Central Alaska Network
Vital Signs Monitoring Plan

Phase I Report

By

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Executive Summary

- Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve have been organized into the Central Alaska Network (CAN) for the purposes of carrying out ecological monitoring activities under the National Park Services' Vital Signs Monitoring program.

- Development of the Vital Signs Monitoring programs is required to occur in three phases. This document summarizes progress of the Central Alaska Network in Phase I, and provides the basis for management and peer review of the conceptual development of the program thus far.

- This Phase I report provides introductory and background material about the CAN, including: the goals and preliminary objectives; overviews of the natural resources of each park and of the important resource management issues; overviews of past and current monitoring; a description of the process the network has used for in development of the program; and conceptual models of important ecological relationships within the network.

- The Alaska National Interest Lands Conservation Act of 1980 (ANILCA) created 2 of the 3 parks in CAN and added significant acreage to the third. ANILCA firmly establishes the importance of maintaining natural ecological processes in the vast areas of CAN parks (Chapter 1).

- Although each CAN park preserves unique areas, these parks share common purposes of protecting fish and wildlife habitat and populations and other aquatic resources, providing for recreation and subsistence, preserving scenic and geologic formations, and maintaining extensive areas of undisturbed tundra, boreal forest and temperate rainforest ecosystems. These common purposes unify the network, providing a solid foundation for "thinking like a network" (Chapter 1).

- The goal of the CAN monitoring program is to monitor ecosystems to detect change in its ecological components and to detect change in the relationships among the components (Chapter 2).

- Major milestones met during the first 2 years of CAN monitoring program development include: establishment of a Board of Directors and Technical Committee; hiring of the Network Coordinator and Data Manager; setting of initial goals and objectives; organization of a Scoping Workshop; and writing of the initial chapters of the monitoring plan (this report) (Chapter 2).

- Denali has been the site of a prototype Long-term Ecological Monitoring (LTEM) Program since 1992. The Denali LTEM program has been formally integrated into the CAN to avoid duplication of effort and enhance the overall monitoring effort (Chapter 2).

- Natural resources of the three parks in the Central Alaska Network are similar in many respects. Important resources include mountains and geological processes, including glaciers; a diverse flora revealing landscape history; rivers, including significant salmon rivers; wildlife; and designation as international biosphere reserves. Probably what is most important about the natural resources of these parks is that they exist together in an ecological system with its integrity largely intact.

- Broad-scale resource management concerns of the three parks relate to global industrialization, fish and wildlife management, access and visitor use impacts, and private land development. A conceptual model of how these concerns are related to one another was developed to provide a framework for linking the monitoring effort to resource preservation.

- We have started compiling information on past and current monitoring efforts in the three parks, and we summarize the information we have analyzed thus far. Current monitoring in the network includes monitoring of the water resources, weather, air quality, ultraviolet radiation, glaciers, and monitoring of bird and mammal populations.

- An ecoregions analysis of CAN parks was undertaken as a first step in developing our conceptual models. The parks occur within 4 broad ecoregion types defined by the driving forces of climate and landform. These ecoregions span a gradient from maritime to continental climate regimes, and the mountainous transition zones between them. The ecoregions analysis provides perspective on how the three parks are ecologically similar, different, and related to one another; reveals the importance of marine influences; and suggests several organizing questions (Part II).

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Preface

This document concerns 3 national parks in central Alaska: Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve. These parks have recently been organized into a network—the Central Alaska Network (CAN)—for the purpose of establishing and carrying out an ecological inventory and monitoring program. Development of monitoring programs to be carried out over long periods of time requires a significant investment in strategic planning over several years. The steps to follow in establishing the monitoring portion of the CAN program have been set by national-level guidance and culminate in the publication of a peer-reviewed monitoring plan. The monitoring plans are to be written in three phases, corresponding to three phases of program development, over a period of roughly 3-4 years.

The first report, called a Phase I report, is intended as a preliminary look at the first 5 chapters of the monitoring plan. In later stages of the planning process, additional chapters will be added to the plan describing in detail what will be monitored and why. The chapters in the Phase I report provide important background information and set the stage for further conceptual development of the program. The Phase I report provides an opportunity for scientific and management review of the conceptual foundation of the program and is a critical quality assurance step.

This document is the Phase I report for the Central Alaska Network.

Guide to this Document

In Part I, we provide context for the program's design:

Chapter 1: Purposes of the Vital Signs Monitoring Program— In this chapter, we explain the purpose of the monitoring program, based on enabling legislation and management guidelines that establish the need to monitor natural resources. We answer the question, "who is interested in the information provided by monitoring, and why?"

Chapter 2: CAN Goals and Objectives, and Program Development Process— Here, we describe the overall process used to determine the goals and specific measurable objectives for the CAN monitoring program. We also describe how park vital signs will be selected to monitor park resources and provide information needed to manage the parks.

Chapter 3: Central Alaska Network Parks and Their Natural Resources: An Overview—In this chapter, we give an overview of each park and its natural resources. What are the most important natural resources in each park? What is the importance of the park's natural resources in a regional or national context?

Chapter 4: Resource Protection Concerns— Monitoring should help park managers do a better job at protecting park resources. In this chapter, we highlight the most important resource protection concerns for each park, considering historic information, current issues, and looking to the future. We identify the most important agents of change likely to cause changes in park resources

Chapter 5: Past and Current Monitoring— We present a preliminary summary of natural resource monitoring currently being conducted in each park or that occurred previously. We also review monitoring efforts used on adjacent lands by other agencies.

In Part II, we discuss conceptual models developed to date:

Chapter 6: An Ecoregions Analysis of CAN Parks—Conceptual models are important tools in monitoring program development. We briefly present our philosophy of modeling and the role it will pay in the program's development.

Chapter 7: Putting Central Alaska Network Parks into Ecological Context We discuss ecoregions of Central Alaska Network parks and the use of an ecoregions approach as a conceptual framework for the network monitoring program.

Chapter 8: Conceptual Model of Resource Preservation Concerns—Building on Chapter 4, we present a conceptual model of how the resource preservation concerns are related.

Part I. Introduction and Background

Chapter 1 Purposes of the Vital Signs Monitoring Program

The purposes of the Vital Signs Monitoring Program in the National Park Service relate directly to the purposes of the national park system. In this chapter, we review the legal foundation, set by enabling legislation for the NPS overall, and for CAN parks, specifically, that establish the importance of a program to track natural resource conditions.

Servicewide Legislation and Guidance

In 1916 the National Park Service (NPS) was created as a bureau of the Department of the Interior. Among other things, it is the purpose of the NPS is to set aside public lands for the American people

> "*… to provide for the enjoyment of the same [lands] in such manner and by such means as will leave them unimpaired for the enjoyment of future generations*" (National Park Service Organic Act, 1916).

Ensuring that National Park Service lands are "unimpaired" for the future encumbers a heavy responsibility upon park managers. To fulfill this mandate, park managers must know the condition of their resources and likewise, must know how the condition of those resources is changing. Across the country National Park managers are confronted with increasingly complex and challenging issues, and managers are increasingly being asked to provide scientifically credible data to defend management actions. It is clear that single-species oriented management does not holistically accomplish the mission of National Parks, thus it is important to adopt an ecosystem approach to understand and manage the park's natural resources.

A long-term ecosystem monitoring program is necessary to enable managers to make better informed management decisions, to provide early warning of abnormal conditions in time to develop effective mitigation measures, to convince other agencies and individuals to make decisions benefiting parks, to satisfy certain legal mandates, and to provide reference data for relatively pristine sites for comparison with data collected outside of parks by other agencies. The overall purpose of monitoring is to develop broadly-based, scientifically sound information on the current status and long term trends in the composition, structure, and function of the park ecosystem. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage park resources.

To this end, Congress passed the National Parks Omnibus Management Act of 1998, which stated that the Park Service would initiate an Inventory and Monitoring (I&M) program of park resources and that the program would inform managers of long-term trends in resource conditions. In 2001, this Act was incorporated into National Park Service Management Policies that delineated initiation of an ecological monitoring

program, with the intent that results of the program will help inform managers of appropriate management actions.

To comply with legal requirements, fully implement NPS policy, and guide management activities, the Servicewide Inventory and Monitoring Program focuses on attaining the following major long-term goals:

1. Establish natural resource inventory and monitoring as a standard practice throughout the National Park system that transcends traditional program, activity, and funding boundaries.

2. Inventory the natural resources and park ecosystems under National Park Service stewardship to determine their nature and status.

3. Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments.

4. Integrate natural resource inventory and monitoring information into National Park Service planning, management, and decision making.

5. Share National Park Service accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives.

Attaining these long-term goals is necessary to "manage the natural resources of the National Park System to maintain and perpetuate their inherent integrity." (NPS Management Policies, Chapter 4, 2001). The Management Policies are at the highest level of the directives system for the National Park Service, followed by Directors Orders. To administer the I&M program, the 256 NPS units with significant natural resources were divided into 32 multi-park networks.

Management of national parks is an extremely complicated and difficult task. Many of the threats to park resources, such as invasive species and air and water pollution, come from outside of a park's boundaries, requiring an ecosystem approach to understand and manage the park's natural resources. Managers must be capable of determining whether the changes they are observing in park ecosystems are the result of natural variability or human activities. If the latter, then park managers must understand park ecosystem processes and mechanisms well enough to know what actions are needed to restore natural conditions. Such knowledge can only be gained through long-term research and monitoring.

The monitoring of ecosystems within parks is an important component of the Service's need to maintain ecological integrity of park ecosystems. Ecosystems with high ecological integrity continue to express the evolutionary and biogeographic processes that gave rise to the current biota, and they have a species composition, diversity, and functional organization expected from natural habitats of the region. Systems with

ecological integrity are resilient to environmental disturbance within a natural range of variability. Thus, an ecological system has integrity when it maintains its characteristic compositions, structures, and processes against a background of anthropogenic disturbance.

The overall purpose for monitoring is to protect park resources. One means by which to protect these resources is to identify "vital signs" of ecosystems and measure these over time. Vital Signs are key elements that indicate the health of an ecosystem. Vital signs may occur at any level of organization including landscape, community, population, or genetic levels. They may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes). Vital signs can be any measurable feature of the environment that provides insights into the state of the ecosystem. The term is synonymous with "ecological indicator", but use of the term and the analogy to an individual's health helps the NPS to explain the need for monitoring to managers, Congress, and the public.

The Servicewide Goals of Vital Signs Monitoring are as follows:

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.

2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.

3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.

4. Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.

5. Provide a means of measuring progress towards performance goals.

CAN Parks Legislation and Guidance

The Central Alaska Network (CAN) is composed of Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve (hereafter Denali, Wrangell, and Yukon-Charley). CAN is one of the 32 networks included in the Servicewide Inventory and Monitoring program, and one of 4 networks in Alaska (Fig. 1). Park units within the CAN contain over 8.8 million hectares (21.7 million acres) of parklands with 4.7 million hectares (11.8 million acres) of designated wilderness. Yukon-Charley Rivers National Preserve contains 735,000

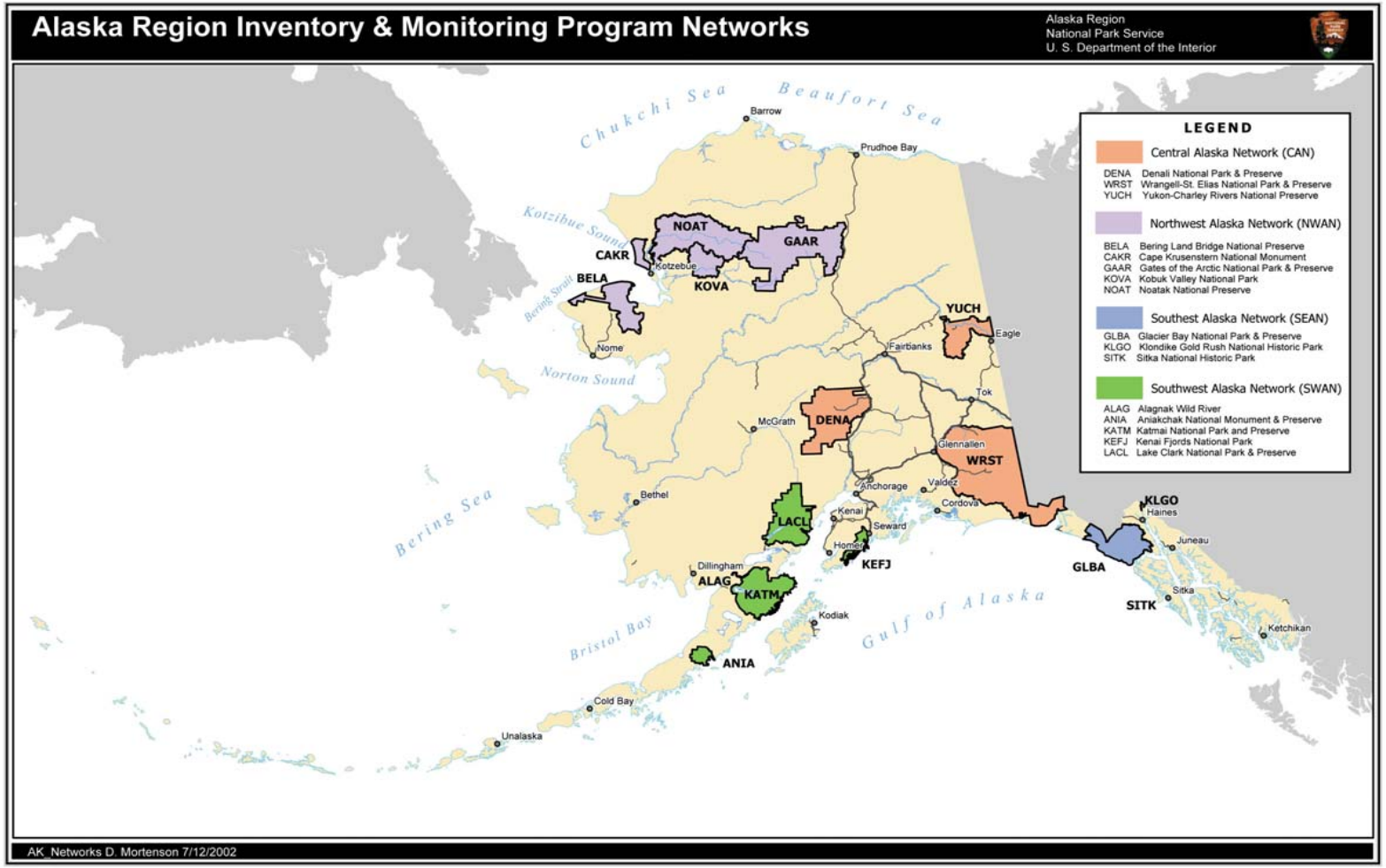


Figure 1. Location of Central Alaska Network and other Alaskan networks.

hectares (1,815,370 acres) (72 percent of total area) of suitable wilderness. Management is the same as if it were designated wilderness. Based on total area, the CAN represents 25% of the land in the National Park System.

The three parks that comprise the Central Alaska Network were created, or had lands added to them with the passage of the Alaska National Interest Claims Land Act (ANILCA) in 1980. Yukon-Charley and Wrangell-St. Elias were created by this Act, while Denali had 1.6 million hectares (4 million acres) added to it. Though ANILCA was passed prior to the inauguration of the NPS Inventory and Monitoring program, the Act contains language that describes the need for an ecological monitoring program. Title I, Section 101(b) of ANILCA states:

- *it is the intent of Congress in this Act to preserve unrivaled scenic and geological values associated with natural landscapes;*

- *to provide for the maintenance of sound populations of, and habitat for, wildlife species of inestimable value to the citizens of Alaska and the Nation, including those species dependent on vast relatively undeveloped areas;*

- *to preserve in their natural state extensive unaltered arctic tundra, boreal forest, and coastal rainforest ecosystems, to protect the resources related to subsistence needs;*

- *to protect and preserve historic and archeological sites, rivers, and lands, and to preserve wilderness resource values and related recreational opportunities including but not limited to hiking, canoeing fishing, and sport hunting, within large arctic and subarctic wildlands and on freeflowing rivers;*

- *and to maintain opportunities for scientific research and undisturbed ecosystems.*

Title II, Section 201 (9) of ANICLA states that Wrangell-St. Elias National Park and Preserve be managed for the following purposes among others:

> *To maintain unimpaired the scenic beauty and quality of high mountain peaks, foothills, glacial systems, lakes and streams, valleys, and coastal landscapes in their natural state:*
>
> > *to protect habitat for, and populations of, fish and wildlife including but not limited to caribou, brown/grizzly bears, Dall sheep, moose, wolves, trumpeter swans and other waterfowl, and marine mammals;*
> >
> > *and to provide continued opportunities, including reasonable access for mountain climbing, mountaineering, and other wilderness recreational activities.*

> *Subsistence uses by local residents shall be permitted in the park, where such uses are traditional in accordance with the provisions of title VIII.*

The General Management Plan for WRST, which identifies park management issues and a response to those issues, establishes that it is to be a park in which visitor access is self-initiated and that natural and cultural resource management will stress nonmanipulative and nonconsumptive management actions and cooperation with the State of Alaska. (cite to WRST history book?)

ANILCA Title II, Sect. 201 (10) states that Yukon-Charley Rivers National Preserve shall be managed for the following purposes, among others:

> *To maintain the environmental integrity of the entire Charley River basin, including streams, lakes and other natural features, in its undeveloped natural condition for public benefit and scientific study;*
>
> *to protect habitat for, and populations of, fish and wildlife, including but not limited to the peregrine falcons and other raptorial birds, caribou, moose, Dall sheep, grizzly bears, and wolves;*
>
> *and in a manner consistent with the foregoing, to protect and interpret historical sites and events associated with the gold rush on the Yukon River and the geological and paleontological history and cultural prehistory of the area.*

Further, the Resource Management Plan for Yukon-Charley Rivers National Preserve outlines a specific goal of "Developing an inventory and long-term monitoring strategy at a scale sufficient to characterize and detect changes on an ecosystems level" (Yukon-Charley Rivers National Preserve Resource Management Plan 1999).

Mount McKinley National Park was established in 1917 by the Act of February 26, 1917 (39 Stat. 938) stating the park was:

> *…set apart as a public park for the benefit and enjoyment of the people…for recreation purposes by the public and for the preservation of animals, birds, and fish and for the preservation of the natural curiosities and scenic beauties thereof...said park shall be, and is hereby established as a game refuge.*

(cite to Denali history book)

The legislative history associated with development of ANILCA (PL6-487, December 2, 1980) states that:

> Four units in large part - …Mount McKinley…- are intended to be large sanctuaries where fish and wildlife may roam freely, developing their social

> structures and evolving over long periods of time as nearly as possible without the changes that extensive human activities would cause. (U.S. Senate, 1979).

In addition, ANILCA Title II, Section 202 (3a) contained the following language pertaining to Denali:

> *The park additions and preserve shall be managed for the following purposes, among others:*
>
> > *To protect and interpret the entire mountain massif, and additional scenic mountain peaks and formations;*
> >
> > *and to protect habitat for, and populations of fish and wildlife including, but not limited to, brown/grizzly bears, moose, caribou, Dall sheep, wolves, swans and other waterfowl;*
> >
> > *and to provide continued opportunities, including reasonable access, for mountain climbing, mountaineering and other wilderness recreational activities.*

Clearly, the information gained from an ecological monitoring program is integral to the ability of CAN park managers to steward the land in a manner consistent with enabling legislation, primarily ANILCA. Although each CAN park preserves unique areas, these parks share common purposes of protecting fish and wildlife habitat and populations, providing for recreation and subsistence, preserving scenic and geologic formations, and maintaining extensive areas of undisturbed tundra, boreal forest and temperate rainforest ecosystems. These common purposes unify the network. This unity in underlying purposes should be a great help to the network as it attempts to establish itself. Because parks have traditionally operated as independent entities, a major challenge in creation of a multi-park monitoring network is overcoming these tendencies. The CAN parks are fortunate in sharing broad goals, providing a solid foundation for “thinking like a network.”

Chapter 2 CAN Goals and Objectives, and Program Development Process

The first chapter addressed the broad goals of monitoring in the context set by the enabling legislation for national parks generally, and for CAN parks, specifically. In this chapter, we present our current thinking about goals and objectives for CAN monitoring, summarize our progress to date, and describe the next steps in program development. Because the CAN is still early in the process of objective setting, this chapter is the most likely to change in later iterations. This chapter is intended as a status report on the development of the overall CAN program, including network-specific goals and objectives. Because the CAN includes a park, Denali, that has been a prototype monitoring park since 1992, we also discuss how the existing Denali program will be integrated into the CAN program.

The CAN recognizes the National Park Service Monitoring Program as a unique opportunity to advance our understanding of the ecosystems that encompass our network of parks. This understanding will come in the form of the monitoring data that are collected, analyzed, interpreted, and reported. Further, we recognize that while scientific work has been conducted in each of the network parks, this information needs to be incorporated with our monitoring efforts to improve our understanding of the holistic functioning of ecosystems within our network. An understanding of our ecosystem function is important because it will best allow us to fulfill the legislative mandate to manage parks in a manner that leaves them "unimpaired for the enjoyment of future generations". At the most basic level, we cannot evaluate appropriate ecosystem function when bounds of natural variability are not known because we cannot identify when conditions are outside an expected range of variation. Similarly, in this situation, reliable identification of resource trends is also difficult.

We have specifically chosen to focus the CAN monitoring program on general ecological function because our parks are, relatively pristine and unstudied. In so doing, the CAN program falls predominantly under Servicewide Goals #1, #3, and #4 (see preceding chapter). These goals concern determining status and trends of ecosystem condition, understanding the dynamics of park ecosystems, and providing data to meet legal mandates. As mentioned in the previous chapter, ecological "vital signs" may occur at any level of ecological organization, thus the several of the "vital signs" we monitor will be of a large-scale ecological scope. While many long-term ecological monitoring programs have focused on anthropogenic causes of change, direct human effects tend to be more limited in our systems. However, scientists expect global climate changes to register first in northern climes, moreover, arctic and subarctic environments may be especially vulnerable to even slight shifts in temperature regimes (National Assessment Synthesis Team 2000). Because of their size, remote and protected status, and resultant near-pristine condition, few regions offer the environmental monitoring opportunity and promise that is possible in the arctic and subarctic parks of Alaska, even though there are zones of intensive disturbance primarily due to mining activity. The relatively untouched nature of these vast parklands can provide important baselines to measure and evaluate

the direction and magnitude of changes brought about by human influences on regional, national, and global scales.

The Integration of Water Quality with Monitoring

In establishing the biological inventories for the CAN, the network took the approach of combining the freshwater fish inventory with water quality efforts. The reasons for doing so are compelling when the size of the network is considered (21.5 million acres) along with the associated logistical costs of conducting fieldwork in the three parks. Due to the integration of the freshwater fish inventory with water quality work, a continued integration of water quality monitoring with the monitoring program has been fully incorporated into our planning process.

The NPS Government Performance and Results Act (GPRA) goal for water resources requires that parks report on 'impaired waters' as defined by section 303(d) of the Clean Water Act. The State of Alaska classifies waters in a tiered system, and the NPS is required to report on water bodies that fall under Tier 2 of the classification (for a complete description of Tiers, see Appendix B). The CAN contains only two streams in Tier 2 (see Appendix B for description) and will report on those streams, but will also be looking holistically at water quality throughout the network in conjunction with the rest of the monitoring program.

Goals of the Central Alaska Network

It is the primary goal of the Central Alaska Network to build a holistic picture of change across the ecosystems of the network. Specifically, it is our goal to:

- monitor ecosystems to detect change in its ecological components and;
- to detect change in the relationships among those components.

Further, because we seek a holistic picture of change in our ecosystems; we primarily desire a landscape level scope of inference from our observations. The design of our program must by such that it minimizes bias in our measurements so that inference from our efforts is sound.

It is also our goal to provide a foundation to a monitoring program that will last in perpetuity. We anticipate that over time the information gained from the monitoring program will provide valuable data that will aid appropriate management decisions in the network parks. Thus management issues should be considered in design of the monitoring program, yet those issues should not limit the program because management issues change. A well-designed monitoring program will be related to future issues, including ones that we cannot foresee.

At present, our network goals remain broad as we continue to develop our thinking on the monitoring program. Our direction of thought upon conclusion of the Scoping Workshop and how we will proceed with the program is described in the following section.

CAN Approach to Program Development

Current Thought on the Monitoring Program

Our strategy to reach the stated goal above is to approach to the CAN monitoring program in a stepwise fashion. It is impossible to monitor all attributes of our systems at once; thus our program will evolve over time as we document change and patterns of variation in our ecosystems. This evolution will be slow and adaptive such that we will evaluate the results of our monitoring at regular intervals (e.g. 5 and 10 year intervals). Our initial focus will be on baseline information that will build the foundation of our understanding. Such an approach will allow us to build a robust knowledge of ecosystem change and the patterns of variation in system resources.

At the conclusion of our Scoping Workshop in April 2002, several conceptual developments regarding the monitoring program emerged. Discussions at the workshop were based predominantly on subject-area (physical, terrestrial fauna, vegetation, aquatics) strategies created by the Technical Committee and outlined goals and objectives for the subject area, as well as what would be monitored and how. We found that placing objectives in the context of being "extensive" (park or network wide) and "intensive" a helpful progression of thought. "Intensive" objectives are those that are logistically infeasible to look at network-wide, or are area-specific in their interest/concern. Additionally, we recognized the importance of a common, probabilistic sampling design that is applicable to the entire network. Besides the myriad statistical advantages conferred by such a sample design, we will be able to appropriately link spatial scales of monitoring components for extensive and intensive objectives. This is crucial in attaining the holistic ecosystem picture that is primary in our network goal.

Also during the Scoping Workshop, we conducted an exercise to determine what data subject-area experts deemed most important to collect as part of a monitoring program. We found that physical environment information (e.g. temperature, precipitation, etc.) was highly desired by all subject areas, regardless of the specific objective of the monitoring component. For example, if CAN were monitoring vegetation, botanists would want to know what the summer weather was so that such information could be incorporated into interpretation of results.

Given the above, the CAN is taking the following steps during the upcoming year:

- We will revisit the goals and objectives as outlined by the Technical Committee work groups and classify each as 'extensive' or 'intensive' in nature and prioritize within and among each category.

- We have initiated a contract with a statistical consulting firm to work on a framework for a network-wide sample design. This design should be ready for CAN at approximately the same time as some physical monitoring equipment will be ready to be tested in the field.

- We recognize that data on the physical environment is desired by all subject-areas and so will prioritize those needs first, as well as determining any necessary protocol development for physical science instrumentation.

Overview of CAN Program Development March 2001 - July 2002

The Washington Support Office (WASO) has provided guidance to networks in how they should approach development of their monitoring programs. WASO's recommended approach involves seven steps:

1. Form a network Board of Directors and a Science Advisory committee.

2. Summarize existing data and understanding.

3. Prepare for and hold a Scoping Workshop.

4. Write a report on the workshop and have it widely reviewed.

5. Hold meetings to decide on priorities and implementation approaches.

6. Draft the monitoring strategy.

7. Have the monitoring strategy reviewed and approved.

The CAN, as an entity, began in 2000, when funds for planning and carrying out biological inventories were received. No coordinating staff were hired for the inventories, and initial planning efforts and actions related to starting the monitoring program were taken by existing staff of CAN parks, with significant involvement of the Regional I&M Coordinator and Regional Science Advisor. The main activities in late 2000 and early 2001 were drafting of a network charter to form the Board of Directors, drafting of a position description and beginning the hiring process for a Network Coordinator, and naming of a Technical Committee. Appendix A details the structure and personnel of the CAN.

With the hiring of the Network Coordinator in June 2001, the Central Alaska Network began formal development of its monitoring program and has followed the WASO guidelines since its inception. The primary developments are outlined in Table 1, and a narrative summarizing this development follows.

Table 1. Development milestones of the Central Alaska Network Monitoring program.

Date	Milestone
2001	
March	Board of Directors Established.
June	Network Coordinator begins.
July	Technical Committee appointed and approved.
August	Begin preparations for Scoping Workshop.
September	Yukon-Charley and Wrangell park-level workshops held.
October	Park priorities assimilated by Technical Committee and Work Groups established
November	Work Groups established, intensive work begins to prepare for Scoping Workshop.
2002	
April	Scoping Workshop held in Fairbanks.
May	Network Database Manager begins.
June	Integration between CAN and Denali Long-term Ecological Monitoring program is formalized.
July	Intensive work begins to prepare Phase I Report.

*June 2001.-*Network Coordinator begins position.

August - October 2001. - In August 2001, the Technical Committee held its first meeting during which the process for decision-making was determined. Also at that meeting a timeline was developed that would allow the network to be prepared for the Scoping Workshop in April 2002. Based on that timeline, we held park-based meetings to discuss the monitoring program with park staff and to determine their priorities for the program during September and October of 2001. We did not hold a meeting at Denali because a monitoring program has been in place there since 1992.

In October 2001, the Technical Committee reconvened to discuss and assimilate the results of the park-based meetings. Based on the discussion at this meeting, we established four Work Groups (Aquatics, Physical Components of the Ecosystem, Flora and Terrestrial Fauna), with each person on the Technical Committee taking part in one Group. Additional Park staff, or external experts were recruited to take part in Work Groups where necessary.

November 2001 - March 2002. - After the Work Groups were established, each group began meeting individually to establish a 'strategy' of how to approach the monitoring program for that ecosystem component. These strategies were intended to be starting points for discussion during the Scoping Workshop and to facilitate fitting the components of the ecosystem monitoring program together. Additionally, the Technical Committee met 3 times in person and twice by

conference call to be updated on Work Group level progress and the plan for the Scoping Workshop. A notebook with background information about the network and summarizing the Technical Committee's approach to the program.

April 2002. - The Scoping Workshop was held and helpful input was received from invited guests on the goals and direction of the program. During this meeting an overall framework to the monitoring program was developed that couches work in the context of "extensive" and "intensive" objectives. Additionally the importance of a common sample design for the program was agreed upon by the Technical Committee and invited experts. During this workshop it was also recognized that the planning process CAN was going through was very similar to re-prioritization of the Denali LTEM program. A true integration between the programs would confer many advantages to both programs as well as economy of effort.

May - July 2002. - Specifics of the integration between CAN and the Denali LTEM program were outlined and agreed upon by the Board of Directors. A formal document regarding the integration was prepared and submitted to WASO for approval. Writing of the Phase I Report was initiated.

The Role of the Denali Long-term Ecological Monitoring Program in the CAN

In 1991, the NPS selected several parks representing different biogeographic provinces, to serve as prototypes for development of Long-term Ecological Monitoring programs. Denali National Park and Preserve was one of these prototypes, chosen to test methods for monitoring in subarctic parks. In developing its program over the last 11 years, Denali has worked closely with the U.S. Geological Survey-Alaska Science Center, on both the conceptual framework and specific protocols. As a member of the Central Alaska Network, Denali National Park and Preserve plays a unique role in its membership in the network.

To date, discussions of the structure of the CAN monitoring program fully integrate Denali as a part of the network. We will define the nature of the intensive work that takes place in Denali and explain how it compliments and fits with the efforts in the rest of the network in the Draft Monitoring Plan submitted in January 2003.

Recent efforts of the Denali Long-term Ecological Monitoring program (Denali LTEM) have focused on reframing the objectives of the program. Included in this effort has been the exploration of the feasibility of probability-based sampling designs that include the entire park in the sampling frame. This reprioritization was initiated after a program review in 1997 that revealed the program was not meeting the monitoring needs of the park. In 2000, a new conceptual document was published outlining the new direction of the program (Oakley and Boudreau 2000). Since the inception of the CAN, the staff of

the network parks have striven to integrate the Denali LTEM program with the CAN program, however exactly what the nature of the integration would entail was unclear.

During the CAN Scoping Workshop in April 2002 the advantages of complete integration of Denali into the CAN program became clear, as well as how that integration might be accomplished. Due to the stage of development of the Denali LTEM program, the reassessment of the program, and the staff participation in the network it was logical to fit the Denali LTEM program with the network organization. The documents required for the Denali review were essentially the same documents needed by CAN, but completing them for Denali alone would short-circuit the development of CAN goals and objectives. These factors led to a convergence of thought that developing a plan for fully integrating the Denali LTEM program into the CAN would benefit both Denali and the network. The key advantages would be to:

- avoid staging duplicative and possibly confounding conceptual planning efforts at the same time;
- to bring Denali's data management effort up to required standards following the guidance of the CAN Data Manager;
- avoid the alternative of completely severing the Denali program from the network, in which case the network loses significant participation by key Denali LTEM staff in the areas of physical sciences, vegetation and wildlife.

Next Steps

In the coming year (FY 2003), the CAN will focus on development of the Phase II report and synchronizing the the annual work planning cycle with park-level planning schedules. The Phase II report will integrate findings from the Scoping Workshop into the goals and objectives of the program.

Chapter 3 Natural Resources of Central Alaska Network Parks:

What's Important?

In this chapter, we present an overview of natural resources in each Central Alaska Network park. We briefly introduce the setting of each park, then describe the natural resource themes of each. These "themes" highlight what we consider to be the most important natural resource features of each park—often the features the park was created to preserve. Whenever possible, we highlight the importance of each park's resources in a regional, national and international context. After considering each park individually, we present a brief synthesis of the important similarities and differences among the parks.

In summary, these parks contain resources of national and international significance. These resources include:

- mountains and opportunities to observe major geologic processes associated with mountains, including glaciation and volcanism;
- a diverse flora revealing influences from the Pleistocene;
- important resident and migratory wildlife populations;
- rivers, including major rivers with significant salmon runs;
- recognition as international biosphere reserves.

Yukon-Charley Rivers National Preserve

Yukon-Charley encompasses 1 million hectares (2.5 million acres) of subarctic vegetation and complex landforms. Yukon-Charley is in eastern interior Alaska, and borders Yukon Territory, Canada (Fig. 2). The small bush communities of Eagle, Eagle Village, Circle City, Central, and Circle Hot Springs are the closest communities to the preserve.

The large and historically important Yukon River and nearly undisturbed Charley River offer an intriguing contrast in river ecosystems, and provide human access to this roadless area. The Yukon and its tributaries provide important habitat for both anadromous and resident fish. Annual runs of three Pacific salmon species help define a cycle of life important to cultural traditions thousands of years old. The Yukon River corridor within Yukon-Charley is characterized by south-facing bluffs vegetated by unique plant communities believed to represent steppelands more widespread during the Pleistocene. Historic and present human activity has had little impact on populations of rare endemic plants. In contrast to the turbid and massive Yukon River, the Charley River, which flows into the Yukon, is a clearwater river whose entire watershed is contained within the preserve.

Geologic and paleontologic resources in Yukon-Charley are significant. The exposed sedimentary record is nearly complete back to Precambrian formations. North of the

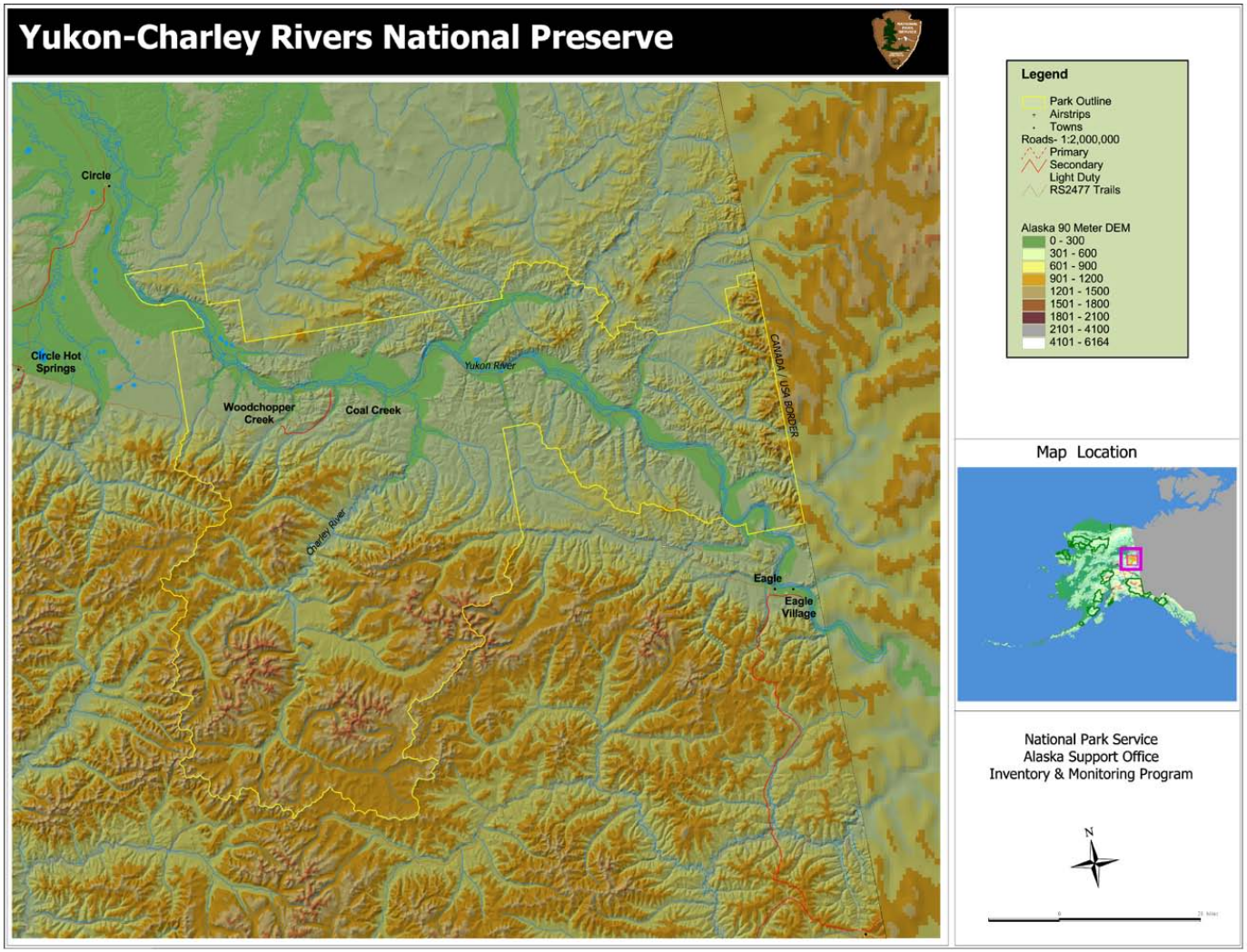


Figure 2. Yukon-Charley National Preserve, AK.

Yukon River lies the most ancient terrane in Alaska, perhaps the original continental margin. Highly fossilized formations reveal important evidence of very early marine and estuarine life forms and the environment in which they lived .

The combination of complex geologic structure, severe semi-arid continental climate, frequent occurrence of fire and discontinuous permafrost soils have interacted over time to create a complex mosaic of taiga and tundra biotic communities. A diversity of subarctic flora and fauna reflect this combination of physical processes, largely unaffected by Pleistocene glaciation. Hundreds of species of vascular and non-vascular plants create a mosaic of wildlife habitats, and provide for a variety of human uses. Some plant associations may represent relict "arctic steppe" communities isolated by the passage of time and climate change (Young 1976). Four narrowly endemic plant species are listed as species of concern for federal threatened or endangered status (Murray and Lipkin 1987).

A rich ecological assemblage of native subarctic mammals thrives in the Yukon-Charley's diverse habitats. Dall sheep, moose and two distinct caribou herds are found throughout the area. Fourteen species of furbearers inhabit the preserve, of which marten and lynx are the most economically valuable. Grizzly and black bears also occur throughout the preserve. Small mammals, including mice, voles and shrews, are important in the food web. The hardy wood frog is the lone native amphibian. A climate characterized by seasonal extremes precludes the occurrence of reptiles.

At least 160 species of birds, most of them migrants, occur within Yukon-Charley. This geographic location allows for unusual observations of errant bird species from more southern and eastern temperate regions. The once endangered American peregrine falcon attains one of the densest breeding populations in North America, with an estimated at 100-125 pairs breeding on Yukon River and Charley River cliffs within the preserve. This spectacular bird is one of seventeen species of raptors found in the area.

Many fish, wildlife and plant species are important for contemporary subsistence uses by local Athabaskan and non-native peoples in the seasonal economy of the region. The Preserve is an area of compelling archeological potential. Evidence suggests that this region was geographically and environmentally suitable for very early human habitation. It may have seen intensive use, perhaps continuously since initial occupation, up to the present period of Athabaskan habitation.

The two most significant geographic attributes for prehistoric peoples were the presence of the Yukon River and the absence of an extensive Wisconsin glaciation. The Yukon was a migration route, leading populations from Beringia into interior Alaska and the northern temperate zone. Lack of glaciation provided favorable living conditions for early occupants, and perhaps concentrated wildlife into accessible areas. This region's archeological resources could well illuminate the controversial timing and nature of the peopling of the New World (Griffen and Chesmore 1988).

Three aspects of the natural resources of Yukon-Charley stand out as especially important from a regional and national context. All are directly related to the presence of the Yukon River and its important tributaries within the preserve. These resources are: (1) arctic steppe plant communities associated with river bluffs; (2) breeding Peregrine Falcons, and (3) the rivers themselves.

Arctic Steppe Plant Communities

The arctic steppe plant communities that occur within Yukon-Charley are unique assemblages of native species on south-facing river bluffs (Wesser and Armbruster 1991) along the Yukon (Edwards and Armbruster 1989) and Charley rivers, and other Yukon tributaries. These plant communities contain four species of concern: *Cryptantha shackletteana*, *Draba murrayi*, *Eriogonum flavum* var. *aquilinum*, and *Podistera yukonensis*. Only two isolated populations of *C. shackletteana* and *P. yukonensis* have been discovered.

In the past, botanists from the United States, former Soviet Union, and Canada have conducted research on Yukon, Charley, and Kandik river bluffs in an attempt to inventory species present in representative communities. According to Murray *et al.* (1983) the portion of the upper Yukon within the Preserve includes "…the most extensive system of steppe bluffs and also the largest array of endemic and disjunct taxa…" found in Alaska. Yukon River surveys (Roland 1990) included photo-documentation and plant sampling at 8 bluffs including Woodchopper bluff, Biederman bluff, Kathul Mountain, Nation bluff, and Montauk bluff. Surveys on the Kandik River revealed the presence of *Draba murrayi*, and two other steppe plants, *Erysimum asperum* var. *angustatum*, and *Phacelia mollis* (Roland 1991). Charley River surveys revealed communities very similar to those investigated on Yukon River bluffs, and several rare species were documented (Roland 1990).

Botanists have also sporadically visited representative sites in the Ogilvie Mountains north of the Yukon to examine communities present there. The northeast corner of the Preserve contains the only extension of the Canadian Ogilvie Mountains into Alaska. Geologically distinct, the Ogilvies provide unique habitat for plant assemblages. Investigation of these communities may provide documentation for range extensions for a number of rare plants currently known to occur only in Canada.

Past research suggests that arctic steppe species exist at the limits of their environmental tolerance and therefore may be sensitive to climate changes. Arctic steppe communities are considered modern "remnants" of past vegetation types that may have been widespread during the Pleistocene (Edwards and Armbruster 1989). These remnant communities may provide botanists with the most tangible examples of a landscape long since vanished. Current increased interest in monitoring the effects of global climate change could lead to utilization of these communities as "indicators" of changes in climatic variables. Because of their geological stratigraphy and exceptional ecological significance, four bluffs supporting arctic steppe communities have been proposed for inclusion in the National Natural Landmark System.

Peregrine Falcons

Yukon-Charley was established in part to ensure the protection of habitat for and populations of the then endangered American peregrine falcon. Yukon-Charley provides nesting habitat for one of the densest populations of peregrine falcons within any federally protected area in North America. Listed by the U.S. Fish and Wildlife Service under the Endangered Species Act, the peregrine falcon has become a symbol of conservation. Recovering from a well-documented decline throughout North America twenty-five years ago, populations are now more secure. Peregrine falcon populations within Yukon-Charley are used as index populations for the U.S. Fish and Wildlife Service's endangered species recovery plan.

Rivers

Yukon-Charley contains important inland freshwater resources including the entire 0.44 million hectare (1.1 million acre) Charley River watershed. Yukon-Charley's enabling legislation defined the foremost purpose to "maintain the environmental integrity of the entire Charley River basin…for public benefit and scientific study." Because of its value as a virtually undisturbed free-flowing river, the Charley has been designated a Wild River in the National Wild and Scenic Rivers System. The Tatonduk, Nation, and Kandik rivers, which originate from Canadian headwaters, each exhibit unique ecosystems and physical characteristics. The Kandik River may exhibit one of the highest levels of primary productivity found in an interior Alaska stream. While some small tributaries have historically sustained activities that altered stream flows, water quality, and aquatic habitat (e.g., placer mining), these four large Yukon River tributaries remain essentially pristine.

The Yukon River also holds regional and national significance as one of the five largest rivers in North America, 206 kilometers (128 miles) of which flows from the Canadian border through Yukon-Charley. The Yukon River drains watersheds in nearly half of Alaska, three-quarters of the Yukon Territory, and parts of British Columbia. The turbid Yukon River has historically sustained the effects of human development as the human population fluctuated dramatically throughout the past 100 years. For example, much of the Yukon River corridor was logged to provide fuel for steamships during the gold rush days.

The anadromous and resident fishes (approximately 14 species) of the Yukon and its tributaries (including the Charley River basin) are valuable components of the natural ecosystems for which Congress established Yukon-Charley. They are very important to consumptive users that live along the Yukon and depend on harvest from annual salmon runs. Late summer runs of chinook and chum salmon are harvested using primarily gill nets and fish wheels. To a lesser extent, Arctic grayling , northern pike, and whitefish are harvested along clear flowing Yukon tributaries near Eagle, Circle City, or various other locations accessible by light aircraft or boat.

Denali National Park and Preserve

Denali in located in interior and southcentral Alaska (Fig. 3) and is composed of 2.4 million hectares (6 million acres). Most of Denali is accessible only by foot, dogsled, or aircraft. Only one road provides vehicular access, mainly during the summer season. This road runs westward through the northern portion of the mountains to Kantishna. The small communities of Healy, McKinley Village, Cantwell, and Talkeetna are adjacent to the eastern park boundary. Bush communities adjacent to the western and northern boundaries include Minchumina, Nikolai, Telida, and McGrath.

Near the geographic center of Alaska, Denali surrounds Mt. McKinley, which hinges the great arc of the Alaska Range (Brown 1993). From Mt. McKinley's high buttresses and perpetual ice fields, glaciers descend radially, sculpting great gorges in the granite and sediments of the cluster peaks that form the massif. Then the landscape falls away through barren rock canyons to lake-dotted tundra benches, flat and treeless, and finally, to wide valleys formed by turbid glacial rivers, their braided beds flanked by spruce forest (Brown 1993).

The Alaska Range is a barrier to air movements and precipitation from maritime influences to the south, thus creating a transitional climate. Areas on the south side of the range are significantly wetter, with twice the precipitation of the north side. Temperatures on the south side of the range have less variation and tend to be warmer in winter and cooler in summer. North of the Alaska Range, a continental climate prevails.

Soils in mountainous areas are sparse because such areas consist of steep, rocky slopes, icefields, and glaciers with very thin or no soils. These soils are characterized by poor drainage, shallow permafrost, and thick surface layers of partially decomposed organic matter. Permafrost is intermittently present throughout the lowlands north of the Alaska Range and is continuous at higher elevations both north and south of the Range. Thicknesses up to 30 meters (100 feet) have been recorded on the north side, near the park entrance.

Denali's vegetation is characteristic of subarctic areas where the growing season is less than 100 days and soils are nutrient-poor. The taiga, or boreal forest, is found at the lowest elevations and consists of black spruce, with stands of white spruce, paper birch, and aspen on better drained sites. Understory vegetation consists of low shrubs, herbs, mosses and lichens. Tree line is encountered at 792 m (2,600 feet), and forests give way to shrublands consisting of moist tundra plants such as dwarf birch, willows, and sedges. Above 1,036 m (3,400 feet), shrubland is replaced by alpine tundra, which consists of low growing mats of avens only a few centimeters high.

Many headwater drainage systems originate in the Alaska Range. Streams of glacial origin are common and are characterized by shallow, swift flows over gravel beds. Many of these streams and rivers are silty, braided, and have wide gravel floodplains filling mountain valleys. Clear streams, fed primarily by snowmelt and precipitation, also occur throughout the area. Outside of the mountains, especially in the northwest lowlands, there

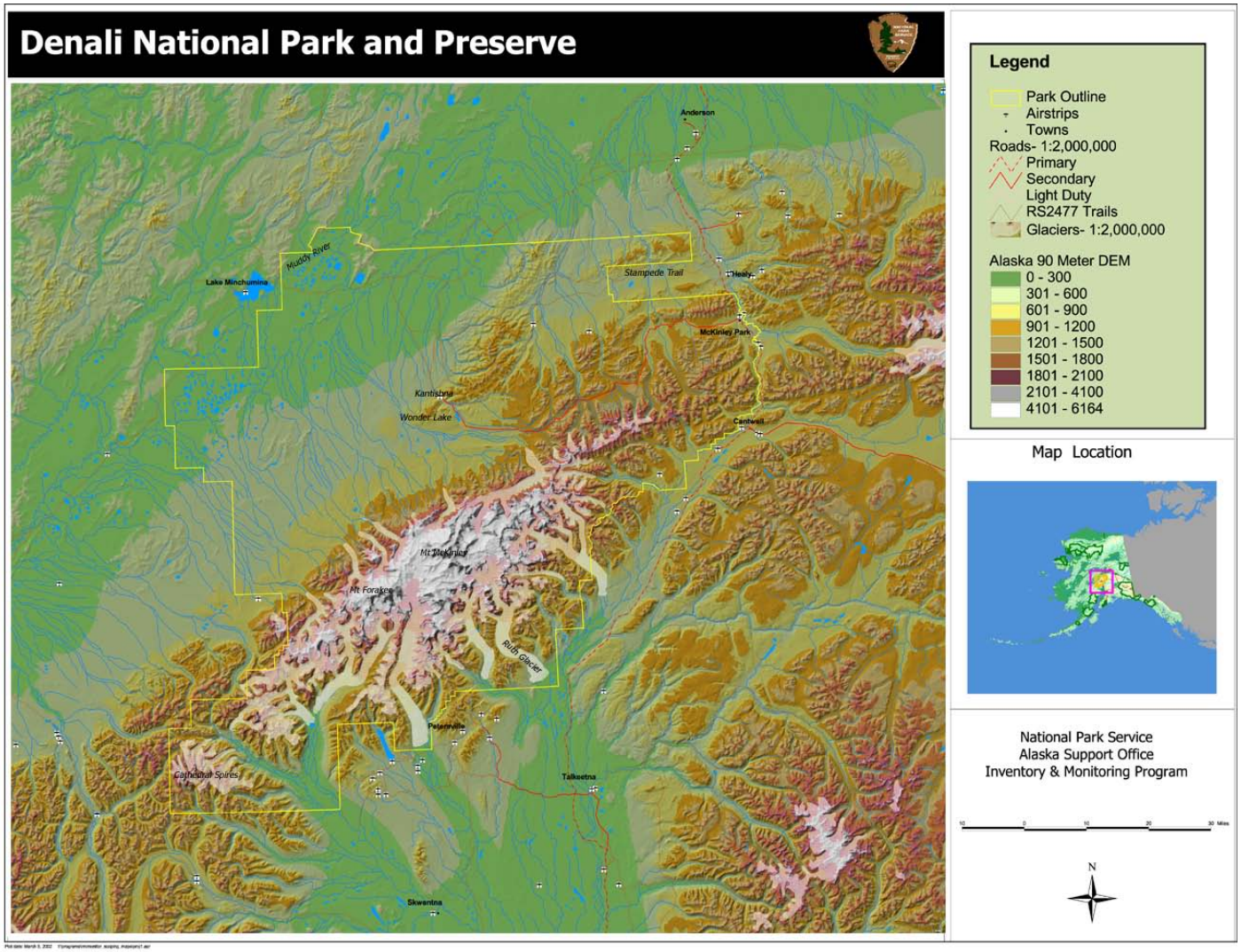


Figure 3. Denali National Park and Preserve, AK.

are many meandering rivers and streams with slow currents. The mountains contain few lakes, although water-filled kettles on moraines and ponds from beaver-dammed creeks occur in places. Many lakes and ponds occur in the northwestern lowlands.

For a least 11 millennia, humans have been seasonally attracted to Denali because of concentrations of game animals (Brown 1993). Subsistence activities in Denali are dynamic and diverse with hunting usually occurring in the fall and winter months, fishing concentrated during summer and fall, and trapping efforts occurring in mid to late winter months when snow cover is adequate and fur is prime. Berry picking and use of plant greens occurs in the summer and fall months. Timber harvest usually occurs in winter when frozen rivers, lakes and snow make access and transportation more efficient. Subsistence harvests vary considerably from year to year due to such factors as weather, migration patterns, natural cyclic population fluctuations, or from political and regulatory factors.

Three aspects of the natural resources of Denali stand out as especially important from a regional or national context. These resources are mountains and glaciers, wildlife, and designation as an international biosphere reserve.

Mountains and Glaciers

Much of Denali is mountainous. Elevations range from 60 m (200 feet) to 6,666 m (20,230 feet) at the top of Mt. McKinley, the highest peak in North America. One-third of the park and preserve consists of mountains and ridges about 1219 m (4,000 feet) in elevation.

Currently, glaciers cover 17% of the land area of the park, and much of Denali's landscape was shaped by glaciers. Glaciers are numerous and tend to be larger and longer on the south side of the range than on the north. The larger glaciers range between 56 and 72 kilometers (35-45 miles) long. The largest glacier on the north side is the 55 kilometer (34 mile) long Muldrow Glacier.

Wildlife

Denali was created originally (as Mt. McKinley National Park) in 1917 mainly because of its wildlife resources (Mech et al. 1998). In the early years, scientific interest in Denali centered on the large mammals because the park's status as a game refuge offered scientists the unique opportunity to study the life histories of animal populations over a significantly large range of the subarctic (Brown 1993).

Denali is well-known for its diversity of wildlife. Based on current information, there are 10 species of fish, 1 amphibian, 37 species of mammals, and 167 species of birds known in the park. There are an unknown number of species of invertebrates.

Large mammals include moose, caribou, wolves, grizzly and black bears, and Dall sheep. Scientific studies of wolves and their prey have been conducted in Denali for over 60 years, starting with the work of Adolph Murie described in his classic monograph, *The Wolves of Mount McKinley* (Murie 1944). The Denali study is the second longest comprehensive study of wolves and their prey in the world (Mech et al. 1998).

Although much of the emphasis on Denali's wildlife focuses on larger mammals, Denali supports a large suite of smaller carnivores, rodents, lagomorphs, insectivores, and at least one species of bat. These species inhabit a variety of habitats across Denali and form integral links in Denali's food web. Many of the furbearers, beavers, and snowshoe hare are important resources for subsistence users in Denali. Many of the rodents are prey sources for many larger omnivores and carnivores. For instance, beavers are one of the primary alternate prey animals for wolves in summer, especially in Denali's western half (Mech et al. 1998), grizzly bears may prey heavily on mice and voles when they are available, and golden eagles depend heavily on snowshoe hare and arctic ground squirrel during the breeding season. Many herbivores, including snowshoe hare and arctic ground squirrel, are important forces in browsing and dispersing vegetation across the landscape. Little is known about the distribution and abundance for most of these species across the park.

Denali's birds include species whose ranges include 6 continents, all converging on this rich subarctic landscape each spring to breed. At least 149 species of birds occur regularly in Denali. Of these, nearly 80% are migratory. In 2001, the American Bird Conservancy recognized Denali for its significance in the ongoing effort to conserve wild birds and their habitats, and designated Denali a *Globally Important Bird Area*. Partners in Flight Working Group, a partnership of organizations concerned with conservation of neotropical passerine bird species, identified 19 bird species as "priority species" for Central Alaska. Sixteen of these priority species are known to occur in Denali. Denali supports many studies on birds including the longest ecological studies of golden eagles and gyrfalcons in the subarctic and arctic regions of North America (e.g., McIntyre 1995).

Twenty-two species of waterbirds (loons, grebes, swans, and ducks) breed in Denali. Trumpeter swans and Tule greater white-fronted geese are three migratory waterfowl species that are of particular interest in Denali. The numerous wetlands on the southside and in the northwestern portion of Denali support an abundance of breeding waterfowl, including at least 400 pairs of trumpeter swans. The Tule greater white-fronted goose, a subspecies of the greater white-fronted goose, is considered "at risk" by the International Waterfowl Research Bureau . This subspecies uses and breeds in wetlands adjacent to the Kahiltna River, Lake Creek, the vicinity of the Tokositna Glacier, and in wetlands along the Petersville Road.

International Biosphere Reserve

Denali is a designated as an International Biosphere Reserve under the United Nations Educational and Scientific and Cultural Organization Man and the Biosphere Program.

The purposes of biosphere reserves are to assure worldwide protected areas where long-term ecological research will be possible on natural processes to compare with human altered areas and to assure protection of genetic diversity.

Wrangell-St. Elias National Park and Preserve

Wrangell-St. Elias encompasses 5.3 million hectares (13.2 million acres) in southcentral Alaska (Fig. 4). The park extends to the Canadian border on the east and to the Northern Gulf of Alaska on the south. The small communities of Glennallen, Copper Center, Chitina, Nabesna, and Slana are adjacent to the park, located on state highways that follow the western and northern border of the park. McCarthy is a small community located within the park, near the historic Kennicott mine, and is accessible by a 97 kilometer (60 mile) gravel road. Another gravel road, the Nabesna Road, travels towards the center of the park from the northern boundary.

Wrangell-St. Elias spans three climatic zones (coastal, transitional, and continental), and includes four major mountain ranges (the Wrangell Mountains, Chugach Mountains, St. Elias Mountains, and the Alaska Range). Large expanses of open, low elevation terrain occurs within the Copper River basin, a relic of the huge pro-glacial Lake Ahtna, which formed behind an ice dam at the confluence of the Copper and Chitina Rivers during the Pleistocene. The valley floor is now covered with braided river channels and surficial deposits mixed from alluvium and glacial outwash. Most of the rivers and streams in Wrangell-St. Elias are heavily influenced by glacier activity.

Water resources within Wrangell-St. Elias include vast expanses of wetlands and numerous lakes and ponds. Over 1.2 million hectares (3 million acres) of the park are palustrine (marsh-like) wetlands. There are over 18,400 hectares (46,000 acres) of natural lakes including six large lakes and over 500 small ponds and lakes under 400 hectares (1,000 acres) in size. Dynamics of water processes in the landscape are controlled in part by the extreme winter weather. Five different types of permafrost occur commonly throughout the park that strongly affects surface water dynamics. Ice flows and periodic ice jams can cause brief but sometimes catastrophic flooding in low-lying areas.

Several aspects of the natural resources of Wrangell-St. Elias stand out as especially important from a regional and national context. These resources are: (1) geological processes including glaciation and volcanism, (2) a diverse flora revealing landscape history, (3) rivers, including rivers with major anadromous fish populations, (4) wildlife, and (5) designation as an international biosphere reserve.

Geologic Processes Including Glaciation and Volcanism

Wrangell-St. Elias is noted for its geological diversity. The region has attracted researchers to investigate volcanism, glaciation, plate tectonics and quaternary geology. The Nizina and Chitistone Canyons are areas where the geologic record is well represented and extensively exposed. The geologic history clearly exhibits the dynamic

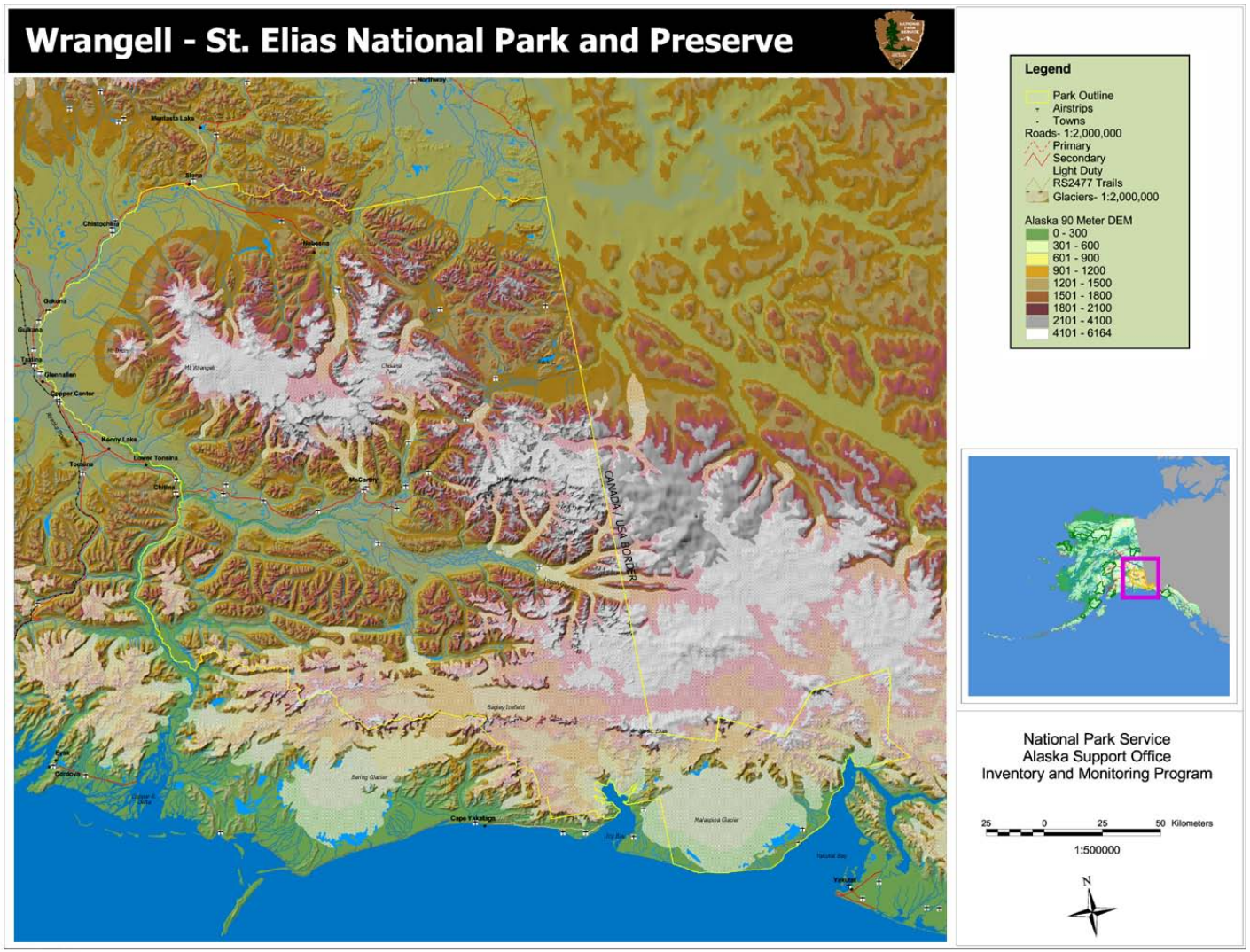


Figure 4. Wrangell-St. Elias National Park and Preserve.

nature of the processes involved in the formation of the Wrangell and St. Elias mountain ranges.

A defining characteristic of the mountain ranges in Wrangell-St. Elias is heavy glaciation. The park contains over 1.6 million hectares (4 million acres) of glaciers including the Nabsena glacier, which is over 71 kilometers (44 miles) long. Several of North America's highest peaks are within the park including Mt. St. Elias [5,489 m (18,008 feet)] and Wrangell Mountain [4,269 m (14,005 feet)], an active volcano. From these mountains flow hundreds of glaciers varying tremendously in size. The Malaspina is one of the largest piedmont lobe glaciers, and the aforementioned Nabesna Glacier is one of the longest valley glaciers. Other glaciers, such as the Hubbard Glacier, terminate at tidewater and are known for their surging and retreating. Extensive ice fields also occur within the mountain ranges.

The area is seismically active because the Yakutat terrane—the underlying plate just offshore of the park--is accreting to North America. The associated volcanism--the park has recorded nine volcanic episodes in the last decade--and active faults zones generate frequent earthquakes. The park also contains numerous geysers, hot springs or thermal pools. This area of volcanic activity is known as the Wrangell Volcanic Field, and it covers more than 104,000 hectares (400 square miles), extending through the middle of the park from the international border to Glennallen.

Flora Revealing Landscape History

Wrangell-St. Elias encompasses a unique cross section of boreal, subarctic and coastal ecosystems in Alaska with floristic influences from Beringia, the Yukon, the arctic and the Pacific Mountain systems. The diversity of plant communities in this region is unsurpassed for a park unit in Alaska due in part to the expansiveness of the park, the three climatic zones it covers (maritime, transitional, continental) and the wide variety of geologic features found within its boundaries.

Large areas within Wrangell-St. Elias have never been surveyed botanically. This is most obvious in the range maps in the Flora of Alaska (Hulten 1969) in which the "Wrangell Void" is seen for many taxa in areas where these taxa are expected to occur. Inventory work over the last decade has significantly advanced our understanding of the flora of Wrangell-St. Elias, however. Currently, there are 832 vascular plant species documented by vouchers within Wrangell-St. Elias. Major plant communities in Wrangell-St. Elias can be described based on their topographic locations. These communities occur in lowlands, uplands, sub-alpine areas, and alpine areas.

The south-facing bluffs along the White, Nabesna, Chitina and Copper Rivers are similar to the steppe found in Yukon-Charley, but not as extensive. Numerous rare and endemic plant species have been found in these communities, which may be refugia. Other unique plant communities in Wrangell-St. Elias are associated with distinctive landforms and lithologies such as sand dunes, mud volcanoes, volcanic ash, limestone, lakes and

wetlands. These communities often harbor uncommon species and species with disjunct distributions. Alaska-Yukon endemic species are more common in the Alaska Range and northern Wrangell Mountains. This trend corresponds to our understanding of plant migration after the Pleistocene Epoch from refugia in the upper Yukon Valley, the Alaska Range and Beringia, the northern part of Wrangell-St. Elias being closest to these migration corridors. In addition, there may have been unglaciated refugia within the Late Wisconsin ice sheet adjacent to Lake Ahtna in the northwestern region of the park, and in the dry northern interior of the Park bordering the Tanana Valley and the southeastern edge of Beringia. As described for the steppe communities of Yukon-Charley, these refugial communities and communities with rare plants and disjuncts may be at the edges of their ranges and may be sensitive to environmental changes.

There are 76 vascular plant species in the park's flora which have an Alaska Natural Heritage state rank of three or less (known from fewer than 100 localities) and are treated as rare species by the National Park Service. Although none of the rare species are considered threatened or endangered by the U.S. Fish and Wildlife Service, three species (*Cryptantha shacklettenana*, *Carex laxa* and *Taraxacum carneocoloratum*) are listed as Species of Concern. The rare flora is distributed somewhat evenly throughout the mountain ranges of the park, but there is a predominance of rare plants in the Chitina River basin. There is a trend for rare plants to occur in the alpine zone, above 1200 m elevation, in dry sites, in the alpine-herb talus slope plant community, on southerly aspects and on slopes of 20 – 40 degrees. Rare plant populations are often at the edges of their geographic and ecological ranges and may be good indicators of environmental changes for ecological monitoring.

Rivers and Fish

Four large river watersheds occur within the Wrangell-St. Elias--the Copper, Chitina, White, and Tanana rivers--dividing the landscape with major salmon fisheries in the summer overlaid by access routes across the frozen surfaces in the winter. Wrangell-St.Elias is home to a tremendous array of fish resources. Fish habitat ranges from large glacial rivers and streams to small clear water streams, as well as a range of lentic habitats ranging from tundra ponds to large lakes. With hundreds of miles of streams draining into two of Alaska's largest river systems, Wrangell-St. Elias contains a diverse range of fish species as well as many abundant populations, including salmon populations that support large fisheries. The Copper River and most of its tributaries are migration routes for sockeye, coho, chum, and king salmon, and this river supports important subsistence fisheries within park boundaries. Small lakes and clear water tributaries contain lake trout, Dolly Varden, burbot, grayling, cutthroat and rainbow trout, sculpin, suckers, and whitefish.

Anadromous fish, including salmon and rainbow steelhead trout, dominate the fish communities in the Copper River. These fish transport large quantities of marine derived nutrients into otherwise nutrient poor systems. These marine derived nutrients support many of our aquatic ecosystems. Dolly Varden and slimy sculpins inhabit many of what appear to be inhospitable, steep, silt-laden glacial streams. Lake trout and arctic grayling

dominate many of our lake systems as the top predator in the aquatic food web. Some of the northernmost populations of rainbow steelhead trout occur within Wrangell-St. Elias.

Wildlife

Protection of fauna populations, especially mammals, birds and fish, was an important consideration in establishment of Wrangell-St. Elias. Based on current information, there are 16 documented and 14 expected species of fish, 4 species of amphibians, 239 species of birds, and approximately 38 species of terrestrial mammals and 9 species of marine mammals that occur in Wrangell-St. Elias. The park is also home to unknown number of invertebrate species.

Large mammals are common in the park and are also an important subsistence resource. Dall sheep, grizzly bears, black bears, caribou and moose are large species that inhabit the park. Smaller mammal species, including snowshoe hare, arctic ground squirrels, red squirrels, and marten, provide a food base for larger mammalian and avian predators as well as some subsistence takes and fur trappers.

Alaska's system of National Parks and Preserves contains approximately 40% of the state-wide population of Dall sheep. Wrangell-St. Elias alone contains >25% of both the statewide population and harvest of Dall sheep in Alaska. Two small caribou herds are found in the park, the Mentasta herd, and the Chisana herd. The Mentasta herd is a small caribou herd that uses the slopes of Mount Sanford and Mount Drum in northern Wrangell-St. Elias. The Chisana herd resides further east, in the Chisana area. Moose are another important ungulate species. Moose are a major prey species for wolves and grizzly bears. The park has populations in all areas including a small population in the Malaspina Forelands. Most of the large ungulate species found in the park are subject to subsistence hunts.

The park supports a diversity of small mammals. They are an important prey base which supports predators like the gray wolf. Small mammal inventory work in 2001 and 2002 has greatly expanded our understanding of their presence and occurrence in Wrangell-St. Elias (Cook and MacDonald 2002b). The discovery of the tiny shrew at Carden Hills and Braye Lakes in the northeastern corner of the park constitutes a new species for Wrangell-St. Elias and significantly expands the known range of the species. This study also provided the first documentation of the water shrew and tundra shrew in Wrangell-St. Elias, and provided new information on several other species, including meadow vole, long-tailed vole, brown lemming, northern bog lemming, and singing vole.

Three species of bats occur in the general area of Wrangell-St. Elias. Little brown bats occur south of the Yukon River and are known to occur in the park. Silver haired bats and Keen’s bat occur in southeast Alaska and may occur in Wrangell-St. Elias near Yakutat.

Harbor Seals inhabit the coastal waters of Icy and Disenchantment Bays in southern Wrangell-St. Elias; their populations are largely unknown. Sea otters are present, and

Steller's sea lions occur in both Icy and Disenchantment Bays. Dall's porpoise and harbor porpoise, and 5 species of whales have been recorded in or near the bays.

There are records for 239 species of birds in the park with approximately 53 species listed as residents. Wrangell-St. Elias has two passerine migratory routes that pass through the park and an abundance of coastal bird communities in Icy Bay. Surveys have been conducted of seabirds, bald eagles, and trumpeter swans.

International Biosphere Reserve

In 1979, the United Nations Educational and Scientific and Cultural Organization established the geographic region now containing both Wrangell-St. Elias and Kluane National Park as a World Heritage Site. This area was specifically noted for its importance in representing "incredible geological processes" namely glacier dynamics, and "premier wilderness". In 1992, Glacier Bay National Park and Preserve and Tatshenshini-Alsek Provincial Park were added to the World Heritage designation making the combined 9.2 million hectares (23 million acres) one of the largest protected areas in the world.

Natural Resources of Central Alaska Network Parks: A Synthesis

The natural resources of the three parks in the Central Alaska Network are similar in many respects. The parks have very similar faunas and generally similar floras and vegetation community patterns. They have major rivers, many streams, lakes, ponds and wetlands. All 3 parks provide for subsistence uses by local rural residents. Two of the 3 parks have extremely tall mountains and extensive glaciers, which are remnants of the last glaciation. The 3rd park is entirely located in the unglaciated corridor known as Beringia. The network parks are therefore linked by Pleistocene history of the region.

The parks are also similar in having intact predator-prey systems involving wolves and multiple ungulate prey species, and grizzly bears; compared to parks in the rest of the country, this aspect of their ecosystems is unique. The parks have many notable fish and wildlife populations, including Dall sheep in Wrangell-St. Elias, peregrine falcons in Yukon-Charley, and golden eagles in Denali. However, even attempting to describe these species and populations as "notable" or "more notable" than other species and populations in these parks gives a misleading impression, because what is probably most significant is the integrity of the ecological systems. The designations of both Denali and Wrangell-St. Elias as recognized biosphere reserves in a worldwide context may capture the most important feature of the natural resources of the Central Alaska Network parks: The parks provide the space and time to see and hopefully understand natural processes occurring at large spatial scales and long temporal scales.

Chapter 4 Resource Preservation Concerns

In this chapter, we present an overview of the resource preservation concerns of Central Alaska Network parks. For the monitoring program to be relevant, it must provide data useful to protection of park resources, now and in the future. To ensure relevancy over time, the monitoring program needs to address broad concerns and not be limited to the issues of today, because the issues will change (McDonald et al. 1998). We therefore review current issues and look ahead to identify future issues. Because Central Alaska Network parks are arguably among the most pristine of any parks, developing the monitoring program to provide information useful for addressing future issues is especially important.

We gathered material for this chapter in several ways. The most recent Resource Management Plans for each park were reviewed (NPS 1998, NPS 1997, NPS 1999). Resource Management Plans are long-range plans that identify the inventory, monitoring, research, mitigation and enforcement activities needed to protect park resources. A recent analysis and model of Denali resource preservation concerns developed for the conceptual design of the Denali Long-term Ecological Monitoring program (Oakley and Boudreau 2000:51-61) was also used. We held meetings with Yukon-Charley and Wrangell-St. Elias staff in fall 2001 to solicit additional input. We have also relied heavily on insights from past and current natural resource managers, physical scientists and biologists working in each park.

We found the resource preservation concerns of all three parks were similar. We therefore present the broad-scale concerns affecting the network parks, including examples of how these concerns are manifested in each park. Some concerns were park-specific, and we then present these unique concerns, which include coastal issues for Wrangell-St. Elias (the only park in the network with coastline), and military jet training activities over Yukon-Charley. Our discussion concludes with a conceptual model of the concerns and ideas about future issues.

Broad-Scale Concerns of All Network Parks

The broad-scale concerns of Central Alaska Network parks fall into four categories:

1. Concerns stemming from **global industrialization**: These include climate change, long-distance air pollution, and effects on migratory birds and fish when they are not present in network parks.

2. Concerns relating to the general topic of **fish and wildlife management**, especially as they relate to protecting and providing for subsistence uses, while maintaining biodiversity in intact ecosystems. These concerns are united by a lack of information about the status and trends and predator prey-relationships of harvested populations necessary to support sound recommendations about

3. harvest. Fish and wildlife habitat management issues are not restricted to consumptive uses, however. They also include such topics as habituation of wildlife and bear-human interactions.

4. Concerns relating to **access** and **visitor use impacts**.

5. Concerns relating to **private land development**, both within and adjacent to network parks. This topic includes issues related to mining development and settlement along park boundaries.

We discuss each of these four categories of concern in the following sections. The concerns are not independent from one another, and relationships among the concerns are discussed in a later section that presents a conceptual model of the resource preservation concerns.

Global Industrialization

In 1997, Vitousek et al. (1997) presented a short but sobering picture of human domination of the earth' ecosystems. Human population growth, and growth in use of resources by humanity, is maintained by agriculture, industry, fishing and international commerce. These activities change the earth's surface with two major effects: (1) changes in major biogeochemical cycles, and (2) adding or removing species. These alterations to the functioning of the earth's ecosystems are driving global climatic change and the irretrievable loss of biological diversity. This conceptual model of humanity's role in the earth's ecosystem, circa 2000, provides a broad context for considering resource protection concerns of Central Alaska Network parks. Although remote and presumably pristine, the surrounding world is changing so quickly due to human activities that this broad perspective is needed.

The Denali Resource Management Plan (Denali National Park and Preserve 1998) raised this concern. The plan noted that the most significant potential adverse effects on Denali from industrialization resulted from activities in areas far away from Denali. Concerns stemming from global industrialization fell into three categories: climate change, air pollution, and effects on migratory species populations. These concerns relate to all parks in the network.

Climate Change - Overall climate warming trends documented elsewhere are also being detected in much of Alaska, including Denali (Juday 2000). Dramatic melting of snow and ice in Alaska has been occurring over the last few decades due to warmer climate. Warming has caused melting of permafrost and permanent snowfields as well as a reduction in seasonal snowfall and shorter seasons of river and lake ice. Continued warming will cause further reductions in snow cover, permafrost and a corresponding shift in landscape processes. Changes to the network park ecosystems due to climate change include: decreases in useable moisture for plant growth; increases in fire occurrence and intensity; thawing of permafrost layer reducing slope stability, and changes in glaciers.

Many of these changes could contribute to a shift in vegetative community types. Models predict community shifts from tundra to forest, black spruce to deciduous forest, and forest to grasslands, bogs and wetlands (Starfield and Chapin 1997, Alaska Regional Assessment Group 1999). Warmer temperatures will result in a longer growing season, and changes in precipitation and community types will result in changes in vertebrate distribution and habitat use. Riparian areas, wetlands, dry habitats, and areas with discontinuous permafrost are the most vulnerable to warming temperatures and will provide the best signals of change (Weller and Lange 1999).

One of the most important changes that could occur in network parks from climate change is a change in the wildfire regime. Wildfire is one of the most influential environmental processes in tundra and taiga ecosystems, and is a dominant process in Central Alaska Network parks. All of Yukon-Charley, the northwestern quadrant of Denali, and parts of Wrangell-St. Elias are substantially affected by wildfire. The current vegetation mosaic and habitat diversity in these areas reflect the complex effects of fires that have occurred over the past 100 years. The frequency and intensity of wildland fires are dependent on long-term climate conditions. There has been an increase in the number of fire starts and acres burned as Alaska's Interior region sees a climate warming and drying trend. This has created landscape scale changes to vegetation, soils and underlying permafrost creating a dynamic mosaic within the ecosystem.

Fire is considered to be a critical component in maintaining a wide variety of plant communities, including remnant arctic steppe. The fire management program goal of network parks is to protect human life, property and significant resources while allowing fire to fulfill its role as a dynamic natural process. The majority of the network park lands are within the 'limited' fire suppression category. This category allows fires to be observed without suppression actions.

Little is known about the potential management implications of a potential increase in the burn cycles within Interior Alaska. Alaska currently utilizes Canadian fire behavior models to determine the intensity and conditions under which the fire will burn. Ecosystem level information would be useful in developing an Alaska-based model for predicting wildland fire behavior. Understanding the role fire plays on the soils (permafrost), vegetative succession, animal movements, erosion and tree line movement will better prepare fire managers for fire season decision making.

Because of the importance of climate change to ecological processes in network parks, a conceptual model of likely changes, based on the current and massive research effort in this area, would be useful.

Long-distance Air Pollution - Long-distance transport of air pollutants is the 2nd major concern of Central Alaska Network parks stemming from global industrialization. Air pollution monitoring at Denali since the early 1980s has documented the occurrence of low levels of Arctic Haze. Arctic Haze is a winter pollution phenomenon. Pollutants, most likely from Eurasian sources, become trapped in the stable winter air mass that hangs over the arctic and extends down into North America and Eurasia, creating Arctic

Haze (Shaw 1995). Recent data have suggested pulses of contaminants apparently transported directly from Asia (C. Cahill, University of Alaska Fairbanks, pers. commun.). Ecological effects of these particular air pollutants in Alaskan ecosystems are currently unknown. Because Yukon-Charley and Wrangell-St. Elias lack air quality monitoring stations, we do not have definitive information about the occurrence of Arctic Haze and Asian dust in these parks. However, both types of pollution are the result of broad atmospheric deposition patterns that likely affect much of interior Alaska, including these parks.

Effects on Migratory Species When They are Not in the Parks - All network parks provide habitat for migratory birds and fish. Industrialization elsewhere on the globe could adversely impact migratory birds of network parks. Most of the bird species that breed in network parks are migrants who spend most of the year elsewhere in North, Central or South America, at sea in the North Pacific, or on South Pacific islands. One species, the Arctic Warbler, winters in Southeast Asia, and another, the Northern Wheatear, winters in central Africa. While global industrialization may not affect the breeding habitat of these species in network parks, the same may not be true of their migratory paths or wintering habitats. Adverse impacts could include reduced overwinter survivorship and increased contaminant levels.

Similarly, global industrialization could affect the anadromous fish of network parks. Salmon that spawn and rear young in the streams and rivers of network parks spend most of their lives at sea. Changes in the oceanic environment due to global industrialization could affect the number of salmon returning to network parks. Salmon are an important subsistence resource and transport marine nutrients into terrestrial ecosystems. Changes in salmon populations could affect ecosystem processes in some areas of network parks.

An important role that Central Alaska Network parks can play with respect to migratory species, besides protection of important habitat for reproduction and overwintering, is to call attention to population changes. Providing information on status and trends of migratory species in protected habitats can help influence conservation actions elsewhere.

Fish and Wildlife Management

This category addresses consumptive uses of fish and wildlife—a major issue for all ANILCA parks due to the underlying philosophy of this key piece of legislation. ANILCA specifically allowed for consumptive use of wildlife resources (i.e., hunting, trapping, and fishing) within national preserves, and for subsistence uses by local, rural residents in both national parks and preserves. ANILCA also requires the National Park Service, in cooperation with the Alaska Department of Fish and Game, to manage for "healthy" populations of fish and wildlife species within national preserves, and “natural and healthy” populations in national parks.

Historically, the Alaska Department of Fish and Game managed both sport- and subsistence-harvests of wildlife within network parks. In 1990, however, the State of Alaska was ruled to be out of compliance with the subsistence sections of ANILCA, and

responsibilities for managing subsistence harvest of wildlife within national parks were delegated to the parks. Under the current legal situation, the Alaska Board of Game establishes regulations for hunting and fishing seasons, harvest limits, and methods and means for non-federally qualified subsistence users in the national preserves. The Federal Subsistence Board establishes regulations for hunting and fishing seasons and harvest for federally qualified subsistence users in parks and preserves.

The complexity of the fish and wildlife management scheme requires current, accurate information on fish and wildlife populations, their habitat needs and prey base information for effective decision-making. To ensure good stewardship and consistency with National Park purposes and management policies of fish and wildlife resources, basic population and distribution information, harvest tracking, and consistent monitoring are essential. These data allow managers to determine if management objectives for the populations are being met. With information of this type, managers can propose any necessary changes to state and federal harvest regulations to protect resources from excessive harvest.

Most of the concerns related to “fish and wildlife management” in network parks concern large mammals subject to human harvest, for subsistence and for sport. In Yukon-Charley, most large mammal populations are believed to be healthy or improving, with the exception of moose. Moose harvest has been steadily increasing over the past 10 years while bull:cow ratios have been declining. During the last population survey in 1999, the bull:cow ratio was at a point that biologists felt was on the edge of being unhealthy. Consistent monitoring of the moose population is necessary to determine if new harvest regulations need to be proposed. In Denali, current levels of harvest of large mammals are believed to be quite low. However, increased settlement in the Railbelt is expected to increase demand for consumptive uses of wildlife in Denali.

In Wrangell-St. Elias, management of large mammal harvests is an ongoing concern, mainly due to inadequate information about status and trends of populations occurring in a vast region. Key populations of management interest are the Mentasta and Chisana caribou herds, moose, Dall sheep, brown and black bear, wolves and furbearers.

Currently, both caribou herds in Wrangell-St. Elias are decreasing in size, and both are important subsistence resources for local rural residents. Hunting has been terminated on the Mentasta herd due to low recruitment into the already decreasing population. The Chisana herd uses land in both the United States and Canada. The mix of management objectives between the land management agencies and countries is challenging. Some of the management proposals involve intervention--both predator control and calf protection--that would be contrary to NPS management principles.

Moose are also an important management concern for Wrangell-St. Elias. They are a major prey species for predators and scavengers, an aesthetic attraction for visitors, a game species for sport hunters and a meat source for subsistence hunters. Moose populations in Wrangell-St. Elias have been monitored by Alaska Department of Fish and Game biologists from Glennallen, Tok, and Juneau and by Tetlin National Wildlife

Refuge biologists from Tok. Monitoring methods and areas of coverage by monitoring efforts have varied, leading to uncertainty about population status and trends.

Wrangell-St. Elias contains one of the largest populations of Dall sheep in Alaska. In the past, the park has contributed approximately 29% of the statewide harvest. In the northern section of Wrangell-St. Elias, current regulations allow the harvest of full-curl rams by sport-hunters from land designated as National Preserve. In the remainder of Wrangell-St. Elias, local subsistence hunters are permitted to harvest any Dall sheep on both Park and Preserve lands, and sport-hunters are also permitted to harvest any ram, though from Preserve lands only. Recent monitoring indicates that total numbers of Dall sheep may have decreased by approximately 50% in some areas. There is widespread concern that liberal hunting seasons for Dall sheep (i.e., "any sheep") and accessibility may be contributing to declining populations of mature rams.

Management of consumptive uses of fish is also important in the network, primarily in Wrangell-St. Elias. Wrangell-St.Elias is responsible for the administration and in-season management of Federal subsistence fisheries in the Copper River. Copper River subsistence fisheries provide a substantial amount of salmon for consumption by both rural and urban Alaskans. Three Federal subsistence salmon fisheries occur in the Copper River: the Chitina Subdistrict, the Glennallen Subdistrict, and the Batzulnetas Area fisheries. Nearly 40,000 salmon are harvested annually by Federally-qualified subsistence users. An additional 160,000 or more salmon are harvested in the Copper River in state-managed subsistence fisheries. Commercial harvests in the Copper River District typically range between 700,000 to 1,250,000 salmon each year.

Nearly 11,000 households have participated in subsistence fisheries in the Wrangell-St. Elias under state regulations in past years. In 2002, approximately 170 households participated in subsistence fisheries under Federal regulations. These federally-qualified subsistence fishers may use fishwheels, dipnets or rod and reel to take salmon.

The Batzulnetas Area fishery occurs entirely within the designated park boundary. Batzulnetas is the site where Ahtna elder Katie John operates her fishwheel, and her lawsuit over federal protection of subsistence fishing rights resulted in the ninth circuit court decision commonly referred to as the *Katie John* decision. This ground-breaking decision resulted in the expansion of Federal management throughout over 60 percent of Alaska’s lakes and rivers. The Batzulnetas Area fishery has a high public profile, and solid information about Copper River salmon stocks is necessary for proper decisions.

Information regarding the subsistence fisheries harvest in the Copper River is relatively limited. A sonar counting station near the mouth of the river provides estimates of the number of salmon that migrate into the Copper River. Wrangell-St. Elias operates a weir in Tanada Creek, upstream of the Batzulnetas Area fishery. Both federal and state fishers are required to return an annual harvest report. In-season harvest information is not available.

The heart of the most difficult management issues regarding consumptive uses of fish and wildlife lies in the difference between management objectives among agencies. Alaska, like most states, manages for sustained yield of fish and wildlife species. Under the sustained yield paradigm, harvested species are more valuable than non-harvested species or predators of the harvested species. This paradigm directly contradicts NPS policy to preserve fundamental biological and physical processes, as well as individual species, features, and plant and animal communities. The NPS maintains, as parts of parks, all native plants and animals in their natural abundance (NPS management policies 2001 4.1)

Fish and wildlife management concerns of network parks are not limited to consumptive uses. Also of concern are effects on wildlife species stemming from park visitation. These concerns include habituation of wildlife species, particularly those species that readily adapt to human presence. A related concern is bear-human interactions. These concerns require active management on the part of parks to prevent and minimize negative interactions and creation of nuisances involving wildlife. Among the network parks, these concerns are currently most important in Denali, which has the highest visitation.

Access and Related Visitor Use Impacts

Access is probably the largest underlying issue and one that is related to many of the other concerns. Transportation and access into all three parks is largely undeveloped by current standards. ANILCA requires the parks (that were established under ANILCA) to provide adequate and feasible access to inholdings within the parks. Access to inholdings and mineral development sites can be challenging to resolve in a manner consistent with other uses and values of the park.

Increased visitation presents two large resource issues. The visitors themselves impact resources in ways we have yet to understand and quantify. As visitation increases there is pressure to provide new trails and access opportunities into these large wilderness parks. There is also a very strong push to make these very large wilderness parks more accessible by ground transportation.

Managing access to prevent resource degradation is a major challenge for all network parks. The challenges are somewhat different among the parks because of their histories and locations relative to Alaskan settlement. Yukon-Charley and Wrangell-St. Elias have no way to count visitors as they enter the park and no way to know where they are going. This situation makes it very difficult to quantify and predict visitor impacts upon resources.

In Denali, issues related to public access are among their most significant concerns. Three types of access change could occur:

1. A new primary access corridor that would increase the level of disturbance within the core park. Park managers consider this to be the most significant change.

Repeated proposals to extend the Stampede Trail as a northern access to the park indicate a high potential for this kind of access change.

2. Increased density of access corridors (primarily foot trails) off the Denali Park Road and other access nodes within the park.

3. Proliferation of access corridors from existing and emerging growth centers on the park perimeter. These growth centers currently include the Stampede area near Healy, the McKinley Village area near park headquarters, and Cantwell. The completion of a visitor center in the Tokositna region would open up areas on the south side of the park.

Increasing both motorized and non-motorized access can significantly alter Denali. Non-motorized uses such as hiking, climbing, rafting, kayaking, canoeing, biking and dog mushing are focused in a few areas of the park, leaving large areas unaffected. Recent increases in motorized uses, such as snow machines and aircraft (for flightseeing), have been observed.

Roads and trails can change the land physically. The presence of people and vehicles on these roads and trails can be disturbing to wildlife. Impacts from access also can include: habitat loss and fragmentation, creation of edge effects, impediment to movement corridors or disturbance of normal activity patterns of wildlife, changes in hydrologic regimes, introduction of exotic plants, introduction of contaminants, air quality degradation, and, phenomena such as fugitive dust.

Like other ANILCA Parks, Wrangell-St. Elias is required to provide adequate and feasible access to inholders and subsistence users. Currently, most of this access is via all-terrain vehicles and fixed winged aircraft. Wrangell-St. Elias also permits recreational use of all-terrain vehicles on 17 established trails. The demand for recreational all-terrain vehicle use is projected to increase, mirroring the Alaska and national trends in use of these vehicles. Unlike at other parks, all-terrain vehicles are considered a customary and traditional means of transportation in Wrangell-St. Elias (Wrangell-St. Elias General Management Plan 1986). Past research and monitoring within Wrangell-St. Elias have indicated that all-terrain vehicle use has caused adverse impacts on Park lands, including shifts in species composition, decreased frequency and cover of plant species, thermokarsting, erosion, and increased trail width (Cook 1990a). Of particular concern are the numerous areas where the trails traverse wetlands, permafrost soils, and steep slopes. Research in other Arctic areas shows that sites will continue to degrade if the organic mat has been destroyed, even if use ceases (Rickard and Brown 1974, Sparrow et al. 1978, Walker et al. 1987). One, if not the most, significant impact caused by all-terrain vehicle use is the impairment to pristine landscapes, which was a purpose for which the park was established.

All-terrain vehicle use is not an issue unique to Wrangell-St. Elias. All Alaskan ANILCA parks are required to provide access for subsistence users and inholders. Throughout much of Alaska off the road system, all-terrain vehicles are a primary method of travel.

Due to their reduced cost and availability, all-terrain vehicles are experiencing increased popularity and use, both in and outside of NPS units (Sinnot 1990). Therefore, this issue is not only presently highly significant to resource preservation within Wrangell-St. Elias, but the problem is expected to get worse, both within Wrangell-St. Elias and throughout the region.

Another resource preservation concern stemming from access relates to development of major access corridors. Access to inholdings and mining operations often require the use of bulldozers and other heavy equipment, and in some cases, new roads. Within Wrangell-St. Elias, there are 110 potential RS-2477 rights of way covering 1,472 miles. Development of some of these RS 2477 rights of way would significantly change the character of the park.

Private Land Development in and near Network Parks

Private land development is a major concern for network parks. For Wrangell-St. Elias and Yukon-Charley, development on private lands within park boundaries is an especially important concern because ANILCA provided for substantial acreages of inholdings and mining claims. Denali has some issues concerning private land development in the park, but also has more imminent concerns related to development on park boundaries because Denali borders the Parks Highway corridor where human population is expanding.

There are several types of non-federal land ownership including fee simple private land, Native corporation land, Native Village land, Native allotments, veteran allotments, state-owned submerged lands and mining claims. Much of these lands may be subject to mineral exploration and development as well as the construction of tourist facilities. In Yukon-Charley, approximately 136,000 hectares (340,000 acres) of land are privately owned. In Wrangell-St. Elias, nearly 400,000 hectares (1 million acres) are in the variety of non-federal land status mentioned above.

The State of Alaska has authority over the beds and subsurface minerals of navigable rivers. These lands are subject to mineral location and extraction under state law. Within Yukon-Charley, state placer mining claims have been located in the Yukon River downstream from the mouth of Coal Creek, in the heart of the preserve. The state routinely issues permits for small suction dredge operations on navigable rivers, and a few small recreational suction dredges have operated on the Charley River in the past. Negative impacts to water resources and quality of wilderness experience could result from any of these operations. There are no specific federal regulations to govern such activities.

The potential for oil and gas exploration and development on non-federal lands in Yukon-Charley is also a concern. Likely areas include the headwaters of currently pristine rivers, such as the Kandik, Nation and Tatonduk. Development in these areas could affect water quality and aquatic habitat downstream. Collection of baseline data is

necessary for evaluation and mitigation of future impacts to natural and cultural resources.

There has also been an increase interest from private landowners in developing tourism-related facilities on private lands within the Yukon-Charley and in close proximity to its boundaries. Development proposals range from bicycle trails along the Yukon River to lodge facilities and guided fishing and hiking trips. There has been an increase interest in operating tourism services from Coal Creek administrative area. Little is known about the effects of increased riverboat activity or additional fishing pressure on the Yukon River and its tributaries. A new grand hotel is being built in Circle City, with plans to take riverboat trips up the Yukon River to tour historic sites and experience the area. There is also a private individual currently living in Eagle who is constructing a river boat with the intention of developing a riverboat tourism operation. The cumulative effect of internal and external development pressures on the ecosystem is not well understood for Yukon-Charley.

For Denali, private land development concerns stem primarily from settlement. Settlement refers to the construction and occupation of permanent human structures. Human settlement affects areas both within the park and along the borders of the park. Within the park, at the eastern and western ends of the Park Road, settlement associated with park operations has intensified as the number of park visitors has grown. With increasing demand for public access, the number of businesses on private inholdings in Kantishna offering accommodations for park visitors also has increased. Continued rapid growth in human population within the Railbelt causes concern about settlement impacts along the eastern, southern and northeastern borders of the park.

Mineral extraction on lands adjacent to Denali is also possible. The Usibelli Coal Mine, in the Healy area, provides some indication of the value of the region for mining. The area at the eastern end of the Stampede Trail known as the “Wolf Townships” is open to mineral entry. Coal deposits are present in the Otto Lake area, also in the Stampede region, and the State of Alaska could promote development of these deposits. Areas around the park also have been explored for oil and gas, and some regions offered in state oil and gas lease sales. Extensive placer mining also has occurred in the Cache Creek area on the southern border of the park. Thus, while the current level of mineral extraction around Denali is low (except for Usibelli Coal Mine), the area has a recognized potential that could become attractive depending on economic conditions and regional growth.

Placer and lode mining in the Kantishna Hills region of the park early in the twentieth century has adversely affected streams, their riparian zones, and some uplands. When the price of gold increased in the 1980s, there was a resurgence of mining in the park. Restoration of these mined areas is another park preservation concern that relates to mineral extraction.

All federal lands within Wrangell-St. Elias are closed to new mineral entry. ANILCA provided for the continuation of existing patented and valid unpatented mining claims on which there exists the potential for mineral development. There are currently a total of

316 patented and 27 unpatented mining claims and mill sites covering an estimated 2,516 hectares (6,290 acres) of private lands and 196 hectares (491 acres) of federal lands with mineral rights. The primary economic commodities are copper and gold. Owners of valid existing mineral rights have the right to develop adequate and feasible access across public lands.

Currently, there are three approved mining plans of operations for mines in Wrangell-St. Elias. Small-scale placer mining and hard rock mineral exploration have occurred since the park was established. Regulations promulgated from the 1976 - Mining in the Parks Act control mining related activities on federal claims within units of the National Park System. Future proposals to develop the mineral properties within Wrangell-St. Elias are highly probable. An Environmental Impact Statement was prepared to evaluate a range of alternatives for managing mining activities, analyze cumulative impacts and mitigate environmental impacts. The Record of Decision - Final Environmental Impact Statement - Cumulative Impacts of Mining – Wrangell-St. Elias preferred alternative was to acquire all mining claims. This alternative is the most environmentally preferred because if the mining claims are acquired, mining would not occur. Initially, funding was not available for acquisition, and the NPS was directed to process mining plans of operations and prepare environmental assessments as required by the National Environmental Policy Act. Funding to acquire mining claims was first appropriated in 1998, and since then the park has pursued acquisition of mining claims from willing sellers.

In addition, there are approximately 278,372 hectares (695,930 acres) of non-federal lands (mostly native lands) within Wrangell-St. Elias, some of which cover known mineral belts and potential hydrocarbon fields. These may host economically extractable resources. Limited regulatory authority exists for controlling mineral development on these non-federal lands within Wrangell-St. Elias.

There are an estimated 400 sites in Wrangell-St. Elias where mineral exploration and/or development occurred in the past. Many sites have been identified but not inventoried. Impacts to the landscape, vegetation, soils, fluvial systems persist. Some of these sites also pose threats to visitor safety.

A recent issue in Wrangell-St. Elias concerning private inholdings stemmed from a massive spruce bark beetle infestation. The infestation was widespread in central Alaska, and killed mature white spruce trees on 100,000 hectares (400,000 acres) within the administrative boundary of Wrangell-St. Elias. Many of the dead trees in the park were on lands owned by Native Corporations, and salvage logging, which would have required new roads, was planned. Economic factors prevented substantial logging from occurring, but for several years, this issue was promiment. A major research effort was launched which resulted in significant advancement of understanding of Copper River Basin forests and their response to a major natural disturbance (Wesser and Allen 1999).

Park-specific Concerns

Some resource preservation concerns are unique to the individual parks in the network. Currently, two such concerns are apparent and worth separate discussion. These are coastal concerns for Wrangell-St. Elias, and military training overflights for Yukon-Charley.

Coastal Concerns in Wrangell-St. Elias

Unlike the other parks in the network, which are landlocked, Wrangell-St. Elias includes 201 kilometers (125 miles) of coastline and 558 hectares (1,395 acres) of intertidal lands. The coastal area of Wrangell-St. Elias also includes rapidly moving tidal glaciers, whose advances and retreats create an especially dynamic environment. Resource preservation issues relating to Wrangell-St. Elias coastal areas mainly concern marine mammals and birds, and lack of information about their population status and trends.

The status of harbor seals in Wrangell-St. Elias, specifically Icy Bay, is largely unknown, yet these areas appear to be important breeding and feeding grounds. Several factors may affect seal and sea lion populations in this area. Local residents have reported declines in Steller's sea lions in Yakutat Bay. A sea lion rookery/haul out area along the Malaspina forelands supported about 200-300 animals in the early 1980s. Harbor seals may be experiencing similar declines but no data are available. Proposed development of private lands in the Icy Bay area could affect unstudied pinniped populations. Offshore oil leasing in the northern Gulf of Alaska may occur west of Icy Bay and south of Yakutat Bay. Marine mammals are at risk from potential oil spills and pollution if oil is developed in adjacent offshore areas. Logging is occurring along west and east of Icy Bay. Increases in logging-related boat traffic may disturb seals. Increases in tourism in Icy Bay by cruise ships and kayakers trying to observe calving glaciers may also disturb seals hauled out on ice bergs. Commercial fishing occurs throughout Yakutat Bay and may affect seal populations.

Steller's sea lion populations in western Alaska have declined severely since the early 1980s. Decreasing population trends were first documented in the eastern Aleutian Islands, where they are most dramatic, and later in the central Gulf of Alaska. From 1956 to 1985 populations from the central Gulf of Alaska to the central Aleutian Islands declined 52%. As a result of these documented declines, the Steller's sea lion was declared threatened under the U.S. Endangered Species Act in November 1990. As with harbor seals, Steller's sea lion populations in southeast Alaska do not appear to be declining, although monitoring efforts here have been patchy and information from Wrangell-Saint Elias suggest declines may be occurring in the Yakutat area.

Marbled and Kittlitz's murrelets are two marine bird species whose populations have declined in some areas in recent years. Wrangell-St. Elias coastal areas could be important, especially for Kittlitz's murrelets, who favor glacial waters for feeding. Recent surveys in 2002 should reveal the relative importance of Wrangell-St. Elias coastal areas to these and other marine birds.

Military Training Overflights in Yukon-Charley Rivers

Fairbanks, located only 160 kilometers (100 miles) southwest of Yukon-Charley, is home to Eielson Air Force Base. Eielson supports the northernmost U.S. fighter wing in the world, the 354th Fighter Wing. Their Thunderbolt II and F-16 Viper aircraft provide the United States with combat ready forces capable of reaching anywhere in the Northern Hemisphere at a moment's notice. Eielson is also home to Cope Thunder, the largest aerial exercise in the Pacific region, held four times a year. To support training of the 354th Fighter Wing and Cope Thunder exercises, a number of Military Operations Areas have been established. Because of its proximity to Fairbanks, Yukon-Charley falls within some of these Military Operations Areas.

Four Military Operations Areas cover the entirety of Yukon-Charley. These Military Operations Areas support low to medium flight intensities. Projected military traffic is 7 to18 aircraft per day during routine training, and 164 to 206 per day during Major Flying Exercises (Lawler and Haynes 1998). Supersonic activity is allowed at or above 1,524 m (5,000 ft.) above ground level. Flight restrictions occur seasonally along the Yukon, Charley, and Kandik river corridors in order to protect nesting peregrine falcons, and over the Cirque Lakes area in early summer to protect Dall sheep during lambing. The Federal Aviation Administration recommends a minimum altitude of 610 m (2,000 ft.) above ground level for aircraft flying over park and wilderness areas to minimize disturbance to wildlife and visitors. Military jet aircraft flights are most concentrated in the southwest corner of the preserve.

Lacking authority over air space and military operations, the NPS options are limited to determining the effects of flights on its resources. Extreme low-level [under 610 m (2000 feet) above ground level] military flight activities occur throughout Yukon-Charley creating high noise events with occasional sonic booms. Mammalian and avian wildlife species are subjected to various levels of disturbance associated with low-level jet activity. Peregrine falcons, Dall sheep, caribou, grizzly bears, and other raptors all inhabit steep, elevated terrain and are therefore more susceptible to disturbance of low flying aircraft. Aircraft following natural terrain features likely disturb river bluff inhabitants. More frequent jet activity in summer coincides with nesting and parturition times for most raptor, ungulate and predator species. This overlap in activities can potentially exaggerate impacts to populations.

Although not common occurrences, crashes within Yukon-Charley have occurred in the past (DiFolco 1998), and the potential for crashes will increase in the future as jet aircraft activity in Military Operation Areas over Yukon-Charley increases. This brings an additional risk to the resources. Military aircraft carry large quantities of fuel and other hazardous materials that contaminate a large area of soil, vegetation and aquatic

resources when a crash occurs. Containment of spills and other crash impacts is further complicated by military security concerns and the delay in NPS staff receiving access to the site.

Looking Ahead to the Future

If we have analyzed the current resource preservation concerns of network parks correctly, we will be in position to design a long-term monitoring program to provide information that will help current and future park managers preserve resources. But what if the issues change? Is there something obvious we have overlooked? For the program to be robust to future information needs, we need to put some effort into thinking about what future issues might be. By taking a long view, we can build a program that will work, despite our uncertainty about future events (Schwartz 1991).

Vitousek et al. (1997) suggested that human changes in the earth's ecosystems were of two broad types: changes in biogeochemical cycles and adding or removing species. A recent analysis by the National Academy of Sciences reached similar conclusions (National Academy of Sciences 2001). They urged efforts to understand the relationship between biodiversity and ecosystem functioning, which they felt would be of great practical significance.

In terms of the current resource concerns of Central Alaska Network parks, the perspective provided by these strategic analyses of global issues suggests that we should also be thinking about the potential for invasive species to become established in these parks. The question of invasive species is an aspect of an overall biodiversity question and suggests that continuing to gather information about species present in the parks is important. Recent work in Denali, Wrangell-St. Elias and other parks in Alaska has demonstrated the presence of exotic plants associated with road corridors and other access sites [Densmore et al. (2001), and Mary Beth Cook (xxxx)]. Experts at the Central Alaska Network scoping meeting recommended that the potential for ecosystem change due to establishment of invasive species, or range changes of species such as lodgepole pine, not be underestimated (M. Walker, University of Alaska Fairbanks, pers. commun.). The role of climate change in facilitating introduction of invasive species also needs to be kept in mind.

Currently, the major resource preservation concerns of the network parks, although related by access, seem to occupy separate spheres of influence in the network parks. Denali has many visitors, but relatively limited subsistence use, and the main areas used by visitors and by subsistence users do not overlap. In Wrangell-St. Elias, consumptive uses of fish and wildlife are relatively high; visitation is relatively low. In Yukon-Charley, visitation and subsistence are both at relatively low levels and do not generally conflict. With increasing population growth and demand for mineral resources, one can picture visitation and demand for services for park visitors, conflicting with demand for private land development within the parks. Increases in either the visitation sphere, or the private land development sphere, could interfere with consumptive uses of fish and

wildlife, especially subsistence uses. Providing future resource managers with information that could help address these converging trajectories of increasing human uses would be a valuable contribution of the monitoring program. As the selection of monitoring attributes for the Central Alaska Network program continues, we should continually ask ourselves, “How will the data help with these types of concerns?”

Chapter 5 Past and Current Monitoring in CAN Parks and their Neighbors

The Natural Resource Challenge (NRC) represents the first service-wide effort to fund long-term monitoring. While the Inventory and Monitoring portion of the NRC is an opportunity to establish new facets of an ecological monitoring program, it is important to also examine past and current monitoring conducted by parks and their neighbors. Doing so will allow us to build upon those efforts and gain the maximum amount of understanding of park natural resources.

The areas that are now protected in Central Alaska Network parks have long histories of scientific exploration and environmental research. The history of monitoring (repeated data collection) is probably the longest at Denali, since it has been a park since 1917. As ANILCA parks, both Wrangell-St. Elias and Yukon-Charley have shorter histories of NPS supported monitoring. The focus of this section is the current and historic monitoring that is occurring by both the parks and their partners and neighbors.

This chapter is a work in progress, reflecting our initial efforts to gather and organize information about past and current monitoring activities in Central Alaska Network parks. Our “data mining” task also involves the entry of information into the Servicewide databases for existing datasets (Dataset Catalog), literature citations (NatureBIB), and species occurrence information (NPSpecies). Our “data mining” effort is still ongoing and will continue for some time. What we present here is a first, rough-cut. We include Tables 2 and 3 show monitoring efforts we are aware of but for which we did not have time to include brief descriptions for this report.

The focus of our initial search effort was monitoring conducted by the parks; we have yet to conduct a comprehensive search of efforts by other agencies. However, in our search of existing efforts by parks, we found many efforts by other agencies that are integral to natural resource management in Central Alaska Network parks, and these are included here.

We present the monitoring efforts in the following order: physical environment (e.g., weather, air quality, snow, glaciers), aquatic (including water quality and quantity, aquatic invertebrates and fish), vegetation, birds, and mammals. We first review historic efforts, then describe current monitoring. To comprehensively show the monitoring efforts in each park, Figures 5-7 illustrates by park (Yukon-Charley, Denali, and Wrangell-St. Elias, respectively) where efforts have taken place.

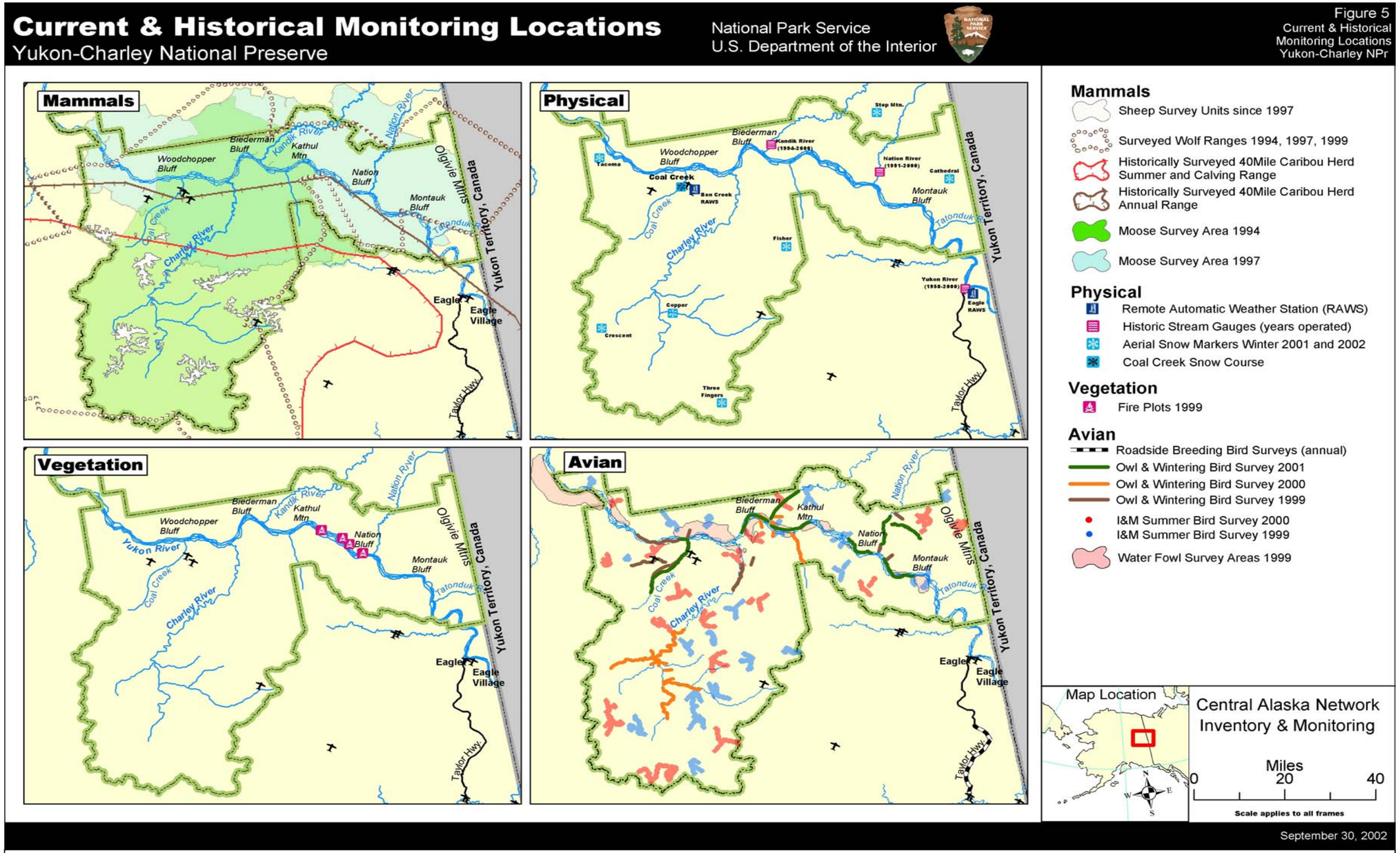


Figure 5. Current and historic monitoring for Yukon-Charley Rivers National Preserve, AK.

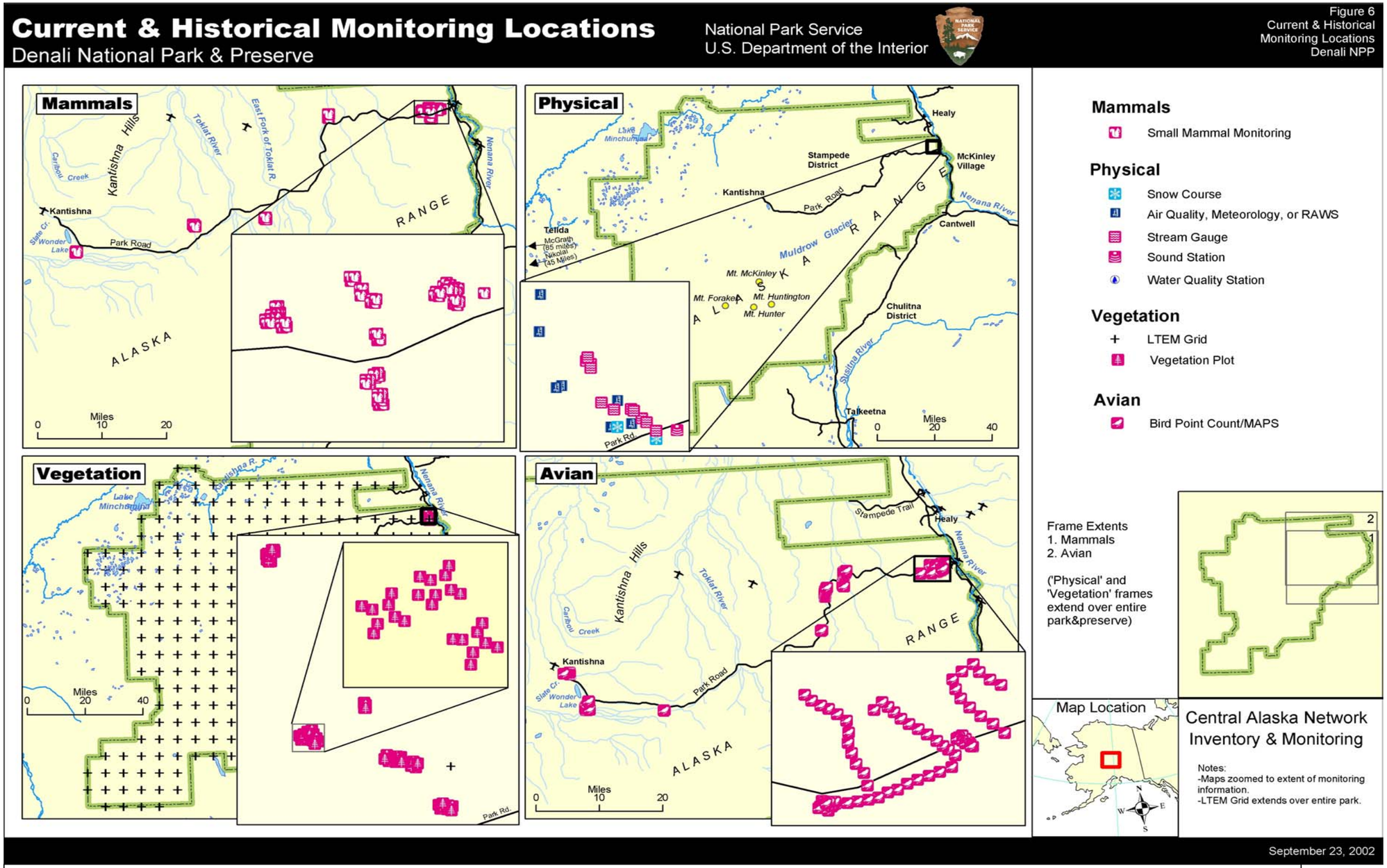
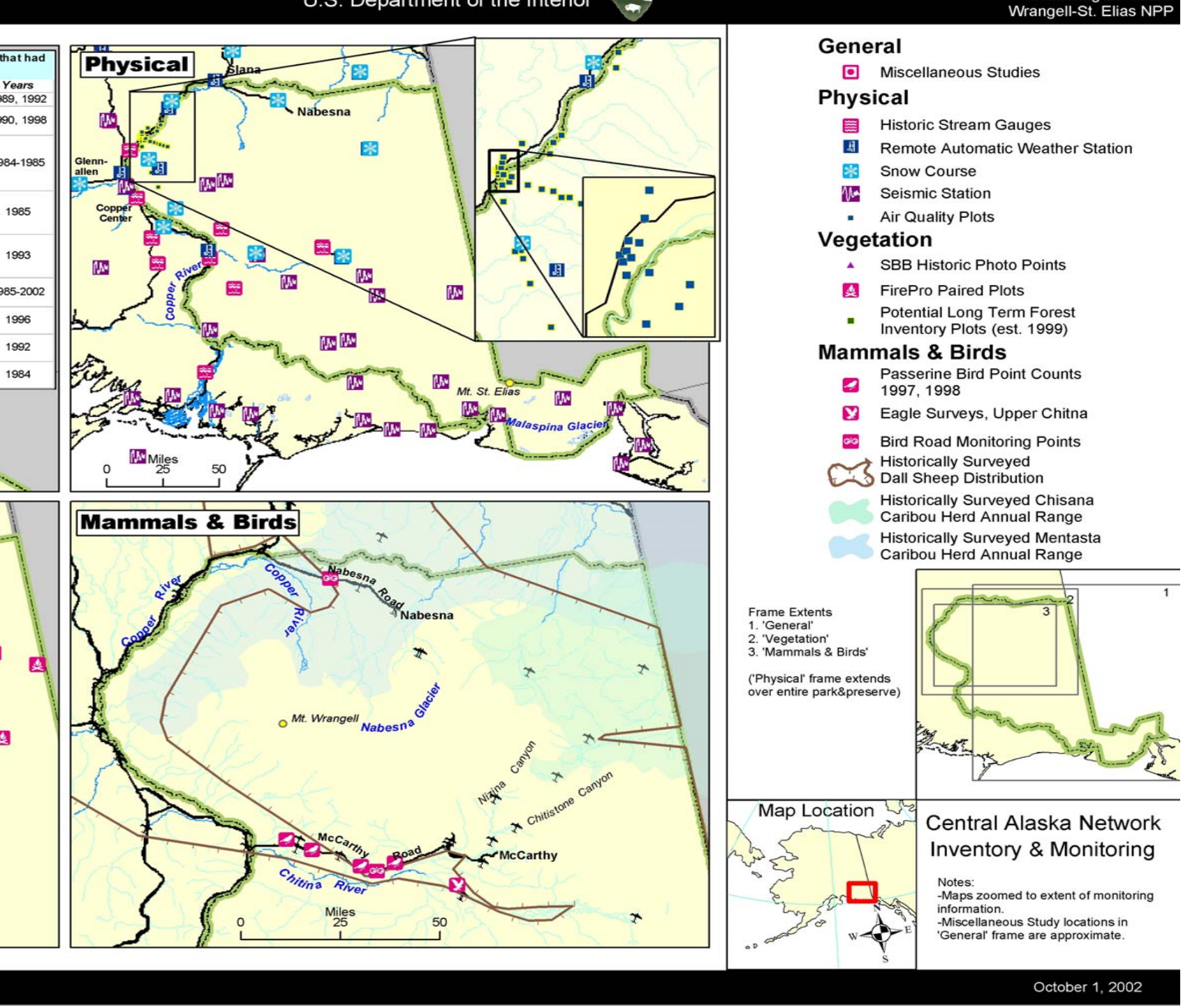


Figure 6. Current and historic monitoring at Denali National Park and Preserve.



St. Elias National Park and Preserve.

Physical Environment

Features of the physical environment within Central Alaska Network parks that are monitored include weather, air quality, ultraviolet-b radiation, seasonal snow characteristics, and glaciers. Except for glacier monitoring at Denali, the parks conduct none of these efforts independently. These monitoring programs are generally conducted in partnership with others as part of national or statewide programs. The partners include the National Weather Service (weather), Alaska Fire Service (weather), Environmental Protection Agency (ultraviolet B radiation), Natural Resources Conservation Agency (snow), and the National Park Service Air Quality Division (air quality).

Weather

Weather conditions in Central Alaska Network parks are monitored in a variety of locations by two main programs: the National Weather Service and the Alaska Fire Service. These programs are aimed at providing real-time weather data for aviation, fire management, and other human activities. At Denali, a number of additional weather monitoring activities also occur.

National Weather Service - The National Weather Service operates weather stations at an array of sites in the Central Alaska Network region; only two are located actually within a park: one at Denali Park Headquarters and one at McCarthy. The nearest site to Yukon-Charley is at Eagle. A number of sites are located around the perimeter of Wrangell-St. Elias, including Yakutat, Chitina, Gulkana, Slana, Nabesna, and Northway. Sites near Denali include Healy, Nenana and Minchumina. Many of the sites have been operated continuously since 1949, but others have been operated intermittently. Data at these sites are collected daily and include temperature and precipitation. Data are available on the web at: http://www.wrcc.dri.edu/summary/climsmak.html.

The Denali Park Headquarters record is the longest climate record from a mountainous site in western North America (Juday 2000). These data are affectionately referred to as the “doggy data” because the weather station is located in the dog kennels at park headquarters. The doggy data are of great interest to many researchers and are one of the most frequently requested data sets from the park (Sousanes 2000). They can be found at the aforementioned website operated by the National Weather Service, as well as at http://fnemd-1.iab.uaf.edu/statserver/

Alaska Fire Service - The second type of weather monitoring that occurs in Central Alaska Network parks is conducted as part of the wildland fire management program of the U.S. Department of the Interior. This program, managed by the Alaska Fire Service, collects current weather, primarily during the fire season, for use in fire behavior modeling. These data are collected via Remote Automated Weather Stations, referred to as RAWS. The stations remotely transmit data every hour. The attributes measured include air temperature, average wind speed and direction, peak wind speed and direction, precipitation, relative humidity, fuel temperature and solar radiation.

There are currently a total of 19 RAWS in or near Central Alaska Network parks. In north central Yukon-Charley, stations are located just to the east of the preserve in Eagle, and at Ben Creek. These RAWS are maintained year round. Data may be intermittent during periods of low light in the winter. In and near Denali, RAWS are located 7 sites: Healy, Ruth Glacier, Talkeetna, Telida, Lake Minchumina, McKinley River and Wonder Lake. In and near Wrangell-St. Elias, RAWS are located at 10 sites: Jatahmund Lake, Kenny Lake, May Creek, Northway, Slana, Tazlina, Chisana, Chitina, Gulkana, and Chistochina. Weather data from all Alaska RAWS are immediately available on the Internet at http://fire.ak.blm.gov/scripts/wx/viewctrl.asp.

Additional Weather Monitoring at Denali - In addition to the National Weather Service and Alaska Fire Service programs, several other weather monitoring efforts occur at Denali. The Denali Long-term Ecological Monitoring Program includes the operation of 6 weather stations in the Rock Creek watershed near park headquarters. These stations were established in 1992. These weather stations are arrayed on an elevational gradient from 724 m (2,367 feet) to 1346 m (4,400 feet). The Denali Long-term Ecological Monitoring Program has recently begun coordinating with the park's Maintenance Division to record snow depths and temperatures along the park road corridor. The addition of air temperature and relative humidity sensors along the road will provide valuable information for both the practical and scientific aspects of the road corridor conditions. Weather data are also collected at the air quality monitoring site at Denali Park headquarters because weather data are needed to interpret air quality data. The latest developments in weather monitoring at Denali include the establishment of a high-altitude weather station on Mt. McKinley and the addition of weather stations with satellite telemetry capabilities at Toklat Road Camp, Stampede Mine Airstrip, and Dunkle Mine Airstrip.

Air Quality

The only air quality monitoring site in Central Alaska Network parks is located at Denali. The air quality monitoring program has been operating without interruption since 1980. It is primarily funded through the National Park Service's Air Resources Division, which manages a nationwide network of stations. The goal of air monitoring is to track the spatial and temporal trends of airborne contaminant concentrations through a nationwide array of monitoring stations. The air quality station at Denali includes monitoring instruments from various nationwide air quality monitoring networks, including:

- National Atmospheric Deposition Program (NAPD)
- Interagency Monitoring of Protected Visual Environments (IMPROV)
- National Park Service Gaseous Pollutant Monitoring Network (ozone)

Support from the Denali Long-term Ecological Monitoring program supplements the national program funding, and allows park and regional goals to be met in addition to the nationwide objectives funded by the Air Resources Division. Recently some additional air quality monitoring near Denali has been conducted in relation to the Healy Coal Mine.

In the past, air quality monitoring at Denali has been restricted to measurement of the air. Recently, there has been interest in also monitoring for air pollution effects, and the Western Region of the NPS has created the Western Airborne Contaminant Assessment Program. As part of this program, lichen samples were collected in Denali in 2002 to support the development of protocols to assess airborne contaminant accumulation and effects in lichen communities. Results of this work will guide protocol development for air pollution effects monitoring in Alaska.

Ultraviolet Radiation

As for air quality, the only monitoring site for ultraviolet-B radiation within the network is at Denali. In September 1996, the National Park Service and the U.S. Environmental Protection Agency signed an interagency agreement to cooperate on a program of long-term monitoring of environmental stressors in National Park System (NPS) units and research the effects of the stresses on ecosystems. This program is called the Park Research and Intensive Monitoring of Ecosystems Network (PRIME Net). Denali was selected as one of the PRIME Net locations, and a Brewer spectrophotometer was set up at Denali Park headquarters, adjacent to the air quality monitoring site.

A Brewer spectrophotometer measures different wavelengths of light and focuses on the ultraviolet spectra (UV-B radiation is in the 300-320 nm range of light). The instrument tracks the sun as it monitors the variation in solar irradiance throughout the day. It also records other data such as total column ozone and ambient concentration of gases. These data are then used to calculate the dose of ultraviolet radiation at the surface of the Earth. Because of the influence of sun angle, clouds, and other forms of air pollution, the seasonal variation in UV-B detected at the surface is large. Therefore, it will take many years of monitoring to detect trends in the incidence of UV-B.

Seasonal Snow Cover

Central Alaska Network parks are covered by snow for 8-9 months a year, and the timing, depth, and condition of the snow cover are important for understanding hydrological conditions and many other aspects of the regional ecosystem. As for weather, monitoring of the seasonal snow cover is accomplished in cooperation with other agencies, in this case, the U.S. Department of Agriculture's Natural Resource Conservation Agency (NRCA). NRCA establishes a variety of snow measurement systems (e.g., aerial snow markers, snow pillows) in major watersheds throughout the state to allow prediction of annual water supply.

Within Central Alaska Network parks, snow measurements have been made at Denali for many years. The 10 snow course and aerial markers located in and around Denali are visited on a monthly basis during the snow season, usually November through May. In 2002, additional snow markers and courses were added to more effectively cover variable terrain and integrate with other long term monitoring programs. Two additional snow courses were installed in the summer of 2002 at Stampede Mine Airstrip and Dunkle Mine Airstrip. These sites are co-located with new weather stations installed at the same

time. Additional aerial markers were established at sites on the south side of the range near the Eldridge Glacier, Tokosha Mountains, Upper West Fork Yentna, the confluence of the Lacuna and Yentna Glaciers, and near the Pika Glacier.

Snow measurements have not been made at Yukon-Charley until very recently. In 2001, 6 aerial markers were established at a diversity of sites that represent various elevations, slopes, aspects and terrain. Markers are read from the air with via Cessna 185 planes within 2 days prior to 1 November, 1 December, 1 January, 1 February, 1 March, 1 April and 1 May. During winter of 2001-02, a snow course was also established at Coal Creek. The course consists of 5 stations spaced every 5 m. Prior to establishment of these sites in Yukon-Charley, the only snow information for this area was from Mission Creek in Eagle. At this site, a snow pillow, snow course, and precipitation gauge are used to obtain snow density, depth and water content.

The NRCS measures snow at a number of sites in the vicinity of Wrangell-St. Elias. These include snow courses at Chistochina, Dadina Lake, Jatahmund Lake, Kenny Lake, May Creek, Mentasta Pass, Sanford River, Tazline, and Tolsona Creek.

All snow course data are compiled by major river basin and published by the NRCS. The data are available at their web site: http://www.ak.nrcs.usda.gov/

Recently, additional snow monitoring has been conducted at Denali in relation to snow machine activities in the park. The current effort is a special study but could be continued into the future, depending on management needs. In this project, the physical aspects of the snowpack that allow adequate support of snowmachine travel without causing adverse impacts to vegetation and soils are measured. In 2002. the depth and density of the snowpack in the Broad Pass area south of Cantwell, and along the Stampede Corridor were studied by visiting established sites on a bi-weekly schedule. The study began in the early season (late November-December) to determine if the areas used by snowmachiners and within the boundaries of the park had adequate snowcover for travel without disturbance to resources.

Glaciers

Currently, glacier monitoring within Central Alaska Network parks occurs only at Denali. However, glaciers in Wrangell-St. Elias have received extensive study by glaciologists. Some of these studies are long-term, but we have not yet evaluated their potential role in the network. The U.S. Geological Survey operates two long-term glacier monitoring sites in Alaska as part of its Benchmark Glacier Program. These include the Gulkana Glacier (located in the Alaska Range north of Wrangell-St. Elias and west of Denali) and the Wolverine Glacier (located on the Kenai Peninsula).

At Denali, glacier monitoring is included in the Denali Long-term Ecological Monitoring Program. Since 1991, mass balance measurements are conducted on two index glaciers (Traleika, Kahiltna) and a benchmark glacier (East Fork Toklat), maintaining one of the longer glacier monitoring records in Alaska. Measurements of mass balance and

movement are made in late May and early September, at the end of the accumulation and ablation seasons. Benchmark glacier monitoring is more intensive than index glacier monitoring, and eleven long-term measurement stakes are surveyed and assessed for mass balance trends in 2002. In addition, cooperation with the second year of a three-year project, three field surveying campaigns were completed on the Muldrow glacier to characterize "normal" glacier movement (as opposed to "surging" movement). An identified trend in the historical movement patterns of the Muldrow glacier suggests that a dramatic surge could be imminent (within a few years).

Aquatic Environment and Biota

Compilation of current monitoring of water quality, quantity and biological attributes of water bodies in Central Alaska Network parks is still underway. Monitoring of the aquatic environment relies heavily on the U.S. Geological Survey (USGS) for water quantity and water quality measurements. Currently, biological monitoring of aquatic resources is minimal.

Water Quantity and Quality

Within Yukon-Charley, the USGS maintained water flow gauging stations on the 70-mile River and Alder Creek from 1910-1912. Flume Creek was monitored in 1910 and 1913. The Kandik River was monitored from 1994-2000, the Nation River from 1991-2000 and the Yukon River at the town of Eagle from 1950-2000. There are presently water flow gauging stations on the Yukon (by Eagle), Nation and Kandik rivers, which are maintained by the USGS. Water level measurements are used to equate discharge. Current data and historical information is available on the Internet for every half-hour interval (http://www.ak.water.usgs.gov).

At Wrangell-St. Elias, USGS gauging stations have been operated in and around the park for many years, however few of them (6 of 17) have been located within the boundaries. There are currently no active gauging stations within Wrangell-St. Elias. The longest record is from 1950-1990 just outside the boundary of the park on the Copper River near the town of Chitina. Most other records are 3-6 years in length and range from the early 1900's to the late 1970's.

At Denali, water flow measurements of Rock Creek were made as part of the Denali Long-term Ecological Monitoring program, but these have been discontinued. An inventory of water quality in Denali streams was conducted in the mid-1990s. A cooperative study with USGS was initiated in 2001 at Denali to determine the occurrence and distribution of polyaromatic hydrocarbons in park aquatic environments. Semi-permeable membrane devices designed by USGS scientists at the Columbia Environmental Research Center to mimic the bioconcentration of hydrophobic organic contaminants. The devices were deployed in stream systems in Denali to collect polyaromatic hydrocarbons over an extended period of time.

In Wrangell-St. Elias, baseline limnological studies were conducted of Copper, Tanada and Prtarmigan Lakes in 1993. These lakes are sites the park has identified as being likely to be developed and the information is intended to serve as a baseline to assess rates of lake eutrophication.

Biological Monitoring of Aquatic Habitats

In 1992 macroinvertebrate sampling began in Rock Creek in Denali. The goal of the sampling was to develop a baseline data set, and establish methodologies that could be used for long-term ecological monitoring. However, data collected in 1992-1993 showed that Rock Creek supported only 3 taxa. Therefore, in 1994, 27 sites along the park road were examined for the presence of macroinvertebrate taxa. Results from this work showed that streams and rivers could clearly be divided into separate groups based upon their invertebrate fauna. Protocol development for macroinvertebrate monitoring in Denali streams has continued to the present, and recommended protocols are expected this year.

The only other biological monitoring of aquatic habitats in Central Alaska Network parks is of salmon. In Yukon-Charley, the Alaska Department of Fish and Game began conducting surveys for spawning salmon in the early 1970's, prior to the establishment of Yukon-Charley as a preserve. Summer chum salmon and fall King and coho salmon are counted from fixed-wing aircraft on the Charley, Nation, Kandik, Tatonduk, and 70-mile Rivers. The surveys are conducted at least every 3 years and are dependent on availability of money, suitable weather and qualified observers.

In Wrangell-St. Elias, Tanada Lake provides spawning and rearing habitat for two sockeye salmon. In 1991, monitoring was initiated on the lake to 1) determine if variations in water quality and zooplankton biomass correlate with variations in adult sockeye salmon escapement into the lake; 2) to determine if lake productivity is affecting juvenile sockeye survival. Two sampling stations were established in1991. Each station is sampled 6 times (once a month) beginning in late May at breakup (ice-off) through the end of October (approximate time of ice-on). Water samples at each station are taken at 1 m and 40 m. Parameters measured include; temperature and dissolved oxygen profiles to a maximum depth of 55 m, light penetration, conductivity, total dissolved solids, pH, alkalinity, hardness and secchi disk transparency. Water samples are analyzed for total solids, total dissolved solids, suspended solids, total phosphorus, total filterable phosphorus, total Kjeldahl nitrogen, total ammonia, nitrate & nitrite, reactive silicon, particulate organic carbon, total particulate phosphorus, total particulate nitrogen, chlorophyll *a* and phaeophytin.

Vegetation

At Yukon-Charley, landcover classification maps of vegetation community types were created in 1998 with 1991 Landsat TM satellite imagery (Ducks Unlimited 1998). Due to the large role that fire and succession play in the Yukon-Charley ecosystem, it is important to update landcover maps. Not only do large areas directly burn within the preserve within a ten-year period, but an even larger percent of the preserve is in early successional stages (10 – 30 year old burns) that are known to change rapidly in structure and composition. Yukon-Charley vegetation maps need to be viewed as dynamic products that need periodic updating in order to monitor landscape changes in vegetation and be useful for wildlife habitat studies. Currently, there is no program for vegetation monitoring at Yukon-Charley.

A fire effects study in the Upper Yukon area includes plots within Yukon-Charley. Fifteen randomly located permanent plots were established in September 1999 in order to examine vegetation recolonization rates and succession following fire in black spruce forest. All plots are accessible by riverboat and by foot. Study plots are arranged along 4 randomly chosen transects that are ≥ 2 miles apart. Each transect has 3 – 4 plots that are placed 200 m apart. Plots are circular with a 10 m radius. Point intercept methods are used to obtain percent cover of all vegetation species. Depth of active layer is sampled concurrently at intercept points. Photo points were established, and standing dead, downed dead and tree density and DBH were measured.

Vegetation monitoring has been an important component of the Denali Long-term Ecological Monitoring program since its inception in 1992. The approach for vegetation monitoring was modified in 2001 in response to reviewers comments received in 1997. The present objective of the program is to detect landscape-level changes in the vegetation cover of the Park that occur over decadal time scales via randomly chosen permanent plots. More intensive monitoring will continue to take place in the Rock Creek watershed, which was the original focus area of the monitoringprogram. Across elevation gradients of forest, treeline and tundra, white spruce reproduction and seed germination are measured, and permanent vegetation plots are measured every eight years. In the future it is anticipated that for a small subset of the landscape-level permanent plots process-related variables such as growth and reproduction of tree species and vegetation phenology will be examined.

At Wrangell-St. Elias, a major study of the effects of a spruce bark beetle infestation that occurred in the mid-1990s was made. Part of this study included establishment of permanent plots with the intention of revisiting them. This study also established permanent photo points at a number of sites, including along the McCarthy road.

Birds

Only one park in the network, Yukon-Charley, has conducted an intensive inventory of bird populations to assess overall presence and distribution of birds. In 1998, Yukon-Charley was selected to receive funding from the NPS Servicewide Inventory and

Monitoring Program to conduct this intensive inventory work on birds. The goals of the project were to: 1) design and implement an avian inventory plan in Yukon-Charley with methodology suitable for large parks and preserves that have minimal access and; 2) to obtain geographic data layers to characterize habitat. Specific objectives for the inventory included determining associations between bird abundance by species and habitat characteristics during the breeding season and to extrapolate the information to obtain park-wide abundance and distribution estimates. The program also sought to document owl species presence/absence by ecological subsections.

A variety of bird monitoring occurs in Central Alaska Network parks. The efforts are focused on waterfowl, raptors and passerines. Some seabird surveys have also occurred along the Wrangell-St. Elias coast.

Waterfowl - An annual count of trumpeter swans was conducted in Wrangell-St. Elias from 1984-1992. Population size, annual breeding effort and locations of brood rearing and staging areas data were collected. The U.S. Fish and Wildlife Service conducts swan surveys, generally every five years, and portions of Denali have been included in that monitoring effort.

Raptors - At Wrangell-St. Elias, surveys were initiated in 1989 and continued until 1994 to document the presence and distribution of bald eagle nest sites along the Copper and Chitina River corridors. Yukon-Charley has partnered with the U.S. Fish and Wildlife Service to monitor occurrence and productivity of peregrine falcons nesting along the Yukon and Charley Rivers since the early 1980's. Observers float the rivers annually to observe peregrines and produce an annual estimate of their productivity. Golden Eagle and gyrfalcon nesting ecology has have been monitored continuously at Denali since 1988. Work is focused in the northeast section of the park for these species. The goal of this monitoring is to examine nesting ecology of both species and measure survival and sources of mortality of birds.

Passerines - Passerine bird populations are monitored via a variety of methods by various programs. Within Central Alaska Network parks, these include the Breeding Bird Survey, off-road point counts conducted in accordance with Boreal Partners in Flight methods, and the Monitoring Avian Productivity and Survivorship program. The latter program involves use of mist nets to capture birds so they can be marked and recaptured. This allows population parameters such as productivity and survivorship to be measured. Another program that occurs in network parks is the Christmas Bird Count.

The Breeding Bird Survey is commonly called the BBS. The BBS is organized by the USGS and Canadian Wildlife Service and is a continent-wide program that deploys observers on maintained roads. BBS routes are present within Central Alaska Network parks in Denali and Wrangell-St. Elias (Yukon-Charley has no roads). BBS survey routes have been conducted along the Denali park road since 1992. Within Wrangell-St. Elias, BBS routes have been conducted along the Nabesna and McCarthy Roads since 1989. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile

radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete.

In Alaska, where the road system is relatively limited, other methods of documenting passerine bird populations are important. The methodology for this is called the "off-road point count" and has been developed under the Partners in Flight program. Specific off-road point count methods have been developed for Alaska. Off-road point counts have been conducted in all Central Alaska Network parks,

In Wrangell-St. Elias, off-road points counts were initiated near the McCarthy road, the Nabesna road, May Creek and the settlement of Chisana in 1993. Between 8 and 20 routes are conducted annually. Routes are walked and at approximately every 200m, observers listen for all bird calls for an 8-minute period. Additionally, the distance from the observer to the bird is recorded. Off-road point counts were also conducted at Wrangell-St. Elias in 1997 and 1998 at 4 study sites within areas of spruce bark beetle infestation. These sites could be revisited in future years to track response of bird populations to response of the vegetation to the death of mature white spruce trees.

In Yukon-Charley, avian populations are estimated annually in the Coal Creek area by conducting off-road point counts. This work is initiated in 1997. As part of the aforementioned intensive inventory of Yukon-Charley bird populations ,which used a probability-based design, off-road point counts were conducted at many sites in Yukon-Charley. This inventory was designed with the idea that it could be the basis for long-term monitoring of passerine bird populations in the preserve.

In Denali, both on-road point counts (essentially BBS-type surveys) and off-road point counts have been conducted (mainly in spruce forest) in the Denali Park road corridor as part of the Denali Long-term Ecological Monitoring Program. This work continued between 1992 and 2001. In 2002 major changes in passerine monitoring were proposed in response to comments received from peer-reviewers in 1997. The revised objectives of the passerine monitoring are to describe spatial patterns of species distribution and develop indices of species relative abundance. In addition passerine monitoring would also describe and assess the spatial and temporal variability of bird assemblages and describe how passerine populations and communities respond to changes in vegetation and climate. Pilot work to assess the co-location of passerine and vegetation monitoring was undertaken in 2002 on the park-wide vegetation monitoring plots.

Mist netting of passerines under the Monitoring Avian Productivity and Survivorship Program has also occurred at Denali as part of the Denali Long Term Ecological Monitoring Program. Mist net stations have been operated in Denali since 1992. Results from Denali stations are thought to be essential for understanding population trends of passerines on a continental scale in North America. Peer reviews of the Denali program in 1996 and 1997 suggested the program needed to address several issues to best serve the needs of Denali. The peer reviewers also suggested that a thorough review of the data collected to date. The U.S. Geological Survey (USGS), Biological Resources Division, Alaska Science Center is currently spearheading an analysis of the mist net data on a

statewide scale. Results from these analyses will provide Denali and the network with guidance on if and how to continue the mist netting program.

Mammals

Mammal populations monitored in Central Alaska Network parks include small mammals, furbearers, snowshoe hares, wolves, grizzly bears, caribou, moose, Dall sheep, and mountain goats. In Wrangell-St. Elias and in Yukon-Charley, monitoring of ungulates and wolves is conducted by or in close cooperation with the Alaska Department of Fish and Game in relation to harvest management. In Denali, a long-term study of wolf-prey relationships has been conducted, continuing work started by Adolph Murie in the 1940s.

Small Mammals - Monitoring of small mammal population dynamics in the road corridor of Denali has been conducted since 1992. In 2002, the eleventh year of sampling in the Rock Creek watershed was conducted in an effort to document patterns of inter- and intra-annual variation in small mammal abundance. Other sites in Denali where small mammal populations have been monitored include the west end of the park road along the McKinley Bar trail, and at two additional locations along the park road (Teklanika River and Stony Creek).

Furbearers and snowshoe hares - In Yukon-Charley, track surveys of marten, lynx, fox and snowshoe hares were conducted beginning in 2001 using aerial videography techniques. The purpose of this effort is to develop and test the methodology, with the expectation that the method will be used in many locations in Interior Alaska to track population indices for furbearer species. Annual track counts will provide an index to population trend, as well as provide animal locations for habitat selection analyses. Random transects will be placed across the landscape and will be flown at approximately 500 ft above ground level. High-resolution digital video footage is taken from a camera port in the belly of a Cessna 185. A global positioning system (GPS) is linked into the camera system so as to assign XY coordinates to each video frame. Visibility correction factors are presently being developed for different terrain and habitat types. Footage is viewed in the office and data in entered into a database that includes track species, location, days since snowfall and various habitat parameters. Surveys will be repeated every 3 years in order to monitor changes in population size, distribution and habitat selection. This effort will be continuing in 2002 to finish development of the monitoring protocol.

In Wrangell-St. Elias, another method of evaluating snowshoe hare abundance has been used. An index of snowshoe hare abundance is determined based on hare pellet transects. Each year, hare pellets are enumerated along predetermined transects along the McCarthy and Nabesna roads, along May Creek and near the settlement of Chisana. This methodology is based on that used at the Kluane boreal forest study site in Yukon Territory, Canada.

Wolves - In Yukon-Charley, wolves are presently being monitored using radio telemetry methods. This monitoring effort is in response to a wolf sterilization program being conducted by the Alaska Department of Fish and Game in areas adjacent to the preserve. Wolves that reside in Yukon-Charley are exempt from the program and are being used as a reference population for the sterilization effort. This wolf monitoring program will continue until sterilization efforts are complete in 2003. After 2003, less expensive and labor intensive snow tracking methods may be employed every 3 years to monitor the Yukon-Charley wolf population, following methods of Becker (1991) and Becker and Gardner (1992).

At Denali, wolf monitoring has been conducted since the 1980s as part of long-term research into wolf-prey dynamics. The overall goal of this work is to monitor population characteristics of wolves and their major prey species (caribou and moose) in sufficient detail to understand the population trends of each species in the context of the interrelationships that comprise the Denali wolf/prey system. This work strives to gain understanding of the roles that winter severity, differential landscape use, and relative vulnerability of prey species play in wolf/prey relationships in Denali and, ultimately, in determining the abundance and population trends of all 3 species.

Moose - Beginning in 1994, aerial moose surveys have been conducted within the northern portion of the Yukon-Charley. This portion comprises 51 percent of the preserve and occurs from the Charley Foothills to the northern preserve border. Methods described in Gasaway et al. (1986) are followed for this survey. Surveys provide estimates of fall population size, sex and age composition and trend across years. At Wrangell-St. Elias, moose surveys are conducted in cooperation with the Alaska Department of Fish and Game and Tetlin National Wildlife Refuge. Trend counts have been determined annually since the 1950's.At Denali, moose population monitoring has been conducted as a part of the wolf-prey study.

Caribou - The Alaska Department of Fish and Game monitors the Forty-Mile Caribou herd whose range includes Yukon-Charley. Radio collars are used to locate the herd in the fall just prior to calving and just after calving. Aerial photo counts are then used to obtain overall population estimates and sex and age composition. Cow:calf, cow:yearling, and cow:bull ratios and population size trends are monitored annually, and this monitoring effort is expected to continue into the future.

In Wrangell-St. Elias, the Mentasta caribou herd is surveyed via a cooperative effort between the park, the Alaska Department of Fish and Game, and the USGS-Alaska Science Center. These surveys were initiated in the early 1970's and are conducted annually.The Chisana caribou herd survey is conducted by the park and the Alaska Department of Fish and Game. The herd has been surveyed annually since the late 1980's.

The Denali Caribou Herd has been monitored intensively as part of the wolf-prey study.

Dall Sheep - Surveys to estimate the population of Dall sheep in Wrangell-St. Elias were initiated in 1949, and have been conducted consistently since the 1960's. For these surveys the park in broken into 31 units and the population is estimated for each unit. In Yukon Charley, aerial sheep surveys are conducted every 3 years in areas available to Dall sheep within the preserve in order to monitor population trends. These areas are broken down into survey units for comparisons between years: 5580 (area along NW border of YUCH), Twin Mountain, Cirque Lakes, Charley River, Sorenson Mountain, Diamond Fork, and Copper Creek. Surveys are conducted from the end of June through the beginning of July during which ewes, lambs, yearlings and rams are counted. When available, a sightability correction factor is calculated from radio-collared sheep to obtain a population estimate. In Denali, the Dall Sheep population has been studied in various years, but no consistent monitoring effort has been conducted.

Mountain Goat - The Alaska Department of Fish and Game conducts a population survey for mountain goats annually on McColl Ridge in the upper Chitina River valley. Fixed-wing aircraft are used for this survey and an index to population size is obtained.

Information Still Being Gathered

At the time of writing of this report, there are current and historic monitoring projects of which we are aware, but still need to collect pertinent information on. The following table indicates those efforts for which documentation efforts are ongoing.

Table 2. Current and historic monitoring in Denali National Park and Preserve for which documentation efforts are ongoing.

Monitoring Project	Current	Historic
Grizzly bears	X	
Spawning salmon	X	
Dall sheep		X
Succession of the Muldrow glacier		X
North American passerine migration count		X
Merlin productivity		X
Fire Pro paired vegetation plots		X
Vegetation succession after fire		X
Tanana valley vegetation succession		X
Riparian zone vegetation structure		X
Assessment of exotic plant distribution along the park road corridor		X
Reclamation and restoration of riparian areas after mining		X
Production and availability of berries		X

Table 3. Current and historic monitoring in Wrangell-St. Elias National Park and Preserve for which documentation efforts are ongoing.

Monitoring Project	Current	Historic
Food Habits and Range Condition of Bison and Sympatric Ungulates on the Upper Chitina River		X
Alaska Shrub-tussock Community Response to Selected All-terrain Vehicle Use		X
FIREPRO Paired Plots 1982-86		X
Vegetation Trends on the Mentasta Caribou Range		X
Inventory of Vascular Flora of the Bagley Icefield		X
Element Concentrations of Baselines for Moss, Lichen, Spruce and Surface Soils in and Near Wrangell-St. Elias National Park and Preserve		X

Part II. Conceptual Models

Chapter 6 Introduction to Central Alaska Network Conceptual Models

Development of conceptual models is a required step in design of the Vital Signs Monitoring Program for each network. This requirement is based on lessons learned about monitoring program design from the NPS experience with its prototype parks program, and from many other monitoring programs. What these lessons demonstrate is that every monitoring effort is based on some underlying understanding of how the ecosystem in question works. This underlying understanding forms a mental model, often not written for others to read and discuss. To ensure a successful monitoring effort, these underlying models need to be explicit and available for discussion, evaluation, and refinement (Maddox et al. 1999).

Part II of the Central Alaska Network Monitoring Plan is reserved for the conceptual models we develop to guide design of the program. In this Phase I report, we include two chapters on conceptual models. This short introductory chapter provides background on conceptual modeling as an integral aspect of ecological monitoring and our general approach to modeling in the Central Alaska Network. The following chapter presents work to date using an ecoregions approach as a broad conceptual framework for further program development.

Reasons for Development of Conceptual Models as Part of Monitoring

Models are purposeful representations of reality (Starfield et al. 1994). Conceptual models provide a mental picture of how something works, with the purpose of communicating that explanation to others. Models (of all types) work best when they include only the minimum amount of information needed to meet the model's purpose (Starfield 1997).

Conceptual models play several useful roles in monitoring program design, including:

- Formalizing current understanding of the context and scope of the ecological processes important in the area of interest;
- Expanding our consideration across traditional discipline boundaries, fostering integration of biotic and abiotic information;
- Facilitating communication among scientists from different disciplines, between scientists and managers, and between managers and the public (Thomas 2001).

The key point about conceptual models is their role in communication among people with different points of view (Abel et al. 1998). Conceptual models can take a variety of forms—from narrative descriptions to schematic diagrams or flowcharts with boxes and arrows. Regardless of form, the success of a model depends on its ability to share viewpoints and develop a common understanding based on multiple viewpoints.

Central Alaska Network Approach to Conceptual Modeling

The Central Alaska Network has decided to focus on Servicewide Goal #3:

> *Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments.*

The network intends to monitor ecosystems to detect change in ecological components, and in the relationships among those components. We seek to build a holistic picture of change in our ecosystems; thus, we primarily desire a landscape level of inference from our observations. This focus of the network is appropriate because Central Alaska Network parks include vast acreages of pristine lands. Presumably, ecosystem processes here are among the least affected by direct human influences. Because human influences are currently less dominant than other influences in Central Alaska Network ecosystems, this network provides an opportunity to understand these influences as they change through time.

How does the goal of the network affect our general approach to modeling? Most importantly, we are looking for holistic models that integrate knowledge about the ecosystems of the Central Alaska Network parks. We are also looking for models that can help us grasp the large spatial scale of the network, without losing focus on processes occurring at smaller spatial scales. Scale issues (both spatial and temporal) are among the most important we have to grapple with (Dayton and Tegner 1984), and which our models must address.

Because one of the reasons Central Alaska Network parks were formed was to preserve subsistence ways of life, we also have a reason to include humans in our holistic models of ecosystem functioning. This view of humans as a natural part of the network landscape should logically extend outside our boundaries. Taken altogether, these ideas suggest the use of models that are as holistic as possible and that take advantage of our understanding of the hierarchical nature of ecosystems.

The Central Alaska Network therefore will begin its conceptual modeling process by exploring the ecoregions of the network. Our intent is that an ecoregions analysis will provide the broadest scale framework for understanding the ecosystems of the network, and within which all other models will fit logically. We have noted that other networks are starting by developing specific models for selected ecosystems (e.g., wetlands, rivers, prairies) within their parks, and we may do that later. The Central Alaska Network

approach is to develop and maintain a broad framework to foster the integration we view as central to our approach.

Next Steps

Publication of this report unveils the first iteration of conceptual models for the Central Alaska Network program. If the modeling process works as we intend, the models will generate discussion among network program managers and scientists. These discussions, and external review of this Phase I report, including these chapters on models, will help guide our next modeling steps. The models will be refined, or torn up and thrown away and new ones developed. In either case, we will view the effort as successful, because we view the process of modeling as more important than the production of models (Starfield 1997). What we learn in the process of building and revisiting our models is key. We also do not want to become so attached to our models that we are not afraid to jettison them when new information (or a new way of looking at things) suggests that a new model is needed.

Chapter 7 Putting Central Alaska Network Parks into Ecological Context

The Central Alaska Network is vast: 8.8 million hectares. The network spans an area that is 650 km from east to west, and 650 km from north to south. Within this broad area, the three parks—Denali, Wrangell-St. Elias, and Yukon-Charley Rivers—are roughly equidistant from each other, with their nearest borders separated by 180-250 km. If the Central Alaska Network were a state, it would be the third largest state, behind Alaska and Texas, and before California—the network is slightly larger than Nevada and Arizona combined. Central Alaska Network parks are 25 percent of the acreage included within the entire National Park System.

Design of a monitoring program for a network of this spatial extent calls for a unifying framework of some type. When the 15 national park system units in Alaska were divided into four Inventory and Monitoring networks, the ecological similarity of the parks was a defining criterion. We have therefore chosen further exploration of an ecoregions approach as a starting point for our conceptual modeling effort. In this chapter, we discuss available information about the ecoregions of Central Alaska Network parks to put the network into ecological context. A short consideration of ecoregions in general, based largely on the concepts of Bailey (1996, 1998), is provided first as background. We conclude with a discussion of the implications of this analysis for further design of the program.

In summary, Central Alaska Network parks occur within four broad ecoregion types defined by the driving forces of climate and landform. These ecoregions span a gradient from maritime to continental climate regimes, and include the mountainous transition zone between them. This mountainous transition zone contains extremely tall mountains with polar climate. This ecoregions analysis provides a useful perspective on a number of topics important in the design of a long-term ecological monitoring program for Central Alaska Network parks, including:

- understanding how the three parks are ecologically similar, different, and related to each other and the lands between them;
- offering a holistic paradigm for considering aquatic resources;
- changing our perspective on the significance of marine influences within what we have considered to be a largely terrestrial setting;
- challenging us to develop a broader understanding of the role of fauna, including humans, in ecosystem processes; and,

- suggesting several potential organizing questions for further discussion.

Ecoregions in General

Land classification is a process of arranging information about land units to understand their similarities and relationships better. In recent years, the ecoregions idea has emerged as the most useful land classification system for supporting sustainable resource management practices (Bailey 1996, 1998). Ecosystem geography is the study of the distribution, structure, and processes of differentiating ecosystems as interacting spatial units at various scales. The resulting synthesis illustrates causal interrelationships. Using causal factors to distinguish ecosystems, starting at the broadest spatial scale, provides a logical hierarchy of ecosystems, with smaller units nested within larger ones.

At the broadest spatial and temporal scales, **climate**, as a source of energy and water, is the common attribute and the prime controlling factor of ecosystems. The major controls on climate are latitude, and for terrestrial regions, continental position, and topography. Continental position is important because it relates to prevailing winds and moisture regimes largely determined by the ocean. Thus, oceanic conditions must be taken into account when trying to understand macroclimate of the continents.

At the next level of controlling factor (for terrestrial regions), we find **landform** and geomorphic processes, which relate to geological substrate, surface shape, and relief. At the meso- and microscales, soil and vegetation patterns derive from landform, because landform controls key factors affecting soil development and plant growth. Within the context set by macroclimate and landform, microscale conditions determine **soil moisture availability,** including permafrost characteristics. Slight differences in slope and aspect modify the mesoclimate to create local climate at any given site. These slight differences in slope and aspect affect soil moisture conditions that determine the vegetation community.

Mountainous regions, with their great altitudinal range and topographic complexity, present a special case in ecoregions definition. Altitudinal zonation (most obvious in vegetation but also seen in animal communities) occurs because increasing altitude affects climate in a manner similar to increasing latitude. Mountain ranges tend to form definable ecological units whose character depends on the climate zone in which the unit lies. The presence of mountains, especially large mountains, modifies macroclimate and is an important determinant of mesoscale ecoregions.

Thus, in defining ecoregions linked by causal factors driving ecosystem properties, climate and landform provide the first level of grouping. To define more specific units (within the context set by climate and landform), we include mesoscale and microscale factors, especially those affecting soil conditions.

A major theme integral to the ecoregions concepts of Bailey (1996, 1998) is that larger systems encompass smaller systems and control the operation of the smaller systems. It follows also that what goes on in one system affects what goes on in other systems.

Another perspective that emerges is how aquatic and riparian systems are closely associated with terrestrial systems and do not need a separate classification system. They are part of the ecosystem pattern for a region. Terrestrial and aquatic components of landscapes are not independent and cannot exist separately. As an example, a floodplain consists of an active channel, former channels, wetlands, and terraces. While each of these component parts differs from the others, the process of floodplain development unites them.

Ecoregions of Central Alaska Network Parks

We now turn to a consideration of the specific ecoregions of Central Alaska Network parks. In considering the ecological settings of these parks, we are fortunate to have the newest ecoregions map for Alaska to work from (Nowacki et al. 2002, Spencer et al. in press; available digitally at http://agdc.usgs.gov/data/projects/fhm/). Prior ecoregions mapping efforts for Alaska used different methodologies and mapping philosophies (e.g., Gallant et al. 1995, Nowacki and Brock 1995). The recent effort took advantage of newly available digital data sets. The most recent effort was also supported by many agencies in recognition that at the statewide scale, a single ecoregions map would be the most helpful in supporting ecologically based management across both agency and ecological boundaries. On the new map, 32 ecoregions are defined (Nowacki et al. 2002). These ecoregions fall into eight divisions aligned along major bioclimatic gradients related to climate, vegetation, and disturbance (Figure 8).

Central Alaska Network parks occur in 12 of the 32 ecoregions defined for Alaska (Tables 4 and 5). Of these 12 ecoregions, only one, the Wrangell Mountains Ecoregion, is wholly contained within the network. Although each of the three parks has at least one ecoregion in common with the other two parks (Tables 4 and 5), overlap among parks at the level of the ecoregion is not great. Looking at the next level up in the hierarchy, the 12 ecoregions found in network parks fall into four ecoregion divisions that span the gradient between boreal and maritime zones (Figure 8, 9). These are the *Coastal Rainforest*, *Coast Mountains Transition*, *Alaska Range Transition*, and *Intermontane Boreal* divisions (see Appendix C for descriptions of ecoregion divisions and ecoregions in the network). Each of these ecoregion divisions within the Central Alaska Network includes substantial acreages in roughly equal proportions (Figure 11).

Thus, the major gradients within the Central Alaska Network range from boreal areas that are dry, have high seasonal temperature fluxes (i.e., continental climate), and where fire is an integral feature of landscape processes, to maritime areas that are wet, have low seasonal temperature fluxes (i.e., maritime climate), and where wind is the main

disturbance factor. In between these areas that are strongly boreal and strongly maritime, lie 2 broad, mountainousunits that are aptly labeled “transitional.” Within this transitional band, dominant factors from both continental and maritime divisions are locally affected by extreme topographic features. The resulting environments have a combination of environmental processes (e.g., boreal forest ecosystems without permafrost).

A Closer Look at Climate

By definition, the main driving force behind the ecoregion types in the Central Alaska Network is climate, warranting a closer look at the climate patterns within the region. Walter Climate Charts (Walter 1963, Walter et al. 1975, Walter 1979) provide a convenient way to summarize and compare climate among sites (see Figure 12 for a guide to reading Walter Climate Charts). Walter Climate Charts for a representative long-term National Weather Service weather station site in each ecoregion division are shown in Figure 13. The strongly maritime site (Yakutat) representing the *Coastal Rainforest Division* (Figure 13d), and the strongly continental site (Eagle), representing the *Intermontane Boreal Division* (Figure 13a) are easily distinguished by differences in precipitation amount and timing, and in temperature ranges. The climate graphs for these sites demonstrate the extremes of climate found within the Central Alaska Network region. Generalized climate—as represented by average annual temperature and average annual precipitation—for sites in and around Central Alaska Network parks shows the ameliorating influence of proximity to the ocean (Figure 14).

Climate patterns in the two transitional ecoregion types are more complex, reflecting the influence of maritime climate interacting with topographic features, namely tall mountains. In the Cook Inlet Basin ecoregion, on the western end of the *Alaska Range Transition Division*, temperatures drop and precipitation increases as one moves from the coast north to the Alaska Range (see the S-N gradient represented by Anchorage, Willow, Skwentna, and Talkeetna shown in Figure 15c). In the Copper River Basin Ecoregion, on the eastern end of the *Alaska Range Transition Division*, the climate patterns (and their causes) are less immediately clear (Figure 15b). McCarthy receives more precipitation than the other sites in the ecoregion (Chitina and Gulkana), presumably due to its position relative to prevailing maritime storms. Interestingly, Slana, on the eastern end of the *Alaska Range Transition Division*, and Denali Park, at the western end, are at similar elevations and have nearly identical climate graphs, demonstrating the appropriateness of the ecoregion classification.

Nabesna (Figure 13c)—which appears to have the only long-term weather record for a site within the *Coast Mountains Transition Division*—has colder temperatures and less precipitation than nearby sites in the *Alaska Range Transition Division*. This climate pattern reflects Nabesna’s position in the rain shadow of the Wrangell Mountains, and more continental location. Within the *Intermontane Boreal Division*, long-term weather data from existing sites suggests a fairly uniform climate (Figure 16).

The Walter Climate Charts are based on weather data collected over, at most, the past 50 years. As such, they provide a useful glimpse at present-day climate in Central Alaska Network parks. Climate as a driving force in ecological systems, however, is a long-term phenomenon. We must also consider what we know about long-term climate patterns. Pleistocene history (i.e., Was it glaciated or not?) is clearly also an underlying factor in the definition of the ecoregions of Central Alaska Network parks. The *Intermontane Boreal Division* was not glaciated and was part of the Beringian corridor (Pielou 1991). The other ecoregions in Central Alaska Network parks were glaciated during the Pleistocene, and the present-day glaciers of Denali and Wrangell-St. Elias represent a significant percentage of the perennial ice in North America still remaining from the most recent ice age (Pielou 1991:6). (From a global perspective, and certainly from a North American perspective, this seems like a unique feature of the network's ecology). Pleistocene history is therefore also a major driver of present day ecological conditions within Central Alaska Network parks.

From a purely climatological perspective, we can now create a conceptual model of how the ecoregion types of Central Alaska Network parks relate to one another. We can also see what forces outside the network are important drivers of conditions within the network. In simplest terms, this model might be something like what is depicted in Figure 17. The outside drivers include conditions in the Northern Gulf of Alaska, the Bering Sea, and to the north, the summer and winter positions of the Arctic Front. Within the network, the mountainous ecoregions capture moisture coming off the ocean and block its path to the interior regions of the state. To understand the climate patterns within the network per se, we clearly need to be aware of climate patterns in a much larger area (Stenseth et al. 2002).

A Closer Look at Landforms

[This section will address the next driving force down from climate--the geology aspect leading to soils, etc. at the scale of the entire network. This section should also address the geologic drivers that affect water body type and distribution within the network.]

Vegetation

[*This section will address vegetation patterns at the scale of the network and the ecoregional types within.*]

But What About Fauna?

The ecoregions classification splendidly integrates all the major components that we think of when defining ecosystems, except for fauna. How do fauna fit into this ecoregions scheme? For fauna to be used in defining ecoregions, they would have to exert major influences that determined ecosystem properties. Animals, by their adaptability and mobility, generally have much broader distributional ranges than

ecoregions. This leads to a perplexing question: Are animals important or not to the ecoregion classification? To answer this question, we can make a preliminary examination of faunal species occurrence within the parks to see how fauna fit into the ecoregions context. We can also review the growing body of literature that attempts to shed light on the role of animals in ecosystem processes.

Vertebrate faunal communities of Central Alaska Network parks appear to be generally similar, although Wrangell-St. Elias has additional species because of its coastal location. For mammals, 41 species are in common between the three parks, with Wrangell-St. Elias having an additional ungulate species (mountain goat), and several marine mammal species. For fish, network parks have many species in common, although broad scale distribution patterns are more complex than for mammals. Denali has the fewest fish species. Yukon-Charley has some additional fish species due to the presence of the Yukon River, and Wrangell-St. Elias has additional species due to coastal influences. The birds of the three parks are presumably fairly similar, with the main distinction being the marine and coastal species that occur in Wrangell-St. Elias. Further consideration of the faunal affinities of the three parks in the ecoregions context may best await pending completion of ongoing bird, fish, and mammal inventories.

Understanding the role of faunal species in ecosystem processes in northern regions is nascent. The most recent studies include bears (Jacoby et al. 1999, Hilderbrand et al.1999), wolf-prey (Gasaway et al. 1983), moose (Kielland et al. 1997, Kielland and Bryant 1998, Bowyer et al. 1997), hares (Bryant 1987, Krebs et al. 2001), river otters (Ben-David et al. 1998), beaver (Collen and Gibson 2001), and salmon (Cederholm et al. 1999, Helfield and Naiman 2001). The spatial and temporal scales at which fauna exert feedback pressures within ecosystems vary. In most cases, the spatial scales of faunal influence are generally smaller than those of other processes that structure ecosystems (e.g., grizzly bears digging up ground squirrel burrows affects soil structure at the microscale level). In some cases, the spatial scales may be akin to those of mesoclimate. For example, the presence of naturally regulated wolf populations in Alaska presumably has major influences on the number of moose and caribou, which may have major influences on vegetation communities (Berger 1999, Berger et al. 2001). The influence of marine nutrients brought into the terrestrial environment by spawning salmon is also a major influence on ecosystem properties.

The role of humans in influencing ecosystem properties also needs consideration. Climate is the driving force behind the ecosystems in Central Alaska Network parks. Thus, the role of humans in changing earth's climate brings climate change to the forefront of park issues. Human influences on landscapes through other processes are also important, but not at the same scale of influencing climate. By influencing climate, we influence the primary driver of ecosystems around the globe.

For Central Alaska Network parks, human influences on other faunal species are likely to be significant influences on ecosystem properties also. Humans determine whether

predator populations (e.g., wolves and bears) are extirpated, regulated by artificial means (e.g., wolf control), or allowed to fluctuate without human interference. Humans affect populations of major herbivores (e.g., moose), by hunting and predator control. Humans also affect the number of salmon returning to streams. These types of human activities likely play a major but not well-understood role in the ecosystem processes of Central Alaska Network parks.

Implications for Central Alaska Network Monitoring Program Design

How can this ecoregions analysis help set the conceptual foundation of the Central Alaska Network monitoring program? The main contribution of the ecoregions analysis is to provide a common starting point for discussions of network ecology as a whole. This analysis provides a broad perspective on the ecological setting of the network and a framework for further discussion. A number of ideas emerge.

Central Alaska Network parks have broad ecoregion divisions in common.

- All three parks include areas in the *Intermontane Boreal Division*. All of Yukon-Charley, significant portions of the north side of Denali, and a small corner of Wrangell-St. Elias are of this type. The *Intermontane Boreal Regime* therefore strongly links Yukon-Charley and Denali. The Yukon-Tanana Uplands Ecoregion (found in both Yukon-Charley and Wrangell-St. Elias) generally has the most lightning strikes of any ecoregion in the state, and this ecoregion is heavily influenced by fire. The areas within Wrangell-St.Elias that fire would most likely affect are in this ecoregion, and this provides a common linkage to the other two parks, especially Yukon-Charley.

- The *Alaska Range Transition Regime* links Denali and Wrangell-St. Elias. This ecoregion type is characterized by a gradient of maritime climate interacting with topographic complexity (mountains). When the *Coast Mountains Transition Regime* is also considered, one sees that these complex “transitional” areas dominate Denali and Wrangell-St. Elias.

Oceanic influences may be more important than we previously thought.

- Much of Wrangell-St. Elias falls into areas that are maritime or strongly influenced by maritime conditions. Within the network, Wrangell-St. Elias is unique in this way. The Chugach-St. Elias Mountains, Wrangell Mountains, Kluane Range, and Gulf of Alaska ecoregions are within this group. Heretofore, we had been considering Wrangell-St. Elias’ 125 km of coastline as our only coastal interest. This analysis suggests that maritime influences are much broader, and that the ecological linkages between ocean and land deserve more consideration than we have previously given them. Changing ocean conditions might affect temperature and precipitation patterns throughout the maritime-

influenced ecoregions (and what is the ecological fallout from that?). The climate patterns of the northeastern Gulf of Alaska fluctuate at four time scales, and marine climate in this region has flip-flopped 13 times between "cool" and "warm" since the 1850s (Piatt 1999). Thus far, ecologists have primarily focused on the effects of these climate shifts within marine ecosystems. What are the effects within terrestrial ecosystems?

- Salmon likely play a significant role in ecosystem processes of Central Alaska Network parks, suggesting another important linkage with the oceanic environment. What role do humans play in the ecological processes by harvesting salmon?

Seeing aquatic resources as part of the landscape, rather than as discrete entities.

- Bailey (1996, 1998) makes a convincing case for viewing lakes, rivers, streams, and other freshwater habitats as part of the ecosystem rather than as separate entities. Adopting this viewpoint would allow us to move forward with a more holistic design of an overall monitoring program. From the descriptions of the lower-level ecoregions prepared for each of the parks (see Appendix C), it is clear that the various regions differ significantly in their "aquatic" characteristics. Some have abundant surface water in the form of wetlands and lakes; others have none. We need further conceptual modeling to understand the specific drivers that account for the observed distribution of aquatic areas in Central Alaska Network parks, and at what level in the ecoregions hierarchy these drivers occur.

Further Uses of the Ecoregions in the Design Process

- Development of conceptual ecological models for each of the ecoregion regimes in the network would help provide a linkage between the patterns observed and the processes responsible for those patterns. The ecoregion regimes could provide a framework for considering other important factors that need to be accounted for in designing the monitoring program (e.g., compare management concerns and needs among ecoregion regimes). The resource protection concerns of Central Alaska Network parks (see Chapter 4) can now be reconsidered in the ecoregions context by focusing on the spatial and temporal scales matching the concern.

- Because these ecoregion types are based most strongly on climate, this analysis should give us ideas where to position any new weather stations. Fleming et al. (2000) noted both the paucity of weather stations in Alaska, and the biases associated with locations of the weather stations that do exist (e.g., at lower elevations, along rivers and valleys, and away from mountainous and inaccessible areas). The two transitional ecoregion regimes that span the Central Alaska Network are topographically complex and would seem to be underrepresented

among existing climate stations. We now have a framework for considering where additional weather stations will add significantly to our understanding of climate processes in the region.

Potential Organizing Questions

Each monitoring network needs a central question. For example, the Prairie Cluster Long-term Ecological Monitoring Program is organized around the question of "Are prairie remnants in small parks sustainable?" (Thomas et al. 2001). The Cape Cod National Seashore Long-term Ecological Monitoring program is organized around the question of "What happens to an ecosystem when it is inundated with nutrients?" (Roman and Barrett 1999). These types of questions help give a monitoring program a consistent direction and a focus. They can be used to evaluate and prioritize proposed monitoring activities: How will the data help answer the central question?

In our deliberations thus far, we have struggled somewhat with the issue of an organizing question. Part of this struggle may stem from the pristine nature of the Central Alaska Network parks, relatively speaking (note that the organizing questions for Cape Cod and Prairie Cluster are both driven by overwhelming human influences in their regional landscapes). This ecoregions analysis suggests a number of potential organizing questions for the Central Alaska Network parks.

- Can we use the Central Alaska Network as a setting to improve understanding of marine-terrestrial linkages at a broad regional scale? How far inland does marine climate have an influence, and what happens to terrestrial systems when marine climate shifts between "warm" and "cold" periods? How significant are marine faunal influences (present in all three parks in the form of anadromous fish) in terrestrial ecosystem processes?

- This network seems uniquely situated to answer questions related to macroclimate because of the spatial scale of the network. The Central Alaska Network has significant portions of the last remnants of the Pleistocene ice sheets in North America; it also has a portion of the ice-free corridor. By modifying climate, what happens to our ecosystems?

- What is the role of fauna in these ecosystems? If management practices on adjoining lands reduce predator populations, what are the regional ecosystem effects?

These are just three examples of potential organizing questions. Further discussion within the network should raise other questions as different perspectives are added. One approach could be to have different questions at each level of the ecoregions hierarchy--questions that match the driving forces at each level. Perhaps the main value of the

ecoregions analysis thus far is that it gives us a place to start in formulating an organizing question, or a series of linked questions for the network as a whole.

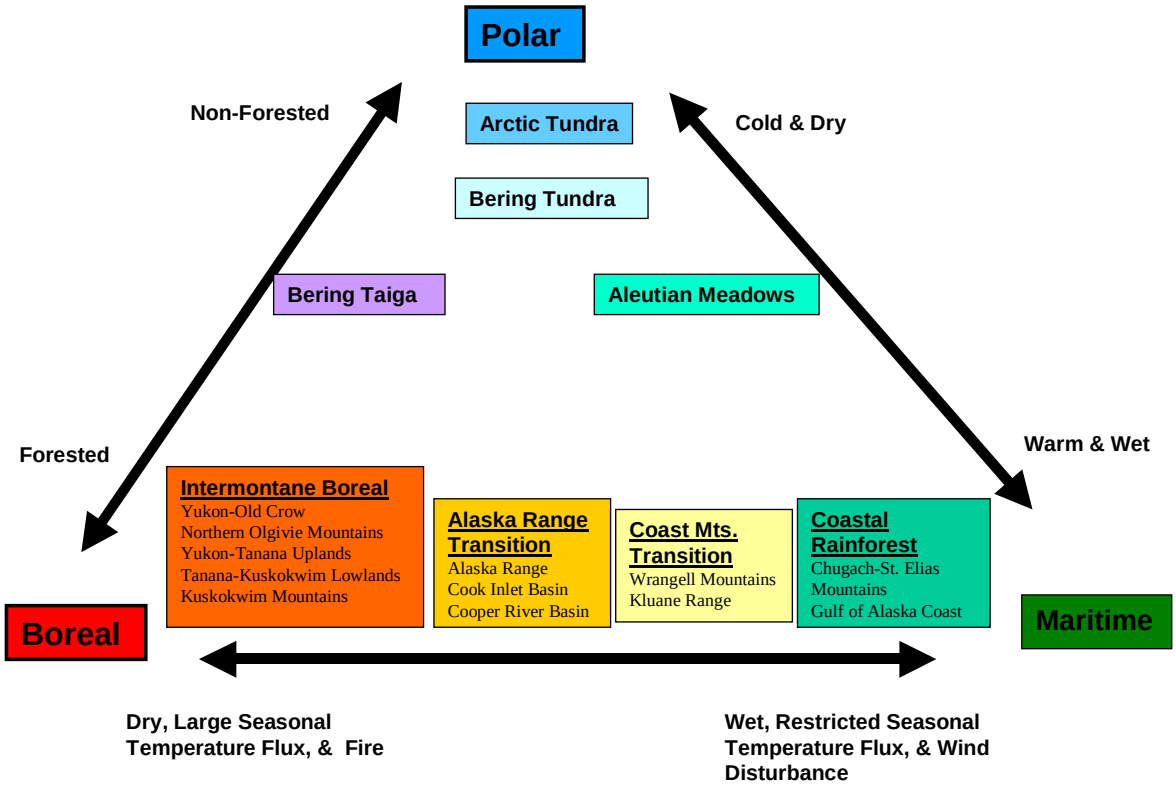


Figure 8. Climatic and environmental relationships among ecoregions in Alaska (from Nowacki et al. 2002). Ecoregions found in Central Alaska Network parks are shown grouped by ecoregion regime.

Figure 9. Location of Central Alaska Network parks relative to ecoregion regime boundaries, based on ecoregions mapping for Alaska by Nowacki et al. (2002).

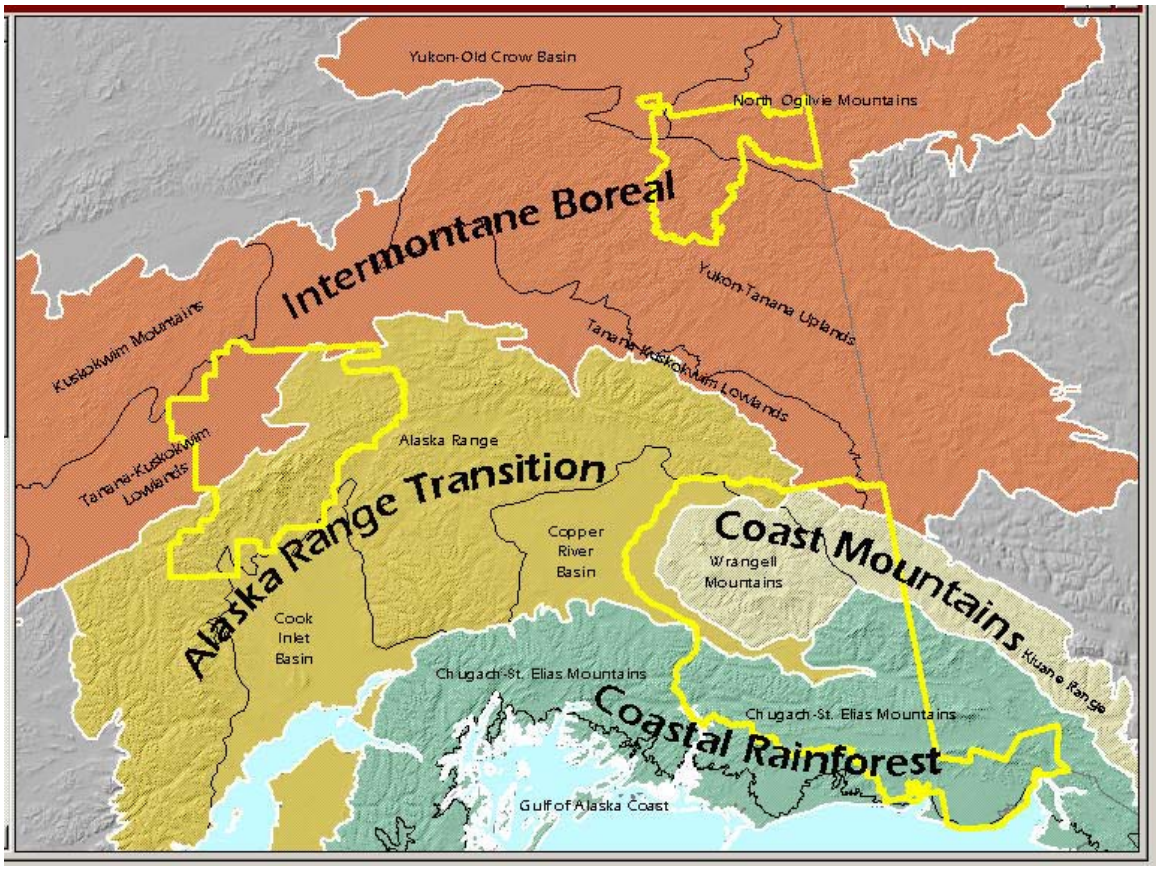


Figure 10. Percentage of land within the Central Alaska Network occurring within ecoregion regimes as defined by Nowacki et al. 2002.

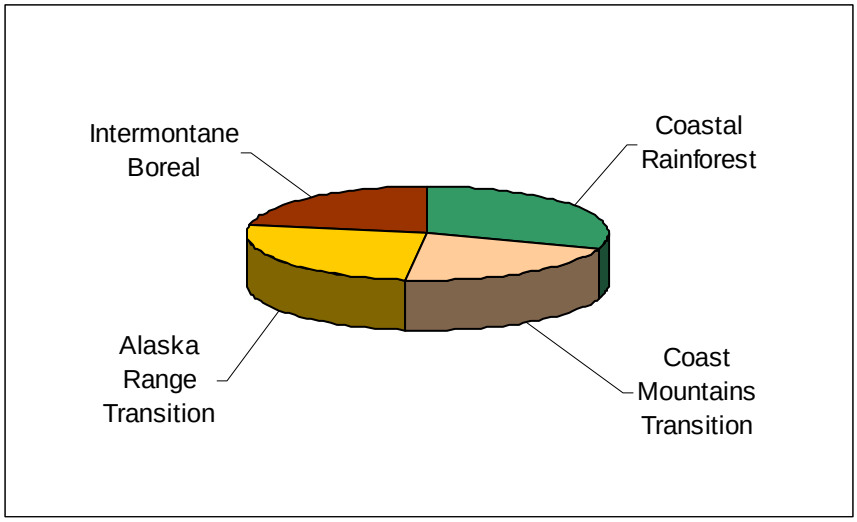


Figure 11. Guide to Walter Climate Charts.

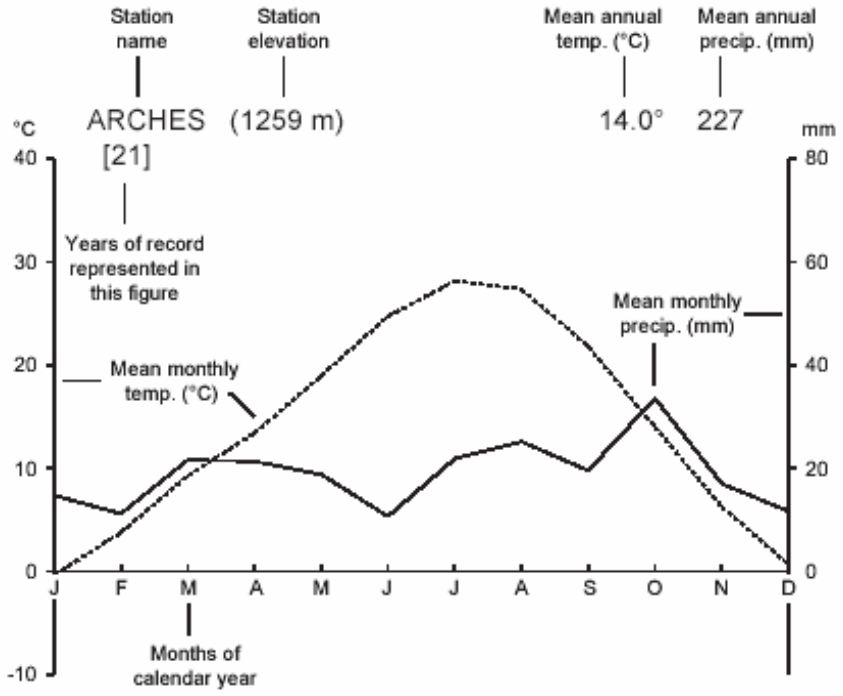
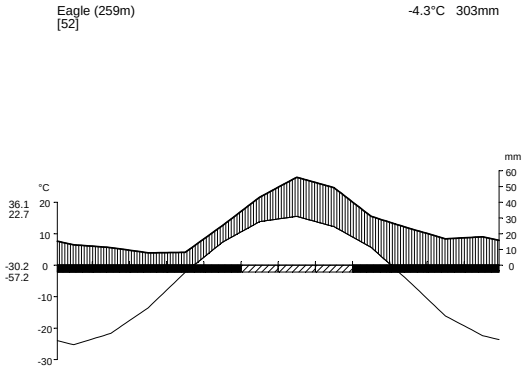
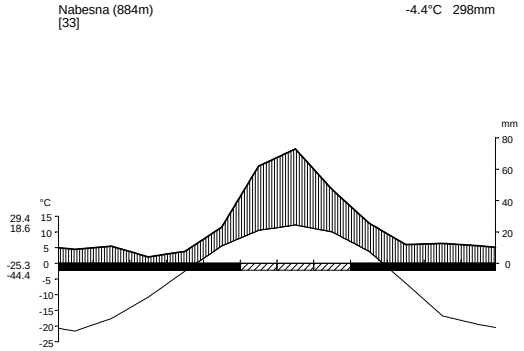


Figure 12. Walter Climate Charts for representative sites within ecoregion regimes occurring in Central Alaska Network parks: (a) *Intermontane Boreal*, (b) *Alaska Range Transition*, (c) *Coast Mountains Transition*, and (d) *Coastal Rainforest*. See Figure 11 for a guide to Walter Climate Charts.

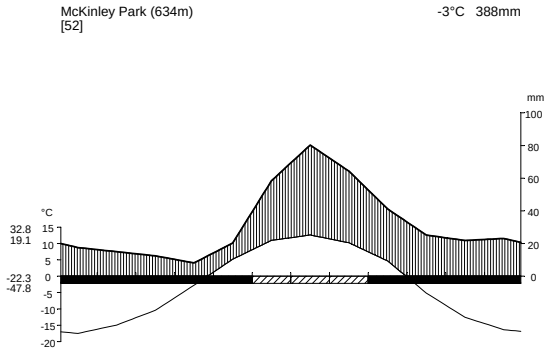
(a) Intermontane Boreal



(c) Coast Mountains Transition



(b) Alaska Range Transition



(d) Coastal Rainforest

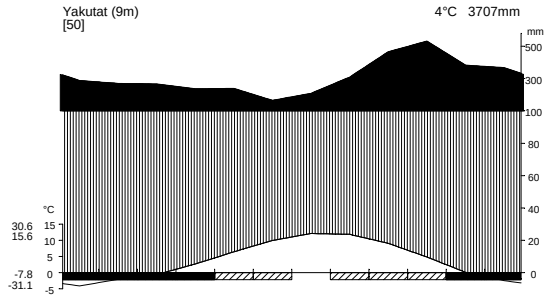


Figure 13. Generalized climate in central Alaska based on long-term National Weather Station records for sites in and around Central Alaska Network parks. Dot colors indicate the ecoregion regime of each site: yellow=Alaska Range Transition, brown=Intermontane Boreal, and tan=Coast Mountains Transition. Yakutat (average annual temperature=4 degrees C, average annual precipitation 3707 mm) not shown due to scale.

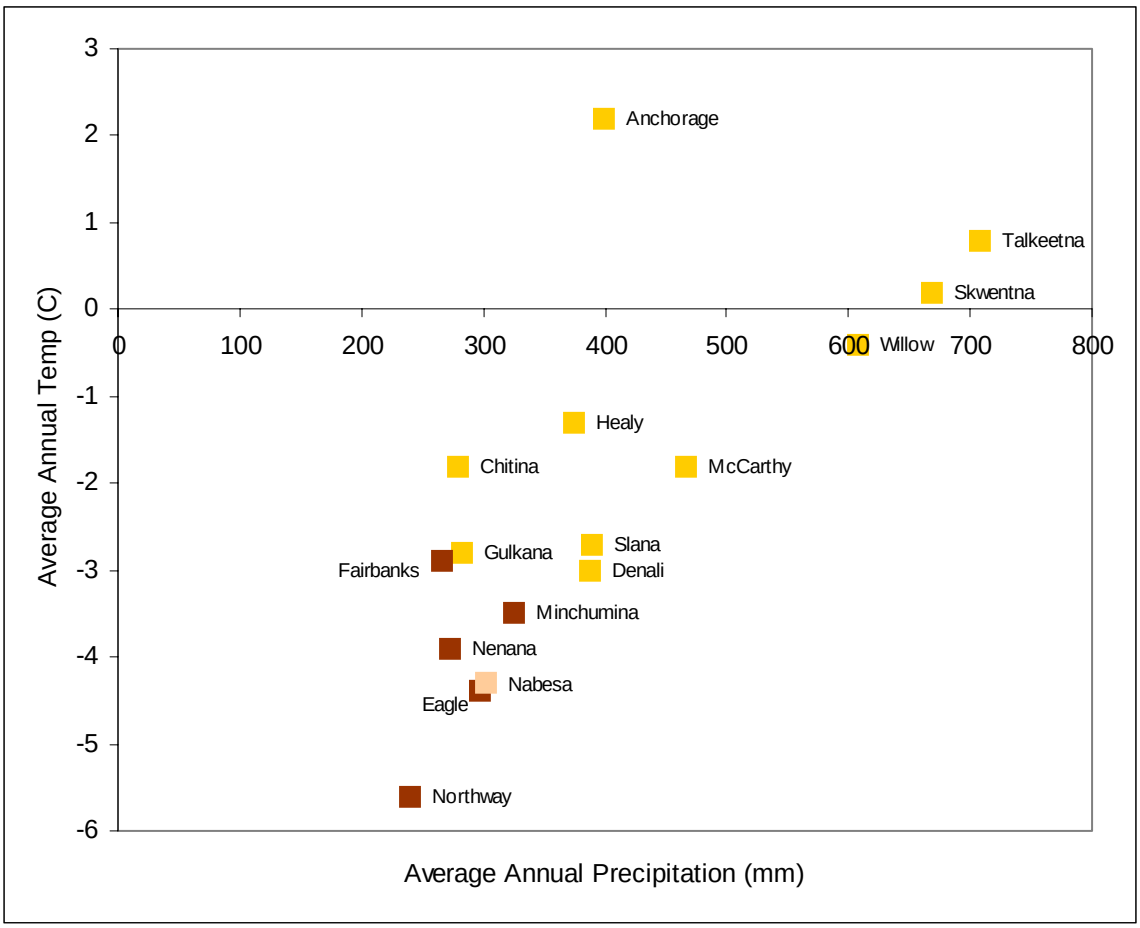
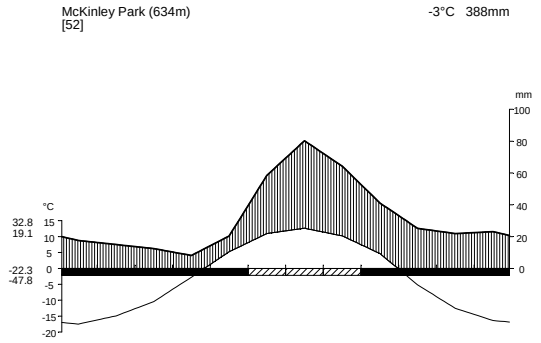
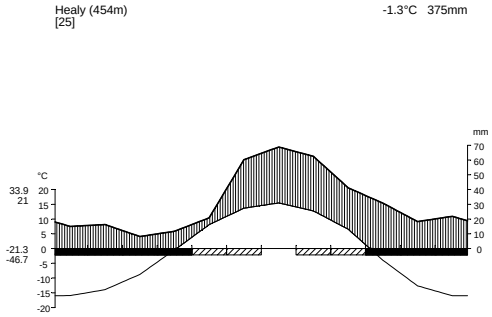
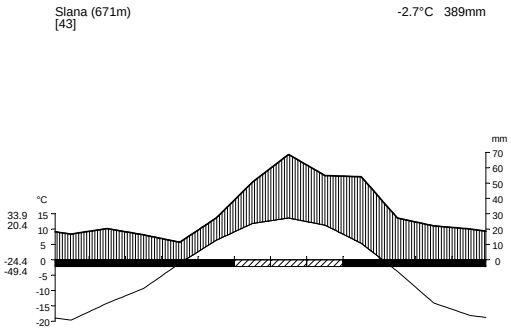


Figure 14. Walter Climate Charts for sites in the *Alaska Range Transition Regime*, organized by ecoregion: (a) Alaska Range, (b) Copper River Basin, and (c) Cook Inlet Basin. See Figure 4 for a guide to Walter Climate Charts.

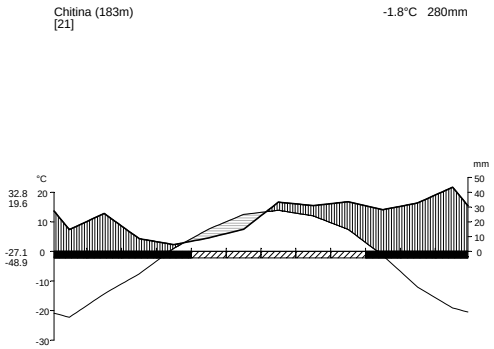
(a) Alaska Range

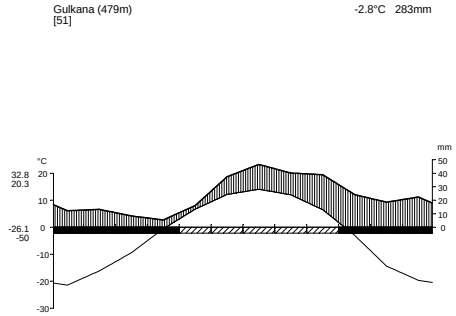


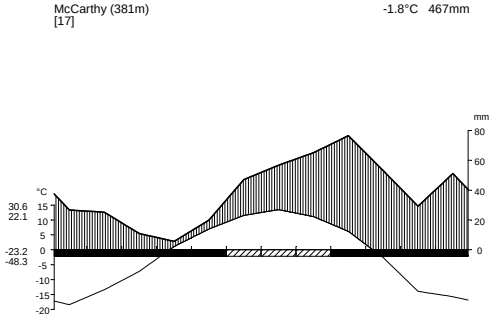




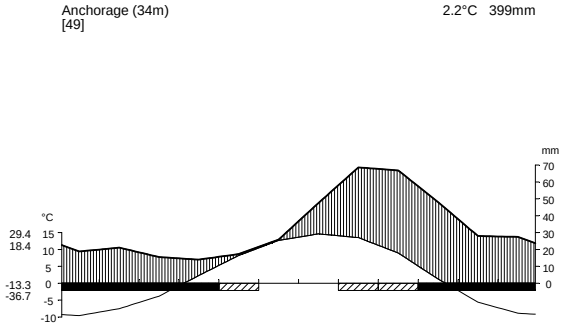
(b) Copper River Basin

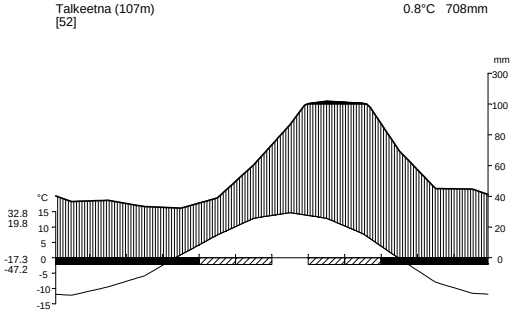


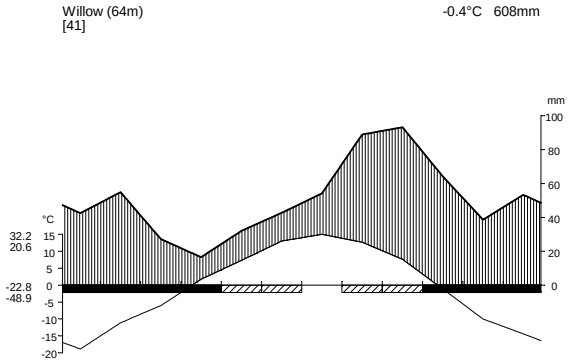




(c) Cook Inlet Basin







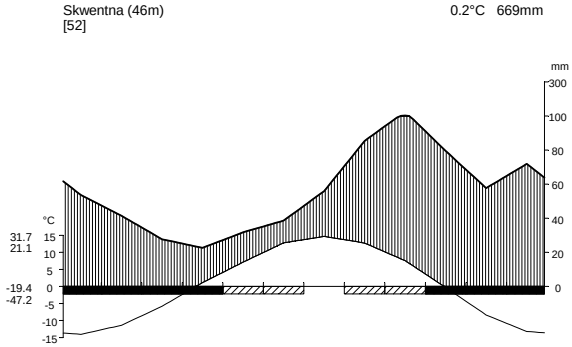
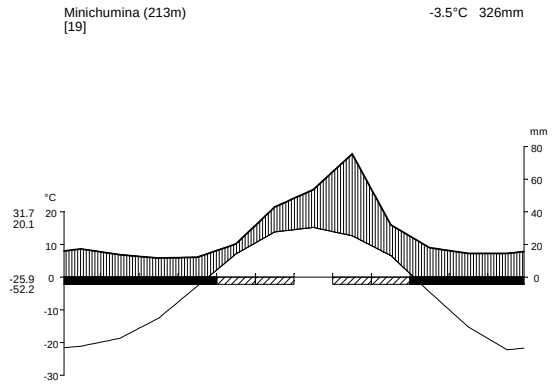
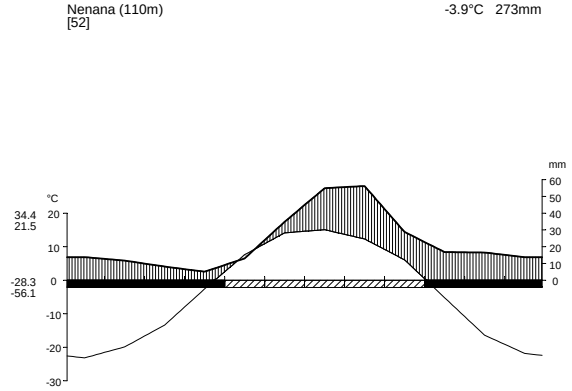


Figure 15. Walter Climate Charts for sites in the *Intermontane Boreal Regime*, organized by ecoregion: (a) Kuskokwim Mountains, (b) Tanana-Kuskokwim Lowlands, (c) Yukon-Tanana Uplands, and (d) North Olgivie Mountains. See Figure 4 for a guide to Walter Climate Charts.

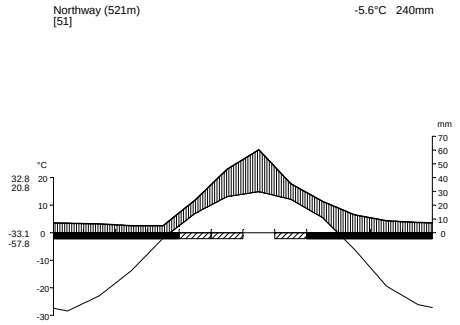
(a) Kuskokwim Mountains

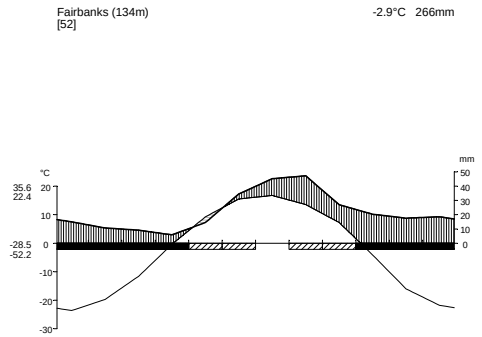


(b) Tanana-Kuskokwim Lowlands



(c) Yukon-Tanana Uplands





(d) North Olgivie Mountains

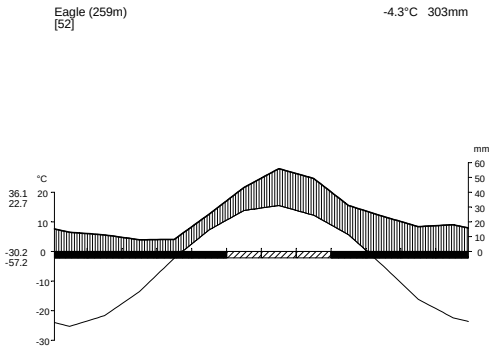


Figure 16. Preliminary conceptual model of climate relationships in the Central Alaska Network region. Major uncertainties about mechanisms and relationships are indicated by "?". This model represents one person's understanding. As additional reviewers comment on the model, the model will change to reflect our common understanding of climate relationships.

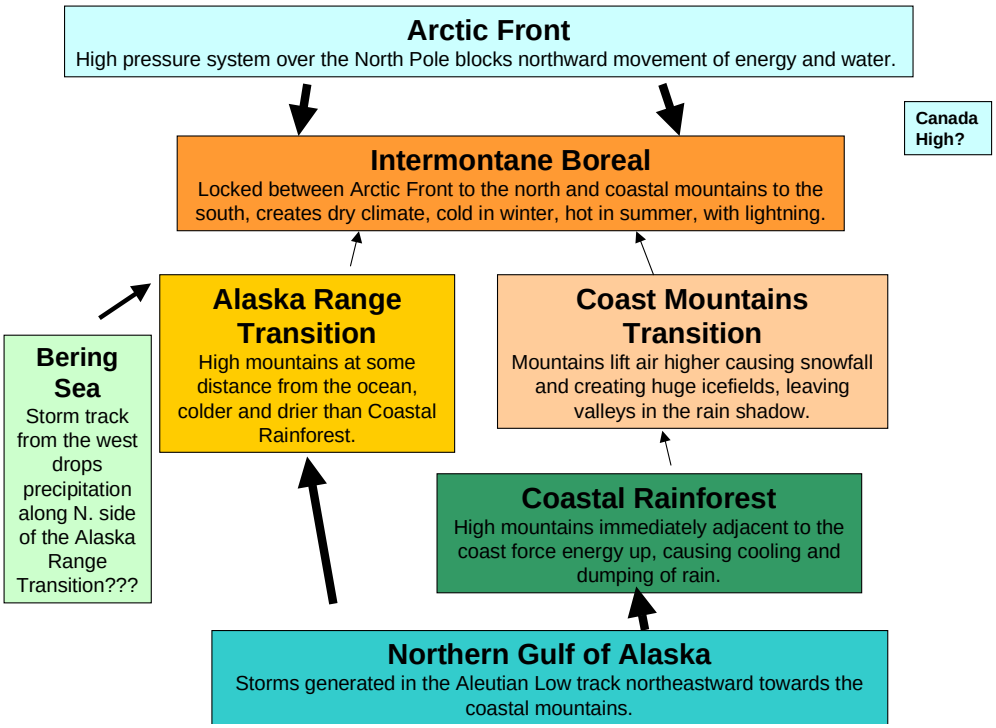


Table 4. Number of hectares of 12 ecoregions found in Central Alaska Network parks, grouped by ecoregion regime (based on ecoregions for Alaska as mapped by Nowacki et al. 2002).

	Hectares in CAN	% of Hectares in CAN
Intermontane Boreal		
Tanana-Kuskokwim Lowlands	890,377	10.1
Yukon-Tanana Uplands	559,746	6.4
North Ogilvie Mountains	466,934	5.3
Yukon-Old Crow Basin	43,705	0.5
Kuskokwim Mountains	7,006	0.1
subtotal	1,967,768	22.4
Alaska Range Transition		
Alaska Range	1,662,746	18.9
Copper River Basin	599,856	6.8
Cook Inlet Basin	31,608	0.4
subtotal	2,294,211	26.1
Coast Mountains Transition		
Wrangell Mountains	1,431,440	16.3
Kluane Ranges	493,506	5.6
subtotal	1,924,946	21.9
Coastal Rainforest		
Chugach-St. Elias Mountains	2,577,471	29.3
Gulf of Alaska Coast	27,304	0.3
subtotal	2,604,775	29.6

Table 5. Number of hectares and brief descriptions of ecoregion regimes and ecoregions found in Central Alaska Network parks. From Nowacki et al. (2002).

	Distinctive Characteristics	Number of Subsections[1]	Hectares in Denali	Hectares in Yukon-Charley Rivers	Hectares in Wrangell-St. Elias	Total Hectares in CAN
Intermontane Boreal Regime	• Strongly continental climate, • Underlain by permafrost in most of the area • Boreal woodlands in an undulating landscape, fires common in summer, • Part of the "Beringia Corridor" sandwiched between the Brooks Range and the Alaska Range, not glaciated during the last glaciation.					
Kuskokwim Mountains	• **Distinguished from Tanana-Kuskokwim Lowlands by being more mountainous.**		7,006			7,006
North Ogilivie Mountains	• Flat-topped hills and eroded remnants of a former plain, representing the western extent of the North American stable platform onto which Pacific and Arctic terranes have attached; • sedimentary (limestone).			466,934		466,934

[1] "Number of subsections" refers to the number of distinct ecological units defined for the ecoregion (with CAN parks) during more detailed ecological mapping for the NPS. See Appendix A for more information.

	Distinctive Characteristics	Number of Subsections[1]	Hectares in Denali	Hectares in Yukon-Charley Rivers	Hectares in Wrangell-St. Elias	Total Hectares in CAN
	• Lakes are rare.					
Tanana-Kuskokwim Lowlands	• An alluvial plain sloping northward from the Alaska Range. • Surface moisture abundant due to topography, permafrost, and poor soil drainage.	3 in DENA 2 in WRST	817,383		72,993	890,377
Yukon-Old Crow Basin	• Gently-sloping basin, vast wetlands.			43,705		43,705
Yukon-Tanana Uplands	• Broad, rounded mountains. • Most **lightning strikes** of any ecoregion (in Alaska).			509,530	50,217	559,746
Alaska Range Transition Regime	• Some climatic moderation afforded by proximity to the Pacific Ocean. • Heavily scoured by ice sheets during the last glaciation, and small ice caps and glaciers remain at high elevations. • Boreal forest occurs at lower elevations.					
Alaska Range	• Accreted terranes from the Pacific Ocean create this arcing mountain range. • Steep slopes with scree, and alpine tundra; shrub communities at lower elevations.	15 in DENA 4 in WRST	1,583,778		78,968	1,662,746
Cook Inlet Basin	• Gently-sloping lowland buried by ice and proglacial lakes	2 in DENA	31,608			31,608

	Distinctive Characteristics	Number of Subsections[1]	Hectares in Denali	Hectares in Yukon-Charley Rivers	Hectares in Wrangell-St. Elias	Total Hectares in CAN
	during the Pleistocene. • Lacustrine deposits. • Numerous wetlands, lakes and ponds.					
Copper River Basin	• Basin formed within the former bed of **Glacial Lake Ahtna**. • Large wetland complex underlain by permafrost and covered with thaw lakes and pond.	10 in WRST			599,856	599,856
Coast Mountains Transition Regimes	• High mountains on the Interior side of coast mountains creating **transition climate** between the ocean and the interior. • Maritime conditions on mountaintops (feeding ice caps and glaciers), grading to continental conditions at lower elevations (boreal forests).					
Kluane Ranges	• Mountains in the **rain shadow** of the Wrangell-St. Elias range • Generally, **ice free**. • Alpine tundra	6 in WRST			493,506	493,506
Wrangell Mountains	• Tall, ice-clad **volcanoes**.	14 in WRST			1,431,440	1,431,440
Coastal Rainforest Regime	• Copious precipitation throughout the year. • Sufficient warmth to support trees at lower elevations.					

	Distinctive Characteristics	Number of Subsections[1]	Hectares in Denali	Hectares in Yukon-Charley Rivers	Hectares in Wrangell-St. Elias	Total Hectares in CAN
	• Massive glaciers and icefields in the mountains.					
Gulf of Alaska Coast	• Temperate rain forests of hemlock and spruce interspersed with wetlands. • Numerous streams and rivers.	1 in WRST			27,304	27,304
Chugach-St. Elias Mountains	• Nunataks, some tidewater glaciers. • Alpine communities	25 in WRST			2,577,471	2,577,471

Chapter 8 Conceptual Model of Resource Preservation Concerns

In this chapter, we pick up where we left off in Chapter 4, where we presented an overview of the most important resource preservation concerns of Central Alaska Network parks. The resource preservation concerns of network parks relate, ultimately, to human population growth and associated demands. These concerns are not independent of one another. In Figure **15**?? , we present a conceptual model of the concerns and how they are related. The purpose of this model is to help see what human activities are affecting the ecosystems of Central Alaska Parks, and how the ecosystems could be affected. This model is expected to be all-encompassing (i.e., provide a framework into which all potential effects could logically fit) and identify where additional, more specific models could be helpful. This model is also expected to help us identify what monitoring attributes will be most informative to preservation of the park ecosystems.

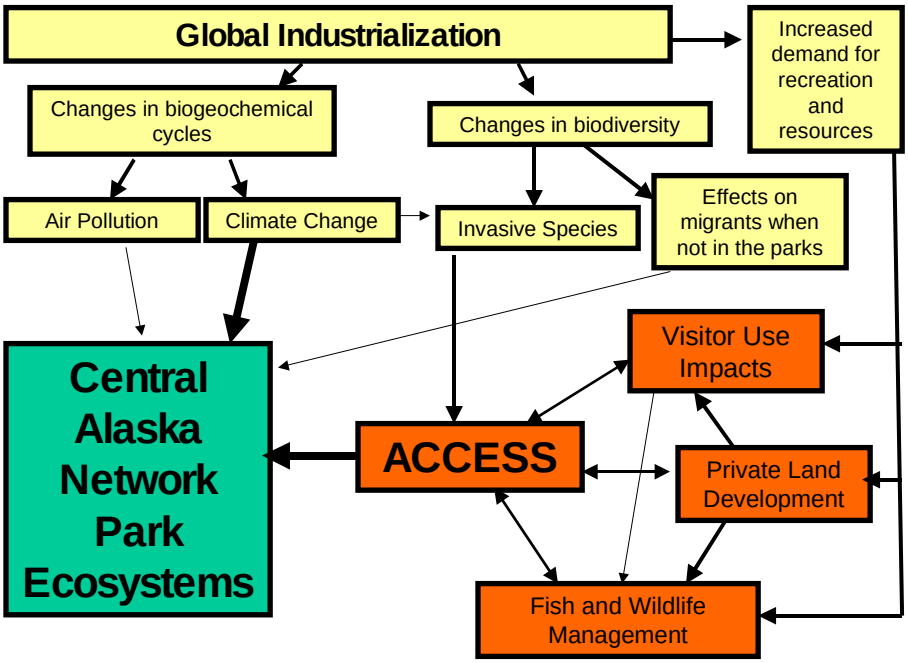
Human population growth and resulting industrialization drives all the concerns facing network parks. Global growth is the driver for climate change, the main source of long distance air pollution, and for impacts to migratory birds and fish. Human population growth will increase settlement in Alaska, particularly in the Railbelt between Anchorage and Fairbanks, leading to local and regional industrialization and additional, closer, sources of air pollution. Increased settlement also will increase the number of nodes of access to the parks, especially Denali. Increased human population also will increase demand for new access to the parks and for increased number of facilities (settlement) within the parks. Increased settlement along the borders also increases demand for animal harvest, which will be facilitated by increased access. Demand for increased access could result in new roads, or upgrades of existing roads (in Denali and Wrangell-St. Elias), which could increase gravel mining in these parks.

This analysis points to <u>access</u> as a central issue that ties together the issues of local and regional industrialization, settlement, fish and wildlife harvest and mining. The issues related to global industrialization— climate change, air pollution, and impacts to migratory birds and fish—represent a second suite of issues. To strategically deploy monitoring effort, a sense of the relative importance or level of concern the parks have about these issues is needed.

The issues that lead to increased pressure for access or result from increased access have the highest level of concern because of their potential to change the undisturbed and unfragmented nature of park ecosystems. The issues of settlement, harvest, and mining are inextricably tied to access and should be considered together. Access issues also are the types of issues that park decisions have a high probability to influence, by careful choices in siting of access routes and nodes and in management of human activity. Parks can also have important influences on decisions related to fish and wildlife harvest and mining within the parks. Because of their potential to significantly impact park ecosystems, and because park decisions can reasonably be expected to prevent or reduce those impacts, the suite of issues related to access rank highest in our listing of resource preservation concerns.

Next in importance to park management are concerns that stem from global industrialization. Pristine air quality is a key value of Denali, a Class I park under the federal Clean Air Act. The issue of air pollution is therefore important, and the documented occurrence of episodes of Arctic Haze and emissions from Asia indicate that network parks need to be vigilant. Climate change, also related to global industrialization, is a concern because of the high potential for warming to change park ecosystems. However, park management will not be in a position to take action that could change that trajectory. In this case, the main role of park monitoring will be to understand the trajectory of change related to warming and the implications for park resources. A similar strategy applies to how the park should view protection of migratory birds and fish that may encounter increased mortality, pollution or habitat loss as a consequence of global industrialization when they are not at network parks. Monitoring these species within the park may provide early warning of problems that are occurring elsewhere.

Figure 17. Preliminary conceptual model of relationships among resource preservation concerns of Central Alaska Network parks. Regional scale concerns shown in orange. Global industrialization aspects (shown in yellow) based on Vitousek et al. 1997.



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Appendix A: Organization and Personnel of the Central Alaska Network

Board of Directors:

Dave Mills (Chair), *Superintendent, Yukon-Charley Rivers National Preserve*
Paul Anderson, *Superintendent, Denali National Park and Preserve*
Gary Candellaria, *Superintendent, Wrangell-St. Elias National Park and Preserve*

Technical Committee:

Maggie MacCluskie (Chair), *Coordinator, Central Alaska Network*

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- Devi Sharp, *Chief of Resources*
- Mason Reid, *Wildlife Biologist*

Denali National Park and Preserve:
- Susan Boudreau, *Chief of Resources*
- Guy Adema, *Physical Scientist*
- Carl Roland, *Botanist*

Yukon-Charley Rivers National Preserve
- Tom Liebscher, *Chief of Resources*
- John Burch, *Wildlife Biologist*
- Nikki Guldager, *Wildlife Biologist*

Sara Wesser, *Alaska Region Inventory and Monitoring Coordinator*

Kirk Lohman, *Alaska Region Science Advisor*

Nancy Deschu, *Alaska Region Hydrologist*

Karen Oakley, *Biologist, Biological Resources Division, US Geological Survey*

Appendix B. Current Status of Waterbodies in Central Alaska Network Parks Listed Under Section 303d of the Clean Water Act

Currently, three streams within Central Alaska Network parks are listed under Section 303d of the Clean Water Act. The state of Alaska lists the impaired streams in four tiers. The definitions for all tiers appear after the creek descriptions. All are included because of effects of mining. Cabin Creek, located in Wrangell-St. Elias, is a Tier 2 stream, listed for acid drainage from the Nabesna Mine, a manganese mine and patented claim. Caribou Creek, in Denali, is a Tier 1 stream, listed for turbidity from past gold mining activity. Slate Creek, also in Denali, is a Tier 2 stream, listed for turbidity from past antimony mining activity. Below, we provide information on the current status of these creeks relative to reclamation activities intended to bring the water quality into compliance with water quality standards. However, national GPRA goals do not require that we report on water bodies on Tier 1.

Cabin Creek

Alaska Department of Environmental Conservation and NPS staff visited the mine site in June 1997 to discuss specifics of a recovery plan with the owner of the Nabesna Mine property. Acidic tailings below the mine site (located on NPS managed lands) may be a contributing factor in compromising the water quality of Cabin Creek. Recovery plan objectives include increasing the low pH of the acidic tailings, revegetating the tailings with indigenous species, and re-construction of the existing drainage ditches around the tailings to divert stormwater run-off away from Cabin Creek. Final implementation and subsequent waterbody recovery analysis has not yet occurred, and Cabin Creek remains on the Tier II Section 303(d) list.

Caribou Creek

Alaska Department of Environmental Conservation staff conducted a helicopter tour of the watershed in June 1997 with the NPS to ascertain the degree of past mining activity in, and adjacent to, the waterbody. Miles of the waterbody have been extensively placer mined. The waterbody has lost its sinuosity along segments of the upper half of the watershed. The NPS priority for the watershed is to continue the process to obtain title to private mining claims. Since the mining claim acquisition process may take at least 3 to 5 more years, development of a waterbody recovery plan is unlikely to begin until the acquisition process is near completion. Thus, Caribou Creek will remain on the Tier I Section 303(d) list for the next several years.

Slate Creek

Alaska Department of Environmental Conservation and NPS staff inspected the antimony mine area (at the creek headwaters) in June 1997 to discuss specifics of the waterbody recovery plan. Recovery plan implementation began in August 1997. The recovery plan includes restoration objectives for four acres of disturbed upland and stream channel

areas in the vicinity of the old antimony mine site. Restoration objectives include placement of fill over the exposed antimony ore body, reconfiguration of the stream channel, increasing the pH of acidic soils, and revegetation of disturbed soils with willow and alder seedlings. Full implementation of the recovery plan will address any water quality issues of the waterbody. Full recovery of the waterbody was expected by April 2000 but has not yet been achieved. Review of the recovery plan is needed prior to moving this water to Tier III. Under Tier III, water quality of the recovered stream will be monitored until the stream is no longer affected by water quality degradation.

Alaska State Definitions of Tiers 1-4

Tier 1 - Waters that require assessments, verification of pollution and controls in place, or needed.

Tier 2 - Waters which have had completed assessments and now required a water body recovery plan of a Total Maximum Discharge Load (TMDL) calculation.

Tier 3 - Water which will be tracked and monitoring.

Tier 4 - Waters that are not water quality limited that require no further action.

Appendix C: Ecoregions and Ecological Units of Central Alaska Network Parks

This appendix provides more detailed descriptions of the specific ecoregions found in the Central Alaska Network parks than is presented in the body of the report. **Summary descriptions of Level 1 Ecoregion Types and ecoregions are taken verbatim from Nowacki et al. in press.** More detailed ecological unit mapping has been undertaken for the 3 Central Alaska Network parks as part of the Inventory and Monitoring Program (Clark 2002, Swanson 1999, Swanson 2001), and lists of the detailed ecological units found in each ecoregion within each park are also included. This appendix therefore includes ecoregions information about network parks from the statewide perspective of Nowacki et al. in press and the park-specific perspectives of other mapping efforts.

The more detailed mapping efforts have been conducted with different levels of on-the-ground information and somewhat different approaches. Denali ecological units are currently being delineated in the process of soil mapping. This effort is being conducted for the park by Mark Clark of the US Department of Agriculture-Natural Resources Conservation Service. Detailed ecological mapping of Wrangell-St. Elias and Yukon-Charley was conducted by Dave Swanson, a private consultant. While the mapping of Denali units has included substantial field work (including soil pits and vegetation observations) over 6 year period, the Yukon-Charley and Wrangell-St. Elias efforts were based on examination of maps of existing information about soils, geology, land cover, etc. Another caveat to keep in mind is that the Yukon-Charley effort preceded development of the Nowacki et al. in press ecoregions map, and boundaries of the detailed ecological units do not exactly match the boundaries of the broader ecoregions of Nowacki et al. in press. In the Wrangell-St. Elias effort, the detailed ecological units were mapped within the ecoregion boundaries of Nowacki et al. in press.

Intermontane Boreal (22% of CAN)

These areas experience extreme seasonal temperature changes from long, cold winters to short moderately-warm summers. Boreal woodlands and forests cover much of this undulating landscape. The continental climate is fairly dry throughout the year, and forest fires rage through summer droughts. This intermontane terrain sandwiched between the Brooks and Alaska Range remained largely ice-free during the last ice age, forming part of the "Beringia Corridor" (Pielou 1991).

Kuskokwim Mountains (0.1% of CAN)

This **subdued terrain** is comprised of **old, low rolling mountains** that have eroded largely without the aid of recent past glaciations. A **continental climate** prevails with seasonal moisture provided by the Bering Sea during the summer. Mountains are composed of eroded bedrock and rubble, whereas intervening valleys and lowlands are composed of undifferentiated sediments. Thin to

moderately thick permafrost underlies most of the area. **Boreal forests** dominate grading from white spruce, white birch, and trembling aspen on uplands to black spruce and tamarack in lowlands. Tall willow, birch, and alder shrub communities are scattered throughout, particularly where **forest fires** burned in the recent past. Rivers meander through this **undulating landscape** following fault lines and highly eroded bedrock seams. These mountains support abundant moose, bears, beavers, and scattered caribou herds.

North Ogilvie Mountains (5.3% of CAN)

This terrain consists of flat-topped hills and eroded remnants of a former plain. This area represents the western extent of the North America stable platform onto which terranes radiating from the Pacific and Arctic Oceans have attached. Sedimentary rocks, especially **limestone**, underlie most of the area. Ridgetops and upper slopes are often barren with **angular, frost-shattered rock outcrops** (resembling castellations) surrounded by **long scree slopes**. These are characteristics of an **unglaciated** area that has undergone long periods of erosion. Shallow soils have developed in rocky colluvium on mountainsides where landslides, debris flows, and soil creep frequently occur. On lower slopes, soils are deeper, more moist, and underlain by extensive permafrost. **Low shrub tundra** of willow, alder, and birch and **aspen and spruce woodlands** occur at lower elevations. These mountains are the source of many streams that eventually feed the Porcupine, Yukon, and Peel Rivers. Lakes are relatively rare. A **strong continental climate** prevails, with prolonged frigid winters lasting from October to May and cool, short summers. Brown bears, wolverine, Dall sheep, caribou, lemmings, and pikas are common inhabitants of these mountains.

Ecological Units within Yukon-Charley Rivers National Preserve

- Biederman Hills
- Yukon River Valley
- Tintina Hills
- Kandik Tableland
- Ogilvie Foothills
- Hard Luck Lowland
- Ogilvie Lime/Dolostone Mountains
- Snowy Domes?

Tanana-Kuskokwim Lowlands (10.1% of CAN)

This **alluvial plain** slopes gently northward from the Alaska Range. The undifferentiated sediments of fluvial and glaciofluvial origin are capped by varying thicknesses of eolian silts and organic soils. Sand dune fields and glacial moraines occur in some areas. A dry **continental climate** prevails with cool summers and cold winters. Even though a rain shadow exists due to the

neighboring Alaska Range, **surface moisture is rather abundant** due to the gentle topography, patches of impermeable permafrost, and poor soil drainage. Permafrost is thin and discontinuous, and temperatures are near the melting point. **Collapse-scar bogs and fens** caused by retreating permafrost are frequent and related to climate warming since the Little Ice Age. Streams flowing across this north-sloping plain ultimately drain into one of two large river systems -- the Tanana or Kuskokwim. Groundwater-charged seeps and springs are common in gravel deposits. **Boreal forests** dominate the landscape with black spruce in bogs, white spruce and balsam poplar along rivers, and white spruce, white birch, and trembling aspen on south-facing slopes. The coldest, wettest areas on permafrost flats support birch-ericaceous shrubs and sedge tussocks. Tall willow, birch, and alder communities are scattered throughout. The mosaic of habitats supports moose, black bears, beavers, porcupines, trumpeter swans, and numerous other waterfowl.

Ecological Units within Denali National Park and Preserve

- Kuskokwim Plain-Eolian Lowlands
- Kuskokwim Plain-Lowland Flood Plains and Terraces
- Kuskokwim Plain-Minchumina Basin Lowlands

Ecological Units within Wrangell-St. Elias National Park and Preserve

- Jatahmund Basin Floodplains and Terraces subsection
- Jatahmund Basin Moraines Subsection

Yukon-Old Crow Basin *(0.5% of CAN)*

This gently-sloping basin along the Porcupine River is comprised of **depositional fans, terraces, pediments, and mountain toeslopes** that ring the **Yukon and Old Crow Flats**. The surfaces surrounding the flats are largely unglaciated and products of millions of years of weathering of the surrounding mountains. Here, deep deposits of colluvial, alluvial, and eolian origin are underlain by continuous masses of permafrost. The **marshy flats** have developed in deep alluvial and glaciolacustrine deposits underlain by discontinuous permafrost. The poorly drained flats and terraces harbor **vast wetlands** pockmarked with dense concentrations of thaw lakes and ponds. On the flats, water levels of lakes are often maintained by spring flooding rather than precipitation. Active fluvial processes are etched throughout the topography featuring **deltaic fans, terraces, and floodplains**. Opaque with glacial silts and shoreline mud, the Yukon River forms an **aquatic maze** of islands, sandbars, meander sloughs, and oxbow lakes as it crisscrosses the lower flats. The rich aquatic habitats support tremendous concentrations of **nesting waterfowl** (in the millions!) and other migratory birds and an abundance of moose, bears, furbearers, northern pike and salmon. A **dry**

continental climate prevails with considerable seasonal temperature variation. Arctic high-pressure systems prevail during the winter bringing clear and frigid weather. In contrast, summers are short but relatively warm. Vegetation varies with soil drainage grading from wet grass marshes and low shrub swamps to open black spruce forests to closed spruce-aspen-birch forests on better-drained uplands. Summer **forest fires** are common.

Ecological Units within Yukon-Charley Rivers National Preserve

- Thanksgiving Loess Plain
- Little Black River Hills

Yukon-Tanana Uplands (6.4% of CAN)

These **broad, rounded mountains** of moderate height are underlain by the metasedimentary Yukon-Tanana terrane. This terrane is a composite of transported crust blocks that includes former volcanic island arcs and continental shelf deposits. Most surfaces are comprised of bedrock and coarse rubble on ridges, colluvium on lower slopes, and alluvium in the deeply incised, narrow valleys. **Climate is strongly continental** with warm summers and very cold winters. The region is underlain by discontinuous permafrost on north-facing slopes and valley bottoms. In valley bottoms, permafrost is thin, ice-rich, and relatively "warm." Vegetation is dominated by white spruce, birch and aspen on south-facing slopes, black spruce on north-facing slopes, and black spruce woodlands and tussock and scrub bogs in valley bottoms. Floodplains of headwater streams support white spruce, balsam poplar, alder, and willows. Above treeline, low birch-ericaceous shrubs and *Dryas*-lichen tundra dominate. This area has the **highest incidence of lightning strikes** in Alaska and the Yukon Territory, causing frequent forest fires. Caribou, moose, snowshoe hares, marten, lynx, and black and brown bears are plentiful. The area's abundant cliffs are important to peregrine falcons. The clear headwater streams are important spawning areas for chinook, chum, and coho salmon.

Ecological Units within Yukon-Charley Rivers National Preserve

- Charley Foothills
- Upper Charley Mountain Tundra
- Upper Charley Valleys
- Three Fingers Supalpine Basin

Ecological Units within Wrangell-St. Elias National Park and Preserve

- Carden Hills Subsection
- Snag-Beaver Creek Plain Subsection
- Wellesley Mountains Subsection

Alaska Range Transition (26.1% of CAN)

Boreal forests occur within the basins and troughs fringed by the Alaska Range. This area is considered transitional since some climatic moderation is afforded by the nearby Pacific Ocean (i.e., maritime moisture). Ice sheets heavily scoured this area during the last glaciation, and small ice gaps and glaciers still exist at high elevations.

Alaska Range (18.9% of CAN)

A series of accreted terranes conveyed from the Pacific Ocean fused to form this **arcing mountain range**. In turn, these towering mountains harbor a complex mix of folded, faulted, deformed metamorphic rocks. **Landslides and avalanches** frequently sweep the steep, scree-lined slopes. Discontinuous permafrost underlies shallow and rocky soils. Because of the Alaska Range's height, a **cold continental climate** prevails and much of the area is barren of vegetation. Occasional streams of Pacific moisture are intercepted by the highest mountains and help feed small **icefields and glaciers**. At the glacier's termini, swift **glacial streams with heavy sediment** loads course down mountain ravines and braid across valley bottoms. Alpine tundra supports populations of **Dall sheep** and **pikas** on mid and upper slopes. Shrub communities of willow, birch, and alder occupy lower slopes and valley bottoms. Forests are rare and relegated to the low-elevation drainages. Brown bears, gray wolves, caribou, Dall sheep, and wolverines are common denizens in the Alaska Range.

Ecological Subsections within Denali National Park and Preserve

- Alaska Range-Teklanika Alpine Mountains and Plateaus
- Alaska Range-Teklanika Boreal Mountains and Plateaus
- Alaska Range-Toklat Basin Lowlands
- Alaska Range-Interior Alpine Floodplains, Terraces and Fans
- Alaska Range-Interior Lowland Floodplains, Terraces and Fans
- Alaska Range-South Central Nonvegetated Alpine Mountains
- Alaska Range-South Central Alpine Mountains
- Alaska Range-South Central Borea and Subalpine Mountains
- Alaska Range-Nonvegetated Alpine Mountains
- Alaska Range-Interior Glaciated Uplands
- Alaska Range-Interior Glaciated Lowlands
- Alaska Range-Alpine Outer Range and Kantishna Hills
- Alaska Range-Boreal Outer Range and Kantishna Hills
- Alaska Range-Interior Boreal Mountains
- Alaska Range-Interior Alpine Mountains

Ecological Units within Wrangell-St. Elias National Park and Preserve

- Jack Valley Subsection
- Mentasta Sedimentary Mountains Subsection

- Nabesna Basin Subsection
- Southern Mentasta Mountains Subsection

Cook Inlet Basin (0.4% of CAN)

This gently-sloping lowland was buried by ice and flooded by proglacial lakes several times during the Pleistocene. As such, the basin floor is comprised of **fine-textured lacustrine deposits** ringed by coarse-textured glacial tills and outwash. **Numerous lakes, ponds, and wetlands** attract large numbers of **waterfowl** (including trumpeter swans) and shorebirds. Dolly Varden and white fish occur in fresh waters. Several river systems support recovering salmon runs and resultant bear and raven populations. The basin is generally free of permafrost. A mix of maritime and continental climates prevails with moderate fluctuations of seasonal temperature and abundant precipitation. This climate, coupled with the flat to gently-sloping, fine-texture surfaces give rise to **wet, organic soils** that support **black spruce** forests and woodlands. Ericaceous shrubs are dominant in open bogs. Mixed forests of white and Sitka spruce, aspen and birch grow on better-drained sites and grade into tall shrub communities of willow and alder on slopes along the periphery of the basin. A mixture of wetland habitats supports numerous moose, black bears, beavers, and muskrats.

Ecological Subsections within Denali National Park and Preserve

- Cook Inlet Glaciated Lowlands
- Cook Inlet-Lowland Flood Plains, Terraces and Fans

Copper River Basin (6.8% of CAN)

This mountain basin lies within the former bed of Glacial Lake Ahtna on **fine-textured lacustrine deposits** ringed by coarse glacial tills. The basin is a **large wetland complex** underlain by thin to moderately thick permafrost and pockmarked with thaw lakes and ponds. A mix of **low shrubs and black spruce forests and woodlands** grows in the wet organic soils. Cottonwood, willow, and alder line rivers and streams as they braid or meander across the basin. Spring floods are common along drainages. **Arctic grayling, burbot, and anadromous sockeye salmon** are common fishes. Black and brown bears, caribou, wolverines, and ruffed grouse are present throughout these wetland habitats. The **climate is strongly continental**, with steep seasonal temperature variation. The basin acts as a cold-air sink, and winter temperatures can be bitterly cold.

Ecological Units within Wrangell-St. Elias National Park and Preserve

- Ahtna Lacustrine Plain Subsection
- Chitina Valley Floodplains and Terraces Subsection
- Chitina Valley Moraines and Hills Subsection

- Duck Lake Plain Subsection
- Kotsina-Kuskalana Hills and Terraces Subsection
- Middle Copper River Floodplain and Terraces Subsection
- Natat Plain Subsection
- Tanada Moraine Subsection
- Upper Copper River Floodplains and Terraces Subsection
- Wrangell Mountains Toeslope Subsection

Coast Mountains Transition (21.9% of CAN)

The high mountains on the interior-side of the coast mountains are exposed to a peculiar mix of climates. Because of their sheer height, these mountains capture ocean-derived moisture as it passes inland. Yet, due to their proximity to the interior, these mountains possess a fair degree of seasonal temperature change similar to a continental climate. Climatic influences change with elevation, with maritime conditions on mountaintops (feeding ice caps and glaciers) grading to continental conditions at their base (boreal forests).

Wrangell Mountains (16.3% of CAN)

This **volcanic cluster of towering, ice-clad mountains** is at the northwest edge of the St. Elias Mountains. This exceedingly steep, rugged terrain is the result of the ongoing collision of the Pacific and North American tectonic plates. Here, relatively recent volcanic flows and debris form a carapace over the Wrangellia terrane. The Wrangell Mountains possess a **peculiar mix of climates** because of their size and geographic location (i.e., on the Interior-side of the Coastal Mountains). The sheer height of the Wrangell Mountains allows interception of moisture-laden air emanating from the north Pacific Ocean. The abundant maritime snows feed **extensive icefields and glaciers** interspersed by **dull gray ridges** draped with **rock shard slopes** and patches of **alpine meadows**. The climate grades to dry continental at lower elevations where the Wrangell Mountains abut the cold-air basin of the Copper River. **Shrublands of willow and alder** with scattered spruce woodlands ring the lower slopes. Spruce and cottonwood grow along larger drainages. The Wrangell Mountains are highly dynamic due to **active volcanism, avalanches, landslides, glaciers, and stream erosion**. Soils are thin and stony and underlain by discontinuous permafrost. Its best-known denizen, the **Dall sheep,** roams throughout the area along with mountain goats, brown bears, caribou, wolverines, and gray wolves.

Ecological Units within Wrangell-St. Elias National Park and Preserve

- Baldwin Mountains Subsection
- Cheshnina Plateaus and Valleys Subsection
- Cross Range Subsection
- Drum-Sanford Footslopes Subsection
- Jacksina Lava Plateau Subsection

- Jarvis Range Subsection
- McCarthy Mountains Subsection
- Mt. Drum Subsection
- Mt. Sanford Subsection
- Mt. Wrangell Mountainside Subsection
- Nabesna Mountains Subsection
- Regal Range Subsection
- Tanada Mountains Subsection
- Wrangell Icecap Subsection

Kluane Range (5.6% of CAN)

The Kluane Range encompasses the drier interior portion of the St. Elias Mountains spanning, from the ablation zone (area where glacial ice melts faster than it accumulates) eastward to a fault line scarp along the Shakwak Valley. It is **generally ice-free** except for occasional glaciers extending from the St. Elias icefields. The area has a **dry continental climate**. It lies within a **partial rain shadow** of the St. Elias Mountains whereby moisture from the Pacific Ocean is effectively wrung from the atmosphere as weather systems rise over these towering peaks. Deformed sedimentary and volcanic rocks of the Wrangellia and Alexander terranes underlie this area. The **high-relief topography** has been exposed to mass wasting, stream erosion, and glacial scouring. Thin and rocky soils have developed in the colluvial veneer that covers most surfaces. Swift streams cascade down steep mountainsides where **scree movement, rock falls, landslides, and soil creep** occur. **Permafrost is discontinuous** with the presence of frost action features such as solifluction lobes, ice-wedge networks, and patterned ground. Vegetation is principally **alpine tundra and barrens** of lichens, prostrate willows, and ericaceous shrubs. Taller shrub communities occur at mid elevations. White spruce is found on lower slopes and valleys along the eastern boundary. Alpine and subalpine habitats support an abundance of Dall sheep, mountain goats, brown bears, caribou, moose, wolves, and wolverines.

Ecological Units within Wrangell-St. Elias National Park and Preserve

- Chisana Basin Subsection
- Nutzotin Igneous Mountains Subsection
- Nutzotin Sedimentary Mountains Subsection
- Solo-Beaver Valley Subsection
- Southern Nutzotin Hills and Mountains Subsection
- White River Basin Subsection

Coastal Rainforest (29.6% of CAN)

These coastal areas adjacent to the North Pacific Ocean receive copious amounts of precipitation throughout the year. Seasonal temperature changes are limited due to proximity to open ocean. These areas warm sufficiently in the summer to allow trees to grow and dominate at lower elevations. Massive ice fields and glaciers are common in the mountains.

Chugach-St. Elias Mountains (29.3% of CAN)

Arcing terranes of Pacific origin have been thrust onto the North American continent forming a **rugged ice-clad mountain chain** surrounding the Gulf of Alaska. This is the largest collection of icefields and glaciers found on the globe outside the polar regions. These towering mountains of faulted and folded sedimentary rocks intercept an **abundance of maritime moisture**, mainly in the form of snow. **Huge icefields, snowfields, and glaciers** surround steep angular and cliffy peaks that are mantled with hanging glaciers; isolated small peaks called nunataks poke up sporadically in the middle of the broad glaciers. In the summer, glacial meltwaters form rivulets and plunge down vertical ice shafts called moulins to join vast amounts of water flowing along the base of glaciers. Where they exude onto coastal flats, glaciers spread to form expansive lobes that gush water at their edges. Some glaciers run all the way to tidewater. Ice sheets swelled during past glaciations, inundating surrounding lands along the coast, as well as the Interior. The sheer height of these mountains together with their expansive icefields, forms an effective barrier for Interior species, except along the Alsek and Copper River corridors. **Thin and rocky soils** exist where mountain summits and slopes are devoid of ice, snow, and active scree. Here, **alpine communities** of sedges, grasses, and low shrubs grow which, in turn, support Dall sheep, mountain goats, hoary marmots, pikas, and ptarmigans. Glaciers and icefields have receded, leaving b**road U-shaped valleys**, many with sinuous lakes. Here, deeper soils have formed in unconsolidated morainal and fluvial deposits underlain by isolated pockets of permafrost. Alder shrublands and mixed forests grow on lower slopes and valley floors where moose and brown and black bears forage.

Ecological Units in Wrangell-St. Elias National Park and Preserve

- Bagley-Seward Icefield Subsection
- Bremner Valley Subsection
- Bering and Stellar Glaciers Subsection
- Churchill-Bona Massif Subsection
- Chitina Moraines Subsection
- Chitina and Logan Glaciers Subsection
- Copper River Canyon Subsection
- Icy Bay Foothills Subsection
- Icefield Ranges and Glaciers Subsection
- Malaspina Glacier Subsection
- Mt. Bear Massif Subsection

- Mt. Logan Massif Subsection
- Northern Chugach Cirque-Glacier Mountains Subsection
- Northern Chugach Foothills Subsection
- Northern Chugach Glaciers and Ridges Subsection
- Nikolai Butte Subsection
- Robinson Mountains Subsection
- Southern St. Elias Mountains Subsection
- Sulzer-Natazhat Mountains Subsection
- Tana Valley Subsection
- University-Centennial Mountains Subsection
- Waxel-Barkley Ridge Subsection
- White-Hawkins Massif Subsection
- Western St. Elias Foothills Subsection
- Yahtse and Guyot Glaciers Subsection

Gulf of Alaska Coast (0.3% of CAN)

Lush, **lichen-draped temperate rain forests** of hemlock and spruce interspersed with open wetlands blanket the shorelines and adjacent mountain slopes along the Gulf of Alaska. A **cool, hypermaritime climate** dominates with minor seasonal temperature variation and extended periods of **overcast clouds, fog, and precipitation**. Snow is abundant in the winter and persists for long periods at sea level. Permafrost is absent. Tectonic events have raised and submerged various portions of the coastline through time. Common forest animals include black and brown bears and Sitka black-tailed deer. Bald eagles, common murres, Bonaparte's gulls, Steller's sea lions, harbor seals, and sea otters teem along its endless shorelines. **Numerous streams and rivers** support Dolly Varden, steelhead trout, and all five species of **Pacific salmon**. Salmon spawning runs deliver tremendous amounts of nutrients to aquatic and terrestrial systems. A fjordal coastline and archipelago exists around Prince William Sound and points west where continental ice sheets repeatedly descended in the past. Here, fjords formed where glacier-carved terrain filled with seawater after deglaciation. At the head of fjords lie broad U-shaped valleys that have steep, deeply incised side walls draped with hanging glacial valleys. A coastal foreland extends from the Copper River Delta southeast to Icy Point, fringed by the slopes and glacier margins of the Chugach-St. Elias Mountains. Here, unconsolidated glacial, alluvial, and marine deposits have been uplifted by tectonics and isostatic rebound to form this relatively flat plain. Because of its geographic position, the foreland is water-drenched through persistent maritime precipitation and overland runoff from the mountains. The organic soils shed water slowly and are blanketed with wetlands among meandering and braided silt-laden streams. Temperate rain forests of hemlock and spruce grow sporadically where soil drainage affords (e.g., moraines, stream levees, and uplifted beach ridges). Rare dusky Canada geese and trumpeter swans nest on these wet flats where brown bears, Sitka black-tailed deer, and moose roam.

Ecological Units within Wrangell-St. Elias National Park and Preserve

- Malaspina Foreland Subsection

Appendix D: Legislation governing all I&M in the National Parks:

Mission Statement, National Park Service Organic Act (1916):

"...to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations hereinafter specified by such means and measures as conform to the fundamental purposes of the said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations".

National Parks Omnibus Management Act (1998):

'7he Secretary shall undertake a program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources. The monitoring program shall be developed in cooperation with other Federal monitoring and information collection efforts to ensure a cost-effective approach".

NPS Management Policies (1988), Chapter 4 (pp 4.1-4.21) - Natural Resource Management.-

"The National Park Service will manage the natural resources of the national park system to maintain, rehabilitate, and perpetuate their inherent integrity (4.1)."

19 a program of natural and social science research will be conducted to support NPS staff in carrying out the mission of the NPS by providing an accurate scientific basis for planning, development, and management decisions" (page?).

"The National Park Service will assemble baseline inventory data describing the natural resources under its stewardship and will monitor those resources at regular intervals to detect or predict changes. The resulting information will be analyzed to detect changes that may require intervention and to provide reference points for comparison with other, more altered environments" (4:4).

"Naturally evolving plant and animal populations, and the human influences on them, will be monitored to detect any significant unnatural changes. Action will be taken in the case of such changes based on the- type and extent of change and the appropriate management policy" (page?).

NPS-75, Natural Resources Inventory and Monitoring (199Z but should now be a "Director's Order'. from executive summary page ii):

"The major goals of the Servicewide inventory and monitoring (I&M) program are:

* to inventory the natural resources and park ecosystems under NPS stewardship to determine their nature and status;

* to monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments;
* and to integrate natural resources inventory and monitoring information into NPS planning, management, and decision making.

NEPA (1969):
Requires knowledge of resource conditions to direct and evaluate effects of management actions.

Forest and Rangeland Renewable Resources Planning Acts (1974, 1976):
Congressional mandates for I&M of natural resources on all U.S. public lands.

Other Legislation providing direction and support for funding expenditures to determine the condition of natural resources in Parks:
Endangered Species Act (1973, amended 1982)
Fish & Wildlife Coordination Acts (1958, 1980)
Migratory Bird Treaty Act(1974) ,
Clean Water Act (33 USC 1251 et seq.)
Clean Air Act (42 USC 7401 et seq., 1963, amended 1977, 1991)

Overall goal of (all) natural resource monitoring in parks is: to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems.

NPS-75, Natural Resources lnventory and Monitoring (1992):
The primary purposes of resource inventories are to:
(1) document the occurrence, location and current condition of physical habitat (water, air, soil, etc.) and major associated taxa (biota);
(2) identify locally rare or threatened and endangered species, locating fragile (or rare) ecosystems and potential "indicator species";
(3) assess the full range of populations,, ecosystem components, processes, and stresses from which to subsample for later long-term monitoring.

The primary objectives of natural resources monitoring are to:
(1) detect changes and to quantify accurately trends in resource conditions;
(2) develop information on the linkages between changes in resource conditions and their causes;
(3) provide field validation for any modeling efforts associated with monitoring,
(4) provide insights into the effectiveness of resource management policies and actions.
Thus, monitoring efforts must be evaluated often to assure that selected monitoring

elements are sensitive to change and that the techniques employed are effective...

... Natural resources monitoring is designed to detect changes and quantify trends in resource conditions. Properly designed, monitoring serves to provide information on linkages between changes in resource conditions and their causes. Monitoring is designed to provide a feedback between natural resource conditions and management objectives and can serve both to trigger management actions and to evaluate their effectiveness.

Resource monitoring is currently conducted in many parks specifically to: (1) determine compliance with environmental standards; or (2) evaluate impacts of visitor and management activities. Air and water quality monitoring systems have been developed to measure physical, chemical, and biological parameters. Long-term studies are also undertaken in response to detected or anticipated human impacts on natural resources.

The purpose of a natural resource ecological monitoring system is to provide a rational basis for taking management actions. Actions based on sound scientific data from monitoring will engender a higher level of confidence and will better ensure that natural resources and ecosystem functions remain unimpaired for future generations. In short, use of monitoring information will increase confidence in managers' decisions and improve their ability to manage park resources.

SERVICEWIDE Long-Term Programmatic Goals (NPS-75):
To comply with legal requirements, fully implement NPS policy, and guide management activities, the Servicewide Inventory and Monitoring Program focuses on attaining the following major long-term goals:

1. Establish natural resource inventory and monitoring as a standard practice throughout the National Park system which transcends traditional program, activity, and funding boundaries.
2. Inventory the natural resources and park ecosystems under National Park Service stewardship to determine their nature and status.
3. Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments.
4. Integrate natural resource inventory and monitoring information into National Park Service planning, management, and decision-making.
5. Share National Park Service accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives.

Attaining these long-term goals is the only, avenue to "manage the natural resources of the national park system to maintain and perpetuate their inherent integrity." (NPS *Management Policies*, Chapter 4, 1988). _