior and arctic distribution that occur in xeric alpine plant associations in the Teklanika Mountains and northern Kantishna Hills, many of which have geographic distributions that are restricted to Beringia.

- **Mesic heath tundra and snowbed-meadow mosaic in the central Kantishna Hills**

  Numerous plant species known primarily from maritime-influenced coastal localities in Alaska were found growing in mesic heath tundra and snowbed meadows in the cirques and valleys of the central Kantishna Hills during this inventory. This discovery of a suite of vascular plant taxa with strong coastal affinities growing in a small area within the central Kantishna Hills represented the documentation of a novel floristic pattern for central interior Alaska. For instance, our collections were the first known localities in interior Alaska for several taxa, including *Athyrium alpestre*, *Ranunculus occidentalis*, and *Rhododendron camtschaticum*. The presence of this coastal floristic element within the interior region of the Park was a unique facet of Alaska's phytogeography revealed by this inventory.

  Aside from the major range extensions for *Athyrium alpestre*, *Ranunculus occidentalis*, and *Rhododendron camtschaticum*, numerous other taxa of mostly coastal distribution were collected in this region of the Park. These taxa included the following species: *Cassiope stelleriana*, *Draba borealis*, *Juncus drummondii*, *Luetkea pectinata*, *Phyllodoce aleutica*, *Primula cuneifolia* spp. *saxifragifolia*, *Vahlodea atropurpurea*, and *Veronica wormskjoldii*, among others (see Plate 6.18). The co-occurrence of a relatively large suite of taxa with coastal affinities is noteworthy, and suggests that the climate regime of this area of the Kantishna Hills may be different from other areas in the interior mountains of the Park. Perhaps, for instance, this area receives higher precipitation and more summer cloudiness than neighboring areas, resulting in an environment that is more similar to coastal areas of the state.

- **Xeric alpine plant associations in the Teklanika Mountains and northern Kantishna Hills**

  The significant collections made in the Teklanika Mountains included several plant taxa that are narrowly endemic to generally unglaciated and periglacial parts of Beringia, including *Douglasia gormanii*, *Eritrichium splendens*, *Erysimum pallasii*, *Festuca*

Plate 6.18 Two species with primarily coastal distributions that occur in the Kantishna Hills in Denali National Park and Preserve: *Primula cuneifolia* (left) and *Phyllodoce aleutica* (right).

Plate 6.19 Four endemic species that occur in the Interior Alpine – Outer Ranges Floristic Region, clockwise from top left: *Eritrichium splendens*, *Stellaria dicranoides*, *Artemisia globularia*, and *Saxifraga reflexa*.

lenensis, *Phlox richardsonii*, *Stellaria dicranoides,* and *Synthyris borealis* (see Plate 6.19). The habitat preferences of this set of xerophytes were very different from the set of significant taxa with coastal associations that were found in the central and northern Kantishna Hills. These endemic taxa occurred within a matrix of dry *Dryas*-graminoid tundra, rubble slopes and rock outcrops. Sites that supported these endemic taxa were generally quite dry and exposed, and had relatively low amounts of vegetative cover. Many of these taxa also occurred more frequently in facies that received higher amounts of solar radiation, such as south-facing slopes. In addition to the narrowly endemic species that were found in this area, a larger set of noteworthy taxa that are generally restricted to unglaciated regions within the Alaska portion of their geographic range was also documented by collections within the Interior Alpine Outer Ranges Floristic Region. This larger set of noteworthy taxa included the following species: *Anemone multiceps*, *Arenaria capillaris*, *Artemisia globularia*, *Astragalus aboriginum*, *Campanula uniflora*, *Bupleurum americanum*, *Claytonia tuberosa*, *Minuartia elegans*, *Primula eximia*, *Saxifraga spicata*, *Saxifraga calycina*, *Selaginella sibirica*, *Senecio yukonensis*, *Silene repens,* and *Smelowskia calycina*.

The co-occurrence of this set of species in the interior mountains of the Park is in accordance with our understanding that these species evolved within the landscape context of repeated exposure to the extreme, hyper-continental conditions of the Beringian refugium during glacial periods. It is likely that the distribution of these endemic species has repeatedly expanded during glacial maxima when the landscape was more open and tundra-like. Conversely, during interglacial periods (such as the present), the ranges of these taxa have likely contracted to the barren and windswept areas where we find them today. In fact, many of these taxa do show an interrupted, spotty distribution pattern suggestive of the fragmentation of a previously larger geographic range.

E. Summary of Results for Interior Alpine Alaska Range Floristic Region

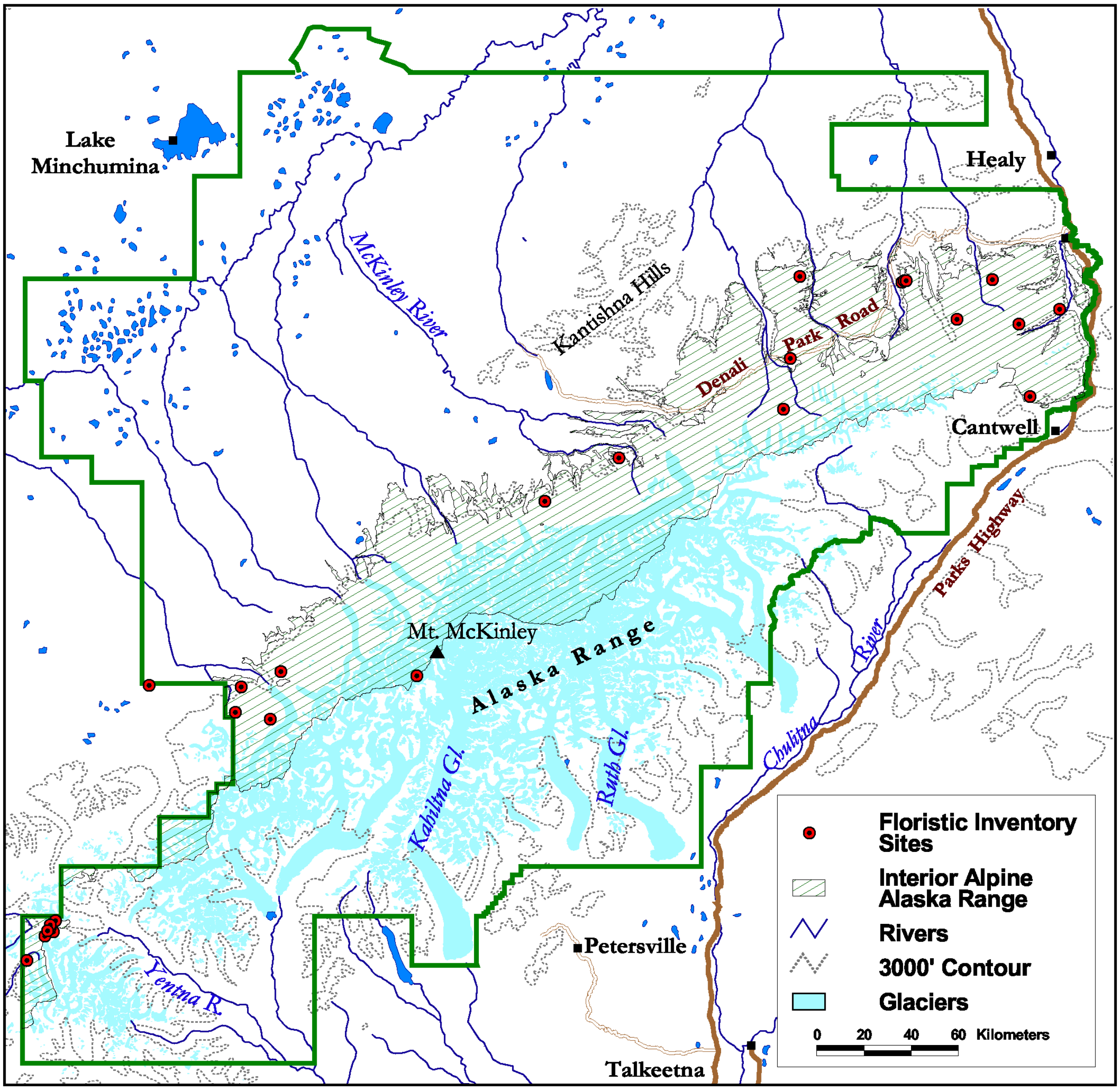


Figure 6.15 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Interior Alpine Alaska Range Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.7 General summary of Floristic Inventory effort and results for the Interior Alpine Alaska Range Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	# of specimens
Number of sites surveyed in region:	27	N/A
Total number of hours in surveys:	248.5	N/A
Average number of survey hours per site:	9.2	N/A
Average number of surveyors per site:	1.6	N/A
Total number of collections in region:	707	
Number of taxa new to the Park (pre-1998) found in region:	31	51
Number of taxa with major range extension into region:	4	4
Number of taxa with range extension into region:	8	9
Number of AKNHP-tracked taxa found in region:	18	51
Number of AKNHP element occurrences:	51	51
Number of Alaska - Yukon endemic taxa collected in region:	24	86
Number of Amphiberingian endemic taxa collected in region:	30	86

Plate 6.20 Representative photograph of Interior Alpine Alaska Range Floristic Region showing Shellabarger Pass near the western corner of Denali.

1. Physiography

The Interior Alpine Alaska Range Floristic Region encompasses approximately 4,800 km^2 on the northwest side of the drainage divide formed by the crest of the Alaska Range (for map see Figure 6.15, a representative photo is shown in Plate 6.20). The Southcentral Alpine Floristic Region borders the southern and eastern perimeter of the Interior Alpine Alaska Range Floristic Region, and, to the north and west, the Interior Alpine Alaska Range Floristic Region is bounded by the Interior Boreal Upland and the Interior Alpine Outer Range regions. The landscape of this region was thoroughly alpine in character, with elevations spanning from 700 meters to the summit of Mt. McKinley at more than 6,100 meters. An estimated 76 percent of the area in this region lay at elevations between 800 and 1800 meters (Figure 6.16). Slope angles in the region were (predictably) steep, and 45 percent of the area of this region (and 62 percent of its surface area) was occupied by terrain with slope angles of 50 degrees or more (Figure 6.16). The remaining 55 percent of the area was divided relatively evenly among the lower-angle slope classes (Figure 6.16). This floristic region lay to the north and west of the drainage divide formed by the Alaska Range crest, and the terrain was therefore dominated by slopes inclined primarily to the north and west. In fact, an estimated 63 percent of the area lay on slopes inclined either north or west, versus 37 percent inclined in either a southerly or easterly aspect (Figure 6.16).

2. Surficial geology

This floristic region encompassed a large section of the central Alaska Range, and thus contained a diverse cross section of lithology, alpine landforms and soils attributes. The surficial geology of much of this region was dominated by colluvium derived from bedrock of mixed lithologies (Figure 6.16; calculated from Clark and Duffy 2004). Much of the bedrock in this region, particularly at lower elevations, was of sedimentary and metamorphosed sedimentary origin. However, the region also included large areas of intrusive acid-igneous bedrock, schistose rock and isolated areas of marine sediments and limestone (Figure 6.16). In lower elevation areas and river terraces within this region, unconsolidated sediments derived from glacial drift and alluvium occurred over bedrock units (Figure 6.16**)**. Areas containing these surficial deposits cover an estimated 27 percent of the Interior Alpine Alaska Range Floristic Region.

Permafrost was not a dominant attribute of this floristic region, as it was for many of the lowland regions north of the Alaska Range crest. An estimated 34 percent of the area was occupied by soil units that were classified as having sporadic permafrost, with another 14 percent containing soil units with discontinuous permafrost (Figure 6.4).

3. Landcover patterns

Unvegetated rocky high alpine areas and glaciers occupied about half of the area of the Interior Alpine Alaska Range Floristic Region of the Park. Glacial ice and permanent snow fields accounted for approximately 20 percent of the area, and unvegetated surfaces accounted for another roughly 30 percent of the region (Figure 6.16, Figure 6.17). The primary vegetated landcover types in this region included dwarf scrub tundra (15.2 percent), low shrub birch-ericaceous-willow (12.4 percent) and sparse vegetation (8.9 percent; Figure 6.16). Additional,

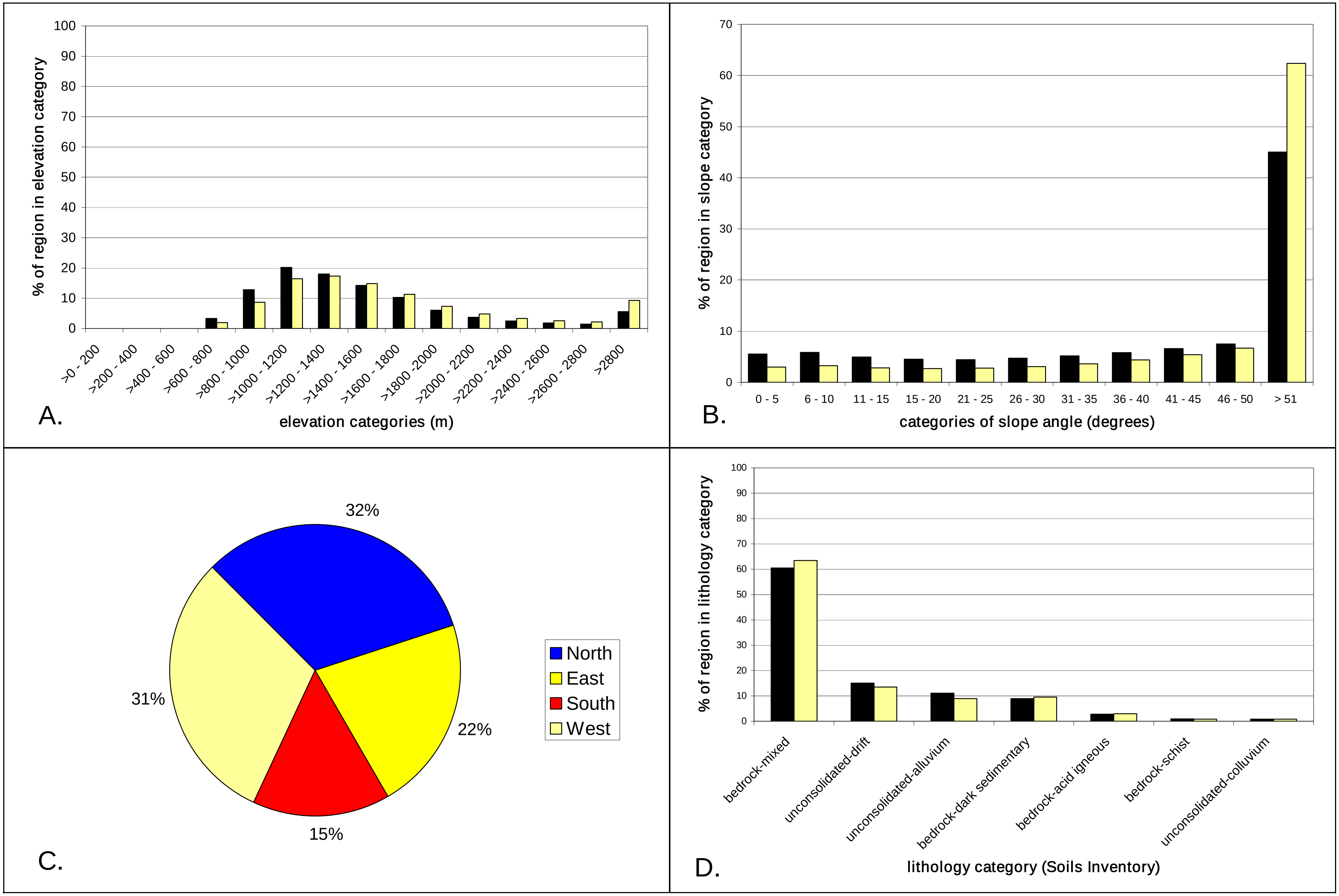


Figure 6.16 Four graphs showing the percentage of the landscape of the Interior Alpine Alaska Range Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.

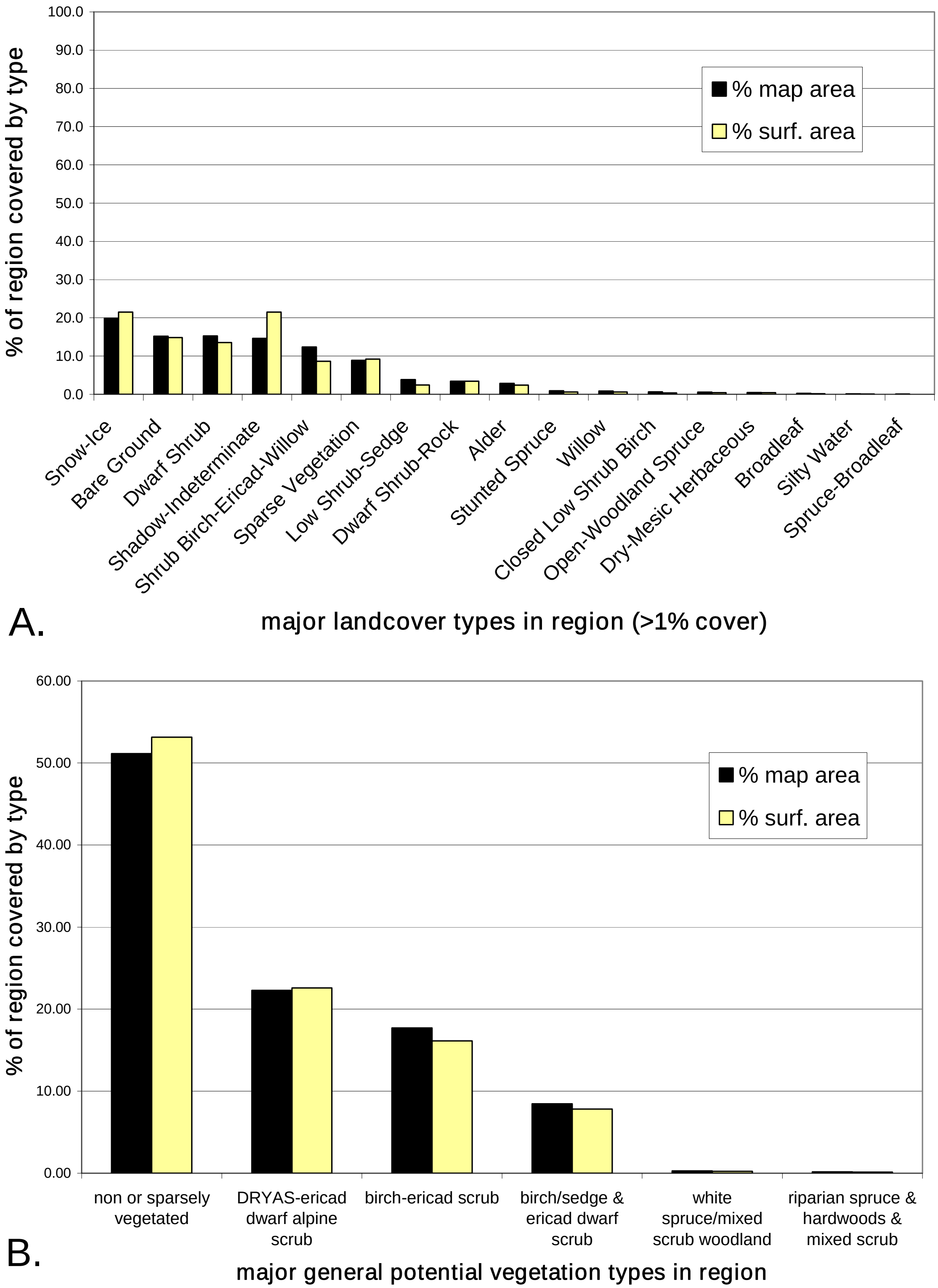


Figure 6.17 Histograms showing the percentage of the landscape in Interior Alpine Alaska Range Floristic Region distributed among categories of landcover type and general potential vegetation classes.

less spatially extensive components of the landscape of this region included alder, stunted spruce, willow, and closed dwarf shrub birch (Figure 6.16).

The general potential vegetation for the region identified by the Soils Inventory largely reflected the current landcover, with slightly over 50 percent of the area non-or sparsely vegetated, 20 percent of the area supporting dwarf scrub tundra, and shrub-birch-ericaceous shrub covering approximately 18 percent of the area (Figure 6.16; Clark and Duffy 2004).

4. Fire on the landscape

Fire has played a negligible role in the vegetation dynamics of the Interior Alpine Alaska Range Floristic Region over the past 50 years, with none of the landscape affected by fires during this period of time (Figure 6.5).

5. Summary of inventory results in region

We performed vascular plant inventories of 27 sites in the Interior Alpine Alaska Range Floristic Region of the Park. These surveys required 249 hours of field survey time and resulted in the collection of 707 vascular plant specimens (see Table 6.7). This region of the Park was the most thoroughly collected area of the Park prior to this inventory. Nevertheless, our collections resulted in the documentation of 18 taxa that were not known to occur in the Park prior to 1998 (see Table 6.7). We recorded major range extensions for four taxa in the Interior Alpine Alaska Range Floristic Region, including *Draba borealis*, *Draba corymbosa*, *Phlox richardsonii* and *Carex spectabilis*. Range extensions for an additional eight species were also documented by collections made in this region during the floristic inventory, including *Carex lapponica*, *Draba crassifolia*, *Epilobium leptocarpum*, *Juncus drummondii*, *Kobresia sibirica*, *Phippsia algida*, and *Stellaria umbellata*. Fifty-one element occurrences of 31 taxa considered rare by the AKNHP were collected in the Interior Alpine Alaska Range Floristic Region. Collections in this alpine region resulted in the documentation of the highest numbers of both AKNHP-tracked species and element occurrences found in any single floristic region in the Park (see Table 7.1).

6. Notable plant associations surveyed in region

The Interior Alpine Alaska Range Floristic Region contained the highest numbers of rare and endemic plant species of all of the floristic regions in the Park. The majority of these taxa occurred in well-drained, very open and exposed segments of the landscape, including alpine fellfields, rock outcrops and rubble slopes, as well as dry tundra habitats. Other botanically rich (but very spatially restricted) features of the interior Alaska Range's alpine landscape were seepage areas and small alpine rivulets. In these areas, cation-rich ground waters have percolated to the surface and created mossy, well-watered microsites within an otherwise xeric landscape.

The significant collections that were made in this region during this inventory came from three general plant association types: 1) xeric alpine slopes: tundra, fellfield, outcrops and rubble slopes, 2) wet alpine seeps and rivulets, and 3) forb-herbaceous meadows in transitional climatic areas in the vicinity of low Alaska Range passes into the Cook Inlet drainage. The three sites

Plate 6.21 *Dryas octopetala* dwarf-scrub tundra is a common feature of the Interior Alpine Alaska Range landscape. The bench in the foreground (in the vicinity of Mystic Pass) supports this vegetation.

Plate 6.22 Four species that are common in tundra in the Interior Alpine – Alaska Range Floristic Region, clockwise from upper left: *Minuartia arctica*, *Salix arctica*, *Pedicularis capitata*, and *Anemone parviflora*.

inventoried in this region in areas with surficial geology derived from limestone were also particularly rich, containing eight of the twenty one AKNHP-tracked plant species that were collected in the region.

- **Plant associations in xeric alpine slopes: tundra, fellfield, outcrops and rubble slopes**

  Dry tundra in the interior mountains of the Park was characterized by high relative cover of *Dryas octopetala* and a suite of dwarf-scrub tundra taxa such as *Arctostaphylos alpina*, *A. rubra*, *Empetrum nigrum*, *Loiseleuria procumbens*, *Salix arctica*, and *Diapensia lapponica* (see photo in Plate 6.21). Common grasses in dry tundra included *Poa arctica*, *Poa glauca*, *Trisetum spicatum*, and *Festuca brachyphylla*, and common forb taxa included *Antennaria* spp., *Campanula lasiocarpa*, *Potentilla uniflora*, *Senecio resedifolius*, and *Silene acaulis*. Alpine rubble slopes generally supported scant plant cover, particularly of the common dwarf shrub tundra taxa. These open areas commonly supported only scattered individual plants with less than five percent total plant cover. Vascular plant species that were frequently observed in rubble slopes included several species of *Draba*, *Festuca brachyphylla*, *Trisetum spicatum*, *Papaver mcconnellii*, *Saxifraga bronchialis*, and *Stellaria longipes*, among others (see Plate 6.22).

  Considerable collecting effort had occurred in these dry areas of interior alpine segment of the Alaska Range landscape prior to this inventory project. Nevertheless, significant new floristic information was gathered within this region during this project. The majority of rare and endemic species documented in this region generally occurred in dry, rocky tundra and rubble on alpine slopes. This included multiple new localities for the following species tracked by the AKNHP for Alaska: *Arenaria capillaris*, *Douglasia alaskana*, *D. gormanii*, *D. ruaxes*, *Festuca lenensis*, *Oxytropis huddelsonii*, *Phlox richardsonii*, *Stellaria alaskana*, *Taraxacum carneocoloratum*, and *Thlaspi arcticum* (see Plate 6.23).

  Major range extensions for *Draba corymbosa* and *Phlox richardsonii* were documented by collections made in dry alpine communities within the Interior Alpine Alaska Range Floristic Region in the Park. In addition, range extensions were documented for *Minuartia biflora* and *Senecio tundricola* from dry alpine sites in the region.

- **Wet alpine seeps and rivulets**

  Seepage areas and localized sites with saturated soil conditions represented a very small proportion of the alpine landscape in the interior region of the Park (see photo in Plate 6.24). The coarse rocky substrates, steep slope angles, and generally low annual precipitation resulted in a preponderance of well-drained, rather xeric plant communities across this landscape. A rich and floristically interesting assemblage of plants occurred in seepage areas and saturated spoils within the alpine zone, in spite of the spatially-restricted nature of these habitats. The vegetation of these sites was composed of high cover of sedges such as *C. lachenalli*, *C. microchaeta*, and *Carex podocarpa;* the grasses *Arctagrostis latifolia* and *Poa paucispicula;* and numerous forb species including many

Plate 6.23 Four species endemic to Alaska-Yukon that occurred in the Interior Alpine Alaska Range Floristic Region were, clockwise from upper left*: Smelowskia borealis*, *Douglasia alaskana*, *Claytonia scammaniana*, and *Papaver mcconnellii*.

Plate 6.24 Mossy seepage areas in the alpine zone present unusual edaphic conditions in this steeply sloping, rapidly-drained landscape.

alpine saxifrages such as *Saxifraga nelsoniana*, *Saxifraga hirculus*, and *Saxifraga hieracifolia*.

Range extensions for *Draba crassifolia*, *Juncus drummondii*, *Kobresia sibirica*, *Phippsia algida*, and *Stellaria umbellata* were documented by collections from wet alpine areas in the interior Alaska Range. In addition, *Aphragmus eschscholtzianus* and *Carex lapponica*, taxa which are considered rare in Alaska by the AKNHP, were collected in wet alpine areas within this region (see Plate 6.25).

- **Forb-herbaceous meadows in transitional climatic areas in the vicinity of low Alaska Range passes into the Cook Inlet drainage**

Areas in close proximity to the two low passes over the Alaska Range in the Denali National Park and Preserve region (Broad Pass in the north and Mystic Pass in the south) had transitional climates and thus exhibited a "mixing" of north side and south side vegetation types and plant taxa. For example, lush forb-herbaceous meadows, similar to those that predominated on open slopes in the lower alpine and subalpine areas south of the Alaska Range crest, occurred north of the crest in these areas. These communities were observed in the vicinity of Shellabarger Pass and the upper Windy Creek drainage near Cantwell.

Lush meadow plant communities supported a flora that was unusual for the interior region of the Park, including typical "south side" taxa such as *Lupinus nootkatensis*, *Senecio triangularis*, and *Veratrum viride*. Ten species that were not known to occur in the Park prior to 1998 were collected from meadow communities in these transitional areas of the Park: *Athyrium filix-femina*, *Carex micropoda*, *Carex spectabilis*, *Draba borealis*, *Epilobium leptocarpum*, *Juncus drummondii*, *Lupinus nootkatensis*, *Pyrola minor*, *Senecio triangularis*, and *Vahlodea atropurpurea*. The collections of *Carex spectabilis* and *Draba borealis* in meadows in the vicinity of Shellabarger Pass represented major extensions for these species ranges.

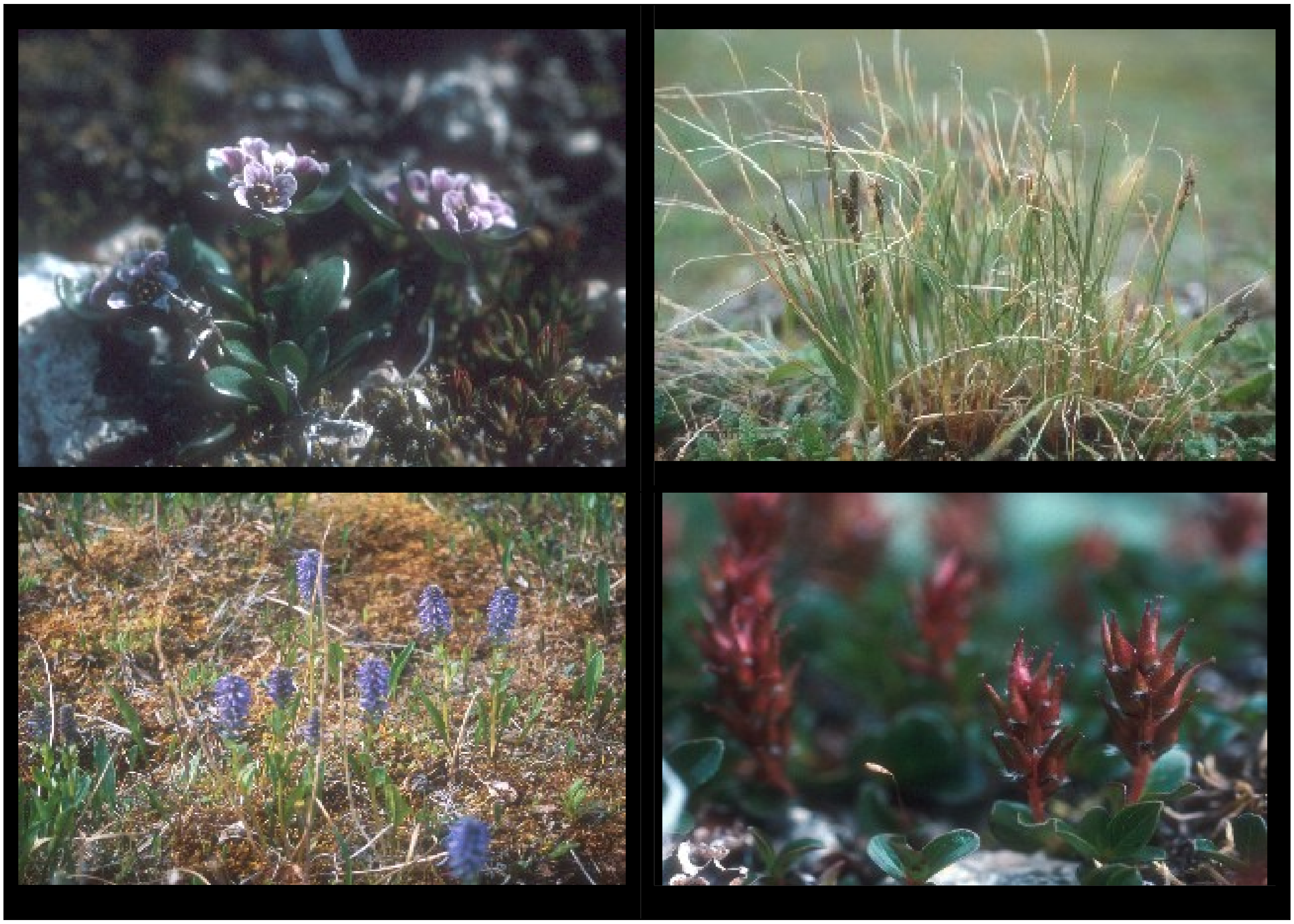


Plate 6.25 Four species that occur in alpine seepage areas in the Interior Alpine – Alaska Range Floristic Region of Denali National Park and Preserve, clockwise from upper left: *Aphragmus eschscholtzianus*, *Kobresia sibirica*, *Salix polaris*, and *Lagotis glauca*.

Plate 6.26 Aerial view of mixed white spruce – paper birch forest in the Southcentral Boreal Lowland Floodplain and Alluvial Fan Floristic Region of Denali National Park and Preserve.

F. Summary of Results for Southcentral Boreal Floodplain and Alluvial Flan Floristic Region

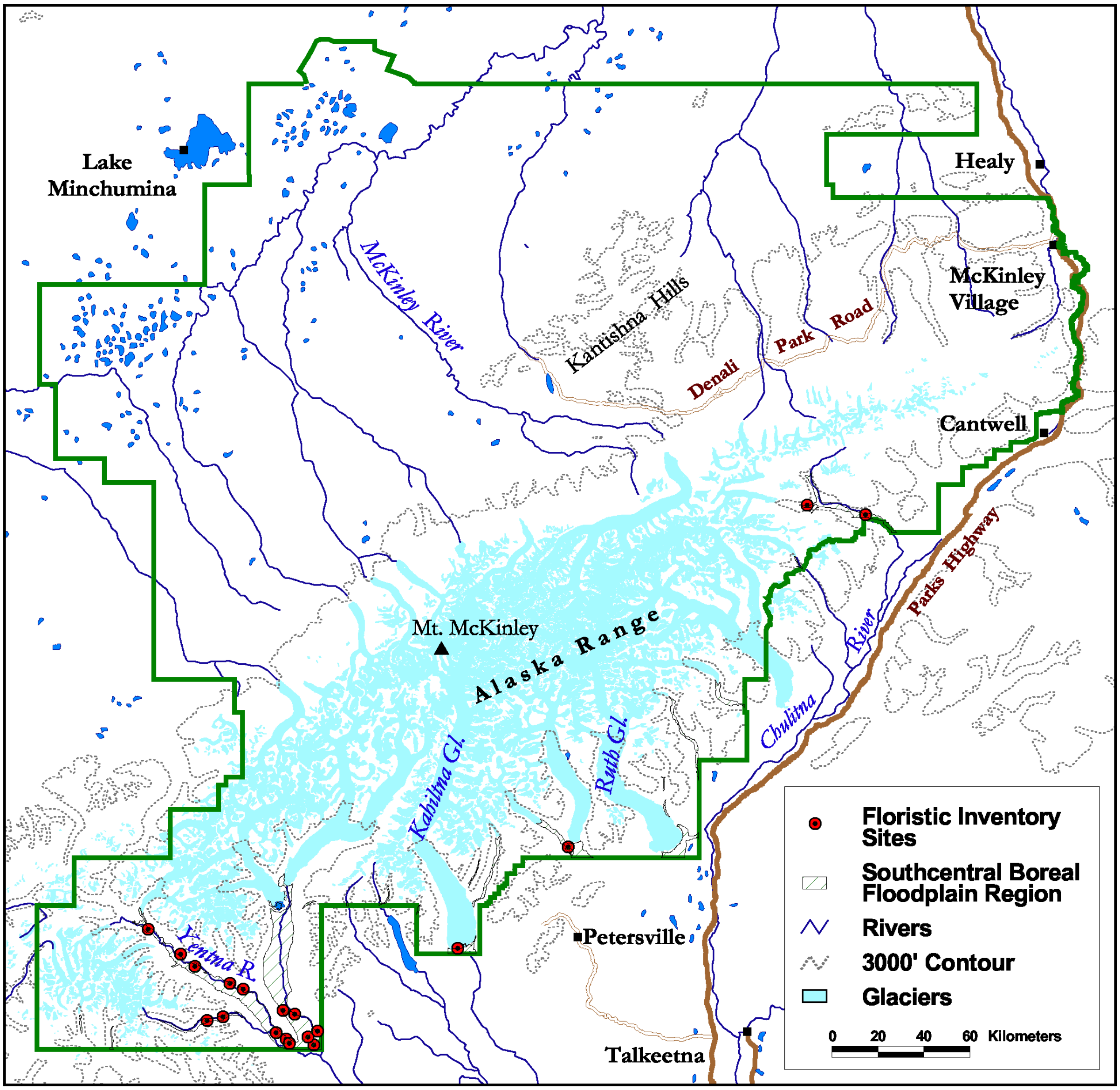


Figure 6.18 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.8 General summary of Floristic Inventory effort and results for the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	No. of specimens
Number of sites surveyed in region:	19	N/A
Total number of hours in surveys:	67	N/A
Average number of survey hours per site:	3.5	N/A
Average number of surveyors per site:	1.6	N/A
Total number of collections in region:	174	174
Number of taxa new to the Park (pre-1998) found in region:	52	69
Number of taxa with major range extension into region:	2	2
Number of taxa with range extension into region:	13	17
Number of AKNHP-tracked taxa found in region:	8	15
Number of AKNHP element occurrences:	15	(15)
Number of Alaska - Yukon endemic taxa collected in region:	2	3
Number of Amphiberingian endemic taxa collected in region:	0	0

Plate 6.27 Representative photograph of Southcentral Boreal Floodplain and Alluvial Fan Floristic Region, showing an area along the East Fork of the Yentna River.

1. Physiography

The Southcentral Boreal Floodplain and Alluvial Fan Floristic Region consists of the lowland terraces and active floodplains and alluvial fans of glacial rivers draining the south side of the Alaska Range that lay within the Park (for map, see Figure 6.18). This region covers approximately 298 km^2, primarily in the immediate vicinity of the Yentna, Kahiltna, Tokositna and Chulitna Rivers (see photo in Plate 6.27). Terrain elevations in this floristic region ranged from below 100 m to over 800 m, although 87 percent of the surface of this region lies below 400 m (Figure 6.19). Slope angles in this region were low, with 89 percent of the terrain lying at slope angles of 15 degrees or less (Figure 6.19). The distribution of the terrain of this floristic region among different aspects resembled the other south side floristic regions, with south and east aspects occurring in 60 percent of the area, and slopes with generally north and west aspects occupying only 40 percent of the region's area (Figure 6.19).

2. Surficial geology

The surficial geology of this region consisted almost entirely of unconsolidated sediments deposited by the large rivers draining the glaciers of the southcentral Alaska Range, including the Yentna, Kahiltna, Ruth, and Eldridge glaciers (Figure 6.19). Soil units containing permafrost were not observed in this region of the Park (Figure 6.4; Clark and Duffy 2004).

3. Landcover patterns

The major landcover classes (Figure 6.20) in this region represented a chronosequence of successional seres (for a series of representative photos of these stages, see Plate 6.30). This sequence begins with silty flowing waters and active channels (12 percent of the region's area) and progresses to barren silt and cobbles, freshly deposited by the river (24 percent of the region's area), followed by scrub thickets (five percent). The mid-successional scrub types are replaced, over time, by broadleaf forest (primarily riparian poplar forests) which covered 14 percent of the region's area. The final stage of succession in the region is the establishment of well-developed spruce-broadleaf forest, (20 percent of the area; Figure 6.20). Other notable landcover types in the region included peatland (1.2 percent), herbaceous shrub (1.2 percent), and wet herbaceous (0.4 percent). These wetland types occurred in depressions and other poorly drained sites within the lowland landscape.

4. Fire on the landscape

Due to the presence of large water bodies throughout this floristic region and the relatively moist understory conditions found in the vegetation there, fire was not a frequent source of disturbance in the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region. In fact, no large fires have been recorded in the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region during the past 50 years.

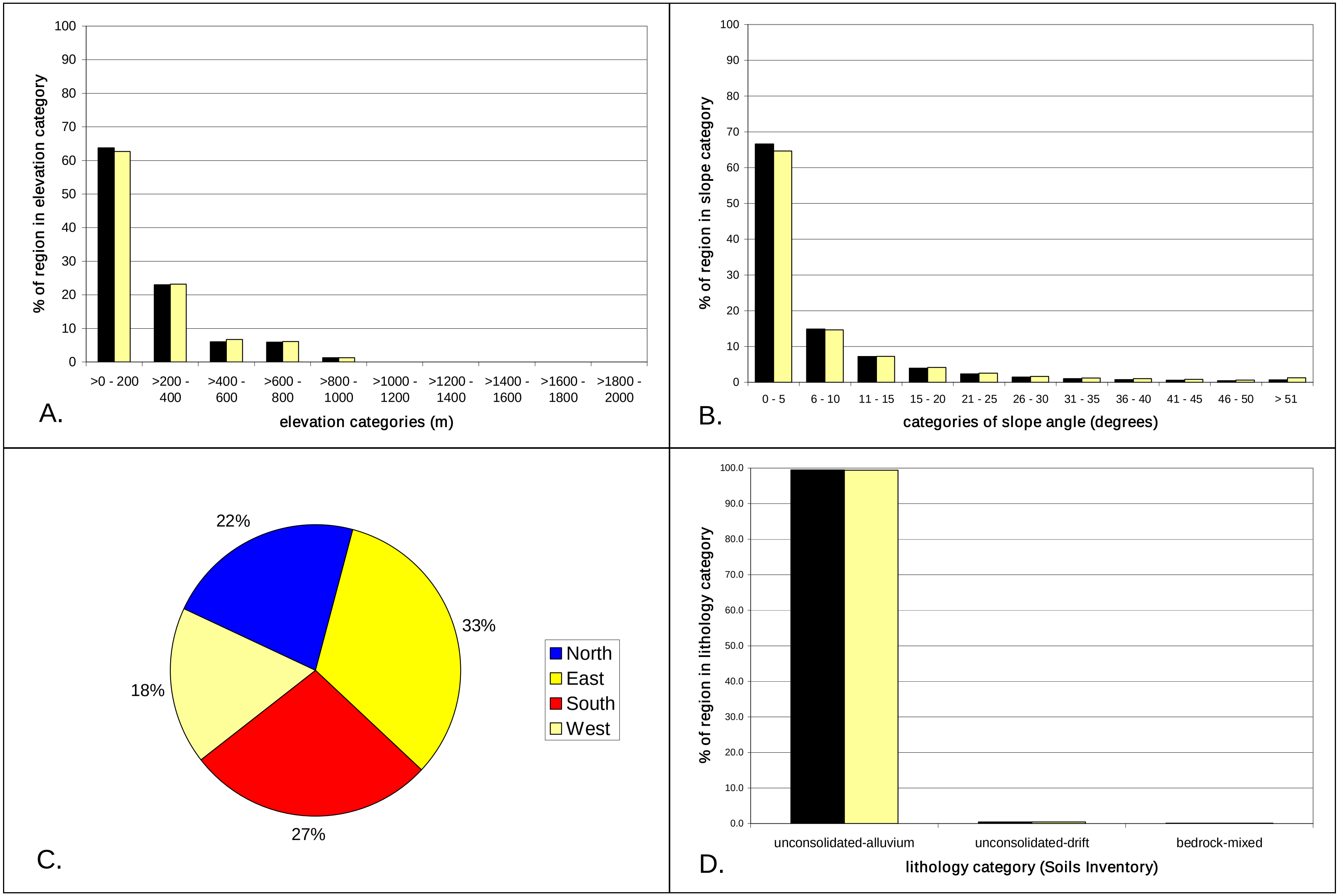


Figure 6.19 Four graphs showing the percentage of the landscape of the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.

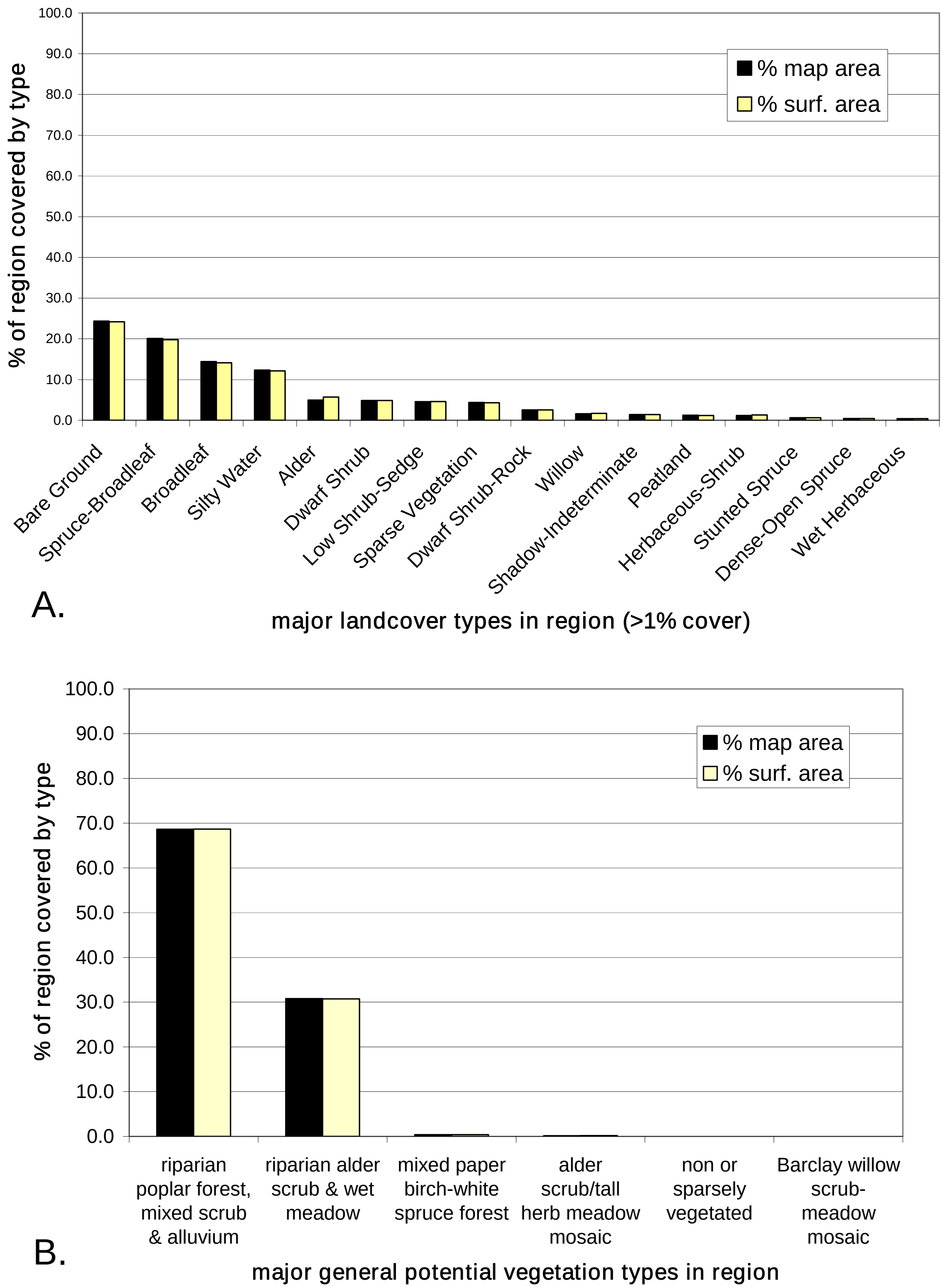


Figure 6.20 Histograms showing the percentage of the landscape in Southcentral Boreal Floodplain and Alluvial Fan Floristic Region distributed among categories of landcover type and general potential vegetation classes.

5. Summary of inventory results in region

The Southcentral Boreal Floodplain and Alluvial Fan Floristic Region was similar to the other areas south of the Alaska Range crest in that very little plant collecting effort had occurred in this region prior to the initiation of this inventory project. A few collections had been made at the base of the Kahiltna Glacier by Les Viereck in 1956 during reconnaissance work for his glacier succession study. Our collecting efforts were focused on the largest contiguous areas representing this floristic region in the Park: the floodplains of the Yentna and West Fork Chulitna rivers. We also inventoried sites on the floodplains of the Tokositna and Kahiltna rivers and along Fourth of July Creek, a tributary of the lower Yentna River.

We performed surveys of 19 sites within the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region of the Park. These surveys required 67 hours of field survey time and 174 voucher specimens were collected during this work. This set of collections documented 52 taxa new to the Park as well as 15 element occurrences for eight taxa considered rare by the AKNHP (see Table 6.8). Major range extensions were documented for *Cryptogramma stelleri* and *Agrostis exarata* into this floristic region. Range extensions for an additional 13 taxa were also documented by these collections (see Table 6.8).

6. Notable plant associations surveyed in region

Noteworthy collections were made in each of the four primary vegetation types that were surveyed in the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region of the Park. These types included mesic mixed forest, wetlands, aquatic herbaceous communities, and active floodplain areas.

- **Mesic mixed forests**

  Thirteen species new to the Park were collected in forested sites within the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region (see Plate 6.26), including range extensions for *Cinna latifolia*, *Matteuccia struthiopteris,* and *Osmorhiza depauperata*. These collections were made in the lush, shady understory of *Populus trichocarpa* forests on river terraces of the Yentna River. These forests were confined to a narrow bench within this valley, and these areas have likely received periodic flooding due to the constricted nature of the valley and high volume of water draining the steep slopes above. In addition, the Yentna River is extremely braided and its channels actively migrate due to high sediment loads. During our float of this river, we witnessed several areas where river channels had diverted and were flowing through closed poplar forest that supported very large diameter trees.

- **Wetlands**

  Twenty-two species new to the flora of the Park were documented through collections from wetland habitats within the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region (see Plate 6.28). These collections included specimens of four of the seven taxa considered rare by AKNHP that were collected within this floristic region

Plate 6.28 Aerial view of wetland marsh on floodplain of the Tokositna River in the Southcentral Boreal Floodplain Floristic Region of Denali National Park and Preserve.

Plate 6.29 Photograph of aquatic plant habitat on floodplain of the East Fork of the Yentna River in the Southcentral Boreal Floodplain Floristic Region of the Park.

during the inventory project (*Carex interior*, *Cicuta bulbifera*, *Glyceria striata* ssp. *stricta*, and *Pedicularis macrodonta*). A major range extension for *Agrostis exarata* and range extensions for seven additional taxa (*Angelica genuflexa*, *Carex diandra*, *Carex interior*, *Cicuta bulbifera*, *Platanthera dilatata*, *Ranunculus macounii* and *Scirpus validus*) were also documented from wetlands in this region of the Park.

- **Aquatic herbaceous communities**

  Eleven aquatic plant species that were not known to occur in the Park prior to 1998 were documented by vouchers during our collection efforts in the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region (see Plate 6.29). This included two species considered rare by the AKNHP, *Najas flexilis* and *Potamogeton subsibiricus*.

- **Active floodplains**

  Six species new to the Park were collected in active floodplain areas within the Southcentral Boreal Floodplain and Alluvial Fan Floristic Region (see habitat photo in Plate 6.30): *Mimulus guttatus* (Plate 6.31), *Rhinanthus minor*, *Salix lucida*, *Salix pseudomyrsinites*, *Salix sitchensis* and *Veronica americana* (Plate 6.31). In addition, *Salix setchelliana*, a low-growing endemic species of willow that occurs in glacial river floodplains across the Park (but is ranked S3 by the AKNHP), was also collected at two sites within this floristic region of the Park.

Plate 6.30 Four photographs representing floodplain succession on the glacial river floodplains in the Southcentral Boreal Lowland Floristic Region: (clockwise from upper left) 1) freshly deposited sand and gravel, 2) open seral herbs, with scattered poplar and alder, 3) *Dryas drummondii* mats with young poplar stand, and 4) mature and multi-layered white spruce-paper birch forest with alder understory.

Plate 6.31 Two plant species new to the Park that occurred in the Southcentral Boreal Floodplain Floristic Region: *Carex viridula* (left) and *Mimulus gutatus* (right).

G. Summary of Results for Southcentral Boreal Lowland Floristic Region

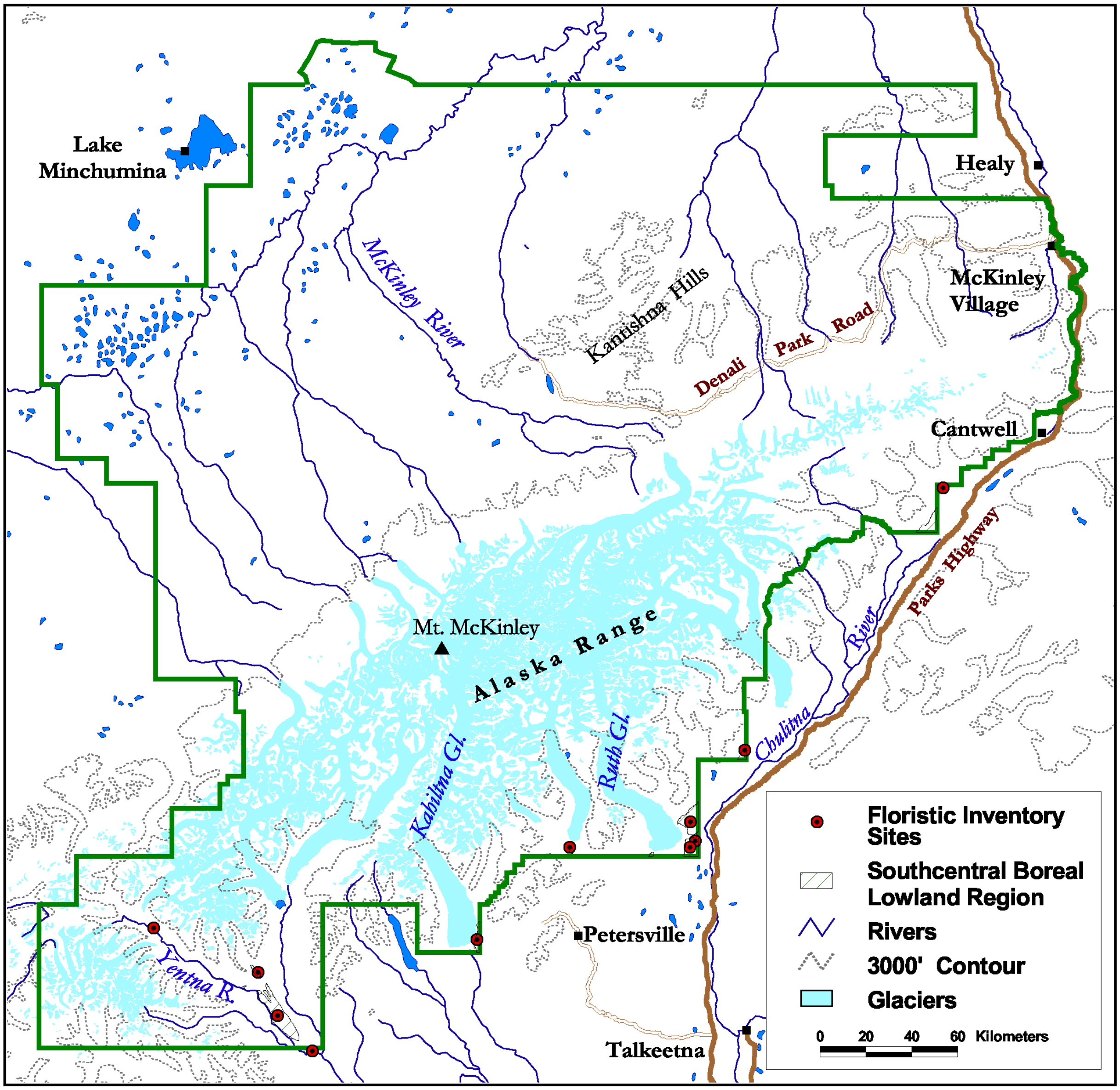


Figure 6.21 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Southcentral Boreal Lowland Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.9 General summary of Floristic Inventory effort and results for the Southcentral Boreal Lowland Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	No. of specimens
Number of sites surveyed in region:	11	N/A
Total number of hours in surveys:	34.1	N/A
Average number of survey hours per site:	3.1	N/A
Average number of surveyors per site:	1.5	N/A
Total number of collections in region:	165	165
Number of taxa new to the Park (pre-1998) found in region:	61	87
Number of taxa with major range extension into region:	3	6
Number of taxa with range extension into region:	13	15
Number of AKNHP-tracked taxa found in region:	7	10
Number of AKNHP element occurrences:	12	12
Number of Alaska - Yukon endemic taxa collected in region:	2	2
Number of Amphiberingian endemic taxa collected in region:	2	3

Plate 6.32 Representative photograph of Southcentral Boreal Lowland Floristic Region showing an area between Chelatna Lake and the base of the Kahiltna Glacier.

1. Physiography

The Southcentral Boreal Lowland Floristic Region constitutes a very small part of the Park landscape and occupied only 73 km^2 divided among four separate areas south of the Alaska Range crest (for map, see Figure 6.21; a representative photo is shown in Plate 6.32). The discontinuous and small extent of terrain in this floristic region made it the least well represented such region in the Park. Because of its small size, the landscape of the region was considerably less diverse than the landscapes of the other floristic regions of the Park. Elevations ranged between less than 100 m to approximately 700 m elevation, although there was no terrain in this region that was in the 400 m to 600 m elevation category (Figure 6.22). Slope angles in this low lying region of the Park were low to moderate, with 83 percent of the area occupied by slopes of 15 degrees or less (Figure 6.22). The distribution of the terrain among aspects in this region resembled the other south side floristic regions, with south and east aspects occurring in 59 percent of the area, and north and west aspects occupying 41 percent of the region's area (Figure 6.22).

2. Surficial geology

Surficial geology of this region consisted almost entirely of unconsolidated sediments of glacial origin, primarily drift from the most recent glaciation (Figure 6.22; Clark and Duffy 2004). Ninety eight percent of the region was covered by glacial drift deposits and approximately two percent was covered by surface waters (Figure 6.22).

3. Landcover patterns

The primary landcover types in the Southcentral Boreal Lowland Floristic Region of the Park were spruce-broadleaf forest (58 percent of the region; see Plate 6.33), alder scrub (12 percent), low shrub birch-ericaceous (5 percent), and peatlands (5 percent) (Figure 6.23; Boggs et al. 2001). The spruce broadleaf type included relatively lush spruce-birch forest on toe slopes and foothills, and spruce-poplar forests that developed on young to medium-aged alluvial terraces that may have experienced periodic flooding. Alder scrub occurred in more recently disturbed sites and valley slopes in this floristic region. The low shrub birch-ericaceous landcover type was generally restricted to the Broad Pass area at the northern extent of this region, which graded into interior areas where dwarf birch vegetation was a dominant element of the landscape. Peatlands occupied the very lowest and wettest surfaces of this region which had not been recently disturbed. These types occurred in sites with very restricted drainage and large accumulations of peat. Sedge species including *Carex utriculata* and *Carex aquatilis* were abundant in these sites, along with hydrophytic low shrubs such as *Myrica gale* and a suite of forbs including *Scheuchzeria palustris* and *Pedicularis macrodonta* among others.

The general potential vegetation coverage developed by the Soils Inventory reflected the fact that the "climax" stage of succession for this region of the Park was a mixed birch-spruce forest, which was deemed the general potential vegetation type for this entire region, except those areas that were currently covered by surface waters (Figure 6.23; Clark and Duffy 2004).

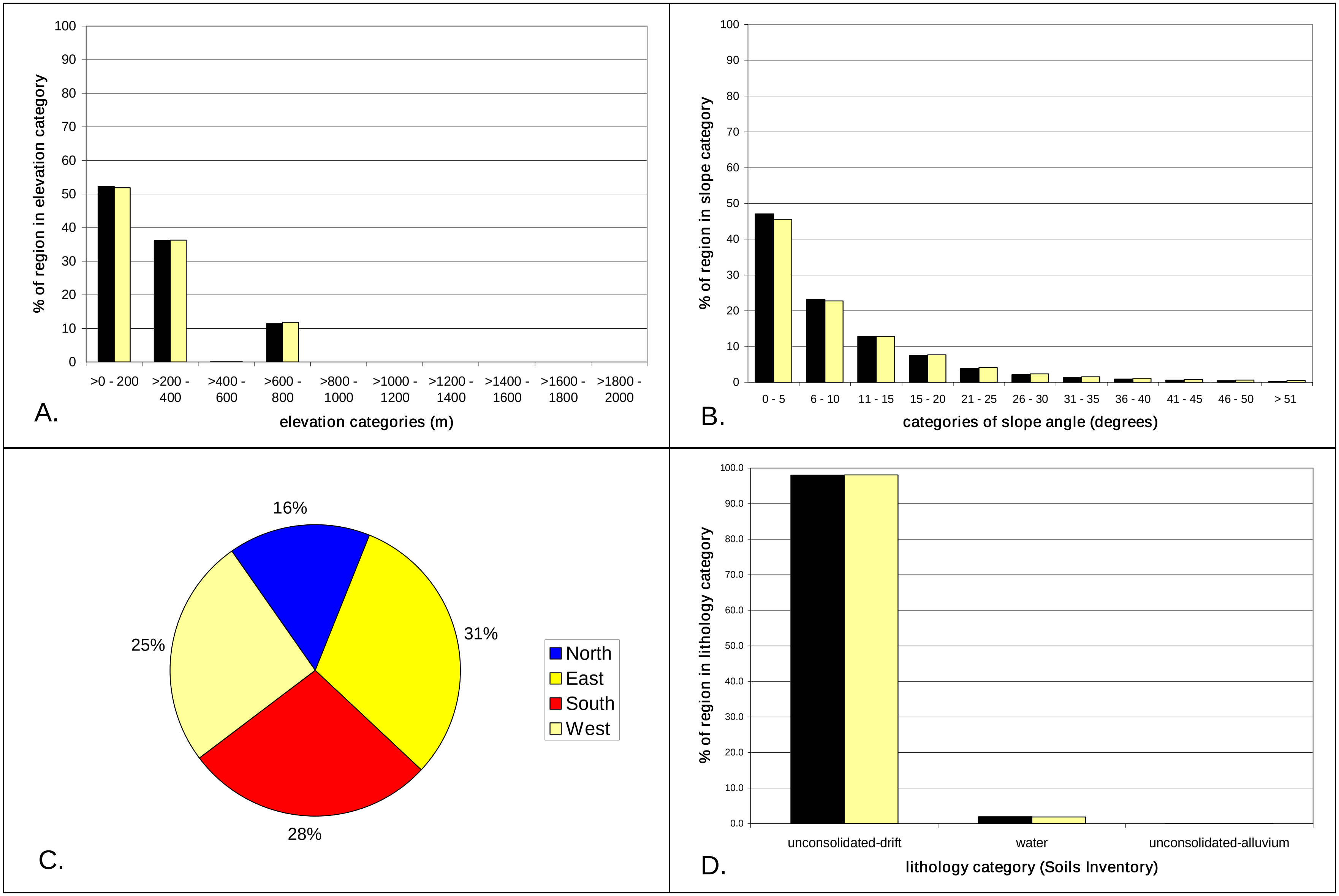
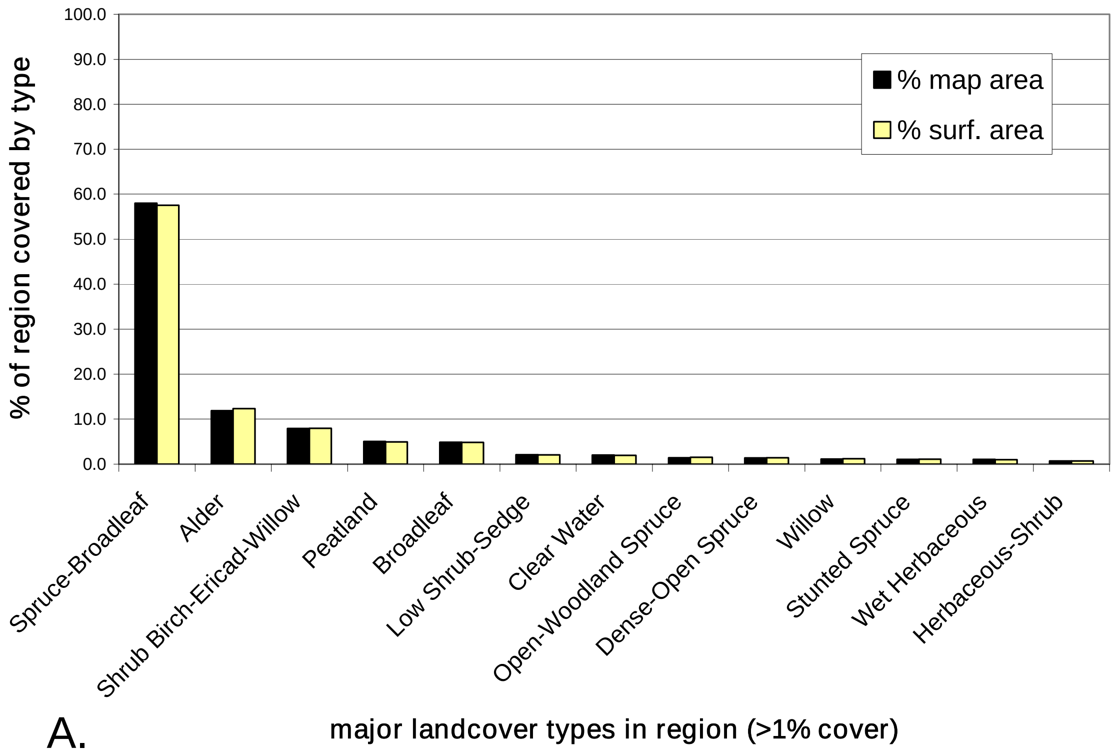


Figure 6.22 Four graphs showing the percentage of the landscape of the Southcentral Boreal Lowland Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.



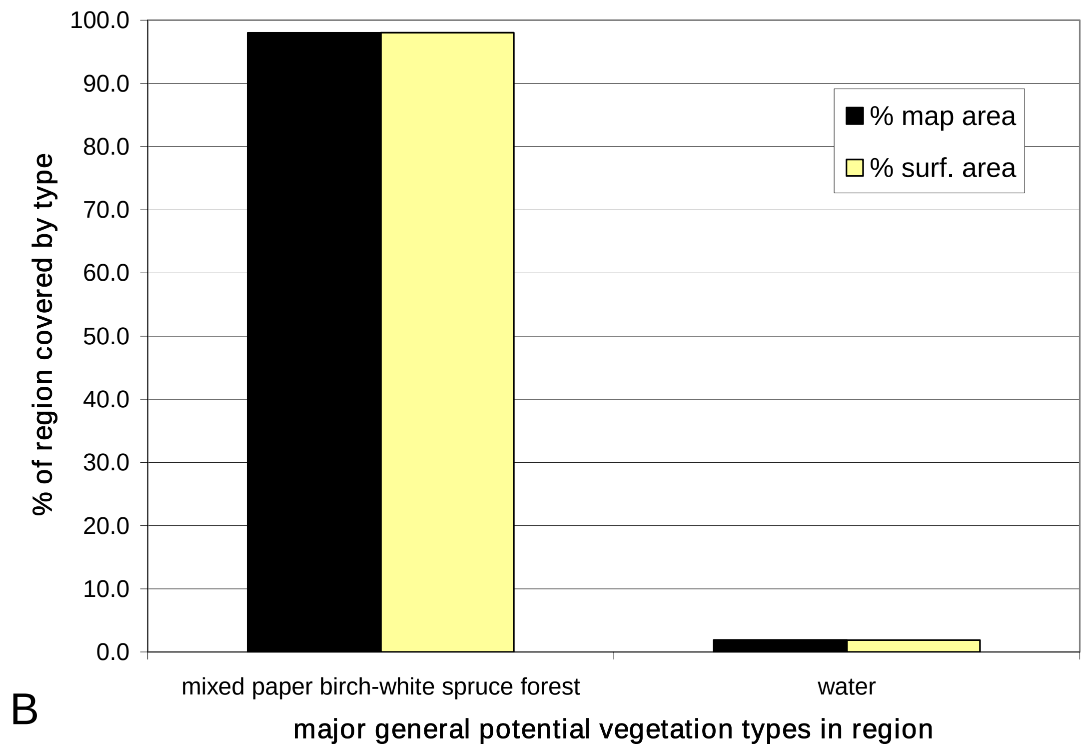


Figure 6.23 Histograms showing the percentage of the landscape in Southcentral Boreal Lowland Floristic Region distributed among categories of landcover type and general potential vegetation classes.

4. Fire on the landscape

Fires have not been recorded in the Southcentral Boreal Lowland Floristic Region during the past 50 years, and were probably a very infrequent event in the area, due to the maritime influence of cool, moist air during the summers.

5. Summary of inventory results in region

This region of the Park covered a very small fraction of the Park landscape, but also represented a unique set of plant associations and thus was the focus of considerable plant collecting efforts, relative to its size, during this inventory project. Because of its small size, we were able to survey sites within each of the polygons represented by this floristic region in the Park. We spent slightly more than 34 hours performing field surveys of 11 sites in the Southcentral Boreal Lowland Floristic Region of the Park. We collected 165 voucher specimens at this set of sites. These collections documented the addition of 61 taxa new to the Park as compared to the pre-1998 flora (Table 6.9). Major range extensions were documented for *Agrostis exarata*, *Aster subspicatus*, and *Potamogeton obtusifolius* from our collections in the Southcentral Boreal Lowland Floristic Region (Table 5.2). In addition, range extensions were documented for 13 taxa as a result of this collecting effort (Table 5.3). Twelve element occurrences for seven taxa considered rare by the AKNHP were described during inventory work in the Southcentral Boreal Lowlands of Denali National Park and Preserve (see Table 7.1).

6. Notable plant associations surveyed in region

Numerous noteworthy collections were made in three different major vegetation types in the Southcentral Boreal Lowland Floristic Region of the Park: mesic mixed forest, bog and fen wetlands, and aquatic herbaceous plant communities.

- **Mesic mixed forests**

  The primary forest type in this region of the Park was mixed, mesic white spruce-paper birch forest (Plate 6.33). These forest communities support a relatively lush understory of shrubs including *Sambucus racemosa* and *Sorbus scopulina*, ferns and forb species such as *Actaea rubra, Delphinium glaucum, Gymnocarpium dryopteris, Phegopteris connectilis*, and *Thalictrum sparsiflorum*. Seventeen species that were not known to occur in the Park prior to 1998 were collected in forested areas of the Southcentral Boreal Lowland Floristic Region. Range extensions for *Cinna latifolia, Oplopanax horridus, Urtica dioica*, *Vaccinium alaskensis*, *Viola glabella* and *V. selkirkii* were documented with vouchers collected in boreal forest in the southcentral lowlands of Denali National Park and Preserve.

- **Bog and fen wetlands**

  Open wetland areas in the southcentral lowlands of the Park represented a very small proportion of the Park landscape (see photo in Plate 6.34). However, because of their unique habitat attributes relative to the majority of the Park landscape, these areas yielded

Plate 6.33 This photograph shows the multi-layered nature of mesic spruce-birch forest in the Southcentral Boreal Lowlands Floristic Region in the Park.

Plate 6.34 An aerial view of bog and fen peatlands in the Cascade Creek drainage in the Southcentral Boreal Lowlands Floristic region.

the most new species and range extensions, *per unit area surveyed*, of any single habitat in the Park. The wetlands that were surveyed in this region of the Park were generally well-developed bogs or fens underlain by significant peat deposits. These wetlands have formed in depressions on the landscape, many of which were once ponds, but have gradually been filled with organic detritus over time. The vegetation of these sites was dominated by grasses and sedges, with a relatively few dominant forb taxa (including *Iris setosa*, *Menyanthes trifoliata* and *Epilobium adenocaulon*). Abundant and common sedge species in these sites included: *Carex chordorrhiza, C. magellanica, C. pluriflora,* and *C. utriculata*. Grass species that were common in southcentral lowland sites included *Arctophila fulva*, *Calamagrostis canadensis*, and *Deschampsia beringensis*. A small set of shrub species were found to occur in these wet meadow habitats as well, including *Chamaedaphne calyculata*, *Myrica gale*, and *Salix fuscescens*.

Thirty-eight species of vascular plants new to the flora of the Park were documented in wetlands within this region (these are listed in Table 6.4; see photos in Plate 6.35), including major range extensions for *Agrostis exarata* and *Aster subspicatus*. Range extensions were documented for *Carex interior*, *C. lyngbyaei*, *C. mertensii*, and *C. oederi*; *Gentiana douglasiana*; and *Deschampsia beringensis* (see Table 5.3). Four species considered rare by the AKNHP were collected from wetland sites in this region: *Carex crawfordii*, *Carex interior, Malaxis paludosa*, and *Pedicularis macrodonta* (see Table 7.1).

- **Aquatic herbaceous plant communities**

Ponds are very common features of the landscape in the Cook Inlet lowlands. In the Park, these ponds were of three general types: 1) beaver ponds formed by the damming of watercourses, 2) kettle ponds formed in depressions in glacial drift sediments, and 3) old oxbows of slow-moving streams. Seven species of aquatic plants new to the Park flora were collected from ponds in the Southcentral Boreal Lowland Region, including a major range extension for *Potamogeton obtusifolius*, a state-level rare plant that was known from only two widely scattered localities in Alaska prior to this inventory effort. The other new aquatic species collected in this region of the Park were the pondweeds *Potamogeton gramineus*, *P. natans*, *P. praelongus* and *P. pusillus,* and the bladderworts *Utricularia intermedia* and *U. vulgaris*.

Plate 6.35 Six vascular plant species that occur in wetland situations in the Southcentral Boreal Lowland Floristic Region of Denali National Park and Preserve are (clockwise from upper left): *Caltha palustris*, *Hippuris vulgaris*, *Tricophorum caespitosum*, *Carex membranacea*, *Vaccinium ovalifolium*, and *Veronica americana*.

H. Summary of Results for Southcentral Boreal Subalpine Floristic Region

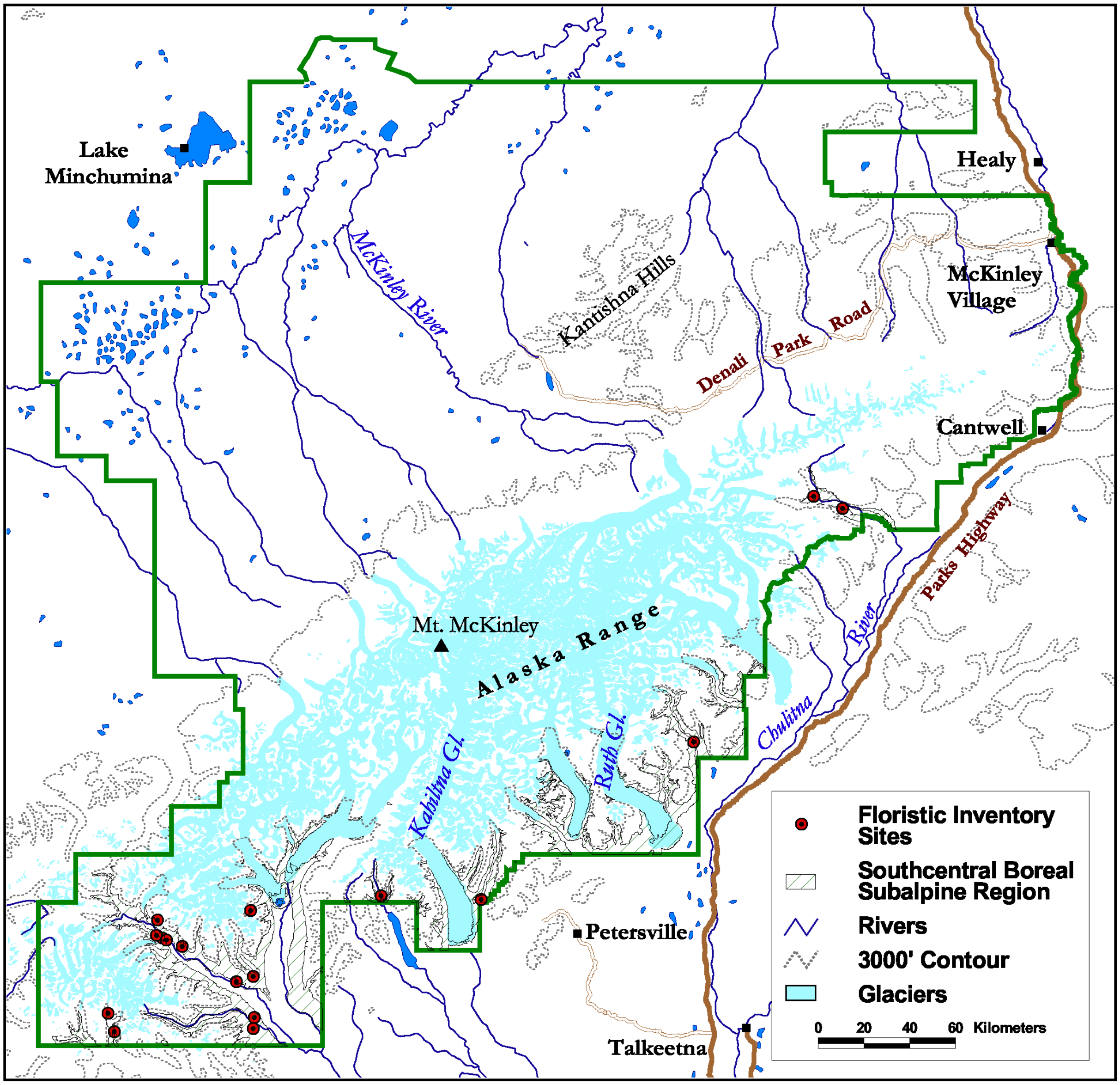


Figure 6.24 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Southcentral Boreal Subalpine Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.10 General summary of Floristic Inventory effort and results for the Southcentral Boreal Subalpine Floristic Region in Denali National Park and Preserve, 1998-2001.

	#	No. of specimens
Number of sites surveyed in region:	17	N/A
Total number of hours in surveys:	72	N/A
Average number of survey hours per site:	4.2	N/A
Average number of surveyors per site:	2.4	N/A
Total number of collections in region:	242	242
Number of taxa new to the Park (pre-1998) found in region:	62	86
Number of taxa with major range extension into region:	7	12
Number of taxa with range extension into region:	21	26
Number of AKNHP-tracked taxa found in region:	10	12
Number of AKNHP element occurrences:	12	12
Number of Alaska - Yukon endemic taxa collected in region:	7	17
Number of Amphiberingian endemic taxa collected in region:	12	14

Plate 6.36 Representative photograph of Southcentral Boreal Subalpine Floristic Region showing a section of the upper Kichatna River drainage in the extreme southwestern corner of the Park.

1. Physiography

The Southcentral Boreal Subalpine Floristic Region occupies approximately 872 km^2 of the Park (for map see Figure 6.24; a representative photo is shown in Plate 6.36). It lies south of the Alaska Range crest, at elevations intermediate between the Southcentral Alpine Region and the boreal lowland regions. This region spans elevations between 100 m and 1500 m, although more than 90 percent of the terrain lay between about 250 and 1000 meters above sea level (Figure 6.25). Because of relatively rapid tectonic uplift and the recently deglaciated nature of the landscape in this region of the Park, slope angles were quite steep in the subalpine region south of the Alaska Range crest, with 57 percent of the area occupied by slopes of 40 degrees or higher (Figure 6.25). The slopes in this region were predominantly south and east facing (Figure 6.25). Sixty percent of the area of this region was occupied by slopes with south or east aspect, with 40 percent of the area occupied by north or west-facing slopes (Figure 6.25).

2. Surficial geology

The surficial geology of the alpine region of the Park was dominated by colluvium derived from bedrock, whereas the surficial geology of boreal areas lying at low elevations was characterized by thick deposits of unconsolidated sediments. The subalpine floristic region included significant areas of both of these surficial geology types. An estimated 59 percent of the area of this region was mantled with glacial drift deposits and 34 percent of the region area had surficial geology units derived from weathering of local bedrock units (Figure 6.25; Clark and Duffy 2004). Permafrost soils were not encountered in this region during the Soils Inventory (Figure 6.4; Clark and Duffy 2004).

3. Landcover patterns

The steep, rocky slopes in the Southcentral Boreal Subalpine Floristic Region supported a mosaic of dense, closed tall alder scrub and forb-herbaceous meadows. Closed alder scrub occupied nearly 50 percent of the area in this region according to the landcover map (Figure 6.26; Boggs et al. 2001). Spruce-broadleaf forest and herbaceous shrub landcover classes were the next most abundant classes, covering an estimated eleven and nine percent of the area of this floristic region respectively (Figure 6.26). Forests occurred on benches, toe slopes, terraces and other less steeply sloping areas of the landscape of this floristic region.

4. Fire on the landscape

No fires are known to have occurred within this region during the past 50 years.

5. Summary of inventory results in region

We performed floristic inventories at 17 sites within the Southcentral Boreal Subalpine Floristic Region of the Park, which required 72 hours of actual field survey time. A total of 242 voucher specimens were collected in this region of the Park, which documented 62 taxa that were not known to occur in the Park prior to 1998 (Table 6.10). This set of 62 new taxa represented the third highest total of taxa new to the Park for a floristic region, behind the Southcentral Alpine

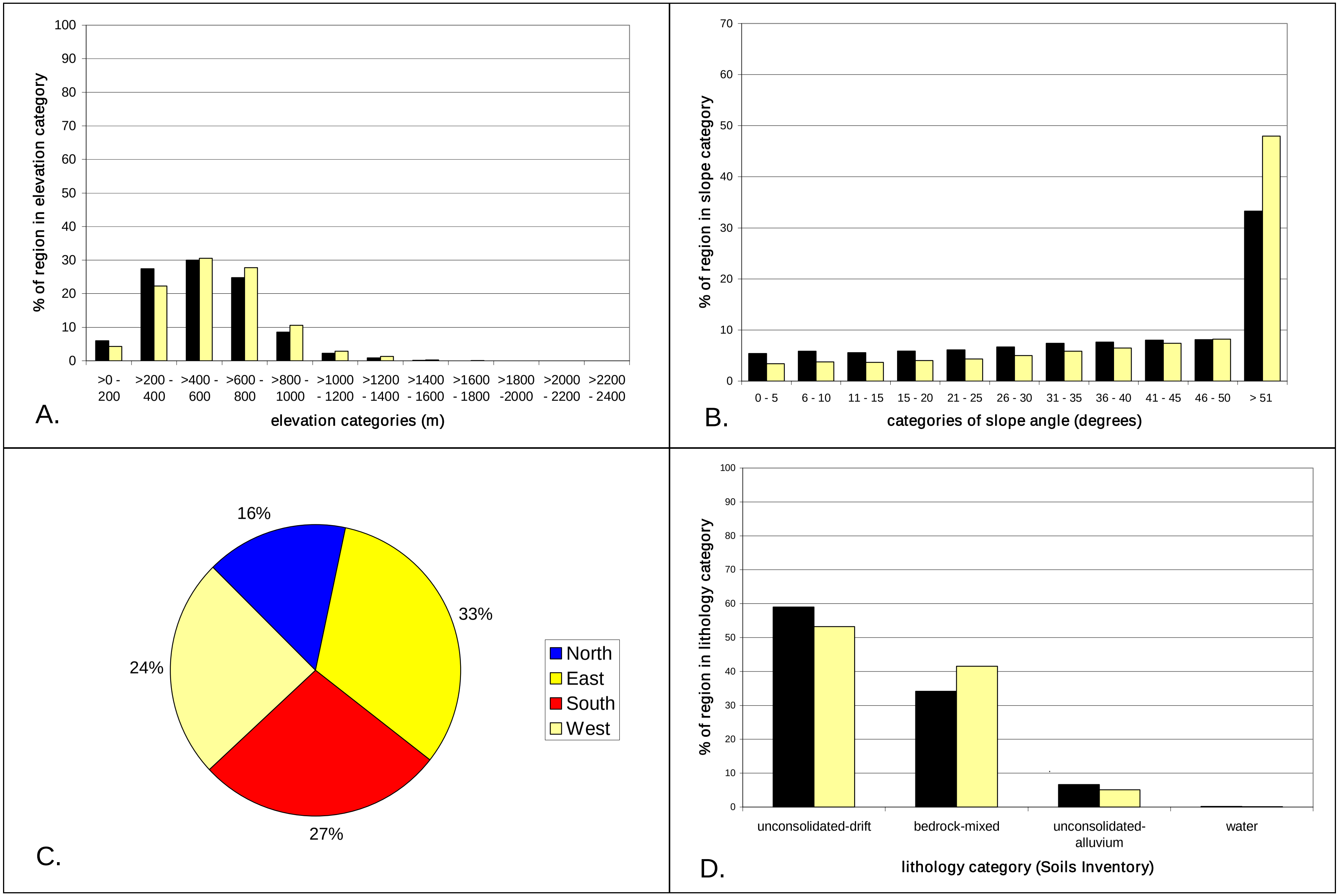
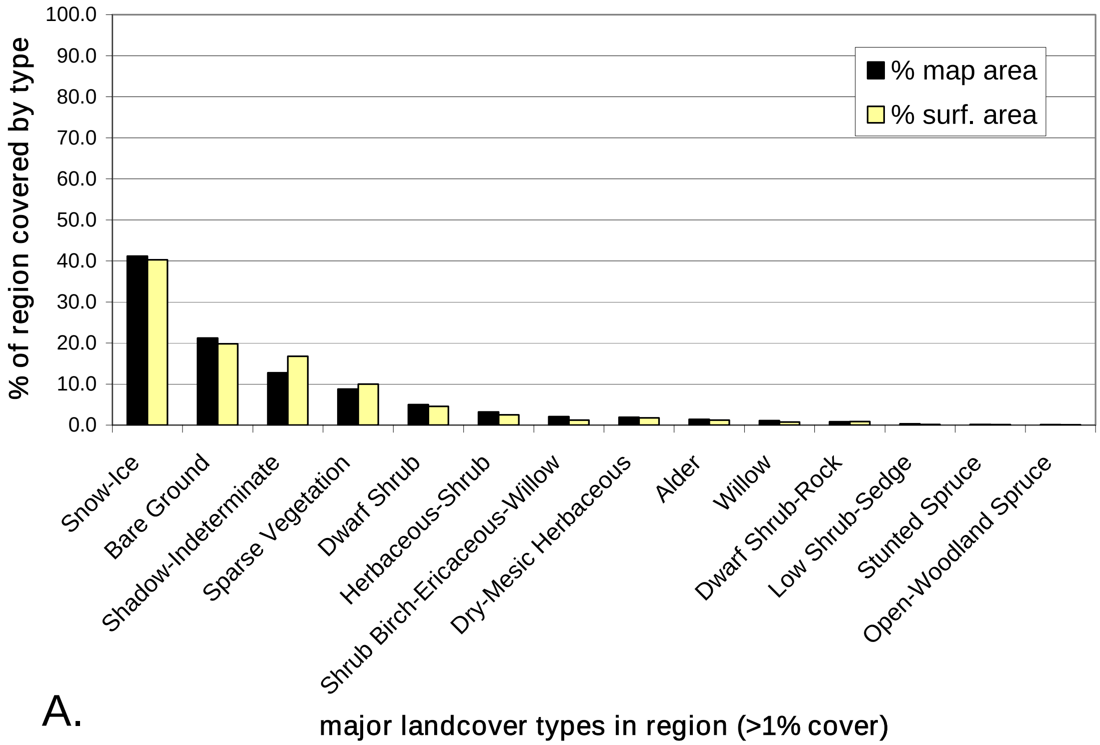


Figure 6.25 Four graphs showing the percentage of the landscape of the Southcentral Subalpine Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show percentage by map area. Yellow bars depict percentage by surface area.



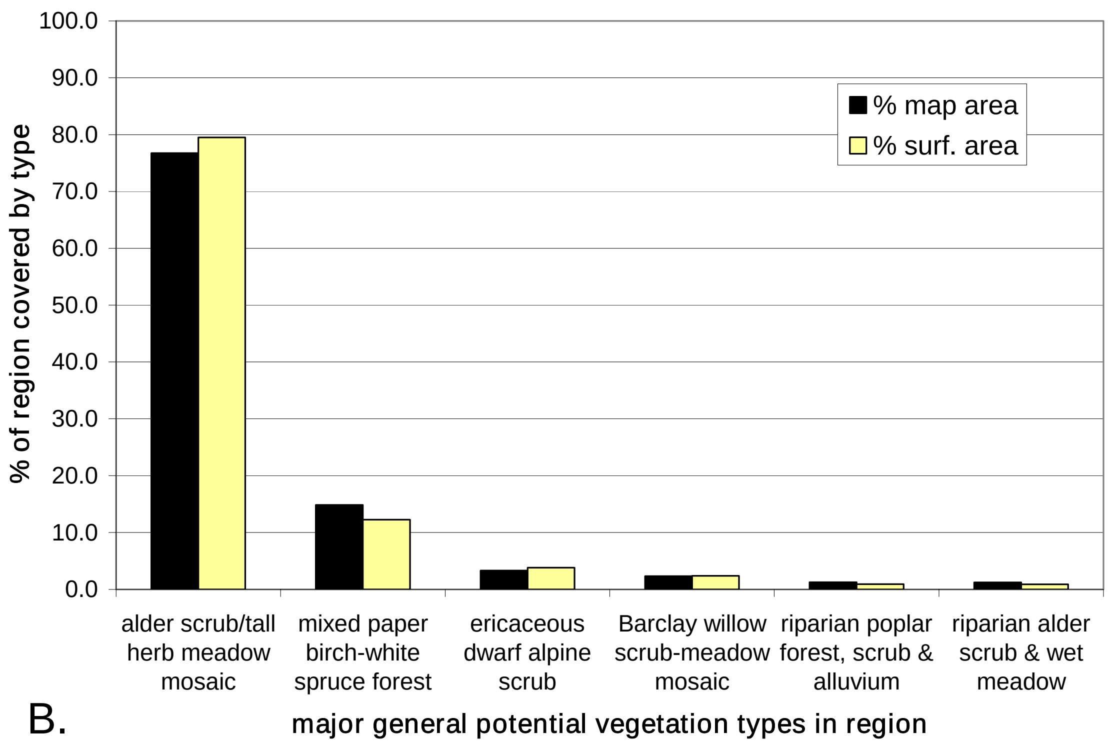


Figure 6.26 Histograms showing the percentage of the landscape in Southcentral Boreal Subalpine Floristic Region distributed among categories of landcover type and general potential vegetation classes.

Mountains (95 species) and Interior Boreal Lowlands (70 species) regions. In addition, we documented major range extensions for the following seven taxa based on collections in this region: *Agrostis clavata*, *Carex echinata* ssp. *phyllomanica*, *Cryptogramma stelleri*, *Lycopodium clavatum* ssp. *clavatum*, *Oxytropis campestris* ssp. *jordalii*, *Papaver lapponicum*, and *Polystichum braunii*. Range extensions were documented for an additional 21 taxa in the Southcentral Boreal Subalpine Floristic Region (see Table 5.3). Twelve element occurrences of ten taxa considered rare by the AKNHP were documented within this region (see Table 7.1).

This region of the Park was very poorly known from a floristic perspective prior to this inventory effort. As a result, our approach was to perform collections in as broad a cross section of landscape positions and vegetation types as possible within this region. This region covered a relatively small area of the Park, essentially encompassing a band of terrain below the open alpine zone, which was dominated by tundra and low scrub-meadow mosaic on slopes and ridges and above the low-relief forested lowlands.

6. Notable plant associations surveyed in region

Notable collections were made in five different plant associations within this floristic region, reflecting the fact that very limited information about the floristic composition of this region was available prior to this inventory effort. Three general plant association types: 1) lush forb-herbaceous meadows, 2), open subalpine wetlands and 3) open communities associated with rock outcrops, yielded the majority of significant collections in this region. Novel floristic information for the Park also resulted from collections in closed alder scrub vegetation and open subalpine floodplain deposits in this floristic region. Notable results for these associations are described below:

- **Lush forb-herbaceous meadows**

  Lush, tall meadows dominated by a diverse assemblage of forbs and graminoid taxa were a conspicuous facet of the subalpine region south of the Alaska Range crest in Denali National Park and Preserve (see Plates 6.37, 6.38 and 6.44). These meadows developed in areas that were free of the ubiquitous dense alder scrub that blanketed much of this region, and often occurred in a habitat mosaic of medium-statured Barclay willow scrub, scattered alder thickets, and recently disturbed rubble slopes. The richest examples of this forb-herbaceous community occurred in south-exposed slopes and associated with the mesic gully features that drained these slopes. One facies of this community also has developed on toe slopes, springing up through recently-deposited slide debris in attractive and floriferous “talus meadows”.

  Twenty-nine vascular plant taxa new to the Park flora were collected in forb meadows in the Southcentral Boreal Subalpine Floristic Region during this inventory project, including range extensions for *Botrychium lanceolatum*, *B. alaskaense*, *Carex pachystachya*, *C. spectabilis*, *Danthonia intermedia*, *Draba stenoloba*, *Euphrasia mollis*, *Listera cordata*, and *Salix stolonifera*.

Plate 6.37 An example of lush forb-herbaceous meadow in the Southcentral Boreal Subalpine zone in the Kichatna River drainage.

Plate 6.38 Two species characteristic of lush forb-herbaceous subalpine meadows: *Lupinus nootkatensis* (left) and *Senecio triangularis* (right).

- **Open subalpine wetlands**

Wetlands in the Southcentral Boreal Subalpine Floristic Region of the Park were of two general types: 1) stable, well-developed wetlands with significant peat accumulation; and 2) younger, riparian and lake-shore strand marshes (see Plate 6.39). The older peatland wetlands were characterized by high cover of *Sphagnum* mosses and dominance by vascular species such as *Tricophorum caespitosum*, and the sedges *Carex limosa*, *C. livida*, *C. magellanica* (Plate 6.40), *C. pluriflora*, and *C. rotundata*. These peatlands also often contained a suite of woody taxa, encroaching into these otherwise open plant communities, including *Myrica gale*, *Chamaedaphne calyculata*, and *Vaccinium* spp. The marsh wetlands in this region were more variable in the composition of dominant taxa, reflecting varied disturbance histories and local site factors.

Nineteen taxa new to the Park were documented by vouchers collected in wetland habitats within the Southcentral Boreal Subalpine Floristic Region. This set of taxa included major range extensions for *Carex echinata* ssp. *phyllomanica* and *Lycopodium clavatum* ssp. *clavatum*, as well as range extensions for *Agrostis thurberiana*, *Angelica genuflexa*, *Carex crawfordii*, *C. enanderi*, *Eriophorum viridi-carinatum*, *Glyceria striata* and *Ranunculus macounii*. Except for *Ranunculus macounii*, all of the above taxa were also considered rare in Alaska by the AKNHP.

- **Open communities associated with rock outcrops**

Most of the subalpine region south of the Alaska Range crest was very densely vegetated relative to sites north of the crest due to the more moderate maritime-influenced climatic regime that prevailed there. As a result, open rock outcrop areas presented a conspicuously different set of habitat attributes and markedly reduced competition for light than surrounding areas of the landscape in this region (see photos in Plate 6.41 and 6.42). Numerous significant collections were made in the relatively few outcrops that were surveyed within this region. The following major range extensions were documented through collections from rock outcrop sites in the Southcentral Boreal Subalpine Floristic Region of the Park: *Agrostis clavata*, *Cryptogramma stelleri*, *Minuartia yukonensis*, and *Oxytropis campestris* ssp. *jordalii*. In addition, range extensions were documented for the following taxa; *Melandrium taylorae*, *Mitella pentandra* and *Polypodium sibiricum*.

- **Closed tall alder thickets**

Closed tall alder scrub was the dominant vegetation type on the subalpine landscape south of the Alaska Range crest (see Plate 6.43). A collection of *Polystichum braunii* was made in dense alder vegetation along the upper West Fork Yentna River, representing a range extension 330 km to the west/northwest of a Valdez area collection cited in Hultén (1968). This locality was the farthest north locality for this species in North America. Two other species new to the Park, *Impatiens noli-tangere* and *Ribes*

Plate 6.39 An example of an open subalpine wetland in the Southcentral Boreal Subalpine Region of the Park. This photo was taken on a bench above Granite Creek near the terminus of Kahiltna Glacier.

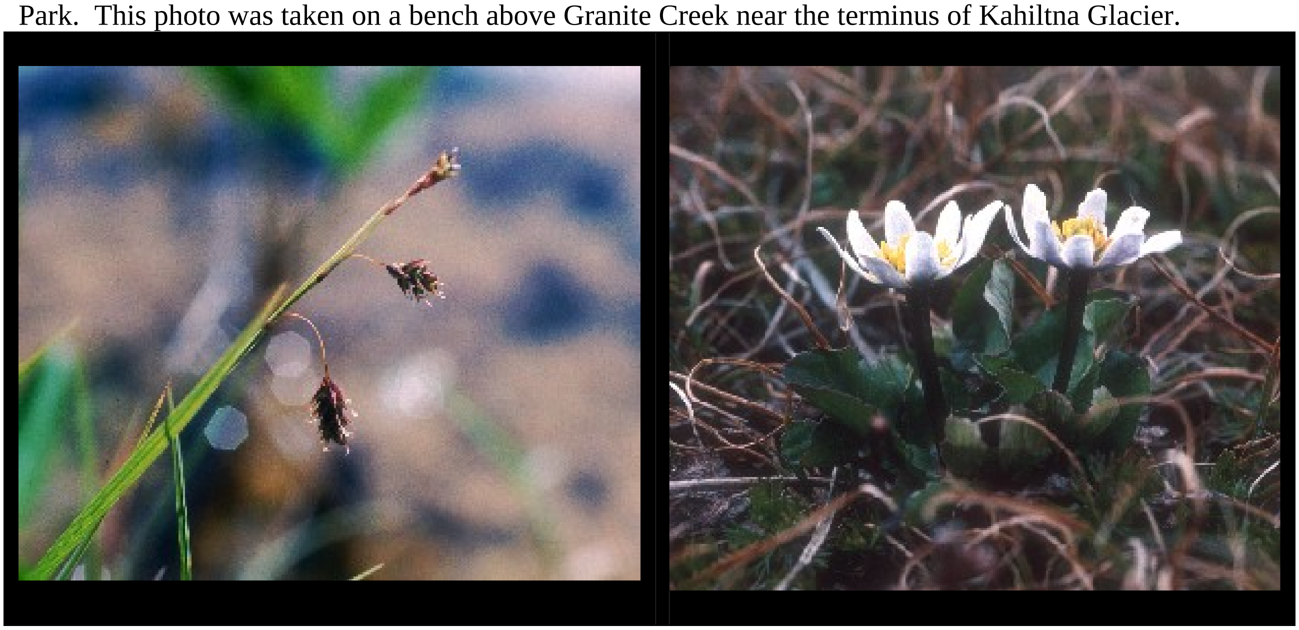


Plate 6.40 Two of the species new to Denali National Park and Preserve that were collected in Southcentral Boreal Subalpine region were *Carex magellanica* (left) and *Caltha leptosepala* (right).

Plate 6.41 Open rock outcrops such as this area in the upper West Fork of the Yentna River offer a very different set of habitat characteristics to plants than the preponderance of the Southcentral Boreal Subalpine zone, which is heavily cloaked in closed shrub vegetation.

Plate 6.42 Two alpine species that are also found in low elevation rock outcrop situations in the Southcentral Boreal Subalpine Floristic Region are *Saxifraga eschscholtzii* (left) and *Carex nardina* (right).

laxiflorum, were also collected in alder scrub vegetation in the Southcentral Boreal Subalpine Floristic Region.

- **Open floodplain vegetation**

Three significant collections of vascular plant taxa were made in open floodplain areas within the Southcentral Boreal Subalpine Floristic Region: *Carex eburnea*, a rare boreal sedge, was collected in the upper West Fork Yentna River; and range extensions for *Carex petricosa* and *Salix sitchensis* were also documented by collections within this region. *C. petricosa* was collected along the West Fork of the Yentna River, and *Salix sitchensis* was collected in the vicinity of Cripple Creek.

Plate 6.43 Steep slopes in the Southcentral Boreal Subalpine Region are densely covered with a mosaic of closed tall alder scrub and tall forb-herbaceous meadows, as seen in this photograph in the Fourth of July Creek drainage in the southwestern corner of Denali National Park and Preserve.

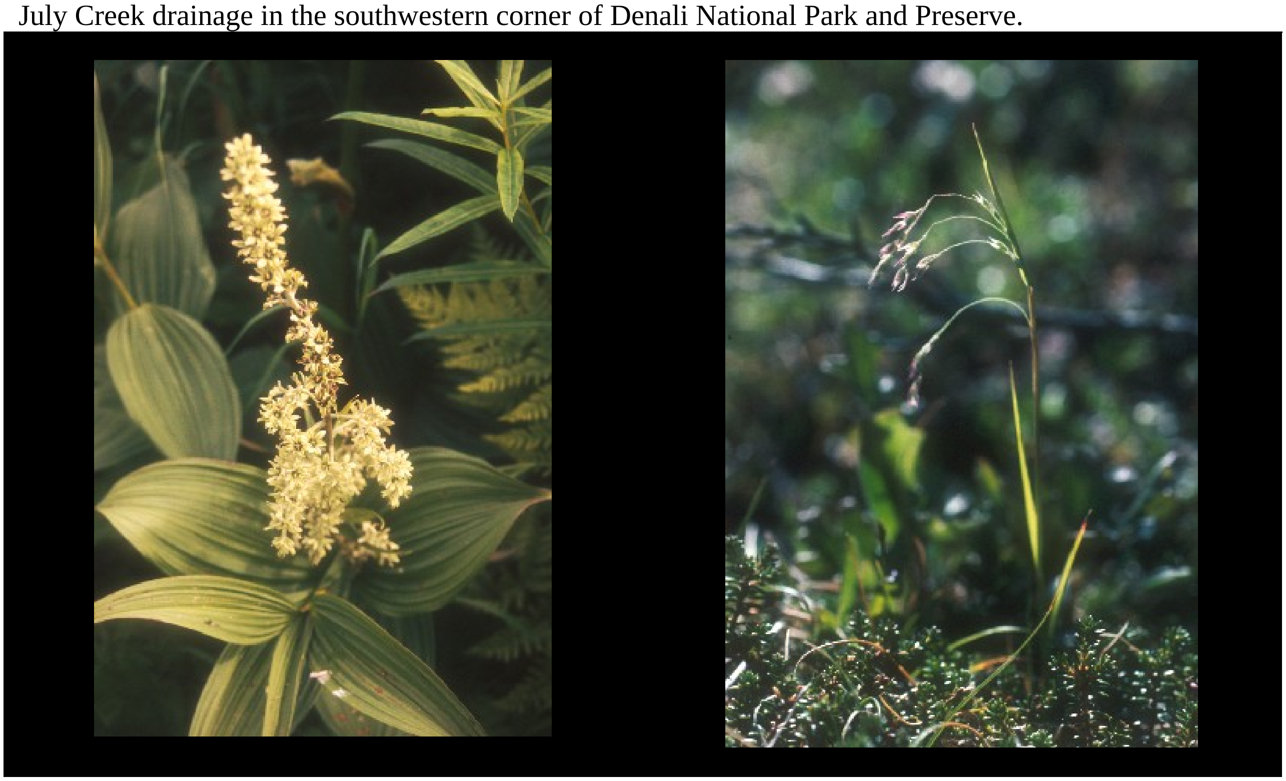


Plate 6.44 Two taxa that are characteristic of the subalpine zone on the south side of the Alaska Range crest in Denali are *Veratrum viride* (left) and *Vahlodea atropurpurea* (right).

I. Summary of Results for Southcentral Alpine Floristic Region

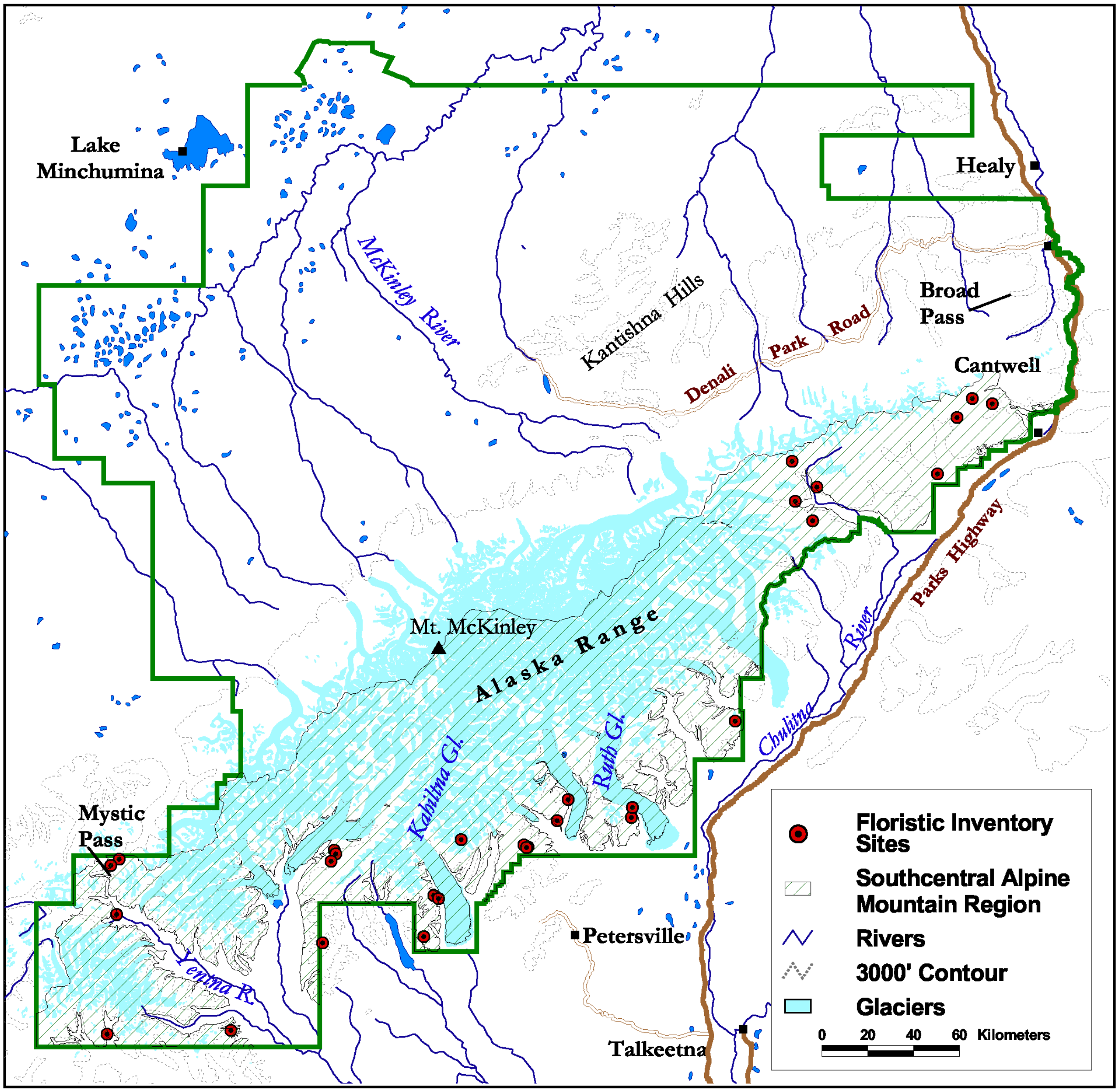


Figure 6.27 Map of Denali National Park and Preserve showing floristic inventory sites surveyed in the Southcentral Alpine Floristic Region, 1998-2001 (Mercator Projection, NAD 1927).

Table 6.11 General summary of Floristic Inventory effort and results for the Southcentral Alpine Floristic Region in Denali National Park and Preserve, 1998-2001.

	Number	No. of specimens
Number of sites surveyed in region:	30	N/A
Total number of hours in surveys:	420	N/A
Average number of survey hours per site:	14	N/A
Average number of surveyors per site:	2	N/A
Total number of collections in region:	1197	1197
Number of taxa new to the Park (pre-1998) found in region:	95	343
Number of taxa with major range extension into region:	5	9
Number of taxa with range extension into region:	36	97
Number of AKNHP-tracked taxa found in region:	15	32
Number of AKNHP element occurrences:	32	32
Number of Alaska - Yukon endemic taxa collected in region:	19	42
Number of Amphiberingian endemic taxa collected in region:	24	79

Plate 6.45 A representative photograph of Southcentral Alpine Floristic Region showing an area draining into Chelatna Lake.

1. Physiography

The Southcentral Alpine Floristic Region occupies 6,930 km^2 in the Alaska Range Mountains south of the crest of the range (Figure 6.27; representative photo is shown in Plate 6.45). Although this was the largest of the floristic regions in the Park, an estimated 42 percent of the region is covered by glacial ice and hence is therefore currently unavailable for colonization by plants. This region encompasses the largest ice fields in the Park, including the Kahiltna, Ruth and Tokositna glaciers. The Southcentral Alpine Floristic Region has an extremely wide range in terrain elevation, spanning elevations from above 200 m (the base of some glaciers) to over 6000 m at the crest of the Alaska Range. The majority of the terrain in the region (69 percent), however, lay at elevations between 800 m and 1800 m (Figure 6.28). Slopes in the Southcentral Alpine Floristic Region were, on average, much steeper than elsewhere in the Park due to the combination of the rapid tectonic uplift in the area and the sculpting of the uplifted mountain massifs by glaciers. Almost 50 percent of the map area of the region was occupied by extremely steep slopes of greater than 50 degrees (Figure 6.28). The remainder of the terrain in the area fell fairly evenly among the less steep slope classes, each of which contained less than 10 percent of the region's total area (Figure 6.28). The Alaska Range trends generally from the northeast to the southwest in the Park, and, as a result, the predominant slope aspects on the southern flank of the range are south and east, aspects which together occupied 59 percent of this region (Figure 6.28). In contrast, north and west aspects occupied only 41 percent of the map area in this region (Figure 6.28).

2. Surficial geology

After glacial ice and permanent snowfields, colluvium derived from diverse bedrock types was the most common surficial geology type in the Southcentral Alpine Floristic Region (Clark and Duffy 2004). The Soils Inventory identified mixed lithology as the predominant parent material in the area (covering 86 percent of the region's area). There were also relatively large segments of the landscape underlain by both acid-igneous and sedimentary geological units in the Southcentral Alpine Floristic Region of the Park (Figure 6.28). An estimated nine percent of the area of this region, concentrated in its lower elevations, was underlain by unconsolidated glacial drift sediments (see Figure 6.28). Soil units containing permafrost were not prevalent in this area, due to the moderation of temperatures by maritime air masses from the Gulf of Alaska and the insulation of the soil during winter by a deep snow pack. In fact, only five percent of this area was estimated to contain soil units with sporadic or discontinuous permafrost, and continuous permafrost was entirely absent from the region (Clark and Duffy 2004).

3. Landcover patterns

The combination of snow, ice and bare ground accounted for 60 percent of the area of this floristic region, based on an analysis of the landcover map (Figure 6.29; Boggs et al. 2001). Due to the presence of considerable terrain shadow in the high relief areas of the region, nearly 13 percent of the area was of undetermined landcover, although much of this was also likely unvegetated terrain because of its steep slope angles. Sparse vegetation occupied about nine percent of the area of this region (Figure 6.29). The sparse vegetation landcover type included alpine fellfields, very sparse tundra, and open riparian areas with large amounts of bare ground

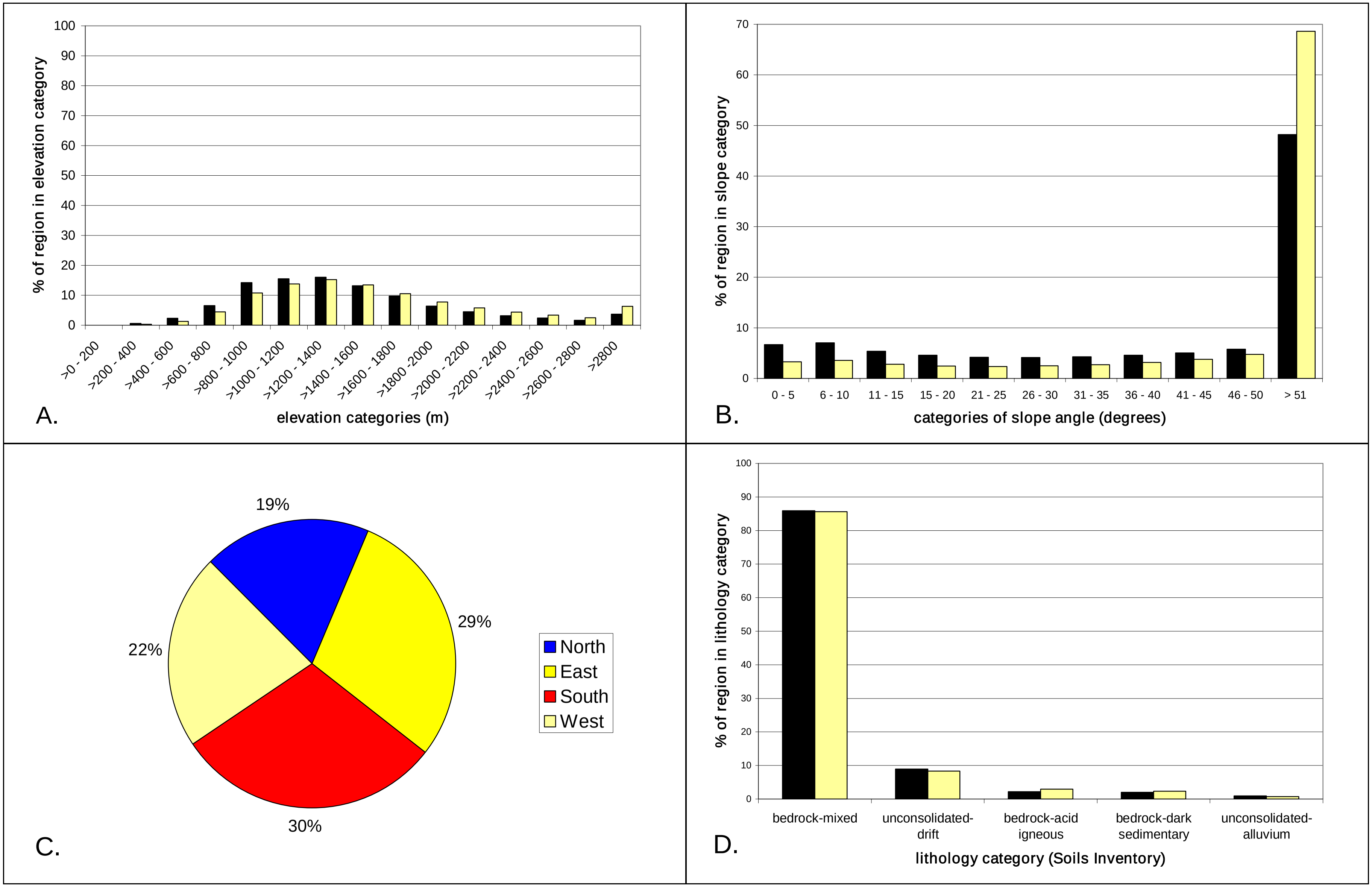


Figure 6.28 Four graphs showing the percentage of the landscape of the Southcentral Alpine Floristic Region distributed among categories of A) elevation, B) slope, C) aspect, and D) lithology. Black bars show the percentage by map area. Yellow bars depict percentage of surface area.

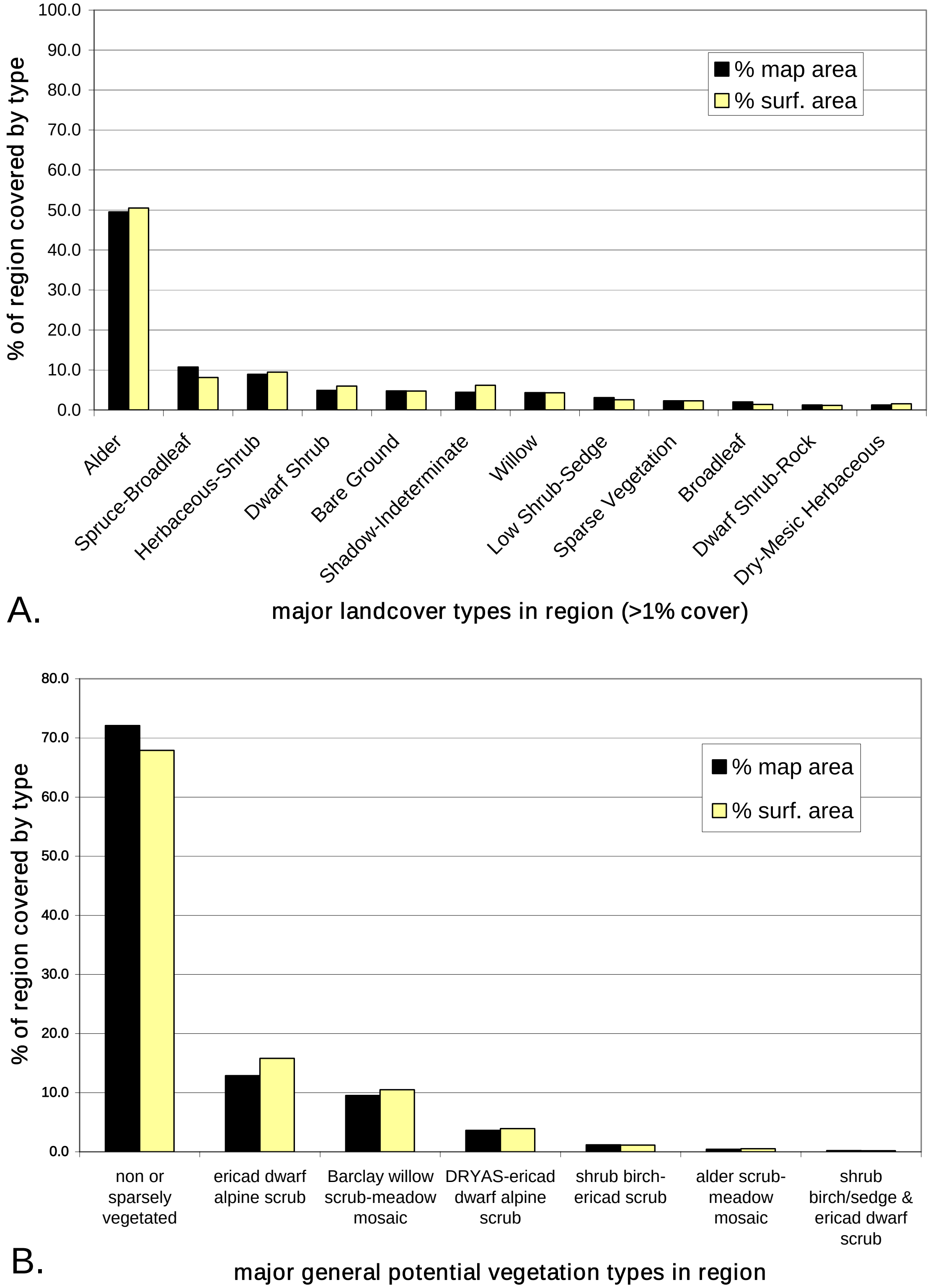


Figure 6.29 Histograms showing the percentage of the landscape in Southcentral Alpine Floristic Region distributed among categories of landcover type and general potential vegetation classes.

separating plant cover. Alpine dwarf scrub was the most common continuously vegetated landcover type in the region, covering an estimated five percent of the area (Boggs et al. 2001).

An analysis of the areal extent of the major general potential vegetation type in this region, showed that ericaceous dwarf scrub types and Barclay willow – medium forb meadow vegetation were expected to develop on 13 and ten percent of the area in this region respectively (Figure 6.29). Minor potential vegetation types in the Southcentral Alpine Floristic Region identified by the soils mapping project included *Dryas* tundra and dwarf birch scrub, which were two very important types in the alpine region north of the Alaska Range in the Park, but were observed much less commonly on the south side.

4. Fire on the landscape

Fires had not been observed on the landscape of the Southcentral Alpine Floristic Region of the Park in the past five decades.

5. Summary of inventory results in region

The Southcentral Alpine Floristic Region was the largest botanically unsurveyed region of the Park prior to this study. Accordingly, this region received the greatest amount of survey effort during this project. We spent 420 hours of field survey time completing vascular plant inventories of 30 sites in this region (Table 6.11). Almost 1,200 specimens were collected in the southcentral mountains, which documented the addition of 95 taxa new to the Park, as compared to the species list for the Park developed in 1998 (Table 6.11). This set of new taxa represented almost 40 percent of the taxa new to the Park that were documented during this study, and is the highest number of new taxa found in any single floristic region of the Park. Thirty-two element occurrences of 15 taxa considered rare by AKNHP were documented within the Southcentral Alpine (Table 6.11). In addition, 19 taxa endemic to Alaska-Yukon were collected there (Table 6.11) and 24 Amphiberingian endemic species were also collected in this region (Table 6.11.). Major range extensions for five taxa were documented in this floristic region, including *Anaphalis margaritacea*, *Athyrium alpestre*, *Botrychium minganense*, *Coptis trifolia*, and *Polystichum lonchitis* (see Table 5.2). Range extensions for an additional 39 taxa of vascular plants were documented in the southcentral alpine zone of the Park (see Table 5.3).

6. Notable plant communities surveyed in region

The paucity of botanical work in this region of the Park that existed prior to the current study meant that all plant communities and landscape positions within the Southcentral Alpine were of interest to the floristic inventory effort. Upon completion of the inventory effort, four general plant community types emerged as particularly significant and characteristic of this region of the Park from a floristic perspective. These types included the following: 1) lush graminoid-forb herbaceous meadows, 2) alpine heath tundra in snow beds, 3) small alpine fens and wetland sites, and 4) dry fellfields and rubble slopes and associated sparse rocky tundra.

Plate 6.46 Lush alpine meadow on slide talus on south side of range near Kahiltna Glacier.

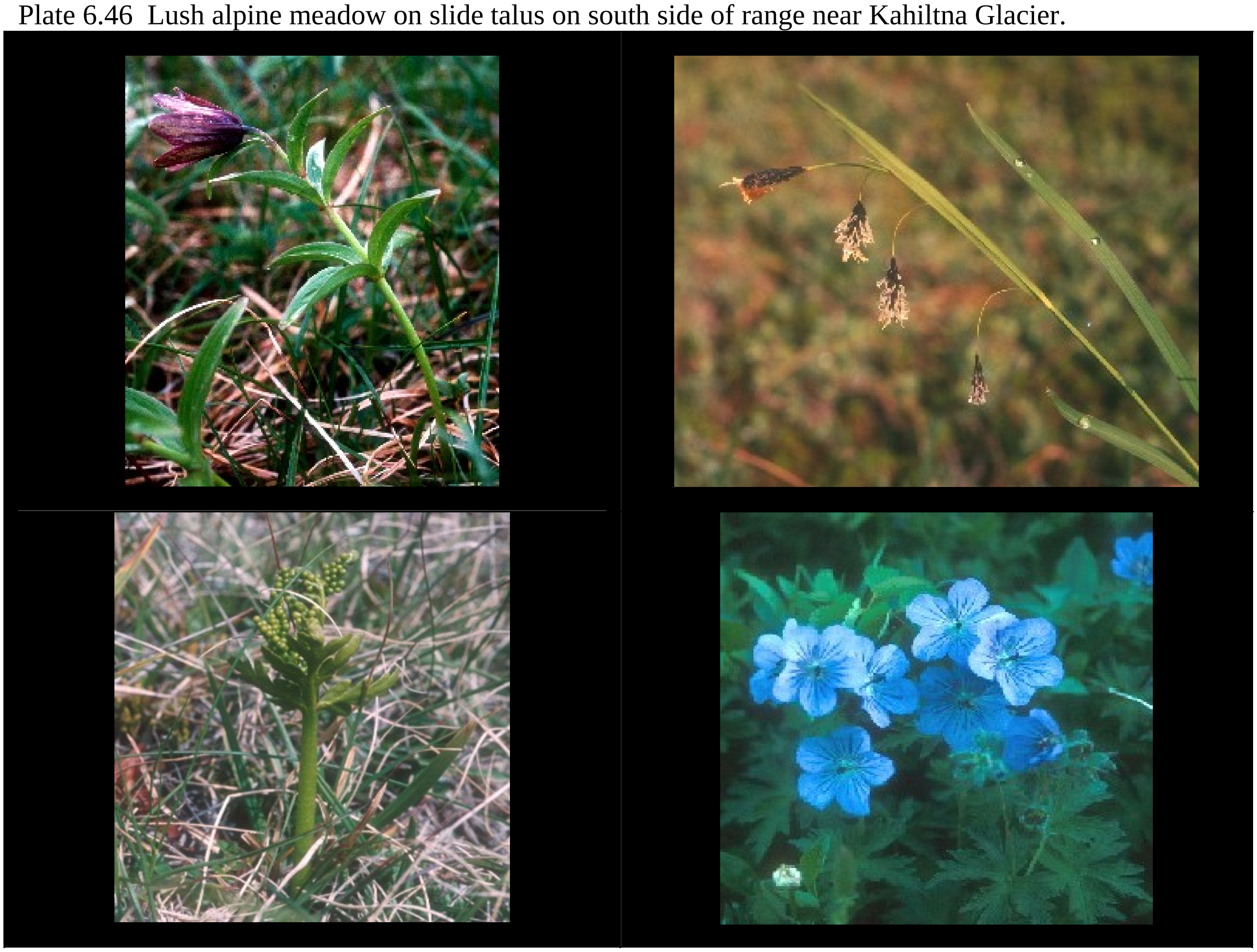


Plate 6.47 Four taxa of lush, south side alpine meadows (clockwise from top left): *Fritillaria kamtschatcensis*, *Carex podocarpa*, *Geranium erianthum*, and *Botrychium lanceolatum*.

- **Lush graminoid-forb herbaceous meadows**

  A particularly significant community type in this region from a floristic perspective was lush graminoid-forb herbaceous meadow which occurred on moderate to steep, well drained slopes in the Southcentral Alpine Floristic Region, frequently on south aspects (see Plates 6.46 and 6.47). This community type often occurred in a vegetation mosaic interspersed with low to medium-statured stands of *Salix barclayi* and other shrubs. The very active geomorphic disturbance regime that was evident in sloping terrain in this region favors the establishment of herbaceous taxa and open, meadow-like plant communities due to the periodic removal of shrubs by mass movement of rock, soil and snow. As a result, these lush meadow habitats were often associated with gully features and avalanche tracks in the mountains and frequently appeared as "talus-meadows" where lush growths of graminoid and wildflower species sprouted up through cobble-sized slide debris.

  This plant association was dominated by herbaceous perennial plant species such as *Anemone parviflora*, *Epilobium angustifolium*, *Geranium erianthum*, *Ranunculus* spp., *Carex podocarpa*, *Festuca altaica*, and *Phleum alpinum*. Lush, medium to tall herbaceous meadow communities were the source of the majority of range extensions and new taxa to the Park found in the Southcentral Alpine Floristic Region during this study. This included the following taxa: *Arnica diversifolia*, *Athyrium alpestre*, *Polystichum lonchitis*, *Fritillaria camschatcensis*, *Mitella pentandra*, *Potentilla diversifolia*, and *Danthonia intermedia*, among others.

- **Alpine heath tundra in snow beds**

  A distinctive alpine tundra community that was dominated by species from the heath family (including *Cassiope stelleriana*, *C. tetragona*, *Empetrum nigrum*, *Vaccinium* spp., and *Phyllodoce* spp.) and a suite of associated forb taxa such as *Luetkea pectinata* was characteristic of the conspicuous "snowbed" areas that occurred frequently on the landscape of the Southcentral Alpine Floristic Region (see Plates 6.48 and 6.49). Snowbeds were sites that commonly retained a thick mantle of late-lying snow well into the growing season. These features resulted from the redeposition the heavy snowpack that falls south of the Alaska Range into areas that trap snow such as leeward slopes, gullies and depression features. Because of the high accumulation of snow on the south side of the range, extremely well-developed examples of this heath tundra occurred commonly and widely in the Southcentral Alpine Floristic Region of the Park. These heath communities were often associated with the formation of conspicuous surface features such as large hummocks and nivation hollows that resulted from physical processes associated with late-lying snow on the landscape (see Plate 6.49).

  Heath-dominated snowbed tundra communities also occurred north of the Alaska Range crest, but less commonly. On the north side of the Range, these associations were generally confined to north aspects, where the vascular plant diversity was frequently relatively low. The heath communities south of the Alaska Range crest appeared to support a greater diversity of species than similar communities that occurred to the north

Plate 6.48 An example of alpine heath tundra in an area of late-lying snow on the southern slopes of the Alaska Range between Chelatna Lake and the Kahiltna Glacier.

Plate 6.49 Geomorphic processes associated with large, late-lying snow packs result in the formation of these large, characteristic earth-cored hummock features. *Cassiope stelleriana* and *Empetrum nigrum* frequently cover these hummocks with the hollows supporting taller *Vaccinium* species.

of the range. Numerous taxa new to the Park were collected in these distinctive heath tundra communities in the Southcentral Alpine Floristic Region. Noteworthy taxa collected in alpine heath communities south of the Alaska Range crest included *Carex anthoxanthea, Diphasiastrum sitchense, Phyllodoce aleutica, Phyllodoce caerulea* (see Plate 6.50*), Salix stolonifera, Vaccinium caespitosum* and *V. ovalifolium*.

- **Alpine fens and wetlands**

Several significant collections were made in fens in the Southcentral Alpine Floristic Region, although this community was quite rare on the alpine landscape (see a photo of one such community in Plate 6.51). This community is frequently dominated by *Tricophorum caespitosum*, sedges such as *Carex pauciflora* and *C. magellanica*, and the rush *Juncus mertensianus*. Significant collections of vascular plant species within these communities in this region included the following: *Coptis trifolia*, *Epilobium luteum* (see Plate 6.52), *Gentiana douglasiana*, *Rubus spectabilis*, and *Swertia perennis* (see Plate 6.52).

- **Dry fellfields and rubble slopes and associated sparse rocky tundra**

The mosaic of tundra and rubble slope habitats that occurs on well-drained ridges and slopes in the alpine region of Denali National Park and Preserve is perhaps the most species-rich area of the landscape in the Park (Plate 6.53 shows a calcareous rubble slope in the upper Yentna River drainage). Dry tundra and associated rubble slopes and fellfields harbored the greatest number of rare and endemic plant species of any area in the Park (Plates 6.54 and 6.55 show photographs of selected endemic species collected in this region). Collections made in well drained tundra within the Southcentral Alpine Floristic Region contributed most of the occurrences of both rare and endemic plants that were documented in this region during the present study. Nine of the 13 species of plant species tracked by the AKNHP that were collected in this region occurred in these dry tundra habitats. These nine species were: *Douglasia alaskana*, *Draba ruaxes* (see Plate 5.54)*, Minuartia biflora, Oxytropis huddelsonii, Papaver alboroseum, Saxifraga adscendens, Stellaria alaskana, Taraxacum carneocoloratum*, and *Thlaspi arcticum* (see Plate 5.54).

A tenth rare alpine species, *Aphragmus eschscholtzianus*, grew in moist pockets of soil in frost boils within fellfields and in the alpine runnels and seeps that drain high rocky tundra slopes. Similarly, 13 of the 19 Alaska-Yukon endemic species collected in the floristic region were found in dry alpine tundra and associated fellfield habitats. Fourteen of the 26 Amphiberingian endemic taxa found in the Southcentral Alpine were collected from dry tundra and rubble slopes.

The occurrence of rare and endemic plant species within dry tundra communities south of the Alaska Range crest was geographically very uneven within this region. In fact, sites within two relatively confined areas were the source of all of these occurrences of rare and endemic taxa in dry alpine tundra within this floristic region. One of these areas includes the general vicinity of Broad Pass at the northeastern extremity of this region,

Plate 6.50 Four vascular plant taxa that occur in alpine heath tundra communities on the south slopes of the Alaska Range in Denali National Park and Preserve (clockwise from upper left): *Cassiope stelleriana*, *Phyllodoce caerulea*, *Gentiana glauca*, and *Loiseleuria procumbens*.

Plate 6.51 This alpine wetland is located between Stern Gulch and the Yentna Glacier in the Southcentral Alpine Floristic Region of the Park.

and the other source area was the vicinity of Mystic Pass at the southwestern end of the Southcentral Alpine Floristic Region in the Park (Figure 6.27). It is worth noting that these taxa only occur on the south side of the range in areas close to low passes over the Range (Broad and Mystic passes).

Plate 6.52 Four wetland taxa that were collected in the Southcentral Alpine Floristic Region of Denali during this inventory were (clockwise from upper left): *Epilobium luteum*, *Juncus mertensianus*, *Juncus biglumis*, and *Swertia perennis*.

Plate 6.53 Steep, calcareous rubble slope in the upper West Fork of the Yentna River drainage in the Southcentral Alpine Floristic Region of Denali National Park and Preserve.

Plate 6.54 Four endemic species that occur in the Southcentral Alpine Floristic Region (clockwise from top left): *Thlaspi arcticum* (Alaska-Yukon endemic), *Draba ruaxes* (Cordilleran endemic), *Astragalus nutzotinensis* (Alaska–Yukon endemic) and *Chrysosplenium wrightii* (Beringian endemic).

Chapter 7 Floristics and Phytogeography of Denali National Park and Preserve

A. Taxonomic composition of the Park flora

There are 753 species (816 taxa including subspecies and varieties) of vascular plants that have been vouchered within Denali National Park and Preserve. This represents about 49 percent of the total number of species in the vascular flora of Alaska. The 753 resident species are members of 250 separate genera, representing 74 families of vascular plants. The Park flora includes representatives of the following major divisions of vascular plants: flowering plants (**Magnoliophyta**; 706 species), ferns and fern allies (**Pteridophyta**; 25 species), lycopods (**Lycopodiophyta**; 11 species), horsetails (**Equisetophyta**; 7 species) and conifers (**Coniferophyta**; 4 species). The set of flowering plants (**Magnoliophyta**) that occurs in the Park includes 214 monocots (class **Liliopsida**) and 492 dicots (class **Magnoliopsida**).

Two of the three most species-rich plant families in the Park flora are graminoid (grass-like) taxa: the sedge family (Cyperaceae) with 97 species and the grass family (Poaceae) with 56 species. The remaining plant families with 30 or more species in our flora area include the sunflower family (Asteraceae) with 66 species, the mustard family (Brassicaceae) with 47 species, the buttercup family (Ranunculaceae) with 33 species, the saxifrage family (Saxifragaceae) with 32 species, the rose family (Rosaceae) with 30 species, and the willow family (Salicaceae) with 30 species.

For comparison, the vascular plant flora of Wrangell-St. Elias National Park and Preserve, which is also located in the southern mainland of Alaska (about 200 kilometers to the east of Denali National Park and Preserve), includes 832 species (887 taxa including subspecies and varieties). The four most specie-rich families in the Denali National Park and Preserve flora are also the most species-rich in the flora of Wrangell-St. Elias National Park and Preserve, which has 100 species in the Cyperaceae, 69 species in the Poaceae, 68 species in the Asteraceae, and 66 species in the Brassicaceae (Cook and Roland 2002). Two things are worth noting about these comparisons: first, whereas Wrangell-St. Elias National Park and Preserve encompasses nearly twice the area of Denali National Park and Preserve, the flora of Denali National Park and Preserve contains roughly 90 percent of the number of vascular plant species found in Wrangell-St. Elias National Park and Preserve. Secondly, the relative numbers of species in the Poaceae and Brassicaceae families are large in the Wrangell-St. Elias National Park and Preserve flora relative to their numbers in the flora of Denali National Park and Preserve (69 species versus 56 in the Poaceae and 66 species versus 47 species in the Brassicaceae).

B. Growth form composition of the Park flora

The floras of high latitude regions generally have high numbers of herbaceous, non-woody plant species relative to the numbers of species with woody growth forms such as trees and shrubs. This holds true in Denali National Park and Preserve where only 11 percent of the vascular plant species have woody growth forms (85 species, including trees, shrubs and dwarf shrubs). The largest growth-form class in the Park flora is herbaceous forbs, almost all of which are perennial species. Sixty percent of the vascular plant species that occur in the Park are forbs (448 species;

Figure 7.1). Graminoids (or grass-like plants) represent about a quarter of the Park's vascular plant species (24 percent, or 178 species). The remaining five percent of the vascular plant species that occur in the Park are ferns and fern allies (25 species, or 3 percent of the total), club-mosses (11 species) and horsetails (7 species).

C. Biogeographic composition of the Park flora

Denali National Park and Preserve straddles the Alaska Range and is centrally located within the southern half of mainland Alaska. The landscape of the Park includes boreal lowlands on both sides of the Alaska Range and the full complement of upland, subalpine and alpine plant communities on both sides of this major mountain range. As a result, the Park flora encompasses all of the dominant biogeographic elements found in Alaska's flora except for strictly arctic taxa and species restricted to coastal southeast Alaska and the Aleutian islands (Figure 7.2). I recognize six major floristic elements within the Park flora: circumpolar species, incompletely circumpolar species, North American species, Amphiberingian species, Amphiatlantic species, and Alaska-Yukon endemic species. Each of these biogeographic elements of the flora is discussed below.

1. Circumpolar species, 31 percent of the flora (**233 species**).
This group includes broadly distributed plant species that occur on all of the continents in the polar region, including both Asiatic and European regions of Eurasia, Greenland and North America. I further divide this group of plants into arctic/alpine taxa that generally occur in treeless landscapes in the arctic or high alpine regions, and boreal species (those primarily found in lowland and montane habitats). A third element of the circumpolar flora is a group of wide-ranging species with broad ecological amplitudes that occur across both arctic and boreal zones, and a fourth category of the circumpolar species are exotic species introduced from other parts of the world into Alaska. The number of species in these categories within the circumpolar flora and examples of taxa from each category are as follows:

A) Arctic-alpine species (83 species) – *Cardamine bellidifolia* and *Silene acaulis*
B) Boreal-montane species (54 species) – *Carex tenuifolia*, *Linnaea borealis* and *Rosa acicularis*
C) Widespread species (81 species) –*Empetrum nigrum*, *Equisetum arvense* and *Poa glauca*
D) Exotic species (15 species) – *Trifolium repens* and *Capsella bursa-pastoris*

2. Incompletely circumpolar species, 16 percent of the flora (**119 species**).
The species in this group have distributions that are similar to the circumpolar plants of boreal distribution, but are not known from either Greenland or Europe, thus have geographic ranges that are not truly circumpolar. Examples of incompletely circumpolar species in the Denali National Park and Preserve flora include *Calypso bulbosa*, *Carex limosa*, *Chamaedaphne calyculata*, *Equisetum fluviatile*, and *Moehringia lateriflora*. Three of the plant species in the incompletely circumpolar plants are introduced weeds in Denali National Park and Preserve: *Descurainia sophia*, *Crepis tectorum*, and *Lappula squarrosa*.

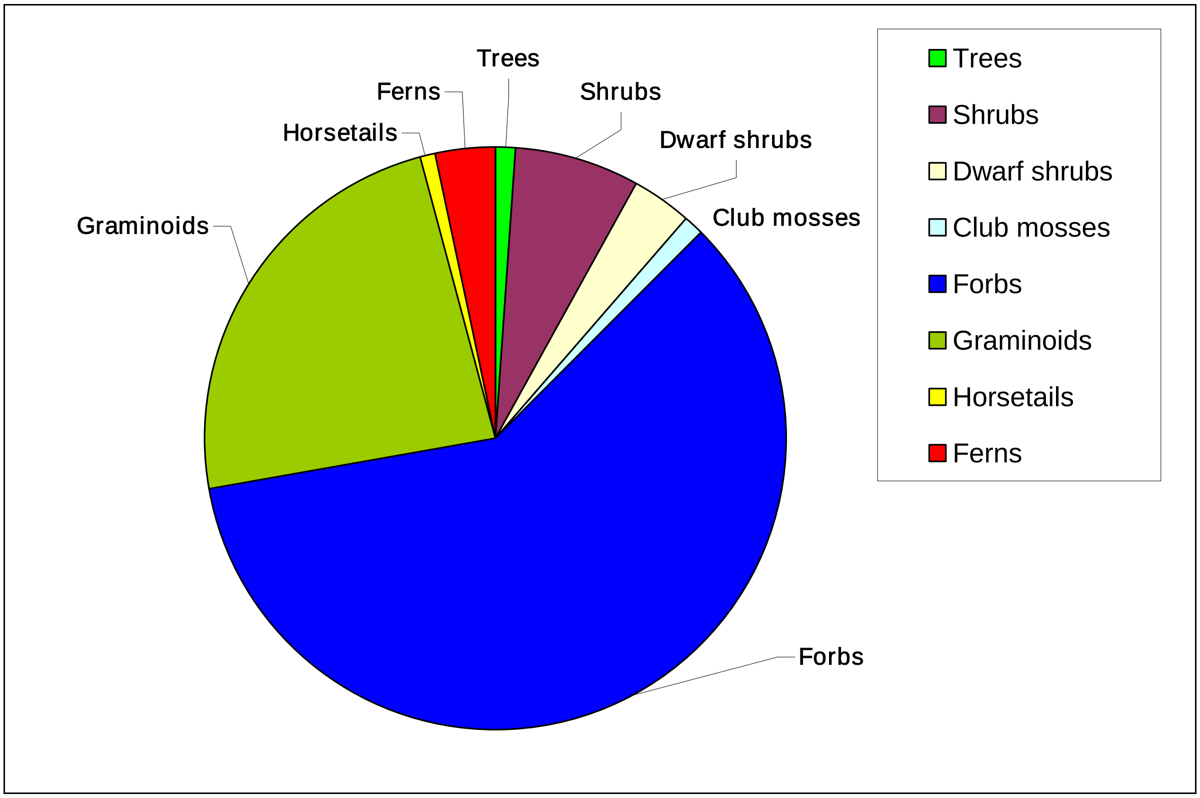


Figure 7.1: Percentage of vascular flora of Denali National Park and Preserve occurring in eight growth forms.

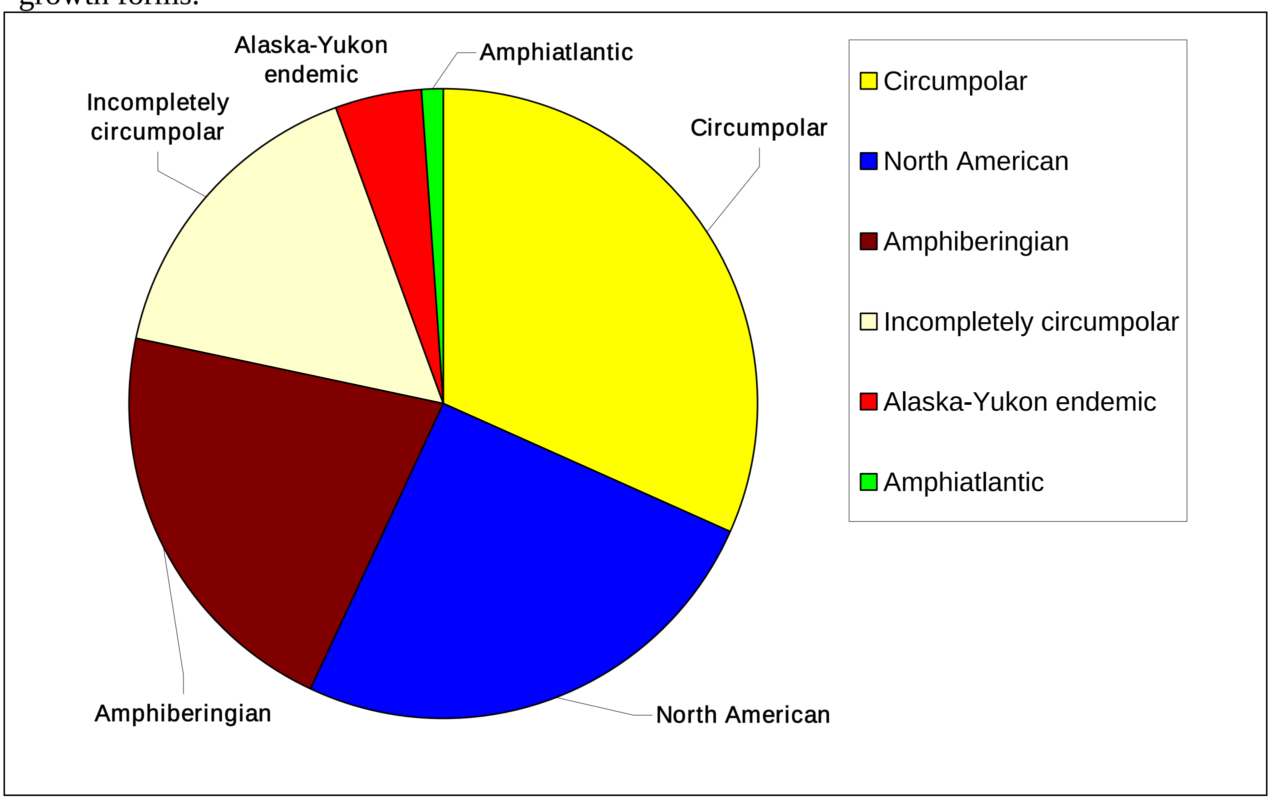


Figure 7.2: Percentage of vascular flora of Denali National Park and Preserve among six dominant biogeographic elements.

3. North American species – 25 percent of the flora (**186 species**).
Taxa in this group have distributions that are generally restricted to the North American continent. I have further separated these taxa into the following subgroups: arctic-alpine and boreal-montane species (see above), Cordilleran species, which are restricted to the western mountains, and Pacific coastal species, which are generally restricted to maritime areas on the west coast of North America. Widespread North American species occur in a wide range of habitats spanning arctic, boreal and temperate areas of the continent.

A) Arctic-alpine species (10 species) – *Primula egaliksensis* and *Erigeron grandiflorus*
B) Boreal-montane species (94 species) – *Shepherdia canadensis* and *Viburnum edule*
C) Cordilleran species (51 species) – *Luetkea pectinata* and *Salix commutata*
D) Pacific coastal species (18 species) – *Lupinus nootkatensis* and *Epilobium luteum*
E) Widespread species (12 species) – *Solidago multiradiata* and *Betula glandulosa*
F) Introduced, exotic species (1 species) – *Lupinus polyphyllus*

4. Amphiberingian species – 23 percent of the flora (**176 species**).
Amphiberingian plant species occur in both North America and northern Eurasia, but are not known from either Greenland or Europe; hence their center of distribution generally lies within Beringia. Amphiberingian endemic species are plants that are generally restricted to Beringia in the North American part of their range (that is, they do not occur much outside of the area defined by Alaska and the Yukon Territory). I further separate the species within the Amphiberingian biogeographic element into the following categories:

A) Arctic-alpine species (48 species) – *Artemisia arctica* and *Senecio atropurpureus*
B) Boreal-montane species (26 species) – *Achillea sibirica* and *Boschniakia rossica*
C) Pacific coastal species (20 species) – *Carex macrochaeta* and *Fritillaria camschatcensis*
D) Widespread species (30 species) – *Parrya nudicaulis* and *Carex podocarpa*
E) Amphiberingian endemic species (52 species) – *Chrysosplenium wrightii* and *Carex pseudoabbreviata*

5. Amphiatlantic species – 1 percent of the flora (**8 species**).
Taxa in this group of species are rare in Alaska's flora; these taxa have distributions that include North America, Greenland and Europe but exclude northern Asia. *Carex nardina* and *Draba crassifolia* are examples of species from this element.

6. Alaska-Yukon endemic species – 4 percent of the flora (**32 species**).
These are species that are restricted to Alaska and Yukon Territory, and sometimes extend into neighboring regions of Northwest Territories and British Columbia.

A) Arctic-alpine species (15 species) – *Thlaspi arcticum* and *Smelowskia borealis*
B) Boreal-montane species (5 species) – *Salix setchelliana* and *Silene williamsii*
C) Cordilleran species (10 species) – *Synthyris borealis* and *Stellaria alaskana*
D) Pacific coastal species (2 species) –*Salix stolonifera* and *Agrostis alaskana*

D. The distribution of state-level rare plants among the Park's floristic regions

In order to examine the distribution of state and globally rare species on the Park landscape in a comprehensive way, I analyzed all preexisting collection data, as well as Floristic Inventory and Soils Inventory collections to determine the distribution of these taxa among the Park's floristic regions. For purposes of this analysis, I have considered only those taxa that are ranked by the Alaska Natural Heritage program as rare globally or in Alaska (global rank of G1, G2 or G3, state-level rank of S1, S2 or S3). The results of these analyses are presented as a matrix showing the known distribution of rare taxa among the Park's nine floristic regions (Table 7.1). Fifty-three vascular plant taxa that are considered rare in Alaska by the Alaska Natural Heritage Program (ranked S3 or lower) are known to occur in Denali National Park and Preserve. Fourteen of these taxa are considered globally imperiled (i.e. they have a global rank of G3 or lower).

This set of state-level rare vascular plant taxa was found to be unevenly distributed across the Park landscape; certain regions harbored relatively large numbers of these taxa whereas other regions contained relatively few rare species. At the largest spatial scale, the north side of the Alaska Range harbored higher numbers of rare species. Of the 53 state-level rare species that occurred in the Park, only eight were entirely absent from floristic regions north of the Alaska Range crest. In contrast, 21 of these rare state-level rare species were absent from regions south of the Alaska Range crest. Among the individual floristic regions, 24 AKNHP tracked taxa occurred in the Interior Alpine Alaska Range Region, which was the largest number of rare species for any single region, and the Southcentral Boreal Lowland Region harbored only five of these taxa, which was the fewest of any of the Park floristic regions (Figure 7.3). The mean number of rare taxa per Park floristic region was 11.7. Five floristic regions had higher than the mean number of rare taxa per region, including the three alpine regions, the Interior Boreal Lowlands (15 taxa) and the Southcentral Boreal Subalpine Region (13 taxa; see Table 7.1). The mean number of region occurrences per state rare taxon was two floristic regions per species, although a few species such as *Salix setchelliana* and *Viola selkirkii* were each present in four separate Park regions.

What explains the conspicuous variation in the number of rare taxa per floristic region? In order to address this question, I calculated the amount of "habitable surface area" in each region using the GIS analyses presented earlier. This number was derived by subtracting the amount of a region's surface area in the following landcover categories: 1) snow and ice, 2) water and 3) barren rock landcover classes from the total surface area of the region. This number thus provides a *rough* measure of the amount of habitable area for vascular plant species in each floristic region of the Park, a quantity referred to hereafter as *HSA* ("habitable surface area"). A linear regression of the number of AKNHP rare species against *HSA* of for nine Denali National Park and Preserve floristic regions indicated that one significant variable determining rare species number in a region is simply the overall size of the floristic region (see Figure 7.4; r^2 = .66; p= 0.008.

Thus, there was a highly significant relationship between floristic region size and the number of rare plant species occurring in a region. Larger regions presumably contain a greater variety of

Table 7.1 The occurrence of species considered rare by AKNHP among the nine floristic regions of Denali National Park and Preserve. A number in a cell indicates the taxon has been documented in the given floristic region (1 – species documented in region by pre-1998 collection, 2- species documented by Floristic Inventory Project collection; 3 – species observed at site in region; 4 – species documented by Soils Inventory collection)

Species	Rank	Int. Alpine AK Range	Int. Alpine Outer Range	Int. Boreal Upland	Int. Boreal Lowland	Int. Boreal Floodplain	SC Alpine	SC Boreal Subalpine	SC Boreal Lowland	SC Boreal Floodplain	**# regions present**
Agrostis clavata	S1S2	0	0	0	0	0	0	**2**	0	0	**1**
A. thurberiana	S2	0	0	0	0	0	0	**2**	0	0	**1**
Aphragmus eschscholtzianus	S3	**1**	**2**	0	0	0	**2**	0	0	0	**3**
Arenaria longipedunculata	S3	0	0	0	0	**1**	0	0	0	0	**1**
Arnica diversifolia	S1	0	0	0	0	0	**2**	0	0	0	**1**
Botrychium alaskense	S2S3	0	**1**	0	0	0	**2**	**2**	0	0	**3**
B. ascendens	S2	**4**	0	0	0	0	0	0	0	0	**1**
Carex adelostoma	S1	0	0	0	**4**	0	0	0	0	0	**1**
C. crawfordii	S2S3	0	0	**2**	0	0	0	**2**	**2**	0	**3**
C. deflexa	S1S2	0	0	0	0	0	0	**4**	0	0	**1**
C. eburnea	S2S3	0	0	0	0	2	0	**2**	0	0	**2**
C. enanderi	S3	0	0	0	0	0	**2**	**2**	0	0	**2**
C. incurviformis	S2	**2**	0	0	0	0	0	0	0	0	**1**
C. interior	S1	0	0	0	**4**	**4**	0	0	**2**	**2**	**4**
C. lapponica	S2	**2**	0	0	**2**	0	0	0	0	0	**2**
C. phaeocephala	S1S2	0	0	0	0	0	**2**	0	0	0	**1**
Ceratophyllum demersum	S2	0	0	0	**2**	0	0	0	0	0	**1**
Cicuta bulbifera	S1S2	0	0	0	**4**	0	0	0	0	**2**	**2**
Cryptogramma stelleri	S2S3	0	0	**2**	0	0	0	**2**	0	0	**2**
Douglasia alaskana	S2S3	**1**	0	0	0	0	**2**	0	0	0	**2**
D. gormanii	S3	**1**	**1**	**2**	0	0	0	0	0	0	**3**
Draba densifolia	S1	**1**	0	0	0	0	0	0	0	0	**1**
D. lonchocarpa var. *vestita*	S2?	**2**	**2**	**2**	0	0	0	0	0	0	**3**
D. ruaxes	S3	**1**	**2**	0	0	0	**2**	0	0	0	**3**
Eleocharis quinqueflora	S1	0	0	0	**4**	0	0	0	0	0	**1**
Erigeron grandiflorus		**1**	**1**	0	0	0	0	0	0	0	**2**
Eriophorum viridi-carinatum	S2	0	0	0	0	0	0	**2**	0	0	**1**

Table 7.1 continued. The occurrence of species considered rare by AKNHP among the nine floristic regions of Denali National Park and Preserve. A number in a cell indicates the taxon has been documented in the given floristic region (1 – species documented in region by pre-1998 collection, 2- species documented by Floristic Inventory Project collection; 3 – species observed at site in region; 4 – species documented by Soils Inventory collection)

Species	Rank	Int. Alpine AK Range	Int. Alpine Outer Range	Int. Boreal Upland	Int. Boreal Lowland	Int. Boreal Floodplain	SC Alpine	SC Boreal Subalpine	SC Boreal Lowland	SC Boreal Floodplain	**# regions present**
Festuca lenensis	S3	**1**	**2**	**2**	0	0	0	0	0	0	**3**
Glyceria pulchella	S2S3	0	0	0	**2**	0	0	0	0	0	**1**
G. striata ssp. *stricta*	S2	0	0	0	0	0	0	**2**	0	**2**	**2**
Limosella aquatica	S3	0	0	0	**4**	0	0	0	0	0	**1**
Malaxis paludosa	S2S3	0	0	0	**2**	0	0	0	**2**	0	**2**
Minuartia biflora	S2	**1**	**2**	0	0	0	**2**	0	0	0	**3**
M. yukonensis	S3	0	**2**	0	0	0	0	**2**	0	0	**2**
Myriophyllum verticillatum	S3	0	0	0	**1**	0	0	0	0	0	**1**
Najas flexilis	S1S2	0	0	0	**2**	0	0	0	0	**2**	**2**
Oxytropis huddelsonii	S2S3	**2**	0	0	0	0	**2**	0	0	0	**2**
Papaver alboroseum	S3	**1**	0	0	0	0	**2**	0	0	0	**2**
Pedicularis macrodonta	S3	0	0	0	**2**	0	0	0	**2**	**2**	**3**
Phlox richardsonii	S2	**2**	**2**	**2**	0	0	0	0	0	0	**3**
Potamogeton obtusifolius	S1	0	0	0	**2**	0	0	0	**2**	0	**2**
P. subsibiricus	S3	0	0	0	**2**	0	0	0	0	**2**	**2**
Salix candida	S2S3	0	0	0	**4**	**4**	0	0	0	0	**2**
Salix setchelliana	S3	**1**	**0**	**1**	0	**1**	0	0	0	**1**	**4**
Saxifraga adscendens ssp. *oregonensis*	S2S3	**1**	0	0	0	0	**2**	0	0	0	**2**
S. nelsoniana ssp. *porsildiana*	S2	**1**	**2**	0	0	0	0	0	0	0	**2**
Smilacina stellata	S2	**1**	0	0	0	0	0	0	0	0	**1**
Stellaria alaskana	S3	**1**	**2**	0	0	0	2	0	0	0	**3**
S. dicranoides	S3	**1**	**1**	0	0	0	0	0	0	0	**2**
S. umbellata	S2S3	**1**	0	0	0	0	0	0	0	0	**1**
Taraxacum carneocoloratum	S3	**1**	0	0	0	0	2	0	0	0	**2**
Thlaspi arcticum	S3	**1**	0	0	0	0	**1**	0	0	0	**2**
Viola selkirkii	S3	0	0	**2**	0	**1**	**2**	**4**	0	0	**4**
# species present		**24**	**13**	**8**	**15**	**6**	**15**	**12**	**5**	**7**	

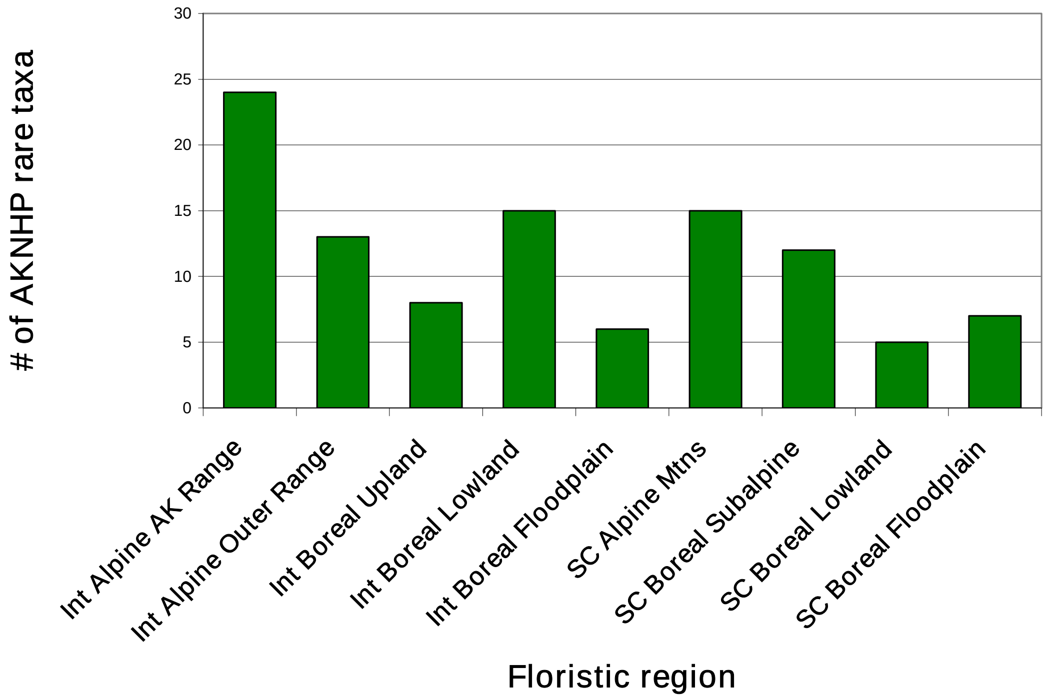


Figure 7.3 The number of state-level rare vascular plant species (taxa ranked below S3 by AKNHP) in each of the nine floristic regions of Denali National Park and Preserve.

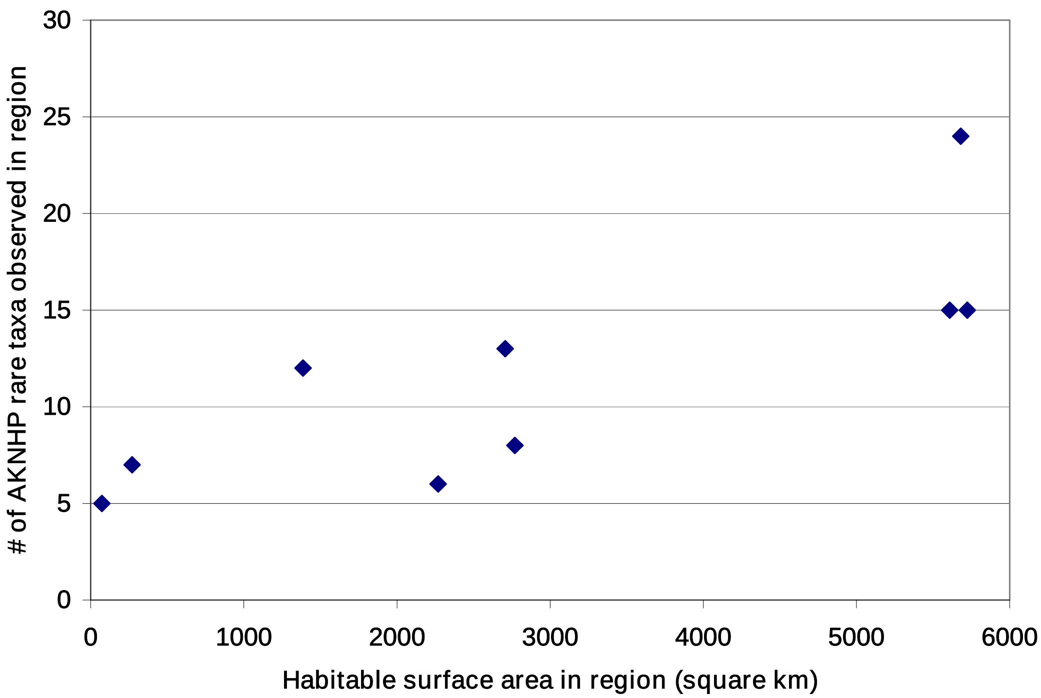


Figure 7.4 The number of state-level rare vascular plant species (taxa ranked below S3 by AKNHP) in each of the nine floristic regions of Denali National Park and Preserve as a function of the amount of habitable surface area within the region.

conditions and habitats (on average) than small regions, thus they tend to harbor a greater diversity of rare species, many of which may be expected to have narrow habitat preferences.

I used a mathematical technique to assess the degree of similarity of the rare plant flora of the nine floristic regions of Denali (Jaccard nearest-neighbor cluster analysis). This analysis uses matrix algebra to assess the overall level of similarity among the lists of species that occur in the different regions. The regions are clustered together based upon the calculated similarity of their floras. The cluster analysis performed on the species occurrence matrix for state-level rare plant occurrences among the nine floristic regions indicated that the highest degree of similarity among two regions was between the two interior alpine floristic regions, which also clustered with the Southcentral Alpine Floristic Region in this analysis (see Figure 7.5). The Interior Boreal Upland Floristic Region clustered with this alpine group at the Jaccard distance of 1.19. The state-level rare floras of the two Southcentral lowland regions clustered with the Interior Boreal Lowland Floristic Region at the 0.894 distance level, and the Interior Boreal Floodplain Floristic Region was joined to this group at a distance of 1.52.

The Southcentral Boreal Subalpine Floristic Region was identified as a conspicuous outlier by this cluster analysis. The southcentral Boreal Subalpine Floristic Region shared very few rare species with the other floristic regions, and contained a relatively high proportion of unique rare species (rare species that were not observed elsewhere in the Park). In fact, 33 percent of the state-level rare taxa that occurred in this region were unique to it alone within the Park. The set of taxa that were unique to the Southcentral Subalpine Floristic Region were Cordilleran species of lush subalpine meadow habitats, such as *Arnica diversifolia*.

The clustering of the regions based upon the composition of their rare floras clearly showed broad floristic differences between alpine and boreal areas of the landscape. All of the alpine regions clustered together, regardless of geographic location, and the boreal regions similarly clustered together. The fact that the lowland regions were more similar to each other than to neighboring upland and alpine areas is worthy of note. The observed similarity among the lowland regions, regardless of their geographic location, was largely due to the presence of a group of rare aquatic and wetland taxa with broad geographic distributions that occurred in boreal wetlands on both sides of the Alaska Range crest, (such as *Cicuta bulbifera*, *Najas flexilis*, and *Potamogeton obtusifolius*).

It should be noted that the definition of rarity used for the analyses presented above does not necessarily reflect local rarity patterns of plant species. There are many species that are rare in the Denali area that are not tracked as rare on a statewide level by AKNHP. Conversely some AKNHP ranked taxa are comparatively common in Denali (such as *Douglasia gormanii*). To address this situation, I have prepared a Park-level list of rare plants species (based on the information gathered during this inventory) for use in planning and management specifically relevant to Denali National Park and Preserve (see Chapter 8; Appendix B).

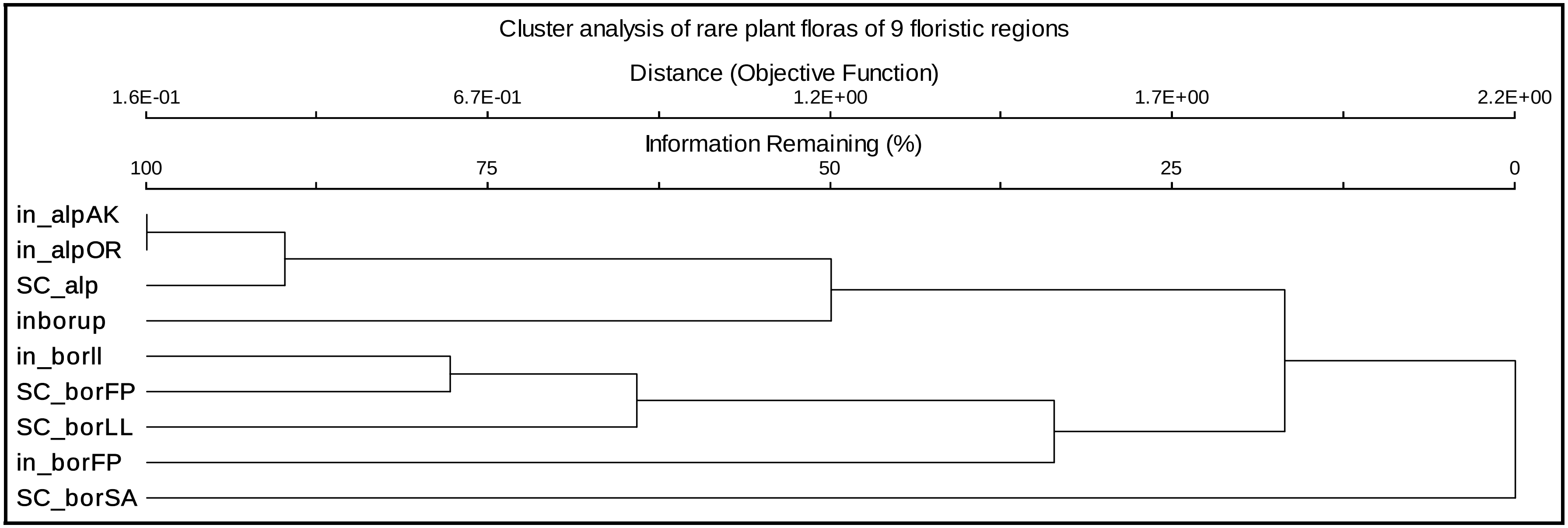


Figure 7.5. Cluster dendrogram showing the results of Jaccard nearest neighbor cluster analysis performed on the matrix of species occurrences of AKNHP rare plants among the nine floristic regions of Denali National Park and Preserve.

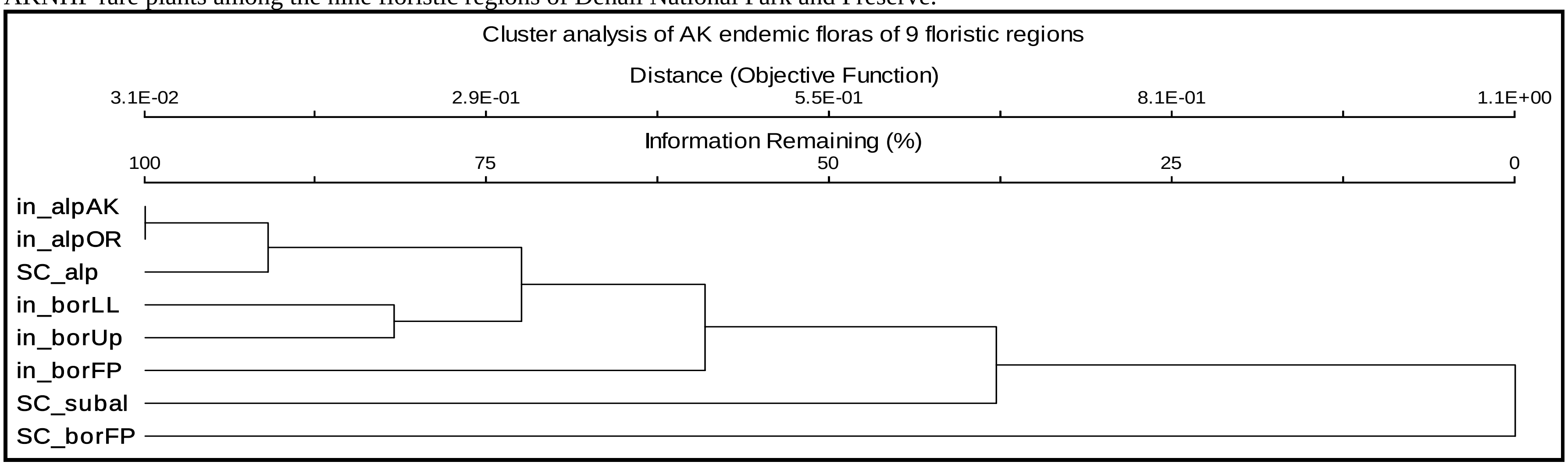


Figure 7.6. Cluster dendrogram showing the results of Jaccard nearest neighbor cluster analysis performed on the matrix of species occurrences of Alaska – Yukon endemic species among the nine floristic regions of Denali National Park and Preserve.

In summary, my examination of the distribution of state-level rare plant species richness and composition among the Park's nine floristic regions showed the following:

a) The Interior Alpine – Alaska Range Floristic Region contained the highest number of rare taxa (24 taxa), followed by the Southcentral Alpine and the Interior Boreal Lowlands floristic regions (15 taxa each). The fewest rare taxa were observed in the Southcentral Boreal Lowland Floristic Region (5 taxa)

b) There was a highly significant relationship between floristic region size and the number of rare vascular plant taxa that occurred in a region.

c) Cluster analysis of the species occurrence matrix for rare plants showed a strong clustering of the regions based on life zone (boreal versus alpine) regardless of geographic location; the Southcentral Boreal Subalpine zone was identified as a conspicuous outlier for rare plant composition because of the large number of taxa unique to that region (primarily Cordilleran taxa of lush subalpine meadows).

E. Distribution of endemic species among the Park's floristic regions

To examine the distribution of the two primary endemic elements within the flora of Denali National Park and Preserve (Alaska-Yukon endemic species and Amphiberingian endemic species) among the different regions of the Park, I analyzed all available specimen records for the area. The results of these analyses were two species occurrence matrices, one for the occurrence of Alaska-Yukon endemic species among the nine floristic regions and a second for the distribution of Amphiberingian endemic species among these regions (Tables 7.2 and 7.3). For this set of analyses, I only included *species-level* endemic taxa (in other words, I excluded endemic taxa that were at the rank of subspecies or variety).

1. Alaska – Yukon endemic species

Thirty-two Alaska – Yukon endemic vascular plant species occur in the Park based on a review of all available collections. The mean number of Alaska-Yukon endemic species per floristic region was 12.4, although there was a large range in the number of Alaska - Yukon endemic species per region (Figure 7.7). The highest number of Alaska - Yukon endemic species was observed in the Interior Alpine Alaska Range Region with 26 species, which represents 81 percent of the total number found in the Park as a whole. The two Southcentral Boreal Lowland floristic regions, on the other hand (Southcentral Boreal Lowland and Southcentral Boreal Floodplains) contained zero and one of these species respectively (Figure 7.7).

The average number of floristic regions in which each Alaska - Yukon endemic species occurred was 3.5. This was nearly twice the mean number of region occurrences per species than that exhibited by the state-level rare species (which was two regions per taxon). Thus the individual Alaska –Yukon endemic species were, on average, more geographically widespread within the Park than the AKNHP state-level rare taxa were. In fact, several of the Alaska-Yukon endemics were observed in five or more of the Park floristic regions, including *Astragalus nutzotinensis*,

Table 7.2 The occurrence of species endemic to Alaska, the Yukon Territory, and neighboring areas of North America among the nine floristic regions of Denali National Park and Preserve. A number in a cell indicates the taxon has been documented in the given floristic region (1 – species documented in region by pre-1998 collection, 2- species documented by Floristic Inventory Project collection; 3 – species observed at site in region; 4 – species documented by Soils Inventory collection)

Species	Int. Alpine AK Range	Int. Alpine Outer Range	Int. Boreal Upland	Int. Boreal Lowland	Int. Boreal Floodplain	SC Alpine	SC Boreal Subalpine	SC Boreal Lowland	SC Boreal Floodplain	**Total # regions**
Agrostis alaskana	0	0	0	0	0	**2**	**2**	0	0	**2**
Aphragmus eschscholtzianus	**1**	**2**	0	0	0	**2**	0	0	0	**3**
Astragalus nutzotinensis	**1**	**2**	**1**	**3**	**1**	**2**	**2**	0	0	**7**
A. polaris	**1**	**2**	0	0	**1**	**2**	0	0	0	**4**
Botrychium alaskaense	0	**1**	0	0	0	**2**	**2**	0	0	**3**
Boykinia richardsonii	**1**	**1**	**1**	**1**	0	**2**	**3**	0	0	**6**
Claytonia scammaniana	**1**	**1**	0	0	0	**2**	0	0	0	**3**
Corydalis sempervirens	0	0	**1**	**1**	0	0	0	0	0	**2**
Cryptogramma sitchensis	0	0	0	0	0	**2**	**2**	0	0	**2**
Douglasia alaskana	**1**	0	0	0	0	**2**	0	0	0	**2**
D. gormanii	**1**	**1**	**2**	0	0	0	0	0	0	**3**
Dryas alaskensis	**1**	**2**	**1**	**1**	0	**2**	0	0	0	**5**
Erigeron purpuratus	**1**	**1**	**1**	0	**2**	**2**	0	0	0	**5**
Eritrichium splendens	0	**2**	**2**	0	0	0	0	0	0	**2**
Melandrium macrospermum	**1**	**2**	0	0	0	**2**	0	0	0	**3**
Oxytropis huddelsonii	**2**	0	0	0	0	**2**	0	0	0	**2**

Table 7.2 (continued) The occurrence of species endemic to Alaska, the Yukon Territory, and neighboring areas of North America among the nine floristic regions of Denali National Park and Preserve. A number in a cell indicates the taxon has been documented in the given floristic region (1 – species documented in region by pre-1998 collection, 2- species documented by Floristic Inventory Project collection; 3 – species observed at site in region; 4 – species documented by Soils Inventory collection).

Species	Int. Alpine AK Range	Int. Alpine Outer Range	Int. Boreal Upland	Int. Boreal Lowland	Int. Boreal Floodplain	SC Alpine	SC Boreal Subalpine	SC Boreal Lowland	SC Boreal Floodplain	**Total # regions**
O. scammaniana	**1**	**1**	0	0	0	**2**	0	0	0	**3**
Papaver mcconnellii	**1**	**2**	**1**	0	**1**	**2**	**2**	0	0	**6**
Phlox richardsonii	**2**	**2**	**2**	0	0	0	0	0	0	**3**
Polygonum alaskanum	**3**	**2**	**1**	**1**	**3**	0	0	0	0	**5**
Salix setchelliana	**1**	0	**1**	0	**1**	0	0	0	**1**	**4**
Salix stolonifera	0	0	0	0	0	**2**	**2**	0	0	**2**
Saxifraga reflexa	**1**	**2**	**3**	**3**	0	**2**	**2**	0	0	**6**
S. spicata	**1**	**2**	**1**	0	**1**	0	0	0	0	**4**
Senecio ogotorukensis	**1**	**2**	**1**	**1**	**1**	**2**	**2**	0	0	**7**
S. yukonensis	**1**	**1**	**3**	**1**	0	0	0	0	0	**4**
Silene williamsii	**1**	**2**	**1**	**3**	**2**	0	0	0	0	**5**
Smelowskia borealis	**1**	**2**	0	0	0	0	0	0	0	**2**
Stellaria alaskana	**1**	**2**	0	0	0	**2**	0	0	0	**3**
Synthyris borealis	**1**	**2**	0	0	0	0	0	0	0	**2**
Taraxacum carneocoloratum	**1**	0	0	0	0	**2**	0	0	0	**2**
Thlaspi arcticum	**1**	0	0	0	0	**1**	0	0	0	**2**
Total # species in region	**26**	**23**	**16**	**9**	**9**	**21**	**9**	**0**	**1**	

Table 7.3 The occurrence of Amphiberingian endemic species among the nine floristic regions of Denali National Park and Preserve. A number in a cell indicates the taxon has been documented in the given floristic region (1 – species documented in region by pre-1998 collection, 2- species documented by Floristic Inventory Project collection; 3 – species observed at site in region; 4 – species documented by Soils Inventory collection)

Species	Int. Alpine AK. Range	Int. Alpine Outer Range	Int. Boreal Upland	Int. Boreal Lowland	Int. Boreal Floodplain	SC Alpine	SC Boreal Subalpine	SC Boreal Lowland	SC Boreal Floodplain	**Total # regions**
Aconitum delphinifolium	**1**	**3**	**1**	**1**	**1**	**2**	**3**	**3**	**3**	**9**
Anemone multiceps	**2**	**2**	0	0	0	0	0	0	0	**2**
Arnica lessingii	**1**	**2**	**1**	**1**	**1**	**2**	**3**	0	0	**7**
Artemisia globularia	**1**	**2**	0	0	0	0	0	0	0	**2**
Astragalus umbellatus	**1**	**2**	**1**	**1**	**1**	**2**	**3**	0	0	**7**
Cardamine purpurea	**1**	**2**	**2**	0	0	**2**	0	0	0	**4**
Carex lugens	0	0	**4**	0	**1**	**4**	0	0	0	**3**
C. microchaeta	**1**	**2**	**1**	0	0	**2**	**2**	0	0	**5**
Castilleja caudata	**3**	**3**	**3**	**1**	**2**	**3**	**3**	**3**	**3**	**9**
Chrysosplenium wrightii	**1**	**1**	0	0	0	**2**	0	0	0	**3**
Claytonia eschscholtzii	**1**	**1**	0	0	0	0	0	0	0	**2**
C. sarmentosa	**1**	**1**	**1**	0	**1**	**2**	**3**	0	0	**6**
C. tuberosa	**1**	**2**	**1**	**1**	0	0	0	0	0	**4**
Cnidium cnidiifolium	**1**	**1**	**1**	0	0	0	0	0	0	**3**
Delphinium brachycentrum	**1**	0	**1**	0	0	0	0	0	0	**2**
Dodecatheon frigidum	**1**	**2**	**1**	0	**4**	**3**	**3**	0	0	**6**
Draba borealis	**1**	**2**	0	0	0	**4**	0	0	0	**3**
D. stenopetala	**1**	**1**	0	0	0	**2**	0	0	0	**3**
Elymus macrourus	0	0	0	**1**	**4**	0	0	0	0	**2**
Eritrichium aretoides	**1**	0	0	0	0	0	0	0	0	**1**
E. chamissonis	**1**	0	0	0	0	0	0	0	0	**1**
Festuca brevissima	**1**	**2**	0	0	0	**2**	0	0	0	**3**
F. lenensis	**1**	**2**	**2**	0	0	0	0	0	0	**3**
Geum glaciale	0	**1**	0	0	0	0	0	0	0	**1**
Hieracium triste	0	**2**	0	0	0	**2**	**2**	0	0	**3**

Table 7.3 (continued) The occurrence of species endemic to Beringia among the nine floristic regions of Denali National Park and Preserve. A number in a cell indicates the taxon has been documented in the given floristic region (1 – species documented in region by pre-1998 collection, 2- species documented by Floristic Inventory Project collection; 3 – species observed at site in region; 4 – species documented by Soils Inventory collection)

Species	Int. Alpine AK Range	Int. Alpine Outer Range	Int. Boreal Upland	Int. Boreal Lowland	Int. Boreal Floodplain	SC Alpine	SC Boreal Subalpine	SC Boreal Lowland	SC Boreal Floodplain	**# regions present**
Lagotis glauca	**1**	**2**	0	0	0	0	0	0	0	**2**
Luzula tundricola	**1**	**2**	0	0	0	**2**	0	0	0	**3**
Minuartia yukonensis	0	**2**	0	0	0	0	**2**	0	0	**2**
Oxytropis mertensiana	0	**1**	0	0	0	0	0	0	0	**1**
Papaver alboroseum	**2**	0	0	0	0	**2**	0	0	0	**2**
P. macounii	**1**	**2**	**3**	**1**	**1**	0	0	0	0	**5**
Poa macrocalyx	0	0	0	0	0	0	**4**	0	0	**1**
P. pseudoabbreviata	**1**	**2**	0	0	0	**2**	**2**	0	0	**4**
Podistera macounii	**1**	**1**	**1**	0	0	0	0	0	0	**3**
Primula cuneifolia	**1**	**2**	0	0	0	**2**	0	0	0	**3**
P. eximia	**1**	**1**	**1**	0	0	0	0	0	0	**3**
Rhododendron camtschaticum	0	**1**	0	0	0	0	0	0	0	**1**
Salix fuscescens	0	0	**1**	**1**	0	**2**	**2**	**2**	0	**5**
S. phlebophylla	**2**	**3**	0	0	0	0	0	0	0	**2**
S. pulchra	**1**	**1**	**1**	**1**	**3**	**3**	**3**	**3**	**3**	**9**
Sanguisorba stipulata	**1**	**3**	**1**	**1**	0	**2**	**2**	0	0	**6**
Saxifraga calycina	**1**	**2**	**0**	0	0	**2**	0	0	0	**3**
S. serpyllifolia	**1**	**1**	0	0	0	**2**	0	0	0	**3**
Selaginella sibirica	**3**	**2**	**2**	0	0	0	0	0	0	**3**
Senecio kjellmanii	**1**	0	0	0	0	**2**	0	0	0	**2**
Spiraea stevenii	**3**	**2**	**1**	**1**	**3**	**2**	**3**	**3**	**3**	**9**
Stellaria dicranoides	**1**	**1**	0	0	0	0	0	0	0	**2**
Taraxacum alaskanum	**1**	**3**	0	0	0	**2**	0	0	0	**3**
T. kamtschaticum	**1**	**2**	0	0	0	**2**	0	0	0	**3**
Viola langsdorffii	**3**	0	**1**	**1**	0	**2**	**2**	0	0	**5**
Wilhelmsia physodes	0	**2**	**2**	**1**	**1**	0	0	0	0	**4**
# species present	**41**	**41**	**23**	**14**	**13**	**28**	**17**	**6**	**5**	

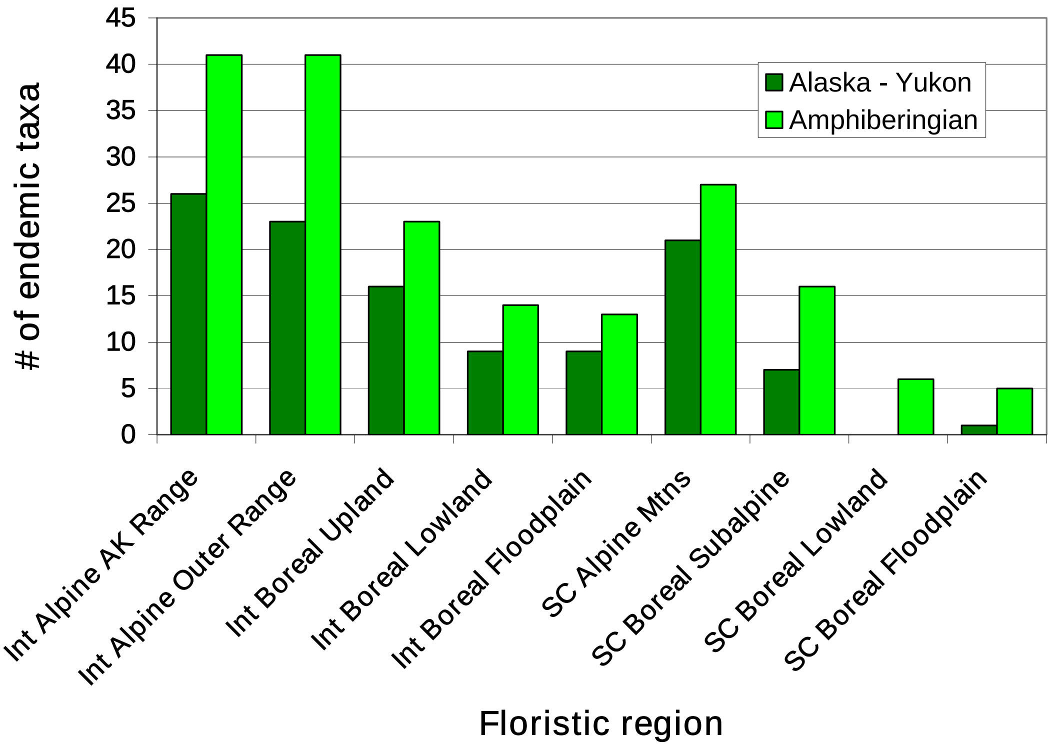


Figure 7.7. Number of A) Alaska–Yukon and B) Amphiberingian endemic species in each of nine floristic regions of Denali National Park and Preserve.

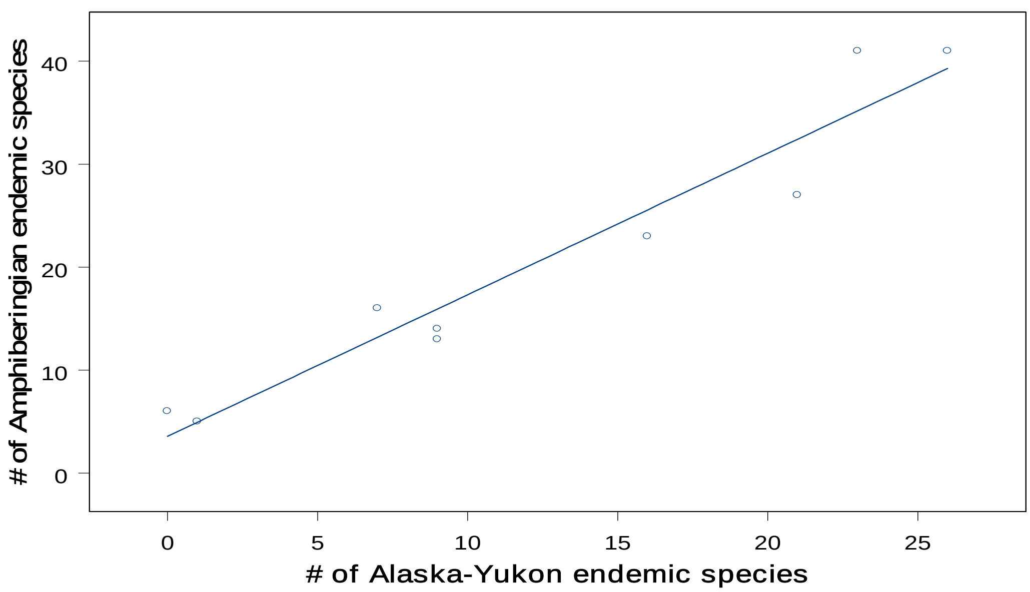


Figure 7.8: Correlation between numbers of Alaska-Yukon and Amphiberingian endemic species among nine floristic regions of Denali National Park and Preserve.

Boykinia richardsonii, *Dryas alaskensis, Polygonum alaskanum*, *Saxifraga reflexa* and *Senecio ogotorukensis*.

There were distinct geographic patterns of occurrence of Alaska - Yukon endemic species on the Park landscape. The interior regions of the Park had considerably higher numbers of endemic taxa as compared to regions on the south side of the Alaska Range. In fact, only three of these 32 endemic species that occur in the Park have not been observed on the north side of the Alaska Range crest: *Agrostis alaskana*, *Cryptogramma sitchensis*, and *Salix stolonifera*. Conversely, nearly one third of the Alaska-Yukon endemic species (ten) occurred north of the Alaska Range crest but did not occur on the south side. Furthermore, the collection locations of those Alaska - Yukon endemic species that did occur south of the Alaska Range crest were clustered in two relatively small areas in close proximity to the two low passes over the Alaska Range in the Denali National Park and Preserve region: Broad Pass in the north and Mystic Pass in the south. (Earlier in this report, I noted the observation that many "north-side" or interior species were found in a small area in the West Fork of the Yentna River drainage, indicating that the Mystic Pass area might be a dispersal corridor for plant species across the Alaska Range.)

Two relatively small sections of the very large Southcentral Alpine Floristic Region thus contained the vast majority of occurrences of these endemic taxa. The relatively endemic-rich areas of the Southcentral alpine mountains were: 1) the West Fork of the Chulitna River north to Windy Creek, and 2) alpine sites in the drainage of the West Fork of the Yentna River.

Remarkably, an examination of all of our collection data showed that only three of the Alaska–Yukon endemic species (and 14 of the Amphiberingian endemic species) were found outside of these two limited areas of the Southcentral Alpine Mountain Floristic Region. Thus the majority of the alpine landscape south of the Alaska Range crest appears to be quite depauperate in occurrences of Alaska-Yukon endemic plant species.

To examine patterns in the concentration of narrowly-distributed Alaska-Yukon endemic species on the Park landscape, I removed the set of widely distributed endemic taxa (those occurring in five or more Park floristic regions) and performed a regression of restricted endemic species richness on habitable surface area (*HSA*) for the nine floristic regions of the Park. In this analysis, the number of narrowly-distributed endemic species in each floristic region represented one observation. The relationship between number of restricted endemic species and *HSA* was *not* significant ($r^2 = .41$; $p = 0.062$). This is a markedly different result than that returned from the regression analysis of the number of AKNHP rare taxa on *HSA*, which showed a highly significant positive relationship between species number and *HSA*. In other words, something other than area best explains the number of narrowly distributed endemic taxa on the Park landscape. Furthermore, an examination of species distribution maps of these narrowly-distributed species leads me to conclude that even if much larger areas of the Southcentral zone were inventoried (thus including areas outside of the Park) very few additional occurrences of endemic taxa would be added to the set that we documented. Thus even the apparent weak relationship between area and narrowly-distributed endemic species number is actually an artifact of the small sizes of the boreal floristic regions within the Park south of the Range.

A cluster analysis performed on the Alaska-Yukon endemic species occurrence matrix showed that the highest degree of similarity in Alaska–Yukon endemic floras was shared by the two interior alpine floristic regions, with essentially no distance between the two species occurrence matrices for these regions (even though the regions themselves differ greatly in total area). This interior alpine cluster was then grouped with the Southcentral Alpine Floristic Region at a distance of 0.125 (Figure 7.6). The Alaska-Yukon endemic floras of the Interior Boreal Lowlands and the Interior Boreal Uplands floristic regions clustered at the 0.22 level, and this group was joined to the cluster of the three alpine floristic regions at a distance of 0.318. The two Southcentral Boreal floristic regions that had Alaska-Yukon endemic species (no endemic species were observed in the Southcentral Boreal Lowland Region, which was thus excluded from the analysis) were very dissimilar to the other floristic regions based on this analysis, largely due to the depauperate nature of their resident endemic floras.

The results of the cluster analyses for Alaska-Yukon endemics was similar to the results for the cluster analysis of the state-level rare plants in that the interior alpine regions were clustered together in both analyses, and the Southcentral Subalpine Floristic Region was quite dissimilar from all of the other regions in both. However, in contrast to the cluster pattern observed for the state rare species, there was a stronger geographic organization of the endemic species occurrence matrix. Specifically, whereas the boreal regions on both sides of the Alaska Range crest were grouped together for the state-level rare taxa, the five interior regions formed a group in the cluster analysis of the Alaska-Yukon endemic taxa.

2. Amphiberingian endemic species

An analysis of all available collections in Denali National Park and Preserve showed that 52 species that are endemic to Beringia, with populations on both sides of the Bering Strait (thus “Amphiberingian” endemics), occur in the Park (Table 7.3). The mean number of Amphiberingian endemic taxa per floristic region was 20.9. There were 41 of these species in both of the interior alpine floristic regions (which represents 79 percent of the total number that occur in the Park), and five and six taxa in the Southcentral Boreal Lowland and Southcentral Boreal Floodplain floristic regions respectively (see Figure 7.7). Interestingly, variation in the number of Amphiberingian endemic species among regions very closely mirrored the observed variation in number of Alaska–Yukon endemic species among regions (see Figure 7.8). In fact, the coefficient of simple correlation between the number of Alaska-Yukon endemic species and the number of Amphiberingian endemic species for the nine floristic regions was exceptionally high (<u>**r = 0.96**</u>; see Figure 7.8).

Only one of the 52 Amphiberingian endemic species, (*Poa macrocalyx*), that occurred in the Park was absent from north of the Alaska Range crest within the Park. In contrast, 21 of the Amphiberingian endemic species that occurred in the Park (or 40 percent of the total) were entirely absent from areas south of the Alaska Range crest. The Amphiberingian endemic taxa that occurred south of the Alaska Range crest were mostly species with a broad geographic distribution in Alaska (such as *Aconitum delphiniifolium*, *Salix pulchra*, and *Spiraea stevenii*). In fact, the mean number of region occurrences for the group of Amphiberingian endemics that occurred south of the range was 4.3. In contrast, the mean number of region occurrences per species for the set of taxa that occur north of the crest was 3.6 regions per taxon, indicating a more restricted geographic range, on average, for the species that occurred north of the crest.

A cluster analysis of the Amphiberingian endemic species occurrence matrix among Park floristic regions showed strong similarities to the dendrogram resulting from the cluster analysis of the distribution of the Alaska-Yukon endemic species among these regions of the Park (see Figure 7.9). The three alpine regions once again showed strong similarity and the two interior boreal lowland regions also clustered together. Due to the extreme paucity of Amphiberingian endemic species in the Southcentral boreal regions, these floras for these two regions were substantially dissimilar to all of the other Park regions.

A regression analysis of the number of Amphiberingian endemic taxa on the amount of habitable surface area for all nine regions did not yield a significant relationship between these two variables (r^2 =.356, p= 0.09). If the pool of species is limited to Amphiberingian endemic of restricted distribution within the Park (those that occur in five or fewer regions), there is an even weaker relationship between region area and endemic species number (r^2 =.284; p= 0.140). Thus, the conspicuous patterns in endemic species richness observed among the Park's floristic regions can not be explained by simple species : area relationships. In fact, I am convinced that even searches of large additional areas of the Southcentral lowlands would fail to reveal populations of significant number of Amphiberingian endemic species that were not found in the current study.

The variation in Amphiberingian species richness (like that of Alaska-Yukon endemic species richness) among the Park's floristic regions was apparently not primarily a function of the area available for plant colonization. In fact, there are individual sites in the alpine zone north of the Alaska range crest that contain higher numbers of these Alaska-Yukon and Amphiberingian endemic species endemic species than entire regions south of the Alaska Range.

3. Summary of the patterns in endemic plant species richness

I observed strong patterns in the distribution and abundance of the two classes of endemic species among the nine floristic regions of the Park. To summarize, I conclude the following:

a) The patterns in species richness of two sets of endemic species (Alaska-Yukon and Amphiberingian) among the floristic regions of the Park are essentially identical (correlation coefficient of species numbers per region: r =0.96).

b) Alpine areas, in general, contain the highest numbers of endemic plant species in the Park. Interior alpine regions of the Park, in particular, contain by far the highest numbers of both sets of endemic taxa.

c) The relationship between numbers of endemic species and region size is not significant for both Amphiberingian species and narrowly-distributed Alaska-Yukon endemic species (this is in contrast to similar analyses for AKNHP rare taxa, which returned highly significant species richness: area size relationship).

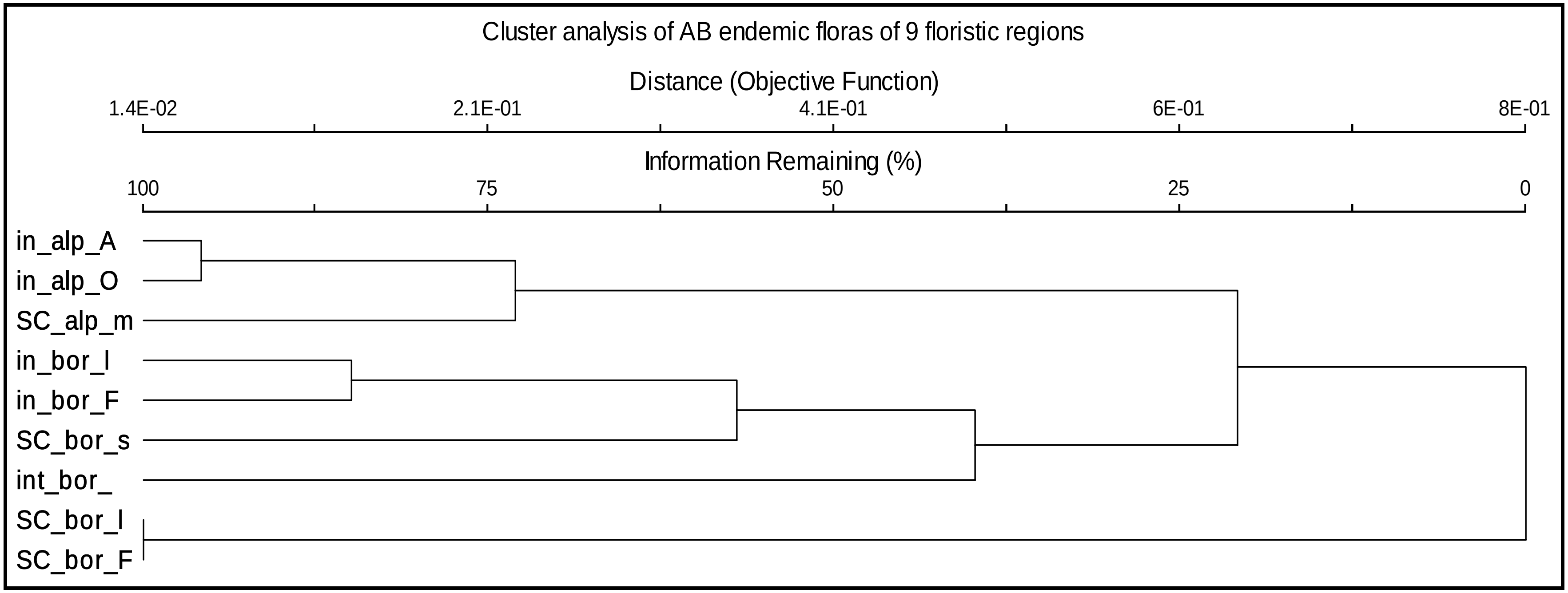


Figure 7.9. Cluster dendrogram showing the results of Jaccard nearest neighbor cluster analysis performed on the matrix of species occurrences of Amphiberingian endemic species among the nine floristic regions of Denali National Park and Preserve.

d) The endemic flora that was observed south of the Alaska Range crest was essentially a subset of that observed north of the crest and, furthermore, the geographic occurrence of these endemic taxa is markedly clustered in two areas close to low passes into interior Alaska.

e) Cluster analyses of the endemic species occurrence matrices indicated a strong geographic similarity among interior regions, and marked dissimilarity of this cluster from the Southcentral boreal regions. (This cluster analysis for endemic taxa contrasted with the same analysis of the AKNHP rare flora occurrence matrix, in which the boreal regions, regardless of geographic location, clustered together and the alpine regions clustered together.)

Two primary questions arise from the consideration of the distribution of endemic species richness in the Park: 1) why are there higher numbers of endemic species in the alpine zone; and 2) why is endemic species richness concentrated north of the Alaska Range and, on the south side, in close proximity to low passes over the range?

The ecological and geographic distributions of individual plant species are the result of individualistic ecophysiological, reproductive and competitive interactions unique to each species. Thus any attempt to generalize about the species richness patterns of 84 taxa (32 Alaska-Yukon endemic species and 52 Amphiberingian endemic species) is fraught with the potential for oversimplification. Nevertheless, the observed patterns in species richness on the Park landscape are real, and our knowledge of the biogeography and ecological history of this region allows for some informed speculation as to the causes of these patterns.

These conspicuous patterns in biodiversity are best understood in the context of large-scale historical and ecological factors operating on the biota of this region over long spans of time. One particularly important and over-arching factor contributing to these distribution patterns is likely the ecological history of Beringia over the course of the Pleistocene and Holocene epochs. Specifically, the entire area south of the Alaska Range crest and significant areas in the mountains north of the range were covered with glacial ice as recently as 16,000 years ago (and these areas have been repeatedly inundated with ice during the glacial maxima of the Pleistocene). The interior of Alaska, on the other hand, (including large portions in the northern section of Denali) constituted a large refugium for plants that was connected to Asia via the Bering Land Bridge. Thus, areas in the Alaska Range, and almost the entire landscape south of the Alaska Range were probably repopulated from source areas in the Beringian refugium upon deglaciation, and from isolated nunataks that existed above the Cordilleran ice sheets.

The lasting selective influences on plant traits imposed by conditions of the full-glacial landscape of Beringia explain some of the variation in endemic species richness that we have observed in today’s landscape. The vegetation of the Beringian refugium was essentially treeless and open, resembling a mosaic of fellfield, tundra and open steppe vegetation more than today’s boreal landscape. These full-glacial ecological conditions must have exerted a strong ecological “filter” on the resident flora. This ecological filter favored species capable of reproducing and dispersing in the cold, dry and open full-glacial landscapes. In fact, we know that many boreal taxa became essentially extinct in Beringia during these periods. In this context, competition for light was negligible due to the low-statured and relatively open vegetation mosaic. The ability to tolerate drought stress and harsh climatic conditions (thus highly continental climatic conditions), on the other hand, was crucial to survival during glacial maxima. I believe it is broadly accurate that the majority of taxa endemic to this region of the world are relatively stress-tolerant taxa generally restricted to open habitats.

With the onset of the Holocene, the climate of Beringia ameliorated as both temperature and precipitation increased, thus permitting (over time) the establishment of larger-statured boreal vegetation across the vast lowlands. Pollen spectra from the full glacial indicate that these dominant boreal taxa (including spruce, birch and alder) were considerably less abundant (even absent) on the full glacial landscape, and have become more abundant through time. This represented a major change in the ecological characteristics of the region. The conditions in the understory of newly formed boreal vegetation would have been considerably different from those prevailing on the landscape during glacial maxima and thus different traits would have been favored in the resident flora. For example, the ability to compete for light (grow tall), and to persist in wetter, more densely vegetated soil conditions would have been important. In addition, the amount of open soil available for seedling colonization was probably greatly reduced with the establishment of dense carpets of feather mosses characteristic of the mesic boreal forest and scrub communities. Thus species requiring pockets of warm (due to high solar energy receipts in summer) and open mineral soil would have been increasingly confined to successional situations and sloping areas of the landscape where soil disturbance is more common.

As the landscape was transformed over time from open, low-statured vegetation of the glacial maxima to the boreal landscape that we know today, many species that were widespread during the full glacial (including many of the Amphiberingian and Alaska-Yukon endemic species that evolved in this ecological context) were increasingly displaced. The process of landscape and climate change that occurred during the Holocene almost certainly fragmented the geographic ranges of our endemic flora, as the ecological “space” available to these species of open areas diminished. Many of the endemics were confined to treeless sites (such as successional communities) in the lowlands and to the alpine zone, where disturbance and/or ecological conditions have either removed or precluded the establishment of dominant boreal plant taxa. In these treeless islands of habitat, these species’ ability to tolerate cold and drought stress is functional and their inability to compete for light is less ecologically exigent. One result of this process is the elevated endemic species richness in the alpine zone of the Park (and in Alaska generally). The expansion of boreal landscapes through the Holocene also explains some of the spotty, interrupted distribution patterns evident in some of our endemic species. Some of these endemic taxa only persist in relatively few, widely-scattered populations within what was once a much more continuous range.

If the general habitat preferences and competitive traits of our endemic flora (shaped by the filter of the Pleistocene climate) have resulted in their “confinement” to alpine areas, as I have contended above, why are these species relatively scarce even in the alpine zone south of the Alaska Range crest? One basic ecological reason is that the maritime-influenced climate, including deep, insulating snowpack, high summer humidity and relatively moderate winters is also conspicuously different from conditions extant in the Beringian refugium, which were extremely continental. Thus taxa that have immigrated from alpine areas with more maritime climates (such as regions south of the ice sheets) may be at a competitive advantage in these Southcentral areas compared to the habitat tolerances of the endemic flora, which are “pre-adapted” to the more continental conditions north of the range.

In addition, the areas where relatively higher numbers of endemic plant species were found south of the Alaska Range crest (such as the West Fork of the Chulitna River and the upper West Fork of the Yentna River) were sites with calcareous sedimentary lithology that, in general, tend to support higher numbers of particular endemic taxa, such as *Thlaspi arcticum*, *Oxytropis huddelsonii*, and *Erysimum pallasii*. Furthermore, the north side of the Alaska Range certainly contains the largest source populations of endemic taxa and thus it stands to reason that dispersal corridors, such as the low passes over the range would ten to support higher numbers of such taxa than areas far from any sources of propagules of these taxa.

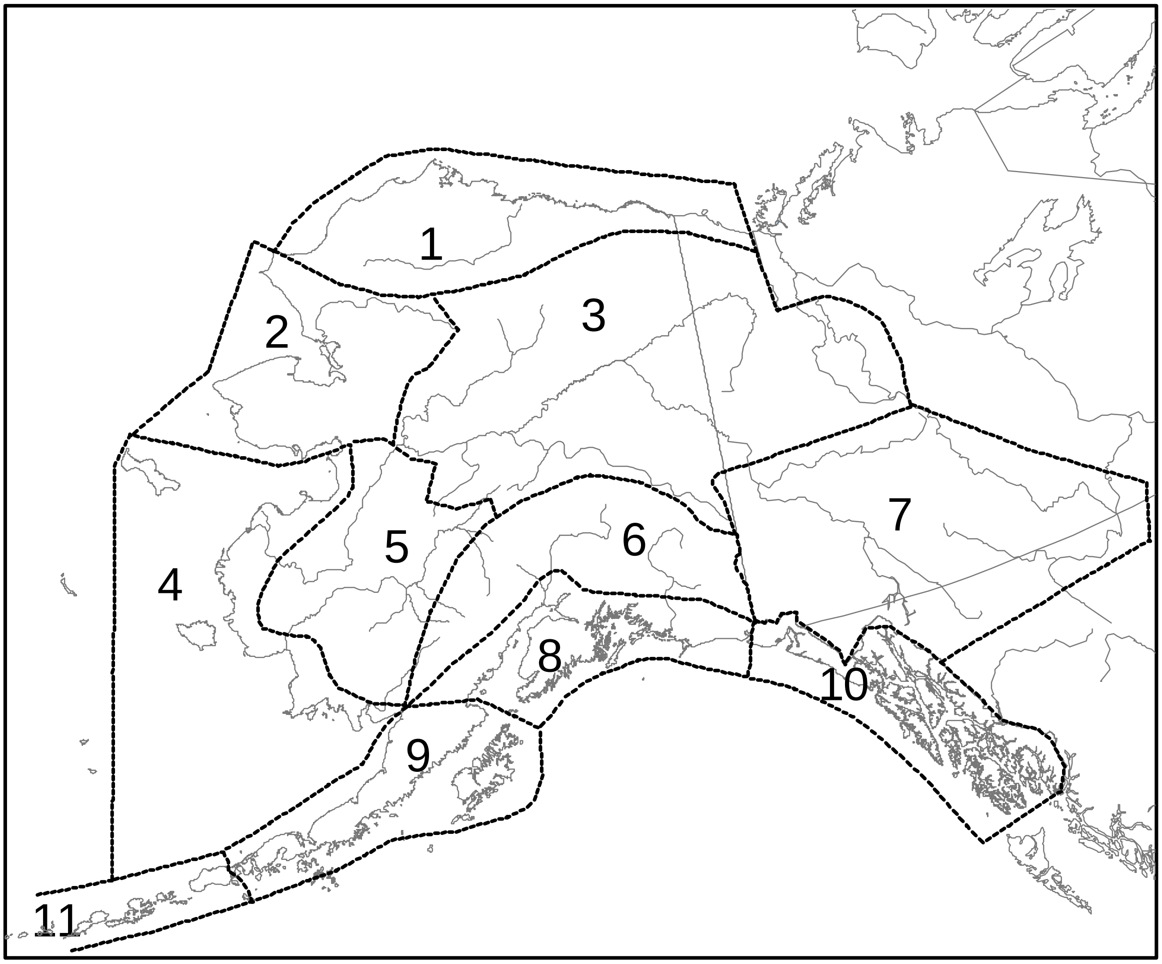
The plant distribution patterns that we have documented in the Park generally conform to what would be expected based on the current understanding of the ecological history of this region. In considering our work in this context, we are able to discern echoes of the long sweep of ecological history of Beringia from the mundane observations of plant specimen data. This intellectual exercise enlivens the information that we collect for purposes of managing the Park and can also be used to help inspire and educate the public regarding the value of protected areas such as Denali National Park and Preserve. The profound yet delicate tracings of evolutionary history, such as those reflected in these plant distribution patterns, are an ancient and precious heritage. Unfortunately, they are often too easily and casually ignored and then erased forever by the clumsy and unconsidered actions of our industrial civilization.

F. Flora of Denali in the context of floristic patterns of Alaska

Hultén (1941-50) identified 11 floristic districts that encompassed the Alaska-Yukon region (Figure 7.10). Four of these districts intersect Denali National Park and Preserve: the Alaska Range district, the Lower Yukon district, the Upper Yukon district and the Central Pacific district. Whereas Hultén drew the boundary of the Central Pacific district south of the Park boundary, the large number of coastal taxa that we have documented in the Southcentral Boreal Lowland and Southcentral Boreal Floodplain and Alluvial Fan regions demonstrate that the flora of these regions are consistent with the coastal areas that Hultén included in the Central Pacific district.

As was mentioned previously, nearly half of the vascular plant species known to occur in Alaska have been documented within Denali National Park and Preserve. This is a relatively high percent of the overall flora, considering the relatively small fraction of the state the Park occupies. This relatively high floristic diversity is likely due to Denali’s central location within Alaska, the diversity of alpine and boreal landscapes that occur there, and its geographic position encompassing several of the major floristic “fault lines” in this region. The most important of these fault lines, insuring a high diversity in the Park flora, is the transition across the Alaska Range crest, which represents the distinct phytogeographic demarcation between the maritime-influenced coastal region and the strongly continental interior. In fact, the maritime-interior floristic boundary that occurs along the crest of the Range in the Park is recognized as the boundary between the Circumboreal Region and the Rocky Mountain Region in Armen

Takhtajan's floristic zonation of the world (Takhtajan 1986), reflecting the fundamental nature of this biogeographic boundary.



Hultén's Floristic Districts

1. Arctic Coast district
2. Bering Strait district
3. Central Yukon district
4. Bering Sea district
5. Lower Yukon district
6. Alaska Range district
7. Upper Yukon district
8. Central Pacific district
9. Eastern Pacific district
10. Western Pacific Coast district
11. Aleutian Islands district

Figure 7.10 Eleven floristic districts identified by Eric Hultén for Alaska and neighboring regions of North America (Hultén 1941-50).

Chapter 8 Synthesis and Recommendations for Conservation

We have learned a significant amount about the composition and distribution of the vascular flora of Denali National Park and Preserve through this inventory project. This information provides us with a more complete understanding of the biogeography and floristics of this area than was available before we began. This new level of understanding both informs our awareness of the value of the Park, and (at least for me) heightens our appreciation for its majestic landscapes. However, increased understanding and appreciation for the Park's rich botanical resources were not the sole goals of this work. Stewardship of these resources is our primary responsibility. It is critical, therefore, that the information we have gathered be used to effect the conservation of the precious botanical heritage in our trust and to educate and inspire those interested in the Park and in Alaska's biota (amateurs and professionals alike). In this chapter, I summarize the key findings of our work with management implications and discuss potential future work relevant to botany in Denali National Park and Preserve.

I begin this chapter with a discussion of some of the management implications of what we have learned through the inventory project. This discussion includes a description of the draft Rare Vascular Plant List for Denali National Park and Preserve prepared as a part of this project (the list of rare plant taxa itself is provided in Appendix B of this report). The final section of this chapter outlines some of the major areas of potential future work in floristics and plant conservation in Denali National Park and Preserve.

A. Implications for management and stewardship of Denali National Park and Preserve:

In addition to providing managers with a nearly complete inventory of the vascular flora of the Park, and extensive data regarding the distribution of these species within the Park, the results of this inventory have delivered the following information for management:

1) This inventory provided an extensive, coarse-scale status report on the extent of exotic plant invasions in undisturbed vegetation on Park lands;

2) I identified a list of rare and sensitive vascular plant taxa, crafted specifically for Denali National Park and Preserve, based on a review of all available plant occurrence data;

3) I identified lists of sets of geographic areas, habitats and individual sites of particular botanical significance or sensitivity on the Park landscape (thus of high priority for protection). This list was prepared by examining the geographic and habitat distributions of the Rare Plant list described above and the full range of floristic data available for the Park.

These three sets of information relevant to Park management are discussed below.

1. Status of exotic invasions in native plant communities of Denali National Park and Preserve

A remarkable fact confirmed by this inventory is the absence of an invasive exotic plant problem in natural areas of Denali National Park and Preserve. Whereas more than 20 exotic vascular plant taxa have become established in developed areas and in the road shoulders within the Park, these exotic taxa were never observed in native plant communities (even those adjacent to the Park Road). In fact, during the course of this rather extensive inventory effort, only three species that we found in native habitats are potentially of exotic origin, based upon my review of the literature. Hultén suggested that the grass *Beckmania szygachne*, the wetland dock *Rumex maritimus*, and the Aster-family forb *Bidens cernua* were species introduced to the flora of Alaska from elsewhere. However, that Hultén was correct in his assessment of these taxa is far from clear. In fact, the most recent comprehensive reference from extreme northwestern North America, William Cody's Flora of Yukon Territory, treats all these species as native, although he says of *Beckmania* that it is "possibly introduced in some situations" (Cody 1996). I am inclined to agree with Cody that there is not sufficient evidence to conclude that any of these taxa are new introductions to Alaska.

In my view, the absence of exotic taxa from these expansive landscapes should be one of the most closely and strenuously protected facets of the natural heritage that has been placed in our trust. A brief review of the huge amount of effort, manpower and resources that are expended annually in trying to correct the myriad exotic species problems that exist in other parts of the world (indeed in other major western U. S. Park lands) should be sufficient support for this proposition. There are 22 exotic plant species that occur in the road corridor of the Park, and essentially none outside of it. In Alaska, as elsewhere, the building of more roads and increasing human development would mean the expansion and dissemination of exotic species. In Alaska, these species have few other avenues of dispersal in this essentially intact mosaic of native plant communities. Conservation of this precious natural heritage demands recognition of all of the true costs of continuing the conversion of natural lands to human-modified landscapes. The considerable mitigation activities required to remove exotic species is one of these costs.

In addition to the importance for ecosystem integrity and its aesthetic value, another important element of the essentially natural pattern of plant distribution on the Park landscape is the scientific value that it represents. The distribution and abundance of the species that occur in these landscapes are the result of the workings of the natural processes of birth, growth, and dispersal of our native species and their symbionts, parasites, predators, and competitors. This rich and intact tapestry woven by the multitude of interactions of species with their environments over geological spans of time is rare indeed on the face of our planet today. There are a vanishing number of places on this planet where students of nature can learn about the factors that control species abundance and distribution without having to factor in direct human interference with natural processes. This uninterrupted tapestry of natural plant communities represents a significant resource to those who would seek to understand the workings of natural ecosystems, and understand the precious heritage we have received from those who have come before us.

2. Rare plant list for Denali National Park and Preserve.

The only comprehensive list of rare and sensitive vascular plant taxa for Alaska is the "tracking list" maintained by the Alaska Natural Heritage Program (as has been mentioned previously). This tracking list provides a valuable reference to land management agencies in the state. However, for high priority conservation areas, such as Denali National Park and Preserve, a statewide list of rare plants is insufficient. For example, there is one, small, disjunct population of *Rhododendron camtschaticum* that occurs in the Kantishna Hills. This species is quite common along the west coast of the state and thus is not of conservation concern on a statewide basis. However, as managers of Denali, we would be negligent if we did not recognize and safeguard this unique interior population of an otherwise coastal plant species. Indeed, such satellite, and atypical, populations may represent the crucial raw material of evolutionary change within a species.

In order to properly manage and preserve the biodiversity of Park ecosystems, I recognized a definite need to identify a list of rare and sensitive taxa specifically tailored for the Park and its resident biota. I have examined all available floristic information for Denali National Park and Preserve and identified an initial draft list of rare plants. This list of taxa is provided in Appendix B. Of necessity, the preparation of such a list is an iterative process that will require periodic evaluation and amendment as new information becomes available.

The list of rare vascular plants for Denali includes the following (often overlapping) sets of taxa: 1) plants ranked S1, S2, or S3 on the AKNHP tracking list; 2) plant taxa known from fewer than 10 localities within the Park (***and*** judged to be genuinely rare, not simply under-collected). Thus some taxa that have been documented at relatively few sites have been left off this initial rare species list because I believe (based on their ecological and geographic distributions) they are likely to be more abundant than collection records indicate. This is most often the case with taxa, such as aquatics, which occur in habitats that are under-represented in collection efforts. As a result, should future work in such habitats fail to yield additional locations, such taxa may ultimately be added to the rare species list for the Park.

3. Areas and habitats of botanical significance and high priority conservation areas

An important result of the project for conservation is an improved ability to identify geographic areas, habitats or plant associations and individual sites of particular botanical significance or sensitivity on the Park landscape. The large floristic data set that we have accumulated allows us to identify those areas with a particularly high priority for protection. However, there are areas with particular significance and/or degree of sensitivity that require an increased level of vigilance and protection. Such high priority conservation areas fall into three general categories, which are:

1) Biogeographically unique areas of the landscape with botanical significance – one example is the Broad Pass region, which represents the northern range limit for a relatively large number of plant species and a dispersal corridor for species between maritime and interior climate zones (see Table 8.1 for a list of unique biogeographic areas on the Park landscape).

2) Notable habitats and plant associations that support multiple species that are rare either in the Park or statewide (see Table 8.2 for a list of these habitats and plant associations).

3) Notable individual sites of botanical significance due to a concentration of multiple species and/or communities of interest in a single area. One such significant site in the Park Road corridor is the Mount Eielson (Copper Mountain) area where a mosaic of dry and wet tundra communities on a variety of different slopes and aspects supports a remarkable and diverse vascular plant flora within a limited area.

Table 8.1 Areas of particular phytogeographic significance in Denali National Park and Preserve.

Area	Significance
South side:	
Broad Pass region	Northern range limit in North America (and globally) for numerous taxa, also a dispersal corridor between Cook Inlet region and interior Alaska.
Region surrounding West Fork of the Chulitna River	This is a large area of sedimentary bedrock on the south side of the Alaska Range with a transitional climate. This region of the Park is apparently a hotspot of botanical diversity, with a mixing of north side and south side alpine and subalpine vascular plant taxa.
Mystic Pass and the upper West Fork of the Yentna River	Dispersal corridor across the Alaska Range for plant taxa; several species generally restricted to interior Alaska occur in Cook Inlet basin only in this vicinity.
North side:	
Satellite ranges of hills north of the Alaska Range (Teklanika Mountains, Roosevelt Hills)	Home to numerous endemic species of dry tundra and rubble slopes, existence of surfaces that have likely supported open vegetation (relict areas) continuously since the last glacial maximum.
Minchumina Basin lakes and associated wetlands	Very extensive lowland wetland basin, large “target” area for aquatic and wetland plant species – this inventory found species new to Alaska in this region, others may await discovery.
Alpine zone of Kantishna Hills	Numerous species with otherwise coastal distributions occur in mesic areas in the Kantishna Hills, perhaps due to increased cloudiness, moisture and precipitation along the crest of this range.
Ion-rich groundwater discharge area (fens) near McKinley River	A large area (30,725 ha) of groundwater discharge and ion-rich fens northeast of the McKinley River was identified by the Soil Inventory Project. This mosaic of wetland types contains numerous rare taxa for the area (Clark and Duffy 2004).

Table 8.2. Noteworthy habitats or plant associations in Park (those containing high numbers of rare or sensitive taxa). These general types are organized by site moisture from wettest to driest.

Habitat type	Significant rare taxa:
Aquatic/hygric types	
Aquatic – selected boreal ponds and lakes	*Callitriche anceps, C. hermaphroditica, Ceratophyllum demersum, Isoetes echinospora, Limosella aquatica, Najas flexlilis*
Marshy, herbaceous strand meadows along streams and ponds	*Allium schoenoprasum, Angelica genuflexa, Aster junciformis, Bidens tripartita, Callitriche anceps, C. hermaphroditica, Carex arcta, Carex crawfordii, Carex lyngbyei, Glyceria striata, Glyceria pulchella, Ranunculus scleratus, Rumex maritimus, Gallium brandegei*
Peatlands and fens in lowlands basins	*Aster subspicatus, Carex adelostema, Carex atherodes, Carex echinata, Carex interior, Carex lapponica, Carex parryana, Carex rariflora, Cicuta bulbifera, Coptis trifolia, Deschampsia beringensis, Eleocharis quinqueflora, Gentiana douglasiana, Eriophorum viridi-carinatum, Lycopodium clavatum* ssp. *clavatum, Malaxis monophylla, Malaxis paludosa, Pedicularis macrodonta, Platanthera stricta, Rubus spectabilis, Salix candida, Toffieldia glutinosa*
Freshwater seeps on gravel bars	*Carex viridula, Arenaria longipedunculata*
Seeps and wet areas in alpine zone	*Aphragmus eschscholtzianus, Claytonia eschscholtzii, Draba crassifolia, Epilobium leptocarpum, Kobresia sibirica, Minuartia biflora, Phippsia algida, Podagrostis thurberiana, Stellaria umbellata*
Mesic types	
Lush forb-herbaceous meadows on south slope of Alaska Range	*Anaphalis margaritacea, Arabis drummondii, Arnica amplexicaulis, Arnica diversifolia, Athyrium alpestre, Gentiana amarella, Carex phaecocephala, Epilobium luteum, Podagrostis aequivalis, Potentilla diversifolia*
Alder scrub	*Anaphalis margaritacea, Cryptogramma stelleri, Epilobium leptocarpum, Poa macrocalyx, Polystichum braunii, Viola selkirkii*
Poplar forest – south side	*Botrychium virginianum, Carex deflexa, Osmorrrhiza depauperata*
Heath tundra - snowbeds	*Deschampsia brevifolia, Geum glaciale, Phyllodoce caerulea, Rhododendron camtschaticum*
Sheltered, mesic rock outcrops	*Cryptogramma sitchensis, Cryptogramma stelleri, Primula mistassinica, Saxifraga spicata, Gentianopsis detonsa* ssp. *yukonensis*
Xeric types	
Subalpine open forb-graminoid slopes and rock outcrops (mesic to xeric)	*Arenaria capillaris, Botrychium alaskaense, Botrychium ascendens, Corydalis sempervirens, Cypripedium guttatum, Erigeron grandiflorus* ssp. *arcticus, Erigeron glabellus, Eritrichium splendens, Gentianopsis detonsa* ssp. *yukonensis, Halimolobos mollis, Melandrium taylorae, Minuartia yukonensis, Monolepis nuttaliana, Phlox richardsonii, Smelowskia calycina*
Calcareous alpine slopes –dry tundra and rubble scattered through Alaska Range (limestone and other calcareous sedimentary and meta-sedimentary rock)	*Aphragmus eschscholtzianus, Artemisia globularia, Braya glabella, Carex incurviformis, Douglasia alaskana, Douglasia gormanii, Draba cinerea, Draba corymbosa, Draba densifolia, Draba ruaxes, Erigeron grandiflorus, Eritrichium chamissonis, Erysimum pallasii, Festuca lenensis, Gentianella tenella, Kobresia sibirica, Oxytropis huddelsonii, Oxytropis mertensiana, Papaver alboroseum, Phippsia algida, Phlox richardsonii, Ranunculus pedatifidus, Saxifraga adscendens, Stellaria alaskana, Stellaria dicranoides, Stellaria umbellata, Taraxacum carneocoloratum, Thlaspi arcticum*
Open floodplain deposits	*Astragalus adsurgens, Astragalus robbinsii, Braya glabella, Carex eburnea, Erigeron glabellus, Halimolobos mollis, Monolepis nuttaliana, Salix setchelliana*

B. Directions for future work:

There are three key components remaining to accomplish in order to for the Park to have a comprehensive set of data and the tools necessary to understand and effectively safeguard the Park's flora on the appropriate scale for a 2.4 million hectare World Biosphere Reserve and major national park. These components include the following:

1) A complete cryptogam inventory of Park lands (including mosses, lichens and hepatics). This is a major missing data set for understanding and managing the biological diversity of the Park.

2) A network of permanent monitoring plots that allow us to quantify the primary landscape-ecosystem gradient relationships, and thus to understand the factors causing the distribution of biological diversity (both of communities and species) and community structure on the Park landscape; and to monitor these critical ecosystem attributes over time to determine if significant changes occur.

3) An operational and active adaptive monitoring program for exotic plant species in the Park.

Cryptogams, including mosses, lichens and hepatics, are important elements of the boreal and alpine landscapes of the Park. From a biodiversity standpoint, this group of organisms likely equals or surpasses the vascular flora (in terms of total numbers of species). These organisms are also crucial determinants of ecosystem function and serve as a primary food source for many animals, including caribou, Dall sheep at certain times of year, and many others. The state of knowledge of the composition and distribution of this inconspicuous set of taxa is much less complete than was true for vascular plants prior to this inventory project. A systematic, voucher-based inventory of the nonvascular plant and lichen flora of the Park is a primary missing element of our vegetation data sets.

The completion of this inventory has provided the Park with a relatively complete, voucher-based vascular flora. This information represents one major step towards understanding and protecting the botanical resources of the Park. The next step is to make progress toward assembling a data set containing rigorous quantitative measurements of the vegetation and physical environment. Such a data set would allow us to understand the primary causal factors that determine community composition and vegetation structure in a more detailed way. Quantitative data will allow us to formulate more powerful predictive models for community and species distributions than is possible with data from a reconnaissance inventory such as we have recently completed. We are currently undertaking a pilot project to design a program for acquiring landscape-scale quantitative data that will allow us to understand and monitor the vegetation of the Park at a landscape scale (Roland et al. 2003).

A third component of the Park botany program in the future will be adopting a monitoring program for exotic plant species. Currently, as was discussed above, exotic taxa in Denali are confined to the immediate footprint of development. However, new invasions occur each year and some taxa represent a serious threat for becoming invasive into native plant communities.

In particular, *Vicia cracca* and *Melilotus* spp. are potential real problems. There are reports of *Melilotus* becoming established in naturally disturbed gravel bar situations in the vicinity of the Park – including the Nenana River and the lower Teklanika River. Because this problem is not yet a serious one on Parklands, we have the opportunity and obligation of preventing further encroachments of exotic species into Park ecosystems.

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Appendix A

List of new vascular plant taxa vouchered for Denali National Park and Preserve since 1998

Key: † - family new to Park flora
‡ - genus new to Park flora
bolded binomial names are taxa collected during Floristic Inventory Project
☼ - new species collected during Soils Inventory, but not during Floristic Inventory
► - species collected during exotic plant survey work
≠ - taxon not listed for Alaska in Flora of Alaska and Neighboring Territories (Hultén 1968)

Apiaceae
- ***Cicuta*** ‡
    - **Cicuta bulbifera** ≠
    - Cicuta douglasii ☼
    - **Cicuta virosa**
- **Osmorhiza** ‡
    - **Osmorhiza depauperata**

Araceae †
- ***Calla*** ‡
    - **Calla palustris**

Araliaceae †
- **Oplopanax** ‡
    - **Oplopanax horridus**

Asteraceae
- ***Anaphalis*** ‡
    - **Anaphalis margaritacea**
- ***Antennaria***
    - **Antennaria friesiana subsp. friesiana**
- ***Arnica***
    - Arnica amplexicaulis ☼
    - **Arnica diversifolia**
- ***Aster***
    - **Aster junciformis**
    - **Aster subspicatus**
- ***Bidens*** ‡
    - **Bidens cernua**
    - **Bidens tripartita** ≠
- ***Crepis***
    - **Crepis nana var. lyratifolia**
    - Crepis tectorum ►

<u>**Asteraceae (continued)**</u>

Erigeron

Erigeron glabellus

Erigeron pallens

Hieracium ‡

Hieracium triste

Leucanthemum

Leucanthemum vulgare ►

Senecio

Senecio congestus

Senecio pauciflorus ☼

Senecio pauperculus ☼

Senecio triangularis

Solidago lepida

Taraxacum

Taraxacum lacerum

<u>**Balsaminaceae**</u> †

Impatiens ‡

Impatiens noli-tangere

<u>**Betulaceae**</u>

Alnus

Alnus tenuifolia

Betula

Betula neoalaskana ☼

Betula papyrifera var. kenaica

<u>**Boraginaceae**</u>

Eritrichium

Eritrichium splendens

Lappula‡

Lappula squarrosa ►

<u>**Brassicaceae**</u>

Arabis

Arabis holboellii

Descurainia

Descurainia sophia ►

Draba

Draba borealis

Draba cinerea

Draba corymbosa

Draba crassifolia

Draba lonchocarpa

Draba lonchocarpa var. lonchocarpa

Draba lonchocarpa var. vestita

Draba nemorosa

Draba stenoloba

<u>**Brassicaceae (continued)**</u>

Halimolobos ‡

Halimolobos mollis

Lepidium

Lepidium densiflorum ►

Smelowskia

Smelowskia calycina

<u>**Callitrichaceae**</u>

Callitriche

Callitriche anceps

Callitriche hermaphroditica

<u>**Campanulaceae**</u>

Campanula

Campanula uniflora

<u>**Caprifoliaceae**</u>

Sambucus ‡

Sambucus racemosa

<u>**Caryophyllaceae**</u>

Melandrium

Melandrium taylorae

Minuartia

Minuartia yukonensis

Sagina‡

Sagina saginoides

Stellaria

Stellaria borealis subsp. sitchana ☼

Stellaria crassifolia

Stellaria crispa

Stellaria longifolia

<u>**Ceratophyllaceae**</u> †

Ceratophyllum ‡

Ceratophyllum demersum

<u>**Chenopodiaceae**</u>

Chenopodium

Chenopodium album ►

<u>**Cornaceae**</u>

Cornus

Cornus stolonifera

<u>**Cyperaceae**</u>

Carex

Carex adelostoma ☼

Carex aenea ☼

Carex albo-nigra

Carex anthoxanthea

Carex arcta

Carex atherodes

<u>Cyperaceae (continued)</u>

Carex

Carex bonanzensis
Carex brunnescens
Carex buxbaumii
Carex chordorrhiza
Carex crawfordii
Carex deflexa ☼
Carex diandra
Carex eburnea
Carex echinata
Carex echinata subsp. phyllomanica
Carex eleusinoides ☼
Carex enanderi
Carex interior
Carex laeviculmis
Carex lapponica
Carex lasiocarpa
Carex livida
Carex lugens ☼
Carex lyngbyaei
Carex macrochaeta
Carex magellanica
Carex maritima
Carex mertensii
Carex nigricans
Carex oederi
Carex pachystachya
Carex pauciflora
Carex petricosa
Carex phaeocephala
Carex pluriflora
Carex pyrenaica
Carex rariflora
Carex rostrata
Carex rupestris
Carex spectabilis
Carex tenuiflora
Carex williamsii

Eleocharis ‡

Eleocharis acicularis
Eleocharis palustris
Eleocharis quinqueflora ☼

Eriophorum

Eriophorum angustifolium subsp. scabriusculum
Eriophorum gracile

<u>**Cyperaceae (continued)**</u>

Eriophorum

Eriophorum viridi-carinatum

Kobresia

Kobresia sibirica

Scirpus ‡

Scirpus microcarpus

Scirpus validus

Trichophorum

Trichophorum alpinum

<u>**Dryopteridaceae**</u>

Athyrium ‡

Athyrium alpestre

Athyrium filix-femina

Gymnocarpium

Gymnocarpium dryopteris

Matteuccia ‡

Matteuccia struthiopteris

Polystichum ‡

Polystichum braunii

Polystichum lonchitis

<u>**Elaeagnaceae**</u>

Elaeagnus ‡

Elaeagnus commutata

<u>**Empetraceae**</u>

Empetrum

Empetrum nigrum subsp. nigrum ☼

<u>**Equisetaceae**</u>

Equisetum

Equisetum variegatum subsp. alaskanum ☼

<u>**Ericaceae**</u>

Chamaedaphne

Chamaedaphne calyculata

Phyllodoce ‡

Phyllodoce aleutica subsp. glanduliflora

Phyllodoce caerulea

Vaccinium

Vaccinium alaskensis

Vaccinium caespitosum

Vaccinium ovalifolium

Vaccinium uliginosum subsp. microphyllum

<u>**Fabaceae**</u>

Astragalus

Astragalus aboriginum

Astragalus eucosmus subsp. sealei ☼

Astragalus robbinsii

<u>**Fabaceae (continued)**</u>

Lupinus

Lupinus nootkatensis

Melilotus

Melilotus albus ►

Oxytropis

Oxytropis campestris subsp. jordalii

Oxytropis huddelsonii

Vicia

Vicia cracca ►

<u>**Gentianaceae**</u>

Gentiana

Gentiana douglasiana

Gentianella ‡

Gentianella amarella

Gentianella tenella ☼

Gentianopsis ‡

Gentianopsis detonsa ☼

Swertia‡

Swertia perennis

<u>**Haloragaceae**</u>

Hippuris

Hippuris montana

Myriophyllum

Myriophyllum sibiricum

Myriophyllum verticillatum

<u>**Iridaceae**</u> †

Iris ‡

Iris setosa

<u>**Isoetaceae**</u> †

Isoetes ‡

Isoetes echinospora

<u>**Juncaceae**</u>

Juncus

Juncus alpinus

Juncus bufonius

Juncus castaneus subsp. leucochlamys

Juncus drummondii

Juncus mertensianus

Juncus oreganus ☼

Juncus stygius

Luzula

Luzula piperi ☼

<u>Lamiaceae</u>
Scutellaria ‡
Scutellaria galericulata ☼
<u>Lemnaceae</u> †
Lemna ‡
Lemna minor
Lemna trisulca
<u>Lentibulariaceae</u>
Utricularia ‡
Utricularia intermedia
Utricularia minor
Utricularia vulgaris
<u>Liliaceae</u>
Allium ‡
Allium schoenoprasum
Fritillaria ‡
Fritillaria camschatcensis
Tofieldia
Tofieldia glutinosa
Veratrum ‡
Veratrum viride
<u>Lycopodiaceae</u>
Diphasiastrum
Diphasiastrum sitchense
Lycopodium
Lycopodium clavatum subsp. clavatum
Lycopodium dendroideum
<u>Myricaceae</u> †
Myrica ‡
Myrica gale
<u>Najadaceae</u> †
Najas ‡
Najas flexilis
<u>Nymphaceae</u>
Nymphaea ‡
Nymphaea tetragona
<u>Onagraceae</u>
Circaea ‡
Circaea alpina
Epilobium
Epilobium adenocaulon
Epilobium lactiflorum ☼
Epilobium leptocarpum
Epilobium luteum

<u>**Ophioglossaceae**</u>
- ***Botrychium***
  - Botrychium ascendens ☼
  - **Botrychium lanceolatum**
  - **Botrychium minganense**
  - Botrychium virginianum ☼

<u>**Orchidaceae**</u>
- ***Calypso*** ‡
  - Calypso bulbosa ☼
- ***Cypripedium***
  - **Cypripedium guttatum**
- ***Goodyera*** ‡
  - **Goodyera repens**
- ***Listera***
  - **Listera cordata**
- ***Malaxis*** ‡
  - **Malaxis monophylla**
  - **Malaxis paludosa**
- ***Platanthera***
  - **Platanthera dilatata**
  - **Platanthera stricta**

<u>**Pinaceae**</u>
- ***Larix*** ‡
  - **Larix laricina**

<u>**Plantaginaceae**</u> †
- ***Plantago*** ‡
  - **Plantago major**

<u>**Poaceae**</u>
- ***Agrostis***
  - **Agrostis alaskana**
  - **Agrostis borealis**
  - **Agrostis clavata**
  - **Agrostis exarata**
  - Agrostis geminata ☼
  - **Agrostis thurberiana**
- ***Alopecurus***
  - **Alopecurus alpinus**
- ***Bromus***
  - **Bromus cilatus**
- ***Calamagrostis***
  - Calamagrostis lapponica ☼
  - Calamagrostis stricta subsp. stricta ☼
- ***Cinna*** ‡
  - **Cinna latifolia**

Poaceae (continued)

Danthonia ‡

Danthonia intermedia

Deschampsia

Deschampsia beringensis

Deschampsia brevifolia

Elymus

Elymus alaskanus subsp. borealis ☼

Elymus repens ►

Elymus trachycaulus subsp. andinus

Elymus trachycaulus subsp. novae-angliae

Elymus trachycaulus subsp. trachycaulus

Festuca

Festuca richardsonii

Festuca vivipara

Glyceria ‡

Glyceria borealis

Glyceria grandis

Glyceria pulchella

Glyceria striata

Poa

Poa arctica subsp. lanata

Poa macrocalyx ☼

Poa palustris

Podagrostis ‡

Podagrostis aequivalis ☼

Vahlodea ‡

Vahlodea atropurpurea

Vahlodea atropurpurea subsp. latifolia

Vahlodea atropurpurea subsp. paramushirensis

Polemoniaceae

Phlox ‡

Phlox richardsonii

Polygonaceae

Polygonum

Polygonum aviculare

Polygonum lapathifolium

Polygonum pennsylvanicum

Rumex

Rumex maritimus

Polypodiaceae †

Polypodium ‡

Polypodium sibiricum

<u>Potamogetonaceae</u>

Potamogeton

Potamogeton epihydrus
Potamogeton foliosus
Potamogeton friesii
Potamogeton gramineus
Potamogeton natans
Potamogeton obtusifolius
Potamogeton pectinatus
Potamogeton praelongus
Potamogeton pusillus
Potamogeton subsibiricus
Potamogeton zosteriformis

<u>Primulaceae</u>

Lysimachia ‡

Lysimachia thyrsiflora

<u>Pteridaceae</u>

Cryptogramma

Cryptogramma acrostichoides
Cryptogramma stelleri

<u>Pyrolaceae</u>

Pyrola

Pyrola chlorantha
Pyrola minor

<u>Ranunculaceae</u>

Actaea

Actaea rubra subsp. arguta

Anemone

Anemone multiceps

Caltha

Caltha leptosepala
Caltha natans

Coptis ‡

Coptis trifolia

Ranunculus

Ranunculus lapponicus
Ranunculus macounii
Ranunculus occidentalis
Ranunculus occidentalis subsp. occidentalis
Ranunculus pensylvanicus
Ranunculus sceleratus
Ranunculus tricophyllus var. eradicatus

<u>**Rosaceae**</u>

Geum

Geum macrophyllum subsp. macrophyllum

Potentilla

Potentilla diversifolia

Potentilla hookeriana

Potentilla pennsylvanica

Potentilla virgulata

Rubus

Rubus pedatus

Rubus spectabilis

Sorbus

Sorbus scopulina

<u>**Rubiaceae**</u>

Galium

Galium brandegei

Galium triflorum

<u>**Salicaceae**</u>

Salix

Salix candida ☼

Salix interior

Salix lucida

Salix pseudomyrsinites

Salix rotundifolia subsp. dodgeana ☼

Salix sitchensis

Salix stolonifera

<u>**Saxifragaceae**</u>

Heuchera ‡

Heuchera glabra

Mitella ‡

Mitella pentandra

Ribes

Ribes laxiflorum

<u>**Scrophulariaceae**</u>

Euphrasia

Euphrasia mollis

Lagotis

Lagotis glauca subsp. glauca

Limosella ‡

Limosella aquatica ☼

Mimulus ‡

Mimulus guttatus

Pedicularis

Pedicularis macrodonta

Rhinanthus ‡

Rhinanthus minor

<u>Scrophulariaceae (continued)</u>

Veronica

Veronica americana

Veronica scutellata ☼

Veronica serpyllifolia ☼

<u>Selaginellaceae</u> †

Selaginella ‡

Selaginella selaginoides

Selaginella sibirica

<u>Sparganiaceae</u>

Sparganium

Sparganium minimum

<u>Typhaceae</u> †

Typha ‡

Typha latifolia

<u>Urticaceae</u> †

Urtica ‡

Urtica dioica

<u>Violaceae</u>

Viola

Viola glabella

Appendix B

List of Rare Vascular Plants for Denali National Park and Preserve

Family	Taxon	AKNHP Global and State Ranks
Apiaceae	ANGELICA GENUFLEXA	
	CICUTA BULBIFERA	G5, S1S2
	OSMORHIZA DEPAUPERATA	
Asteraceae	ANAPHALIS MARGARITACEA	
	ARNICA AMPLEXICAULIS	
	A. DIVERSIFOLIA	G5, S1
	ARTEMISIA GLOBULARIA	
	ASTER JUNCIFORMIS	
	A. SUBSPICATUS	
	BIDENS TRIPARTITA	
	ERIGERON GLABELLUS	
	E. GRANDIFLORUS ssp. ARCTICUS	G4T3T4, S3
	TARAXACUM CARNEOCOLORATUM	G3Q, S3
Boraginaceae	ERITRICHIUM SPLENDENS	
Brassicaceae	APHRAGMUS ESCHSCHOLTZIANUS	G3, S3
	ARABIS DRUMMONDII	
	BRAYA GLABELLA	
	DRABA CINEREA	
	D. CORYMBOSA	
	D. CRASSIFOLIA	
	D. DENSIFOLIA	G5, S1
	D. RUAXES	G2, S3
	ERYSIMUM PALLASII	G4
	HALIMOLOBOS MOLLIS	
	THLASPI ARCTICUM	G3, S3
Callitrichaceae	CALLITRICHE ANCEPS	
	C. HERMAPHRODITICA	
Caryophyllaceae	ARENARIA CAPILLARIS	
	A. LONGIPEDUNCULATA	G3G4Q, S3
	MELANDRIUM TAYLORAE	
	MINUARTIA BIFLORA	G5, S2
	M. YUKONENSIS	G3G4
	STELLARIA ALASKANA	G3, S3
	S. DICRANOIDES	G3, S3
	S. UMBELLATA	G5, S2S3

Ceratophyllaceae	CERATOPHYLLUM DEMERSUM	G5, S2
Chenopodiaceae	MONOLEPIS NUTTALLIANA	
Cyperaceae	CAREX ADELOSTOMA	G4, S1
	C. ARCTA	
	C. ATHERODES	
	C. CRAWFORDII	G5, S2S3
	C. DEFLEXA	G5, S1S2
	C. EBURNEA	G5, S2S3
	C. ECHINATA subsp. ECHINATA	
	C. ECHINATA subsp. PHYLLOMANICA	
	C. ELEUSINOIDES	
	C. INCURVIFORMIS	G4G5, S2
	C. INTERIOR	G5, S1
	C. LAPPONICA	G4G5Q, S2
	C. LYNGBYEI	
	C. PARRYANA	G4, S1
	C. PHAEOCEPHALA	G4, S1S2
	C. RARIFLORA	
	C. VIRIDULA var. VIRIDULA	
	ELEOCHARIS QUINQUEFLORA	G5, S1
	ERIOPHORUM VIRIDI-CARINATUM	G5, S2
	KOBRESIA SIBIRICA	
Dryopteridaceae	ATHYRIUM ALPESTRE	
	POLYSTICHUM BRAUNII	
Ericaceae	PHYLLODOCE CAERULEA	
	RHODODENDRON CAMTSCHATICUM	
Fabaceae	ASTRAGALUS ADSURGENS	
	A. ROBBINSII	
	OXYTROPIS HUDDELSONII	G3, S2S3
	O. MERTENSIANA	
Fumariaceae	CORYDALIS AUREA	
	C. SEMPERVIRENS	
Gentianaceae	GENTIANA DOUGLASIANA	
	GENTIANELLA AMARELLA	
	G. TENELLA	
	GENTIANOPSIS DETONSA subsp. YUKONENSIS	
Haloragaceae	MYRIOPHYLLUM VERTICILLATUM	G5, S3
Isoetaceae	ISOETES ECHINOSPORA	
Liliaceae	ALLIUM SCHOENOPRASUM	S2
	SMILACINA STELLATA	G5
	TOFIELDIA GLUTINOSA subsp. BREVISTYLA	

Lycopodiaceae	LYCOPODIUM CLAVATUM subsp. CLAVATUM	
	L. DENDROIDEUM	
Najadaceae	NAJAS FLEXILIS	G5, S1S2
Onagraceae	EPILOBIUM LEPTOCARPUM	
	E. LUTEUM	
Ophioglossaceae	BOTRYCHIUM ALASKAENSE	G2G3, S2S3
	B. ASCENDENS	G3?, S1
	B. VIRGINIANUM	G5T5, S1S2
	B. YAAXUDAKEIT	
Orchidaceae	CALYPSO BULBOSA	
	CYPRIPEDIUM GUTTATUM	
	MALAXIS MONOPHYLLA	
	M. PALUDOSA	G4, S2S3
	PLATANTHERA STRICTA	
Papaveraceae	PAPAVER ALBOROSEUM	G3G4, S3
Poaceae	AGROSTIS CLAVATA	G4G5, S1S2
	A. GEMINATA	
	AGROSTIS THURBERIANA	G5, S2
	ALOPECURUS ALPINUS	
	BROMUS CILATUS	
	DESCHAMPSIA BERINGENSIS	
	D. BREVIFOLIA	
	FESTUCA LENENSIS	G4, S2S3
	GLYCERIA PULCHELLA	G5, S2S3
	G. STRIATA subsp. STRICTA	G5T5Q, S2
	PHIPPSIA ALGIDA	
	POA MACROCALYX	
	PODAGROSTIS AEQUIVALIS	
Polemoniaceae	PHLOX RICHARDSONII subsp. RICHARDSONII	G4T2T3Q, S2
Polygonaceae	RUMEX MARITIMUS	
Portulacaceae	CLAYTONIA ESCHSCHOLTZII	
Potamogetonaceae	POTAMOGETON OBTUSIFOLIUS	G5, S1
	P. SUBSIBIRICUS	G3, S3
Primulaceae	DOUGLASIA ALASKANA	G2G3, S2S3
	D. GORMANII	G3, S3
	PRIMULA MISTASSINICA	
Pteridaceae	CRYPTOGRAMMA SITCHENSIS	
	CRYPTOGRAMMA STELLERI	G5, S2S3

Ranunculaceae	COPTIS TRIFOLIA RANUNCULUS CYMBALARIA R. PEDATIFIDUS R. SCELERATUS	
Rosaceae	GEUM GLACIALE POTENTILLA DIVERSIFOLIA RUBUS SPECTABILIS	
Rubiaceae	GALIUM BRANDEGEI	
Salicaceae	SALIX CANDIDA S. SETCHELLIANA	G5, S2S3 G3G4, S3
Saxifragaceae	SAXIFRAGA ADSCENDENS subsp. OREGONENSIS S. NELSONIANA subsp. PORSILDIANA S. SPICATA	G5T4T5, S2S3 G5T3T4, S2
Scrophulariaceae	LIMOSELLA AQUATICA PEDICULARIS MACRODONTA	G5, S3 G4Q, S3
Violaceae	VIOLA SELKIRKII	G5, S3