Denali National Park and Preserve

Resource Stewardship Strategy
2008 - 2027

September 30, 2009

Approved by: _____ 11/2/09

Regional Director, Alaska Region — *Date*

Recommended by: _____ 9/14/09

Superintendent, Denali National Park & Preserve — *Date*

Denali National Park and Preserve. 2009. Resource Stewardship Strategy 2008-2017. Denali National Park and Preserve, Denali Park, Alaska. 238 pp.

Executive Summary

Introduction

The *Resource Stewardship Strategy 2008 - 2027* (RSS) provides strategic guidance for the research, resource management, and resource education programs of the National Park Service at Denali National Park and Preserve.

The RSS is a program planning document that serves as a bridge between the qualitative statements of desired conditions established in the park General Management Plan (GMP) and the measurable goals and implementation actions determined through park strategic planning. The RSS is not a decision-making document. It is an analytical document that focuses on identifying and tracking indicators of desired conditions, recommending comprehensive strategies to achieve and maintain desired conditions over time, and assessing and updating these comprehensive strategies periodically based on new information and the results of completed activities.

The RSS provides the park with a strategy for investing both human and fiscal resources in the stewardship of natural and cultural resources. It also reports accountability toward progress in attaining and maintaining desired resource conditions at the park.

Denali has long recognized the importance of information-based decision making as well as the need to increase the understanding of the public about park issues through a science- and scholarship-based approach. In 2003, the park included the need for a strategic science plan as a park focus area, in part in response to the development of an integrated resource, education, and research program at Denali (the Center for Resources, Science, and Learning). The Murie Science and Learning Center was established at that time.

Director's Order 2-1 mandating the preparation of a Resource Stewardship Strategy, to replace a Resource Management Plan at parks nationwide, provides a useful approach for developing the science strategy needed at Denali. Denali will be the second unit in the National Park system, and the first park with extensive natural resources, to complete an RSS. Thus, Denali's RSS document may serve as a prototype for other large parks managing natural and cultural resources.

As much as possible, preparers of the document at Denali followed the guidance in the draft *Midwest Region Resource Stewardship Strategy Planner's Manual*. The draft manual was developed during the production of the first RSS for Herbert Hoover National Historic Site. Denali staff adopted new approaches to the RSS preparation where necessary to address the types and extent of natural resources found at Denali.

Fundamental and Other Resources and Values - Desired Condition

The first step in developing Denali's Resource Stewardship Strategy was to identify the resources and values that the National Park Service is responsible for preserving at Denali. These resources and values are contained in Congressional direction to the National Park Service through legislation such

as the park's enabling statutes, the National Park Service Organic Act of 1916, and the Clean Air Act. This identification is typically accomplished in a park's Foundation Statement.

Fundamental Resources and Values

Fundamental resources and values are the particular systems, processes, experiences, scenery, sounds, and other features that are central to achieving the park's purposes and maintaining its significance. Denali's fundamental resources and values are those that Congress identified specifically for the park through its enabling legislation, including both the Mount McKinley National Park Act of 1917 and the Alaska National Interest Lands Conservation Act of 1980. These resources and values may be synthesized for Denali as follows:

1. Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem.
2. Wilderness character, wilderness resource values, and wilderness recreational opportunities.
3. Scenic and geologic values of Mount McKinley and the surrounding mountain landscape.
4. Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features.

Other Important Resources and Values

Denali National Park and Preserve has *other important resources and values* that are not primary to the park's purpose and significance, but are important for both park management and visitors. These are resources and values that Denali possesses and has a legal mandate to protect, but which do not account for the establishment of the park and preserve. These other important resources and values include:

5. Historic, archeological, and ethnographic resources.
6. Paleontological resources.
7. Air quality.
8. Subsistence resources and opportunities.
9. Scientific research, education, and interpretation about natural ecosystems and geologic features and processes.

Desired condition statements for each resource or value are provided by the park's General Management Plan. While some desired conditions apply parkwide, others are specific to particular legislatively designated areas (Old Park, Denali Wilderness, park additions, preserve) or to management zones described in the General Management Plan.

Status of Resource Knowledge

The second step in developing Denali's RSS was reviewing an understanding of the work that has been accomplished relative to *desired condition* for each of the park's fundamental and other resources and values.

The status of knowledge, regarding biological, physical, and cultural resources, as well as park visitation and the human environment in and around the park, was assessed to identify available information, research mandates, and data gaps. Key findings in this resource review section include:

- The park has completed numerous resource inventories, but many more are needed (e.g., landcover, nonvascular plants, glaciers, water quality, soundscape, lightscape, paleontological resources, fish, amphibians, invertebrates, birds, archeological sites, cultural landscapes, ethnographic resources, and museum objects).

- The patterns of natural variability and the interactions among many park resources are not well understood, making it difficult to define desirable resource conditions. Achieving this understanding is complicated by the particularly rapid influence of global climate change on the condition of Subarctic ecosystems.

- The Central Alaska Inventory and Monitoring Network (CAKN) Network, and earlier monitoring efforts, provide information about how to monitor many park resources. However, monitoring protocols still need to be developed and implemented for some CAKN "vital signs" (e.g., grizzly bears and Dall's sheep), and other key resources (e.g., visitor experience and resource conditions in the backcountry).

- Environmental responses to management actions need to be more completely evaluated in some cases (e.g., restoration and recovery of disturbed lands; gravel extraction; and hazardous fuel treatment).

- The consumptive use of park resources by subsistence and other users is not well-documented either historically or in the present.

- While some aspects of the park's history have been documented, many aspects have not, including scientific and mountaineering histories.

- Visitor carrying capacity needs to be defined in some management zones of the park. Some significant types of park visitation need to be accounted for, and the park's model for estimating visitation needs to be improved.

- The relationship of surrounding human communities and land uses to park visitors and resources is not completely understood.

Indicator Selection and Condition Assessment

The third stage in the development of the RSS required the following steps to identify indicators of resource conditions and to use the indicators to assess resource conditions:

1. Identify attributes or characteristics of each significant resource.
2. Consider influences that can impact the condition of resource attributes.
3. Determine indicators for each resource attribute, i.e., what can be measured about the attribute that best indicates resource condition? Make sure indicators are effective in supporting interpretive themes and resource integrity.

4. Specify a target value for each indicator that represents the desired condition of the resource.
5. Measure current conditions using the indicators.
6. Assess the difference between current condition and desired condition for each indicator.

Key findings in the selection of indicators and assessment of resource condition include:

- The RSS Team identified 119 indicators of resource condition.
- A research program is needed to identify indicators related to visitor experience.
- Targets were set for 80 indicators.
- Research and planning are needed to identify targets for the remaining indicators, and to assess the current condition for 73 of the 119 indicators.

Comprehensive Strategies and Projects

The final step in the development of the RSS was the development of comprehensive strategies and associated projects to assure that the National Park Service is attaining and maintaining the desired conditions for all park resources and values. To that end, the 19 comprehensive strategies that were developed address one of three needs:

- Monitoring and managing park resources and visitor activity to assure that targets for each indicator are achieved.
- Filling data gaps necessary to define and evaluate indicators and targets for park resources.
- Implementing research or resource management activities required by legislation or the park's General Management Plan.

The comprehensive strategies identified for Denali are listed in Table 1. The RSS describes 99 specific projects to implement these strategies.

Table 1. Comprehensive strategies for Denali's RSS.

Base Knowledge of Park Resources Strategy A: Complete biological, physical, and cultural resource inventories. Strategy B: Develop an understanding of basic ecological relationships necessary for management decision-making. Strategy C: Develop the historic contexts necessary to evaluate resources and generate nominations for National Register significance. **Monitoring Resources** Strategy D: Develop and/or implement vital signs monitoring protocols for physical and biological resources to monitor long-term ecological change. Strategy E: Monitor natural resources that may need management response. **Management and Mitigation** Strategy F: Develop and implement plans to monitor and manage vulnerable park resources.	Strategy G: Restore and monitor disturbed lands. Strategy H: Determine and monitor visitor carrying capacity by management area. Strategy I: Minimize habituation of park wildlife. Strategy J: Detect, monitor, and mitigate environmental influences external to the local natural ecosystem. Strategy K: Mitigate the risk of wildland fire to park infrastructure and cultural resource sites. Strategy L: Preserve the museum collection and rehabilitate and preserve park historic structures. Strategy M: Monitor and manage consumptive uses of park resources, including subsistence use. Strategy N: Enhance and increase the effectiveness of wildlife protection by deterring illegal activities.	**Parks and People** Strategy O: Improve estimation of park visitation. Strategy P: Monitor trends in adjacent community populations, land use, and local economy. **Data Management** Strategy Q: Develop and implement effective data management strategies for use by managers, specialists, and the public. **Education and Communication** Strategy R: Facilitate the education of all audiences (external and internal) about resource issues in and around Denali to gain support for the park's management decisions. Strategy S: Develop staffing and infrastructure to enhance bridges between research and interpretation, and to facilitate higher levels of understanding and preservation of park resources.

Strategies Integral to the Success of Other Strategies and Projects

In addition to the 19 comprehensive strategies, the National Park Service will pursue several other strategies that underlie the success of all the other strategies and projects. These are not discreet projects, but rather they are general ways of doing business that should continuously be addressed and budgeted for. These support strategies include:

Conduct periodic strategic program reviews. Periodically review the park's staffing situation, in order to identify potential or impending deficiencies or strengths. Identify projects, make appropriate budget plans, and form strategic partnerships to solve staffing needs. Fill identified staffing needs to accomplish the strategies and projects that have been identified.

Provide adequate staff training, development, and learning opportunities. Maintain a high level of expertise and professionalism among resources, enforcement, education, and interpretation staff. Provide multiple opportunities for staff to learn, develop new skills, acquire new knowledge, become familiar with new equipment or techniques, and distribute research results.

Collaborate with other agencies and institutions. Work with other land management agencies, federal, state or private biologists and researchers, and universities to maintain high standards of inventory, management, and research activities. Collaborate with other enforcement agencies to cultivate an interest in wildlife protection.

Engage external research partners. Develop and circulate information on resource knowledge gaps to researchers. Facilitate research and provide basic logistics to attract quality research that will inform park management and protection activities. Examples of ongoing partnerships include partnerships with the University of Alaska (UA) Geophysical Institute, the UA Geology Field Camp, Cooperative Ecosystem Study Units, and the U.S. Geological Survey.

Maintain accountability for mitigation prescribed through environmental analysis. Monitor compliance with and effectiveness of mitigation measures prescribed through NEPA environmental analysis (Environmental Impact Statements, Environmental Assessments) of new development projects, including no net loss of wetlands.

Funding Denali's Resource Stewardship

One purpose of the RSS is to guide the park's investment (human and fiscal) in the stewardship of cultural and natural resources. The RSS assigns funding needs for implementing RSS strategies via projects to several National Park Service funding sources, and also provides a means of accountability for funds used to attain and maintain desired conditions of park resources.

Currently the total expenditure of funds for resource stewardship at Denali (i.e., resource management, historical restoration, resource education, resource planning, and resource protection) is less than one quarter of the park's total expenditures (approximately 5 of 21 million).

The RSS budget indicates that funding will be adequate to address the key stewardship issues affecting the park only if the current resource stewardship funding is sustained (and increased to account for inflation) *and* is supplemented by increases in funding. These funding needs will have to compete for priority within the park, Alaska Region, and NPS Servicewide. Supplemental increases of approximately $500,000 are needed from both the park's annual operational base budget (Operation of the National Park Service or ONPS) *and* from NPS project funds (Servicewide Comprehensive Call (SCC), Concession Franchise Fee (CFF), or Federal Lands Recreation Enhancement Act (FLREA) funds). The funding analysis also assumes that two large needs for attaining desired conditions (restoration of disturbed lands and fixing deficiencies in the museum collection) continue to receive funding support via special base fund allocations through FY2010.

The implementation of comprehensive strategies is aided greatly by the current high-quality monitoring and research efforts at Denali; the high degree of integration of the park's resource stewardship with the Central Network Inventory and Monitoring Program; the efficiencies developed during the Core Operations Analysis; and the significant investment of park CFF and FLREA funds to resource stewardship.

More than two-thirds of funding for RSS projects at Denali is non-base. The nature of this funding is highly variable. In 2003, the park did not yet have significant CFF funding; in 2007, this funding was reduced by over 75%. In 2005, Federal Lands Recreation Enhancement Act (FLREA) legislation disqualified many resource stewardship projects that had been previously funded under Fee Demonstration (Fee Demo) legislation.

It will be difficult to maintain the current level of non-ONPS funding without both the continued flexibility in use of other fund sources and the continued commitment by park management to resource stewardship while facing other high-priority park needs.

The long-term stability of resource stewardship efforts will remain vulnerable until an increased proportion of the program is base-funded—as the Central Alaska Network Inventory and Monitoring Program was base-funded by the Natural Resource Challenge.

It is also important to reiterate that the RSS does not address *all* the resource stewardship projects that could enhance management of the park, but instead focuses on those needs that are critical to maintaining the desired condition of park resources and values, as well as on the park's legal mandates.

Contents

Executive Summary iii

Introduction iii
Fundamental and Other Resources and Values - Desired Condition iii
Status of Resource Knowledge iv
Indicator Selection and Condition Assessment v
Comprehensive Strategies and Projects vi
Strategies Integral to the Success of Other Strategies and Projects viii
Funding Denali's Resource Stewardship viii

Contents xi

Figures xii

Tables xii

Introduction 1

Purpose and Need for a Resource Stewardship Strategy 1
Park Purpose and Significance 1
Desired Conditions 7
Relationship to Other Park Plans 15
Relationship to NPS Inventory and Monitoring Program 18
Context of the Park's Resources 19
Status of Resource Knowledge 28
Education and Interpretation Themes 89

Comprehensive Strategies 93

Indicator Selection and Condition Assessment 93
Comprehensive Strategies – Relationship to Park Resources and Values 133
Comprehensive Strategies – List of Strategies and Projects with Timeline and Budget 142
Expert Review of Comprehensive Strategies 175
Projected Funding Needs to Implement the RSS 175

Finalization and Implementation 185

Finalization 185
Implementation - Tracking and Evaluating Annual Progress 185

References 186

Appendices 205

Appendix A: Interdisciplinary Team and Stakeholders 206
Appendix B: Indices Identified and Used – Cultural Resources 207
Appendix C-1: Resource Assets and Current Conditions – Cultural Resources (Structures and Cultural Landscapes) 209
Appendix C-2: Resource Assets and Current Conditions – Cultural Resources (Museum Objects) 221
Appendix D: Resources Attributes, Current Conditions, and References – Natural Resources 222
Appendix E: Public Involvement and Expert Review Response 230
Appendix F: Additional Employee Needs, Line Items for Construction, Funding Sources, and Project Prioritization 233

Figures

Figure 1. Map of Denali National Park and Preserve. 5

Figure 2. Park Development Zone, Denali National Park and Preserve. 9

Figure 3. Backcountry management areas or subzones for Denali National Park and Preserve, as defined in the 2005 Backcountry Management Plan. 10

Figure 4. Distribution of Denali's ONPS (base) budget in FY2009. 176

Figure 5a: Current organizational chart (all divisions). 177

Figure 5b: Current organizational chart (Center for Resources, Science, and Learning). 178

Figure 6. Optimal organizational chart (Center for Resources, Science, and Learning). 179

Figure 7. Resource stewardship expenditures (FY2003–FY2009) in comparison to total park expenditures. 180

Figure 8. Natural resources funding (FY2003-FY2009) by fund source. 181

Figure 9. Cultural resources funding (FY2003-FY2009) by fund source. 182

Figure 10. Funding in support of resource stewardship (FY2003-FY2009) by program area. 183

Figure 11. Past resource stewardship expenditures and projected 10-year RSS implementation costs by fund source. 184

Tables

Table 1. Comprehensive strategies for Denali's RSS. vii

Table 2. Summary of current and projected park plans. 17

Table 3a. Natural resource inventories and documentation. 78

Table 3b. Natural resource studies and research reports. 81

Table 4a. Cultural resource inventories and documentation. 85

Table 4b. Cultural resource studies and research reports. 86

Table 5. Subsistence documentation, studies, and research reports. 87

Table 6. Park visitation and neighboring communities—documentation, studies, and research reports. 88

Table 7: Education and interpretation themes in relationship to resource condition-dependent visitor experiences and park resources and values. 91

Table 8: Attributes, influences, indicators, and target values for park-wide resources. 94

Table 9: Attributes, influences, indicators, and target values for legislatively-defined areas. 120

Table 10: Attributes, influences, indicators, and target values for management zones. 126

Table 11. Comprehensive strategy to complete physical, biological, and cultural resource inventories for Denali. 144

Table 12. Comprehensive strategy to develop an understanding of basic ecological relationships necessary for management decision-making. 147

Table 13. Comprehensive strategy to develop the historic contexts necessary to evaluate resources and generate nominations for National Register significance. 148

Table 14. Comprehensive strategy to develop and/or implement vital signs monitoring protocols for physical and biological resources to monitor long-term ecological change. 152

Table 15. Comprehensive strategy to monitor natural resources that may need management response. 154

Table 16. Comprehensive strategy to develop and implement plans to monitor and manage vulnerable park resources. 155

Table 17. Comprehensive strategy to restore and monitor disturbed lands. 157

Table 18. Comprehensive strategy to determine and monitor visitor carrying capacity by management area. 158

Table 19. Comprehensive strategy to minimize habituation of park wildlife. 159

Table 20. Comprehensive strategy to detect, monitor, and mitigate environmental influences external to the local natural ecosystem. 160

Table 21. Comprehensive strategy to mitigate the risk of wildland fire to park infrastructure and cultural resource sites. 162

Table 22. Comprehensive strategy to preserve the museum collection and rehabilitate and preserve park historic structures. 163

Table 23. Comprehensive strategy to monitor and manage consumptive uses of park resources, including subsistence use. 164

Table 24. Comprehensive strategy to enhance and increase the effectiveness of wildlife protection by deterring illegal activities. 166

Table 25. Comprehensive strategy to improve estimation of park visitation. 167

Table 26. Comprehensive strategy to monitor trends in adjacent community populations, land use, and local economy. 168

Table 27. Comprehensive strategy to develop and implement effective data management strategies for use by managers, specialists, and the public. 169

Table 28. Comprehensive strategy to facilitate the education of all audiences (external and internal) about resource issues in and around Denali to gain support for the park's management decisions. 171

Table 29. Comprehensive strategy to develop staffing and infrastructure to enhance bridges between research and interpretation and to facilitate higher levels of understanding and preservation of park resources. 172

Table 30. Comprehensive strategy to support other strategies and projects. 174

Introduction

Purpose and Need for a Resource Stewardship Strategy

The Resource Stewardship Strategy (RSS) serves as a bridge between the qualitative statements of desired conditions established in the park General Management Plan (GMP) and the measurable goals and implementation actions determined through park strategic planning. The RSS is not a decision-making document. Instead it is an analytical document that focuses on identifying and tracking indicators of desired conditions, recommending comprehensive strategies to achieve and maintain desired conditions over time, and assessing and updating these comprehensive strategies periodically based on new information and the results of completed activities. The RSS provides the park with a strategy for investing both human and fiscal resources in stewardship of cultural and natural resources. It also reports accountability toward progress in attaining and maintaining desired resource conditions at the park.

The peer-reviewed comprehensive strategies focus on an integrated, interdisciplinary approach. Stakeholders who have an interest in resources within and in areas adjacent to the park have been informed about the preparation of the RSS, ensuring that these stakeholders understand the role of the RSS in the park planning framework (see Appendix A).

Implementation of the RSS and its comprehensive strategies will identify a reasonable range of alternative actions to attain and maintain desired conditions. These implementation alternatives will be the subject of appropriate environmental planning and compliance documentation when specific actions or undertakings are considered. The authority for the RSS lies within the GMP and its associated environmental compliance documents and is limited by those documents. The Denali GMP consists of four documents, an original GMP and three major amendments:

- 1986 *General Management Plan*
- 1997 *Entrance Area and Road Corridor Development Concept Plan*
- 1997 *South Side Denali Development Concept Plan*
- 2006 *Backcountry Management Plan*

Resource Stewardship Strategy will be implemented as funds are made available.

Park Purpose and Significance

The park purpose is a clear statement of why Congress and the president established the park as a unit of the National Park System as derived from the law(s) establishing the park. The purpose of Denali National Park and Preserve has evolved from the time Congress established the original Mount McKinley National Park to the present and has increased in complexity because of the different mandates that apply to the Old Park (the original Mount McKinley National Park), the national park additions (added by ANILCA), the national preserve (also added by ANILCA), and the designated wilderness (covering most of the Old Park).

Mount McKinley National Park (Old Park)
In 1917 Congress established Mount McKinley National Park as 1) "a public park for the benefit and enjoyment of the people" and 2) a "game refuge." Consistent with these purposes, the statute directed the Secretary of Interior to publish rules and regulations "aimed at the freest use of the said park 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." (39 Stat. 938).

Denali National Park and Preserve
In 1980 Congress passed the Alaska National Interest Lands Conservation Act (ANILCA, 16 USC §§ 3101-3233, Pub. L. 96-487) that enlarged and renamed the unit Denali National Park and Preserve. Section 101 of ANILCA describes the broad purposes of the new conservation system units throughout Alaska, including enlarged national parks and preserves such as Denali. These are the following:

- Preserve lands and waters for the benefit, use, education, and inspiration of present and future generations.
- Preserve unrivaled scenic and geological values associated with natural landscapes.
- Maintain sound populations of, and habitat for, wildlife species.
- Preserve extensive, unaltered ecosystems in their natural state.
- Protect resources related to subsistence needs.
- Protect historic and archeological sites.
- Preserve wilderness resource values and related recreational opportunities such as hiking, canoeing, fishing, and sport hunting.
- Maintain opportunities for scientific research in undisturbed ecosystems.
- Provide the opportunity for rural residents engaged in a subsistence way of life to continue to do so.

Section 202 stated that the Denali National Park and Preserve additions are to be managed for the following specific purposes:

- To protect and interpret the entire mountain massif and the additional scenic mountain peaks and formations.
- To protect habitat for, and populations of fish and wildlife, including, but not limited to, brown/grizzly bears, moose, caribou, Dall's sheep, wolves, swans, and other waterfowl.
- To provide continued opportunities, including reasonable access, for mountain climbing, mountaineering, and other wilderness recreational activities.

Denali Wilderness
Section 701 of ANILCA designated the "Denali Wilderness of approximately one million nine hundred thousand acres" (later remapped at 2.1 million acres) under the Wilderness Act as depicted on a map referenced in Section 202 of ANILCA and including 99% of the former Mt. McKinley National Park. According to the Wilderness Act, these lands are to be "administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and so as to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness."

Denali National Preserve
Section 1313 of ANILCA addresses the purpose of national preserves created by the act.

> A National Preserve in Alaska shall be administered and managed as a unit of the National Park System in the same manner as a national park except as otherwise provided in this Act and except that the taking of fish and wildlife for sport purposes and subsistence uses, and trapping shall be allowed in a national preserve under applicable State and Federal law and regulation.

It is important to distinguish a "purpose" from an allowable use. The ANILCA language specifies that the Preserve has the same purpose as the rest of the park, and is distinguished only by having an additional allowable use. Likewise, in the park and preserve additions subsistence is an allowable use, but not a purpose. ANILCA Sec. 202(3)(a) reads, "Subsistence uses by local residents shall be permitted in the additions to the park where such uses are traditional...."

Fundamental Resources and Values

The Fundamental Resources and Values are part of the foundation for all planning and management at the park. The particular features, systems, processes, experiences, scenery, and sounds that are fundamental to achieving the park's purposes and maintaining its significance constitute its Fundamental Resources and Values. Denali's fundamental resources and values are those which Congress identified specifically for the park through legislation. These resources and values may be synthesized as follows:

1. **Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem.**

The original Mount McKinley National Park was established as a "game refuge" set aside in part for "the preservation of animals, birds, and fish." ANILCA indicated the park additions were established "to protect habitat for, and populations of fish and wildlife," thereby extending this fundamental purpose to the entirety of the expanded park and preserve. ANILCA also established a purpose of protecting entire ecosystems, not just wildlife. Denali's large size, remoteness, and early protection of the original park make possible the ongoing preservation of an intact natural ecosystem sufficient to support even large, wide-ranging mammals such as caribou and wolves.

2. Wilderness character, wilderness resource values, and wilderness recreational opportunities.

The passage of ANILCA in 1980 recognized the wilderness resource values of the original park and the additions. Section 701 designated 99% of the former Mount McKinley National Park (now mapped at 2.1 million acres) as the Denali Wilderness to be managed under the provisions of the Wilderness Act which states wilderness lands should be "administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness...and for the gathering and dissemination of information regarding their use and enjoyment as wilderness." ANILCA specified a purpose of the park additions as "to provide continued opportunities, including reasonable access, for mountain climbing, mountaineering, and other wilderness recreational activities." Section 101 of ANILCA provided that a general purpose of the Alaska conservation system units is to "preserve wilderness resource values and related recreational opportunities such as hiking, canoeing, fishing, and sport hunting" and section 102 defines wilderness in the same manner as the Wilderness Act. A wilderness suitability study in 1986 found that virtually all of the park additions and preserve with the exception of some mining-disturbed lands in the Kantishna Hills were suitable for wilderness designation.

The key components of wilderness described in the Wilderness Act include 1) generally appearing to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable and 2) opportunities for solitude or a primitive and unconfined type or recreation. Denali possesses both very accessible wilderness recreational activities and activities that are very remote and require self-reliance, significant time commitments, and thorough advance planning. Denali also offers the opportunity for visitors who never leave a bus or airplane to enjoy the undeveloped wilderness character of the park.

3. Scenic and geologic values of Mount McKinley and surrounding mountain landscape.

Management of the original Mount McKinley National Park was intended in part, "for the preservation of the natural curiosities and scenic beauties thereof...." ANILCA expanded the national park to include the entire Mount McKinley massif, and specified one purpose of the park additions to be "protect and interpret the entire mountain massif and the additional scenic mountain peaks and formations." In addition to Mount McKinley, the tallest mountain in North America, Denali contains a myriad of other high Alaska Range mountains, including Mount Foraker and the Cathedral Spires, some of the largest glaciers in North America, and glacier-carved gorges such as the Ruth Gorge.

4. Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features.

Congress set aside the original Mount McKinley National Park "as a public park for the benefit and enjoyment of the people..." A general purpose of all of the ANILCA lands is to "preserve lands and waters for the benefit, use, education, and inspiration of present and future generations." Because of the location and conservative management of the Denali park road, the park is one of the best places in the world for the public to observe large northern mammals in their natural habitat. Visitors also have many opportunities to observe smaller mammals and birds, some of which are rarely seen elsewhere in North America. Mount McKinley, other Alaska Range features such as the Ruth Gorge and Ruth Amphitheater, and many other scenic features are also a source of visitor enjoyment and inspiration.

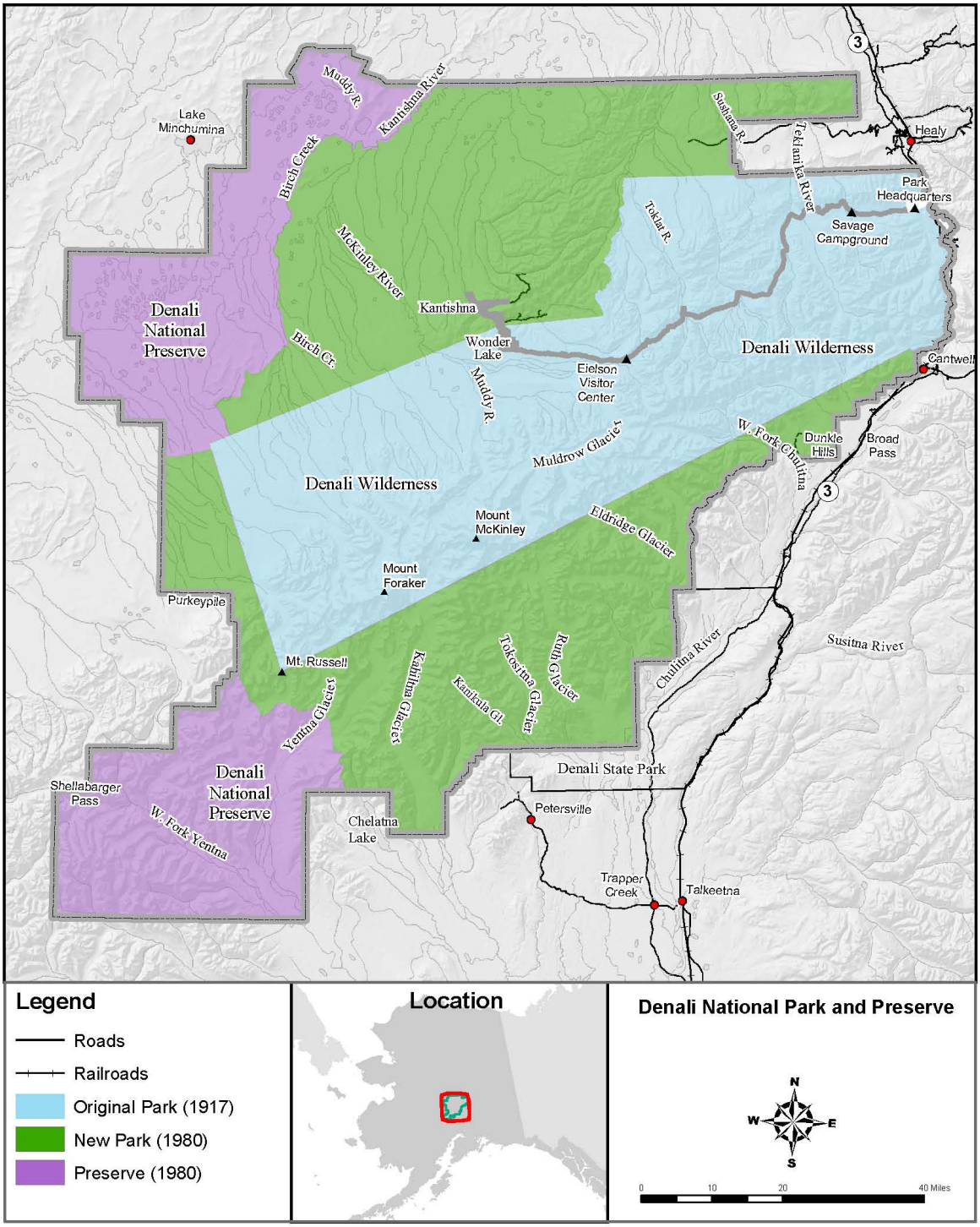


Figure 1. Map of Denali National Park and Preserve.
Denali comprises three areas: original Mt. McKinley National Park (blue), new park additions added in 1980 with ANILCA legislation (green), and preserve also added in 1980 (purple).

Other Important Resources and Values

The fundamental resources and values are those which are so significant that Congress felt it was important to designate a national park to protect them. Denali National Park and Preserve has other important resources and values that are not primary to the park's purpose and significance but are important for both park management and visitors. These are resources and values that Denali possesses and which the National Park Service has a legal or policy mandate to protect – including general direction for all the ANILCA conservation system units – but which do not account for the establishment of the park and preserve. These other important resources and values include:

5. Historic, archaeological, and ethnographic resources.
Denali has 262 known cultural resource sites within the park's boundaries, including both prehistoric and historic sites. It is anticipated that additional resources will be found as inventories are conducted and completed. Protection of historic, archaeological, and ethnographic resources is mandated by several federal laws and regulations and by NPS policy. A general purpose of ANILCA conservation system units is to "protect historic and archeological sites."

6. Paleontological resources.
Denali has over 300 paleontological sites and thousands of specimens, ranging from fossil marine and terrestrial micro-fauna (i.e., forams, conodonts, radiolarians) and micro-flora (i.e., pollen) to larger marine invertebrates and terrestrial plants and animals, and, as a recently discovered resource, dinosaur trace fossils. These fossils represent most of the bio-geologic time, from Early Paleozoic to Recent, and require appropriate understanding and protection. Recent discoveries of fossilized tracks and other prints of hadrosaurs, theropods, and birds from the Cretaceous period have added a new dimension to park resources protected under the NPS Organic Act.

7. Air quality.
Denali has exceptionally clean air that is a resource in its own right, but also supports visitor enjoyment of the park's scenic resources and the health of the park's ecosystem. Denali is designated a Class I airshed under the Clean Air Act.

8. Subsistence resources and opportunities.
ANILCA generally specifies a purpose for Alaska conservation system units as "provide the opportunity for rural residents engaged in a subsistence way of life to continue to do so." Specifically for Denali, ANILCA identifies subsistence as a permitted use, but not as a purpose. Subsistence users actively harvest Denali resources particularly in the northwestern park and preserve from Lake Minchumina, in the southeastern park additions near Cantwell, and in the Kantishna Hills.

9. Scientific research, education, and interpretation about natural ecosystems and geologic features and processes.
General language from both ANILCA and the Wilderness Act indicate that lands designated under these laws include education and research among their purposes. ANILCA mentions interpretation of the mountain massif and other geologic features to be a specific purpose for the Denali additions. Section 4(b) of the Wilderness Act states that education and research are primary public purposes within areas preserved as wilderness.

Desired Conditions

The park GMP specifies desired conditions for most of Denali's fundamental and "other" resources and values. Desired conditions are a qualitative description of the integrity and character for a set of resources and values, including visitor experiences that the NPS has committed to achieve and maintain. Some of these desired conditions are articulated for the entire park and preserve, others apply only to specific management zones (also called "management areas" in some Denali plans). This Resource Stewardship Strategy (RSS) focuses on providing park managers with recommended comprehensive strategies to guide National Park Service (NPS) investment in achieving and maintaining the desired conditions for the park's cultural and natural resources.

When most of the Denali GMP documents were crafted, articulating desired conditions was not an explicit objective of the planning process. As a result, although the desired conditions are present in the text they must be extracted and, in some cases, interpreted with reference to statutes.

Park-Wide Desired Conditions

Park-wide desired conditions generally address natural and cultural resources. Wilderness resources, subsistence, and visitor enjoyment of resources are addressed only within specific legislative or management areas.

1. Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem.

1.1 The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained. (GMP)

1.2 The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations. (GMP)

3. Scenic and geologic values of Mount McKinley and surrounding mountain landscape.

3.1 Scenic and geologic values are preserved. (ANILCA)

5. Historic, archaeological, and ethnographic resources.

5.1 Historic and archeological sites, and the resulting identified cultural landscapes are appropriately protected. (GMP)

5.2 Historic objects and ethnographic resources are appropriately preserved. (GMP)

5.3 The National Park Service will ensure the preservation of resources associated with native peoples whose cultural memory, traditions, and lives are closely associated with the park and its general vicinity. (GMP)

6. Paleontological Resources

6.1 Paleontological resources will remain unimpaired. (NPS Organic Act)

7. Air Quality

7.1 Denali will achieve the highest attainable air quality levels and visibility standards consistent with the applicable Clean Air Act designations and the mandates specified by ANILCA and the NPS Organic Act; Denali is designated as a Class I airshed. (GMP)

Management Zone-Specific Desired Conditions

The GMP delineates zones that correspond to management prescriptions in an area-specific context. The different prescriptions for resource condition, visitor experience, and appropriate management activities reflect the suitability of specific areas for specific uses. Area-specific desired conditions include qualitative descriptions as well as guidance on visitor experience opportunities and appropriate kinds and levels of management, development, and access (modes of transportation) for each area of the park. Denali's management zoning is complex because it was created in four different processes.

1) ANILCA resulted in distinct legal mandates for three areas within Denali. (See Figure 1.)
    a. The "Old Park," or the former Mount McKinley National Park, containing both the i) Denali Wilderness and ii) a small amount of non-wilderness around the park road corridor;
    b. The "national park additions" including all the lands added by ANILCA except national preserve; and
    c. The "national preserve" which is distinguished from the park additions primarily by the allowance for sport hunting.
2) The 1986 General Management Plan created four different management zones which spanned the entire park and preserve. These included the Park Development Zone, Natural Zone, Historic Zone, and the renamed Inholdings Special Use Area.
3) The 1997 Entrance Area and Road Corridor Development Concept Plan/GMP Amendment (GMP-EARC) subdivided the Park Development zone into 13 sub-zones, some of which were not utilized or were replaced by zones in the Backcountry Management Plan. The Park Development Zone is depicted in Figure 2.
4) The 2006 Backcountry Management Plan/GMP Amendment (NPS 2006a) subdivided the Natural Zone into 12 sub-zones. (See Figure 3; Corridors and Portals are small areas not depicted at this scale)

The desired condition statements associated with each of these management areas are listed below. The source of the desired condition statement is indicated in parentheses.

Legislatively-Defined Areas

Old Park

1. Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem.

1.3 Human activity will not result in a decrease of wildlife viewing opportunities along the park road. (GMP)

1.4 The community of life is untrammeled by human activity. (Wilderness Act)

National Park Additions

1. Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem.

1.5 Wildlife populations should be natural and healthy (ANILCA).

8. Subsistence resources and opportunities.

8.1 The utilization of the public lands in Alaska is to cause the lease adverse impact possible on rural residents who depend upon subsistence uses of the resources of such lands. (ANILCA, GMP)

8.2 The opportunity for qualified local rural residents to continue traditional subsistence activities will be protected. (NPS Subsistence Mission Statement)

National Preserve

1. Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem.

1.6 Wildlife populations should be healthy (ANILCA).

8. Subsistence resources and opportunities.

8.1 The utilization of the public lands in Alaska is to cause the lease adverse impact possible on rural residents who depend upon subsistence uses of the resources of such lands. (ANILCA, GMP)

8.2 The opportunity for qualified local rural residents to continue traditional subsistence activities will be protected. (NPS Subsistence Mission Statement)

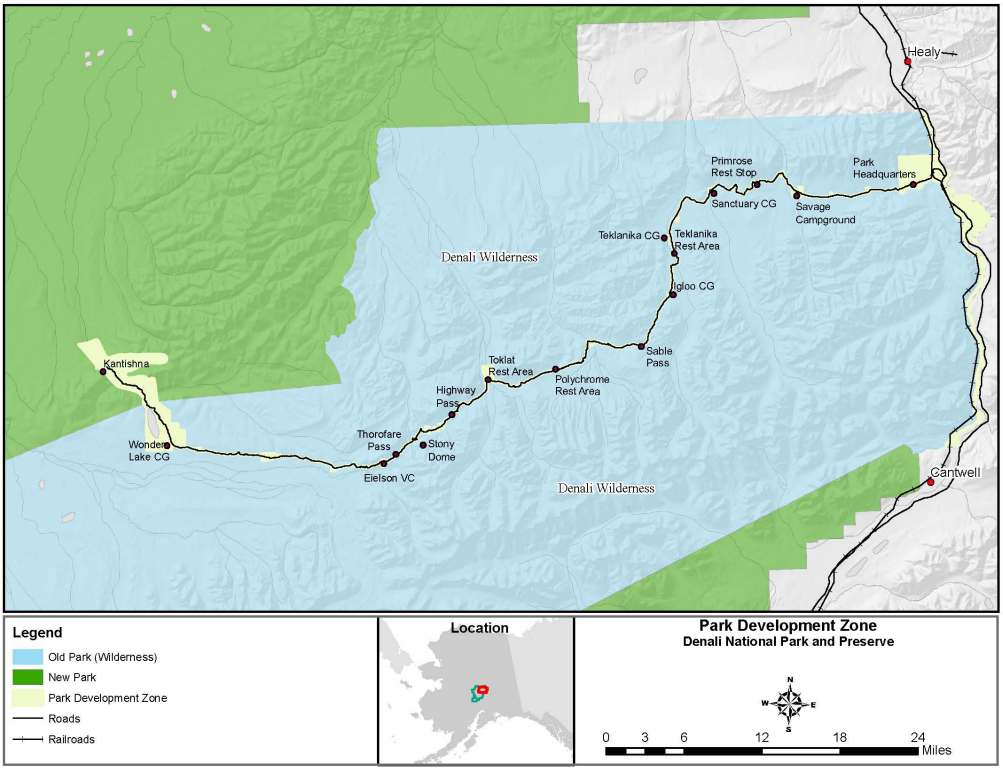


Figure 2. Park Development Zone, Denali National Park and Preserve. Most of the Park Development Zone (shaded light green) borders the Denali Park Road, the George Parks Highway, or the Alaska Railroad.

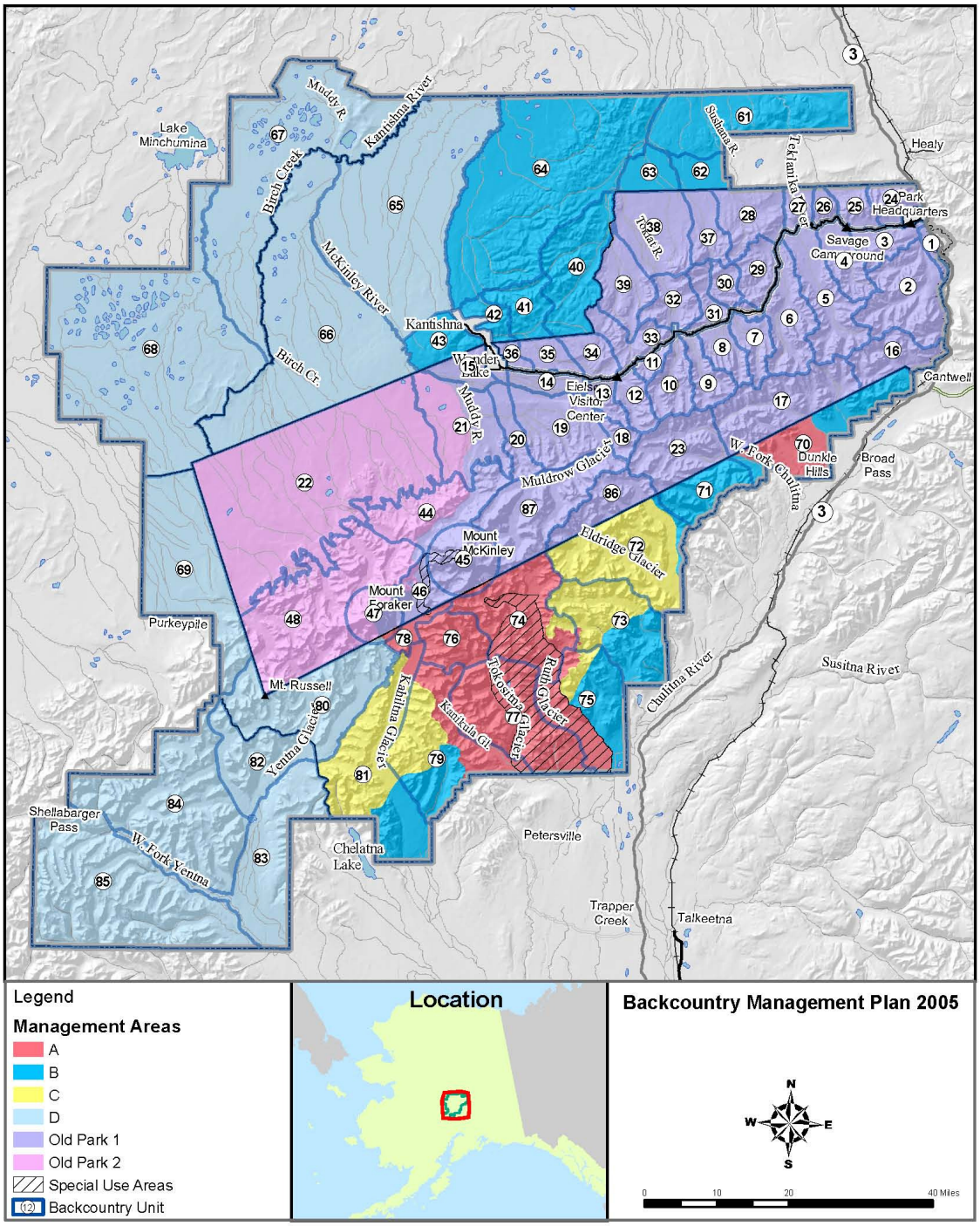


Figure 3. Backcountry management areas or subzones for Denali National Park and Preserve, as defined in the 2005 Backcountry Management Plan.

Management Zones

Park Development Zone

The park development zone (see Figure 2) corresponds with the wilderness exclusion in the Old Park and includes some lands around the park road and portions of the Moose Creek and Skyline mining access routes in Kantishna (national park additions). Lands in this zone are managed to accommodate major development and intensive use.

4. Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features.

4.1 Visitors will discover a variety of facilities and services that meet the needs of varied audiences seeking different levels of experience with the park's resources. (GMP)

Sub-zone desired conditions

Appendix D of the *Entrance Area and Road Corridor Development Concept Plan* presents the sub-zones within the Park Development Zone. There are two major divisions of the Park Development Zone which have different mixes of sub-zones and different goals for visitor experience. These are:

Park Road: portions of the Park Development Zone west of Savage River.

Entrance Area: portions of the Park Development Zone east of Savage River.

Qualitative statements of desired conditions can be assembled into the following categories:

4.2(a) Sights and sounds of people, vehicles, and facilities
4.2(b) Wildlife and scenic viewing opportunities

4.2(c) Natural landscape and wilderness character Snippet_300D72779.idms

The sub-zones are described as follows.

Level 1 Development (D-1): This sub-zone includes areas in which major permanent facilities are located. It may include commercial facilities, interpretive facilities, and other administrative and support facilities such as offices, maintenance buildings, and employee housing. The sights and sounds of people and vehicles are common in this sub-zone.

Level 2 Development (D-2): This area includes visitor services and administrative support facilities such as campgrounds, rest areas, and trail heads. This sub-zone does not allow for commercial facilities and buildings are limited to smaller structures. While the sights and sounds of people and vehicles are common, these areas are immediately adjacent to backcountry or designated wilderness.

Sensitive Resource Protection: This area includes all wildlife closures, which may border on a road but extend into designated wilderness. Human presence within these areas comprises an immediate threat to wildlife populations or other critical resources and is therefore allowed by permit only.

Railroad Right-of-Way: This sub-zone is similar to the "Special Use Zone" designation in the 1986 GMP in that it is not owned and managed by the National Park Service. Cooperative management with the Alaska Railroad is essential

	to ensure that conflicts with other park uses and resources do not occur.
Motorized Sightseeing 1:	This sub-zone allows for frequent, year-round traffic that includes commercial vehicles. The visitor experience generally depends on a vehicle and may include some scenery and wildlife viewing.
Motorized Sightseeing 2:	This sub-zone is designated for access to developed and administrative areas and may include some commercial traffic. Another primary activity is wildlife and scenery viewing that is generally dependent on a vehicle.
Motorized Sightseeing 3:	The primary activity in this sub-zone is wildlife and scenery viewing that is generally dependent on a vehicle. Commercial vehicles are restricted in these areas.
Wildlife Viewing 1:	This sub-zone includes part of the gravel section of the park road on which the primary purposes include wildlife and scenery viewing. Visitors travel on one of the bus systems and private vehicles are restricted. The only facilities present include the park road and generally one rest area for every hour of travel. Visitors can expect a greater level of traffic in this sub-zone than in wildlife viewing sub-zone 2. As many people as possible are able to view major Alaskan mammal species in their natural habitat.
Wildlife Viewing 2:	This sub-zone includes the gravel section of the park road on which greater restrictions (rules of the road) apply. Buses are given the right-of-way and the primary purposes include wildlife and scenery viewing. Visitors must use one of the bus systems and private vehicles are restricted. The only facilities include the park road, one or two visitor contact stations, and generally one rest area for every hour of travel. Visitors can expect a lower level of traffic than in wildlife viewing sub-zone 1. As many people as possible are able to view major Alaskan mammal species in their natural habitat. The character of the road is in keeping with the character of the land: a primitive, low-speed road located in a wild and pristine land.
Pedestrian:	This sub-zone provides a wilderness threshold feel even though sights and sounds of people and development are nearby. Trails are well-defined, frequently used, and rarely take people more than 1 mile from a trailhead or other development.
Hiker:	This sub-zone provides a sense of being immersed in a natural landscape, although most comforts and conveniences are within 5 miles away. Visitors must commit some time and physical exertion and the only facilities present are unpaved trails or marked routes.
Backcountry Day Use:	This sub-zone provides a wilderness threshold feel although it may be close to roads, campgrounds, or other development. In some cases visitors may need greater route-finding skills than in the hiker sub-zone. There are no designated trails or routes in this sub-zone.

Natural Zone

The 1986 General Management Plan established this zone and articulated desired conditions related primarily to natural processes. The 2006 Backcountry Management Plan addressed the same zone and added desired conditions related to wildlife, wilderness resource values and wilderness recreational opportunities. The Backcountry Management Plan also anticipated the Resource Stewardship Strategy by establishing indicators and standards for the desired conditions that vary by management zone.

1. Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem.

1.5 These lands will be managed to ensure that natural processes prevail. (GMP)

1.6 In the backcountry, there will not be statistically significant changes in wildlife populations, distributions, and demographics that result from visitor use. (GMP)

2. Wilderness character, wilderness resource values, and wilderness recreational opportunities

2.1 All backcountry areas generally appear to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable.

2.2 All backcountry areas have outstanding opportunities for solitude or a primitive and unconfined type of recreation. (GMP).

Sub-zones

The sub-zones (also called "backcountry management areas") identified in the Backcountry Management Plan (see Figure 3) addressed differences of degree in defining desired conditions for the qualities identified above. These desired conditions were defined in terms of qualitative statements and standards for 10 different indicators which include the following:

2.1(a) Landscape modifications
2.2(a) Trail and campsite disturbance
2.2(b) Evidence of modern human use
2.2(c) Litter and human waste
2.2(d) Natural sound disturbance
2.2(e) Encounters with people
2.2(f) Encounters with large groups
2.2(g) Camping density
2.2(h) Accessibility
2.2(i) Administrative presence

Specific indicator statements and target values or standards for each indicator in each management zone are found in the Backcountry Management Plan (NPS 2006a). General statements of the desired condition for each sub-zone are below.

Management Area A:	Provide a diversity of opportunities for wilderness recreational activities that are relatively accessible to day-users and to those who have limited wilderness travel skills or equipment.
Management Area B:	Provide opportunities for wilderness recreational activities suitable for day-users and overnight users that are remote and require self-reliance.

Management Area C:	Provide opportunities for climbing and mountaineering experiences in a wilderness setting.
Management Area D:	Provide opportunities for extended expeditions that are remote and require self-reliance, significant time commitment, and thorough advance planning.
Portal:	Provide high-use airplane landing areas that provide access to remote parts of the park and preserve. Year-round or seasonal.
Portal – Major Landing Area:	Provide high-use airplane landing areas that are suitable for both day use and expedition drop-off and pick-up. Seasonal, May-September.
Corridor:	Provide high-use travel routes via ground or water that provide access to remote parts of the park and preserve. Year-round or seasonal.
Backcountry Hiker:	Provide day use trails into the backcountry in areas that are accessible to many visitors. Year-round or seasonal.
Ruth Special Use Area:	Provide for high use of transportation services during the season when large numbers of day users are accessing the Ruth Amphitheater. Seasonal, May-September.
Management Area OP1:	Provide opportunities for day use and overnight wilderness recreational activities that are remote and require self-reliance in an area that has limited opportunities for motorized access.
Management Area OP2:	Provide opportunities for extended expeditions that are remote and require a high degree of self-reliance, significant time commitment, and thorough advance planning in an area that has limited opportunities for motorized access.
West Buttress Special Use Area:	Provide a seasonal route to the summit of Mount McKinley that can accommodate large numbers of climbers during the primary climbing season. Seasonal, late April to mid-July.

Historic Zone

Lands in this zone are managed primarily to preserve cultural resources. In Denali this zone includes all the sites and structures that are listed on or are eligible for the National Register of Historic Places. Appropriate uses in this zone include visitor appreciation and study of cultural features and adaptive use of historic structures for other park purposes.

5.1 Historic and archeological sites, and the resulting identified cultural landscapes are appropriately protected. (GMP)

Inholdings Special Use Area

Within the park and preserve are privately-owned lands, some unpatented mining claims in the Kantishna Hills, lands conveyed to the State of Alaska, and certain segments of the State road and railroad right-of-way easements. The National Park Service recognizes these inholdings and respects the rights of the landowners. There are no desired conditions expressed for this management zone.

South Denali

South Denali is an evolving destination for the national park created in conjunction with other public and private landowners on the south side of the Alaska Range where there are spectacular views of Mount McKinley and Alaska Range mountains and glaciers. However, most of the visitor activity would occur on non-federal lands. There are no management zones for South Denali. Desired conditions are expressed only as purpose statements which can be extracted from the *South Side Denali Development Concept Plan and Environmental Impact Statement*. These include:

4. Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features.

4.2 Opportunities for high quality, resource-based destination experiences and information, orientation, and recreation services and facilities convenient to park visitors are provided.

4.3 Establish methods, responsibilities, and necessary steps to control unwanted secondary impacts of tourism and to minimize conflicts between different visitor groups.

4.4 Ensure that, viewed as a whole, facilities and services benefit all visitors, including Alaska residents, independent travelers, and package tour travelers.

General resource protection

- Facilities and access in a location and manner that minimizes impacts on resources, local lifestyles, and communities are developed.
- Minimize and mitigate adverse effects on fish and wildlife resources, habitat, cultural resources, local rural quality of life, and existing public land resource uses, including subsistence uses.

Relationship to Other Park Plans

The Resource Stewardship Strategy is a program plan as defined in NPS Management Policies. Program management planning for a park provides a bridge between the broad direction provided in park's GMP and specific actions taken to achieve goals. These plans provide a comprehensive approach for a single park program area across all or most of the park. Other program plans include a Wilderness Management Plan, Commercial Services Plan, Land Protection Plan, and Denali Education Plan. Program management plans provide comprehensive recommendations about specific actions needed to achieve and maintain the desired resource conditions and visitor experiences.

Park-level strategic planning remains a critical step in decision-making by park management on the allocation of park financial and human resources. While the GMP describes the desired conditions that are to be ultimately achieved for the park, the park's 5-year and annual performance plans (strategic planning) describe what realistically can be achieved based on foreseeable financial and human resources. The RSS provides 10- to 20-year comprehensive strategies to provide a logical, very long-term investment in achieving and maintaining these desired conditions. The activities comprising these comprehensive strategies inform the sequence, duration, and association between more detailed recurring and non-recurring implementation actions that would be considered during park strategic and implementation planning.

The park already possessed a number of implementation plans at the time this RSS was developed. Where appropriate, information included in these implementation plans has been incorporated into this RSS. Implementation plans were reviewed for consistency with the comprehensive strategies recommended through this RSS. If any implementation plan goals, objectives or actions were found to be inconsistent with these comprehensive strategies they were noted in the administrative record for use during the next update of the affected implementation plan. A summary and review of planning documents associated with or affected by the RSS is located in Table 2.

Table 2. Summary of current and projected park plans.

Type of Plan/Plan Title	Status	Notes
General Management Plan (15-20 Years)		
Foundation for Planning and Management	Complete, 2007	
General Management Plan	Complete, 2006	A consolidated GMP document was prepared in 2007 (NPS 2007e) that synthesized the park's 1986 GMP with its 3 major amendments: the 1997 Entrance Area and Road Corridor Development Concept Plan, the 1997 South Side Denali Development Concept Plan, and the 2006 Backcountry Management Plan.
Program Management Plans (Approx. 15-20 Years)		
Resource Stewardship Strategy	Complete, 2009	
Education Plan	Complete, 2009	
Wilderness/Backcountry Management Plan	Complete, 2006	Included in the General Management Plan
Commercial Services Plan	Complete, 2006	A Commercial Services Plan for the backcountry was included in the 2006 Backcountry Management Plan. Other commercial services planning was completed in the park Entrance and Road Corridor DCP.
Land Protection Plan	Complete, 1986	Current document needs revision.
Strategic Plans (1-5 Years)		
Park Strategic Plan	Current	
Annual Performance Plan	Current	
Implementation Plans (variable timeline)		
Denali Park Road Vehicle Management Plan	In Process	To be completed in 2010
Subsistence Off-Road Vehicle Management Plan	Complete, 2007	NPS 2007d
Wolf-Human Conflict Management Plan	Complete, 2007	NPS 2007c
South Denali Implementation Plan	Complete, 2006	NPS 2006
Fire Management Plan	Complete, 2004	NPS 2004
Bear-Human Conflict Management Plan	Complete, 2003	NPS 2003
Reclamation of Mined Lands Program	Complete, 2001	
Subsistence Management Plan	Complete, 2000	NPS 2001

Relationship to NPS Inventory and Monitoring Program

The NPS Inventory and Monitoring Program, initiated through the Natural Resource Challenge, uses a 'network' approach, where parks are grouped with other parks with similar ecosystems. Denali is part of the Central Alaska Network (CAKN), with Wrangell St.-Elias National Park and Preserve and Yukon-Charley Rivers National Preserve. CAKN has completed a Vital Signs Monitoring Plan (MacCluskie 2005). This plan responds to a requirement in the 1998 National Parks Omnibus Management Act that the NPS conduct long-term inventory and monitoring of park resources.

Biological Inventories. Biological inventories were completed in 2005. These inventories documented the occurrence of 90 percent of the plant species, 90 percent of the small mammal species, and 90 percent of the freshwater fish species hypothesized to exist in Central Alaska Network parks.

Vital Signs Monitoring. The 2008 field season was the third year of CAKN program implementation after three phases beginning in 2001: (1) gathering and assessing existing information, (2) developing a conceptual ecosystem model and vital signs, and (3) developing monitoring protocols for the vital signs that were to be monitored first. The Vital Signs Monitoring Plan was completed in 2004 and peer-reviewed in 2005. Implementation began in 2006. The broad goals of the CAKN monitoring program are to: (1) better understand the dynamic nature and condition of park ecosystems; and (2) provide reference points for comparisons with other, altered environments. The focus of the CAKN program is to monitor ecosystems in order to detect change in ecological components and in the relationships among components, rather than to track if GMP objectives are met or maintained.

There are 36 identified Vital Signs for the CAKN. Three vital signs refer to air and climate, two refer to geology and soils, four refer to water, four refer to human use, five refer to ecosystem pattern and processes, and eighteen refer to biological integrity. The network produced full protocols for the 11 initial Vital Signs (Climate, Air Quality, Snowpack, Vegetation, Water Quality, Macroinvertebrates, Passerines, Peregrine Falcons, Golden Eagles, Moose, and Wolves). Protocols are peer-reviewed, revised as necessary, and given final approval from the Alaska Region Monitoring Coordinator. Currently, four Vital Signs protocols (Air Quality, Climate, Snow Pack, and Vegetation) have been given final approval. The remaining seven are in various stages of scientific review.

Sampling for several of the vital signs uses sample locations based on a systematic grid. The "plots" or minigrids are 6.25 km^2, with the SE corner of each minigrid 20 km distant from the corners of adjacent minigrids. Sampling at minigrids provides statistical integrity and allows integration of data about plants, animals, and physical features.

The Vital Signs monitoring program provides important information on key ecosystem indicators for Denali, some of which have been useful in developing the indicators and standards for this Resource Stewardship Strategy. However, the CAKN vital signs indicators were developed to serve all three parks that are a part of CAKN (not just Denali) and are directed at measuring long-term ecological change (not on measuring desired conditions as described in the Denali GMP).

Prior to the organization of parks into networks like the CAKN, Denali was selected as one of four prototype parks in 1991 for the NPS Long-term Ecological Monitoring program. The program

selected three watersheds for monitoring, and during an in-depth design phase of the program (1992-1995), the monitoring scope was reduced to the Rock Creek watershed near park headquarters. The program was then developed (1996-1998) with the help of the USGS – Biological Resource Division (Oakley and Boudreau 2000). The single watershed model limited the applicability of data across a majority of Denali Park. A 2001 program review (Boudreau and Timmons 2003) set in motion the idea of a landscape monitoring approach. When the Denali LTEM program was integrated with the Central Alaska Network, the monitoring protocol development and ecosystem design work completed for the LTEM program was easily transferred to the CAKN monitoring development process.

Context of the Park's Resources

Denali National Park and Preserve's 6.2 million acres is located in central Alaska, straddling the Alaska Range.

The landscapes of Denali National Park and Preserve are a legacy of the region's geological history and the advance and retreat of glaciers. One of the major influences on Denali's ecosystems is the Alaska Range, the massive wall of rock, glacial ice, and snow running from southwest to northeast across the Park's six million acres (2.4 million hectares). It towers above and separates the Kuskokwim and Tanana river basins to the north from the Susitna River lowlands to the south. This mountain barrier creates two major climate zones in the park and dramatic elevation differences. As a result, the ecosystems range from lowlands with taiga forests, braided glacial river floodplains, and meandering sloughs; to subalpine woodlands, meadows, and scrub tundra (willow, alder, and dwarf birch); to alpine low-shrub tundra slopes and steep peaks, including Denali (Mount McKinley) at 20,320 feet (6,194 meters).

Denali National Park and Preserve is located in the Matanuska-Susitna Borough and the Denali Borough. The Game Management Units that fall within or adjacent to the park are: 20C (north), 20A (northeast boundary), 13E (east), 16A (south), 16B (south), and 19D (west).

Natural Resources

Geologic History

The oldest rocks in the Park, collectively called the Yukon-Tanana terrane, were ocean sediments deposited in shallow seas during the Paleozoic era some 300 to 500 million years ago. Later in the Paleozoic and into the Early Mesozoic (100 to 300 million years ago), other terranes, fragments of the larger continental plates, migrated north on the Pacific Plate and attached to the Yukon-Tanana terrane, creating the current jigsaw puzzle of rocks from many depositional environments.

During the last 100 million years, the assembled terranes buckled from the continuous tectonic collision, uplifting the present day topography of the Alaska Range. About six million years ago, a regional uplift that began in the Alaska Range spread north to push up the Outer Range (Mts. Healy, Margaret and Wright) (Fitzgerald et al. 1993).

Around 70 million years ago, alternating warm near-tropical conditions and cooler, drier periods enhanced erosion and deposition in sedimentary basins such as the Cantwell, where dinosaurs walked among ancestral lakes, braided streams, and alluvial fans. Volcanic eruptions dominated the scene 40 to 50 million years ago, creating the colorful rocks at Polychrome Pass. Subsurface magma cooled to become the granitic bulk of Mt. McKinley and Mt. Foraker (Cole 1999).

Because the Pacific Plate continues to collide with and slide beneath Alaska, the buckling and uplift continues, creating a seismically active area around Mt. McKinley. Generally The Denali fault system extends for about 750 miles (1200 km), generally following the Alaska Range through the park. Technically, this crustal fracture is a "right-lateral strike-slip fault," that is, to an observer facing the fault, the opposite side moves right. Some geologists (Forbes et al. 1974) suggested that fault movements have been as great as 250 miles (400 kilometers). In November of 2002, the 7.9M earthquake centered on the Denali fault east of the Park ruptured the surface with up to 30 feet (9 meters) of strike-slip offset. Seismic events of similar magnitude may occur in the Park in the future.

Glacial History

During the past two million years, Denali's history has been characterized by repeated advances and retreats of a massive ice sheet. Over half of Denali (Alaska Range and south) was intermittently covered by an extension of the ice sheet in Canada. During glacial maxima, valley glaciers dominated the northern foothills of the Alaska Range and ice lobes extended into the lowlands. As many as seven major glacial advances and several minor advance-retreat sequences have been identified on the north side of the range (Thorson 1986). Landforms such as sculpted valleys, terraces, moraines, and kettle ponds are common in the northern river valleys.

During these Pleistocene glaciations, the northern area of the park was part of Beringia—a vast ice-free refuge for plants and animals, connected to northeastern Asia by the Bering Land Bridge and isolated from the rest of North America by the ice sheet. These areas in Denali were probably colder and much drier than the present climate, so trees were essentially absent and the vegetation was more tundra-like than today. Because of this history of repeated land connections to northern Eurasia with isolation from the rest of North America, there is a high degree of similarity of animals and plants between interior Alaska and north Asia.

Glacial ice has retreated significantly since the Pleistocene. Today, only about 16 percent of the park is covered by ice or perennial snow fields. However, glaciers continue to have a cooling effect near their termini and downstream. Glacial melt waters affect local weather conditions and reconfigure floodplains downstream. Glacial action has been a major factor in breaking down rocks to produce the soils on which Denali's ecosystems depend (Clark and Duffy 2004).

Climate

There are two distinct climates in the park, separated by the Alaska Range. They differ not only in physical measurements, but also in the types of vegetation and landscape features they produce. The transitional maritime climate on the south side of the Alaska Range is influenced by the prevailing weather patterns of the Gulf of Alaska, with milder air temperatures with less seasonal variation and more precipitation. Temperatures in the northwest area of the park are typical of an interior climate with very warm summers and cold winters. Park headquarters lies in another transitional zone

between the northern flanks of the Alaska Range and the Interior and has slightly cooler summers and warmer winters than sites farther north away from the direct affects of the Alaska Range.

At park headquarters (north of the Alaska Range), daily weather observations have been recorded since 1925. Temperature extremes range from 91° F (33°C) to -54° F (-48°C). Summers are short and warm, and winters are long and cold. The average daily high temperature in July is 66° F (19°C), and the average daily low temperature in January is -8° F (-22°C). Total precipitation is relatively low at 15 inches (382 millimeters). The sub-zero temperatures in winter coupled with relatively low snowfall contribute to the presence of widespread permafrost.

The climate south of the Range is transitional between the mild and moist conditions near the Gulf of Alaska and the cold and dry of Interior Alaska. The mean annual precipitation at Talkeetna, just southeast of the border of the Park, is 28 inches (711 millimeters), nearly double that at headquarters. The average daily high in July is 68° F (20 °C) and the average daily low temperature in January is 1.4° F (-17°C). Along the southern flanks of the Alaska Range snowfall is high, and snowcover is often present through late spring. Permafrost is generally absent.

Natural Processes

The local ecosystems are shaped by the physical environment (e.g., geology, glaciers, and climate). Interactions among these factors and the habitat preferences of plants create the mosaic of vegetation on the landscape. For example, stunted scattered spruce in northern areas of the park grow over permafrost, while more lush vegetation is supported on permafrost-free areas. In addition, natural disturbance and processes such as earth movements, wildland fire, and water flow alter the local landscape patterns.

The major processes on Denali's landscape vary across ecological zones. Geomorphic processes such as landslides, avalanches, and other mass movements predominate in the alpine region. Freeze-thaw conditions, especially in the active layer above permafrost, often create landform features such as slumps, gelifluction (creeping soil lobes), frost heaves, hummocks, and ice-wedge polygons. Thermokarst features (ground subsidence from melting permafrost) are found in isolated plateaus in the northeast portion of the park.

Fire plays a dominant role in modifying the lowlands, particularly in the basins north of the Alaska Range that are characterized with low precipitation and hot summers. The action of flowing water is another important process in boreal lowlands. Large braided glacial rivers such as the McKinley, Toklat, Yentna, and Chulitna are constantly reshaping the land by shifting channels, creating new floodplain deposits, and eroding old terraces with established forests. Beavers also have a considerable influence on the distribution of wetlands by impounding streams, especially in forested lowlands of the Yentna, Susitna, Kantishna, and Kuskokwim river basins.

Ecological Classification of Denali Landscapes

Denali's landscapes have been classified according to the accepted ecological unit hierarchy for Alaska (ECOMAP 1993). Under this classification, there are five ecological sections, primarily based on topography and climate, within the park. The finer-scale classifications within sections (subsections

and landtype associations), which are based on soils and vegetation, were mapped as a part of the intensive Denali Soil Survey project (Clark and Duffy 2004).

The ecological sections in Denali are:

Yukon-Kuskokwim Bottomlands. This section represents the bottomland ecosystems along the larger rivers of Interior Alaska, and includes the boreal lowlands of the northwestern third of the park. Although basically flat terrain is typical (broad valleys and basins), some low rolling hills occur. Riparian and lake features are abundant, including meandering streams, side sloughs, oxbow lakes, and thaw lakes. Elevation generally ranges from 120 to 650 meters. Dominant vegetation spans from mesic to hydric (spruce (*Picea* spp)- poplar (*Populus* spp) forests, to more moist (open black spruce (*Picea mariana*) forests), to hydric floodplain thickets of willow (*Salix* spp) and alder (*Alnus* spp) scrub, and wet sedge meadows.

Kuskokwim Mountains. This section is characterized by deep narrow valleys between northeast-trending ridges that have rounded to flat summits and broad, gentle slopes. In Denali, this section includes several isolated ranges of hills rising out of the Yukon-Kuskokwim Bottomlands. Elevation ranges from 170 to 1,350 meters. This section consists of deep ocean floor and continental fragments of the Tozitna, Ruby, Innoko, and Nixon Fork terranes. Open black spruce (*Picea mariana*) forests are abundant. Alpine vegetation of sedges and shrubs cover most hills and ridges. White spruce (*Picea glauca*)-paper birch (*Betula neoalaskana*) communities are also common.

Cook Inlet Lowlands. This section comprises separate river valleys along the southeastern border of the park. These boreal lowlands (level to rolling surfaces) were formed as river floodplains to some extent, but more so through glacial action. Landforms include glacial plains, hills, and outwash plains. Elevation ranges from sea level to 1,000 meters. Soils are formed primarily in volcanic ash, glacial drift, and organic materials. Lowland black spruce (*Picea Mariana*) forests are abundant. Bottomland spruce (*Picea* spp) - poplar (*Populus* spp) forests are adjacent to larger river drainages, along with thickets of alder (*Alnus* spp) and willow (*Salix* spp) scrub.

Alaska Mountains. This section consists of steep, rugged mountain ridges separated by broad valleys. Elevation ranges from 200 meters in valleys to greater than 6,000 meters on mountain peaks. The Section comprises fragments of deep ocean floor rock, as well as continental fragments of Peninsular, Kahiltna, and Wrangellia terranes. A substantial portion of the area is barren of vegetation. Where vegetation exists there are alpine communities of dwarf scrub types. Spruce (*Picea spp*.) woodlands are common at lower elevations and riparian spruce-hardwood forests occur infrequently at low elevations in valley bottoms. The Alaska Mountains section, on the north and west slopes of the Alaska Range, makes up the largest portion of Denali National Park and Preserve.

South Central Mountains. Like the Alaska Mountains, this section consists of steep, rugged mountain ridges separated by broad valleys with a similar elevation range (200 meters to more than 6,000 meters). However, in this section (the Alaska Range south and east of the crest of the range), the climate is more strongly maritime-influenced, with considerably higher precipitation as the result. Compared to the Alaska Mountains Section, the South Central Mountains Section is warmer and wetter conditions in winter, and cooler and cloudier in summer.

Ecology of Plants and Wildlife

There are 39 species of mammals and 165 species of birds currently documented in Denali, along with one amphibian and 15 species of fish. Within park borders, there are more than 750 species of vascular plants along with approximately an equal number of nonvascular plant species (mosses, lichens and liverworts). Countless species of smaller organisms, from insects to bacteria and algae, complete the biological makeup of the park.

Terrain, soils, climate and history determine the plant and animal communities that inhabit Denali's vast and varied landscape. The plant and animal communities can be broadly placed—based primarily on elevation—into boreal lowland, subalpine, and alpine communities. The high alpine areas are unvegetated and inhospitable to most life.

Boreal Lowland Communities

Denali's lowlands includes black spruce forests and woodlands in areas underlain by permafrost (mostly north of the Alaska Range) and white spruce and paper birch forests in well-drained upland areas and river corridors. Forests (taiga) have become established after the last glacial retreat (within the last 6,500 years), but probably also existed during earlier interglacial periods. Recently disturbed and warmer south-facing slopes support stands of trembling aspen and balsam poplar. River bars support early successional herbaceous plants scattered among groves of balsam poplar, aspen, and spruce.

Shrubs that grow slowly in the cold soils of black spruce forests include alder, dwarf birch, Labrador tea, shrub cinquefoil, several species of willow, and blueberry. Black spruce stands burn periodically, so trees seldom reach ages beyond 120 years. Common shrubs in the more nutrient-rich spruce-birch forests are dwarf birch, rose, willows, and high-bush cranberry. Mosses are also common in the understory of spruce forest.

Interspersed in Denali's forested areas are dry, open sites, wetlands, and kettle-hole ponds. Dry sites often include a tangle of kinnikinnik, rose, and soapberry. The warmest, driest sites on the north side of Denali are dry meadows of grasses, sagebrush, scattered juniper shrubs, and herbaceous perennials. Because equivalent slopes on the south side of the Alaska Range have more moisture, they can be lush meadows of grasses, lupine, geranium, and cow parsnip. Wetland and riparian areas support sedges, rushes, grasses, forbs, and mosses.

An assortment of resident and migratory birds lives within Denali's lowland forests including northern goshawk, great-horned owl, boreal owl, woodpeckers, black-capped and boreal chickadees, ruby-crowned kinglet, yellow-rumped warbler, and white-winged crossbill. Wetlands are nesting grounds for sandhill cranes, trumpeter swans, common loons, many species of waterfowl, arctic tern, northern waterthrush, and rusty blackbirds.

The most noticeable mammal in spruce forests is often the red squirrel, due to that commonness, bold behavior, and daytime activity. But other species with more secretive lifestyles, including voles, lemmings, shrews, snowshoe hares and flying squirrels, are also common in the taiga. These small mammals provide the food base for a variety of medium-sized predators, including lynx, marten, and red foxes. Several species of large mammals live at low densities throughout the lowland areas of Denali but are more common in higher elevation areas. These include moose, wolves, caribou, and

grizzly bears. The black bear is the only large mammal species that is more common in the lowland areas of the park than at higher elevations.

Subalpine Communities
In subalpine areas, there is a mosaic of scrub vegetation (dwarf birch, alder, and willow), open spruce woodland, and meadow. The pattern depends on drainage, topography, and site history. Near treeline, the land cover shifts from open woodland to tundra shrubs (willow, blueberry, dwarf birch, rhododendron), dwarf shrubs (bearberry, mountain avens, crowberry, and netted willow), grasses, and annual plants.

South of the Alaska Range, the subalpine zone yields dense thickets of alder, devil's club, and shrubs with a more coastal distribution. The vegetation is more productive, particularly in the Kahiltna and Yentna River drainages, because of greater precipitation and a milder climate.

Birds of this zone include willow ptarmigan, northern harrier, merlin, upland sandpiper, northern hawk-owl, arctic warbler, olive-sided flycatcher, gray-cheeked and Swainson's thrushes, fox sparrow, golden-crowned sparrow, blackpoll warbler, and orange-crowned warbler.

The subalpine zone of Denali is the area most visited by humans today, and provides the scenery and the wildlife viewing that we commonly associate with the park. It is here that the park road provides not only vistas of the Alaska Range, but unparalleled opportunities for visitors to see grizzly bears, caribou, Dall's sheep, moose and wolves. Other commonly seen mammals in the subalpine zone are arctic ground squirrels, snowshoe hares, porcupines, and red foxes.

Alpine Communities
The species growing in Denali's alpine tundra vary according to site characteristics and geographic location. If there are frequent landslides and avalanches, many high slopes are barren or support only a few scattered herbaceous plants. But typically, Denali's alpine tundra includes mountain avens, dwarf willows, dwarf shrubs (such as bearberry, cassiope, and crowberry), grasses, and forbs.

Where snowmelt is late, as on north-facing slopes, the alpine zone also includes spring beauty, mountain heather, mountain sorrel, and buttercups. In sunny but moist areas, the vegetation is a mixture of dwarf shrubs and sedges. On windswept ridges, lichens add to the relatively sparse cover of mountain avens and grasses. Dry sites can be variable (scattered grasses to complete plant cover) depending on the growing conditions, but harbor some of the park's rarer plants, including many species with evolutionary roots in the Beringian tundra and ultimately in Asia.

A diverse community of open-landscape birds lives in the alpine region of Denali including golden eagle, gyrfalcon, white-tailed ptarmigan, American golden-plover, surfbird, long-tailed jaeger, horned lark, northern wheatear, and gray-crowned rosy finch.

Dall's sheep are among the most obvious and spectacular residents of Denali's alpine habitats. Other large mammals, including wolves, caribou and grizzly bears, spend much of their time in the alpine zone. Pikas and hoary marmots are two of the park's mammal species that live only in alpine areas.

Unvegetated High Alpine
Nearly one-third of the park is made up of high, glaciated mountains and bare rock outcrops. The upper limit of plant growth is about 7,500 feet (2290 meters). Above 8,000 feet (2440 meters), alpine areas are generally covered by glacial ice. Only scattered traces of vegetation occur there, mostly lichens on isolated patches of bare rock. No birds or mammals make their homes in these barren reaches, but wolverines, wolves and caribou occasionally negotiate high mountain passes, ravens and redpolls are seen at very high elevations, and many species of birds migrate over the mountains. Aside from some humans conduct expeditions on glaciers and peaks during the spring and early summer climbing season, the mountains and icefields are nearly devoid of life.

Natural Resources Beyond Park Borders

Many birds that breed in Denali migrate long distances to reach the park, some from as far away as South America, Asia, and Africa. Great numbers of sandhill cranes and trumpeter swans create a stirring sight as they migrate in skeins above Denali. Each year, king, silver, and chum salmon migrate more than 1000 miles (1600 kilometers) from the Bering Sea to spawn and die in Denali's rivers, providing an important food source for many mammals and birds. None of the park's mammal species undertake long-distance migrations, but caribou of the Denali herd regularly venture outside of the park boundaries, especially in winter when windblown ridges north and east of the park provide easier foraging. Many of the wolf packs move freely in and out of park boundaries, either as part of their normal range or in seasonal movements that follow the caribou herd.

Cultural Resources

Cultural resource sites in Denali represent both historic and pre-historic use of park lands. The archeological sites found in the park are mainly hunting lookout sites. The most substantial of these sites is the Teklanika Archeological District which dates to 5000 – 8000BP. Historic sites and structures document the historic use of the region by miners, trappers, native groups, scientists, mountaineers, and park administration. These resources include cabins, mining and trapping sites and equipment, Patrol cabins, and the park Headquarters Historic District. These resources are the tangible evidence of the rich cultural heritage of Denali.

Although humans have been present in the Denali area for at least 11,000 years, the park represents a rare place where human influence has never fundamentally altered the natural ecosystems. From the end of the last ice age until roughly 100 years ago, the upland areas of Denali were occupied seasonally by bands of hunters and gatherers who lived the rest of the year in lower forested areas near the larger rivers. Because none of the large navigable rivers flowed near the high Alaska Range, the area that was to become the park was among the last parts of Alaska to be explored by non-natives. Explorers, prospectors, and trappers trickled into the area in the 1890s, and a series of gold strikes between 1903 and 1906 briefly brought large numbers of miners into the Kantishna area.

Concern about market hunting in the game-rich Alaska Range foothills was one of the driving forces that led to the creation of Mount McKinley National Park in 1917 (Brown 1993). The Alaska Railroad was completed through Broad Pass and the Nenana Valley in 1923, providing tourist access to the park, and the park road to Kantishna was completed by 1938. Since 1972, tourists have had easy access to the park by way of the George Parks Highway between Anchorage and Fairbanks.

Subsistence

Within the 1980 additions to Denali National Park and Preserve, the opportunity for continued traditional subsistence uses of natural resources by local rural residents is allowed. For many rural residents, uses of these natural resources ensure more than survival; they help sustain a traditional way of life. To be eligible for subsistence use in the ANILCA additions to Denali National Park, a person must be a local rural resident living in one of Denali's designated subsistence resident zone communities, or have a special subsistence use permit issued by the Superintendent. The communities of Cantwell, Lake Minchumina, Nikolai, and Telida are recognized as subsistence resident zones for Denali.

Park Visitation and Neighboring Communities

Approximately 400,000 people visit the park each year. The bulk of visitation arrives through the entrance area of the park where the Denali park road intersects the George Parks Highway and the Alaska Railroad. Sight-seeing and wildlife-watching along the Denali park road are the primary activities, in which almost 300,000 visitors participate each year. The National Park Service restricts vehicle use along the park road, so virtually all travel is on concession-operated tour buses, buses to lodges located on inholdings in Kantishna, and the park's concession-operated bus transportation service. Increasingly visitors participate in other activities in the park – including interpretive and educational programs, browsing exhibits at the Denali Visitor Center, and hiking on trails in the entrance area. Relatively few and possibly declining numbers participate in backcountry activities that range from easy day-hikes to multi-week mountaineering expeditions to the summit of Mount McKinley. Many visitors also participate in activities offered by commercial enterprises that originate outside the park and in some cases only use adjacent lands, such as river rafting, flightseeing, ORV and jet boat tours, and horseback riding. Activities on adjacent lands are particularly important in the park's evolving alternative destination on the south of the Alaska Range known as "South Denali," where the park's boundaries are inaccessible except by air. Approximately 14,000 visitors arrive on southern park glaciers by airplane, most of them landing only briefly as part of a scenic air tour.

A small portion of visitation occurs during winter months, when visitors participate in skiing, snowshoeing, and dog mushing. Extensive but unquantified snowmachine use occurs primarily on the south side of the Alaska Range.

The communities surrounding Denali may be divided into three groups – urban, rural, and bush. The national park is situated along the major intercity road and rail corridor connecting the state's two largest cities, Fairbanks and Anchorage, through which virtually all Denali-bound visitation passes. Along with the urbanizing southern Matanuska-Susitna Borough, which includes the cities of Palmer and Wasilla, these urban areas represent one portion of the greater Denali-area community whose residents have an economic or recreational interest in Denali.

Closer to the national park boundaries are the rural communities of the Denali Borough – including Healy, Nenana Canyon, McKinley Village, and Cantwell – and the northern Matanuska-Susitna Borough including Talkeetna, Trapper Creek, and the "Y." The economy of the northern Matanuska-Susitna Borough is largely dependent on tourism (not all of which is Denali-related) and a workforce that commutes elsewhere for employment. The Denali Borough has a diverse economy for its small population of only 1,800 year-round residents, including the only coal mine in the state, a power plant, and an Air National Guard base. However, tourism drives growth in the Borough and the combination of visitors and seasonal employees roughly triples the year-round population during summer months.

Finally, the "bush" communities are those not connected to the road system, but near to the park's remote boundaries. Residents may use the park or preserve for subsistence activities with very small amounts of tourism and non-subsistence hunting (in the preserve only) and fishing. These communities include Skwentna in the Matanuska-Susitna Borough and Lake Minchumina, Nikolai, and Telida in unincorporated parts of the state north and west of the park's boundaries.

Murie Science and Learning Center

The Murie Science and Learning Center (MSLC) is a collaborative effort among Denali National Park and Preserve, seven other Alaska national parks, and several significant park partners. The goal of the MSLC is to promote scientific research to aid park managers and to provide science-based education programs and information to students, educational institutions, and the visiting public. Focus areas include:

- Promoting understanding of how science benefits park management decisions
- Promoting and facilitating research about the arctic and subarctic ecosystems in Alaska's parks
- Actively sharing scientific findings in a compelling and understandable way
- Promoting resource stewardship through partnerships

The Future

Despite being a wilderness park, Denali faces threats from human activity on many scales, including increased tourism and development, introduction of exotic species, increased hunting pressures and accumulation of trace amounts of global airborne contaminants. The retreat of glaciers and changes in vegetation due to changes in climate are easily seen in photos taken only decades apart. These influences and their effects are difficult to measure, but they may dramatically alter the distribution and visibility of wildlife. Park management faces an increasing challenge to protect resources in the face of climate change and other human effects.

Status of Resource Knowledge

Appropriate knowledge of park natural (physical, biological) and cultural resources is essential for the NPS to effectively meet its resource stewardship responsibilities. This knowledge is provided through basic resource *inventories*, long-term *monitoring* of resource conditions, investigations and *research*. In addition, adaptive management requires ongoing knowledge about natural systems and how management decisions affect them.

To meet the NPS responsibilities of resource stewardship, information about park resources must be of sufficient quality and completeness to be useful and reliable for making stewardship decisions. Remediation of shortfalls in resource knowledge is integrated into comprehensive strategies in this RSS. Specific, focused investigations may be required to provide the level of resource knowledge necessary to manage complex issues. When the need is identified, such investigations are integrated into the comprehensive strategies in the RSS.

Integrated Resources

Resources at Denali National Park and Preserve do not always fall neatly into the classification of Natural Resources and Cultural Resources. Social Science projects have gathered information about park visitors or park users and their perceptions of the park. Some resource programs span natural, cultural, and social areas. For example, the subsistence program may be described as a way of life (cultural, social resources) in which traditional knowledge is used to harvest or utilize biological resources. Other integrated programs include wildland fire and the Inventory and Monitoring Program of the Central Alaska Network. In addition, some studies (e.g., study of park road capacity) or issues (e.g., climate change) are interdisciplinary or multi-disciplinary in nature. The Resource Stewardship Strategy for Denali included cross-disciplinary thinking about resource knowledge and values.

Program Areas other than Natural or Cultural Resources	Section of Denali Resource Stewardship Strategy		
	Status of Resource Knowledge	Comprehensive Strategies and Projects	Budget Tables
Wildland Fire Program (Alaska Region, Western Area, Denali)	Separate section follows Natural Resources	No special section	Uses same budget classes as Natural and Cultural Resources
Subsistence Program	Separate section follows Cultural Resources	No special section	Uses same budget classes as Natural and Cultural Resources
Park Visitation and Neighboring Communities (Social Science)	Separate section follows Cultural Resources	No special section	Uses same budget classes as Natural and Cultural Resources
Central Alaska Network (CAKN) Inventory and Monitoring Program	Integrated into Natural Resources Section	Strategy D	Identified as I&M Funding Source
Murie Science and Learning Center	Description in Context of Park Resources, but not included in Status of Resource Knowledge	Strategy R and S	Uses same budget classes as Natural and Cultural Resources

Natural Resources

PHYSICAL RESOURCES

Contemporary knowledge of Denali's physical resources comes from a relatively short history of exploration, research, and monitoring efforts. Physical resource information for much of the park is general in nature, with detailed research of processes and features limited to specific areas surrounding development or specific events. Inventory and monitoring of the physical environment is developing into a very informative data set, but is also highlighting a lack of system-wide change analysis. The inter-relationships of physical drivers and analysis of the effects of our changing climate and evolving landscape will likely be a primary focus for the next phase of research and monitoring.

Specific management-oriented physical resource information has been developed in areas such as water resources and soundscapes due to frontcountry development, mined land restoration, and increasing human use. There is an ongoing effort to be able to distinguish natural change from any anthropogenic effects on climate, permafrost, glaciers, air quality—the important drivers of Denali's ecosystem processes. Finally, Denali is a very large place, with a tremendous collection of physical features. Recent studies have identified the first of what are apparently vast paleontological resources. This summary of current information serves as a valuable baseline for future work and effective park management.

Physical Resources – Inventory

Geologic Resources Evaluation. (Geologic Resources Division 2004)
The Geologic Resources Evaluation Scoping Report and Digital Maps produced are part of a national effort conducted by the NPS Geologic Resources Division to inventory existing geological data for parks and to produce a composite geologic map by digitizing and assimilating existing geologic maps. A formal scoping session was held with staff from Denali, Alaska NPS regional office, USGS, and NPS Geologic Resources Division. Information and data discovered as part of the scoping meeting and library research resulted in this report and a GIS product that presents existing data in a digital form. See also http://www2.nature.nps.gov/geology/inventory/gre_publications.cfm

Climate Inventory. (Sousanes 2004b; Redmond and Simeral 2006)
Sousanes (2004b) provides an inventory of existing climate monitoring stations and historical data, in and adjacent to Denali National Park and Preserve, completed in 2002 as a key part of the effort to determine appropriate locations for a systematic approach to climate monitoring through CAKN. A more formal inventory, Redmond and Simeral (2006), was completed as part of an NPS-wide climate inventory effort in cooperation with the Western Region Climate Center. The report identified 40 weather and climate stations in or near Denali. Given the large areas, long-term measurements from within the boundaries are quite scarce. The record from Denali at McKinley Park is the longest, covering 8 decades. The inventory presents common standard data including site locations, site metadata, spatial variations and mean climate, and climate change detection.

Soils Survey and Ecological Site Inventory of Denali. (Clark and Duffy 2004)
This soil survey was the first comprehensive park-wide soil survey. The project described soil map units for more than 2000 points throughout the park, including soil horizons and plant species, and created a photo-record of landscape, vegetation, and soils. The information was used to create an ecological classification for Denali and updated the Denali portion of the Alaska ecological classification. Detailed ecological site inventory information and a park-wide soils map are available as spatial data in the park's GIS. This information provides mangers and scientists with a powerful tool for understanding the variation across park landscapes and developing predictions about important properties of any area of the park and preserve.

Water Resources Stewardship Planning (Mangi Environmental Group 2005, Karle 2007b)
Denali's water resources are diverse and are subject to ongoing management issues, such as long-term monitoring of pristine systems, restoration plans for State Section 303d Listed (Clean Water Act) streams, multiple sub-standard park road stream crossings, floodplain mining operations, and wastewater management. To effectively develop and prioritize water resource goals, Denali undertook a formal planning effort in cooperation with the NPS Water Resources Division. Two documents resulted from the two-phase planning process, an overview document and a strategic stewardship document. The Water Resources Information and Issues Overview Report (Mangi Environmental Group 2005) provides a detailed summary of existing information and identifies the known water resource issues. The second phase included strategic planning focused on water resource issues, the identification of water resource goals, and the development of strategies to meet those goals. The Water Resources Stewardship Report (Karle 2007b) provides the resulting framework for water resources management.

Water Quality – Parkwide
(Miller 1981, Saltonstall 1988, Stottlemyer and McLoone 1990, Emmett et al 1996, Edwards and Tranel 1998, Schalk et al 2001)
Water quality studies range from water chemistry baseline studies on both north and south side watersheds, to sediment transport and a discussion on the use of radio-tagged rocks to track sediment movement in large braided rivers. Some water resource studies were specifically conducted as part of the park's Long-Term Ecological Monitoring (LTEM) program now incorporated into the Central Alaska Network I&M Program.

Water chemistry and quality have been assessed throughout the park (1985-1988) in small first and second-order watersheds (Stottlemyer and McLoone (1990) and in clear water and glacier-fed streams (Edwards and Tranel 1998). Surface water chemistry is highly correlated with watershed bedrock type, and is different between north and south sides of the Alaska Range. Saltonstall (1988) sampled water from the Jenny Creek watershed and from feces of animals and other humans throughout the park to document the presence of *Giardia lamblia* cysts in Denali. He documented *Giardia* cysts in beaver ponds and the first finding of caribou-borne *Giardia*.

Schalk et al. (2001) researched methods to delineate floodplains and assess erosion potential on large braided river systems in Denali. Even though cross-section data (flood depths, degree of inundation, and water surface profiles) from the Toklat and Teklanika Rivers were used to construct hydraulic computer models, accurate bank erosion predictions are difficult to determine because of the hydrologic activity and highly erodible banks associated with large, braided rivers. The NPS conducted a study of the Toklat River gravel removal site (Karle 1989) to analyze the fluvial processes of the Toklat River basin. In a companion study, Emmett et al. (1996) monitored the movement of material in the Toklat River. With higher transport rates (range less than 10 to 3000 megagrams per day), mean bedload increased. They also placed radio transmitters inside cobbles to determine bedload transport rates. Movement of bedload in the Toklat is 500 - 2,000 meters during a 6- to 8-week period of high flow, primarily during the first few days of submersion.

Surveys of water quality (via fishery resources) were conducted in Denali during the summer of 1981 (Miller 1981). Fish were found to be present in 22 of the 26 streams examined. Arctic grayling (*Thymallus arcticus*) had the widest distribution of all fish species found, which included Dolly Varden, lake trout, King salmon, and slimy sculpins.

Water Quality – Rock Creek (Stottlemyer 1992)
Stottlemyer (1992) reported extensively on the Rock Creek sampling. Intensive sampling in Rock Creek was used to highlight the benefits of using a watershed ecosystem design. He looked at changes in upstream-downstream water chemistry in relationship to nitrogen mineralization and noted high contributions of nitrogen from alders growing along Rock Creek.

Water Quality – Wonder Lake (LaPerriere and Casper 1976, Gubula et al 1995, Brabets pers. com.)
The first comprehensive limnological studies of Wonder Lake occurred in the mid-70's (LaPerriere and Casper 1976) with measurements of temperature, pH, depth, conductivity, dissolved oxygen, nutrient chemistry. They created the first complete bathymetric map of the lake, and studied the lake's primary production (light penetration, algal C-14 productivity, and vascular hydrophyte colonization) and the factors influencing it.

In 1991, sediment cores from Wonder Lake were analyzed as part of a study to investigate the atmospheric deposition of organochlorine compounds in the United States (Gubala et al. 1995),

including anthropogenic contaminants (e.g., polycyclic aromatic hydrocarbons (PAHs), dioxins, dibenzoburans, and polychlorinated biphenyls (PCBs). Concentrations of PCBs were the highest of any remote arctic or subarctic lake surveyed in the circumpolar north. Due in part to those findings, Wonder Lake, along with McLeod Lake, are included in a project to assess a number of western U.S. and Alaska national parks for presence of organic compounds and metals from long-range transport. The sediments in these lakes were sampled in 2004, along with other resources such as snow and lichens. The project is being conducted by the Western Airborne Contaminants Assessment Project (WACAP), and project cooperators include the NPS, USGS, EPA, and others. Analysis is currently underway, and the final report is scheduled for publication in 2007.

In 2006, USGS cooperators investigated Wonder Lake water quality as part of a three-year comprehensive limnological study of Wonder Lake (described in Physical Resources - Research section); it included investigation of the possibility of contamination of Wonder Lake from human use at the nearby campground by sampling the lake at three locations for E. coli, water chemistry, and productivity. *E. coli* sampling resulted in zero counts for all locations, and nutrient levels were extremely low at all locations (Tim Brabets, USGS, pers. com. 2006).

Water Quality – Kantishna Hills Mining District
(Meyer and Kavanaugh 1983, West and Deshcu 1984, Deschu 1985a, b, Deschu and Kavanaugh 1986, Emmett and Deschu 1986, Van Maanen and Solin 1988, Emmett and Averett 1989, Oswood et al. 1990, Stottlemyer and McLoone 1990, Edwards and Tranel 1998, Frenzel and Dorava 1999, Frenzel 2000)

Resource studies of the Kantishna Hills Mining District were mandated by the ANILCA legislation. The NPS, along with many other agencies, conducted these studies over a six-year period (1979 to 1985). These have been summarized by Deschu (1985a). Placer-mined streams in Kantishna (Caribou, Glacier) have been studied to determine the effects of mining activities on physical and biological characteristics. Limited comparisons have been made to two unmined streams (Moonlight, Myrtle) (Deschu 1985a).

Various researchers have looked at the effects of mining on:

- Macroinvertebrate communities (Oswood et al. 1990, Frenzel and Dorava 1999)
- Algae and moss abundance (Oswood et al. 1990, Frenzel and Dorava 1999)
- Channel morphology and streambed particle size (Meyer and Kavanaugh 1983, Emmett and Deschu 1986, Van Maanen and Solin 1988, Emmett and Averett 1989, Frenzel and Dorava 1999)
- Fish (Meyer and Kavanaugh 1983, Frenzel and Dorava 1999)
- Riparian vegetation and aquatic habitats (Meyer and Kavanaugh 1983)
- Turbidity and sediment transport (Meyer and Kavanaugh 1983,)
- Organochlorines, semi-volatile organic compounds, and trace elements (Frenzel 2000)
- Heavy metals (antimony, arsenic, lead, mercury, and iron) (West and Deschu 1984, Deschu 1985b, Deschu and Kavanaugh 1986, Stottlemyer and McLoone 1990)
- Heavy metals in fish (West and Deschu 1984, Deschu 1985b)

Oswood et al. (1990) also studied unmined streams and how they are impacted by heavy metals. Recovery after mining activity has also been studied (Edwards and Tranel 1998).

Water Quality – Dunkle Hills (Deschu 1985a)
As part of the National Water Quality Assessment Program of the Cook Inlet Basin, the United States Geological Survey (USGS) conducted water quality studies in Costello Creek and Colorado Creek in 1999-2000. Placer-mined streams (Colorado, Costello) have been studied to determine the effects of mining activities on physical and biological characteristics. Limited comparisons have been made between Colorado and Costello and two unmined streams (Moonlight, Myrtle) (Deschu 1985a).

Physical Resources – Monitoring

Air Quality and Visibility Monitoring (NPS Air Resources Division 2002, US DOI 1999)
Air quality monitoring has been ongoing in Denali since 1980. Within the NPS, air quality monitoring is managed nationally through participation in several established programs, each targeting a specific aspect of air quality. Denali participates in the National Atmospheric Deposition Program (NADP), the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, and the Clean Air Status and Trends Network (CASTNet). Data and reports from each monitoring network are available from the NPS Air Resources Division web site at http://www2.nature.nps.gov/air/index.cfm. Periodically, the NPS Air Resources Division (2002) summarizes air quality data from each nationwide monitoring network for all participating parks.

From 1997 through 2004, a spectrophotometer measuring ultraviolet-B (UV-B) and total column ozone operated in Denali as part of the Park Research and Intensive Monitoring of Ecosystems Network (PRIMENet). The network objective was to monitor changes in UV-B incidence at the earth's surface that may affect human health and ecosystem processes. PRIMENet represented an interagency effort between the Environmental Protection Agency (EPA) and the National Park Service (NPS). Data and graphs from the monitoring program can be obtained from the EPA's UV-Net website at http://www.epa.gov/uvnet/. An interim report (NPS 1999) summarizes network results.

Climate and Snowpack Monitoring (Sousanes 2004a, c)
Climate monitoring in Denali began in 1925 when a National Weather Service Cooperative station was installed near present-day Park Headquarters. Since that initial installation, additional sites have been installed through various monitoring efforts, including the Federal Aviation Administration sites at Park Headquarters and Minchumina, fire weather sites, Long-Term Ecological Monitoring sites, and Central Alaska Network monitoring sites. Fourteen stations are currently operating within Denali, all recording core weather parameters (temperature, precipitation, relative humidity, wind speed and direction, solar radiation, snow depth, and soil temperature) with data available in "near-real-time" through an agreement with the Western Regional Climate Center. Snowpack is monitored in cooperation with the Natural Resource Conservation Service through six snowcourses, seven aerial markers, and two snow telemetry (SNOTEL) sites (Kantishna and the Tokositna Valley). The University of Alaska Fairbanks International Arctic Research Center operates an experimental climate monitoring station on Denali Pass, but those data are not included in CAKN's monitoring efforts (http://www.iarc.uaf.edu/mt_mckinley/index.php). These climate stations provide baseline climate data for the Central Alaska Network. Denali's data are used in larger-scale climate monitoring and modeling efforts.

Glacier Monitoring (Roush and Brease 1998, Mayo 2001, Adema 2007, Adema et al. 2007)
Glacier monitoring using a formal protocol began in 1991 as a part of the Long-term Ecological Monitoring program (Roush and Brease 1998, Mayo 2001) and has been summarized (Adema 2007, Adema et al. 2007). The objective of this glacier monitoring protocol is to monitor changes to glacial systems over time by measuring changes in glacial extent and index mass balance measurements on the Traleika and Kahiltna Glaciers, and in mass balance measurements on the East Fork Toklat Glaciers. Trends in glacial systems over the last 15 years differ by glacier (Adema 2007, Adema et al. 2007).

Seismic Monitoring – Earthquakes
The Tectonics and Volcanoes monitoring component of the CAKN Vital Signs monitoring program will use existing sources of information to monitor the occurrence of major earthquakes and volcanic eruptions affecting CAKN parks. The Alaska Earthquake Information Center, in cooperation with the University of Alaska Geophysical Institute operates three permanent seismometers in Denali, supported by two repeater stations. Two summaries are provided for the annual CAKN report: an annual summary of the number and location of earthquakes and an annual summary of volcanic inputs (the occurrence, timing, and duration of ash clouds from volcanic eruptions passing over Denali using remote-sensed imagery (i.e., MODIS), and air quality data from the air quality monitoring station). Additional information can obtained from the Alaska Earthquake Information Center. http://www.aeic.alaska.edu/.

Soundscape Monitoring (Hults 2004a, b, c, 2005; Hults and Burson 2006, Withers 2006)
Denali began researching soundscape monitoring techniques and applications in 2001 in order to find an effective way to measure baseline sound levels so park management can protect sound resources. An extensive project in Yukon-Charley has explored the effect of sound on raptors (Ambrose et al. 2005). Development of soundscape protocols began in 2005. The goal is to detect and monitor soundscape changes in representative ecoregions of Denali, including biological and physical sounds (biophony and geophony). Soundscape monitoring will integrate with other monitoring efforts of the CAKN. Many elements of the protocol are already in use at Denali. (Hults and Burson 2006, Hults 2004a, b, c, 2005, Withers 2006)

Permafrost Soils Monitoring (Karle and Jorgenson 2004, Osterkamp 2005, Schuur and Vogel 2007)
The specific monitoring objectives of the Permafrost Vital Sign are to: (1) Detect broad-scale trends in permafrost condition across the landscape of CAKN parks by monitoring the abundance and distribution of thermokarst and other permafrost-related terrain features in index areas. 2. Detect broad-scale trends in permafrost condition across the landscape of CAKN parks by monitoring temperatures in existing boreholes in and near CAKN parks. The basic approach to monitoring permafrost condition will be four-fold: (1) use of aerial photographs of index areas to monitor the number and distribution of thermokarst and permafrost terrain features over time; (2) use of direct measurements of permafrost temperatures in existing boreholes in and near CAKN parks; (3) monitoring of ground temperatures and active layer depths at climate stations and vegetation monitoring grid locations; and, (4) monitor an index of basic gas exchange balance. Existing data summary, analysis and protocol recommendations have been developed with technical assistance from Karle and Jorgenson (2004), Osterkamp (2005), and Schuur and Vogel (2007).

Water Quality
(Hanneman 1993, Karle 1997, Thorsteinson and Taylor 1997, Roberts and Milner 1998, Conn and Milner 1999, Karle and Sousanes 2000, MacCluskie and Oakley 2005, Milner et al. 2006)

The original design of the Denali LTEM program centered on a watershed approach, and much of the monitoring effort was focused in the Rock Creek Watershed, located near park headquarters. Several of the studies described below were funded directly through that program.

In terms of water resources, the CAKN program has identified the following vital signs to be monitored: (1) the abundance, water quality, and size of shallow lakes and ponds, (2) macroinvertebrate communities of shallow lakes and ponds, and (3) trends in flow and flood dynamics of rivers and streams. Protocols are currently being developed for the first two vital signs, and are scheduled to be developed for the third at a later date (MacCluskie and Oakley 2005).

Thorsteinson and Taylor (1997) described the LTEM watershed approach to long-term ecological monitoring in Denali. They noted that Rock Creek was selected because (1) there were existing data from previous studies; (2) the watershed included an elevational gradient for vegetation and successional patterns, (3) it was accessible and already had monitoring infrastructure. By sampling water chemistry, nutrient status, retention of organic matter, and primary production, Popovics (1999) determined that phosphorus is the limiting nutrient of the Rock Creek system. Popovics also noted that physical factors such as limited organic matter retention, increased stream discharge, and unstable channel morphology characteristics are more significant than phosphorus or the measured water quality constituents in limiting Rock Creek productivity.

Use of aquatic macroinvertebrates as monitoring tools were investigated by Roberts and Milner (1998) because they thought the organisms integrated the geology, water source, and terrestrial vegetation of the watershed. They used TWINSPAN to classify 58 rivers sampled for macroinvertebrates in 1995 into 8 distinct river types, primarily based on nutrient chemistry and channel stability. Among-river variations were greater than within-river variation. Their multivariate model will predict the community assemblage of a particular stream in Denali (Conn and Milner 1999).

Milner et al. (2006) continued to assess the use of macroinvertebrate communities for biological monitoring in Denali National Park, Alaska. Macroinvertebrate communities were studied from 1994 to 2001/2002 (except 1997) in six 'reference' streams in Denali with no known degradation. Among other findings, they noted that abundance of individual taxa varied markedly from year to year. Overall, abundance decreased over the study period, particularly with respect to mayflies. Stonefly taxa showed lower persistence and were sometimes absent from a stream in any particular year. The authors note that there exists a wide range of natural variation in benthic macroinvertebrate communities in pristine Denali streams; this large natural variation limits the applicability of composition metrics for the biological monitoring of water quality in these systems.

Karle (1997) compiled protocols for the sampling and analysis of aquatic systems for the park's LTEM program. Included in the report are protocols for assessing stream morphology and hydrology, sampling water quality, and measuring water quantity. A comprehensive report by Karle (1998) included five years of data and explanations of study sites and methods. Karle and Sousanes (2000) described the use of stream channel reference sites to monitor water quality and geomorphic parameters as part of the park's LTEM program. Other studies also looked at water quality in the Rock Creek watershed. For example, Hanneman (1993) sampled for heavy metals and noted that high alkalinity concentrations appear to be precipitating heavy metals, thereby decreasing dissolved metal concentration in stream water.

Stream and River Monitoring – Water Quality (Karle 1997, 1998, 2007b; Milner and Roberts 1997)
When the CAKN river/stream protocols are developed, these protocols will (1) detect changes over time in hydrologic regime; timing of spring melt; velocity; and extreme high and low water levels, (2) determine the composition and spatial distribution of aquatic organisms within selected rivers/streams, and (3) detect changes in stream productivity. The CAKN monitoring of river and stream flow (hydrological monitoring) will be incorporated with the biological monitoring the moving water systems. The Aquatic Ecologist for CAKN will pilot field studies to test sampling methods leading to completion of the protocol by FY2009. A major factor in stream flow monitoring is the cost to install and operate stream gauges. Alternative methods (e.g., pressure transducers, continuous recorders) will be investigated as part of protocol development. Protocol development will be guided by previous work, including stream characterization and macroinvertebrates (Milner and Roberts 1997) and stream channel reference sites and aquatic monitoring protocols (Karle 1997, 1998, and 2007b). Karle (2007b) provides an analysis of Denali's long-term water resource management goals and a strategic framework for monitoring these resources.

Lakes and Ponds – Water Quality and Quantity (MacCluskie and Oakley 2005)
The fundamental question to be addressed by this protocol is: Is the surface area, number, and distribution of shallow lake and pond systems changing, and if so, what is happening to the biota that depend on these systems (MacCluskie and Oakley 2005)? The specific monitoring objectives of the Water quality Vital Sign are: 1. Detect decadal-scale trends in the size, distribution, and number of shallow lakes and ponds in Central Alaska Network Parks. 2. Detect decadal-scale trends in the water quality (chemistry) of shallow lakes and ponds in Central Alaska Network Parks. This objective includes monitoring four core variables as directed by the NPS Water Resources Division, including temperature, turbidity, pH and dissolved oxygen. 3. Detect decadal-scale trends in the structure and composition of vegetation in shallow lake and pond margins in Central Alaska Network Parks. 4. Detect decadal-scale trends in species richness and abundance of macroinvertebrate taxa in shallow lake and pond ecosystems in Central Alaska Network Parks.

Stream Channels – Toklat Gravel Acquisition
(Gravel Assessment Plan Environmental Assessment 2003, Karle 2007a)
The Gravel Assessment Plan Environmental Assessment (2003) allows for 11,500 yards of gravel to be extracted from the Toklat River channel in the vicinity of Toklat Road Camp each year. An integral part of the mitigation for the permitted extraction is monitoring of extraction activities and impacts on the floodplain. Karle (2007a) provides the monitoring guidelines and limits of concern for extraction activities.

Impaired Waterways – Caribou Creek and Slate Creek
Caribou and Slate Creeks, both in the Kantishna Mining District, have been partially restored on some sections, but are still listed on the State of Alaska 303(d) list of impaired waterways. A Total Maximum Daily Load (TMDL) or other approved management mechanism that assures pollution controls are in place (such as a Waterbody Recovery Plan), is required for a polluted waterbody to be removed from the 303(d) list. Plans have been prepared in PMIS and included as part of the Centennial Challenge. The USGS has been awarded a water quality partnership project to assess water quality and begin a formal monitoring program.

Physical Resources – Research

Limnology of Lakes Including Wonder Lake
A three-year NPS-USGS water quality project (2006-2008) seeks to (1) determine the present limnology and water characteristics of Wonder Lake, (2) determine whether or not there have been human impacts to the water quality of Wonder Lake, (3) utilize hydrodynamic and water quality models to determine "threshold" levels of nutrients of other water quality constituents that would severely impact the water quality of Wonder Lake, (4) chose a number of other "index" or "benchmark" lakes in Denali for water quality sampling to provide a better overview of the lacustrine systems in Denali.

Toklat Gravel Renewal (Karle 2007a)
Karle (2007a) provides an in-depth analysis of the Toklat River floodplain in the vicinity of the Toklat Road Camp and provides a calculated renewable gravel load.

Mile 45 Slump (Brease 2007)
Beginning in 1993, NPS staff has tracked the flow rate and shape of a major slump adjacent to the Denali park road at Mile 45 (e.g., Brease 2007). The research was started in cooperation with Federal Highways research and installation of monitoring wells.

Drunken Forest (Brease 2001)
A significant mass movement visible from the Denali Park road, near Mile 4, has been surveyed periodically since 1987 (Brease 1995, 2001) to provide baseline information on the changing landscape. The slump begins on the Hines Creek Strand of the Denali fault system.

Geologic Mapping (Reed 1961, Reed and Nelson 1961, Csjetey et al. 1992)
Geologic mapping in Denali began with Alfred Brooks in 1911 and has continued since that time. Major bedrock geologic mapping includes three USGS documents (bulletins, maps, and miscellaneous investigations) at 1:250,000 scale (Reed 1961, Reed and Nelson 1961, and Csjetey et al. 1992).

Paleontological (Santucci and McClelland 1998, Blodget 2001, Fiorillo et al. 2006a, b, 2009)
Denali has rich paleontological resources, but relatively little paleontological research. Reconnaissance-level geologic mapping, and a few journal articles have revealed some 40 rock units with fossil material and several hundred paleontological sites within the park. In an effort to produce a paleontological site inventory, a literature search was begun in 1997 and it revealed some 276 known localities in the park. This information is summarized in "National Park Service Paleontological Research" (Santucci and McClelland 1998). Blodget (2001) has identified Devonain (Emsian & Frasnian) marine invertebrates in limestones of the Farewell terrane, including a new species of Brachiopod (*Myrospirifer breasei*).

A paleontological investigation of the Cantwell Formation (Late Cretaceous to Early Tertiary) in Denali has been initiated by the National Park Service, in cooperation with Anthony Fiorillo of the Dallas Museum of Science through a NPS Challenge Cost Share initiative. Outcrops of this thick rock unit exist in much of the central part of the park. It is particularly visible along the eastern length of the park road. The Cantwell Formation within the park contains the first record of dinosaurs in the Alaska Range. This record consists of tracks of small, medium, large, and very large-sized theropods (meat eaters), as well as hadrosaurs (plant eaters). The survey has discovered over 20 dinosaur and fossil bird footprint localities. These sites are located in the Igloo Creek/Tattler Creek area and on the

north side of Double Mountain. Some sites contain individual tracks while other localities contain hundreds of tracks. The most frequent footprint type found among all sites is the tracks of a medium-sized theropod. The tracks attributable to this animal measure approximately 20-25 cm in length. This length provides an estimated hip height of approximately 90 cm and a body length of approximately 3 m. Additional theropod tracks range from small tracks (10-14 cm in length) to very large tracks (over 50 cm in length). In addition to the more common theropod tracks, there are two sites that contain tracks attributable to hadrosaurs. These initial results demonstrate that Denali is an exciting, rich, new area for dinosaur studies (Fiorillo et al. 2006a, b). A pterosaur manus track was discovered in 2008 (Fiorillo et al. 2009).

Tectonics and Seismic Activity

(Forbes et al. 1974, Reed and Lamphere 1974, Plafker et al.1991, Fitzgerald et al. 1993, Csejtey 1996)
Tectonic activity is the dominant force behind Denali's landscape. Much of the research on tectonics in the park focuses on the Denali fault system, attempting to characterize the age, timing and movement character of the fault system. Many researchers interpret the Denali fault (McKinley strand) to be an intermittent or continuous right-lateral strike-slip movement that has occurred since at least 50 million years ago. The authors' speculation about the amount of offset range from hundreds of kilometers (i.e., Forbes et al. 1974) to a few tens of kilometers (i.e., Reed and Lamphere 1974). Other authors have suggested a little less strike-slip movement and have emphasized a dip-slip or thrust component of the fault system (i.e., Csejtey 1996). Two investigations of uplift history have been reported using fission-trac analysis concluding that the latest uplift of the Alaska Range began about 6 million years ago, and continues today at the rate of 1 mm per year (Plafker et al.1991, Fitzgerald et al. 1993).

UAF researcher Jeff Freymueller has established a network of fixed sites on which GPS monitoring grids can be deployed to determine surface deformation through high precision geodesy (study of the shape of the earth used to measure deformation across fault zones). Peter Haussler (USGS) has also worked to understand the timing and history of the tectonically active portions of the Alaska Range. In addition to standard seismic monitoring, the Geophysical Institute at the University of Alaska Fairbanks has done considerable research on the Denali Fault seismicity and has recently been investigating an unusual swarm of earthquakes in the Kantishna area. University of Alaska Geophysical Institute deployed five temporary seismometers around the swarm in 2007 to better characterize the earthquakes and tectonic structure. No publications are available as of the completion of this document.

Glacial Change

(Brooks et al. 1911, USGS Photo Archives, Pewe 1957, Millett 1960, Post 1960, 1969, Harrison 1964, 1969, Echelmeyer et al. 1987, Arendt et al. 2002, Adema et al. 2007)
Researchers have long had interest in Denali's glaciers, as the park contains some of the most visible and dramatic glacial landscapes in interior Alaska. Early USGS researchers, including A. H. Brooks (Brooks et al. 1911) and S. H. Cathcart (USGS Photo Archives) first documented in the glaciers in the 1910's and 1920's. Following their exploratory surveys, a major research effort by Bradford Washburn began in the 1940's which resulted in numerous maps, surveys, and an unequaled photo record. Austin Post also used photography to record the status of Denali's glaciers on an annual basis, starting in the 1950's, archived at the UAF-Geophysical Institute library. Research has continued intermittently on the Peters (Echelmeyer et al. 1987), Muldrow (Pewe 1957, Millett 1960, Harrison 1964, 1969) and other glaciers (Echelmeyer et al. 1987, Harisson 1964, Harrison 1969, Millett 1960, Pewe 1957, Post 1960, Post 1969 Adema et al. 2007). Denali glaciers have been included in regional glacier assessments. The most recent comprehensive research on glacier change was published by Arendt et al. (2002),

where glacial trends of more than thirty Alaskan glaciers, measured by vertical change in longitudinal profiles over time, were related to sea-level change.

Permafrost (Clark and Duffy 2004, McDonald et al 2004)
There is a limited history of permafrost research in Denali, despite the fact that more than half of the park's landscape is classified as permafrost. The first comprehensive permafrost distribution map of the park was produced as part of the first comprehensive soil survey (Clark and Duffy 2004). Kyle McDonald et al. (2004) have included two sites in Denali in a series of Alaska and global sites at different latitudes to investigate the ability of spaceborne sensors to monitor seasonal freeze/thaw dynamics (variables related to vegetation growing season and associated carbon dynamics) within boreal forest ecosystems. Results of this work have served as a primary justification for NASA's Hydrospheric States Mission (Hydros) satellite planned for launch in 2010 to better characterize seasonal freeze/thaw cycles in the northern high latitudes.

Glacial History (Wahrhaftig 1958, Werner 1982, Dortch 2006)
Glacial history in Denali has been studied by multiple field researchers, and is still only generally understood. Two of the more comprehensive quaternary geology studies include Warhaftig (1958) and Werner (1982). Warhaftig (1958) describes the surficial geology and glacial advances north of the Alaska Range from the eastern park boundary west to the Wonder Lake area. Werner (1982) provides a better understanding of climatic and environmental change in the Wonder Lake area during the last 20,000 years, including in-depth analysis of Wonder Lake moraine patterns, radiocarbon dates, and Wisconsinan glacial advance history for the Muldrow Glacier. Other researchers continue to refine local sections of Denali's glacial history. Further refinement and additional dating of glacial extent is ongoing (e.g., Dortch 2006).

Stream Restoration
(Karle and Densmore 1994, Karle et al. 1996, Major 1996, Densmore and Karle 1997, Karle 2000, Karle and Densmore 2001)
Techniques for the hydrologic restoration of placer-mined streams and floodplains were developed in Kantishna and described by Karle and Densmore (1994). This study described the design of channel geometry using hydraulic capacity and shear stress equations for a 2-year project on Glen Creek. The authors also described the need to dissipate floodwater energy on newly constructed floodplains by constructing alder bundles adjacent to the channel. A small flood near the end of the project provided data on channel design, stability, and floodplain erosion.

A companion paper described the revegetation techniques used on the project, and the effects of the flood on the streamside vegetation (Densmore and Karle 1997). Karle et al. (1996) examined the streambed stability and structure, and macroinvertebrate density and diversity before, during, and after the Glen Creek restoration project, in an effort to describe and quantify temporal changes to those systems due to the restoration activities. They noted an increase in sediment fines during channel disturbances, and low numbers and diversity of macroinvertebrates before and during restoration. Two years after channel construction, streambed stability improved and the percentage of fines in the streambed decreased. The authors concluded that restoration activities resulted in only short-term deleterious conditions, and the rapid improvement in stream conditions suggested that the short-term disturbances attributable to channel restoration were justified.

Based on nine years of cross-section surveys at the Glen Creek project site, Karle and Densmore (2001) reviewed the original hydraulic design process, and described changes to the channel and floodplain geometry over time. They noted that their original estimates for new floodplain

revegetation were accurate in areas where remnant topsoil and organic overburden materials were still available for use during construction. However, the use of the alder brush bars proved to be ineffective against large bed and bank shear stresses during high water events, even at the closer spacing of one channel width. The low critical shear stress of a non-cohesive, unvegetated gravel bank requires that substantial and continuous of bank stabilization, such as willow brush layering, be used during stream channel reconstruction. Additionally, it is important that hydraulic design calculations be as accurate as possible, and attempt to account for all possible conditions that may be encountered during field construction.

Karle (2000) described the stream restoration program at Denali, and listed the project sites to date. He described the Caribou Creek restoration project, and outlined the watershed based approach for future stream restoration projects at the park.

The use of macroinvertebrate sampling to evaluate the short- and long-term effects of stream restoration methods was reported by Major (1996). In that study, benthic samples were collected on a restored stream in Kantishna, as well as a control stream. Major reported that macroinvertebrate numbers were low throughout the restoration period, but densities and diversity improved after restoration was complete and the stream channel stabilized. However, researchers could not distinguish between restoration activities and natural recovery as the cause for macroinvertebrate recovery.

Limitations (Gaps) in Physical Knowledge

Glacier Inventory
A formal glacier inventory has not been completed for Denali's ice covered area, approximately 17% of the park. A formal evaluation of glacier extent and existing conditions will allow for a more complete analysis of change that will be observed in the future.

High Elevation Climate
Consistently acquiring reliable, high-quality climate data from higher elevations in Denali has proven problematic. University of Alaska research is attempting to operate a station at Denali Pass, but technology currently does not allow for long-term monitoring of high elevation climate.

System Response to Changes in Climate
Little work has been done to determine the landscape scale response of physical systems to changes in climate. Effects of these climate changes on the hydrologic and cryospheric systems will have a significant effect on ecosystems.

Recovery Progress of Disturbed Lands
It is not well understood how quickly disturbed lands in the Kantishna mining district will recover. Restoration efforts in some areas may or may not assist in recovery of healthy ecosystems. Monitoring and evaluation of reclamation efforts will help determine which elements are most useful.

Effects of Changing Permafrost
Denali's northern portion is dominated by a permafrost landscape. The permafrost controls surface hydrology and plays an important role in the dynamics of the 12,000+ park lakes. As the permafrost reacts to a warming climate, the ecological effects will be important to monitor.

Paleontology Inventory and Database and Protection Plan
While Denali staff and cooperators have recently discovered many tracks of dinosaurs and other fossils in the Cantwell Formation, relatively little is known about the paleoecology and overall paleontological resources of the park. It is likely that many areas of the park have rich paleontological resources, but little effort has been expended so far to find new fossils. Additionally, little effort has been expended to inventory and ground truth existing or known fossils or fossil sites.

Soundscape
Baseline conditions of the park's soundscape are not well documented.

Lightscape – Night Skies
Denali's dark night skies in winter are currently taken for granted. As tourist shoulder seasons grow, and development near the park continues, it will be important to develop baseline conditions and better understand where the major threats to night sky lie.

Water Quality
Compared to many parks and natural areas in the lower 48 states, Denali National Park and Preserve has a limited database of its water resources. For example, studies of surface water quality in Denali have been sporadic in the past, and generally focused on the Kantishna Hills mining district. Some studies have focused on contaminated aquifers in populated areas, generally in response to oil spills. Essentially, there is no comprehensive database for water quality, stream discharge, lake levels, or visitor use levels. A list of data gaps in water-related baseline inventory and monitoring is provided by The Mangi Environmental Group (2005).

As a result, there is a basic lack of understanding of the park water systems. Without a baseline inventory of current conditions, understanding water resource ecosystems, threats to those ecosystems, and whether or not water resource goals are being met becomes an almost impossible task. A baseline inventory of current water resource conditions is the first step towards achieving the park's Water Resource Goals.

Hydrologic data collection, and specifically stream gauging data, has been deficient in Alaska in general, and in Denali in particular. The only programmatic stream gauging measurements were conducted by the U.S. Geological Survey on the Teklanika River. Ten years of daily discharge measurements are available, from 1965 through 1974. Several years of stream gauging data were also obtained by NPS, as part of the Long-Term Ecological Monitoring Program. A gauging station was located on Rock Creek, and was operated only during the summer months.

Research Needs in Response to Ecological Threats

Soundscape Modeling
With more accurate soundscape modeling routines, the park can effectively manage motorized uses in order to protect the natural soundscape.

Hydrology Change with Changing Climate
The changing climate is certain to affect park hydrology, including glacier systems and permafrost systems. It is not well understood how those changes will impact park ecosystems.

Gravel Renewal
Current road management practices require local gravel sources for maintenance of the Denali park road. A better understanding of gravel renewal rates in large stream channels will provide information to evaluate how sustainable in-park gravel mining operations may be.

BIOLOGICAL RESOURCES

Contemporary knowledge of Denali's biological resources include measuring and describing the range and distribution of the park's plants and animals, monitoring trends in the abundance and distribution of specific species or other biological indicators, and gathering data to answer specific questions of scientific or management importance.

Inventory, monitoring, and research activities are not mutually exclusive. For example, monitoring often includes research, inventories often lead to monitoring, and research often reveals gaps in inventory and monitoring programs. The synthesis of varied sets of information to provide a comprehensive understanding of the park's ecology provides the most challenging and rewarding tasks for resource managers.

Biological Resources – Inventories

The earliest attempts at inventories in Denali resulted from the activities of explorers, naturalists, and scientists in Mt. McKinley National Park (now known as Denali) as they mapped the region's landforms and biological communities and listed the species encountered during their journeys. Contemporary inventories either target specific ecological systems or use more sophisticated sampling designs and statistical methods to sample across the vast scale of the park and preserve.

Soils Survey and Ecological Site Inventory of Denali (Clark and Duffy 2004)
This project documents the plant communities and soil profiles for more than 200 sites. This project provides a detailed Ecological Site Inventory and Soils Map for all of Denali, including spatial data readily available in the Park GIS. It is a valuable database to consult to learn the result from the interactions among soils, climate, and the biological history of the area. It provides mangers and scientists with a powerful tool for understanding the variation across park landscapes and developing predictions about important properties of any area of the park and preserve.

Vascular Plant Inventory of Denali (Roland 2004)
During this four-year field project, vascular plant inventories were performed for >200 sites across Denali, adding 224 species to the park and preserve checklist. This project provided a voucher-based species list and distribution information for the more than 750 species of vascular plants known to occur in Denali.

Species Lists and Faunal Inventories (Dixon 1938, Murie 1944, 1962)
Many of the early explorers of Denali, along with the park managers, scientists and visitors that came after them, produced lists of the animal species that they observed. To date, 165 bird species, 39 mammal species, 15 fish species, and one amphibian species have been documented in Denali. No reptiles are native to interior Alaska. Dixon (1938) and Murie (1944, 1962) provided early accounts of

the birds and mammals of Mount McKinley National Park. Milner et al. (2006) described invertebrate animal life in Denali's freshwater systems.

Central Alaska Network Fish Inventory (Markis et al. 2004)
The Central Alaska Network conducted a freshwater fish inventory in Denali in 2003 as part of the National Park Service Inventory and Monitoring Program. The inventory sampled fish populations at sites in the northwest portion (Yukon-Kuskokwim Bottomlands) of Denali. In addition to resident fish species, several migratory species including king salmon (*Oncorhynchus tshawytscha*), silver salmon (*Oncorhynchus kisutch*), and chum salmon (*Oncorhynchus keta*) migrate more than 1000 miles (1600 kilometers) from the Bering Sea to spawn and die in Denali's rivers, providing an important food source for many other animals.

Bird Inventories
No comprehensive inventory of bird species in Denali has been conducted. At least 168 bird species have been documented in Denali since 1906. Most historic studies focused on listing the bird species occurring in the area and, in limited cases, describing the natural history of a species. More recently, studies were conducted to determine population trends, identify nesting areas, and describe nesting habitat for specific species in response to management needs, and to understand how birds respond to changes in their environment. Few of Denali's many historic bird-related projects occurred at the landscape scale. Rather, most studies were species-specific or were conducted in the northeast portion of Denali along the Denali park road corridor in the Alaska Mountains ecological unit.

Small Mammal Inventory (Cook and MacDonald 2002)
A small mammal inventory was conducted in Denali in 2002 (Cook and MacDonald 2002). Trapping was conducted at four sites, designed to represent a variety of habitats. To date, 25 species of small mammals have been documented in Denali—the small mammal species expected to occur in Denali. However, knowledge of their abundance and distribution is lacking.

Biological Resources – Monitoring

The Long-Term Ecological Monitoring (LTEM) program and its successor, the Central Alaska Monitoring Network (CAKN), have identified a number of species or species assemblages as vital signs that are monitored to provide indicators of trends in Denali's ecosystems. Other monitoring is done because of its importance in making management decisions, or in answering scientific questions that require long-term data sets.

Landscape-Scale Vegetation Monitoring Program (MacCluskie and Oakley 2005)
The CAKN vegetation monitoring program was begun in 2001 and is based upon a probabilistic grid sampling design that covers much of the northern portion of the Park. This is an ongoing project that is part of the CAKN Vital Signs monitoring program. More than 500 permanent vegetation monitoring plots have been installed and measured in Denali as a part of this program, which provides quantitative information about the vegetation, soil and landscape of the park. These plots are scheduled to be revisited every 7 years, to detect changes in the vegetation cover of the park at a landscape scale. This project has provided a wealth of information on Denali's plants, but as a widespread long-term monitoring effort, its greatest value lies in the continued sampling and re-sampling of sites over many years.

Exotic Plant Assessment (Densmore, McKee, and Roland 2001)
This project provided an inventory of the exotic plants that occur along the Denali Park Road. Ongoing work by the Park is adding information regarding the distribution and abundance of exotic plants in the Park each year.

Anadromous Fish Monitoring (USNPS 2001)
Aerial surveys of salmon runs in and downstream from Denali were conducted in 2000 (U.S. NPS 2001). In a cooperative venture with the Alaska Department of Fish and Game, live capture fishwheels have been operated on the Kantishna and Toklat Rivers since 2000 for the marking and tagging of chum salmon. These projects should be continued if they are providing useful data for evaluating park ecosystems. The location of salmon spawning areas in Denali is not well-described and further aerial surveys should be conducted. Denali's subsistence management plan also recommends the gathering of historical data on fish harvest by subsistence users, and the gathering of traditional ecological knowledge about fish populations and fish harvest.

Monitoring Golden Eagle Reproductive Success
(McIntyre and Adams 1999, McIntyre 2002, Kochert and Steenhof 2002, Kochert et al. 2002, McIntyre and Collopy 2006, McIntyre et al. 2008, Martin et al. 2009a, b)
This study was started in 1987 and continues as part of the CAKN Vital Signs monitoring program. Results of this project have identified one of the largest breeding populations of golden eagles in North America and provided internationally significant information on golden eagles nesting at northern latitudes (McIntyre and Adams 1999, McIntyre 2002, Kochert and Steenhof 2002, Kochert et al. 2002, McIntyre and Collopy 2006, McIntyre 2008, Martin et al. 2009a, b).

Trumpeter Swan Population Surveys (McIntyre 2006, Moser 2006)
This monitoring project was started in 1975 and is conducted by the US Fish and Wildlife Service (FWS) as part of their statewide surveys. These surveys are conducted every five years throughout all known and potential nesting habitat, including Denali. Denali provides funding to conduct these surveys in the park and preserve. This long-term data set documented the increase in Trumpeter Swans throughout Alaska and is invaluable for measuring the response of Trumpeter Swan populations to the effects of global climate change (McIntyre 2006, Moser 2006).

National Breeding Bird Survey
The national Breeding Bird Survey (BBS) is a long-term, large-scale, international avian monitoring program initiated in 1966 to track the status and trends of North American bird populations. Two BBS routes were established along the Denali park road in the 1970s and BBS were conducted intermittently between then and the early 1990s. The two BBS routes in Denali have been conducted annually since 1994, providing limited information about birds along the Denali park road, but making significant contributions to efforts to detect trends of birds in Alaska and North America.

Monitoring Passerine Abundance and Distribution (Roland and McIntyre 2006, McIntyre 2007)
A project to monitor passerine birds and their abundance and distribution was started in 2001 and continues as part of the CAKN Vital Signs Monitoring Program. The project is conducted in the northeastern portion of Denali and provides quantitative information about the abundance and distribution of birds in that region and information on how birds respond to changes in their habitats. This project is integrated with the Vegetation Monitoring Program described above (Roland and McIntyre 2006). Over 400 sampling points were surveyed between 2001 and 2005, providing new information on the abundance and distribution of Denali's songbirds. Each survey point is visited every three years to detect changes in the abundance and distribution of birds in this region. This

project has provided a wealth of information and is different from other bird projects in Denali because it is based upon a randomized design that allows design-based inferences to be made across its sampling universe. This project is conduct in cooperation with the Alaska Bird Observatory. Apparent changes in the abundance and distribution of birds have been described (McIntyre 2007).

Christmas Bird Count (McIntyre et al. 2006d)
The Christmas Bird Count (CBC) is the longest-running and most widespread bird survey in the Western Hemisphere. A CBC was started in the area in 1992 by a local community member and continues today. Data collected on CBCs are valuable on multiple scales; on a hemispheric scale, CBC data are valuable for monitoring broad-scale trends of bird species abundance and distribution. Statewide, CBC data are valuable for monitoring numbers of birds wintering in Alaska. Locally, CBC data are valuable for monitoring the presence and relative abundance of winter birds in this area. The CBC is the only ongoing bird project focused on resident and wintering birds in this area (McIntyre et al. 2006d).

Mammal Monitoring
(Oakley 2003, Burch et al. 2004, Adams and Roffler 2008, Meier 2009, Meier et al. 2009)
Several species of large mammals were identified by the CAKN as vital signs to be monitored. Monitoring plans for wolves and moose were written and are ready for implementation review (Burch et al. 2004, Meier et al. 2009). A monitoring plan for caribou in the CAKN is being written. Plans for monitoring grizzly bears and Dall's sheep will be produced in coming years. Since 1986, radio telemetry has been used to monitor the distribution and numbers of the Denali caribou herd, in conjunction with ongoing caribou research (Adams and Roffler 2008). Also since 1986, wolves in Denali have been studied with radio telemetry in order to monitor their numbers and movements, and to answer other research and management questions (Meier 2009). A long-term monitoring program for small mammals has been conducted in the Rock Creek drainage near park headquarters since 1992 (Oakley 2003).

Bear/Human Information Management System (NPS 2003, NPS 2006c)
The Bear/Human Information Management System (BHIMS) has been developed to standardize the collection of bear data across all national parklands in Alaska (NPS 2003). The system provides a structured method of collecting bear/human conflict data, and a tool to organize and analyze those data. BHIMS aids in the identification of individual problem bears or areas, enhances human safety, improves bear management plans, and leads to better conservation of bears. Denali BHIMS data are reported annually in a Wildlife-Human Conflict Management Summary report (e.g., NPS 2006c).

Moose Surveys
(Troyer 1974, Gasaway et al. 1986, VerHoef 2000, Owen and Meier 2005, Owen and Meier 2006, Owen and Meier 2008)
Aerial moose surveys have been conducted in Denali intermittently, at least since 1974 (Troyer 1974, Singer 1984, Meier et al. 1991, Owen and Meier 2005, Owen and Meier 2008). Sampling methods have changed with developments in technology and sampling theory. Most surveys have depended on methods developed by the Alaska Department of Fish and Game (Gasaway et al. 1986, VerHoef 2000). According to the CAKN draft moose monitoring protocol (Burch et al. 2004), a moose survey is planned for a 1000-square-kilometer area north of the Alaska Range in Denali every three years, rotating with the other two CAKN parks. The most recent large-scale moose survey in Denali was conducted in November 2008 (Owen and Meier 2008). In addition to the north side surveys, smaller moose surveys are regularly conducted in the Cantwell and Yentna areas south of the Alaska Range, in

order to assess moose populations in these areas affected by subsistence harvest (Owen and Meier 2006).

Dall's Sheep Surveys
(Troyer and Grosnick 1977, 1979; Singer et al. 1981, Taylor et al. 1988, Stahlnecker 1995, Phillips 2009)
For many years, park staff conducted ground-based sheep surveys along the park road corridor to obtain information on sheep age and sex composition (Taylor et al. 1988, Stahlnecker 1995). These surveys provided an index of sheep productivity and were conducted on an annual basis between 1979 and 1988 by Denali staff. Methodology for the counts was adapted from ground surveys conducted by the Alaska Department of Fish and Game prior to that time. The ground-based surveys were supplemented by aerial surveys in several years to obtain estimates of sheep abundance (Troyer and Grosnick 1977, 1979; Singer et al. 1981; Taylor et al. 1988; Stahlnecker 1995). Generally, these surveys were conducted in the traditional sheep surveys units east of the Muldrow Glacier using fixed-wing aircraft except that the surveys in 1981 and 1987 were conducted with helicopters. Western park and preserve areas have been surveyed for sheep rarely in the past (Singer et al. 1981, Stahlnecker 1995) and surveys were conducted without any standardized survey units among years. Within the last two decades, surveys of Dall's sheep were conducted in 1997, and 2008-2009 (Phillips 2009).

Biological Resources – Research

A rich diversity of biological research has been conducted in Denali, including pioneering predator-prey research dating back more than a half century (Murie 1944). Some 10-20 new permits are issued for biological research in the park each year. The new Discover Denali Research Fellowship Program, instituted in 2006 and funded by the Murie Science and Learning Center, as well as additional grants provided for research from the MSLC provide funding to non-NPS researchers to work in the Denali area.

Wood Frog Research (Hokit and Brown 2006, Chestnut et al. 2008)
The only amphibian in interior Alaska, the wood frog (*Rana sylvatica*) is widespread in Denali. Recent studies have documented the distribution of breeding sites for these frogs in a portion of the park (Hokit and Brown 2006). In 2005, researchers sampled wood frogs from a variety of sites in Denali, looking for evidence of chytrid fungus in the park's frog population (Chestnut et al. 2008).

Bird Research
(Laing 1985, Kertell 1986, Swem et al. 1994, Wilbor 1996, O'Grady 2001, Shook 2002, McIntyre 2002, McIntyre et al. 2006a, 2006b, 2006c, Shaw et al. 2006, McIntyre et al. 2008, Martinet al. 2009a and 2009b, McIntyre et al. 2009)
A number of bird studies have been conducted in Denali since 1980 (McIntyre 2002). A study on breeding ecology of merlins was carried out between 1983 and 1993 (Laing 1985, Wilbor 1996). Swem et al. (1994) report on the biology of gyrfalcons in Alaska, including Denali. Movements of juvenile gyrfalcons after leaving natal areas in western and interior Alaska are reported by McIntyre et al. (2009)Two short-term studies on the nesting ecology of Northern Hawk Owls were conducted by Kertell (1986) and Shook (2002). A MAPS (Monitoring Avian Productivity and Survival) project was conducted as part of Denali's LTEM Program from 1993 to 2001 (O'Grady 2001). An avian point count project, using unadjusted point counts located along non-randomly placed transects to collect data on breeding songbirds in Denali, was conducted as part of Denali's LTEM program from 1993 to 2001. The project was revised and changed to the Passerine Monitoring Project in 2001 as described above.

Research based on Denali long-term golden eagle monitoring has provided new information on golden eagle ecology in North America (McIntyre et al. 2006a, McIntyre et al. 2006b, McIntyre et al. 2006c, McIntyre et al. 2008, Martin et al., 2009a, b) (see above). A one year monitoring program for H5N1 Avian Influenza in Arctic Warblers was conducted in 2007 as part of the US Fish and Wildlife Service's statewide surveillance program (Shaw et al. 2006).

Predator-Prey Studies
(Murie 1944, Haber 1977, Mech et al. 1998, Belant et al. 2006, Adams and Roffler 2008)
The wolf studies of Adolph Murie (Murie 1944) laid the groundwork for a re-examination of the roles of predators in ecosystems, and for the conservation of all species in national parks. Dr. Gordon Haber has studied Denali's wolves since 1967 (Haber 1977). Since 1986, wolf packs in Denali have been monitored by radio telemetry. This work has resulted in numerous scientific publications and one book (Mech et al. 1998). Research on the population dynamics of the Denali Caribou Herd has been supported by the National Park Service since 1983. Current methodologies were put into practice in 1986 to census the population annually and estimate calf production, calf recruitment, adult female survival, and herd composition, representing the longest and most consistent effort of its kind on caribou in North America. This research is carried out by Dr. Layne Adams of USGS Alaska Science Center (Adams and Roffler 2008). Since 1991, research on grizzly bear populations in the western part of Denali has been conducted by Dr. Jeffrey Keay, Gerald Belant, and Patricia Owen. This work focuses on the survival and productivity of bears in the area beyond the road corridor, stretching west to the Kuskokwim headwaters. A study of grizzly bears and black bears on the south side of Denali was also conducted from 1998 to 2000 (Belant et al. 2006, Owen and Mace 2007).

Response of Wildlife to Park Road Traffic (Phillips et al. in review)
Park biologists studied movements of wildlife in relation to the park road in 2006-2007. Twenty grizzly bears were fitted with GPS collars in 2006 (May – September) and 20 Dall's sheep were fitted with GPS collars. Movements of sheep varied by sex, geographic area, time of day, and terrain ruggedness.

Limitations (Gaps) in Biological Knowledge

Nonvascular Plant Inventory
A key missing ingredient in our understanding of Denali's vegetation resources is a nonvascular plant inventory of the park. This is a critical information need because of the importance of nonvascular plants (mosses, lichens, and liverworts) in the northern flora and ecosystems. There are currently plans to undertake a nonvascular plant inventory of the Park beginning in 2008.

Sampling Designs for Fish and Amphibian Inventories
Although surveys of fish and frog populations have been conducted (Markis et al. 2004, Hokit and Brown 2006), such surveys have not been conducted on a parkwide basis, and they did not use randomized sampling methods. Given the sensitivity of amphibian and fish species to environmental changes, the timely accomplishment of parkwide surveys should be a high priority.

Invertebrate Inventory and Monitoring
Similar to the vertebrate studies discussed above, invertebrate studies in Denali have tended to be restricted in their geographic scope and targeted toward specific areas and scientific questions. Parkwide, statistically designed sampling of terrestrial and aquatic invertebrate species would provide a valuable baseline for evaluating future changes in the park's ecosystems. Invertebrate species are often

overlooked, but in numbers, diversity, biomass, and ecological function they probably overshadow the impacts of all vertebrate animal species by a wide margin.

Parkwide Inventory and Bird Checklist Assessment
One of the limitations to Denali's knowledge base is the lack of information regarding birds throughout the park. This has resulted in a bird checklist that is based on incomplete information that often lacks proper documentation (i.e., vouchered specimens or voucher photographs). A parkwide bird inventory assessing the presence, distribution, and breeding status of all birds is critical for the future management of birds in Denali. Birds are Denali's most diverse group of vertebrates, yet we lack information on them for most of the park and during most of the year (see below). This project also is needed because of rapid population declines of several species that occur in Denali (e.g., Blackpoll Warbler, Rusty Blackbird), and potential negative effects on wetland and alpine birds in response to a warming climate.

Ecology of Resident Species
A significant knowledge gap in Denali is the ecology of resident birds. Nearly all the historic and contemporary bird studies conducted in Denali focus on the breeding season, yet the breeding season is far shorter than the non-breeding season. More information is needed about Denali's resident birds and their year-round requirements to understand how they may respond to global climate change and other perturbations.

Population Dynamics of Ptarmigan
Willow and rock ptarmigan are important food resources for subsistence hunters and mammalian and avian predators, but there is no information on the abundance, distribution, or population trends of these species in Denali. Efforts should be made to conduct annual surveys to estimate the abundance and distribution of ptarmigan in Denali. Ptarmigan density and distribution has been identified as a proposed vital sign by the CAKN.

Investigations of Wildlife Diseases
H5N1 Avian Influenza is an example of a zoonose, a disease that is capable of moving between wildlife and human populations. Rabies is another example of a disease that has long been a concern anywhere that humans and wildlife coexist. Apart from human health concerns, wildlife diseases have the potential for causing large changes in the structure and function of ecosystems. Climate change, with the associated changes in the distribution and health of wildlife populations, could very well exacerbate the effects of wildlife diseases.

Dall's Sheep Surveys
Prior to 2008, the most recent survey of Dall's sheep in Denali was conducted in 1997. Dall's sheep were identified as a key vital sign to be monitored in CAKN parks (MacCluskie and Oakley 2005), but a monitoring plan has not been developed. Because of the importance of Dall's sheep in the establishment of Denali, their visibility and importance to the visitor experience, and their potential sensitivity to climate change, this species should receive more emphasis in park plans and budgets than it has in the past.

Mesocarnivore and Furbearer Surveys
A taxonomically diverse group of species have not been well- studied in Denali. These are the medium-sized mammals including coyote (*Canis latrans*), red fox (*Vulpes vulpes*), lynx (*Lynx canadensis*), wolverine (*Gulogulo*), river otter (*Lutra canadensis*), marten (*Martes americana*), mink (*Mustela vison*), and beaver (*Castor canadensis*). Many of these species are valuable furbearers, harvested by subsistence

users in the 1980 additions to Denali. Surveys of the distribution and abundance of these species have not been carried out.

Small Mammal Monitoring Plans
A network-wide monitoring plan for small mammals in CAKN has not been developed. The existing small mammal monitoring program in Denali is a legacy of the LTEM and should be continued; however, consideration should be given to a wider range of habitats and a randomized sampling scheme to conduct small mammal surveys. The distribution and density of snowshoe hares (*Lepus americanus*) and arctic ground squirrels (*Spermophilus parryii*) were identified as CAKN vital signs. Both of these species are widespread primary consumers that form vital links in the Denali food webs.

Grizzly Bear Monitoring
Grizzly bears were identified as a key vital sign to be monitored in the CAKN, but a monitoring plan has yet to be developed. The Alaska Department of Fish and Game has developed line-transect aerial survey methods that may be useful (Becker 2001). The presence of radio-collared bears in a portion of Denali may help to test and calibrate survey methods.

Harvest Levels and Impacts of Subsistence Use
Although subsistence harvest of many mammal species takes place in the 1980 additions to Denali National Park and Preserve, and sport harvest occurs in the Preserve areas, there is not a good system for monitoring harvest levels. In most of these areas (those portions that lie in Game Management Units 16, 19, and 20), subsistence harvest of large mammals does not require a registration permit, and there is no enforceable requirement for a harvest report. Only in GMU 13 is there a requirement for a registration permit to harvest moose or caribou on park lands. There is not a requirement for subsistence users to report the numbers of furbearers that they harvest on NPS lands. This lack of information makes the assessment of subsistence impacts impossible, and seriously hinders the ability of NPS to evaluate the natural and healthy nature of wildlife populations. As recommended in the report "Who's Counting?" (National Parks Conservation Association 2006), more and contemporary data are needed to evaluate harvest impacts on Alaskan parks. The report specifically recommends updated community harvest surveys for Denali subsistence communities. In addition, the instatement of registration permit hunts in the Yentna drainage (GMU 16B), the Kantishna area (GMU 20B), and the Minchumina area (GMU 19D) would allow NPS to understand existing harvest levels and evaluate changes in harvest. A reporting requirement for numbers of furbearers harvested in "new park" areas by subsistence users would also facilitate the evaluation of the impacts of subsistence use.

Research Needs in Response to Ecological Threats
In setting priorities for future biological research in Denali, it is worth focusing on the most significant threats to the integrity of park resources, as best we can foresee them. Currently, we recognize three primary challenges to Denali's ecosystems:

(1) Global and Regional Climate Change and Associated Ecological Responses.
Examples of research needs include: What is the status of permafrost in the park, and how is it changing? Is the frequency, intensity or phenology of wildland fire changing on the Park landscape? Is vegetation phenology changing in response to climatic changes – and in what way (investigated at multiple spatial scales)? Is productivity and reproductive effort of dominant species within different vegetation types changing over time? How does this relate to the quality and quantity of wildlife forage? Can we develop realistic and useful models of wildlife habitat based upon vegetation and landscape variables? Can these models be used to project changes in the future in response to climate

change? How are aquatic plant communities changing with warming and drying of the landscape? What is the influence on waterfowl and moose habitat? What are the potential impacts of landscape change to botanical biodiversity and our rare and endemic flora? What is the impact of climate change on habitat specialist such as arctic ground squirrel, pika, and Dall's sheep?

(2) Increased demand for access and development in park lands and neighboring areas for resource extraction, tourism, and consumptive use.

Examples of research needs: What is the current pattern and intensity of disturbance of vegetation and soil resources from hikers, campers and other use of the landscape by non-motorized users? What are the short and long term potential impacts from snowmachine, ORV, and dogsled use of the park landscape? How quickly do different vegetation types regenerate naturally following different types of disturbance from park users (e.g., OHV, hiking)? What are the best methods and materials to control or eradicate high-priority exotic plants and reduce the potential for them to invade into natural vegetation? What are the primary vectors for the transport of exotics into the park and how can the transport of exotics be reduced?

(3) Deposition of global or regional contaminants on park and preserve lands.

Examples of research needs: Are contaminants accumulating in park terrestrial ecosystems? What are they, where do they come from and what is their geographic or ecological pattern? What impacts are local, regional and global contaminant plumes having on sensitive lichen and moss communities? What baseline conditions for monitoring air and water quality can be established using nonvascular plants as bio-indicators?

FIRE

Our current knowledge of fire in Denali is classified into Fire Inventories, Fire Monitoring, and Fire Research. Inventories include measuring and describing the range and distribution of wildfire in the park as well as tools and data that are available that can be used to better understand fire. Inventories also include existing data that help managers make decisions regarding fire in Denali. Monitoring includes studying trends related to fire characteristics and fire effects (e.g., effects on vegetation) in the park. Research includes gathering data to answer specific questions of scientific or management importance. These three broad groups are not mutually exclusive. For example, monitoring often includes research, inventories often lead to monitoring, and research often reveals gaps in inventory and monitoring programs.

Fire – Inventories

The fire inventories and database tools have evolved since the inception of the management of wildland fire in Denali. Contemporary inventories are conducted using more sophisticated sampling designs and statistical methods to sample across the vast scale of the park and preserve, or alternatively, targeting inventories to optimize our knowledge of specific ecological systems. The following fire inventories help maintain and achieve the park's natural ecosystems and components; wilderness character and values; subsistence resources and opportunities; and historic, archeological, and ethnographic resources. Fire inventories also contribute to scientific research, education, and interpretation about natural ecosystems and geological processes.

Fire Cause Reports -Human vs. Natural
(U.S. D.I., NPS, AK Region. Denali National Park and Preserve Fire Report Archives 2007)
These reports (1202 Fire Reports) provide insight into the historical management of fire in the park and preserve. The database includes all fire statistics and administrative information from 1946-2007. Prior to 1946, incomplete fire reports exist in the Denali resource archives.

Fire Protection Points Inventory
(U.S. D.I., NPS, AK Region, Alaska Western Area Fire Management Archives 2006)
The fire protection points inventory relates to the management of wildland fire at or near Cultural Resources. It provides information needed for managers to implement the appropriate management response to wildland fire. It also provides managers an inventory of sites within fire prone areas and allows managers to select a pre-determined response.

Fire Management Zones (U.S.D.I., NPS, AK Region, Alaska Regional GIS Database 2007c)
This information is managed by the State of Alaska, Department of Natural Resources, Division of Forestry. This GIS coverage determines the default appropriate management response for managing wildland fire. These areas are determined based on the attributes defined in the Alaska InteragencyWildland Fire Management Plan. The designations for these areas are: Critical, Full, Modified and Limited.

Digital Elevation Model (U.S.D.I., NPS, AK Region, Alaska Regional GIS Database 1999)
This coverage provides a digital representation of topographic information required for modeling fire growth parameters. This digital elevation model is based on approximately 60 meter grid that is coarse scale and not the optimal scale for modeling fire growth parameters.

Soils Inventory (U.S.D.A., Natural Resources Conservation Service 2004)
This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a planimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information. Fire Management anticipates using this information as it relates to the possible vegetation successional pathways within a designated soil type.

Denali Firepro Aerial and Ground Truth Fuels Mapping
(U.S. D.I., NPS, AK Region, Archives, 1992)
Field data for 307 Denali Fire Management Ground Truth (GT) and 537 Intensive Mapping Area (IMA) polygons was collected by Fire Management personnel from 1983 to 1992. Data collection included documentation of plot location, quantified vegetation description and photo documentation. Original field materials (air photos, datasheets and photo documentation) are on file in the Alaska Regional Office of the National Park Service, Anchorage, Alaska. Ground Truth (GT) point locations and Intensive Mapping Area (IMA) polygons were originally marked on Alaska High Altitude Program (AHAP) color infra-red (CIR) aerial photos. These locations were transferred from the AHAP CIR aerial photos to USGS quads and digitized in ArcInfo.

MODIS Imagery
(USDA Forest Service, Remote Sensing Applications Center, MODIS Imagery Archives 2007)
MODIS (or Moderate Resolution Imaging Spectroradiometer) are instruments installed on satellites developed by NASA that produce data of the Earth's surface. The MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths (see MODIS Technical Specifications). These data help improve people's understanding of global

dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. Fire managers at Denali use the MODIS Thermal Anomalies product when monitoring active fire(s) in and around the park. The product includes fire occurrence (day/night), fire location, the logical criteria used for the fire selection, and an energy calculation for each fire. The product also includes composite 8-day-and-night fire occurrence (full resolution), composite monthly day-and-night fire occurrence (full resolution), gridded 10-km summary per fire class (daily/8-day/monthly), and a summary of fire counts per class (daily/8-day/ monthly). The Level 2 product includes various fire related parameters including the occurrence of day and nighttime thermal anomalies, flagged and grouped into different temperature classes with emitted energy from the fire. These parameters are retrieved daily at 1-km resolution. The images produced by MODIS indicate the location of a fire but not the actual size. Alaska NPS has created GIS coverage with information gathered by MODIS from 1999 through 2007. The information has a potential correlative relationship with burn severity but has yet to be tested.

Fuels Characteristics Classification System
(USDA Forest Service, Fire and Environmental Research Applications Team 2006)
The Fuels Characteristics Classification System is a national fuelbed database used for determining emissions, fire behavior indices and fuel potential. The system facilitates communication of fire hazard among users and provides an indexed representation of the intrinsic capacity of each fuel bed for surface fire behavior, crown fire and available consumption of fuels.

Fire – Monitoring

The Long-Term Ecological Monitoring (LTEM) program and its successor, the Central Alaska Monitoring Network (CAKN), have identified Ecosystem Pattern and Processes (Fire and fuel dynamics - Long-term trend of fire frequency, average fire size, average burn severity, total area affected by fire) and a number of species or species assemblages as vital signs that are monitored to provide indicators of trends in Denali's ecosystems. Other monitoring is done because of its importance in making management decisions, or in answering scientific questions that require long-term data sets. The following monitoring activities contribute to maintaining and achieving the park's natural ecosystems and components, scenic and geologic values of Mount McKinley, visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features. The identified monitoring activities also contribute to the scientific research, education and interpretation about natural ecosystems and geological processes.

Fire History Maps – Polygon (U.S. D.I., BLM Alaska Fire Service GIS Database 2007)
The GIS coverage of historical wildland fire perimeters contains fires greater than 1000 acres between 1950 and 1987, inclusive, and fires greater than 100 acres between 1988 and 2007, inclusive. Also contains 10 meter buffers around reported start locations for fires greater than 1000 acres for which no perimeter has been located. Graphical display of wildland fire history in Alaska. Some estimates of acreage burned and wildfire distribution may be made, but there are over 300 missing fires that will impact the results of such use. The majority of fires typically occur in the Minchumina and Toklat Basins. Fires generally do not occur over 3000 ft. elevation. This GIS coverage indicates the high fire frequency portion of the park and preserve.

Fire History Maps – Point (LaMay 2007)
Coverage containing historic ignition points of fires that have burned within park boundaries from 1956 to 2006. Data were compiled from Alaska Fire Service, BLM and the State of Alaska Department of Forestry, and National Park Service park records. Point coordinates were recorded on Fire Report

sheets and are of variable quality. This coverage is subject to review and yearly updates (the last update was in May 2007). This coverage is based on and derived from the AK NPS fire occurrence Access database maintained by Karen Lamay, Fire Program Assistant, NPS Alaska Region. This coverage indicates where/when a fire occurred and how large the fires became, the high fire frequency portion of the park and preserve, and the source of ignition (Human vs. Natural Causes). The majority of human caused fires are along transportation corridors (Road and Railroad) and human improvements.

Burn Severity (U.S.D.I., NPS, AK Region, Alaska Regional GIS Database 2007)
Extended assessment burn severity datasets for the Denali fires derived by applying the Normalized Burn Ratio to pre- and post-fire Landsat imagery. Display burn severity condition of areas burned in Denali National Park & Preserve. The purpose of this dataset is to develop a robust mapping methodology and consistent data products that allow federal land managers and fire ecologists to evaluate and compare burn severity within individual fires and between fires across various ecosystems. These products will help land managers to more effectively plan, implement and monitor fire recovery activities. Data sets include Denali National Park and Preserve fires from 2000 – 2005. Initial analysis of the small dataset indicates that how large a fire becomes in not an indicator of the proportion of high, moderate or low burn severity. A smaller fire has approximately the same proportion of high, moderate or low burn severity as a large fire.

Lightning Occurrence - Point Location (U.S.D.I., BLM Alaska Fire Service GIS Database 2007)
GIS Coverage of lightning data from 1986 through the present (with the exception of 1987 and 1989) is available through the Alaska Fire Service. Lightning is the primary source of ignition in the Minchumina and Toklat Basins of Denali. The data provided by this coverage is used by fire managers at Denali primarily for fire detection but can also be useful when studying patterns and frequency of lightning and how it may correspond with the frequency of fire starts in Denali.

On Site Weather/Fire Indices/Fire Behavior/Smoke Observations
(U.S.D.I., NPS, AK Region, Alaska Western Area Fire Management Archives 2008)
Fire monitoring is the systematic process of collecting and recording data on fire location, behavior, fire effects and smoke dispersal and concentration. An additional objective is to correlate observed fire behavior with predicted/modeled fire behavior. In most cases, safety issues for on-site fire monitors have precluded on-the-ground observation opportunities. However, remotely automated tools such as the use of HOBO data loggers and the use of fire management's portable RAWS have been successfully used on fire use incidents in Denali National Park and Preserve since 2005. Ground personnel were able to successfully monitor from the ground in 2005, so plans are in place to explore more options of safe on-the-ground monitoring. Otherwise observations have been taken from aerial observation while mapping/scouting fire incidents. The current fire behavior models for Alaska fuels have not been empirically tested in Alaska. There was enough anecdotal evidence of their effectiveness that they were adopted in the late 1980s and early 1990s, but since that time no formal case studies or field trials have been documented. There is a continuing need for field verification of the predicted spread rates, fireline intensities and mortality as currently modeled by the CFFDRS or other models.

Photo Documentation
(U.S. DI, NPS, AK Region, Alaska Western Area Fire Management Archives 2008)
Photo documentation measures trends in fire behavior through the duration of the fire, as well as captures a historical ocular record. Digital photos - 1999-2007, Hardcopy photos - Limited/Park Archives.

Weather Data (Western Region Climate Center)
Gathering historical weather data, verifying its accuracy and studying it to identify significant trends that produce similar fire behavior trends including those events that signal the end of the fire season is an important task to examine long term changes over time. Use of historical fire weather data assists managers in forecasting fire season character. Prior to the 1993 fire season, Denali fire weather data was collected in an inconsistent manner, hence there are significant "holes" in the data. (Certain stations failed to perform, moved to new locations or were discontinued). Following 1993, fire weather became more consistent and was collected at permanent remote automated weather stations.

Accurate weather inputs are necessary for good fire behavior prediction results. Long term assessments can be difficult due to the lack of detailed forecasts for extended time periods. Any long term fire behavior analysis needs to consider factors such as relative humidity, wind, and instability which are not available with these long term forecasts. Given that limitation, analysts fall back to the historical record, or climatology, to establish a range of possible conditions to examine. Beyond seven days, forecasts are generally limited to identifying temperature and precipitation trends for a variety of time periods over large areas. Typical fire seasons exhibit trends including start and build up periods, peak periods, lulls, and season ending sequences. Within each of these periods, the range and frequency of various fire weather inputs in the historical record, such as winds of concern, can be examined. The mid- and long-range forecasts followed by analysis establish likely fire weather inputs for a given remaining fire season. The analysis in turn helps forecast the weather effect on the range and type of fire behavior that can be expected. Only then, can expected fire growth be modeled with any level of confidence.

Long term records such as the weather record and calculated Canadian Forest Fire Danger Rating (CFFDRS) indices offer a good look at the typical season. It is highly likely a given year will be like others based on yearly patterns. However the determination of experiencing a normal fire season can only be answered by comparing current weather and index trends to historical averages. Also, estimating fire season end can be generally assessed by comparing average and extreme years, as well as analyzing those weather sequences that lead to slowing or stopping fire spread.

Historical fire weather has been used to monitor fire trends closely in Denali National Park and Preserve, especially in the implementation of Limited and Wildland Fire Use incidents. FireFamily Plus and the Rare Event Risk Assessment Program (RERAP) have been used extensively in conjunction with historical fire weather to look at long term fire potential probabilities. Assessments examine historical weather for significant and/or rare events, as well as determining odds of given events occurring. However a broader application presents itself in tracking changes in trends.

Paired Plots (Ahlstrand 1983, Wolf 1994)
The fire effects paired plot project began in 1981 under the direction of Gary Ahlstrand – NPS Alaska Regional Research Ecologist. The purpose of the project was to assess vegetation change and succession as a result of fire. Fire management teams established paired vegetation plots in burned and representative unburned habitat adjacent to the burned area. Burned sites of varying ages were identified and selected for study from historic fire reports, 1:60,000 color infrared aerial photography, and aerial reconnaissance. Some plots were established in front of active wildfires; in these cases, control plot pairs were not established. Plot data that was collected included photographic slides of plot, tree density by size class and species (15m x 30m quadrats, vegetation cover class for 30 Daubenmire frames (20 x 50 cm), tree cores/cookies, fuels and soils data (on some plots), and general plot location descriptions. Between 1983 and 1988, approximately 485 plots were installed across 9 different parks in Alaska. Most of the plot locations were not permanently marked, however at least 8

plots in Yukon – Charley Rivers, 5 plots in Wrangell – St. Elias, and 11 plots in Denali were permanent. A majority of the plot data are still in paper form. The information collected has not been summarized or presented in a report (Wolf 1994).

Hazard Fuels Plot Database (Allen 2004)
The purpose of this study was to document the pre and post condition of the vegetation and fuels around structures in the Denali frontcountry that were thinned in 2004. The goals of this study were to 1) evaluate the implementation of the hazard fuels prescription described above, 2) monitor the effects of the fuels treatments on vegetation and fuels, 3) model the effects of the fuels treatment on fire behavior and 4) determine maximum efficiency in hazard fuels reduction techniques used at Denali and applied elsewhere in interior Alaska. For maximum effectiveness of reduced fire intensity and firefighter safety, a balance needs to be developed between reducing canopy cover and firefighting techniques that provide for firefighter safety. Plots were measured from 2003 through 2006. Selected plots will be monitored while they contribute to study goals.

Videography Plots (Allen 2007)
Vegetation in the boreal forest is rejuvenated largely by stand-replacing fires. Models that predict vegetative response across habitat types over time based on pre-burn conditions and burn severity will allow managers to develop models of vegetation succession to develop a GIS layer for fuels. Forty-four plots were installed in the northwest part of Denali as part of a pilot study which began in 2004. The purposes of the study are to reclassify the "Burn" portions of the landcover classification, test the use of videography as a method for landcover classification, validate predictive fire models used by fire managers, validate successional patterns compared to burn severity, and identify fire effects on moose browse under varying burn severity levels and age of burn. The current landcover condition needs to be identified for the areas classified as "burn" and to avoid future inadequacies of a complete fuels map, based on landcover classifications, for fire managers a 0 to 15 year plant successional model needs to be developed. The information gathered from the plots will ground truth remote sensing fuel model GIS coverage based on succession models. Plant successional pathways are likely to be influenced and directed by burn severity and fire frequency.

Moose Browse Utilization - Post Burn (Weddle 2005)
Current fire severity indexes (NBR), on a landscape scale, needs to be tested as a tool for fire effects analysis on fauna. Understanding the natural variability related to fire is necessary in order to identify potential abnormal effects associated with long-term climate change or management activities. Moose browse utilization (browse architecture) was surveyed while conducting the videography plots in 2005 and 2006. These plots were installed to help determine moose utilization of burned areas based on burn severity. Anticipated insights include burn severity, which will contribute to determining the pattern of moose utilization of previously burned areas and when those areas will be utilized.

Central Alaska Network (CAKN) Vital Signs Level I Monitoring (Vegetation Structure and Composition) (MacCluskie 2005)
The Central Alaska Network of Vegetation Structure and Composition monitoring measures absolute and relative abundance of growth-form classes, abundance and composition of dominant species, distribution and abundance of discrete vegetation types, species richness, species composition, basal area of tree species, and the depth of active layer. The scope of this monitoring project provides an opportunity to intensely monitor vegetation succession when these sites are disturbed over time due to fire.

Fire – Research

Fire management actions at Denali will incorporate research efforts designed to increase understanding of local fire ecology, behavior and effects. The following monitoring activities contribute to maintaining and achieving the park's natural ecosystems and components, subsistence resources and opportunities and historic, archeological and ethnographic resources. The identified monitoring activities also contribute to the scientific research, education and interpretation about natural ecosystems and geological processes.

Utilizing Satellite Imagery to Estimate Burn Severity (Sorbel et al. 2004)
This project assessed the Normalized Burn Ratio's ability to determine burn severity in Alaskan black spruce and tundra ecosystems through the installation of Composite Burn Index field plots on large fires occurring in Denali and Noatak National Preserve from 1999 – 2001. The linear regression showed a positive correlation between ground and remote sensing measures of burn severity and a good fit with a r^2 value of 0.7024. These results demonstrate that the NBR is a suitable measure and predictor of burn severity in Alaska's national parks.

Vegetation and Soil Development at an Upland Taiga Site, Alaska (Mann et al. 1999)
The taiga is an immense biome where processes of ecosystem development over millennial time scales are poorly understood. This project described vegetation and soil development along a geological chronosequence of stream deposits spanning 12,000 years in central Alaska. The youngest two geomorphic surfaces are not forested, have only incipient soil horizons, and are disturbed frequently by ice jams and flooding. On the forested surfaces above the floodplain, the fire return interval was 40-60 years in the 150 years preceding fire suppression beginning in the A.D. 1920s. A continual rain of loess affects all geomorphic surfaces, accumulating to thicknesses of 15 to 20 cm on the oldest surface. In contrast to other boreal chronosequences, soil parameters changed little after aforestation, probably due to repeated disturbance by loess deposition, fire, and fire-induced tree throw and soil erosion. Those shrub, forb, and tree species that are known to be avid root sprouters after fires increase in importance along the chronosequence. The researchers suggest the vegetation becomes progressively "fire hardened" as species accumulate that are capable of reproducing vegetatively after fires. The brief fire return interval and the predominance of clonal species indicate that an important part of post-fire succession is the re-establishment of the pre-fire dominants from underground parts. The widely described scheme for post-fire succession in upland Alaskan taiga in which deciduous trees are replaced over time by white spruce does not occur here. Soil and vegetation along the chronosequence suggest that after several millennia a stable state is reached where frequently burning, aspen-white spruce-ericaceous shrub vegetation grows on well-drained, poorly developed soils. The researchers suggest this ecosystem perpetuates itself through positive feedbacks involving clonal reproduction by the dominant plant species, the vegetation's effects on the fire regime, and the effects of the fire regime on arresting soil development and preventing the invasion of white spruce forest and peatland vegetation.

Limitations (Gaps) in Fire Knowledge

Fire mangers in Alaska face significant challenges unique to this vast region. Fire and fuels management goals in Alaska are hindered by a limited understanding of fire history and the controls of fire regimes. However, unlike other regions, fire managers make decisions in the absence of long-term fire history records and limited empirical knowledge on the relationships between fire, climate and vegetation. Current and future climatic change also challenge land managers as they consider the impacts of increasing temperatures on boreal forest fire regimes and the cascading effects this could

have on other ecosystem processes. These unknowns impose a major challenge to fire management efforts to anticipate the impacts of future vegetation and climate change on boreal forest fire regimes.

Gaps in Landcover Classification
The landcover classification process currently is unable to detect differences of vegetation type within fire from 0 to 17 years of age. Currently Fire Management applies the landcover classification coverage to developing a fuels map for managing large scale fires.

Fire History Parameters prior to 1950
A compilation of return intervals, by vegetation type and geographical area, fire size, frequency and duration for Denali would enable fire managers and resource managers to make more informed decisions about fire management. Across Alaska the diversity of vegetation/fuel types, topography and micro site climate all influence the fire return intervals. Relatively few studies have been conducted to determine the fire return intervals in Alaska.

Fire Return Intervals/Fuels
The large fire history database includes many occurrences where old fires stop the progression of new fires across the landscape. What are the characteristics (age, fuel load, vegetation type, moisture, etc.) that allow these older fires to act as fuel breaks for new fires?

Smoke Inventory
The natural range of hazy conditions near Mt. McKinley is unknown.

Social Effects of Fire Exclusion
Projects are underway to model fire risk associated with different types of fuel treatments. Primary emphasis has been on predicting the effects of fuel treatments on forest condition (vegetative response) and fire risk mitigation (fuel loading and fire weather indices). Fuel treatments will also influence values associated with recreation, subsistence lifestyles, and other human dimensions in forested landscapes. Spatial simulation of future landscapes under different treatment scenarios may prove useful in land use planning and measuring human response to proposed changes.

Proofing CFFDRS Indices vs. Actual Fire Behavior Parameters
Fire management decisions in Alaska are based on the ability to predict fire risk and burning conditions. Most fire management agencies in Alaska have adopted the Canadian Forest Fire Danger Rating System (CFFDRS) as a method for predicting fire danger, behavior, and severity. The original fuel moisture drying algorithms were developed in eastern red pine and jack pine stands, which do not occur in Alaska and there is some question whether the CFFDRS indices adequately and accurately address drying trends in continuous and non-continuous permafrost laden organic soils. Results from Ottmar's work closely links duff moisture with forest floor consumption. Some investigations have been done, but research is needed to:

- Evaluate CFFDRS indices and drying trends in different geographic regions across Alaska.
- Evaluate the use of weather station and soil moisture probes data to adequately represent duff moisture.
- Determine whether overwinter drying values or default startup values should be utilized,
- Evaluate whether existing CFFDRS equations and assumptions should be altered to better reflect drying conditions during the fire season.
- Evaluate the relationship between CFFDRS indices and probability of ignitions, rate of spread, duration and depth of organic fuel consumption.

- Evaluate whether drought indices in use with other fire danger rating systems would be useful to utilize in Alaska.

The Effects of Fire Exclusion
Only a small percentage of the total fires in Alaska contribute to the large acres burned each year. Development of an approach that would assign a probability of burning to unburned areas in Alaska would enable managers to develop risk assessment models for communities, establish long-term monitoring and research sites to gather integrated baseline data related to wildland fires, and assess the effectiveness of small acreage fuel treatments and prescribed burns

Secondary Fire Effects – Subsistence
Alaskan residents depend heavily on fish and wildlife resources found near their communities. When fires alter the landscape there is often concern over the fire effects on these resources. Requests for increased suppression in these areas are common. Integrated research that documents short and long-term effects of fire and suppression on subsistence resources and their habitats would improve the ability of land managers to respond to these concerns. Frequent concerns raised at public meetings include habitat utilization relative to vegetation succession for moose or caribou, salmon and fire interactions, fur bearer response, berry productivity, and the cumulative effects of all recent (< 25years) fires combined.

Secondary Fire Effects - Hydrology/Wetlands
How fire alters hydrological characteristics in the boreal forest is poorly documented. The relationships between fire severity, size, season and hydrology characteristics such as permafrost changes, lake drying patterns, water budgets, sediments, temperature, debris, subsidence, nutrients and aquatic organisms in stream drainages and wetlands would provide valuable insights for managers. These data could also be integrated to fish, wildlife and climate change studies to respond to subsistence and resource concerns.

Secondary Fire Effects - Landscape Ecology/Wildlife
Wildland fire management decisions can have a major influence on the distribution and productivity of wildlife habitat. Current fire management allows prescriptive constraints to be imposed upon wildland fire that to some extent will control fire size, location, frequency, rate of spread, and burn severity patterns. However, the large-scale spatial correlation between this activity and the distribution of wildlife and wildlife habitat across the landscape needs to be evaluated and used to inform managers and the public.

Public Perceptions of Fire Management (Social Science)
Previous research has shown that public attitudes and responses toward fire management activities (fire use, suppression, fuels management) are closely linked to public perceptions of agency purposes, the relationship of those purposes to public interests, and trust in the agency to fulfill those purposes. Little scientific information about the general public relationship(s) with the land management agencies in the context of fire management is available.

Primary and Secondary Order Fire Effects and Climate Change
Climate strongly influences the occurrence and extent of fires in Alaska. Climate models project that rapid Arctic warming will continue. For Alaska, the Hadley and Canadian models project 1.5-5°F (1-3°C) more warming by 2030, and 5-12°F (3-6.5°C) (Hadley) or 7-18°F (4-10°C) (Canadian) by 2100. It remains unclear what effects climate change will have on fuels, burn severity, intensity, natural

ignition sources (lightning frequency and temporally) and how these parameters will impact plant and wildlife ecology. Information on the potential changes in fire behavior and fuels under changing climate scenarios is needed for fire management to respond to the predicted changes in fire activity. This project is currently funded from the Joint Fire Science Program.

Vegetation: Impacts of Repeat Fires on Vegetation
Impacts to both vegetation and wildlife by successive fires over the same landscape have received little if any attention. Research is needed about changes to upland and other habitats from frequent fires over prolonged periods (i.e., 40 years), and corresponding effects to wildlife and how those habitats are used.

CULTURAL RESOURCES

Denali National Park and Preserve contains significant cultural resources in each of the sub-disciplines of archeology, history, historical archeology, ethnography, cultural landscapes, and museum collections. The surrounding area is known to have been inhabited for over 11,000 years and contains some of interior Alaska's best-known prehistoric research sites. The park itself has experienced a rich cultural history, characterized by the interaction of traditional Native groups, explorers, miners, mountaineers, and scientists with the park's unique natural environment. The park resource base also has potential for growth. As research continues additional resources will be located.

Cultural Resources – Inventories

The NPS Cultural Resource Program requires five inventories (databases) to be maintained at each park unit. They are the List of Classified Structures (LCS), Archeological Sites Management Information System (ASMIS), Cultural Landscapes Inventory (CLI), National Catalog of Museum Objects, and the National Register of Historic Places (NRHP).

List of Classified Structures (LCS)
Denali's LCS inventory (completed in 1995) consists of 131 historic structures in the park. The list includes cabins, structures associated with park headquarters, bridges, roads, and tailings piles, all fitting the definition of "structure" as defined by the LCS program. While the LCS is considered "complete", additional structures may be identified in the course of the current archeological survey.

Archeological Sites Management Information System (ASMIS)
As of September 2009, the ASMIS database contains 262 known sites including both historic and pre-historic. This database will grow as the archeological survey process, currently underway, will identify more sites in the coming years.

Cultural Landscapes Inventory (CLI)
As of September 2009, there are three completed CLI in the park: the Headquarters Historic District, the Wonder Lake Ranger Station, and the Neversweat (Comstock) Mine. Several other cultural landscapes have been identified but have not been inventoried: the Kantishna Mining District (in progress), Teklanika Archeological District, and the Road Corridor.

Inventory of Museum Objects
The Collections Management Report (CMR) for 2009 summarizes total collections for Denali at 370,309 items. The CMR classifications include 6,174 archeological artifacts, 1 ethnographic item, 662 historic objects, 348,642 archives, 4 art objects, 14,163 biological specimens, 620 paleontological specimens, and 43 geological items. The classification of all items is currently under review and it is expected that these numbers will change. Park collections are dynamic and will also increase over time as new objects and specimens are added to the collection as a result of research activities and donations.

National Register of Historic Places (NRHP)
Denali currently has three listings on the NRHP. These include a historic district (Park Headquarters Historic District); a thematic nomination (the Patrol Cabins of Mount McKinley); and an archeological district (Teklanika Archeological District). Several other properties have Determinations of Eligibility (DOE) for listing by the State Historic Preservation Officer (SHPO): Wonder Lake Ranger Station, C-Camp Recreation Hall, Savage Tourist Camp Site, Stampede Mine, Quigley House, Kantishna Roadhouse, Banjo Mill, Busia Cabin, Glacier City, and Denali Park Road).

Cultural Resources – Monitoring

The Cultural Resource Monitoring Program at Denali is driven by requirements of the park inventories. The LCS, ASMIS, and the National Catalog have condition assessments required in one form or another.

The LCS program requires that each structure be monitored and have a condition assessment that is no more than six years old. This generates a schedule of which structures need to be monitored and assessed each year. The park keeps to the yearly schedule, usually exceeding the number of structures monitored and assessed.

The ASMIS database also has a requirement for monitoring and condition assessments. Unlike the LCS, ASMIS does not dictate the schedule for monitoring and assessing condition. Instead, ASMIS allows for a local archeologist or cultural resource specialist to establish the monitoring schedule.

Museum collections environment is constantly monitored and visually inspected. Temperature and relative humidity are downloaded from data loggers on a regular schedule to insure consistency within the collection storage room. Visual inspection of museum objects for pest infestations and other threats is as important as monitoring the environment.

Cultural landscape monitoring is not as straight forward as other cultural resource monitoring programs. Cultural landscapes are made up of buildings and structures, archeological sites, natural systems and features, and circulation patterns. The buildings and structures are monitored through the LCS and the archeological sites through ASMIS. The circulation patterns and the natural systems and features are a much more conceptual aspect of the landscape but any changes to these are monitored and noted.

Cultural Resources – Research

There are a number of required baseline research reports for cultural resource programs. These include:

Archeological Overview, Inventory, and Assessment
(Griffin 1990, Wygal 2007, 2008, Wygal and Krasinski 2009)
An *Overview and Assessment of Archeological Resources Denali National Park and Preserve* (Griffin 1990) identifies 187 cultural sites in Denali and provides significant background information for interpreting those sites. A thorough review of all previous archeological research conducted within the park is also included in this report. A 4-year inventory and evaluation of known and newly discovered archeological sites across the park landscape occurred 2006-2009 (Wygal 2007, 2008, Wygal and Krasinski 2009). During the four years, 23 new sites were discovered and evaluated. In 2009, Teklanika West (HEA-001) (West 1965, 1996) was re-evaluated through additional excavation by UAF researcher Ben Potter (pers com).

Archeological Identification and Evaluation Studies
(Gudgel-Holmes 1989, Lynch 1996, Haynes et al. 2001)

Archeological Investigation of Five Remote Tracts of Land (Lynch 1996) is a study conducted as part of a land exchange plan. The tracts included small surveys in the Dunkle Mine area, Healy/Stampede Corridor, and the Swift Fork River to the west. Twenty-two cultural resource sites were identified as a result of the study.

Predictive Model of Aboriginal Site Types and Locations for a Catchment Basin Along the Denali Park Road Within Denali National Park and Preserve (Gudgel-Holmes and Holmes 1989) identifies types of site and predicts the location of those site along the park road corridor from park entrance to Savage River bridge.

Ethnographic Overview and Assessment (Haynes et al. 2001)
Denali National Park and Preserve: Ethnographic Overview and Assessment (Haynes et al. 2001) identifies and documents the traditional lifeways and historic and contemporary activities of Alaska Native peoples associated with the park. Also included are village histories of four Resident Zone communities of Nikolai/Telida, Cantwell, Tanana, and Lake Minchumina.

Cultural Affiliation Studies
(Bishop 1978, Gudgel-Holmes 1979, 1988, 1991, Morton 1983, Schneider et al. 1984, Johnson et al. 1999, Kari 1999)

These studies have resulted in the following publications:

- *Subsistence Resource Use in the Proposed North Addition to Mt. McKinley National Park* (Bishop 1978) documents and describes subsistence use patterns as of the mid-1970s in the proposed north additions to the park divided into three areas: Lake Minchumina, Nikolai/Telida, and the area east of the McKinley River.

- *Ethnohistory of Four Interior Alaskan Waterbodies* (Gudgel-Holmes 1979) explores the historic occupancy and use of the Upper Kuskokwim, Nenana-Wood, Kantishna, and Nowitna Rivers.

- *Native Place Names of the Kantishna Drainage* (Gudgel-Holmes 1991). The report documents Athabaskan place names for geographic features and sites in the Kantishna region.

- *Interviews with Native Elders* (Gudgel-Holmes 1988). This is a companion document to the Native Place Names Study.

- *Native Place Names Mapping in Denali National Park and Preserve* (Draft) (Kari 1999). Collection and compilation of Athabaskan geographic place names for approximately 1650 features.

- *Traditional Use Cabins and Other Shelters in the North Additions to Denali National Park and Preserve* (Johnson et al. 1999). The study provides historical and ethnohistorical information about the use of cabins and other shelters associated with trapping in the north additions.

- *Geese House Report* (Morton 1983). Geese House is a natural rock formation which holds special significance in the oral tradition of the Native people of the Kantishna area.

- Land Use in the North Additions of Denali National Park and Preserve: An Historical Perspective (Schneider et al. 1984). This report describes subsistence use and activities as well as cultural resources in the North Additions of 1980.

Historic Resource Study (Brown 1991)
A History of Denali – Mount McKinley Region, Alaska: Historic Resources Study of Denali National Park and Preserve, Volume 1: Historical Narrative (Brown 1991). The study provides a comprehensive historical overview of the park.

Cultural Resources Base Map
A cultural resource base map exists to some degree.

Park Administrative History (Norris 2006, 2008)
Crown Jewel of the North: An Administrative History of Denali National Park and Preserve includes two volumes. Volume 1 (Norris 2006) is concerned with park management issues and administration from the park's establishment to 1980 and the passage of ANILCA. Volume 2 (Norris 2008) addresses general park history since 1980 as well as specialized themes.

Scope of Collections Statement
This basic curatorial planning document guiding the park's acquisition and preservation of museum objects is in process at this time.

Specific Resource Studies
(Pearson 1953, Brown et al. 1982, Stroud 1985, Bundtzen 1988, Buzzell 1989, Kain 2001)

- *A History of Mount McKinley National Park, Alaska* (Pearson 1953). A brief history of the park written by the park superintendent, Grant Pearson.

- *From Myth to Reality: Travel Experiences and Landscape Perspectives in the Shadow of Mount McKinley, Alaska* (Evans 1987). History of events leading to the construction of the park road and describes travel conditions on the park road.

- *A History of Mining in the Kantishna Hills* (Bundtzen 1988).

- *Cultural Resources Investigation in the Dunkle Mine and Kantishna Hills Study Area* (Brown et al.

1982). Reviews the area history and archeology, identifies and evaluates historic and archeological resources found in these areas.

- *History of the Concession at Denali National Park* (Stroud 1985).
- *Cultural Resource Management, Denali National Park and Preserve, Alaska* (Kain 2001). This document is a thematic history of the park addressing management of cultural sites and resources.
- *Cultural Resource Investigation in the Dunkle Mine and Kantishna Hills Study Area* (Brown et al. 1982). This study identifies and describes cultural resources at the Dunkle Mine and the Kantishna Mining District.
- *Overview of Mining in the Kantishna District, 1903-1968* (Buzzell 1989). This manuscript is a history of mining in the Kantishna District, describing the mining activities in each of the drainages in the Kantishna Hills.

Limitations (Gaps) in Cultural Knowledge

In order to meet the desired future condition of protecting cultural resources (historic and archeological sites, historic objects and ethnographic resources) it is important to identify all of these resources in the park.

Complete Inventory of Archeological Sites

While park staff knows about the vast majority of historic structures and objects, the park does not have a complete inventory of archeological sites. The sites currently in ASMIS have been primarily identified through compliance-driven survey. To date, there has been no systematic archeological survey of Denali. Some of the oldest archeological sites in Alaska are located just outside the park boundary, so it is very likely that similar sites will be found in the park itself. The archeology survey being completed in 2009 (Wygal 2007, 2008,) will not identify all sites in the park as the survey will be taking places in areas where there is a high potential for sites. In a park of six million acres, archeological surveys must be done in manageable blocks in order to secure funding for the survey and managing workload. Also, new developments like global warming, have prompted new types of archeological survey, such as, snow patch archeology.

Complete Inventory of Cultural Landscapes

Of the five identified cultural landscapes in Denali, only one has been inventoried. The other four cultural landscapes: the Kantishna Mining District, the Wonder Lake Ranger Station, Teklanika Archeological District, and the Road Corridor; need to be inventoried and entered into the CLI. There are certainly more cultural landscapes in the park than have been identified to date, so more work will need to be done in that regard. One landscape that needs to be identified is a prehistoric cultural landscape that will include the unique landforms, natural and cultural resources that were part of the prehistoric human environment in DENA and the archeological sites that resulted from patterns of prehistoric land use.

Accurate Inventory of Museum Objects

Although the National Catalog of Museum Objects database contains 336,500 records, many of those records are not complete (some fields not filled out) and or accurate (i.e., description field does not

contain adequate information) to be a useful tool for research. There is also a considerable backlog of cataloging. The database needs to be "cleaned up" and the backlog cataloging needs to be eliminated.

Evaluation of Sites and Structures for NRHP
Another desired future condition to be met is the protection of sites and structures listed on or eligible for the NRHP. All sites and structures need to be evaluated for significance and listed on the NRHP as necessary. In addition, the draft nominations need to be finalized and sent to the SHPO and the DOEs need to be written as nominations and submitted to the SHPO. This is actually a second step of the Historic Resource Study.

Once the archeological survey is complete the new sites will need to be evaluated for NRHP significance and placed on the NRHP if eligible. The Archeological Overview and Assessment will also need to be updated upon completion of the survey work.

Stratefied Archeological Study
Another useful research and survey project that should be conducted is a stratified archeological study. Strata would be delineated according to variables identified in existing biological, geological, geoarcheological, ethnohistorical, historical and archeological research. The research would include numerous site location models, including those of the North Alaska Range Project and the predictive model of the aboriginal site types along the road corridor.

Documentation of Ethnographic Resources
Ethonographic resources are essentially absent from the park museum collection and little is known about these park resources. Athabaskan elders have identified numerous Native place names within the park reflecting a history of traditional use but few of the identified sites have been examined by archeologists to document the physical remains associated with that use. This information has potential to document, confirm or challenge late historic through contemporary traditional use practices, and also to develop land use models for comparative study with prehistoric site types and locations.

Revision of Cultural Resource Base Map
The Cultural Resource base map needs updating and a comprehensive digital layer should be developed.

Scientific Legacy of Denali
Since its inception, Denali National Park and Preserve has functioned as a scientific laboratory as well as a recreational preserve. This function began with the wildlife observations of Sheldon and Murie and continues today. This project would provide a comprehensive history of science in Denali. The study will identify and describe the park's significant research projects (purpose, methods and results).

Mining History of the Kantishna Mining District
Mining has played a major role in the history of Denali National Park and Preserve. Extensive research exists and needs to be assembled into a comprehensive study. This study will allow park staff to recognize both the impacts and influence of mining on the park resources and develop management strategies for those resources. The park will also gain a better understanding of the significance of mining on the local, state, and national levels.

Mountaineering History of Mt. McKinley
This study would document man's fascination with conquering North America's highest peak. Tracing the earliest attempts by Dr. Cook to conquer the mountain and the successful accents by the Sourdough and Karstens-Stuck Expeditions will provide the context future and ever increasing expeditions. Although the challenge of climbing the mountain was and remains the primary focus of mountaineers, many more themes need to be researched. Scientific studies, such as weather patterns, topographical mapping, cosmic rays and equipment research are important topics to be addressed. Access to the region is another important subject in the history of mountaineering, especially the role of aviation as it relates to both access and rescue.

SUBSISTENCE

One of the purposes of ANILCA is to provide the opportunity for local, rural residents engaged in a subsistence way of life to continue to do so. Accordingly, Congress provided for traditional subsistence uses by qualified local rural residents within the ANILCA additions to Denali National Park and Preserve. Many native and non-native local rural residents engage in and depend on, resources from the park and preserve for personal consumption, cultural identity, and to maintain a subsistence way of life.

Subsistence activities are dynamic and diverse with hunting usually occurring in the fall and winter months, fishing concentrated during the summer and fall, and trapping efforts occurring in mid to late winter months when snow cover is adequate for travel and fur is prime. For obvious reasons, berry picking and the use of plant greens occur in the summer and fall months. Timber harvest typically occurs in the winter when frozen rivers, lakes and snow cover make access and transportation more efficient.

Subsistence harvests may vary considerably from year to year because of such factors as weather, migration patterns, natural cyclic population fluctuations, or from political and regulatory factors. lthough subsistence resource use was probably much greater historically than it is now in Denali, the seasonal rounds, use patterns, and relative importance of certain species are similar today. Flexibility and adaptability continue to be important components in the success of a successful subsistence lifestyle because of changing environmental and political conditions and the annual or seasonal variations in availability of many resources.

To achieve this complex synthesis of protection and use, beginning in 1980 Denali National Park began the process to discuss and develop a subsistence management program and has developed a subsistence management plan (NPS 2001). This program is informed by various inventory, monitoring, and research projects.

Wildlife

The NPS is charged with conserving natural and healthy populations of fish and wildlife on parklands and healthy populations in the preserves. In general, the natural resources of Denali National Park and Preserve are in excellent condition. The habitat within and surrounding the park and preserve is basically intact, the structure and composition of the ecosystem is unaltered, and ecosystem processes are functioning naturally.

Currently, the only wildlife population considered to be in need of extra protection is the Denali Caribou Herd, which has been closed to both federal subsistence and state hunting in Game Management Unit 20C since 1977 (National Park Service 2002). Overall, wildlife populations are still regulated by nature within the park and preserve and subsistence harvest within the new additions is considered to be of minimal influence at this time.

Community profile studies conducted for Denali's subsistence communities (Bishop 1978, Stickney 1980, Holen et al. 2006) indicate a dependence primarily upon moose, caribou, rock and willow ptarmigan, spruce grouse, hare, ducks and geese, salmon, and a few species of freshwater fish. Large mammals that are less frequently used include black bear, brown bear and Dall's sheep. Fresh water fish include burbot, dolly varden, grayling, lake trout, northern pike, rainbow trout and whitefish (Burr 2002, Williams et al. 2005). Important fur animals include marten, mink, red fox, wolf, lynx, weasel, wolverine, land otter, beaver, and muskrat (Bishop 1978, Johnson et al. 1999).

Fisheries

A cooperative fall chum salmon mark-recapture project was initiated in 1995 on the Tanana River and has operated through 2006. The information gathered includes estimates of in-season and post-season abundance of fall chum in the Tanana (above the mouth of the Kantishna River) and Kantishna Rivers, migration rates of fall chum in the Kantishna River drainage, and run timing in the Kantishna drainage. Data are available as tags deployed and recovered, and peak catch per hour (on what date) for both coho and chum. Graphs of the estimates indicate trends over the decade plus of the project. Over time these surveys have provided monitoring of the fish resource (not just inventory). Prior to the initiation of this project, little was known about numbers of distribution of fall chum salmon in the upper portion of the Kantishna watershed. During the 7 years of tagging the upper Kantishna drainage is though to have experienced both the largest (108,000 in 2005) and the weakest (21,000 in 2000) fall chum salmon runs in the past thirty or more years.

In 2000 a project was initiated to provide estimates of salmon on upper Kantishna River summer chum, chinook, fall chum and coho salmon abundance, through aerial reconnaissance and ground surveys of the upper Kantishna and its tributaries. In cooperation with the ADF&G the goal of project was to coordinate aerial stream surveys and field mapping efforts of anadromous fish spawning grounds and fish species stream utilization.

In 2003, the Central Alaska Network initiated a fish inventory in the north and western portion of Denali. The goal of the project was to document at least 90% of the freshwater fish species known or expected to occur in lakes and streams in each Network's parks. For Denali, the expected list of fish was 12 species. Fish inventory results achieved 91 percent of the expected (not 100 because the inconnu was "expected" but not encountered). Three fish species were added to the list in 2003 (they were not on the original list of 12 "expected") and these species were not part of the 91 percent. The total number of fish species documented to date in Denali to 14.

In 2005 the Community Harvest Monitoring Assessment project was completed for the park's resident zone communities of Cantwell, Lake Minchumina, Telida, and Nikolai. This study provided both current and past baseline information on the community's fish and wildlife needs and annual harvests (Williams et al. 2005). The results include a description of current and traditional fisheries use for each of the resident zone communities including fish locations and spawning habitat, preferred fish species, fish abundance, contemporary fishing technology, and conservation measures related to subsistence fishing.

Subsistence Firewood and Log Use

Cantwell is Denali's largest subsistence use community and has the potential to focus use on a relatively small geographic area. Cantwell's population has increased in from 89 in the 1980 census to 147 in the 1990 census to 222 in 2000. The community of Cantwell is located just 3 miles from Denali National Park and has relatively easy access to park resources (U. S. Census Bureau 2000).

The demand for and use of subsistence timber resources by qualified subsistence users in Denali National Park and Preserve does is likely to increase in the future. Several requests have been received from subsistence users for cabin logs to re-roof existing trapline cabins and to reconstruct cabins. In addition, some of Denali's resident zone communities have increased in population which could lead to more requests for timber resources.

Manage Subsistence Eligibility – Resident Zone Communities

Through National Park Service rule making in 1981, four communities near Denali Park were designated as Subsistence Resident Zone communities for the Park. Cantwell, Lake Minchumina, Telida, and Nikolai were identified as communities with significant concentration of subsistence users who have customarily and traditionally utilized park resources.

Community use profiles were documented over a 5-year period for Cantwell (1999), Lake Minchumina (2001-3), Telida (2001), and Nikolai (2002-2003) (Williams et al. 2005). Denali National Park completed an assessment study for the Park area, which included village history reports for Tanana, Telida, Nikolai, Cantwell and Lake Minchumina. Village history reports were prepared by representatives from the communities. A native place names mapping project was completed. Information collected will help document the extent of use territories for the five Native groups (Upper Kukokwim, Lower Tanana, Ahtna, Koyukon, and Dena'ina) associated with Denali (Kari 1999).

Traditional and Customary for Access to Subsistence Use of Denali

The different means and methods of subsistence access and the seasonal timing of use are critical for acquiring resources and are as diverse as the resources being sought. Common methods of traditional access include hiking, skiing, snowshoeing, dog sled teams, horses, snowmachines, motor boats, canoes, motor vehicles, and off road vehicles under certain conditions. Subsistence users from McKinley Village, and more recently individuals from Cantwell, use motor vehicles for driving the Park Road to access the Kantishna Hills. Currently, there is no known use of aircraft by local rural subsistence users to access preserve lands for the taking of subsistence fish or wildlife.

A research study was completed in 2005 that documented and evaluated the traditional modes of access for subsistence purposes in Denali National Park and Preserve (NPS 2005). This report is a compilation of existing and new information gather in 2004-2005 pertaining to the use of ORVs as a means of access for subsistence purposes on Denali National Park lands in the Cantwell area. This report was instigated on behalf of eight Cantwell subsistence users and the Denali Subsistence Resource Commission requesting that the Superintendent review the 1986 Denali National Park & Preserve General Management Plan's determination that ORV use was not a traditional means of access for subsistence purposes and a re-consider that determination in light of new information provided by Cantwell residents regarding their traditional use of ORVs for access to subsistence resources.

Subsistence Trapline Management Plan

In an effort to understand the land uses of the north additions of Denali National Park and Preserve, park managers have undertaken several subsistence related studies. In 1978, a "Subsistence Resource use in the Proposed North Additions to Mt. McKinley National Park" study was conducted to documented current and recent subsistence use in the proposed north additions to the park (Bishop 1978).

In 1984, a "Land use in the North Additions of Denali National Park and Preserve and Preserve: An Historical Perspective" study was conducted to complement the earlier work of Richard Bishop and provide park managers with additional information for understanding the land uses of the north additions. This report identifies and describes significant places and trapping areas within and areas near the park and preserve (USNPS 1984).

Between 1986 and 1993 the park sponsored an extensive wolf research project including the areas north of the Alaska Range. This has been the only significant furbearer study that the park has conducted.

In 1999, a subsistence cabin study was completed documenting the historical and contemporary use of cabins and structures associated with subsistence use activities in the north additions to Denali National Park and Preserve (Johnson et al. 1999).

Some initial marten harvest data has been cooperatively collected from Denali subsistence users. Data from the ADF&G furbearer harvest and sealing records have been acquired and incorporated into the park's database. Information from the state's community profile database for selected communities associated with the Denali area has been acquired.

The issues regarding subsistence trapping (e.g., trapline cabin use, seasons and bag limits for certain furbearers, clarification of NPS trapping regulations, harvest reports for wolves, proposals to the ADF&G to create trapping buffer zones around Denali, and petitions to the superintendent to close park lands to trapping) have been brought before the Denali Subsistence Commission for review and comment.

Customary and Traditional Use

Customary and traditional (C&T) use determinations made by the Federal Subsistence Board identify which wildlife species or fish stocks have been customarily and traditionally taken as a subsistence resource and which communities or areas are eligible to harvest them. To hunt or fish in a particular area or for a particular species an individual must have a positive C&T determination. These determinations are listed in the Federal Subsistence Management Regulations booklet by game management unit and fishery management area.

Ethnographic Overview and Assessment

An ethnohistorical study of the Ingalik Athabaskans of the northern and western sides of Denali was conducted during the 1960s (Hosley 1961, 1966, 1968). Hosley examined the cultural changes brought on by acculturation, social organization, and the hunting, fishing, trapping and gathering activites of the Native residents of the area. Additional ethnohistoric research was conducted in the Upper Kuskokwim area for navigability determinations (Gudgel-Holmes 1979).

During the 1960s the U.S. Department of the Interior prepared two environmental impact statements for possible additions to National Parks lands (US DOI 1974a, 1974b). These documents provide demographics of nearby communities as well as brief descriptions of hunting and fishing activities of local residents. The National Park Service funded research providing historical as well as contemporary information on subsistence activities by these communities.

The Alaska Department of Fish and Game, Division of Subsistence conducted research projects during the 1980s, describing the current demographics, socioeconomic conditions, and hunting and fishing activities for the Upper Kukokwim communities (Stickney 1980, 1981; Stokes 1982, 1984; Andrews 1984).

Other documents are available that describe the social and economic conditions of the Upper Kuskokwim region (Patterson 1973, Selkreg 1975, Tanana Chiefs Conference 1983, Toghotthele Corportation 1983). Information on the historical exploration and settlement of the Upper Kuskokwim River is available in Oswalt (1980).

A recent study is available describing the wild resource harvest and uses by the residents of Lake Minchumina and Nikolai (Holen et al. 2006). The primary goal of this study was to update and expand information about subsistence uses, needs, and areas traditionally used for subsistence harvests by the subsistence resident zones communities of Denali National Park and Preserve, Lake Minchumina and Nikolai.

Ethnographic information on the Ahtna Athabaskan people who settled in Cantwell and their traditional patterns of use is available from studies of Copper River Basin people (Reckord 1983, de Laguna 1982, Kari 1983). Planning documents also provide some social and economic information (Selkregg 1977)

In the 1990s the National Park Service initiated several ethnographic and subsistence related studies. A local ethnography was prepared for Athabaskans and their use of land in the Kantishna River Drainage (Gudgel-Holmes 1991). The Kantishna oral history project initiated documentation of the Athabaskan oral traditions, native place names, associated stories and use areas. A report was prepared on the Traditional Use of Cabins and Other Shelters Associated with Subsistence Uses in the North Additions to Denali to document the historical and contemporary use of cabins and other shelters associated with trapping by local residents in and around the Denali area.

The communities of Cantwell, Lake Minchumina, Nikolai and Telida are identified as subsistence resident zones communities containing a significant concentration of residents who have customarily and traditionally used Denali National Park lands for subsistence purposes. In 2001 a report was completed that identified and documented the traditional lifeways and historic and contemporary activities of Alaska Native peoples and resident zone communities associated with the park (Haynes et al 2001).

Limitations (Gaps) in Subsistence Knowledge

Wildlife harvest information

Reported harvest information for large animals, furbearers, waterfowl and fish can be found through the Alaska Department of Fish and Game harvest records, sealing documents, and registration permits. Most of this harvest information is lumped together for the entire Game Management Unit or

subunits irrespective of park or preserve boundaries, making review or use of the data very difficult. Harvest information is reported on a voluntary basis resulting in highly variable reliability of data. Much of the older harvest data has not been digitized or entered into computer databases. With such a range and variety of subsistence resource information, which is often gathered in the short term and not related to other works, it makes it difficult to formulate the information into a long term consistent database for subsistence management. Particularly noticeable, is a lack of information regarding subsistence use for the southern additions to Denali National Park and Preserve.

Definition of "Natural and Healthy"
Long term protection of fish and wildlife is necessary to ensure the continuation of the opportunity for a subsistence way of life. Consequently, subsistence uses on public lands must be conducted in a manner consistent with the conservation of natural and healthy populations in Parks as mandated by ANILCA. The term "conservation of healthy populations of fish and wildlife" is defined in Federal Subsistence regulations but the term "natural" is not included as part of the definition. Congress, in writing ANILCA, clearly intended for parks to be managed differently, with respect to fish and wildlife resources, from other Federal lands. A team of NPS natural resource managers from across the State have been asked to work on a definition of "natural and healthy."

Subsistence Fisheries Studies
In 2000, the Subsistence Resource Commission members recommended several topics for potential studies: 1) evaluate and assess the Highpower Creek fishery (on the west edge of the northern Preserve) as it was an important fishery use area in the past but is not a significant use area today, 2) conduct a chum assessment in Moose Creek, and 3) evaluate number of king salmon present in Clear Creek (tributary to the Kantishna River just above the mouth of the Toklat River), and below Bearpaw River.

Assessment of Timber Resources and Development of Timber Management Plan
A timber management plan would be useful to guide harvest and monitoring of timber resources. Denali National Park and Preserve does not have a subsistence firewood and log management program. No formal assessments have been made of timber resources, local management practices or timber use strategies. Inventorying and monitoring of forest resources should occur. Information on past and contemporary use, harvest areas and means of transportation is needed to facilitate a forest resources management program.

Monitoring Subsistence Use of and Impacts Related to ATV Use along Routes in the Cantwell Area
The present extent of impacts to vegetation and soils would be evaluated, ground monitoring plots established and accurate maps of existing trails and roads will continue to be developed.

Establish Furbearer Harvest Monitoring Program and Revise Harvest Reporting
Park staff and the Subsistence Resource Commission need to work with local trappers and the state to establish a furbearer harvest monitoring program. There is a need to develop harvest reports for furbearers that are more specific in identifying harvests that occur from the park or preserve lands. Information will be obtained from the ADF&G and USFWS database on furbearer populations, monitoring studies, and harvest data information. Data needs to be organized and where appropriate entered into the park's computerized database. Data should be evaluated to identify gaps in furbearer information and develop proposals for future population monitoring studies.

Review and Update Resident Zones
Resident zones may be added or deleted based upon whether a community contains a significant concentration of subsistence users who have customarily and traditionally utilized park resources. NPS recognizes the necessity for continued development and modification of the subsistence program based on review and input from the subsistence users, advisory councils and commissions, the general public, and legal and technical advisors. Future review of eligibility, including resident zones, will be done with the full participation of the above named parties.

Review Customary and Traditional Use
The Federal Subsistence Board makes customary and traditional use determinations for use of fish and wildlife species on a community or area basis. For the most part, these community and area customary and traditional determinations are adequate to meet local rural users' needs, but occasionally they exclude individuals who have traditionally utilized park resources but do not live in the community or area with a positive use determination.

Oral Histories of Traditional and New Technologies of Subsistence Activities
Research efforts need to continue documenting oral history of subsistence users to develop historical themes related to subsistence users and lifestyles. Continue to develop the subsistence photo collection, conduct subsistence oral history interviews and acquire subsistence produce subsistence and culturally related publications. Develop an interactive computer program to increase awareness of understanding about, and importance of subsistence use of local residents. Identify and document the emergence of contemporary traditional subsistence practices, the adoption and use of new technologies regarding subsistence activities, and the impact of the NPS and federal subsistence management regulations and policies on the subsistence way of life.

PARK VISITATION AND NEIGHBORING COMMUNITIES

Most social science studies at Denali have focused on park visitors. Information about park visitors can be divided into: visitor/user characteristics (numbers and demographics), visit characteristics, visitor/user experience, and visitor response to management. Some studies provide information in more than one category but are listed below in the primary category for which they were conducted. Information related to subsistence users is addressed in the Integrated Resources section. This summary contains only information developed specifically for Denali National Park and Preserve. There are many sociological studies addressing visitor experience and management of natural areas in Alaska and elsewhere that likely have relevance to Denali's visitors.

Visitor and Visit Characteristics

Monthly Public Use Report (NPS 2007a)
The monthly public use report database contains estimates of monthly park visitation and annual summaries for key visitor data from 1997 to the present, including total recreation visitors, overnight stays, backcountry users, mountain climbers, scenic air tour passengers, and tour and shuttle bus ridership among others. Winter and summer months are included. There are methodological problems with the formula used to calculate total recreational visitation and there are existing proposals to address these deficiencies. Annual visitation data from 1922 to 1996 is available, but prior to 1996 a different methodology was used to calculate visitation which overstated visitor numbers in

the latter years of the period. Some source databases and reports contain additional details such as the backcountry user database, the annual mountaineering summaries, and the air taxi/scenic air tour database and annual summaries.

Alaska Visitor Statistics Program
(Alaska Department of Community and Economic Development 2001)
The Alaska Department of Community and Economic Development (ADCED) has performed several surveys of Alaska visitors through the Alaska Visitor Statistics Program, and some of the results can be broken out for Denali visitors including demographics, mode of arrival to and departure from Alaska, purpose of trip, duration of trip, trip type (independent, package, inde-package), and previous visits. The last data available with specificity to Denali is 2001 (ADCED 2001).

Visitor Use Surveys (NPS 1997, 1999)
One week surveys were conducted in the summers of 1996 and 1999 to determine visitor and visit characteristics. Sampling methodology provided a substantial bias toward certain types of independent (as opposed to package tour) travelers, so the surveys are best understood as reflecting the visit characteristics of the particular types of visitors surveyed. Visit characteristics identified include trip purpose, group size, vehicle type, and length of stay (NPS 1997, 1999).

Visitor Segments and Forecast (Human Development Report 2006)
The *Needs Assessment and Feasibility Study for a Community Transportation System* (HDR 2006) described the various segments of Denali summer visitation and their typical general itineraries, and provided a forecast of park visitation through 2015.

Other Park Users and Visitors
Limited information is available about several user groups, including sport hunters in the preserves, winter visitors including those visitors accessing the park additions by snowmachine, and non-commercial airplane visitors who fly over or land.

Visitor Experience

Backcountry Visitors
(Bacon et al. 2001, Christensen et al. 2005, Lawson and Manning 2002, 2003, Swanson et al. 2002, Tyrrell 2005, Womble 1979)
Four surveys provide information about visitor experience in the backcountry of the park. In 2000, a survey of backcountry visitors entering the backcountry along the park road corridor during summer months provided information about demographics, trip characteristics, the influence of direct and indirect human presence and the influence of aircraft on the backcountry experience, reaction to management policies and regulations, trip satisfaction and motivation, and visitor choices when evaluating tradeoffs between resource protection, visitor experience, and management restrictions (Swanson et al. 2002, Lawson and Manning 2002, 2003). This survey was designed in part to replicate a similar but less exhaustive survey conducted for Mount McKinley National Park backcountry users in 1977 (Womble 1979), and provided some comparative results on norm stability over time (Bacon et al. 2001). A survey conducted in 2004 assessed factors influencing visitor experience for fly-in recreational visitors on the south side of the Alaska Range and the response to management strategies (Christensen et al. 2005). Finally, a survey of winter users of the park road assessed visitor response to aufeis maintenance activities (Tyrrell 2005).

Frontcountry Visitors (Machlis and Dolsen 1989)
A one-week survey conducted under the auspices of the Visitor Services Project (VSP) in August of 2006 provides a variety of information about the success of park facilities and services from representative groups of visitors. A previous VSP was conducted in Denali in 1988 (Machlis and Dolsen 1989). In progress is a 3-year integrated carrying capacity study for the Denali park road which includes a component identifying indicators and standards of quality and assessing the public acceptability of management strategies for the Denali park road. The larger study plan calls for a before-after-controlled impact (BACI) study to test the impacts of changes in road traffic.

Visitors and Management

A number of studies regarding backcountry use restrictions were conducted after the initial backcountry permit system was put in place in the 1970s (Bultena et al. 1981, Plager and Womble 1981, Plager 1982). Visitor response to management options was also tested in more recent backcountry studies (Swanson et al. 2002, Christensen et al. 2005). The Visitor Services Project study of 2006-2007 addresses the acceptability of park entrance fees, and the ongoing park road study will test the tolerance of visitors for road restrictions.

One unpublished paper evaluates the visitor willingness to pay for wildlife viewing experiences at Denali (McCollum et al. 1998). There is limited information on the impact of recreation fees at Denali.

Research Mandates

Backcountry Visitor Surveys
The 2006 *Denali National Park and Preserve Backcountry Management Plan, General Management Plan Amendment, and Environmental Impact Statement* pledged that surveys of all backcountry users would be conducted at least every five years. These surveys, to include displaced users, will provide data to monitor success of park management strategies in achieving standards set in the plan. The surveys must measure the following:

- number of encounters with evidence of modern human use
- percentage of visitors encountering litter or human waste
- number of encounters with other parties and large parties
- ability to camp out of sight and sound of others
- quality of interaction with NPS ranger patrols and researchers

Entrance Area Indicators and Standards
The 1997 *Entrance Area and Road Corridor Development Concept Plan* committed the National Park Service to develop a visitor experience/resource protection (VERP) program for the frontcountry. While the park road is presently being addressed through a social science component of a larger study, this commitment still needs to be met for the entrance area (east of Savage River).

Limitations (Gaps) in Knowledge about Visitors

There are several significant gaps in knowledge related to visitors and visitor experience:

Dispersed Entry Visitors
There is little knowledge regarding those visitors who enter the park other than on the park road. These "dispersed entry visitors" arrive by flying over the park in commercial or private aircraft, landing at remote landing strips or lakes, snowmachining across park boundaries in the winter, or motorboating up park rivers during the summer. The National Park Service lacks any understanding of the numbers or demographics of these visitors, the characteristics of their visits, or their experiences and expectations while at Denali.

Day-Use Backcountry Visitors
While overnight backcountry users are generally well-understood (with the exception of some of the dispersed entry visitors), the number, demographics, and experience of day users are not known at all. Although overnight backcountry visitation is declining at the park, it is suspected that day use may actually be increasing consistent with recreational trends nationally.

Total Visitation
The model used to estimate annual park visitation (Monthly Public Use Report) is flawed. While it provides information on the gross magnitude of visitation, its design precludes recognition of significant changes in visitation patterns and it contains inconsistencies that produce illogical results.

Local Communities
Support and use of the park by residents of local communities is important for park management, but there is no research into the perceptions of local urban, rural, or bush communities regarding the national park.

Economic Impact
A perpetual concern for management, local communities, the state of Alaska, and the state Congressional delegation is the impact of the national park on the regional economy, particularly the impact of visitor expenditures but also the impact of federal expenditures.

Visitor Experience – Entrance Area and South Side
Although research into visitor experience has been conducted for visitors in the backcountry and on the park road, there is no understanding of visitor experiences and expectations in the park entrance area – where a diversity of visitor opportunities has been added in recent years – or in the evolving South Denali area which is being developed as a new park destination.

RESOURCE PROTECTION

The seriousness of threats to resources by illegal harvests, Off-Highway Vehicle and snowmobile incursions, and theft or disturbance to paleontological sites is compounded by factors such as the large scale of the park and its location on both sides of one of the world's largest mountain ranges. The ability of resource protection staff to be effective at protection in potential problem areas is frequently compromised by the ability to get there—traveling these long distances takes considerable time and coordination of logistics, and the extreme and highly variable weather conditions may delay or

complicate travel. Denali's location adjacent to the major transportation corridor in the State and within a few hours drive of two of its largest cities means that the use of the park or lands immediately adjacent to it, particularly along the eastern boundary, will continue to grow. Therefore, these threats to park resources will continue to exist and very likely increase. Our understanding the hunting and OHV issues continues to be limited by the lack of adequate ranger staff and support for aerial patrols along with a need for better training and data management.

Illegal Harvest of Wildlife

Evaluation of Case Incident Records and other historic information indicates that Moose, Caribou, Dall's Sheep, and Grizzly Bear have been taken illegally during the fall hunting season in every major region of the park and preserve. Locations with repeated problems are frequently linked with an access portal or corridor such as an airstrip, an OHV (Off Highway Vehicle) trail near the boundary, a river, or a portion of the park near a roadway. The primary areas for OHV-related problems have typically been locations that are either near the park road or Highway 3 (Parks Highway) such as Broad Pass, the Stampede Road corridor, or near Kantishna. However, recent ranger patrols have found OHV and hunting use in more remote and previously unused areas such as the lower Toklat River and Sushana River. Locations such as the preserve lands in the southwest corner of the park require access by airplane area, so incidents there are generally related to landing locations. Illegal activity is also suspected along major rivers such as the Tokositna, Yentna, and Muddy Rivers.

Historical information shows that aerial poaching of wolves and other furbearers such as wolverine has also occurred in the past, generally during late winter when daylight is increasing and snow conditions are the best for aerial tracking. Animals that frequent the high open country in the Old Park west of Wonder Lake are particularly vulnerable. Airplane assisted hunting of wolves was not allowed for a number of years on the lands adjacent to the park. The recent renewal of State of Alaska predator control programs near the park boundary increases the potential for illegal harvest within the park.

OHV and Snowmobile Incursions

Case Incident Reports and other records from aerial survey work over the park also indicate that the number of incidents of illegal OHV or snowmachine use has significantly increased in the past 15 years due to changes in the capability and availability of these vehicles. Most OHV incursions occur during the fall hunting season. Large areas along the eastern boundary of the park are accessible by OHVs due to the presence of a major highway corridor and reasonable terrain for OHV use. The northeastern boundary of the park, the Stampede Trail corridor, and Broad Pass have been and are likely to continue to be the major problem areas. There is also the potential for problems at new locations such as the park lands at the end of the Petersville Road as use levels, availability, and technology all continue to change.

Illegal snowmobile use is primarily a problem in the Denali Wilderness. Large numbers of snowmachine users ride in the Broad Pass area due to the easy access from Highway 3. Incursions into the Denali Wilderness have occurred most frequently on Windy Creek, Cantwell Creek, the Bull River, and the West Fork of the Chulitna.

Theft or Disturbance to Paleontological Resources

The recent discovery of dinosaur tracks and other fossils in the Cantwell geologic formation has increased public knowledge of these locations and visitation to the sites. The largest concentration of

fossils found to date is very accessible from the park road. Advances in GPS technology combined with the ability to distribute information via the Web means that these sites can be easily pinpointed and quickly exposed to many people. There is now a greater potential for theft or disturbance as well as the development of other associated impacts such as trail formation to the sites.

EXAMPLES OF INTEGRATED STUDIES: CLIMATE CHANGE

Denali's natural resources are responding to global climate change. Some of these changes are easily visible and others are more subtle:

Monitoring vegetation and landscape change through repeat photography. Over a 30-year period, based on visual comparison of aerial photography (1976, 2005), spruce has expanded its range across the landscape, open water areas are smaller, "pond-drying" is common, and woody vegetation has invaded open wetland sites.

Monitoring climate trends. Weather observations have been recorded at Denali for 80 years (since 1925). In recent years, the number of snow free days has increased and the growing season has lengthened. Average warming in Alaska since the 1950s has been 4°F (2°C).

Monitoring permafrost. Permafrost temperature profiles measured in boreholes near Healy show consistent warming since 1991. The borehole temperatures are very close to 0°C. At the point when borehole temperatures reach 0°C, there is the potential for significant landscape change.

Monitoring mass balance, thickness, and terminus location of glaciers. Denali glaciers continue to show negative balance and steady thinning.

Monitoring extent and duration of wildfires. Fire statistics over the last five years show an increase in fire size and duration. The Moose Lake Fire in 2002 was the largest single fire on record for Denali (117,920 acres) and the Highpower Creek Fire (2005) lasted 81 days – well beyond the average of 24 days. There has not yet been an increase in the average numbers of fires per year, but lightning activity levels have increased. There were a record number of lightning strikes in June 2005 in Interior Alaska. 2005 was the second largest fire season on record – 4 million acres burned with widespread smoke in June and July.

Monitoring bird populations. Bird population monitoring has revealed that trumpeter swans have expanded their range (and increased in numbers) to include higher elevation lakes (based on 2005 survey). Orange-crowned warblers, golden-crowned sparrows, and Lincoln's sparrows are much more common in Denali than they were 75 years ago (based on bird surveys in 2001 to 2005).

EXAMPLES OF INTEGRATED STUDIES: PARK ROAD CAPACITY

In 2006, Denali began a multidisciplinary study designed to optimize the visitor experience along the park road while protecting wildlife. Since 1972, traffic on the park road has been limited mostly to buses, and since 1986, a use limit of 10,512 vehicle trips annually has been effect. Faced with increasing visitation and pressure to defend or change the limits to road traffic, the park wishes to develop a greater understanding of the impacts of traffic volume and traffic patterns on the physical, biological, and social environment of the park.

A **GPS telemetry study of grizzly bears and Dall's sheep** is intended to detect impacts of traffic on animal movements near the road

A **social survey** will study the expectations and experiences of park visitors and of experienced road users

A study of **logistical and physical constraints on traffic** will examine traffic congestion, maintenance and construction needs, dust and noise levels, and other factors that constrain traffic

A comprehensive model of park road traffic will be developed to predict the effects of changes in traffic volume and timing

If the model and an environmental impact statement suggest that an increase in traffic volume is feasible, an experimental increase in road traffic, timed so as to produce the greatest value in understanding impacts, will be undertaken as part of a Before-After-Control-Impact (BACI) study.

STATUS OF RESOURCE INFORMATION - TABLES

The following tables (Tables 3a, 3b, 4a, 4b, 5, and 6) provide a summary of the status and completeness of resource knowledge for Denali National Park and Preserve. The limitations in resource knowledge are addressed by the comprehensive strategies.

Table 3a. Natural resource inventories and documentation.

*These definitions were used for data quality (column 4):

1 = Data address purpose, role, and function for which collected
2 = Data address much of purpose, role, and function, but is inadequate in some aspects
3 = Data do not adequately address much of purpose, role, and function
4 = Data do not exist or are currently being developed

Natural Resources Inventories and Documentation	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Natural Resource Bibliography (of projects completed in park)	90%	Incomplete	2	NRBib includes many references; Resources Technical Library contains many but not all reports resulting from resource and research studies in Denali
Basic Cartographic Layers	90%	Incomplete	2	Basic cartographic data is nearly complete, but certain elements are still in development (Ikonos, detailed topography).
Geology	80%	Incomplete	2	Geologic Resources Evaluation Scoping Report and Digital Maps were completed in 2004 (Inventory of existing geological data and digital composite geologic map of existing geologic maps). Still lacking detailed mapping of the McKinley Quad.
Paleontology	10%	Incomplete	4	Little known about overall paleontology and paleoecology. Reconnaissance studies in key areas have revealed an extensive resource, of which relatively little is known.
Soils	100%	Complete	1	*Soils Survey and Ecological Site Inventory of Denali National Park Area, Alaska* 2004, Detailed inventory of vegetation, landform, and soils; soils map for Denali, including spatial data readily available in the park GIS
Weather and Climate	100%	Complete	1	Inventory of existing climate monitoring stations and historic data in and near Denali (2004), NPS-wide climate inventory w/ Western Region Climate Center (2006)
Air Quality	67%	Ongoing	2	Sites at HQ and Trapper Creek established
Water Body Location and Classification	100%	Complete	2	USGS National Hydrography dataset and CAKN hydrography analysis tool (2004)

Natural Resources Inventories and Documentation	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Water Quality - General	50%	Incomplete	3	The Mangi Environmental Group (2005) summarizes existing knowledge. General survey complete, detailed analysis incomplete. Gravel renewal study complete.
Water Quality - Kantishna Hills Mining District	50%	Incomplete	3	NPS-USGS partnership study scheduled for FY08-10
Glacier Inventory	25%	Incomplete	3	Formal inventory has not been completed of glacier extent and existing conditions
Soundscape	30%	Incomplete	2	Formal protocol in development, park-wide baseline not yet well established
Lightscape (Night Sky)	0%	Incomplete	4	No baseline data
Vegetation Map	50%	Incomplete	3	Landcover map complete, but not detailed vegetation map
Wetlands Map	25%	Incomplete	3	FWS National Wetlands Inventory inadequate for most park management purposes.
Floodplains Map	30%	Incomplete	3	Certain areas completed for management purposes, no parkwide approach
Benthic Communities	25%	Incomplete	4	CAKN monitoring is beginning to observe.
Vertebrate Inventories	<10%	Incomplete	2	165 bird species, 39 mammal species, 15 fish species, 1 amphibian species; no reptiles native to Interior Alaska; early naturalists provided accounts of native species
Fish Inventories	100%	Complete 2004	1	Central Alaska Network Fish Inventory documented 15 species; >90% of those expected to occur; surveys have not been conducted on a park-wide basis or using randomized sampling methods
Bird Inventories	100%	Incomplete	4	No park-wide comprehensive bird inventory of abundance and distribution; checklist of birds based on incomplete information
Small Mammal Inventory (species)	<10%	Partial Inventory in 2002	1	Trapping at four sites, CAKN inventory; 25 species of small mammals have been identified. No comprehensive inventory of small mammal distribution and abundance.
Amphibian Inventories	100%	Incomplete	4	Denali's only amphibian is the wood frog; Several researchers have investigated distribution and abundance of wood frogs at selected locations (e.g., near Wonder Lake), but there has been no park-wide comprehensive inventory of wood frog distribution and abundance
Invertebrate Inventory	100%	Incomplete	4	Macro-invertebrates have been described for some Denali streams and rivers; there has been no park-wide, statistically-designed studies of terrestrial and aquatic invertebrates
Vascular Plant Inventory—native	100%	Complete 2004	1	4-year project; >200 sites; added 224 species, bringing total to >750

Natural Resources Inventories and Documentation	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Non-vascular Plant Inventory	100%	Incomplete	4	Inventory of mosses, lichens, and liverworts begins in 2007
Federal/State Threatened/Endangered Species	100%	Complete	1	No listed species are found in the park/preserve
Species of Concern	100%	Incomplete	4	58 species of plants and animals have been identified as species of management concern
Fire Cause Reports – Human vs. Natural	100%	Complete	2	Database 1946-2007 (1202 Fire Reports - Includes all administrative information, acres, start date), pre-1946 hard copy reports. Not all fires are reported.
Fire Protection Points Inventory	75%	Ongoing	2	On-going inventory of infrastructure, cultural, and natural resources affected by fire
Fire Management Zones	100%	Ongoing	1	Number of acres within each zone (full protection, limited option, suppression)
Digital Elevation Model	100%	Complete	2	Required for modeling fire growth parameters. Data is coarse scale and not the optimal scale for modeling fire growth parameters.
Denali Firepro Aerial and Ground Truth Fuels Mapping	100%	Complete 1980s	3	Map vegetation, coarse scale for fire management fire modeling
MODIS Imagery	100%	Ongoing	2	GIS Coverage 1999-2007; remote sensing heat detection tool
Fuels Characteristics Classification System	100%	Complete 2005	2	A national fuelbed database used for determining emissions, fire behavior indices and fuel potential

Table 3b. Natural resource studies and research reports.

*These definitions were used for data quality (column 4):

1 = Data address purpose, role, and function for which collected
2 = Data address much of purpose, role, and function, but is inadequate in some aspects
3 = Data do not adequately address much of purpose, role, and function
4 = Data do not exist or are currently being developed

Natural Resources Studies and Research	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
MONITORING				
Air Quality and Visibility	67%	Ongoing	2	Denali is Class I park; participates in NADP, IMPROVE, and CASTNet
Climate and Snowpack	90%	Ongoing	1	Lacking consistent data for higher elevation areas. Data are all served nationally.
Glaciers	80%	Ongoing	2	LTEM/CAKN protocol
Disturbance Monitoring - Earthquakes	100%	Ongoing	1	Alaska Earthquake Information Center and UAF-Geophysical Institute provide adequate information
Sound Quality	30%	Ongoing	2	Formal protocol in development, 30% of baseline complete.
Permafrost Soils	20%	Ongoing	4	In development through CAKN
Water Quality - Stream and River	20%	Ongoing	4	Protocol in development
Water Quality - Lakes and Ponds	80%	Ongoing	2	Protocol near complete
Functional Morphology – Stream and River	50%	Ongoing	3	Toklat scrape monitoring ongoing, disturbed lands in Kantishna in planning
Impaired Waterways – Caribou Creek and Slate Creek	50%	Ongoing	4	Caribou -need final restoration and formal monitoring plan for removal from list. Slate – reclamation and monitoring needed.
Landscape-Scale Vegetation	75%	Ongoing	1	Sampling on systematic grid; >500 vegetation plots installed as of 2007 and will be revisited at 7-year intervals
Exotic Plant Assessment	25%	Ongoing	1	most vulnerable areas have been surveyed
Anadromous Fish Monitoring	25%	Ongoing	2	need to identify all salmon streams, quantify runs
Monitoring Golden Eagle Reproductive Success	90%	Ongoing	1	20 year history
Trumpeter Swan Population Surveys	100%	Ongoing	1	USFWS survey every 5 years
National Breeding Bird Survey (BBS)	<1%	Ongoing	1	two routes conducted annually on park road
Nonmigratory Bird Species	10%	Incomplete	2	Need more information on resident bird species
Monitoring Passerine Abundance and Distribution	10%	Ongoing	1	sampling is integrated with vegetation monitoring
Christmas Bird Count	<1%	Ongoing	1	very little of the park is accessible in December

Natural Resources Studies and Research	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Monitoring Arctic Warblers for H5N1 Avian Influenza	<10%	Completed	1	project completed in 2006
Large Mammal Monitoring	50%	Incomplete	1	CAKN monitoring protocols for wolves and moose are in review; for caribou is being written; for grizzly bear and Dall's sheep need to be written. More information on wildlife diseases is needed.
Impacts of Harvest on Large Mammal Populations	25%	Incomplete	2	Harvest levels in and around the park/preserve need to be better documented.
Medium-sized Mammals, Mesocarnivores, and Furbearers	10%	Incomplete	2	More information is needed on furbearer harvest levels, mesocarnivore and beaver population dynamics.
Small Mammal Monitoring	<1%	Ongoing	1	LTEM project in Rock Creek is ongoing. Dynamics of cyclic small mammals is poorly understood.
Moose Surveys	75%	Ongoing	1	3 areas regularly surveyed
Fire History Maps – Polygon	100%	Incomplete	1	GIS Coverage 1950 - 2007, Excepting fires not reported/discovered. Indicates where/when a fire occurred and how large the fires became. The majority of fires typically occur in the Minchumina and Toklat Basins. Fires have not occurred over 3000 ft. elevation. Indicates the high fire frequency portion of the park and preserve.
Fire History Maps – Point	100%	Incomplete	1	GIS Coverage 1955 - 2006, Excepting fires not reported/discovered. Indicates where/when a fire occured and how large the fires became. Not all fires were reported
Burn Severity	25%	Ongoing	1	GIS Coverage 2000 - 2005, Satellite Derived. How large a fire becomes in not an indicator of the proportion of high, moderate or low burn severity. A smaller fire has approximately the same proportion of high, moderate or low burn severity as a large fire, based on a small dataset.
Lightning Occurrence – Point Location	100%	Ongoing	1	GIS Coverage 1986-2007, Missing 1987 and 1989. Lightning is the primary source of ignition in the Minchumina and Toklat Basins.

Natural Resources Studies and Research	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
On Site Weather/fire Indices/Fire Behavior/Smoke Observations	1%	Ongoing	4	2005 Portable RAWS - Highpower Fire. Project objectives: Correlate predicted/modeled with actual fire behavior (includes fire narrative)
Photo Documentation	7%	Incomplete	3	Digital photos - 1999-2007, Hardcopy photos - Limited/Park Archives
Weather Data	<25	Incomplete	2	Following 1993 fire weather was collected at permanent remote automated weather stations. Fire Weather parameters and the subsequent Canadain Forest Fire Danger Rating Indices assist fire managers in determining fire season and burn characteristics (e.g., season length, fire duration, fire frequency, resistance to extinguishment, rate of spread)
Paired Plots	<1	Ongoing	3	(1982 and 1983) Permanent plots established to assess vegetation succession.
Hazard Fuels Plot Database	75%	Ongoing	1	Database 2003-2006 selected plots will be monitored into perpetuity. Project for determining maximum effeciency in hazard fuels reduction techniques used at Denali and applied elsewhere in interior Alaska.
Videography Plots	<50%	Ongoing	1	Project for ground truthing remote sensing fuel model GIS coverage based on succession models. Anticipated insights include: Plant successional pathways are likely to be determined by burn severity, slope, elevation and fire frequency.
Moose Browse Utilization – Post Burn	50%	Incomplete/ Ongoing	2	Project for determining moose utilization of burned areas based on burn severity.
Vegetation Structure and Composition (CAKN)	75%	Ongoing	1	Sampling on minigrid system is ongoing. Ecosystem response to fire and climate change, succession and disturbance processes are not well understood.
RESEARCH				
Wonder Lake Limnology	50%	Ongoing	2	To be completed 2008
Toklat Gravel Removal	50%	Ongoing	2	Ongoing
Mile 45 Slump	50%	Ongoing	2	Needs cumulative analysis
Drunken Forest	50%	Ongoing	2	Needs cumulative analysis
Geologic Mapping	80%	Needed	4	Needed for McKinley Quad

Natural Resources Studies and Research	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Paleontological Research	20%	Needed	4	Only survey style information to date
Tectonic and Seismic Activity	80%	Ongoing	2	Seismic and tectonic research underway
Glacial Change	50%	Incomplete	2	Need more analysis of change
Permafrost	20%	Incomplete	4	Protocol in development
Glacial History	80%	Incomplete	2	Refinement of known limits possible
Stream Restoration	50%	Incomplete	3	Only selected streams restored to date
Wood Frog Research	<10%	Ongoing	1	3 studies have been conducted in recent years
Bird Research	100%	Incomplete	4	some important studies are needed
Predator-Prey Studies	50%	Ongoing	1	Brown bears and Dall's sheep are not well studied.
Utilizing Satellite Imagery to Estimate Burn Severity	100%	Complete	2	Assessing burn severity from Satellite Imagery. Generally effective tool for assessing burn severity, though improvements might be evidences through focused assessments by vegetation type.
Ecosystem Effects of Climate Change	<10%	Incomplete	3	Responses of flora and fauna to climate change are poorly understood.
Visitor effects on vegetation	25%	Ongoing	1	Studies of foot traffic and ORV impacts, mitigation measures are ongoing.

Table 4a. Cultural resource inventories and documentation.

*These definitions were used for data quality (column 4):

1 = Data address purpose, role, and function for which collected
2 = Data address much of purpose, role, and function, but is inadequate in some aspects
3 = Data do not adequately address much of purpose, role, and function
4 = Data do not exist or are currently being developed

Cultural Resource Inventories and Documentation	Coverage/ Compre-hensive-ness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Archeological Overview and Assessment	40%	Complete 1990	2	
Archeological Inventory of Sites	10%	Incomplete	4	
Archaeological Identification/Evaluation Studies	0%	Incomplete	4	
Archeological Site Management Information System (ASMIS)	90%	Ongoing	2	
Collection Condition Survey	0%	Needed	4	
Cultural Landscape Inventories (CLI)	20%	Incomplete	3	Headquarters completed in 2001, all other indentified Cultural Landscapes are incomplete.
Cultural Resources Base Map	40%	Incomplete	3	
Ethnographic Overview and Assessment	100%	Complete 2001	1	
Historic Structure Reports	65%	Incomplete	1	Many are done, updates as needed.
Monitoring Collections Environment	100%	Ongoing	1	
Ethnographic Resources Documentation	20%	Incomplete	3	
List of Classified Structures (LCS)	100%	Complete 1995 Ongoing	1	
Automated National Catalog System (ANCS+)	50%	Incomplete, Ongoing	3	Latest 100% Inventory - 2006
National Register of Historic Places (NRHP)	20%	Incomplete, Ongoing	4	
Park Administrative History	50%	Incomplete, Volume I, 2006	2	
Scope of Collections Statement	0%	Incomplete	4	
Native Place Names Map	0%	Needed	4	
Cultural Resource Monitoring	70%	Ongoing	1	

Table 4b. Cultural resource studies and research reports.

*These definitions were used for data quality (column 4):

1 = Data address purpose, role, and function for which collected
2 = Data address much of purpose, role, and function, but is inadequate in some aspects
3 = Data do not adequately address much of purpose, role, and function
4 = Data do not exist or are currently being developed

Cultural Resource Inventories and Documentation	Coverage/ Compre-hensive-ness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Historic Resource Study	100%	Complete 1991	2	
Cultural Affiliation Studies	20%	Incomplete	2	
Scientific Legacy of Denali	50%	Incomplete	3	
Mining History of Kantishna Mining District	50%	Incomplete	3	
Mountaineering History of Mt. McKinley	50%	Incomplete	3	
History of the Park Road	40%	Incomplete	3	

Table 5. Subsistence documentation, studies, and research reports.

*These definitions were used for data quality (column 4):

1 = Data address purpose, role, and function for which collected
2 = Data address much of purpose, role, and function, but is inadequate in some aspects
3 = Data do not adequately address much of purpose, role, and function
4 = Data do not exist or are currently being developed

Subsistence Documentation, Studies, and Research	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality *see defin-itions	Notes
Community profile studies of subsistence use of wildlife, fish, and furbearers	75%	Incomplete, Ongoing	2	Several studies (1978 – 2006)
Knowledge of timing, rates, and escapement of salmon runs in Kantishna watershed	100%	Complete, Ongoing	1	Fall chum salmon mark-recapture project 1995-2006; aerial stream surveys and field mapping of salmon 2000, fish inventory in northwestern Denali 2003
Subsistence firewood and log use: Assessment of timber resources and development of timber management plan	0%	Needed, Ongoing	4	
Manage Subsistence Eligibility: Review and Update Resident Zones	50%	Incomplete, Ongoing	3	Cantwell Resident Zone Status needs to be evaluated
Community Use Profiles	75%	Incomplete, Ongoing	2	Cantwell, Lake Minchumina, Telida, Nikolai
Traditional and customary for access to subsistence use of Denali	75%	Incomplete, Ongoing	2	
Subsistence Trapline Management Plan: Establish furbearer harvest use Monitoring Program and Revise Harvest Reporting	25%	Incomplete, Ongoing	3	
Customary and Traditional Use	50%	Incomplete, Ongoing	2	Studies about park use and harvest information
Ethnographic Overview and Assessment	75%	Incomplete, Ongoing	2	Several studies
Definition of “natural and healthy”	75%	Incomplete, Ongoing	2	
Monitoring subsistence use of and impacts related to OHV use along routes in the Cantwell area	0%	Needed, Ongoing	3	
Oral histories of traditional and new technologies of subsistence activities	50%	Incomplete, Ongoing	2	

Table 6. Park visitation and neighboring communities—documentation, studies, and research reports.

*These definitions were used for data quality (column 4):

1 = Data address purpose, role, and function for which collected
2 = Data address much of purpose, role, and function, but is inadequate in some aspects
3 = Data do not adequately address much of purpose, role, and function
4 = Data do not exist or are currently being developed

Park Visitation and Neighboring Communities—Documentation, Studies, and Research	Coverage/ Compre-hensiveness	Status: Complete, Incomplete, Needed, or Ongoing	Data Quality * (see below)	Notes
VISITOR AND VISIT CHARACTERISICS				
Visitor numbers	95%	Ongoing	2	Annual estimates
Visitor demographics	75%	Complete	3	Prior studies complete
Visitor segments/trip characteristics	70%	Complete 2004	2	Complete for area covered
Visitor forecasts	80%	Complete 2004	1	Complete for area covered
VISITOR EXPERIENCE & RESPONSE TO MANAGEMENT				
Backcountry visitors	95%	Complete	1	Most recent studies complete
Frontcountry - park road visitors	100%	Ongoing	1	Current study in progress
Frontcountry - entrance area visitors	20%	Needed	3	Current studies complete but limited.
South Denali visitors	0%	Needed	4	
LOCAL COMMUNITIES				
Community surveys	0%	Needed	4	
Economic impact	0%	Needed	4	
RESEARCH MANDATES				
Backcountry visitor surveys	0%	Needed	4	
Entrance area indicators and standards	0%	Needed	4	

Education and Interpretation Themes

Educators and interpreters facilitate a physical, intellectual, and emotional experience for the visitor based on the park purpose and significance, and on the park's fundamental and other important resources and values. These resources and values serve as the basis from which park-wide education and interpretation themes are established. Resource condition can directly impact desired visitor experiences, just as human interactions with the resources can affect resource condition. Interpretation and education programs ultimately strive to encourage commitment to resource stewardship within visitors. Visitors will care about park resources when they find personal meanings in the education and interpretation themes that are based on those resources. Comprehensive education and interpretation planning includes research that analyzes visitor experience resulting from education and interpretation based on the themes.

All Denali's education and interpretation themes have a clear connection to resource stewardship and resource condition and these themes were considered while developing the RSS and the comprehensive strategies. Denali's education and interpretive themes are listed here (see also Table 7):

Denali's Education and Interpretation Themes

Extensive Natural Ecosystems:
Denali's intact, natural ecosystem embodies a wisdom from which humans can learn and promote the workings of a healthy planet for a sustainable future.

Wildlife and Wildlife Habitat:
The size and ecological integrity of Denali preserves a home of extraordinary quality for populations of large northern mammals, birds, and other wildlife, where they can live and be observed interacting with one another and their natural habitat with minimal human disruption.

Mount McKinley (Denali):
Mount McKinley's magnitude captivates human imagination and inspires exploration and the protection of the Denali region's landscapes, wildlife, and wilderness.

Wilderness Values and Wilderness Recreation:
Denali's wild lands create a refuge from modern civilization where we can discover, challenge and connect with the primal pulses and prevailing forces of nature.

People and the Land:
The ways Denali shapes and is shaped by the character, lives and values of people past and present offers us insights into our relationship with our natural heritage.

Dynamic Change:
Denali preserves a dynamic landscape, ever shifting, changing, and adjusting to cycles and processes, seen and unseen.

The connection among visitor experience, interpretive themes, and resource condition is an important consideration in defining desired conditions for park resources and values. Visitor experiences and the linkages of these experiences with fundamental resources and values and other important resources and values are given in Table 7.

Most education and interpretation themes apply to visitor experiences parkwide, i.e., within all management zones and legislatively defined areas. However a few visitor experiences link best to certain management zones or legislatively defined areas (e.g., natural zone or Old Park). Notes about these zone- or area-specific experiences are explained following the visitor experience in the list below. Letters for the visitor experiences are used in Table 7.

Resource condition-dependent visitor experiences are summarized as:

Resource Condition-Dependent Visitor Experiences at Denali

A. Visitors will discover a variety of facilities and services that meet the needs of varied audiences seeking different levels of *experience with the park's resources*.
(GMP- Park Development zone only: park road and entrance area)

B. All backcountry areas will provide opportunities for *wilderness recreational activities*.
(GMP- Natural zone)

C. Visitors will have the opportunity to *view wildlife in its natural habitat*.
(GMP- parkwide, but most strongly stated for the park road).

D. Visitors will have the opportunity to *study and appreciate historic and cultural features*.
(GMP- Historic zone)

E. Visitors will have the opportunity to *view Mount McKinley and other spectacular geologic features and scenery in the Alaska Range*.
(GMP- most strongly stated in reference to South Denali, but also for the park road)

F. Visitors will have the feeling of *being on the threshold of wilderness and immersed in a natural landscape*.
(GMP- most park development sub-zones)

Table 7: Education and interpretation themes in relationship to resource condition-dependent visitor experiences and park resources and values.

Education and Interpretation Theme	Resource Condition - Dependent Visitor Experience	Associated Fundamental Resources and Values	Associated Other Important Resources and Values
Extensive Natural Ecosystems	A, C, F	1. Wildlife populations, habitat, and ecosystems 2. Wilderness character, resource values, recreational opportunities 3. Scenic and geologic values. 4. Visitor enjoyment and inspiration from observing wildlife and other natural features	7. Air quality 9. Scientific research, education, and interpretation about natural ecosystems and geologic features and processes
Wildlife and Wildlife Habitat	A, C, F	1. Wildlife populations, habitat, and ecosystems 2. Wilderness character, resource values, recreational opportunities 4. Visitor enjoyment and inspiration from observing wildlife and other natural features	7. Air quality 9. Scientific research, education, and interpretation about natural ecosystems and geologic features and processes
Denali/Mt. McKinley	A, E, F	2. Wilderness character, resource values, recreational opportunities 3. Scenic and geologic values	9. Scientific research, education, and interpretation about natural ecosystems and geologic features and processes
Wilderness Values and Wilderness Recreation	A, B, F	2. Wilderness character, resource values, recreational opportunities	8. Subsistence resources and opportunities

Education and Interpretation Theme	Resource Condition - Dependent Visitor Experience	Associated Fundamental Resources and Values	Associated Other Important Resources and Values
People and the Land	A, D	2. Wilderness character, resource values, recreational opportunities	5. Historic, archaeological, and ethnographic resources 8. Subsistence resources and opportunities
Dynamic Change	A, E, F	1. Wildlife populations, habitat, and ecosystems 2. Wilderness character, resource values, recreational opportunities 3. Scenic and geologic values 4. Visitor enjoyment and inspiration from observing wildlife and other natural features	5. Historic, archaeological, and ethnographic resources 6. Paleontological resources 7. Air quality 9. Scientific research, education, and interpretation about natural ecosystems and geologic features and processes

Comprehensive Strategies

Indicator Selection and Condition Assessment

The following steps were used to derive comprehensive strategies:

1. Identify attributes or characteristics of each significant resource.
2. Consider influences that can impact attributes or resource conditions.
3. Determine indicators, measurable attributes, or attribute parameters that best indicate resource conditions, taking into account effectiveness of the resource conditions in supporting interpretive themes and resource integrity.
4. Specify a target value for each indicator that represents desired conditions
5. Note the current condition for each indicator (see also Appendices C and D).
6. Assess the difference between current conditions and desired conditions.
7. Build a logical sequence of broad project areas that will allow the desired conditions to be attained in a reasonable time frame.
8. Group projects by similarity of strategy.

The tables below (Tables 8, 9, and 10) provide a synopsis of steps 1-6.

Column 5a in Tables 8, 9, and 10 refers to indicators given in Appendix D (e.g., AppD-1 means Appendix D, row D-1).

Column 9 (last column) in these tables includes the projects (e.g., Strategy A, Project A-1). These projects are developed and described in the following section of this document.

In Denali's *General Management Plan*, the desired condition for many resources and values are given on a park-wide basis and do not vary by management zone. These resources and values are presented first (Table 8—page 94). The desired condition for other resources and values, particularly those related to some visitor experiences, vary by legislated and management area, and are presented in Table 9 (page 120) and Table 10 (page 126).

Table 8: Attributes, influences, indicators, and target values for park-wide resources.
Fundamental resources and values (shaded salmon pink) and other important resources and values (shaded yellow-green) are numbered in the first column. Numbers (and colors) correspond to the list on pages 3-4 and 6 and are also used in the matrix that begins on page 134 (explained on page 133).

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems**: The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	No anthropo-genic changes in species composition	◊ Size of protected area ◊ Lack of human influence surrounding most of the boundary	◊ Degradation of migratory and winter habitat of migrating species ◊ Unsustainable harvest (all kinds) ◊ Climate change ◊ Frontcountry development ◊ Habitat fragmentation inside and outside of park	◊ Number of native animal species losses for anthropogenic reasons (AppD-1) ◊ Number of exotic animal species introduced by human activities (AppD-2)	# native species - no loss due to human activities # exotic animal species - none introduced by human activities	# native species - as far as is known, no loss of native species # exotic animal species - none have been detected	Yes Yes	A-5 A-6 B-14 D-31 D-32 D-35 D-36 J-66 J-68

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems**: The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	Natural regulation of animal numbers and distribution	◊ Size of protected area ◊ Lack of human disturbance ◊ Protection from hunting	◊ Possible loss of habitat due to climate and vegetation change ◊ Potential for increased harvest in certain areas ◊ Disturbance in wintering areas ◊ Inhibition of normal migration patterns	◊ Numbers, demography, and distribution of caribou in the Denali Caribou Herd (AppD-3) ◊ Numbers, demography, and distribution of moose (AppD-4) ◊ Numbers and distribution of Dall's sheep (AppD-5)	Herd size and demography of each species remains within the range observed 1987 - 2007	Caribou - slowly increasing Moose - stable Sheep - stable	Yes Yes Yes	D-37 D-38 D-39
(1) **Wildlife populations, habitat, ecosystems**: The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	Natural regulation of animal numbers and distribution	◊ Size of protected area ◊ Lack of human disturbance ◊ No anthropogenic caused habitat fragmentation	◊ Habitat change ◊ Introduced diseases ◊ Wetlands drying due to permafrost melt ◊ Changes in hydrology caused by climate change ◊ Cascading effects of climate change including changes in composition of snow pack (surface hardness)	◊ Population size and distribution of beavers (AppD-6) ◊ Population size and distribution of snowshoe hares (AppD-7) ◊ Population size and distribution of Arctic ground squirrels (AppD-8) ◊ Population sizes and distribution of small mammals (AppD-9)	To be determined To be determined To be determined To be determined	Unknown High Unknown Unknown	Unknown Unknown Unknown Unknown	D-26 D-28 D-35 D-36 J-67

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	Natural regulation of animal numbers and distribution	◊ Size of protected area ◊ Lack of human disturbance ◊ No anthropo-genic-caused habitat fragmentation	◊ Habitat change in the park ◊ Loss of wintering habitat ◊ Loss of lakes and ponds ◊ Lead poisoning on wintering grounds	◊ Population size and distribution of Trumpeter Swans (AppD-10) ◊ Density (abundance) and distribution of willow ptarmigan across their 8-11 year population cycles (AppD-11) ◊ Diversity, distribution, and density of passerine birds (AppD-12)	To be determined To be determined To be determined	Increasing Unknown Unknown	Unknown Unknown Unknown	A-5 D-26 D-32 D-33 D-35
(1) **Wildlife populations, habitat, ecosystems:** The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	Naturally functioning predator-prey systems	◊ Size of protected area ◊ Climatic stability ◊ Public perceptions and value of the park as a natural laboratory, resulting in effective protection	◊ Predator control activities near the park ◊ Excessive harvest ◊ Lack of public sympathy	◊ Population sizes, demography, and distribution of wolves (AppD-13) ◊ Population sizes, demography, and distribution of grizzly bears (AppD-14)	Population size and demography of each species remains within the range observed 1987 - 2007	Wolves - declining Grizzly Bears - unknown	Yes Unknown	D-26 D-40 D-41 J-67

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	Naturally functioning predator-prey systems	◊ Size of protected area ◊ Lack of human disturbance ◊ Abundance of nesting substrate and prey resources	◊ Repeated low-level over-flights during critical nesting period ◊ Loss of wintering habitat and habitat used by non-breeding birds ◊ Possibility of lead poisoning during migration and on wintering areas	◊ Population size, distribution, and reproductive success of nesting population of golden eagles in northeastern region of Denali (AppD-15)	Population size, distribution, and breeding success remain within the observed range of natural variability (1987-2007)	Population size - increasing	Yes	D-34
(1) **Wildlife populations, habitat, ecosystems:** The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	Natural behavior of animals	◊ Size of park ◊ Isolation ◊ Park management policies	◊ Habituation ◊ Visitation ◊ Inappropriate human behavior ◊ Ability of humans to easily enter wildlife habitat ◊ Unreasonable visitor expectations	◊ Number of bear-human interactions as measured by BHIMS database (AppD-16)	Number of bear-human interactions (BHIMS) - no significant increase from 1997-2007 data	Number of bear-human interactions - stable	Yes	I-61

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems**: The natural abundance, behavior, diversity, and ecological integrity of native animals as part of their ecosystems will be maintained.	Natural behavior of animals	◊ Size of park ◊ Isolation ◊ Park management policies	◊ Habituation ◊ Visitation ◊ Inappropriate human behavior ◊ Ability of humans to easily enter wildlife habitat ◊ Unreasonable visitor expectations	◊ Number of recorded interactions between humans and wildlife other than bears (AppD-17) ◊ Number of recorded cases of wildlife damage to property (AppD-18) ◊ Number of recorded cases of wildlife obtaining human food (AppD-19)	# human-wildlife interactions, wildlife damage to property, or cases of feeding of wildlife - no significant increase from 1997 - 2007 data	# interactions - stable # cases of wildlife damage to property - stable # cases of wildlife obtaining food - stable	Yes Yes Yes	I-62 I-63

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Wetland function	◊ Effective protection ◊ Size of park ◊ Lack of exotic species	◊ Contamination ◊ Drying ◊ Changes in natural flow patterns ◊ Exotic species	◊ Number of acres of functional wetland lost to park infrastructure and development after 2007 (AppD-20) ◊ Wetland plant community structure (AppD-21)	# acres of functional wetland - no net loss in park after 2007 Wetland community structure - no significant changes when sites are re-sampled on 7-year rotation by vegetation monitoring program	No acres lost (2007) Unknown	Yes for 2007, unknown beyond Unknown	D-42 D-43 G-54 G-55
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Natural movement of fish and other aquatic species	◊ Water ◊ Effective passages (bridge, culvert)	◊ Dams, other barriers ◊ Contamination ◊ Temperature barriers	◊ Fish movements (AppD-22)	Fish movements - No new restrictions or obstacles to fish movements from construction projects after 2007	Unknown	Yes for 2007, unknown beyond	D-30 D-31 G-53

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Lake ecosystem function	◊ Large number of lake basins ◊ Variety of lake types	◊ Exotic aquatics ◊ Lake drying	◊ Total acres of lake surface area of lakes over 1 acre (AppD-23) ◊ Number of lakes over 1 acre of surface (AppD-24) ◊ Selected standard measurements of limnological ecosystem function (i.e. primary productivity) (AppD-25)	Lake surface area – total acres is within range of natural variation Number of lakes - no change from range of natural variation To be determined	Unknown Unknown Unknown	Unknown Unknown Unknown	B-14 B-15 D-26 D-28 D-29 D-43

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Absence of anthro-pogenic contami-nants	◊ Clean air/water legislation ◊ International POPs treaty ◊ Size of park ◊ Remoteness ◊ Distance from industry ◊ Minimal agricultural development in Alaska ◊ Low human population density in Alaska	◊ Intercontinental transport of toxic airborne contaminants ◊ Global fractionation ◊ Increasing global development ◊ Increasing global human population ◊ Local development (shallow gas, etc.)	To be determined (after the final WACAP report is published) (AppD-26)	To be determined	Unknown (some current values will be available from the final WACAP report)	Unknown	J-64

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Natural assemblages of aquatic species	◊ Lack of exotics ◊ Lack of development	◊ Contamination	◊ Aquatic species richness, distribution, and abundance (AppD-27) ◊ Percent native aquatic invertebrate species (AppD-28) ◊ Number of salmon entering park streams (AppD-29) ◊ Species richness, distribution, and abundance of non-migratory fish (AppD-30)	Species richness, distribution, & abundance are within range of natural variation % native aquatic invertebrate species – 100% # salmon entering park streams - no significant decrease compared to 2007 Species richness, distribution, & abundance of non-migratory fish are within range of natural variation	Unknown % native aquatic invertebrate species – 100% (no exotic aquatic invertebrate species have been detected) # salmon entering park streams - ADF&G has estimated size of Kantishna and Toklat River salmon runs 15 species of freshwater fish have been identified in the park	Unknown Yes Yes Unknown	B-14 D-31 D-33 J-66 J-67

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Water quality and soil / water interface	◊ Size ◊ Remoteness ◊ Restricted Access ◊ Limited development	◊ Park road ◊ Increased development ◊ Climate change ◊ Intercontinental contaminant transport ◊ Placer-mining ◊ Gravel acquisition	◊ Water chemistry (AppD-31) ◊ Presence of contaminants in aquifers – Nitrate, DRO, GRO, Benzene (AppD-32) ◊ Presence of air-transported organchlorines (AppD-33) ◊ Presence of *E. coli* (AppD-34) ◊ Effects of CaCl (dust palliative) (AppD-35) ◊ Turbidity and heavy metals in placer-mined streams (AppD-36) ◊ % of streams and lakes unimpaired by development or mining activity (AppD-37) ◊ Compliance with federal and state water quality standards (AppD-38)	Water chemistry - no significant human-caused change Aquifers - Nitrate - <5mg/L, others - no visual sheen Organchlor-ines –to be determined *E. coli* - 30-day mean <20FC/100ml Effects of CaCl – to be determined Turbidity - within range of natural variation % streams and lakes unimpaired – 100% Compliance with federal and state water quality standards – yes	Water chemistry - Caribou, Slate may be outside natural range of variation Aquifers - Nitrate – up to 25 mg/L; others – visible sheen Organ-chlorines – unknown *E coli* - unknown CaCl – unknown Turbidity – Slate, Caribou creeks may be outside natural range of variation % unimpaired - >99% Compliance – no	No No Unknown Unknown Unknown No No No (Slate and Caribou impaired)	D-28 D-29 G-52 G-53 G-54 G-55 J-64

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Water quality – potential influences	◊	◊ Coalbed methane activity (potential) ◊ North access development (potential)	◊ Water quality (salts, heavy metals) (AppD-39) ◊ Water chemistry (turbidity, organic pollutants) (AppD-40)	Water quality – no significant CBM-caused change Water quality – no significant road-caused change	Water quality – unknown Water quality - unknown	Yes (no detri-mental action has occurred) Yes (no detri-mental action has occurred)	D-29 J-64

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** The aquatic habitat of the park and preserve will be protected to maintain natural, self-sustaining aquatic populations.	Functional morphology of aquatic habitat	◊ Remoteness ◊ Size of park ◊ Restricted access ◊ 1985 – mining litigation	◊ Climate change ◊ Mining ◊ Development ◊ Park road ◊ Lack of floodplain delineation	◊ Floodplain morphology (cross-sections, water velocities) near roads and development (AppD-41) ◊ Morphology of placer-mined streams (cross-sections, slope, suspended sediments, riparian vegetation composition) (AppD-42) ◊ Presence of floodplain delineations (100-, 200-, 500-year) for development (AppD-43) ◊ Effects of potential north access road (e.g., stream velocities, sheet flow, turbidity) (AppD-44) ◊ Effects of climate change on hydrologic regime (AppD-45) ◊ Percentage of disturbed riparian acres near mined streams that are restored (AppD-46)	Floodplain – functional stream channels and floodplains Placer-mined streams – stream channels, floodplains, and riparian wetlands are functional Floodplain delineation – delineations for rivers with development North access – functional stream channels and floodplains Climate change – within historical range of variability % riparian acres restored – to be determined	Floodplain – unknown Placer-mining – unstable banks, confined streambeds, non-functional or non-existent floodplains Floodplain delineation – no delineations North access – functional Climate change - unknown % riparian acres restored - unknown	No No No Yes Unknown Unknown	D-26 D-30 G-52 G-53 G-54 G-55

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** These lands will be managed to ensure that natural processes prevail.	Major ecosystem processes are not hindered	◊ Size of park ◊ Effective protection	◊ Contamination ◊ Climate change ◊ Manipulated populations	◊ Plant species composition as measured in vegetation monitoring program (AppD-47) ◊ # native plant species lost (AppD-48) ◊ Presence of exotic plant species (AppD-49) ◊ Anthropogenic change in native plant community distribution (AppD-50)	Plant community composition - does not show human-caused changes # native plant species lost - none Exotic plant species - no introduction of exotic plant species Plant community distribution - no significant anthropogenic change	Plant community composition – being monitored # native plant species lost - none known Exotic plant species - present, but only in developed areas Plant community distribution - no native plant communities are presently at risk	Unknown Yes No Yes	A-3 A-4 A-6 D-26 D-42 D-45 G-54 G-55 J-65 J-68

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems:** These lands will be managed to ensure that natural processes prevail.	Major ecosystem processes are not hindered. Abundance and distribution of habitat is maintained.	◊ Size of protected area ◊ Lack of human influence surrounding most of the boundary ◊ Natural Fire Regime	◊ Climate change ◊ Habitat fragmentation ◊ Fire size/occurrence outside historic natural range of variability	◊ Number of acres burned per year (AppD-51) ◊ Number of natural fire starts per year (AppD-52) ◊ Total duration (days) of fire incidents annually from 1st start date to final declared out date (AppD-53) ◊ Fire season duration (days) and timing (dates) (AppD-54) ◊ Percentage of burns by severity class annually (AppD-55) ◊ Number of fire management actions in the Limited Fire Management Option Areas that deviate from FMP (AppD-56)	# acres burned per year, # natural fire starts per year, and total duration - remain within range of natural variability (1952 – Current) Fire season duration and timing – remain within range of natural variability (1993 - Current)-- to be determined % of burns by severity class annually – remain within range of natural variability (1983 – Current)– to be determined # fire management actions in the Limited FM Option Areas that deviate from FMP - none	# acres burned in 2007 – not analyzed # of natural fire starts in 2007 – not analyzed Total duration in 2007 – not analyzed Fire season duration and timing 2007 - unknown % of burns by severity class - unknown # fire managemen t actions in Limited that deviated from FMP in 2007 - none	Unknown Unknown Unknown Unknown Unknown Yes	A-7 A-9 B-16 B-17 B-18 E-47

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(3) **Scenic and geologic values:** Scenic and geologic values are preserved.	Glaciers	◊ Precipitation ◊ Climate change ◊ Insolation	◊ Climate change ◊ Insolation	◊ Total glaciated area (AppD-57) ◊ Extent and volume of selected glaciers (AppD-58)	Change is driven by non-anthropo-genic processes	Unknown Unknown	Unknown Unknown	D-26 D-27
(3) **Scenic and geologic values:** Scenic and geologic values are preserved.	Rare features (e.g., yedima, travertine, pingos, tectonic signature, very-large igneous rock features)	◊ Time ◊ Remoteness ◊ Size of protected area ◊ Climate change	◊ Climate change ◊ Acid rain ◊ Development ◊ New roads	◊ Inventory of features (AppD-59) ◊ Condition of inventoried features (AppD-60)	Inventory – yes Condition – change is driven only by non-anthropo-genic processes	Incomplete Unknown	No Unknown	A-1
(3) **Scenic and geologic values:** Scenic and geologic values are preserved.	Surface processes (e.g., solifluction, landslides, rock glaciers, and talus slopes)	◊ Restricted access ◊ Limited development ◊ remoteness	◊ Management actions (roads, development, mining) ◊ Development ◊ Climate change	◊ Number of surface major processes that are interrupted (AppD-61)	Interrupted processes equal to or less than condition in 2007	Unknown	Yes (with 2007 baseline)	

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(3) **Scenic and geologic values:** Scenic and geologic values are preserved.	Natural viewshed	◊ Size of protected area ◊ Controlled access ◊ Public support ◊ Designated wilderness ◊ Road design standards	◊ Trail development ◊ Communication equipment ◊ Road design standards ◊ Dust ◊ Development nodes ◊ Power plant construction ◊ Tree-line advance ◊ Roadside shrubbery	◊ Total area (acres) from which park development (e.g., structures) is visible (AppD-62)	# acres – no more than value in 2007	Unknown	Yes (with 2007 baseline)	

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(3) Scenic and geologic values: Scenic and geologic values are preserved.	Soil (including frozen soil)	◊ Visitor planning ◊ Wildland fire ◊ BCMP, FCMP ◊ Restricted access ◊ Remoteness	◊ Management actions – development, land use pattern ◊ Climate change ◊ Increasing visitation ◊ Increasing OHV use ◊ Road maintenance practices (increased sedimentation, interruption of hillslope processes, chemical treatments)	◊ Number of acres of thermokarst (AppD-63) ◊ Carbon balance (AppD-64) ◊ Soil temperature (App-65) ◊ Acreage of human-initiated erosion and soil degradation, including sensitive soils (AppD-66)	Themokarst – all changes within range of natural variation Carbon balance - within range of natural variation Soil temperature - within range of natural variation # acres of human-initiated erosion and sensitive site disturbance - remains at or below level in 2007	Unknown Unknown Unknown Unknown	Unknown Unknown Unknown Unknown	D-28

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(3) **Scenic and geologic values:** Scenic and geologic values are preserved.	Climate Change	◊ Remoteness ◊ Size of protected area ◊ Fire ◊ Snowcover	◊ Increased development ◊ Increase in population of state ◊ Growth/industrialization of adjacent communities ◊ Global impacts – contaminants, temperature increases, extreme weather events	◊ Standard climatic variables (AppD-67) ◊ Economic damage to infrastructure from floods, erosion, and landslides (AppD-68) ◊ Acres affected by insect outbreaks (AppD-69)	Climate - values are within historical variability Economic damage – within range of historic variation Insect damage – within range of natural variation	Climate – unknown Economic damage – yes Insect damage - unknown	Unknown Yes Unknown	B-15
(3) **Scenic and geologic values:** Scenic and geologic values are preserved.	Natural Lightscapes	◊ Remoteness ◊ Size of park ◊ State population ◊ Planning	◊ Adjacent communities ◊ Large scale resource extraction projects ◊ Improper or excessive outdoor light installations	◊ Number acres with impaired lightscape (AppD-70) ◊ Star magnitude (AppD-71)	# acres impaired - none Star magnitude - to be determined	Unknown Unknown	Unknown Unknown	F-50

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(5) **Historic, archaeological, and ethnographic resources:** Historic and archeological sites, and the resulting identified cultural landscapes, are appropriately protected.	Historic structures integrity Historic structure condition	◊ Rehabilitation	◊ Natural weathering ◊ Disturbance ◊ Fire	◊ Percentage of historic and archeological structures in Good Condition (LCS) (AppC1-Column I)	51% of historic and archeological structures in Good Condition (LCS)	Historic Structure Condition Good – 40% Fair – 21% Poor – 40% Archeology Structure Condition - Unknown	No	C-24 F-49 K-69 L-74 Q-89
(5) **Historic, archaeological, and ethnographic resources:** Historic and archeological sites, and the resulting identified cultural landscapes, are appropriately protected.	Site integrity Site condition Parkwide identifi-cation of archeology sites	◊	◊ Natural weathering ◊ Disturbance ◊ Fire	◊ Percentage of identified sites in Good Condition (ASMIS)(AppC-1-Column III)	50% of identified archeology sites in Good Condition (ASMIS)	Archeologic al Site Condition Good – 28% Fair – 42% Poor – 10% Unknown – 20%	No	A-10 A-11 C-24 F-49 K-69 Q-89

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(5) **Historic, archaeological, and ethnographic resources:** Historic and archeological sites, and the resulting identified cultural landscapes, are appropriately protected.	Landscape integrity Landscape condition	◊	◊ Natural weathering ◊ Disturbance ◊ Fire	◊ Percentage of cultural landscapes in Good Condition (CLI) (AppC-1-Column IV)	60% of cultural landscapes in Good Condition (CLI)	Cultural Landscapes Condition Good – 0% Fair – 100%	No	A-13 C-24 F-49 K-69 Q-89
(5) **Historic, archaeological, and ethnographic resources:** Historic objects and ethnographic resources are appropriately preserved.	Historic archeolog-ical, and ethno-graphic resources: Physical condition	◊ Controlled environment ◊ Secure	◊ Pest infestation ◊ Human impacts ◊ Light ◊ Temperature	◊ Percentage of objects in Good Condition (ANCS+) (AppC-2) ◊ Percentage of ethnographic resources in Good Condition (ANCS+) (AppC-2)	100% of historic objects in Good Condition (ANCS+) 100% of ethnographic resources in Good Condition (ANCS+)	Historic Objects Good – 75% Ethno-graphic Resources Condition – Unknown	No No	L-70 L-71 Q-89

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(5) **Historic, archaeological, and ethnographic resources:** The National Park Service will ensure the preservation of resources associated with native peoples whose cultural memory, traditions, and lives are closely associated with the park and its general vicinity.	For Objects in museum collection: Physical condition Resource identification	◊ Controlled environment ◊ Secure	◊ Pest infestation ◊ Human impacts ◊ Light ◊ Temperature	◊ Percentage of resources (objects) in Good Condition (ANCS+) (AppC-2)	100% of resources (objects) in Good Condition (ANCS+)	Good – 75%	No	L-70 L-71 L-72 Q-89

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(5) Historic, archeological, and ethnographic resources: The National Park Service will ensure the preservation of resources associated with native peoples whose cultural memory, traditions, and lives are closely associated with the park and its general vicinity.	For resources that may be archeo-logical sites, cultural landscapes, or ethno-graphic: Physical condition Integrity Resource identifica-tion	◊	◊ Natural weathering ◊ Disturbance	◊ % of archeological sites in Good Condition (ASMIS) (AppC-1, Column III) ◊ % of cultural landscapes in Good Condition (CLI) (AppC-1, Column IV) ◊ Number and condition of ethnographic resources	50% of archeological sites in Good Condition (ASMIS) 50% of cultural landscapes in Good Condition (CLI) Number and condition of identified ethnographic resources listed in inventory	Archeologic al Site Condition Good – 28% Fair – 42% Poor – 10% Unknown – 20% Cultural Landscapes Condition Fair – 100% Number and condition of ethno-graphic resources - Unknown	No No No	A-10 A-11 A-12 A-13 F-49 Q-89

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(7) **Air quality:** Denali will achieve the highest attainable air quality levels and visibility standards consistent with the applicable Clean Air Act designations and the mandates specified by ANILCA and the NPS Organic Act; Denali is designated as a Class I airshed.	Air quality – chemical composition	◊ Remoteness ◊ Distance from industry ◊ Prevailing wind patterns ◊ Clean Air Act protection ◊ Improving emission standards ◊ Low human population density in Alaska ◊ Transportation system in Denali	◊ Coal-fired and other types of power generators ◊ Intercontinental contaminant transport ◊ Increasing size and frequency of wildland fires in North America and Asia ◊ Prevailing wind patterns ◊ Increasing global development ◊ Increasing global human population ◊ Local development (shallow gas, etc.)	◊ Concentration of ground-level ozone (AppD-72) ◊ Atmospheric deposition of sulfur in precipitation (AppD-73) ◊ Atmospheric deposition of nitrogen in precipitation (AppD-74) ◊ Lichen community structure (AppD-75)	Air quality parameters - remain stable or improve, as measured for NPS Performance Management Data System (PMDS) Goal Ia3 Lichen community structure – to be determined	Ground-level ozone concentration - stable Atmospheric deposition of sulfur in precipitation - stable Atmospheric deposition of nitrogen in precipitation - slightly degrading Lichen community structure - unknown parkwide	Yes Yes No Unknown	D-25

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(7) **Air quality:** Denali will achieve the highest attainable air quality levels and visibility standards consistent with the applicable Clean Air Act designations and the mandates specified by ANILCA and the NPS Organic Act; Denali is designated as a Class I airshed.	Visibility	◊ Remoteness ◊ Distance from industry ◊ Prevailing wind patterns ◊ Clean Air Act protection ◊ Improving emission standards ◊ Low human population density in Alaska ◊ Transportation system in Denali	◊ Coal-fired and other types of power generators ◊ Intercontinental contaminant transport ◊ Increasing size and frequency of wildland fires in North America and Asia ◊ Prevailing wind patterns ◊ Increasing global development ◊ Increasing global human population ◊ Local development (shallow gas, etc.)	◊ Visibility on clearest and on haziest days, as measured through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program (AppD-76)	Visibility on clearest and haziest days - remains stable or improves, as measured for PMDS Goal Ia3	Visibility on clearest days - improving Visibility on haziest days - stable	Yes Yes	A-8 D-25

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(6) Paleontological resources: Paleontological resources will remain unimpaired.	Integrity of individual sites and depositional environ-ments Geologic history Knowledge of potentially threatened locations	◊ Natural history record ◊ Visitor appreciation of natural resources ◊ Remoteness ◊ Restricted accessibility ◊ Inventory and/or monitoring frequency	◊ NPS development and other management actions ◊ Visitor impacts ◊ Access to site ◊ Advertisement of site ◊ Fossil hunters ◊ Erosion and other natural processes (e.g., acid rain, run-off)	◊ Percentage of sites effectively protected by management plan (AppD-77) ◊ Percentage of documented paleontological sites that have a good evaluation (AppD-78) ◊ Paleontological inventory (AppD-79)	% Sites protected - 100% % Sites of good quality – to be determined Inventory - complete	Sites protected - 0% % Sites of good quality – unknown Inventory - incomplete	No Unknown No	A-2 F-48
(9) Scientific research, education, and interpretation about natural ecosystems and geologic features and processes Denali serves as a living laboratory for research.	Interest by researchers in research at Denali Knowledge of research opportuni-ities	◊ List of research needed ◊ Efficient research and collecting permit process ◊ Web site and good press releases ◊ Available housing ◊ Cooperative relationships with park staff ◊ Availability of fellowships and funding	◊ Cost and time to travel to Denali ◊ Cost and time to access remote areas in the park ◊ Wilderness restrictions on backcountry access and research methods ◊ Restricted road access	◊ To be determined	To be determined	Unknown	Unknown	L-73 Q-88 Q-89 Q-90 Q-91 R-92 R-93 R-94 R-95 R-96 R-97 R-98 R-99

Desired Conditions for Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(9) Scientific research, education, and interpretation about natural ecosystems and geologic features and processes Park science is shared through education and interpretation to enhance visitor experience and build relationships with park resources and values.	In-person and virtual visitors connect to the park through science Visitors discover how science is used to manage park resources Visitors integrate resource insights into everyday lives	◊ MSLC building, programs, and partnerships ◊ Interpretive programs ◊ Web and other media used to share research ◊ Motivation of visitors, researchers, interpreters, educators ◊ Relationship with Doyon/ ARAMARK for bus opportunities	◊ Reliance on seasonal staff ◊ Insufficient staff to handle program workload ◊ Limited funding for programs, staff, and training ◊ Limited housing for staff or overnight program participants ◊ Limitations with use of wireless networks by non-NPS partners ◊ Misperceptions about options for park visits ◊ Lack of time for communications among park researchers and MSLC or interpretation staff	◊ To be determined	To be determined	Unknown	Unknown	L-73 Q-88 Q-89 Q-90 Q-91 R-92 R-93 R-94 R-95 R-96 R-97 R-98 R-99

Table 9: Attributes, influences, indicators, and target values for legislatively-defined areas.
Fundamental resources and values (shaded salmon pink) and other important resources and values are numbered. Numbers (and colors) correspond to the list on pages 3-4 and 6 and are also used in the matrix that begins on page 134 (explained on page 133). Lettering is blue here and in the matrix (page 134) to indicate that legislatively-defined areas are involved (corresponds to blue lettering on pages 8-9).

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
Old Park								
(1) **Wildlife populations, habitat, ecosystems**: Human activity will not result in a decrease of wildlife viewing opportunities along the park road.	Maintained opportunities for visitors to view wildlife from the park road	◊ Wildlife habituation ◊ Plentiful wildlife populations ◊ Ease of visitor access ◊ Lack of shrubbery ◊ Air clarity	◊ Avoidance of road by wildlife ◊ Restricted access ◊ Obstructed sightlines ◊ Lack of air clarity	◊ Percentage of reported bus trips with sightings of major mammal species (reported by park bus drivers) (AppD-80) ◊ Nesting density of shorebirds along the park road (AppD-81)	% of bus trips with sightings of major mammal species remains within the range of annual means (1976-2006) Density of nesting shorebirds in suitable habitat along the park road is no different than in suitable habitat away from the park road	% of bus trips with sightings of large mammal species - (2006 data) Bear 74% Caribou 87% Moose 58% Dall's Sheep 97% Wolf 39% stable Shorebirds - unknown	Yes Unknown	A-5 D-32 D-38 D-39 D-40 D-41 H-56 I-61 I-62 I-63

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(1) **Wildlife populations, habitat, ecosystems**: The community of life is untrammeled by human activity.	Highest standard of protection, naturalness of animal populations in old park areas.	◊ Wilderness designation ◊ Remoteness ◊ Size of park	◊ High visitation ◊ Road construction ◊ Wildlife habituation ◊ Inhibited wildlife movement	Number of harvested animals in or adjacent to wilderness areas (AppD-82) Numbers and demographic makeup of wildlife populations in old park (AppD-83) Patterns of wildlife migration routes (AppD-84)	Harvest of wildlife in old park - None Numbers and demographic makeup of wildlife populations in old park - Not significantly affected by harvest of animals outside the old park Migration routes - Park road traffic does not cause additional disruptions of migration routes	Harvest of wildlife in old park - Currently none Demographic effects - Unknown Migration routes - Some historic sheep migration routes appear to have been abandoned	Yes Unknown No	D-32 D-35 D-37 D-38 D-39 D-40 D-41 G-54 G-55 H-56 I-61 I-62 M-76 M-77 M-78 N-80 N-81

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
Park Additions and Preserve								
(1) Wildlife populations, habitat, ecosystems: Wildlife populations should be natural and healthy.	Natural wildlife populations (applies to old and new park only, not to preserve)	◊ Size ◊ Remoteness ◊ Low human numbers ◊ Highly regulated harvest ◊ Naturally functioning ecosystem	◊ Single-species management; predator control nearby ◊ excessive harvest ◊ exotic competitors or predators ◊ intensive management in surrounding areas	◊ Numbers (AppD-85), sex ratios (AppD-86), and age distribution (AppD-87) of species subject to subsistence harvested in new park areas	Numbers, sex ratios, age composition of harvested species - no significant difference between harvested and unharvested areas	Unknown Unknown Unknown	Unknown Unknown Unknown	D-35 D-37 D-38 D-39 D-40 D-41 G-54 G-55 H-56 M-77 M-76 M-78 N-80 N-81
(1) Wildlife populations, habitat, ecosystems: Wildlife populations should be natural and healthy.	Healthy wildlife populations	◊ Size ◊ Remoteness ◊ Low human numbers ◊ Highly regulated harvest ◊ Naturally functioning ecosystem	◊ Wildlife diseases ◊ Excessive harvest	◊ Population sizes of harvested species (AppD-88) ◊ Presence of human-introduced diseases in wildlife (AppD-89)	No declines in wildlife numbers caused by harvest No human-introduced diseases in wildlife	No evidence of declines in wildlife numbers No such diseases have been detected	Yes Yes	D-35 D-37 D-38 D-39 D-40 D-41 J-67 M-76 M-77 M-78 N-80 N-81

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(8) Subsistence Resources and Opportunities: Firewood	◊ Oppor-tunities for harvesting firewood	◊ Timber resources protected	◊ Roads, erosion, vegetative loss, clear cutting, and alteration of stand composition ◊ Excessive harvest	◊ % of people cutting firewood without a permit (AppD-90) ◊ Density (abundance) and distribution of timber (AppD-91) ◊ % of people who want to harvest firewood who are able to do so (AppD-92)	To be determined To be determined To be determined	Unknown Unknown Unknown	Unknown Unknown Unknown	B-17 G-54 G-55 M-75 M-79
(8) Subsistence Resources and Opportunities: Cabin Logs	◊ Oppor-tunities for harvesting logs for cabin construc-tion	◊ Timber resources protected	◊ Roads, erosion, vegetative loss, clear cutting, and alteration of stand composition ◊ Excessive harvest	◊ % of people cutting logs for cabin without a permit (AppD-93) ◊ Density (abundance) and distribution of timber (AppD-94) ◊ % of people who want to harvest logs for cabins who are able to do so (AppD-95)	To be determined To be determined To be determined	Unknown Unknown Unknown	Unknown Unknown Unknown	B-17 G-54 G-55 M-75 M-79

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(8) Subsistence Resources and Opportunities: Trapping	◊ Know-ledge of customs and traditions governing trapping	◊ Information for making C & T determina-tions	◊ Not known	◊ % of intergenerational trappers (AppD-96) ◊ % of people who want to trap who are able to do so (AppD-97)	To be determined To be determined	Unknown Unknown	Unknown Unknown	B-17 C-23 M-76 M-79
(8) Subsistence Resources and Opportunities: Trapping	◊ Sustain-ability of harvested popula-tion	◊ Trapping resources protected	◊ Loss of park resources due to consumptive uses ◊ Excessive harvest	◊ Density (abundance) and distribution of furbearers (AppD-98)	To be determined	Unknown	Unknown	B-17 C-23 D-40 M-76
(8) Subsistence Resources and Opportunities: Subsistence Hunting	◊ Con-sumptive uses of fish and wildlife do not disrupt or drive natural processes	◊ Hunting resources protected	◊ Loss of park resources due to consumptive practices ◊ Excessive harvests	◊ % of subsistence hunters who are active (AppD-99) ◊ % of people who want to subsistence hunt who are able to do so (AppD-100)	To be determined To be determined	Unknown Unknown	Unknown Unknown	B-17 D-35 D-37 D-38 D-39 D-40 D-41 F-51 G-54 G-55 J-67 M-77 M-78 M-79

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(8) Subsistence Resources and Opportunities: Subsistence Fishing	◊ Con-sumptive uses of fish and wildlife do not disrupt or drive natural processes	◊ Fishing resources protected	◊ Loss of park resources due to consumptive practices ◊ Excessive harvests	◊ % of subsistence fishers who are active (AppD-101) ◊ Density (abundance) and distribution of fish (AppD-102) ◊ % of people who want to subsistence fish who are able to do so (AppD-103)	To be determined To be determined To be determined	Unknown Unknown Unknown	Unknown Unknown Unknown	D-31 F-51 M-79

Table 10: Attributes, influences, indicators, and target values for management zones.

Fundamental resources and values (shaded salmon pink) and other important resources and values are numbered in the first column. Numbers (and colors) correspond to the list on pages 3-4 and 6 and are also used in the matrix that begins on page 134 (explained on page 133). Lettering is green here and in the matrix to indicate that management zones are involved (see also green lettering on pages 11-15).

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
Natural Area (Backcountry)								
(2) Wilderness resource values and wilderness recreational opportunities: Solitude and crowding	Opportunity for solitude, including privacy, isolation, and freedom from reminders of society	◊ Limits on overnight use in Old Park backcountry ◊ Lack of developed trails and infrastructure in the backcountry ◊ Wilderness designation in the Old Park ◊ Regulation prohibiting snowmachine use in the Old Park ◊ Remoteness of large portions of the area	◊ Congested landing areas/points of departure ◊ Social trail development ◊ High visitor demand for access to Mount McKinley and selected other locations in the southern additions ◊ Busy flightseeing flight paths in some areas	◊ Maximum # of encounters with other parties/large groups (AppD-104) ◊ Percentage of overnight backcountry users who are able to camp out of sight and sound of others (AppD-105)	Target varies by sub-zone (see Backcountry Management Plan (NPS 2006a)	Max # encounters with other parties – 2 (sub-zone OP1); unknown (elsewhere) % of campers who can camp out of sight and sound of others – 100% (subzone OP1); unknown (elsewhere)	# encounters - Yes (old park), unknown (elsewhere) % of campers who can camp out of sight and sound – Yes (subzone OP1), unknown (elsewhere)	H-57 O-83

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(2) Wilderness resource values and wilderness recreational opportunities: Untrammelled (Noise)	Opportunity for solitude: natural sound environ-ment	◊ Few roads in or near the park. ◊ Wilderness designation in Old Park	◊ Motorized noise from planes, snowmobiles ◊ Noise from cars, trains, and buses on borders of wilderness area and from park road	◊ Maximum % motorized noise heard per hour (AppD-106) ◊ Maximum number of motorized noises per day that exceed natural ambient sound level (AppD-107) ◊ Maximum loudness (dBA) of motorized noise (AppD-108)	Varies by sub-zone (see Backcountry Management Plan (NPS 2006a)	Unknown (limited data) Unknown (limited) Unknown (limited)	Unknown Unknown Unknown	D-44 G-54 G-55 H-57 O-82
(2) Wilderness resource values and wilderness recreational opportunities: Untrammelled (Signs of human activity)	Imprint of human-kind's work substantially unnotice-able	◊ Near-absence of developed backcountry infrastructure	◊ Equipment placed in the backcountry for administrative or research reasons ◊ Mining evidence ◊ Constructed trails in the backcountry	◊ Length/width/ number of social trails and area / number of campsites (AppD-109) ◊ # of visitors encountering litter or human waste (AppD-110) ◊ # of encounters with evidence of modern human use (AppD-111)	Varies by sub-zone. see Backcountry Management Plan NPS (2006a)	Unknown Unknown Unknown	Unknown No (old park), Unknown (else-where) Unknown	G-54 G-55 H-57 H-58 O-82 O-83

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
Park Development Zone – Park Road								
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Wildlife	Satisfaction with wildlife observa-tions	◊ Open landscape ◊ Wildlife habituated to buses ◊ Observation-friendly wildlife watching protocols ◊ Road restrictions for number/types of vehicles	◊ Crowding at wildlife stops ◊ Mud/dust ◊ Wildlife absent, distant, or obscured by vegetation	◊ % of visitors satisfied with wildlife viewing experience (AppD-112) ◊ % of visitors with satisfactory observations of 4 or more species of mammals or birds important to them (AppD-113)	To be determined	Unknown	Unknown	G-46 H-56
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Crowding issues	Lack of crowding on park road	◊ Cap on number of vehicles on road	◊ Clusters of tour bus departures ◊ Vehicle bunching at wildlife stops and rest areas	◊ # of visitors reporting conditions that exceed crowding threshold at rest areas and wildlife stops (AppD-114)	To be determined	Unknown	Unknown	H-56

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Limiting visual impairment from development	Lack of observable human develop-ment beyond the edge of the road/ wilderness character	◊ Wilderness designation of most of Old Park ◊ Sensitive planning to restrict development and respect viewsheds	◊ Incremental development	◊ Square footage of footprint of temporary or permanent non-historic structures visible from the park road within the Old Park boundary west of Savage River (AppD-115) ◊ % of visitors who report feeling they traveled through wilderness (AppD-116)	No increase from value in 2007 To be determined	Unknown Unknown	Yes Unknown	H-56
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Ensure basic needs of visitor	Comfort during bus rides	◊ Quality of buses	◊ Quality of buses	◊ % of visitors reporting conditions on the bus or during the bus ride which interfered with their experience (AppD-117)	To be determined	Unknown	Unknown	H-56

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Enjoy and inspire through understanding	Quality of educational experience provided during a bus trip	◊ Knowledge imparted during bus trip ◊ Interpretive training utilized ◊ Visitor services training utilized ◊ Motivation of personnel during bus trip	◊ Knowledge imparted during bus trip ◊ Interpretive training utilized ◊ Visitor services training utilized ◊ Motivation of personnel during bus trip	◊ % of visitors satisfied or very satisfied with the service, information, and interpretation provided during their bus trip (AppD-118) ◊ % of visitors who can identify one or more reasons for which Denali National Park and Preserve was established as a unit of the national park system (AppD-119)	To be determined To be determined	Unknown Unknown	Unknown Unknown	H-56
Park Development Zone – Entrance Area								
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Wildlife	Visitor opportunity to observe wildlife	Additional information to be determined						H-59

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Enjoy and inspire through understanding.	Visitor connection to natural landscape and wilderness character	Additional information to be determined						H-59
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Enjoy and inspire through understanding	Visitor enjoyment	Additional information to be determined						G-46 H-59

Resources & Values	Attributes	Beneficial Influences	Detrimental Influences	Indicators	Target (Desired Condition)	Current Condition	Target Met?	Related Project #
South Denali								
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Enjoy and inspire through understanding	Visitor enjoyment and appreciation of Mount McKinley and the Alaska Range	Additional information to be determined						G-46 H-60
(4) Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features: Wildlife	Wildlife viewing opportun-ities	Additional information to be determined						H-60

Comprehensive Strategies – Relationship to Park Resources and Values

Denali's 19 comprehensive strategies accomplish one of the following three objectives:

(1) Address gaps in knowledge identified in the section Status of Resource Knowledge.

(2) Provide information necessary to inform or monitor the indicators identified in the previous section.

(3) Mitigate or remediate harm done to park resources or visitor experiences when there are identifiable reasons that target values are not achieved or are at risk.

Each comprehensive strategy contains one or more projects. These projects will not become implemented unless the necessary compliance has been completed. No specific actions are suggested at this level of planning.

The relationship of strategies and projects to *Fundamental Resources and Values*, and to *Other Important Resources and Values* are indicated in the following matrix. Some strategies and projects apply parkwide, while others are specific to a legislatively-defined area or a management zone (see codes below that are used in the matrix). Most projects contribute toward *Other Resources and Values* #9 (Scientific research, education, and interpretation about natural ecosystems and geologic features and processes), so the matrix only includes an x in column 9 for the major research and education projects.

Parkwide

X = Parkwide

Legislatively-defined areas

OP = Old Park

NPP = Park Additions ("New Park") and Preserve

Management Zones

BC = Natural Areas (Backcountry)

Road = Park Development Zone – Park Road

Entrance = Park Development Zone – Entrance Area

South = South Denali

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
A1	Special Geologic Features Inventory			x						
A2	Paleontological Resources Inventory						x			
A3	Nonvascular Plants Inventory	x								
A4	Inventory of Rare and Endemic Flora	x								
A5	Inventory of Bird Status and Distribution	x OP								
A6	All Taxa Biodiversity Inventory	x								
A7	Wildland Fire History Prior to 1950	x								
A8	Inventory of Smoke Conditions							x		
A9	Burn Severity	x								
A10	Archeological Survey					x				
A11	Native Place Names Archeological Survey					x				
A12	Native Place Names Map					x				
A13	Inventory of Cultural Landscapes					x				

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
B14	Biological Effects of Climate Change	x								
B15	Physical Effects of Climate Change			x						
B16	Weather, Indices, and Fire Behavior	x								
B17	Ecological Impacts of Fires	x							NPP	
B18	Wildland Fire Return Intervals	x								
C19	Mining History					x				
C20	Mountaineering History					x				
C21	Scientific Legacy					x				x
C22	History of Park Road					x				
C23	Trapping History					x			NPP	
C24	National Register Nominations					x				
D25	Air Quality Monitoring							x		
D26	Monitoring of Climate and Snowpack	x		x						
D27	Glacier Monitoring			x						
D28	Permafrost Monitoring			x						

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
D29	Water Quality Monitoring	**x**		**x**						
D30	Stream Morphology Monitoring	**x**								
D31	Fish Monitoring	**x**							**NPP**	
D32	Monitoring of Passerine Birds	**x, OP**								
D33	Trumpeter Swan Monitoring	**x, OP, NPP**								
D34	Monitoring Golden Eagles and Peregrine Falcons	**x**								
D35	Monitoring Important Herbivore Species	**x, OP, NPP**							**NPP**	
D36	Small Mammal Monitoring								**NPP**	
D37	Caribou Monitoring	**x, OP, NPP**							**NPP**	
D38	Moose Monitoring	**x, OP, NPP**							**NPP**	
D39	Dall's Sheep Monitoring	**x, OP, NPP**							**NPP**	
D40	Wolf Monitoring	**x, OP, NPP**							**NPP**	

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
D41	Grizzly Bear Monitoring	**x, OP, NPP**							**NPP**	
D42	Monitoring Vegetation Structure and Composition	**x**								
D43	Landcover Monitoring	**x**								
D44	Soundscape Monitoring		**BC**							
D45	Monitoring of Plant and Landscape Phenology	**x**								
E46	Monitoring and Assessment of Geohazards				**Road, Entrance, South**					
E47	Documentation and Assessment of Wildland Fires	**x**								
F48	Paleontological Resources Management Plan						**x**			
F49	Cultural Sites Monitoring Plan					**x**				
F50	Natural Lightscapes Monitoring Plan			**x**						
F51	Waterway Navigability	**NPP**								

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
G52	Restoration of Mined Sites in Kantishna	**x**								
G53	Monitor and Mitigate Impacts of Park Gravel Acquisition Operations	**x**								
G54	OHV Trail Rehabilitation	**x, OP, NPP**	**BC**							
G55	OHV Impacts Monitoring	**x, OP, NPP**	**BC**							
H56	Integrated Study of Park Road Capacity	**OP, NPP**			**Road**					
H57	Backcountry Monitoring		**BC**							
H58	Trail and Campsite Impacts Monitoring		**BC**							
H59	Entrance Area Indicators and Standards				**Entrance**					
H60	South Denali Indicators and Standards				**South**					
I-61	Bear Habituation Management	**x, OP**								
I-62	Wolf Habituation Management	**x, OP**								
I-63	Wildlife Habituation	**x, OP**								

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
	Management – Other Species									
J64	Monitoring of Anthropogenic Contaminants	x								
J65	Exotic Plant Species Monitoring	x								
J66	Exotic Animal Species Monitoring	x								
J67	Wildlife Diseases Monitoring	x							NPP	
J68	Integrated Pest Management	x								
K69	Fuel Treatments and Wildland Fire Risk					x				
L70	Improving Collection Standards					x	x			x
L71	Digitizing the Museum Collection					x	x			x
L72	Addressing Catalog Backlog					x	x			x
L73	Creation of Finding Aids for Archival Collections					x				x
L74	Historic Structures Rehabilitation					x				
M75	Timber Resources Management								NPP	

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
M76	Furbearer Trapping Management	**OP, NPP**							**NPP**	
M77	Wildlife Population and Harvest Data	**OP, NPP**							**NPP**	
M78	Wildlife and State Game Regulations	**OP, NPP**							**NPP**	
M79	Documentation of Subsistence Customs and Traditions	**OP, NPP**							**NPP**	
N80	Harry Karstens Wildlife Protection Initiative	**OP, NPP**								
N81	Boundary Marking	**OP, NPP**								
O82	Dispersed Entry Visitation		**BC**							
O83	Day-Hiker Inventory		**BC**							
O84	Visitation Model				**x**					
P85	Human Populations Monitoring				**x**					
P86	Community Survey				**x**					
P87	Economic Impact Model				**x**					
Q88	GIS Database									**x**
Q89	Cultural Resources Data Management					**x**				**x**

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Resource Stewardship Strategies		Fundamental Resources and Values				Other Important Resources and Values				
		1	2	3	4	5	6	7	8	9
Strategy/ Project	Project Name	*Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem*	*Wilderness character, wilderness resource values, and wilderness recreational opportunities*	*Scenic and geologic values of Mount McKinley and surrounding mountain landscape*	*Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features*	*Historic, archaeological and ethnographic resources*	*Paleontological resources*	*Air quality*	*Subsistence resources and opportunities*	*Scientific research, education, and interpretation about natural ecosystems and geologic features and processes* [1]
Q90	Natural Resources Data Management									x
Q91	Data Dissemination and Availability									x
R92	Science-rich Media									x
R93	Trans-disciplinary Communications and Training									x
R94	Researchers-in-Residence									x
R95	Science-based Education Seminars									x
R96	Research and Community Connections									x
R97	Education Staff									x
S98	MSLC Staffing									x
S99	MSLC Facilities Development									x

Strategies and projects in relationship to resources and values—X = Parkwide; OP = Old Park, NPP = Park additions and preserve; BC = Natural Areas (Backcountry), Road = Park Development Zone – Park Road, Entrance = Park Development Zone – Entrance Area, South = South Denali

[1] In this matrix, only the projects with especially important links to research, education, and interpretation are included in the column.

Comprehensive Strategies – List of Strategies and Projects with Timeline and Budget

Denali's comprehensive strategies are presented in narrative and timeline/budget format (Tables 11-31) and are grouped as follows:

- Base Knowledge of Park Resources
- Monitoring Resources
- Management and Mitigation
- Parks and People
- Data Management
- Education and Communication
- Program Management

Originally no calendar years were given within the budget tables for the comprehensive strategies, because the timeline (year 1-20) suggests a sequence of activities rather than the activity programming for any one year. However, for Denali's RSS, year 1 was converted to 2008 (abbreviated because of space constraints in the tables as 08), year 2 to 2009, and so on, for ease of relating projects and funding requests through PMIS. Related and contingent activities may be listed together as a single complex "project." Activities that are not dependent on one another usually appear as separate projects.

Dollar amounts are in thousands of dollars (i.e., multiplied by $1,000) and are estimates in 2009 dollars. The first two columns represent actual dollars spend in 2008 and 2009.

Project funding is colored by fund sources (rows of table) and the colors correspond to those used in the budget bar graph (Figure11 on page 184). Funding sources are: Denali's park base funding (Operation of the National Park Service or OPS); project funding (Servicewide Comprehensive Call (SCC), Concession Franchise Fee (CFF), and Federal Lands Recreation Enhancement Act (FLREA); Inventory and Monitoring (I&M), which is also base funding (ONPS); and Centennial Challenge, which is Flexible Park Base (ONPS).

Park Base Funding | Project Funding | Inventory and Monitoring | Centennial Challenge

The following abbreviations are used in the strategy timeline tables to indicate programming:

Anl - analyze
Con - conduct
Doc - document
Evl - evaluate
Hir - hire
Imp - implement
Inv - inventory
Mng - manage
Map - map
Mon - monitor
Pln - plan/develop study or protocol
Rep - report
Res – research
Rev - review
Rst - restore
Svy - survey
Syn - synthesize
Upd - update

Base Knowledge of Park Resources

Strategy A: Complete physical, biological, and cultural resource inventories.
Identifying species, features, and processes where data gaps now exist will allow an improved basic understanding of park resources. The development and implementation of inventories, surveys, and focused research will improve basic information for making science-based management decisions about physical resources (projects 1, 2), biological resources (projects 3, 4, 5, 6), fire ecology (projects 7, 8, 9), and cultural resources (projects 10, 11, 12, 13). The outcome of these projects will be information that can be used to set or adjust indicators and targets for the condition of park resources in relation to the desired condition. Inventory data can be added to the baseline of park resource information used by the research community in site selection and interpretation of data.

1. **Special Geologic Features Inventory.** Identify and photograph the park's rare or unique geological features including possible "type sections" and periodically monitor their condition. Develop a database to document the location and condition of these geological features.

2. **Paleontological Resources Inventory.** Complete a formal park-wide inventory of known paleontological resources and document their location, abundance, ease of access, risk factors and disturbance, baseline condition, fragility, and protection measures needed, if any.

3. **Nonvascular Plant Inventory.** Conduct a comprehensive park-wide inventory of nonvascular plants (mosses, lichens, and liverworts).

4. **Inventory of Rare and Endemic Flora.** Conduct research to determine the distribution and habitat associations of rare and endemic flora.

5. **Inventory of Bird Status and Distribution.** Conduct an inventory to determine the park-wide presence, distribution, and breeding status of birds.

6. **All Taxa Biodiversity Inventory.** Investigate the feasibility of conducting an All Taxa Biodiversity Inventory (ATBI) in Denali. ATBIs incorporate citizen science, park scientists, and the research community to inventory biodiversity in park ecosystems.

7. **Wildland Fire History Prior to 1950.** Determine fire size, frequency, duration, and return interval by vegetation type and geographical area to enable fire managers and resource managers to make more informed decisions about fire management activities.

8. **Inventory of Smoke Conditions.** Determine the natural range of hazy conditions in the park caused by wildfire smoke.

9. **Burn Severity.** Using pre- and post-fire Landsat imagery, develop a robust mapping methodology and consistent data products to evaluate and compare burn severity within individual wildland fires and among fires across different ecosystems. Analyze burn severity every five years.

10. **Archeological Survey.** Survey high-probability areas to identify archeological resources for protection. Carry out the requirements of the National Historic Preservation Act.

11. **Archeological Survey of Sites with Native Place Names.** Survey sites identified by Athabaskan elders during the Native place names mapping project. Document traditional use patterns from late historic through contemporary periods.

12. **Native Place Names Map.** Convert into map form a report about Native place names in and around the park.

13. **Inventory of Cultural Landscapes.** Conduct a Cultural Landscape Inventory (CLI) to identify resources to be protected, as mandated by the Cultural Resource Management Guideline.

Table 11. Comprehensive strategy to complete physical, biological, and cultural resource inventories for Denali.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
A1	Special Geologic Features Inventory				Inv	Rep					Upd					Upd					Upd
					4	4					6					6					6
					20																
A2	Paleontological Resources Inventory	Pln	Pln	Inv	Inv	Inv	Rev	Rev	Rev	Rev	Rev	Evl	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Evl
		25	25	10	10	5	5	5	5	5	5	10	5	5	5	5	5	5	5	5	10
		0	0	50	50	50						15									15
A3	Nonvascular Plants Inventory	Inv	Inv	Inv																	
		37	37	14																	

Table 11. (continued)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
A4	Inventory of Rare and Endemic Flora	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
			14	14	14	14															
		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
A5	Inventory of Bird Status and Distribution			Pln	Inv	Inv	Inv	Rep													
				10	10	10	10	10													
				127	122	126	61														
A6	All Taxa Biodiversity Inventory									Evl											
										10											
A7	Wildland Fire History Prior to 1950		Pln	Pln	Pln	Pln	Imp	Imp	Imp	Imp	Imp	Rep	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Upd
			1	5	5	5	10	10	10	10	10	2	2	2	2	2	2	2	2	2	10
							50	50	50	50	50	25									
A8	Inventory of Smoke Conditions						Inv	Inv					Upd					Upd			
							25	25					5					5			
A9	Burn Severity		Map	Map	Map	Anl	Map	Map	Map	Map	Anl	Map	Map	Map	Map	Anl	Map	Map	Map	Map	Anl
			2	1	1	5	1	1	1	1	5	1	1	1	1	5	1	1	1	1	5
A10	Archeological Survey	Con	Con	Svy	Con	Svy	Svy	Svy	Con	Con	Svy	Svy	Con	Con	Svy	Svy	Svy	Con	Con	Svy	Svy
		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		130	119		30				35	35			25	25				35	35		
A11	Native Place Names Archeological Survey			Pln	Pln	Pln	Svy	Svy						Rev				Rev			
				2	2	2								2				2			
							60	60													
A12	Native Place Names Map		Map	Map	Map	Map			Pln	Map	Map	Map			Upd				Upd		
				2	2	2			2						2				2		
			18							20	20	20									
A13	Inventory of Cultural Landscapes	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		2	6	49	49	3	3	3	3	3	45	50	3	3	3	3	3	3	3	3	3

Strategy B: Develop an understanding of basic ecological relationships necessary for management decision-making.
Climate and natural processes (e.g., fire) play key roles in shaping Denali's landscapes. Many of the indicators selected in the Denali's RSS have targets described as needing to remain within the "range of natural variation." In response to climate changes, the "range of natural variation" may be changing. Analyses of how Denali's ecosystems are or may become impacted by climate change (projects 14, 15) will provide information about the existing or expected changes in "range of natural variation" so managers can make informed decisions about what can be managed and what is outside the control of management. New investigations and analyses of historical data about fire behavior, fire return intervals, and ecological impacts of fires (projects 16, 17, 18) will provide a better understanding of fire risk for safe fire management, and of ecological relationships in boreal forest and tundra ecosystems.

14. **Biological Effects of Climate Change**. Develop an understanding of how climate change may affect the distribution of plant and animal communities and animal behavior. Develop methods to understand how climate change affects the spread of exotic species. Identify native species of plants and animals that may be particularly vulnerable to the effects of climate change. Develop protocols to monitor effects of climate change on vulnerable species. Develop methods to predict the effects of climate change on the park's fire regime based on weather, fire perimeter, burn severity, and fire behavior data. Cooperate with UAF to model effects of climate change on fire regimes. Initiate projects to develop habitat selection models for important species and to understand how species respond to changes in their habitat.

15. **Physical Effects of Climate Change**. Develop an understanding of how climate change may affect local and regional weather patterns, snowpack, glacial dynamics, permafrost, weathering, air quality, and other aspects of the park's physical environment.

16. **Weather, Indices, and Fire Behavior.** Gather historical weather data, verify its accuracy, and establish good weather predictors associated with fire development, fire behaviors, and the end date of the fire season. Examine historical weather data for commonness and rarity of significant weather events to determine the probability of such events. Compare fire behavior outputs using the Canadian FBP software using Canadian Forest Fire Danger Rating System (CFFDRS) indices versus actual fire behavior. Evaluate the Fire Weather Indices within CFFDRS to predict large fire growth. Determine the utility of moisture probes to model CFFDRS indices, and evaluate whether alternative drought indices would be useful in Alaska.

17. **Ecological Impacts of Wildland Fires.** Gather and analyze existing data (e.g., 1980s paired plot and 2005-2007 videography and moose browse data) in order to investigate the effects of fires, including repeat fires and burn severity, and fire management practices of boreal forests, wildlife habitat, moose utilization, and subsistence resources. Investigate collaboration with Inventory & Monitoring program for long-term monitoring of fire impacts and hydrologic systems.

18. **Wildland Fire Return Intervals.** Analyze fuel characteristics (e.g., vegetation type, fuel load, moisture, and tree age) that allow previously burned areas to act as fuel breaks for new fires.

Table 12. Comprehensive strategy to develop an understanding of basic ecological relationships necessary for management decision-making.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
B14	Biological Effects of Climate Change	Pln	Pln	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con
		20	30	40	50	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
			33	101	22	125	120	260	265	265	265	265	265	265	265	265	265	265	265	265	265
B15	Physical Effects of Climate Change	Pln	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con
		10	10	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
				100	100	100								100	100	100					
B16	Weather, Indices, and Fire Behavior		Pln		Pln	Imp	Imp	Imp	Imp	Anl	Rev	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Upd
			1		25	25	75	25	25	15	5	5	5	5	5	5	5	5	5	5	15
	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
B17	Ecological Impacts of Fires	Anl	Anl	Anl	Anl	Rep				Pln	Mon	Anl	Anl	Rep						Pln	Mon
		8	4	5	5	15				10	55	5	5	15						10	55
B18	Wildland Fire Return Intervals		Syn				Pln	Pln	Pln	Pln	Imp	Imp	Imp	Anl	Rep						
			1				5	5	5	5	15	15	15	10	5						
											15	15	15	5	5						

Strategy C: **Develop the historic contexts necessary to evaluate resources and generate nominations for National Register significance.** To appropriately protect historic and archeological sites and the resulting cultural landscapes, these resources needs to be evaluated for National Register significance (project 24). However, to complete these determinations of eligibility, the sites need to be evaluated in their historic context. The record of historic context is a gap in knowledge, although pieces of the context are available from various sources. Several historical context themes need to be researched and compiled as in-depth histories—mining, mountaineering, science in the park, park road history, and the history of trapping and subsistence activities.

19. **Mining History.** Develop a comprehensive history of mining from primary research and existing documents to help recognize the influences and impacts of mining on park resources.

20. **Mountaineering History.** Document the history of mountain climbing as well as the scientific studies conducted on the mountain.

21. **Scientific Legacy.** Synthesize information about the history of scientific studies conducted in the park, organize it in a historical context, and assess gaps in the documentary record.

22. **History of the Park Road.** Develop a history of the park road—based on historic site and road construction records—to provide a good source for interpretation and management.

23. **Trapping History.** Document the trapping history of Denali before and after the establishment of the park in 1917, and before and after the additions of 1980, to provide valuable information for the historical and subsistence record.

24. Review and determine what sites are eligible for nomination to the National Register of Historic Places (complete Determinations of Eligibility). Write nominations for sites determined to be eligible for appropriate protection. Follow requirements of the National Historic Preservation Act.

Table 13. Comprehensive strategy to develop the historic contexts necessary to evaluate resources and generate nominations for National Register significance.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
C19	Mining History	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Pln	Doc	Doc	Rev	Rev	Rev	Rev	Rev	Rev	Upd	Rev	Rev	Rev
		1	1	1	1	1	1	1	3	3	3	1	1	1	1	1	1	3	1	1	1
										8	8										
C20	Mountaineering History	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Pln	Doc	Doc	Rev	Rev	Rev	Rev	Rev	Rev	Upd	Rev
		1	1	1	1	1	1	1	1	1	3	3	3	1	1	1	1	1	1	3	1
												10	10								
C21	Scientific Legacy	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Pln	Syn	Syn	Syn	Rev	Rev	Rev	Rev	Rev
		1	1	1	1	1	1	1	1	1	1	1	3	3	3	3	1	1	1	1	1
														8	8	8					

Table 13. (continued)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
C22	History of the Park Road	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Upd	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc
		1	15	15	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1	1	1
			23	20																	
C23	Trapping History	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Pln	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Upd	Doc	Doc
		1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	3	1	1
											8	8									
C24	National Register Nominations	Eval	Eval	Eval	Eval	Eval	Eval	Doc	Doc	Eval	Eval	Eval	Eval	Eval	Eval	Eval	Eval	Eval	Doc	Doc	Doc
		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
								55	55										33	33	33

Monitoring Resources

Strategy D: Develop and/or implement vital signs monitoring protocols for physical and biological resources to monitor long-term ecological change.

Monitoring the condition of physical and biological resources will provide the baselines to maintain, preserve, and protect the ecological integrity of Denali. High-standards monitoring will help identify factors that influence the park's ability to maintain natural and healthy populations and natural processes. All the projects listed below (except for Trumpeter Swans (project 33)) develop or implement the peer-reviewed monitoring protocols for fauna and flora identified as vital signs by the Central Alaska Network (CAKN). Not all CAKN vital signs listed as high relevance to Denali are listed here.

25. **Air Quality Monitoring**. Continue to implement air quality and visibility monitoring protocols in order to protect the park's air resources, which are designated Class I under the Clean Air Act. Continue to monitor lichen community structure (as a biological indicator of air quality) using the current vegetation monitoring protocols.

26. **Monitoring of Climate and Snowpack**. Continue to implement the climate and snowpack monitoring protocols in order to evaluate the influence of local and global climate trends on resources within the ecosystem.

27. **Glacier Monitoring**. Quantify broad-scale changes to glacial environments by implementing the existing glacier monitoring protocol. Update the protocol format to meet the standards of the Inventory and Monitoring program.

28. **Permafrost Monitoring**. Develop a permafrost monitoring protocol that incorporates diverse monitoring methods at multiple scales in order to evaluate permafrost status parkwide, identify permafrost trends and how they affect the ecosystem, and contribute to statewide and global permafrost monitoring efforts.

29. **Water Quality Monitoring**. Develop and implement monitoring protocols to measure success toward the park water quality goal: "Water quality of park rivers, streams, lakes, and ponds is improved and/or maintained to support a diverse aquatic community and ecosystem function, and to meet or exceed federal and state water quality standards." This effort includes Central Alaska Monitoring Network (CAKN) lake and stream studies.

30. **Stream Morphology Monitoring**. Develop and implement monitoring protocols to measure success toward the park goal: "Physical channel and floodplain integrity of park streams and rivers is maintained and/or improved to support natural geomorphic processes of fluvial systems and to support natural aquatic flora and fauna."

31. **Fish Monitoring.** Develop and implement a protocol to monitor the distribution and abundance of freshwater fish and of salmon spawning areas. Examine the effects of climate change, contaminants, water quality, and subsistence use on fish populations.

32. **Monitoring of Passerine Birds**. Continue to monitor passerine birds to determine how their abundance and distribution respond to changes in their habitats and to help document their population trends in the park and on a statewide level. Continue to conduct Breeding Bird Survey routes in Denali to assess broad-scale changes in the abundance and distribution of land birds along the two BBS routes and to provide information to state and continental bird monitoring programs.

33. **Trumpeter Swan Monitoring**. Continue to provide financial support to the U. S. Fish and Wildlife Service for monitoring trumpeter swan breeding populations in the park.

34. **Monitoring Golden Eagles and Peregrine Falcons**. Continue monitoring nesting area occupancy and breeding success of golden eagles to detect changes in occupancy and reproductive rates of the territorial populations. Continue to monitor peregrine falcon nest occupancy and breeding success.

35. **Monitoring Important Herbivore Species**. Develop monitoring protocols for important species of small- to medium-sized secondary producers. Species which have been identified as particularly important to Denali's ecosystem include arctic ground squirrels, red squirrels, snowshoe hares, willow ptarmigan, and beavers.

36. **Small Mammal Monitoring**. Continue to estimate annual population size and variation in small mammals in the Rock Creek drainage (using the Long-term Ecological Monitoring protocol).

37. **Caribou Monitoring**. Continue to provide financial support for the monitoring of the Denali Caribou Herd by the United States Geological Survey, Biological Research Division, in order to document the size, distribution, movements, and demographic makeup of the herd. Develop and implement a monitoring protocol for the Denali Caribou Herd.

38. **Moose Monitoring.** Finalize and implement the protocol for moose monitoring. Continue to conduct periodic moose surveys in a standardized 10,000-square-kilometer area north of the Alaska Range. Continue to conduct targeted moose surveys south of the Alaska Range to monitor locally-harvested moose populations.

39. **Dall's Sheep Monitoring.** Develop and implement a protocol to monitor the distribution and abundance of Dall's sheep. Develop and implement a protocol to monitor migratory movements of Dall's sheep, and the impacts of human activity on migration.

40. **Wolf Monitoring.** Finalize and implement the protocol for wolf monitoring. Continue to monitor numbers and territories of wolf packs north of the Alaska Range.

41. **Grizzly Bear Monitoring.** Develop and implement a protocol to monitor the distribution and abundance of brown bears. Continue to monitor cub production and survival of brown bears as a demographic component of the bear monitoring program.

42. **Monitoring Vegetation Structure and Composition**. Continue to implement the grid-based protocol to monitor vegetation communities across Denali.

43. **Landcover Monitoring.** Develop and implement protocols to monitor landcover and long-term landcover trends. Develop a protocol to detect short-term (0-17 years) differences in vegetation types particularly in burned areas. Develop a model for vegetation succession in burned areas.

44. **Soundscape Monitoring.** Develop and implement soundscape monitoring protocols in order to detect changes in soundscapes across the landscape, and to meet the monitoring requirements that are included in the Denali Backcountry Management Plan (NPS 2006a) and any that are developed for frontcountry areas.

45. **Monitoring Plant and Landscape Phenology.** Develop and implement a protocol to monitor the timing of seasonal snow cover, vegetation green-up, maximum greenness, and senescence on the landscape.

Table 14. Comprehensive strategy to develop and/or implement vital signs monitoring protocols for physical and biological resources to monitor long-term ecological change.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
D25	Air Quality Monitoring	Mon	Mon	Mon	Mon	Syn	Syn	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Syn	Syn	Mon	Mon	Mon	Mon
		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
		13	13	15	15	50	50	15	15	15	15	15	15	15	15	50	50	15	15	15	15
D26	Monitoring of Climate and Snowpack	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		100	100	120	120	100	100	100	100	100	100	100	100	120	120	100	100	100	100	100	100
		20	10	40	40									40	40						
D27	Glacier Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		20	20	20	20	50	50	20	20	20	20	20	20	20	20	50	50	20	20	20	20
		15	40	15																	
D28	Permafrost Monitoring	Mon	Mon	Mon	Mon	Mon	Syn	Syn	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Syn	Syn	Mon	Mon	Mon
		20	20	20	20	20	50	50	20	20	20	20	20	20	20	20	50	50	20	20	20
							10	10									10	10			
D29	Water Quality Monitoring	Mon						Mon	Mon	Mon						Mon	Mon	Mon			
		60						60	60	60						60	60	60			
D30	Stream Morphology Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
D31	Fish Monitoring	Dev	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		3	8	30	40	40	25	15	25	35	45	35	25	15	25	35	45	35	25	15	25
			16	79	75	75	20	0	70	55	99	55	70		20	55	75	105	20		20
D32	Monitoring of Passerine Birds	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
D33	Trumpeter Swan Monitoring			Mon					Mon					Mon					Mon		
				1					1					1					1		
				12					12					12					12		
D34	Monitoring Golden Eagles and Peregrine Falcons	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Table 14. (continued)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
D35	Monitoring Important Herbivore Species	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Pln	Imp	Imp	Imp	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		2	2	2	2	2	2	2	5	5	14	5	14	5	14	5	14	5	14	5	14
										145	145	145	105	5	105	5	105	5	105	5	105
D36	Small Mammal Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
D37	Caribou Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		48	48	48	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
		90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
D38	Moose Monitoring		Mon			Mon	Mon		Mon	Mon		Mon	Mon		Mon	Mon		Mon	Mon		Mon
			10			10	10		10	10		10	10		10	10		10	10		10
			35			20	20		20	20		20	20		20	20		20	20		20
			15			15			15			15			15			15			15
D39	Dall's Sheep Monitoring	Con	Con		Mon	Mon		Mon			Mon			Mon			Mon			Mon	
		10	5		10			10			10			10			10			10	
		12	6		30	75															
								30			30			30			30			30	
D40	Wolf Monitoring	Pln	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
		85	120	110	105	120	110	105	120	110	105	120	110	105	120	110	105	120	110	105	120
D41	Grizzly Bear Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Dev	Mon	Mon	Mon	Mon	Svy	Mon	Mon	Mon	Mon	Svy	Mon
		8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
		25	25	25	50	125	25	25	25	85	25	25	25	25	55	25	25	25	25	55	25
D42	Monitoring Vegetation Structure and Composition	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
D43	Landcover Monitoring	Anl	Anl	Upd			Anl		Upd			Anl		Upd			Anl		Upd		Anl
		5	8	8			25		8			25		8			25		8		25
				60					60					60					60		
D44	Soundscapes Monitoring	Mon	Evl	Mon	Mon	Mon	Mon	Evl	Mon	Mon	Mon	Mon	Evl	Mon	Mon	Mon	Mon	Evl	Mon	Mon	Mon
		85	95	100	100	100	100	140	100	100	100	100	140	100	100	100	100	140	100	100	100

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
D45	Monitoring Plant and Landscape Phenology	Pln				Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		8				8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
						40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40

Strategy E: Monitor natural resources that may need management response.
Monitoring geohazards (e.g., the slump at Mile 45 of the Denali Park Road) and wildland fires ensures that park managers have information to make decisions about the management of developed areas in the park to afford the highest degree of staff and public safety possible.

46. **Monitoring and Assessment of Geohazards**. Monitor and assess geohazards (e.g., earthquakes, landslides, avalanches, thermokarst) in the vicinity of developed areas in the park.

47. **Documentation and Assessment of Wildland Fires**. Continue to document wildland fires with GIS coverage of fire perimeters, on-site fire observations, and photography. Compare observed fire behavior with results from existing fire behavior models.

Table 15. Comprehensive strategy to monitor natural resources that may need management response.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
E46	Monitoring and Assessment of Geohazards	Mon	Mon	Mon	Mon	Evl	Evl	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Evl	Evl	Mon	Mon	Mon	Mon
		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
						20	20									20	20				
E47	Documentation and Assessment of Wildland Fires	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc
		6	65	20	20	20	55	20	20	55	20	20	55	20	20	55	20	20	55	20	20

Management and Mitigation

Strategy F: Develop and implement plans to monitor and manage vulnerable park resources.
Certain park resources are particularly vulnerable to human activities or certain management actions (e.g., dinosaur fossil sites, cultural sites, darkness of night sky, and water quality). These projects develop and implement indicators and standards and effective management plans to avoid or minimize the impacts of these activities and actions on park resources. Factors that occur outside park boundaries that affect Denali's resources would be considered as well to achieve and maintain the desired conditions for park resources.

48. **Paleontological Resources Management Plan**. Develop and implement a management plan for paleontological resources to guide research and resource protection, to prioritize searches for new sites, and to develop site monitoring protocols. (See also A2 above).

49. **Cultural Sites Monitoring Plan**. Develop and implement a cultural sites monitoring plan to standardize a rotating schedule for monitoring and assessing the condition of all cultural sites in the park to ensure appropriate protection.

50. **Natural Lightscapes Monitoring Plan**. Develop a monitoring plan to preserve natural lightscapes in the absence of human-caused light, and to minimize the impacts to lightscapes in developed areas by incorporating lightscape-sensitive lighting designs into site plans.

51. **Waterway Navigability.** Acquire all necessary data to assess navigability issues, support continued federal ownership where appropriate, and protect affected water resources within the park regardless of determination of title ownership.

Table 16. Comprehensive strategy to develop and implement plans to monitor and manage vulnerable park resources.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
F48	Paleontological Resources Management Plan	Pln	Pln			Rev					Rev	Upd	Upd			Rev					Rev
						10					10					10					10
		20	20									20	20								
F49	Cultural Sites Monitoring Plan			Pln	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
				5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Table 16. continued

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
F50	Natural Lightscapes Monitoring Plan						Pln	Evl					Evl					Evl			
							4	4					4					4			
								10					10					10			
F51	Waterway Navigability	Doc	Doc	Evl	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Evl	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc	Doc
		4	4	15	4	4	4	4	4	4	4	15	4	4	4	4	4	4	4	4	4
				15								15									

Strategy G: Restore and monitor disturbed lands.

Most of Denali's physical and biological resources are in near-pristine natural condition and therefore the indicators seek to maintain rather than to achieve the desired condition. There are a few areas where the integrity of landscapes has been compromised by placer mining (past) or OHV activities (past and present). Remedial actions are needed to restore disturbed lands (projects 52, 54), and to monitor their recovery and future condition (project 55). It is important with management activities that disturb rivers (e.g., scraping the Toklat River for gravel) that the physical channel, floodplain integrity, and natural geomorphic processes of fluvial systems are maintained so these systems support natural aquatic flora and fauna.

52. **Restoration of Mined Sites in Kantishna.** Revise and implement recovery plans for impaired watersheds (e.g., Slate Creek and Caribou Creek). Develop and implement restoration plans for disturbed mined lands in the Kantishna Mining District. Monitor disturbed and restored lands parkwide to ensure that restoration is effective and natural systems recover.

53. **Monitor and Mitigate Impacts of Park Gravel Acquisition Operations.** In areas of direct management impact from gravel acquisition, monitor and mitigate impacts to fluvial morphology and water quality.

54. **OHV Trail Rehabilitation**. Rehabilitate areas degraded by use of off-highway vehicles (OHVs) in the Cantwell Subsistence Traditional Use Area.

55. **OHV Impacts Monitoring**. Monitor the effects of OHVs on vegetation, wetlands, and other biological resources in areas where these vehicles are allowed for recreational and subsistence use on park and preserve lands.

Table 17. Comprehensive strategy to restore and monitor disturbed lands.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
G52	Restoration of Mined Sites in Kantishna	Rst	Rst	Rst	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		100	100	100	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
		793	244	1400																	
G53	Monitor and Mitigate Impacts of Park Gravel Acquisition	Mon	Mon	Res	Res	Mon	Mon	Mon	Evl	Mon	Mon	Mon	Mon	Evl	Mon	Evl	Mon	Mon	Evl	Mon	Mon
		35	35	100	70	20	20	20	20	20	20	20	20	20	20	50	20	20	20	20	20
		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
G54	OHV Trail Rehabilitation	Imp	Imp	Imp					Rst					Rst					Rst		
		214	205	133					100					100					100		
G55	OHV Impacts Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
		36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36

Strategy H: Determine and monitor visitor carrying capacity by management area.

Protection of park resources and positive visitor experiences are achieved and maintained when the influence of park visitation is known and incorporated into park planning. By developing and implementing monitoring protocols (and indicators and standards) for various management areas of the park (e.g., park road, backcountry, developed areas (trails and campsites, entrance area, South Denali)), which will work for different segments of the visitor population, Denali can comply with the Backcountry Management Plan and maintain quality visitor experiences while protecting park resources.

56. **Integrated Study of Park Road Capacity.** Complete the Park Road Capacity Study and develop indicators and standards for the park road experience beyond Mile 15. Develop monitoring protocols and studies for park road indicators and implement them at regular intervals. If indicated by the initial research, experimentally raise vehicle traffic and implement a Before-After-Control-Impact (BACI) study to determine whether standards are still achieved.

57. **Backcountry Monitoring.** Develop monitoring protocols using indicators of backcountry visitor experiences to address both day and overnight visits and to address year-round use. Develop protocols for monitoring impacts of visitor use on natural resources.

Collect information on new indicators for visitors, such as scenic air tour passengers, whose experience is not adequately measured by existing backcountry indicators. Implement these protocols at regular intervals.

58. **Trail and Campsite Impacts Monitoring.** Quantify specific standards to evaluate the impacts of social trails and backcountry campsites, including the climbing corridor on Denali. Develop and implement a protocol to detect changes in the spatial extent and distribution of these impacts, as required by the Backcountry Management Plan.

59. **Entrance Area Indicators and Standards.** Develop and implement monitoring protocols to ensure that standards for frontcountry visitor experiences are maintained.

60. **South Denali Indicators and Standards**. Develop and implement monitoring protocols to ensure that standards for South Denali visitor experiences are maintained. Conduct studies before and after major facilities are constructed. Incorporate the mandates of partner land management agencies, including the state park system's emphasis on Alaska residents.

Table 18. Comprehensive strategy to determine and monitor visitor carrying capacity by management area.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
H56	Integrated Study of Park Road Capacity	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con										
		20	20	20	20	10	10	10	10	10	10										
		387	200	200	225	250	175	200	200	200	200										
H57	Backcountry Monitoring								Svy					Svy					Svy		
									100					100					100		
H58	Trail and Campsite Impacts Monitoring	Mon	Mon	Mon	Mon	Svy	Svy	Svy	Mon	Mon	Mon	Mon	Svy	Svy	Svy	Mon	Mon	Mon	Mon	Svy	Svy
		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
			50			35	35	35					45	45	45					45	45
H59	Entrance Area Indicators and Standards			Svy					Svy					Svy					Svy		
				100					45					45					45		
H60	South Denali Indicators and Standards				Svy	Svy					Svy					Svy					Svy
					75	100					45					45					45

Strategy I: Minimize habituation of park wildlife.

To keep wildlife wild and humans safe, Denali has developed management plans for addressing bear-human and wolf-human interactions. These projects achieve the natural behavior of animals in Denali, part of the desired condition for the "Wildlife populations, habitat, ecosystems" fundamental resource and value.

61. **Bear Habituation Management**. Revise and continue to implement the management plan for brown bears. Continue to implement strategies to safeguard food and garbage from bears and protect visitor safety. Develop methods to assess the effects of road traffic on bear movements and demography.

62. **Wolf Habituation Management**. Complete and implement a wolf management plan. Continue to protect vulnerable den and rendezvous sites from disturbance. Continue to implement strategies to prevent wolf habituation.

63. **Wildlife Habituation Management – Other Species**. Use aversive-conditioning techniques as appropriate, to prevent wildlife behavior that might jeopardize the survival of wildlife or visitors. Manage human activities in such a way that wildlife does not become food-conditioned or otherwise habituated to human presence in harmful ways.

Table 19. Comprehensive strategy to minimize habituation of park wildlife.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
I-61	Bear Habituation Management	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93
		20	30		30																
I-62	Wolf Habituation Management	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
		4	15		4																
I-63	Wildlife Habituation Management – Other Species	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

Strategy J: Detect, monitor, and mitigate environmental influences external to the local natural ecosystem.

Park borders do not stop certain external influences (contaminants, exotics, diseases) from reaching Denali and impacting Denali's ecosystems. The goal is to identify, avoid, minimize, and mitigate those factors and management actions that increase contaminants, exotic species, disease, and other pests inside Denali to help keep wildlife and plant populations natural and healthy.

64. **Monitoring of Anthropogenic Contaminants.** Monitor the levels of contaminants in aquatic and terrestrial habitats and biota. Implement appropriate recommendations of the Western Airborne Contaminants Assessment Program (WACAP).

65. **Exotic Plant Species Monitoring.** Continue to monitor the distribution and spread of exotic plant species. Investigate the factors that allow exotic plants to enter and spread in the park, and manage exotic plant species where possible.

66. **Exotic Animal Species Monitoring.** Develop and implement a protocol to detect and monitor exotic animal species.

67. **Wildlife Diseases Monitoring**. Maintain awareness of the statewide distribution of significant wildlife diseases. Monitor the occurrence of diseases that pose a threat to park wildlife, with particular attention to human-introduced diseases.

68. **Integrated Pest Management**. Continue to implement an Integrated Pest Management (IPM) program to reduce risks to the public, park resources, and the environment from pests and pest-related management strategies.

Table 20. Comprehensive strategy to detect, monitor, and mitigate environmental influences external to the local natural ecosystem.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
J64	Monitoring Anthropogenic Contaminants								Mon										Mon		
									40										40		
J65	Exotic Plant Species Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
			46	46	46																

Table 20. continued

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
J66	Exotic Animal Species Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
J67	Wildlife Diseases Monitoring	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
J68	Integrated Pest Management	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl	Evl
		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		7	5	5	5	5															

Strategy K: Mitigate the risk of wildland fire to park infrastructure and cultural resource sites.

Knowing more about the response of vegetation after fuel treatments to reduce vegetation around structures in the frontcountry will help determine the most efficient ways to initially treat and maintain structures in full suppression zones. The goal is to protect cultural resources (and other infrastructure) from wildland fire.

69. **Fuel Treatments and Wildland Fire Risk.** Document the pre-and post-treatment condition of the vegetation of the 2004 Denali frontcountry hazardous fuels treatment; monitor the effects of the treatment on vegetation; and evaluate the original prescription. Model fire risk associated with different types of fuel treatments, including the frontcounty hazardous fuels treatment and untreated areas. Determine maximum efficiency in hazardous fuels reduction techniques for application at Denali and elsewhere in Interior Alaska. Address fire hazard in areas within full suppression zones that are untreated in order to prioritize fuel treatments. Plan and implement hazardous fuels reduction project to protect natural and cultural resources as needed.

Table 21. Comprehensive strategy to mitigate the risk of wildland fire to park infrastructure and cultural resource sites.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
K69	Fuel Treatments and Wildland Fire Risk	Imp	Mon	Evl	Rep	Imp	Imp	Evl	Imp	Imp	Imp	Imp	Mon	Upd	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		71	42	48	48	40	40	44	40	40	40	40	50	56	40	40	40	40	40	40	40
			69	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Strategy L: **Preserve the museum collection and rehabilitate and preserve park historic structures.**
Protecting the resources and values associated with historic, archeological, and ethnographic resources requires bringing the museum collections to standards (projects 70, 72) and rehabilitating historic structures (project 74). In addition, Denali will be able protect the museum collection, while still providing for access, by making electronic records (project 71) and by making finding aids (project 73).

70. **Improving Collection Standards.** Write the Scope of Collections Statement (SOCS), an Integrated Pest Management Plan, an Emergency Operations Plan, and a Structural Fire Plan for the Denali museum collection. Purchase equipment and storage materials (e.g., museum cabinets, shelving, archival supplies, and digital storage space). Re-house archival material and store natural history specimens properly. Meet 79 of 82 Collection Standards by completion of this project.

71. **Digitizing the Museum Collection**. Photograph objects in the museum collection and digitize the archival collections in order to enhance object descriptions, document the condition of museum objects, provide visual cues to identify objects, and ensure the preservation and availability of the entire collection. Transfer motion picture film and oral history audiotapes to the medium that is preferred for long-term preservation.

72. **Addressing Catalog Backlog.** Catalog research and management documents to preserve the information and make them accessible for historical and scientific research, beginning with documents related to the ongoing predator-prey study and documents related to mining.

73. **Creation of Finding Aids for Archival Collections.** Create finding aids (documents that list what is available) to protect documents by decreasing the frequency with which they need to be handled.

74. Historic Structures Rehabilitation. Rehabilitate historic structures in the park (e.g., Doty House, Busia Cabin, Pearson Cache, and the Hotel Powerhouse). Improve the condition of these structures from poor or fair to good.

Table 22. Comprehensive strategy to preserve the museum collection and rehabilitate and preserve park historic structures.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
L70	Improving Collection Standards	Imp	Imp	Imp			Imp		Imp		Imp		Imp		Imp		Imp		Imp		Imp
							5		5		5		5		5		5		5		5
		116	105	110																	
L71	Digitizing the Museum Collection				Imp	Imp		Imp		Imp		Imp		Imp		Imp		Imp		Imp	
								5		5		5		5		5		5		5	
					35	35															
L72	Addressing Catalog Backlog			Mng	Mng	Mng		Mng		Mng		Mng		Mng		Mng		Mng		Mng	
								5		5		5		5		5		5		5	
				40	40	40															
L73	Creation of Finding Aids for Archival Collections					Imp	Imp	Imp	Imp		Imp		Imp		Imp		Imp		Imp		Imp
											5		5		5		5		5		5
						30	30	30	30												
L74	Historic Structures Rehabilitation	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst	Rst
		52	46	70	50	70	50	70	50	70	50	70	50	70	50	70	50	70	50	70	50
		575	550	94																	
		221	252	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260

Strategy M: Monitor and manage consumptive uses of park resources, including subsistence use.

Consumptive uses of fish and wildlife (subsistence use or sport) or timber products should not be allowed to disrupt or drive the natural processes of Denali's ecosystems. Management decisions, which protect park resources and thereby continue to provide for subsistence ways of life as well as sport opportunities, will be better informed by developing and implementing monitoring protocols for documenting forest resources (project 75), trapline activities (project 76), and past and contemporary wildlife harvests, harvest areas, and means of transportation (projects 77, 78, 79). Outcomes would include a comprehensive parkwide firewood/log management plan for qualified subsistence users and a furbearer harvest program.

75. **Timber Resources Management**. Establish a monitoring protocol to assess timber resources using plots and aerial photography. Formulate a plan for the subsistence use of forest/timber resources (firewood and cabin logs) in the park.

76. **Furbearer Trapping Management.** Establish a furbearer harvest program, working with local trappers and ADF&G. Obtain furbearer harvest data from trapper surveys and ADF&G records. Assess the effects of various trapline management regimes on the population dynamics of marten and other furbearers.

77. **Wildlife Population and Harvest Data**. Acquire data about wildlife populations and about subsistence and sport harvests. Evaluate existing data for consistency and identify gaps in knowledge of harvest numbers. Conduct wildlife population surveys as needed. Track ADF&G harvest data for game management units that include park lands.

78. **Wildlife and State Game Regulations.** Work with ADF&G and the Alaska Board of Game to identify regulations and management practices that would assist the National Park Service in achieving desired conditions for park wildlife.

79. **Documentation of Subsistence Customs and Traditions.** Document the history of contemporary and traditional subsistence practices, the adoption and use of new technologies for subsistence activities, and the impacts of federal management regulations and policies on the subsistence way of life.

Table 23. Comprehensive strategy to monitor and manage consumptive uses of park resources, including subsistence use.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
M75	Timber Resources Management		Dev	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Upd	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Upd
			2	1	1	1	1	1	1	1	1	5	1	1	1	1	1	1	1	1	5
			22																		
M76	Furbearer Trapping Management		Dev	Dev	Imp	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Upd	Mon	Mon	Mon	Mon	Mon
			1	5	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1
			25	10																	
M77	Wildlife Population and Harvest Data			Pln	Dev	Svy	Mon	Mon	Mon	Mon	Svy	Mon	Mon	Mon	Mon	Svy	Mon	Mon	Mon	Mon	Svy
				5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
						10					10					10					10

Table 23. continued

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
M78	Wildlife and State Game Regulations	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev	Rev
		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M79	Documentation of Subsistence Customs and Traditions			Dev	Svy	Svy	Mon	Mon	Mon	Mon	Dev	Svy	Svy	Mon	Mon	Mon	Mon	Dev	Svy	Svy	Mon
				5	3	3	2	2	2	2	2	3	3	2	2	2	2	2	3	3	2
					25	25						20	20						25	25	

Strategy N: Enhance and increase the effectiveness of wildlife protection by deterring illegal activities.
Curtailing illegal motorized access to park lands and poaching of wildlife helps keep wildlife populations natural and healthy.

80. **Harry Karstens Wildlife Protection Initiative**. Deter illegal OHV activity and illegal hunting through an integrated program. Provide consistent ground and aerial patrol presence, including hiring additional backcountry and winter kennels staff, and by increasing access to helicopter during hunting season. Map OHV trails parkwide. Increase the effectiveness of patrols by regular upgrading training and equipment. Provide training in GIS, GPS, and database management to ranger staff. Organize data and information-gathering tools to improve targeting of patrol activity. Enlist the cooperation of other agency enforcement personnel, volunteer boundary watchers, and local community members. Educate the public about park regulations and the park mission through printed material, maps, and displays.

81. **Boundary Marking.** Mark critical sections of the park boundary and develop a GIS inventory of boundary sign locations so that signs can be effectively monitored and maintained over time.

Table 24. Comprehensive strategy to enhance and increase the effectiveness of wildlife protection by deterring illegal activities.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
N80	Harry Karstens Wildlife Protection Initiative	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		360	375	475	475	550	600	625	625	625	625	625	625	625	625	625	625	625	625	625	625
		59	152	125	125	125	125	75	75	75	75	75	75	75	75	75	75	75	75	75	75
N81	Boundary Marking	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
		84	62						60	40	40					60	40	40			

Parks and People

Strategy O: Improve estimation of park visitation.

Estimates of the number of park visitors by different visitor segments will help park managers to gauge visitor impacts on park resources, provide for quality park experiences to various segments, and to custom-fit park protection messages to each segment. Tools and models are needed to estimate total number of visitors and track numbers in distinct visitor segments, including dispersed entry visitors, and frontcountry and backcountry hikers. Visitor carrying capacity needs to be defined in two management zones. Some significant types of park visitation are not accounted for, and the park's model for estimating visitation needs to be improved.

82. **Dispersed Entry Visitation.** Develop a tool to estimate the numbers and describe the basic visit characteristics for dispersed entry visitors (those who enter the park from locations other than the park road, including those who fly over but may not land).

83. **Day-Hiker Inventory.** Develop a system for estimating day-hiker use both in the frontcountry and backcountry, to answer questions about how many visitors are day-hiking, what their demographic characteristics are, and where and how far they go when day-hiking in Denali.

84. **Visitation Model**. Develop a comprehensive model for estimating visitation to Denali within different visitor segments (e.g., independent travelers, packaged tour visitors with one overnight) during all seasons. Replace the formula presently used in the Monthly Public Use Report with the model that incorporates not only visitor counts but also indirect data from state and other sources.

Table 25. Comprehensive strategy to improve estimation of park visitation.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
O82	Dispersed Entry Visitation		Dev	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon	Mon
				2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
			2																		
O83	Day-Hiker Inventory			Con										Con							
				80										50							
O84	Visitation Model		Pln	Evl	Evl	Evl	Imp	Imp	Imp	Imp	Imp	Rev	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
			8	115	105	105						15									

Strategy P: **Monitor trends in adjacent community populations, land use, and local economy.**
The relationship of surrounding human communities and land uses to park visitors and resources is not well understood. Measuring community understanding and support of Denali in gateway communities from Anchorage to Fairbanks and nearby Bush communities (e.g., Minchumina, Nikolai, Skwentna) will help managers learn if efforts are needed to inform the public about the national park's role in the community's economy. This strategy also coordinates with the CAKN human use vital sign monitoring (project 85).

85. **Human Populations Monitoring.** Develop and implement a CAKN-prescribed monitoring protocol to use state and federal census data to monitor trends in the number of people residing in communities in and near the park.

86. **Community Survey**. Develop a survey to be employed periodically in a random sample of citizens from communities between Anchorage and Fairbanks to measure such things as the public perception of the national park as a beneficial/detrimental influence in

the region; public understanding of the purposes of the park; the reasons for local public use or avoidance of the park; and the response of local community members to current and potential management strategies (including fire management).

87. **Economic Impact Model**. Develop an economic model—potentially in cooperation with other parks or the entire Alaska Region—that demonstrates the impact of Denali on local and regional jobs and on income.

Table 26. Comprehensive strategy to monitor trends in adjacent community populations, land use, and local economy.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
P85	Human Populations Monitoring				Svy	Svy					Svy				Svy					Svy	
					5	5					5				5					5	
P86	Community Survey						Svy									Svy					
							5									5					
							85									85					
P87	Economic Impact Model						Pln					Rev					Rev				
							25					15					15				

Data Management

Strategy Q: Develop and implement effective data management strategies for use by managers, specialists, and the public.
For information about park resources and research to be most useful in support of park management and decision-making, it needs to be stored, organized, and available for distribution or further analysis. Data management must comply with formats that are standardized.

88. **GIS Database**. Assure that the GIS database accurately manages park resource information for efficient use by park and associated researchers and managers, including natural resource data layers, cultural resource base map, access routes (OHV, boat, trail, etc), hunting camps, and available base maps in coordination with AKRO data service standards. Develop new layers as required for park

management through other projects identified in this strategy. Develop tools and training to effectively use geospatial data throughout the park. Where appropriate, make GIS data available to the public through NPS internet sites.

89. **Cultural Resources Data Management**. Standardize and update all records in the Automated National Catalog System (ANCS+) for museum records, the Archeological Site Management Information System (ASMIS) for archeological records, and the List of Classified Structures (LCS) for historic building records.

90. **Natural Resources Data Management**. Develop standardized data management, archiving, and distribution for natural resource data sets, technical reports, and research-related records. Coordinate with the CAKN data management structure and efforts.

91. **Data Dissemination and Availability.** Develop an appropriate Internet data distribution system for commonly requested natural resource data sets (e.g., climate, wildlife, air quality, museum collections, and technical library). Coordinate with CAKN data dissemination efforts.

Table 27. Comprehensive strategy to develop and implement effective data management strategies for use by managers, specialists, and the public.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
Q88	GIS Database	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng
		80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Q89	Cultural Resources Data Management	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng
		25	25	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Q90	Natural Resources Data Management	Mng	Dev	Dev	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng
		40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
			35	50	50																
Q91	Data Dissemination and Availability	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng
		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
			35	75	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

Education and Communication

Strategy R: Facilitate the education of all audiences (external and internal) about resource issues in and around Denali to gain support for the park's management decisions.
The ability to widely share important park protection messages increases when there are professional education staff (project 97), solid communication connections among education and resource staff (project 93), and collaborative partnerships and programs (projects 92, 94, 95, 96).

92. **Science-rich Media.** Create science-rich information and interpretation materials in a variety of media including publications, newsletters, curricula, fact sheets, talking points, websites, and technology-enhanced learning (e.g., on-line digital video).

93. **Trans-disciplinary Communications and Training.** Encourage communications and training across disciplines of science and interpretation (e.g., encourage seasonal interpretive rangers to participate in park research, offer interpretation training seminars for Denali scientists and science training for interpreters). Strengthen regular communications among staff of Murie Science and Learning Center (MSLC) and Center for Resources, Science, and Learning.

94. **Researchers-in-Residence.** Offer park-based sabbaticals for researchers, in order to have researchers collaborate with educators, and communicate the relevance of their projects to various audiences.

95. **Science-based Education Seminars.** Host seminars for specific audiences (e.g., the current MSLC Field Seminars or the *Fire in Alaska* workshop).

96. **Research and Community Connections.** Engage resource staff and researchers in local communities through their involvement in science-based curricula, citizen science programs, teacher trainings, youth camps, and high school or college level internships.

97. **Education Staff.** Support Denali's educational staffing by converting two education specialist positions from temporary subject-to-furlough (TSTF) to permanent subject-to-furlough (PSTF).

Table 28. Comprehensive strategy to facilitate the education of all audiences (external and internal) about resource issues in and around Denali to gain support for the park's management decisions.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
R92	Science-rich Media	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		27	29	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
		46	63	108	62	62	37	37	62	62	62	37	37	62	62	62	37	37	62	62	62
R93	Trans-disciplinary Communications and Training		Imp	Imp	Imp			Imp	Imp	Imp			Imp	Imp	Imp			Imp	Imp	Imp	
					15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
			15	15	15			15	15	15			15	15	15			15	15	15	
R94	Researchers-in-Residence		Imp					Imp					Imp					Imp			
			34					34					34					34			
R95	Science-based Education Seminars	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con	Con
		2		2	20	22	20	22	20	22	20	22	20	22	20	22	20	22	20	22	20
			27	50			75			50			50			50			50		
R96	Research and Community Connections	Imp	Imp	Imp	Imp	Imp	Evl		Imp	Imp	Imp	Imp	Evl		Imp	Imp	Imp	Imp	Evl		Imp
					30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
		10	36	4	30	4	27		5	10	5	10	8		5	10	5	10	8		10
R97	Education Staff	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
				90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
		140	140	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70

Strategy S: Develop staffing and infrastructure to enhance bridges between research and interpretation, and to facilitate higher levels of understanding and preservation of park resources.

Staff and facilities development will bring the Murie Science and Learning Center to the intended level of "fully operational" in support of its goals for Denali and the other MSLC parks.

98. **MSLC Staffing.** Hire an MSLC Research Coordinator and a MSLC Webmaster, and continue to fund an MSLC Education Coordinator, who would work in partnership between the Center for Resources, Science, and Learning and the MSLC.

99. **MSLC Facilities Development.** Fund and build the year-round MSLC Residential Facility to support staff, visiting researchers, and education groups. Funds would either be obtained through project funding or a donation capital campaign.

Table 29. Comprehensive strategy to develop staffing and infrastructure to enhance bridges between research and interpretation and to facilitate higher levels of understanding and preservation of park resources.

(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
S98	MSLC Staffing	Imp	Imp	Hir	Hir	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
		90	90	200	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270	270
					45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
S99	MSLC Facilities Development									Imp											
										900											

Program Management

The National Park Service will pursue several strategies that have budgetary implications and that underlie the success of all the other strategies and projects described. These are not discreet projects but general ways of doing business that should be continuously addressed. The budget table below shows resource support for strategies and projects comes in the form of support from several divisions, informally referred to as Resources, Rangers, and Maintenance. They include the following:

Conduct periodic strategic program reviews. Periodically review the park's staffing situation, in order to identify potential or impending deficiencies or strengths. Identify projects, make appropriate budget plans and form strategic partnerships to solve staffing needs. Fill identified staffing needs in research, enforcement, and interpretation to accomplish the strategies and projects that have been identified.

Provide adequate staff training, development, and learning opportunities. Maintain a high level of expertise and professionalism among resources, enforcement, interpretation, and education staff. Provide multiple opportunities for staff to learn and develop new skills, acquire new knowledge, become familiar with new equipment or techniques, and distribute research results.

Collaborate with other agencies and institutions. Work with other land management agencies, federal, state or private biologists and researchers, and universities to maintain high standards of inventory, management, and research activities. Collaborate with other enforcement agencies to cultivate an interest in wildlife protection at Denali. Consult with Native Alaskan tribes in relation to subsistence resources and cultural programs.

Engage external research partners. Develop and circulate information on resource knowledge gaps to researchers. Facilitate research and provide basic logistics to attract quality research that will inform park management and protection activities. Examples of ongoing partnerships include those with the University of Alaska Geophysical Institute, the University of Alaska Geology Field Camp, partnerships with several regional Cooperative Ecosystem Study Units, and partnerships with USGS researchers.

Maintain accountability for mitigation prescribed through environmental analysis. Monitor compliance with and effectiveness of mitigation measures prescribed through NEPA environmental analysis (Environmental Impact Statements, Environmental Assessments) of new development projects, including no net loss of wetlands. Monitor compliance of resource projects with all other applicable regulations, including the Animal Welfare Act and Wilderness Act.

Table 30. Comprehensive strategy to support other strategies and projects.
(see page 142 for list of abbreviations and color codes for funding sources)

	Resource Stewardship Strategies	Year																			
		08	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
	Resources Administration	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng
		135	184	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150
	Resource Protection (Rangers)	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng	Mng
		1075	1084	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
		187	312	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250

Expert Review of Comprehensive Strategies

Review by subject matter experts, conducted by outside topical specialists, ensures that comprehensive strategies developed by the park are the best management strategies, based on current science and scholarship. The rationale for expert-review suggests that an individual author or team may not catch every flaw in a complicated comprehensive strategy. Expert review from scientific peers increases the probability that weaknesses will be identified and corrected.

Although the RSS does not outline implementation procedures, it does outline the methodical process necessary to improve or maintain current conditions. Experts are asked to look at methods for determining current conditions, methods for measuring changes in those conditions, and the logical sequence of events that are needed to attain desired conditions. They ascertain whether the comprehensive strategies are credible, feasible, and practicable given the current state of art and science in resource management. Each reviewer certifies the review of the document (Appendix E).

Expert Reviewers for Denali's RSS:
(1) Maggie MacCluskie Ph.D., National Park Service, Central Alaska Network I&M Coordinator, Fairbanks
(2) Karen Oakley Ph.D., U.S. Geological Survey, Alaska Science Center, Anchorage

Projected Funding Needs to Implement the RSS

One purpose of the RSS is to guide the park's investment (human and fiscal) in stewardship of cultural and natural resources. The RSS provides accountability of funds used for attaining and maintaining desired conditions as well as projections of needed project and base funding. Although comprehensive strategies can be plotted for a 20-year time period, financial planning is difficult to do over a similar time span. Project planning is generally done for five-years into the future.

This section provides information on past and projected costs of park operations and resource stewardship. Operations represent all activities that are not directly associated with resource stewardship, such as administration, visitor facilities, and visitor programs. Cultural and Natural resource budgets are kept separate for comparison purposes. Past years budget information is taken directly from an NPS administrative software package called AFS-3. Future projections of base funding costs are calculated from current park base funding with the addition of costs related to attaining or maintaining desired conditions in a reasonable time period. The Budget Cost Projection system may become the source of the budget projection. A complete explanation of budget overview value calculation is in Appendix F. This method of cost projection differs significantly from methods associated with the *Park Business Plans* and the *Living Within Our Means 85% Plan*. These two methods take into account limited fiscal resources, while the RSS attempts to project what would be needed fiscally to attain desired conditions within a reasonable time-frame and to maintain those conditions once they are achieved.

Figure 4. Distribution of Denali's ONPS (base) budget in FY2009.
Program area activities in support of resource stewardship are indicated in color. Other park activities funded through ONPS, regardless of program area, are combined into "Other ONPS."

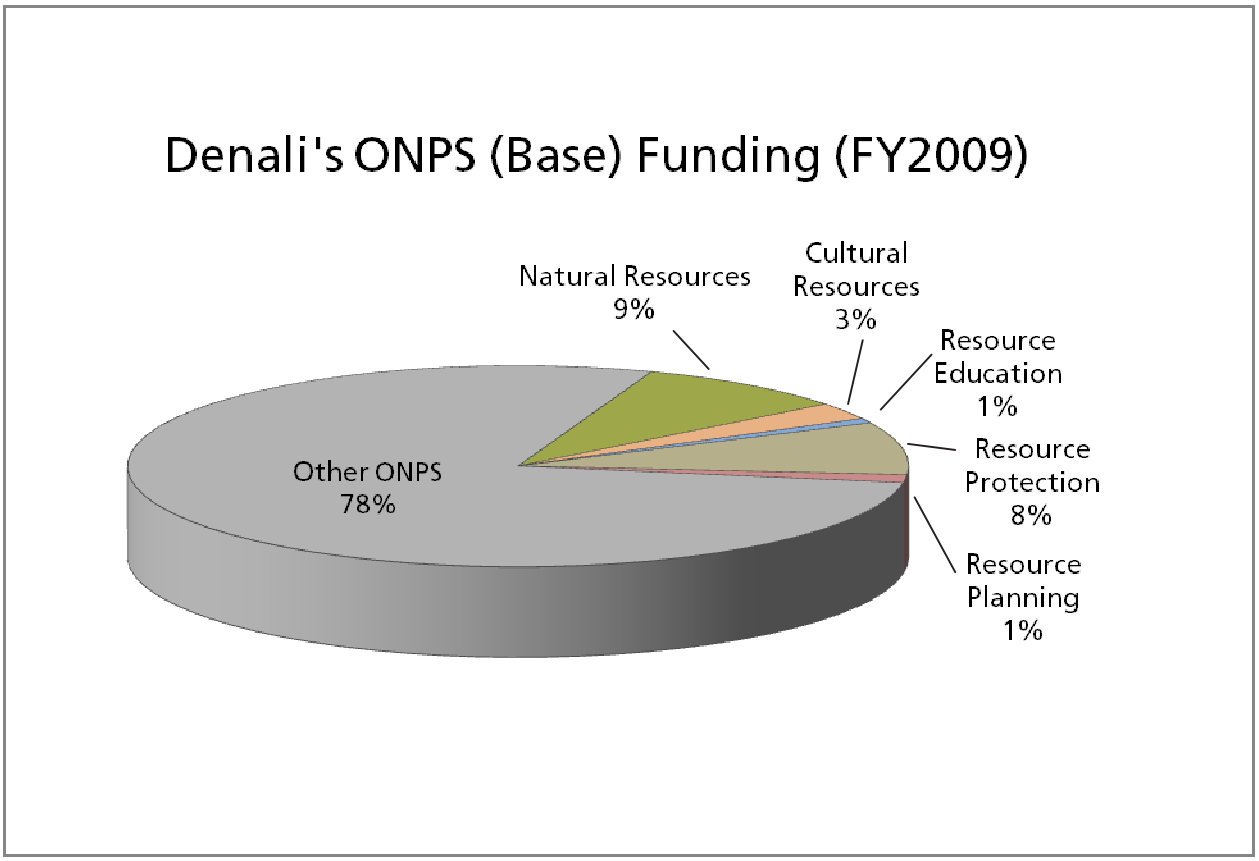


Figure 5a: Current organizational chart (all divisions).

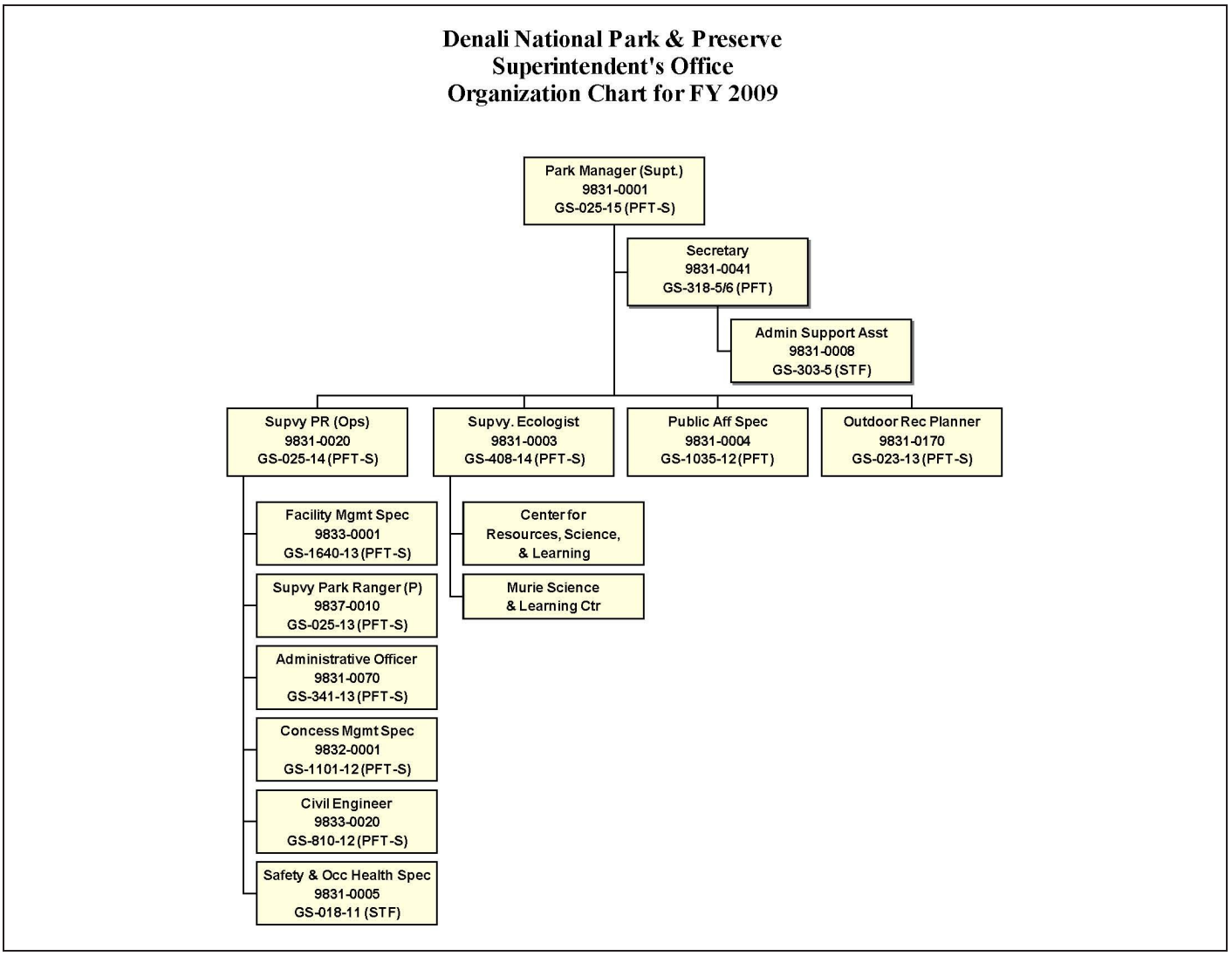


Figure 5b: Current organizational chart (Center for Resources, Science, and Learning).

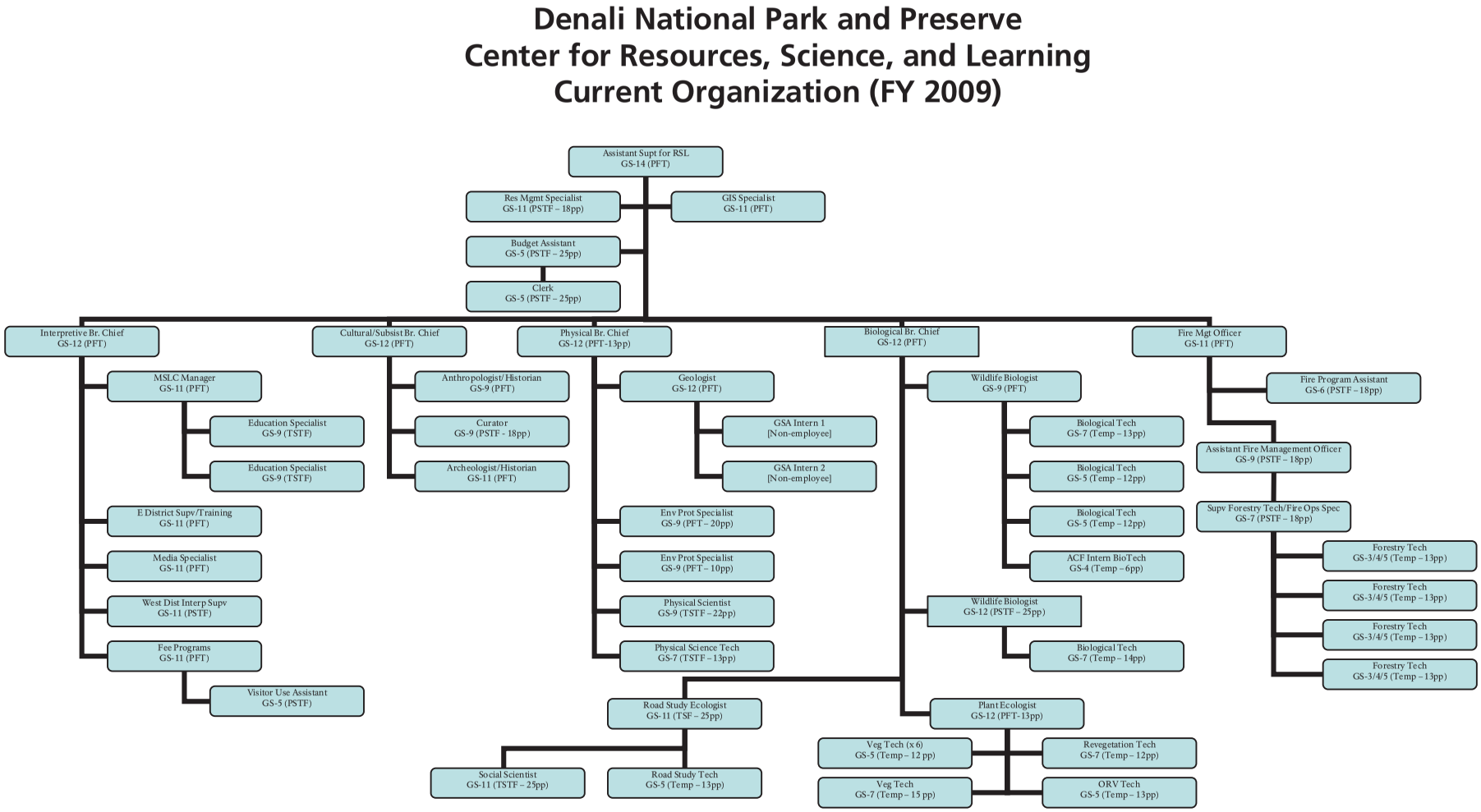


Figure 6. Optimal organizational chart (Center for Resources, Science, and Learning).

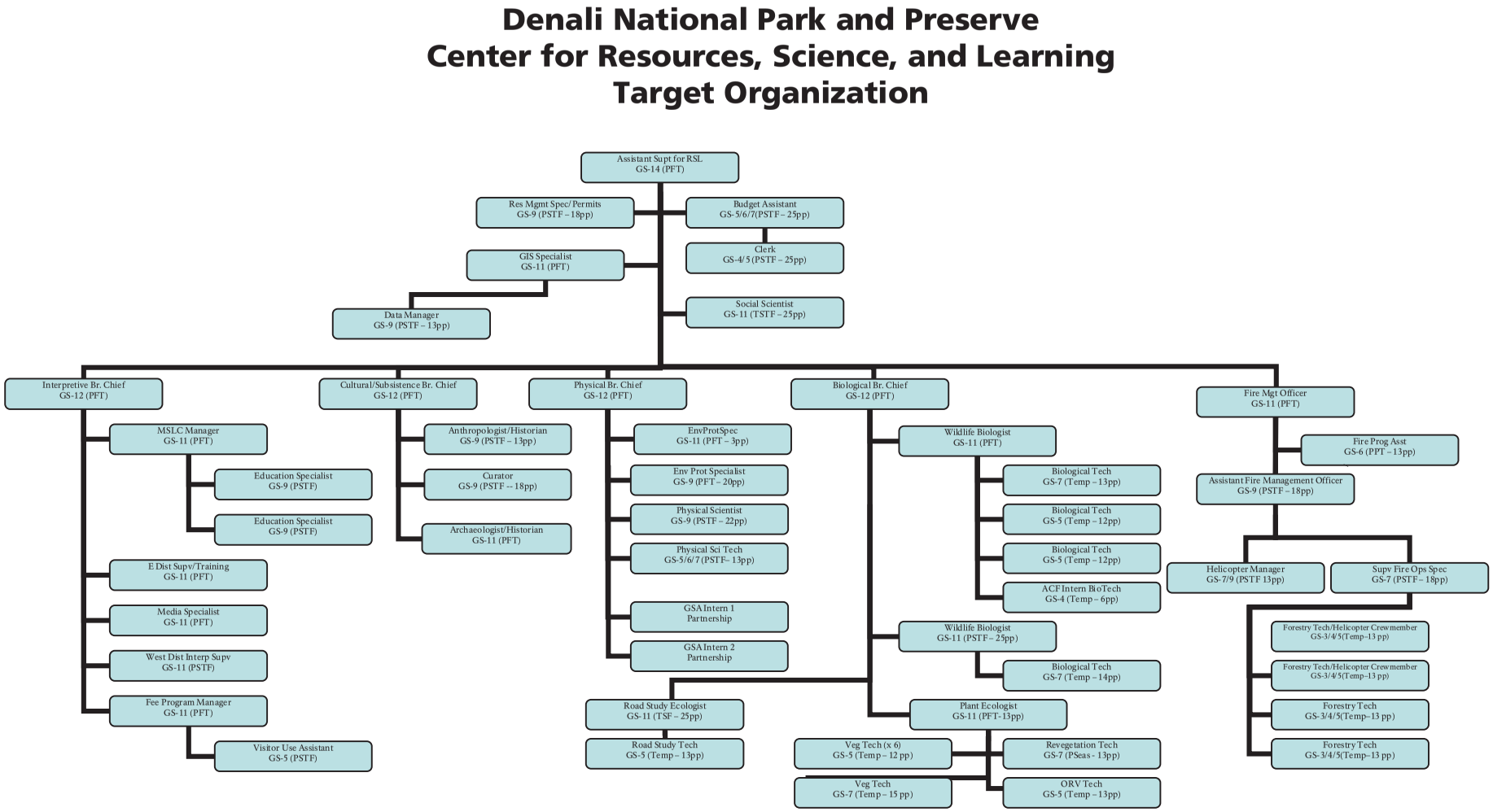


Figure 7. Resource stewardship expenditures (FY2003–FY2009) in comparison to total park expenditures.
Resource stewardship expenditures (total shown as light blue shading) are the sum of funding (all sources) for natural resources, cultural resources, resource education, resource protection, and resource planning. (Expenditures for visitor services unrelated to resource stewardship are not included.) Resource stewardship expenditures funded by base funding are compared to total parkwide expenditures (black bars) which include all non-resource stewardship expenditures such as visitor services not related to resource stewardship. FY2008 and FY2009 are the first two years of funding in support of the Resource Stewardship Strategy.

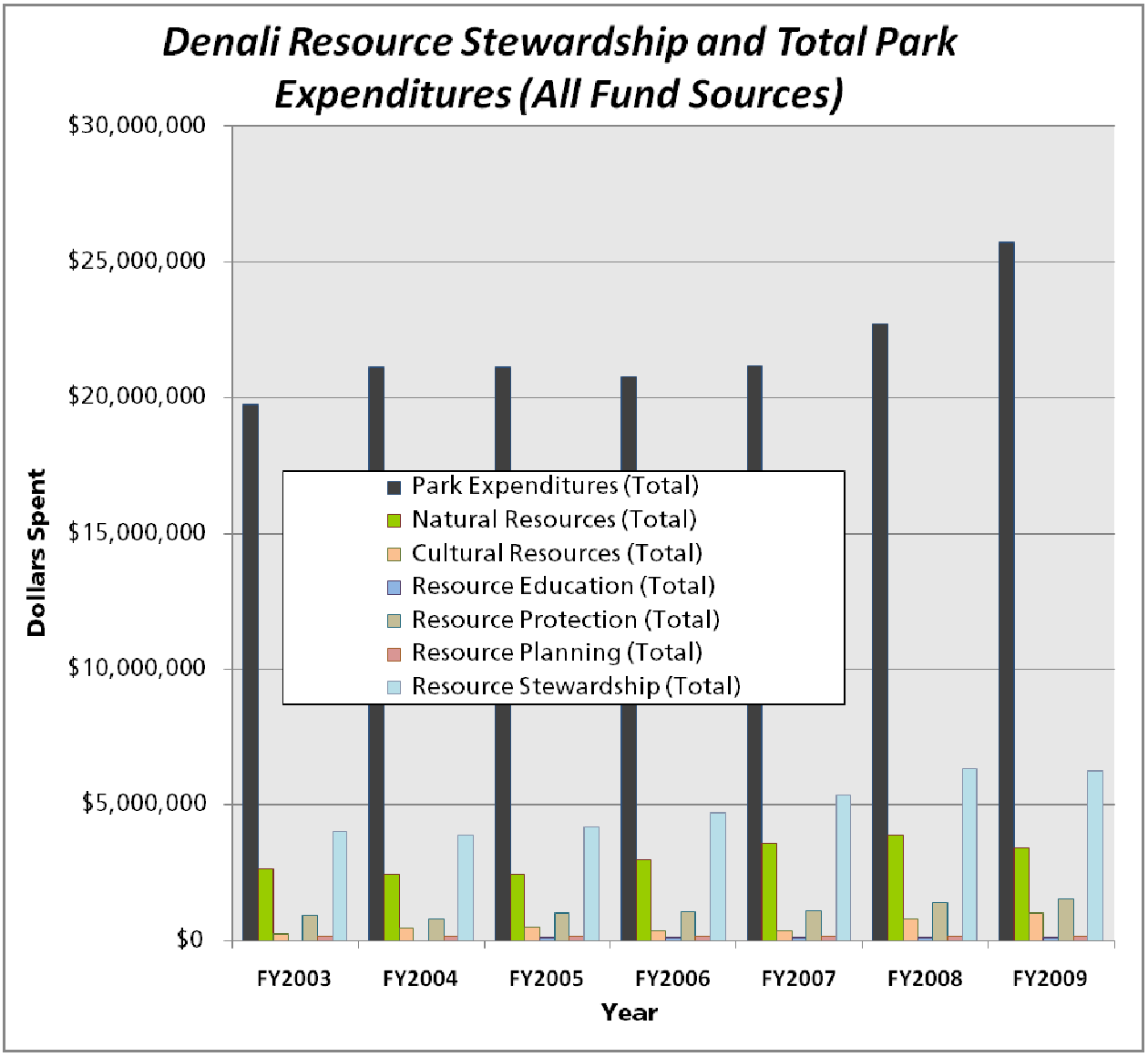


Figure 8. Natural resources funding (FY2003-FY2009) by fund source.

Denali's natural resources expenditures by funding source: Denali's park base (ONPS) funding; "Project Funding (Servicewide Comprehensive Call (SCC), Flexible Park Base (FPB), Concessions Franchise Fee (CFF), and Federal Lands Recreational Enhancement Act (FLREA) funding); and Inventory and Monitoring base (ONPS) funding. Centennial Challenge funding was included as project funding, even though it is flexible base funding. FY2008 and FY2009 are the first two years of funding in support of the Resource Stewardship Strategy.

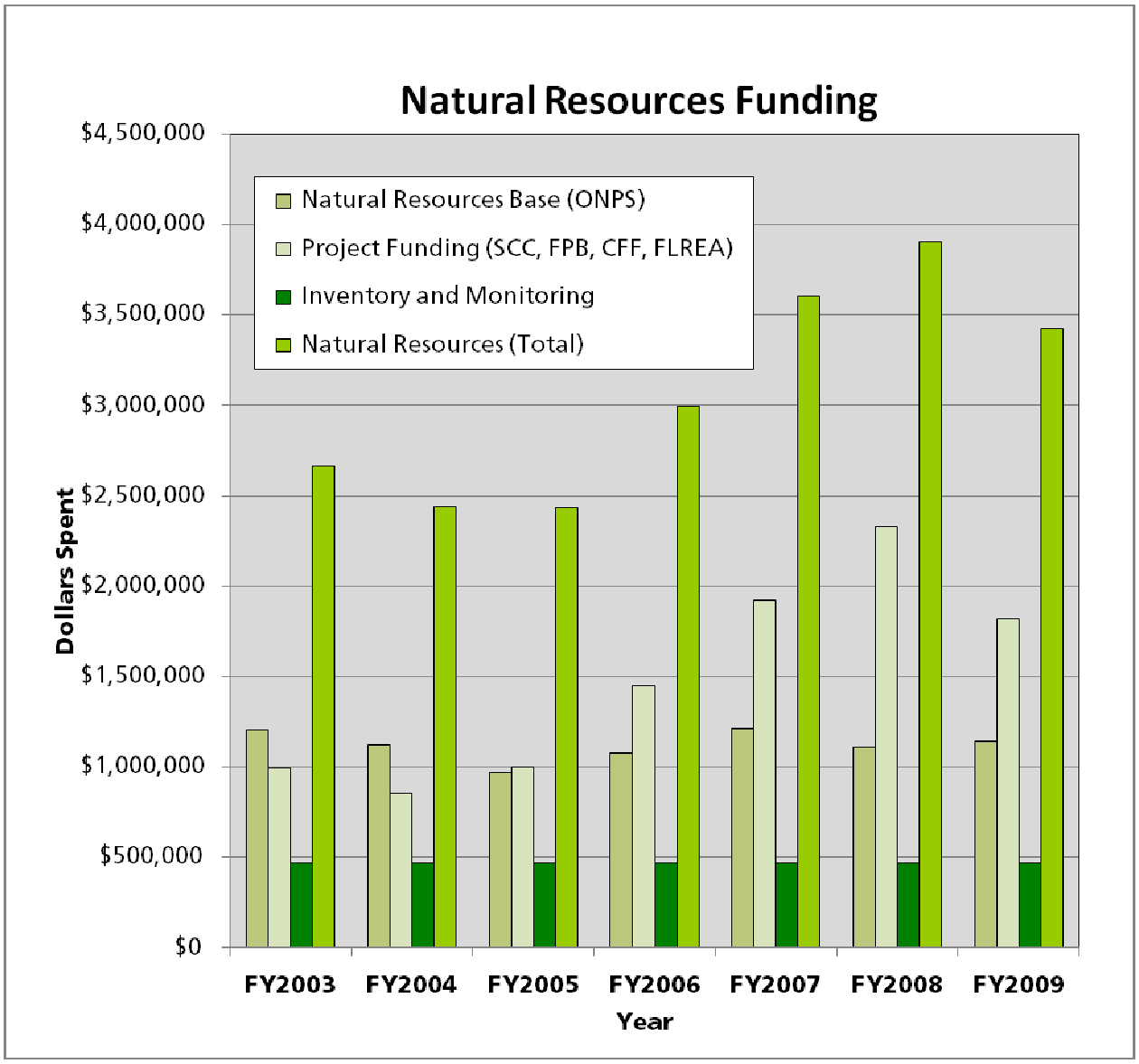


Figure 9. Cultural resources funding (FY2003-FY2009) by fund source.
Denali's cultural resources expenditures by funding source: Denali's park base (ONPS) funding, project funding obtained by the Cultural Division, and maintenance project funding for stabilization or restoration of cultural sites (cabins or other structures). FY2008 and FY2009 are the first two years of funding in support of the Resource Stewardship Strategy.

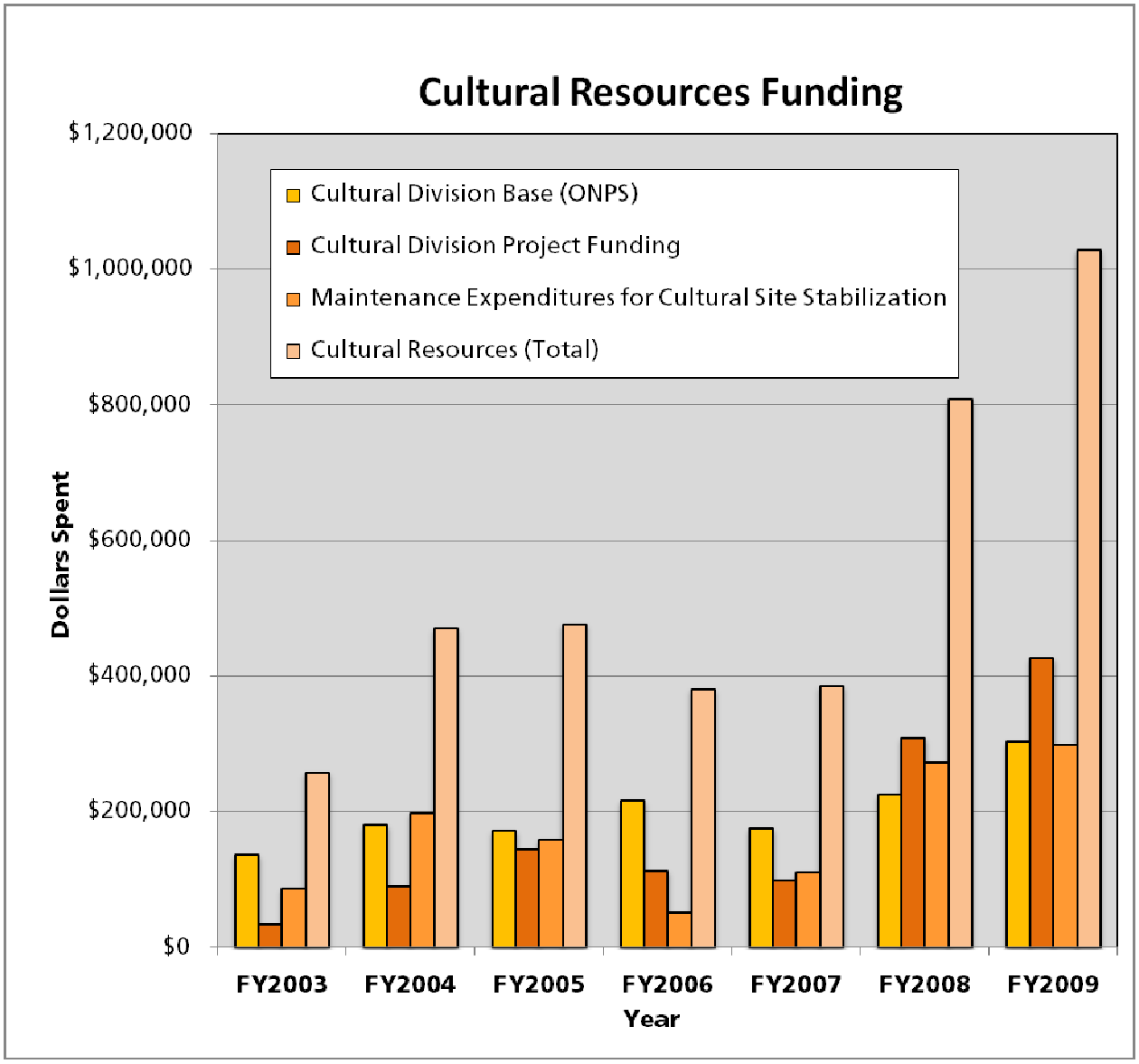


Figure 10. Funding in support of resource stewardship (FY2003-FY2009) by program area.
Denali's expenditures that support resource stewardship include resource education, resource protection, and resource planning. FY2008 and FY2009 are the first two years of funding in support of the Resource Stewardship Strategy. The funds summarized by year are costs that are linked to RSS projects; these costs do not include parkwide expeditures unrelated to resource values, such as visitor services.

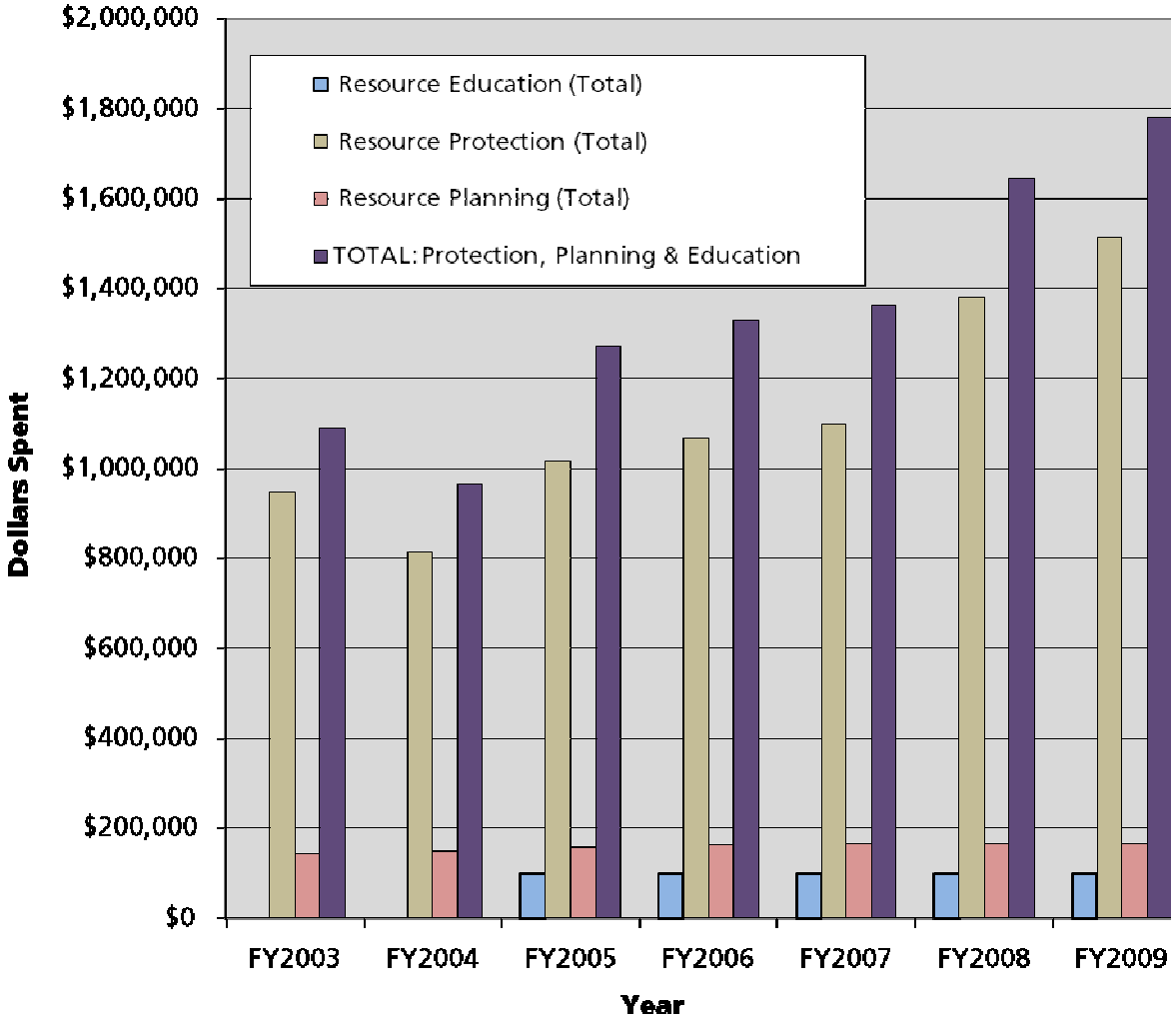
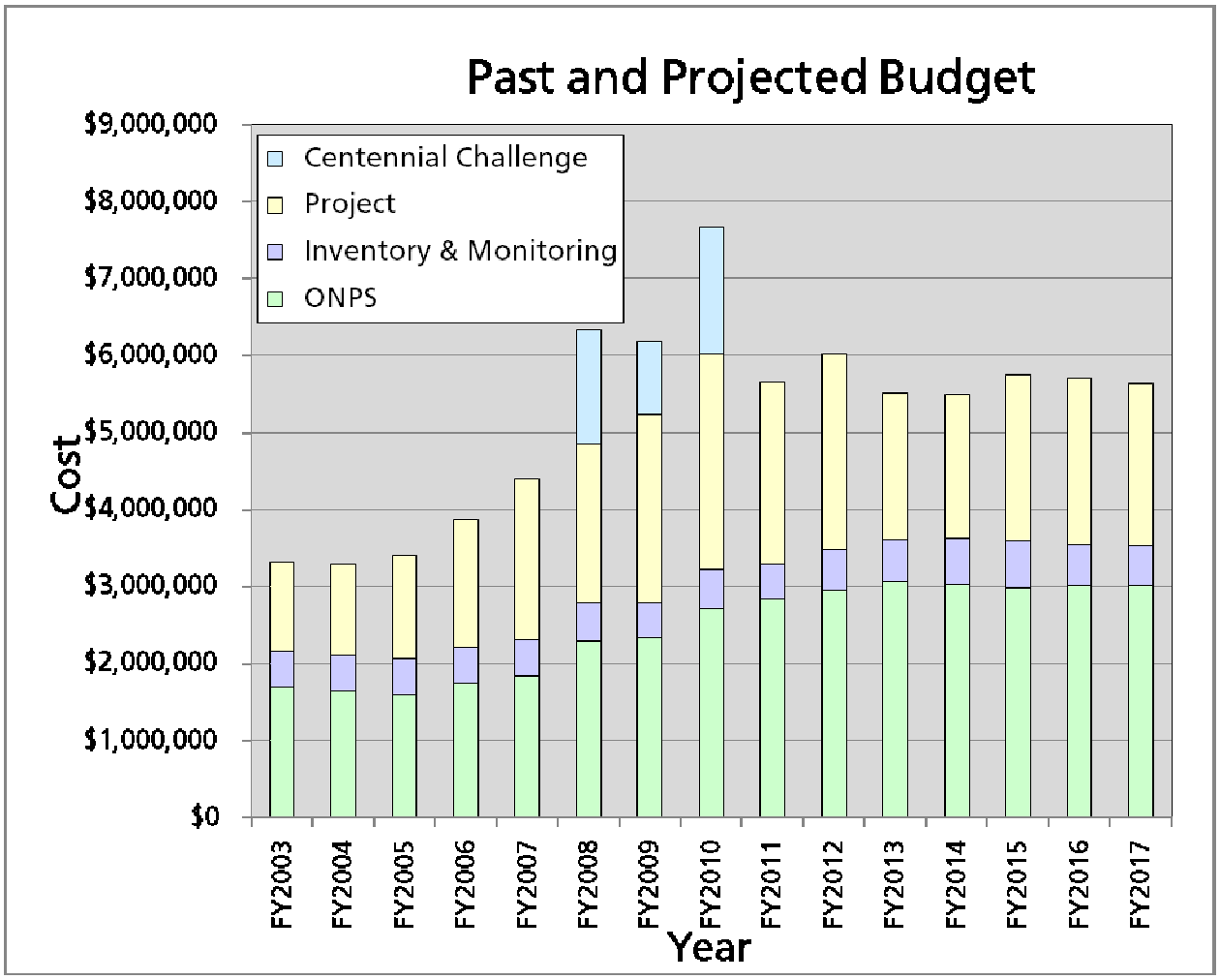


Figure 11. Past resource stewardship expenditures and projected 10-year RSS implementation costs by fund source.
Expenditures for resource stewardship in FY2003-FY2007, and Resource Stewardship Strategy implementation costs for 10 years (beginning FY2008) are shown by actual or potential funding sources: Centennial Challenge funds (light blue), CFF or REA Project funds (yellow), Central Alaska Network Inventory and Monitoring base (ONPS) funds (lavender), and Denali's park base (ONPS) funds (light green). The funds summarized by year are costs that are linked to RSS projects; these costs do not include other parkwide expeditures unrelated to resource values, such as visitor services.



Finalization and Implementation

Finalization

Denali's RSS received expert review by two scientists. The RSS is officially implemented upon signature and final approval of the document by the Alaska Regional Director. The document will be used as the guide for following a logical sequence of activities to attain and maintain desired resource conditions. The environmental planning process will be initiated in developing all implementation plans and decisions that have the potential for negatively impacting the resource or environment.

Implementation - Tracking and Evaluating Annual Progress

Denali's RSS is a working document. Staff will review the RSS every few years to track and document progress and accomplishments in relation to goals. Periodic updates to the RSS will make any needed adjustments to resource condition, additional scholarly or scientific work or data obtained, project descriptions and scope, budget needs, and any changes in project priorities. Comprehensive strategies and projects within this document may have changes made to them to accommodate unpredictable or novel situations. The budget section of this RSS shall be reviewed regularly and updated with actual program costs and estimates of future program needs.

Information from Denali's RSS will be integrated into 5-year plans (resources and parkwide) as they are assembled at appropriate intervals.

References

Adams, L., and S. Farley. 2006. Are salmon an important food source for interior Alaskan wolves? Evidence from stable isotope analysis. Abstract (oral presentation) in program for Alaska Park Science Symposium (September, 2006). Denali Park, Alaska.

Adams, L.G., and B.W. Dale. 1998. Reproductive performance of female Alaskan caribou. Journal of Wildlife Management 62: 1184-1195.

Adams. L.G. 2005. Effects of maternal characteristics and environmental variation on birth masses of Alaskan caribou. Journal of Mammalogy 86: 506-513.

Adams, L., T. Meier, P. Owen, and G. Roffler. 2006. Interrelationships of Denali's large mammal community. Alaska Park Science 5: 36-40.

Adams, L.G., F.J. Singer, and B.W. Dale. 1995. Caribou calf mortality in Denali National Park, Alaska. Journal of Wildlife Management 59(3):584-594.

Adams, L.G. and B.W. Dale. 1998. Timing and synchrony of parturition in Alaska caribou. Journal of Mammalogy 79: 287-294.

Adams, L. G. and G. H. Roffler. 2008. Dynamics of the Denali Caribou Herd, Denali National Park, Alaska: progress report (October 2005 – September 2007). USGS Alaska Science Center, Anchorage, AK. 18pp.

Adema, Guy W. 2007. Glacier monitoring in Denali National Park and Preserve. Alaska Park Science 6(2): 26-30.

Adema, Guy W., Ron D. Karpilo, Jr, and Bruce F. Molnia. 2007. Melting Denali: Effects of climate change on the glaciers of Denali National Park and Preserve. Alaska Park Science 6(1): 12-17.

Ahlstrand, Gary. 1983. National Park Service, Alaska Region Archives. Alaska Regional Office. Anchorage, Alaska.

Alaska Department of Community and Economic Development (ADCED). 2001. Alaska Visitor Statistics Program data.

Alaska Department of Fish and Game. 2006. Our wealth maintained: A strategy for conserving Alaska's diverse wildlife and fish resources. Alaska Department of Fish and Game, Juneau. xviii + 824 pp.

Allen, J. 2004. Fire Monitoring Program in Denali National Park and Preserve. Fire Management Program. Alaska Regional Office. Anchorage, Alaska. 45 pp.

Allen, J. 2004. Hazard Fuels Reduction Monitoring Program – Denali National Park and Preserve. Fire Management Program. Alaska Regional Office. Anchorage, Alaska. 27 pp.

Ambrose, Skip, Christine Florian, and Michael Donaldson. 2005. Influence of low-level military aircraft on American Peregrine Falcons nesting in Interior Alaska, 2001-2003. Unpublished report for the Eleventh Air Force, Elmendorf Air Force Base, Alaska. 59 pp.

Arendt, Anthony A., Keith A. Echelmeyer, William D. Harrison, Craig S. Lingle, Virginia B. Valentine. 2002. Rapid wastage of Alaska glaciers and their contribution to rising sea level. Science 297(5580): 382-386.

Bacon, J., R. Manning, D. Johnson, and M. Vande Kamp. 2001. Norm Stability: A Longitudinal Analysis of Crowding and Related Norms in the Wilderness of Denali National Park and Preserve. *The George Wright Forum* 18: 62-71.

Becker, E. F. 2001. Brown bear line transect technique development, 1 July 1999 - 30 June 2000. Alaska Department of Fish and Game. Federal aid in wildlife restoration research performance report, Grant W-27-3, Study 4.30. Juneau, Alaska 17 pp.

Beckmen, K. 2005. Wildlife health and disease surveillance in Alaska. Federal aid annual research performance report. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau. 13 pp.

Belant, J. L., K. Kielland, E. H. Follman, and L. G. Adams. 2006. Interspecific resource partitioning in sympatric ursids. Ecological Applications: 6: 2333–2343.

Bishop, Richard. 1978. Subsistence Resource Use in the Proposed North Addition to Mount McKinley National Park. Anthropology and Historic Preservation, Cooperative Park Studies Unit, Occasional Paper No. 17. University of Alaska Fairbanks, Fairbanks.

Blakesley, A. 2004. DRAFT Air quality monitoring protocol for Denali National Park & Preserve, Alaska. Central Alaska Inventory and Monitoring Network, Fairbanks, AK.

Boudreau, Susan and Jan Timmons. 2003. Long-term Ecological Monitoring Program, Synthesis and evolution of the prototype for monitoring subarctic parks: 1991-2002 perspective. Denali National Park and Preserve, Denali Park, Alaska. 220pp.

Brease, P. F. 1995. Description, character, and rates of movement of the Drunken Forest slump-earthflow, Denali National Park and Preserve, Alaska. Abstract in 1995 Program for annual meeting of Geologic Society of America (Abstract #16712).

Brease, P.F. 1998. Initiating a paleontology inventory and database at Denali National Park and Preserve pp 53-56 *In* National Park Service Paleontological Research, edited by V.L. Santucci and L. McClelland. NPS/NRGRD/GRDTR-98/01.

Brease, P. F. 2001. Annual Report 1999 - Drunken Forest – MP 5 Denali Park Road. Denali National Park and Preserve, Alaska. Unpublished report. 1 pp.

Brease, P.F. 2007. Monitoring the Landslide at Mile Post 45. Denali National Park and Preserve, Alaska. Unpublished Report. 3 pp.

Brooks, Alfred Hulse, Louis Marcus Prindle, and De Witt Lee Reaburn. 1911. The Mount McKinley region, Alaska. U.S.Geological Survey Professional Paper 70. 234 pp.

Brown, W. E. 1993. Denali: Symbol of the Alaskan wild. An illustrated history of the Denali-Mount McKinley region, Alaska. The Donning Company, Virginia Beach, VA. 223 pp.

Brown, William E. 1991. A History of the Denali - Mount McKinley Region, Alaska: Historic Resource Study of Denali National Park and Preserve. Vol.1. National Park Service, Southwest Regional Office, Santa Fe, New Mexico.

Brown, William E. et al. 1982. Cultural Resource Investigation in the Dunkle Mine and Kantishna Hills Study Area.. National Park Service, Alaska Regional Office, Anchorage, Alaska.

Bultena, G., D. Albrecht, and P. Womble. 1981. Freedom versus control: A study of backpackers' preferences for wilderness management. Leisure Sciences, 4(3): 297-310.

Bultena, G., Field, D. R., Womble, P., and Albrecht, D. 1981. Closing the gates: A study of backcountry use-limitation at Mount McKinley National Park. *Leisure Sciences, 4*(3), 249-267.

Bundtzen, Thomas K. 1978. A History of Mining in the Kantishna Hills. The Alaska Journal 8 (2): 151-161.

Burch, J., T. Meier, M. Reid, and J. Lawler. 2004. DRAFT Moose monitoring protocol for the Central Alaska Network. Central Alaska Inventory and Monitoring Network, Fairbanks, AK.

Burr, John. 2002. Fishery Management Report for Sport Fisheries in the Arctic-Yukon-Kukokwim Management Area, 2000-2001. Alaska Department of Fish and Game Division of Sport Fish. Fairbanks.

Buzzell, Rolfe. 1989. Overview of Mining in the Kantishna District, 1903-1968. MS, Alaska Regional Office, National Park Service.

Cheek, N. H., & Field, D. R. (1978). *Meanings of animals among backcountry hikers in Alaska*: National Park Service, Cooperative Park Studies Unit, College of Forest Resources, University of Washington, Box 352100, Seattle, WA 98195-2100.

Christensen, N., A. Watson, and K. Kneeshaw. 2005. Denali National Park and Preserve Fly-in Recreation Visitor Study. Aldo Leopold Wilderness Research Institute: Missoula, MT.

Clark, M.H and M.S. Duffy. 2004. Soil survey of Denali National Park Area, Alaska. USDI-NPS.

Cole, R. B. 1999. Co-magmatic ties between the Cantwell volcanics and McKinley sequence plutons: Constraint on the early Tertiary offset history of the McKinley fault, central Alaska Range, Geological Society of America Abstract Programs, 31, 46.

Collins, Raymond L. 2004. Dichinanek' Hwt'ana: A History of the People of the Upper Kuskokwim Who Lived in Nikolai and Telida, Alaska. McGrath: Denali National Park and Preserve.

Conn, S.C., and A.M. Milner. 1999. A shift in emphasis: using small things to look at the big picture in Denali National Park & Preserve. In Program and Abstracts: 50th Arctic Science Conference, Science in the North: 50 Years of Change. Denali National Park and Preserve, AK. Sept 19-22, 1999.

Cook, J. S., and S. O. MacDonald. Small mammal inventory of Alaska's national parks and preserves. Denali National Park and Preserve. Preliminary Summary. Unpublished report. 5 pp.

Csejtey, Bela, Jr., Michael W. Mullen, Dennis P. Cox, and Gary D. Stricker. 1992. Geology and geochronology of the Healy Quadrangle, Alaska, USGS Misc. Investigations Series, Map I-1961.

Csejtey, B. 1996. Correlation of rock sequences across the Denali fault in south-central Alaska. U.S. Geological Survey Bull. 2152: 149-156.

Dean, F. C. 1987. Brown bear density, Denali National Park, Alaska, and sighting efficiency adjustment. International Conference on Bear Research and Management 7: 37-43.

Del Vecchio, P. A., B. Shults, and L. G. Adams. 1995. Status and Distribution of the Tonzona Caribou Herd, 1988-1991. Natural Resources Final Report NPS/ARRNR/NRTR-95/27.

Densmore, R. V. 1994. Succession on regraded placer mine spoil in Alaska in relation to initial site characteristics. Arctic and Alpine Research 26:60-69.

Densmore, R.V., and K.F. Karle. 1997. Stream restoration at Denali National Park and Preserve. *In* Proceedings: Thirteenth high altitude revegetation workshop. Colorado State University, Fort Collins. CO.

Densmore, R. V., P. C. McKee, and C. Roland. 2001. Exotic plants in Alaskan National Park units. U.S. Geological Survey report. 144 p. Available online at http://akweeds.uaa.alaska.edu/akweeds_literature.htm

DeSante, D.F., D. R. Kaschube, and T. S. Sillet. 2003. Evaluation of the first ten years of the Monitoring Avian Productivity and Survivorship (MAPS) in Alaska and adjacent Canada. A Report to Boreal Partners in Flight in Two Parts. The Institute for Bird Populations, Point Reyes Station, California, USA.

Deschu, N. 1985a. Water-related research and monitoring in the Kantishna Hills mining district, Denali National Park and Preserve, Alaska. On file at National Park Service, Alaska System Support Office, Anchorage, AK. 104 pp.

Deschu, N. 1985b. Arsenic in sediments, water, and benthic fish in placer-mined and unmined streams, Denali National Park and Preserve, Alaska. Master's thesis, University of Washington. Seattle, WA. 90 pp.

Deschu, N. and R.C. Kavanaugh. 1986. Water quality and the effects of mining in the Kantishna Hills district, Denali National Park, 1983. On file at National Park Service, Alaska System Support Office, Anchorage, AK. 94 pp.

Dixon, J. D. 1938. Birds and mammals of Mount McKinley National Park. U. S. Department of the Interior, National Park Service Fauna Series No. 3.

Dortch, Jason M. 2006. Defining the timing and extent of glaciation in the Central Alaska Range. University of Cincinnati Master's Thesis. 82 pp.

Echelmeyer, Keith, Robert Butterfield, and Doug Cuillard. 1987. Some observations on a recent surge of Peters Glacier, Alaska, U.S.A. Journal of Glaciology 33 (115): 341-345.

ECOMAP. 1993. National hierarchical framework of ecological units. United States Department of Agriculture, Forest Service. Washington, D.C.

Edwards, P. J., and M.J. Tranel. 1998. Physical and chemical characterization of streams and rivers within Denali National Park and Preserve. In cooperation with the U.S. Forest Service, Northeastern Forest Experiment Station, Timber and Watershed Laboratory, Parsons, WV. On file at National Park Service, Denali National Park and Preserve, AK. 102 pp.

Emmett, W.W. and R.F. Averett. 1989. Sediment and channel dataset from 13 Kantishna area stream sites. Unpublished. On file at Denali National Park and Preserve.

Emmett, W.W., R.L. Burrows, and E.F. Chacho, Jr. 1996. Coarse-particle transport in a gravel-bed river. International Journal of Sediment Transport 11(2) 8:21.

Emmett, W.W., and N. Deschu. 1986. Sediment and channel dataset from 6 Kantishna area streams. Unpublished. On file at Denali National Park and Preserve.

Evans, Gail E. H. "From Myth to Reality: Travel Experiences and Landscape Perceptions in the Shadow of Mount McKinley, Alaska, 1876-1938." Thesis UCSB, 1987.

Fiorillo, Anthony R., Paul J. McCarthy, Brent H. Breithaupt, and Phil F. Brease. 2006a. Dinosauria and Fossil Aves Footprints from the Lower Cantwell Formation (Latest Cretaceous), Denali National Park, Alaska., Abstract #001, 2006 Alaska Park Science Symposium, Denali National Park and Preserve, Alaska.

Fiorillo, Anthony R., Paul J. McCarthy, and Brent H. Breithaupt. 2006b. The First Record of Dinosauria and Fossil Aves from the Lower Cantwell Formation (Latest Cretaceous, Denali National Park, Abstract for 102nd Annual Meeting of the Cordilleran Section, GSA, 81st Annual Meeting of the Pacific Section, AAPG, and the Western Regional Meeting of the Alaska Section, SPE (8–10 May 2006).

Fiorillo, Anthony R., Stephen T. Hasiotis, Yoshitsugu Kobayashi, and Carla S. Tomsich. 2009. A pterosaur manus track from Denali National Park, Alaska Range, Alaska, United States. Palaios 24:466-472.

Fitzgerald, P.G., E. Stump, and T. F. Redfield. 1993. Late Cenozoic uplift of Denali and its relation to relative plate motion and fault morphology. Science 259 (22): 497- 499.

Flewelling, R., and D. R. Johnson, D. R. 1981. Wildlife experiences and trip satisfaction in the backcountry: a preliminary summary of the McKinley backcountry survey data. National Park Service, Cooperative Park Studies Unit, College of Forest Resources, University of Washington, Seattle, WA.

Forbes, R. B., Smith, T. E., and Turner, D. L. 1974. Comparative petrology and structure of the McClaren, Ruby Range, and Coast Range belts: Implications for offset along the Denali fault system: Abstract in Geological Society of America Annual meeting Program (Cordilleran Section) 6 (3): 177.

Frenzel, S.A., and J.M. Dorava. 1999. Water-quality data for the Talkeetna River and four streams in national parks, Cook Inlet Basin, Alaska, 1998. USGS Open-file Report 99-459. Anchorage, AK. 58 pp.

Frenzel, S.A. 2000. Selected organic compounds and trace elements in streambed sediments and fish tissues, Cook Inlet Basin, Alaska. USGS Water-Resources Investigations Report 00-4004. Anchorage, AK. 39 pp.

Gasaway, W. C., S. D. DuBois, D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. University of Alaska Biological Paper 22. 108pp.

Griffin, Kristen. 1990. An Overview and Assessment of Archeological Resources, Denali National Park and Preserve, Alaska. National Park Service, Anchorage, AK.

Gubala, C. P., D. H. Landers, M. Monetti, M. Heit, T. Wade, B. Lasorsa and S. Allen-Gil. 1995. The rates of accumulation and chronologies of atmospherically derived pollutants in arctic Alaska, USA. The Science of the Total Environment 160/161: 347-361.

Gudgel-Holmes Dianne. 1979. Ethnohistory of Four Interior Alaskan Waterbodies. Alaska Department of Natural Resources, Anchorage, Alaska.

Gudgel-Holmes, Dianne (ed. and comp.). 1991. Native Place Names of the Kantishna Drainage,Alaska: Kantishna Oral History Project. National Park Service, Anchorage, AK.

Gudgel-Holmes, Dianne (ed. and comp.). 1988. Kantishna Oral History Project, Phase II, Part 1: Interviews with Native Elders. National Park Service, Anchorage, AK.

Gudgel-Holmes, Dianne. 1989. Predictive Model of Aboriginal Site Types and Locations for a Catchment Basin along the Denali Park Road within Denali National Park and Preserve. Typescript report for the National Park Service, Alaska Region.

Haber, G. C., 1977. Socio-ecological dynamics of wolves and prey in a subarctic ecosystem. Ph.D. diss., University of British Columbia, Vancouver.

Hanneman, D. 1993. Heavy metals in Rock Creek, Denali National Park. Master's thesis, University of Alaska-Anchorage. Anchorage, AK. 121 pp.

Harrison, A.E. 1964. Ice surges on the Muldrow Glacier, Alaska. Journal of Glaciology 5(39): 365-368.

Harrison, A.E. 1969. Glacial activity preceding the 1956 Muldrow Glacier surge in Alaska. Canadian Journal of Earth Sciences 6: 4: 1001-1007.

Haynes, Terry L., William Simeone, and David B. Anderson. 2001. Ethnographic Overview and Assessment: Denali National Park and Preserve. Alaska Department of Fish and Game, Subsistence Division, Fairbanks.

Haynes, Terry L., William Simeone, and David B. Anderson. 1999. Draft Ethnographic Overview and Assessment: Denali National Park and Preserve. Alaska Department of Fish and Game, Subsistence Division, Fairbanks.

Hokit, D. G., and A. Brown. 2006. Distribution patterns of wood frogs (*Rana sylvatica*) in Denali National Park. Northwestern Naturalist 87: 128-137.

Holen, Simeone, and Liz Williams. 2006. Wild Resource Harvests and Uses by Residents of Lake Minchumina and Nikolai Alaska, 2001-2002. Alaska Department of Fish and Game, Juneau.

Hooge, P., G. Adema, T. Meier, C. Roland, P. Brease, P. Sousanes, and L. Tyrrell. 2006. Ecological overview of Denali National Park and Preserve. Alaska Park Science 5(1): 7-13.

Hosley, E. H. 1966. Factionalism and Acculturation in an Alaskan Athapaskan Community. Unpublished Ph.D. dissertation, University of California, Los Angeles. University Microfilms, Inc. Ann Arbor, Michigan.

Hults, Chad. 2004a. Central Alaska Network Soundscape Pre-Scoping Meeting 2004 Report. Denali National Park and Preserve, Denali Park, Alaska. Unpublished report. 68 pp. + appendices

Hults, Chad. 2004b. Denali National Park and Preserve Soundscape Annual Report 2004. Denali National Park and Preserve. Denali Park, Alaska. Unpublished report. 151 pp.

Hults, Chad. 2004c. Introduction to Inventorying, Monitoring, and Management of Soundscapes in Alaskan National Parks. Denali National Park and Preserve, Denali Park, Alaska. Unpublished report. 53 pp.

Hults, Chad. 2005. Denali National Park and Preserve Soundscape Annual Report 2005. Denali National Park and Preserve, Denali Park, Alaska. Unpublished report. 105 pp.

Hults, Chad and Shan Burson. 2006. Soundscapes of Denali National Park and Preserve. Alaska Park Science 5(1): 20-22.

Human Development Report (HDR) Alaska. 2006. Needs Assessment and Feasibility Study for a Community Transportation System. Denali National Park and Preserve.

Johnson, Darryll, Dianne Gudgel-Holmes, and James Levy. 1999. Traditional Use Cabins and Other Shelters in the North Additions to Denali National Park and Preserve. Technical Report NPS/CCSOUW/NRTR-99-02. University of Washington Field Station, Seattle.

Kain, Ann B. 2001. Cultural Resource Management, Denali National Park and Preserve, Alaska. M.A. Thesis, Antioch University. 218pp.

Kari, James. 1999. Native Place Names Mapping in Denali National Park and Preserve, Draft. Denali National Park and Preserve. Denali Park, Alaska. 140 pp.

Karle, K. F. 1989. Replenishment potential for gravel removal sites at the Toklat River, Alaska. Master's thesis. University of Alaska Fairbanks. 90 pp.

Karle, K.F. 1997. Protocols for long-term ecological monitoring of aquatic systems in Denali National Park and Preserve. On file at National Park Service, Denali National Park and Preserve, AK. 62 pp.

Karle, K.F. 1998. Stream channel reference sites: analysis of water chemistry and channel morphometry data, Rock Creek, Denali National Park and Preserve. On file at National Park Service, Denali National Park and Preserve, AK. 21 pp.

Karle, K.F. 2000. Restoration of the Caribou Creek watershed. In Proceedings: Environmental and Water Resources Institute of the American Society of Civil Engineers, Watershed Management 2000 Conference: Science and Technology for the New Millennium, Fort Collins, CO. June 2000.

Karle, Kenneth F. 2007a. Toklat River Gravel Extraction. Unpublished report submitted to Denali National Park and Preserve. 47pp.

Karle, Kenneth F. 2007b. Water Resources Stewardship Report, Denali National Park and Preserve, Natural Resource Technical Report NPS/NRPC/WRD/NRTR-2007/051. 76 pp.

Karle, K. F. and R. V. Densmore. 1994. Stream and floodplain restoration in a riparian ecosystem disturbed by placer mining. Ecological Engineering 3: 121-133.

Karle, K.F., and R.V. Densmore. 2001. Results From a Channel Restoration Project: Hydraulic Design Considerations. In proceedings: 2001 Wetlands Engineering and River Restoration Conference, American Society of Civil Engineers, Reno, NV. August 2001.

Karle, K. F., P. J. Edwards, and E. Major. 1996. Streambed disturbances during and after restoration of Glen Creek, Denali National Park and Preserve, Alaska. In Proceedings, American Water Resources Association Annual Symposium-Watershed restoration management: physical, chemical, and biological considerations. Syracuse, NY. July 1996.

Karle, Kenneth, and Torre Jorgenson. 2004. Review of Existing Permafrost Monitoring Projects with Applications and Recommendations for the Central Alaska Network Monitoring Program, unpublished report to Central Alaska Network. 49 pp.

Karle, K.F., and P.J. Sousanes. 2000. Stream channel reference sites for long-term monitoring, Denali National Park. In proceedings: American Water Resources Association 2000 Annual Spring Specialty Conference: Water Resources in Extreme Environments. May 2000.

Keay, J. A. 2001. Grizzly bear population ecology and monitoring. Denali National Park and Preserve, Alaska. Report of project development and findings. USGS Alaska Biological Science Center, Denali Park, Alaska. 18 pp.

Kertell, K. 1986. Reproductive biology of northern hawk-owls in Denali National Park, Alaska. Raptor Research 20:91-101.

Kochert, M., K. Steenhof, C. McIntyre, and E. Craig. 2002. Golden Eagle (*Aquila chrysaetos*). *In* The Birds of North America, No. 684. (A. Poole and F. Gill, eds.). The Birds of North America, Inc. Philadelphia, PA.

Kochert, M. N., and K. Steenhof. 2002. Golden Eagle in the U.S. and Canada: status, trends, and conservation challenges. Journal of Raptor Research 36(1 Supplement):32-40.

Laing, K. 1985. Food habits and breeding ecology of merlins in Denali National Park, Alaska. Raptor Research 19:42-51.

Larsen, A., J. Houghton, J. Black, D. Verbyla, C. Ruedebusch, and R. McGinnis. 2004. DRAFT Shallow lake limnology monitoring protocol, Central Alaska Network National Parks and Preserves, Alaska. Central Alaska Inventory and Monitoring Network, Fairbanks, AK.

Lawson, S. and R. Manning. 2002. Tradeoffs among Social, Resource, and Managerial Attributes of the Denali Wilderness Experience: A Contextual Approach to Normative Research. Leisure Sciences 24: 297-312.

LaMay, K. 2007. Alaska Region Fire Point Database. National Park Service, Alaska Regional Office. Anchorage, Alaska.

LaPerriere, J.D., and L.A. Casper. 1976. Biogeochemistry of deep lakes in the central Alaska Range, completion report. Report No. IWR-68, University of Alaska Fairbanks, Fairbanks, AK. 35pp.

Lawson, S. and R. Manning. 2003. Integrating Multiple Wilderness Values into a Decision-Making Model for Denali National Park and Preserve. Journal for Nature Conservation 11: 355-362.

Loder, A., & Womble, P. (1979). Day hiking and day hikers in Mount McKinley National Park: An exploratory study (No. CPSU/UW S -79-4): Sociology Studies Program, Cooperative Park Studies Unit, College of Forest Resources, University of Washington, P.O. Box 352100, Seattle, WA 98195-2100.

Lynch, Alice J. "Archeological Investigations of Five Remote Tracts of Land." Anchorage, Alaska, Alaska Regional Office, National Park Service, 1996.

MacCluskie, M., and K. Oakley. 2005. Central Alaska Network, Vital Signs Monitoring Program, Phase III report. National Park Service, Fairbanks, Alaska. 304 pp.

MacCluskie, M. 2005. Vital Signs Monitoring Plan. Central Alaska Network. Alaska. U.S. Department of the Interior, National Park Service. 320 pp.

Machlis, G.E. and D.E. Dolsen. 1989. Visitor Services Project: Denali National Park and Preserve. VSP Report 18. Cooperative Park Studies Unit, National Park Service, University of Idaho.

Major, E.B. 1996. Macroinvertebrate analysis to assess stream restoration for the U.S. National Park Service, final report. Environment and Natural Resources Institute, University of Alaska-Anchorage. Anchorage, AK. 24 pp.

Mangi Environmental Group. 2005. Water resources information and issues overview report, Denali National Park and Preserve, Alaska. Technical report NPS/NRQWRD/ NRTR-2005/341, NPS-Water Resources Division, Fort Collins, CO.

Mann, D. and L. Plug. 1999. Vegetation and soil development at an upland taiga site, Alaska. Ecoscience. Vol.6 (2): 272-285.

Markis, J., E. Veach, M. McCormick, and R. Hander, 2004. Freshwater fish inventory of Denali National Park and Preserve, Wrangell-St Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve. Report NPS_AKRCAKN_NRTR_2004_006. 80pp.

Martin, J., C. McIntyre, J.E. Hines, J.D. Nichols, J. Schmutz, and M. MacCluskie. 2009a. Dynamic multistate site occupancy models to evaluate hypotheses relevant to conservation of Golden Eagles in Denali National Park, Alaska. Biological Conservation 142: 2726-2731.

Martin, J., J.D. Nichols, C.L. McIntyre, G. Ferraz, and J.E. Hines. 2009b. Perturbation analysis for patch occupancy dynamics. Ecology 90:10-16.

Mayo, Larry. 2001. Manual for Monitoring Glacier Responses to Climate at Denali National Park, Alaska, Using the Index Site Method. Unpublished report [camera-ready version with disks]. 68 pp.

McCollum, D., M. Haefele and S. Miller. 1998. Attributes and the Value of a Recreation Experience: A Preliminary Analysis of Wildlife Viewing in Denali National Park. USDA Forest Service, (internal document).

McDonald, K.C., J.S. Kimball, E. Njoku, R. Zimmermann, and M. Zhao. 2004. Variability in springtime thaw in the terrestrial high latitudes: monitoring a major control on the biospheric assimilation of atmospheric CO_2 with spaceborne microwave remote sensing. Earth Interactions 8: 1-23.

McIntyre, C. L and L .G. Adams. 1999. Reproductive characteristics of migratory Golden Eagles in Denali National Park, Alaska. Condor 101(1): 115-123.

McIntyre, C.L. 2002a. Birds, bird studies, and bird conservation in Denali National Park and Preserve, Alaska. Arctic Research of the United States 16:22-30.

McIntyre, C. L. 2002b. Patterns in nesting area occupancy and reproductive success of Golden Eagles in Denali National Park, Alaska. Journal of Raptor Research 36(1 supplement): 50-54.

McIntyre, C. L. 2006. Changes in the abundance and distribution of trumpeter swans in Denali National Park and Preserve, Alaska. Alaska Park Science, Volume 5, Issue 2: 24-29.

McIntyre, C. L. 2007. Apparent changes in the abundance and distribution of birds in Denali National Park and Preserve, Alaska. Alaska Park Science 6(2):62-65.

McIntyre, C. L. and M. W. Collopy. 2006. The post-fledging dependence period of migratory Golden Eagles (*Aquila chrysaetos*) in Denali National Park and Preserve, Alaska. Auk 123:877-884.

McIntyre, C. L., D. Wilder, and T. McDonald. 2004. DRAFT Protocol for monitoring the reproductive success of Golden Eagles in the Central Alaska Monitoring Network: Denali National Park and Preserve, Alaska. Central Alaska Inventory and Monitoring Network, Fairbanks, AK.

McIntyre, C. L., M. W. Collopy, and M.S. Lindberg. 2006a. Survival probability and mortality of migratory juvenile Golden Eagles from interior Alaska. Journal of Wildlife Management 70:717-722.

McIntyre, C. L., M. W. Collopy, J. Kidd, A. Stickney, and J. Paynter. 2006b. Characteristics of the landscape surrounding Golden Eagle nest sites in Denali National Park and Preserve, Alaska. Journal of Raptor Research 40: 46-51.

McIntyre, C. L., K. Steenhof, M. N. Kochert, and M. W. Collopy. 2006c. Long-term Golden Eagle studies in Denali National Park and Preserve, Alaska. Alaska Park Science, Volume 5, Issue 1:42-45.

McIntyre, C. L., N. Eagleson, and D. Tomeo. 2006d. Hardy as a Chickadee; Denali's Citizen Scientists. Alaska Park Science, Volume 5, Issue 1:49

McIntyre, C.L., D.C. Douglas, and M.W. Collopy. 2008. Movements of Golden Eagles (*Aquila chrysaetos*) from interior Alaska during their first year of independence. Auk 125:214-224.

McIntyre, C.L., D.C. Douglas, and L.G. Adams. 2009. Movements of juvenile Gyrfalcons from western and interior Alaska following departure from their natal areas. Journal of Raptor Research 43:99-109.

Mech, L.D., L. G. Adams, T. J. Meier, J.W. Burch, and B. W. Dale. 1998. The Wolves of Denali. University of Minnesota Press, Minneapolis, MN. 225 pp.

Meier, T. J. 2009. Annual report on vital signs monitoring of wolf (*Canis lupus*) distribution and abundance in Denali National Park and Preserve, Central Alaska Network: 2009 report. Natural Resource Technical Report Series, *in press*. National Park Service, Fort Collins, Colorado.

Meier, T., J. Burch, and L. Adams. 2006. Tracking the movements of Denali's wolves. Alaska Park Science 5: 30-35.

Meier, T. J., Burch, J. W., Wilder, D., Cook, M. 2009. Wolf monitoring protocol for Denali National Park and Preserve, Yukon-Charley Rivers National Preserve and Wrangell-St. Elias National Park and Preserve, Alaska. Natural Resource Report Series, *in press*. National Park Service, Fort Collins, Colorado.

Meyer, S.C., and R.C. Kavanaugh. 1983. Fish resources and the effects of mining activities in the Kantishna Hills, Denali National Park, 1982. On file at National Park Service, Alaska System Support Office, Anchorage, AK. 104 pp.

Miller, P. 1981. Fisheries resources of streams along the park road and in Kantishna Hills, Denali National Park and Preserve. Unpublished report. On file at National Park Service, Denali National Park and Preserve, AK. 21 pp.

Millett, Marion T. 1960. Advance of the Muldrow Glacier 1957. Geological Society of America, Cordilleran Section Meeting, Vancouver, B.C., May 7, 1960.

Milner, A. M., S.C. Conn, and L. E. Brown. 2006. Persistence and stability of macroinvertebrate communities in streams of Denali National Park, Alaska: implications for biological monitoring. Freshwater Biology 51: 373-387.

Milner, Alexander and Sarah Roberts. 1997. Aquatic macroinvertebrates: their potential application in monitoring long term river ecosystem change in Denali National Park, Alaska. Unpublished report to Denali National Park and Preserve. 16pp.

Morton, Susan. Geese House Report, Prepared for the Doyon Cemetery and Historic Sites Committee. Anthropology and Historic Preservation Cooperative Park Studies Unit. Fairbanks: University of Alaska Fairbanks, 1983.

Moser, T. J. 2006. The 2005 North American Trumpeter Swan Survey. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Denver, Colorado, USA.

Murie, A. 1944. The wolves of Mount McKinley. U.S. National Park Service Fauna Series, No. 5. 238 pp.

Murie, A. 1962. The mammals of Denali. Alaska Natural History Association, Denali Park, Alaska. revised edition 1999. 80 pp.

National Aeronautics and Space Administration-Goddard Space Flight Center, 1995. MODIS Rapid Response Project. USDA Forest Service (USFS) Remote Sensing Applications Center, the University of Maryland, the National Interagency Fire Center, and the USFS Missoula Fire Sciences Lab.

National Park Service (NPS). 1997. Denali National Park Visitor Use Survey. Public Use Statistics Program Center: Denver, CO.

National Park Service (NPS). 1999. Denali National Park Visitor Use Survey. Public Use Statistics Office: Denver, CO.

National Park Service. 2001. Denali National Park and Preserve Subsistence Management Plan. National Park Service, Denali Park, Alaska.

National Park Service. 2003. Denali National Park and Preserve Bear-Human Conflict Management Plan. National Park Service, Denali Park, AK. 166pp.

National Park Service. 2006a. Denali National Park and Preserve Final Backcountry Management Plan, General Management Plan Amendment, Environmental Impact Statement January 2006. National Park Service, Denali Park, Alaska. 375pp.

National Park Service. 2006b. Denali National Park and Preserve Final South Denali Implementation Plan and Environmental Impact Statement. 340pp.

National Park Service. 2006c. Denali National Park and Preserve Wildlife-Human Conflict Management Summary. National Park Service, Denali Park, AK. 13pp.

National Park Service. 2007a. Monthly Public Use Report database. http://www2.nature.nps.gov/stats/

National Park Service. 2007b. National Park Service Research Permit and Reporting System. http://science.nature.nps.gov/research/ac/ResearchIndex

National Park Service. 2007c. Wolf-Human Conflict Management Plan. Denali National Park and Preserve, Denali Park, Alaska. 85pp.

National Park Service. 2007d. Cantwell Subsistence Off-Road Vehicle Management Environmental Assessment. Denali National Park and Preserve, Alaska. pages numbered separately by chapter + appendices

National Park Service. 2007e. Consolidated General Management Plan for Denali National Park and Preserve. Denali National Park and Preserve, Denali Park, Alaska. 221pp.

National Park Service Air Resources Division. 2002. Air Quality in the National Parks, Second Edition. Lakewood, Colorado. 59 pp.

National Park Service. Geologic Resources Division. 2004. Central Alaska Network Geologic Resources Evaluation Scoping Meeting Summary. Unpublished report. 57 pp.

National Parks Conservation Association. 2006. Who's counting? How insufficient support for science is hindering National Park wildlife management in Alaska. National Parks Conservation Association, Anchorage, Alaska. 43 pp. http://www.npca.org/alaska/wildlife/AlaskaReport.pdf

Norris, Frank. 2006. Crown Jewel of the North: An Administrative History of Denali National Park and Preserve, Volume 1. Alaska Regional Office, National Park Service. Anchorage, Alaska.

Norris, Frank. 2008. Crown Jewel of the North: An Administrative History of Denali National Park and Preserve, Volume 2. Alaska Regional Office, National Park Service. Anchorage, Alaska. 458 pp.

Oakley, K. 2003. Small mammals monitoring. Pp. 143-154 *In* Long-term ecological monitoring program. Synthesis and evolution of the prototype for monitoring subarctic parks: 1991 to 2002 perspective. S. Boudreau and J. Timmons, eds. Denali National Park and Preserve.
http://www.nature.nps.gov/im/units/cakn/Documents/DENA_LTEM_Synthesis.pdf

Oakley, K. L., and S. L. Boudreau. 2000. Conceptual design of the long-term ecological monitoring program for Denali National Park and Preserve. Report, USGS-Alaska Biological Center, 1011 E. Tudor Rd., Anchorage, AK, 99503. 116 pp.
http://www.absc.usgs.gov/research/Denali_USGS/downloads/Denali_LTEM_Report_without_cover.pdf

Osterkamp, Thomas E. 2005. Applications of Measurements at Permafrost Monitoring Sites for Documenting Long-Term Change in Denali, Wrangell-St. Elias, and Yukon-Charley Rivers National Parks and Preserves, report to Central Alaska Network. 35 pp.

Oswood, M.W., K.Wedemeyer and J.LaPerriere. 1990. Effects of mining disturbances on stream invertebrates and primary producers in Denali National Park, Alaska. Final report, Cooperative Agreement No. CA-9700-4-8013. 106 pp.

Owen, P.A., and T. J. Meier. 2005. 2004 Aerial Moose Survey, Denali National Park and Preserve. National Park Service, Denali Park, Alaska. 8 pp.

Owen, P.A., and T. J. Meier. 2006. 2005 Aerial Moose Survey, Denali National Park and Preserve. National Park Service, Denali Park, Alaska. 8 pp.

Owen, P.A., and T.J. Meier. 2008. 2008 Aerial Moose Survey, Denali National Park and Preserve. National Park Service, Denali Park, AK. 8 pp.

Owen, P. A., and R. Mace. 2007. Grizzly bear population ecology in Denali National Park and Preserve. Alaska Park Science 6(2): 66-68.

Pearson, Grant H. 1953. A History of Mount McKinley, Alaska. [typescript administrative history prepared by the superintendent, 1953]

Pewe, T. L. 1957. Preliminary report of the 1957 advance of Muldrow Glacier. Geological Society of America Bulletin 68: 1908.

Phillips, L. 2009. 2008-2009 Dall's sheep survey, Denali National Park. 2009 report. Denali National Park, Alaska. 11pp.

Phillips, L., P. Hooge, T. Meier, P. Owen, C. McIntyre, and L. Tyrrell. 2007. An integrated study of road capacity at Denali National Park and Preserve. Alaska Park Science Vol. 6(2): 86-88.

Phillips, L., J. Lawler, C. McIntyre, and T. Meier. in review. Dall's Sheep response to traffic volume in Denali National Park and Preserve, Alaska. submitted to J. Wildl. Mgt.

Plafker, G. 1991. Cenozoic uplift history of the Mt. McKinley area in the Central Alaska Range based on fission-track dating. in Geologic Studies in Alaska by the U.S. Geological Survey, USGS Bulletin 2041, Bradley, D.C., and Dusel-Bacon, C., editors.

Plager, A. K. 1982. Backcountry permit compliance in Denali National Park. Master's thesis. University of Washington, Seattle.

Plager, A. K., and P. Womble. 1981. Compliance with backcountry permits in Mount McKinley National Parks. Journal of Forestry *79*(3) 155-156.

Plager, A. K., and P. Womble. 1981. Compliance with backcountry permits: Case study of Mount McKinley National Park (No. CPSU/UW S-79-9): National Park Service, Cooperative Park Studies Unit, College of Forest Resources, University of Washington, Box 352100, Seattle, WA 98195-2100.

Popovics, L. M. 1999. The effects of soil and stream water quality on primary and secondary productivity of Rock Creek, Denali National Park and Preserve. Master's thesis, University of Alaska Fairbanks. Fairbanks, AK.

Post, A. S. 1960. The exceptional advances for the Buldrow, Black Rapids, and Susitna Glaciers. Journal of Geophysical Research 65 (11): 3703-12.

Post, A. 1969. Distribution of surging glaciers in western North America. Journal of Glaciology 8 (53): 229-240.

Putera, J.A., and J.A. Keay. 1998. Final report. Effect of vehicle traffic on Dall sheep migration in Denali National Park, Alaska. Unpublished report, U.S. Geological Survey, Biological Resources Division, Denali Park, AK.

Redmond, K. T., and D. B. Simeral. 2006. Weather and Climate Inventory, National Park Service, Central Alaska Network. Natural Resource Technical Report NPS/CAKN/NRTR—2006/004. National Park Service, Fort Collins, Colorado.

Reed, J.C. 1961. Geology of Mt. McKinley Quadrangle, Alaska. USGS Survey Bulletin 1108-A, 36 pp. + 1 map (out of print)

Reed, B. L. and M. A. Lamphere. 1974. Offset plutons and history of movement along the McKinley segment of the Denali fault system, Alaska. Geologic Society of America Bull. 85 (12): 1883-1892.

Reed, B.L. and S.W. Nelson. 1980. Geologic Map of the Talkeetna Quadrangle, Alaska. USGS Misc. Invest. Series Map I-1174.

Rexstad, E. 1996. Small mammal sampling protocol for long-term ecological monitoring program, Denali National Park and Preserve.

Roberts, S. and A.M. Milner. 1998. Classification of rivers in Denali National Park, Alaska, for long-term ecosystem monitoring. Presented at the North American Benthological Society Annual meeting, Charlottetown, Prince Edward Island, 1998.

Roland, C. A. 2004. The vascular plant floristics of Denali National Park and Preserve. National Park Service, Central Alaska Network Inventory and Monitoring Program. NPS Final Technical Report CAKN-04-01. xxx + 268 pp.

Roland, C., K. Oakley, E. M. Debevec, and Patricia Loomis. 2004. Monitoring vegetation structure and composition at multiple spatial scales in the Central Alaska Network. Central Alaska Inventory and Monitoring Network, Fairbanks, AK

Roland, C., and C. McIntyre. 2006. Integrated monitoring of physical environment, plant, and bird communities in Denali. Alaska Park Science 5: 46-48.

Roush, J. and P. Brease. 1998. 1991-1997 Glacier Monitoring, Denali National Park and Preserve. Unpublished Report, Denali National Park and Preserve. 33 pp.

Saltonstall, W.L. 1988. *Giardia* in Denali National Park; a preliminary study. Unpublished report. On file at National Park Service, Denali National Park and Preserve, Denali Park, Alaska. 21 pp.

Schalk, B., C. S. Maniaci, and R.F. Carlson. 2001. Floodplain delineation and development of management recommendations for flood hazard zones in Denali National Park and Preserve. Final report. Civil and Environmental Engineering Department, University of Alaska Fairbanks.

Schneider, William, Diane Gudgel-Holmes, and John Dolle-Molle. 1984. Land Use in the North Additions of Denali National Park and Preserve: An Historical Perspective. Research/Resource Management Report AR-9, National Park Service: Alaska Region.

Schuur, Edward and Jason G. Vogel. 2007. Development of monitoring techniques to detect change in carbon cycling in relation to thermokarsts in national parks and preserves. Unpublished Report on file at Central Alaska Network, Fairbanks, Alaska. 20 pp.

Shaw, D.W., S. Guers, C. Henneman, J. Peppert, J. Granger, J. Deluca, B. Cato, C. Krissman, B. Wright and S. Ehlers. 2006. Summary of the Alaska Bird Observatory's 2006 H5N1 Avian Influenza screening effort (Creamer's Field Migration Station, Denali Highway, Denali National Park, and Bethel, Alaska). Unpublished report. Alaska Bird Observatory. Fairbanks, Alaska. 10 pp.

Singer, F. J. 1984. Aerial moose survey, Denali National Park and Preserve. U.S. National Park Service, Natural Resource Survey and Inventory Report AR-84/01. 19pp.

Singer, F. J., J. Dalle-Molle, and J. Van Horn. 1981. Dall sheep count, 1981. Denali National Park and Preserve. National Park Service, Alaska Region Natural Resources Survey and Inventory Report AR-81/06. 2525 Gambell, Anchorage, AK 99503.

Sorbel, Brian et al. 2004. National Park Service Alaska Regional GIS Database. Alaska Regional Office. Anchorage, Alaska.

Sorbel, Brian and Jennifer L. Allen, 2005. Space Based Burn Severity Mapping in Alaska's National Parks. Alaska Park Science. Vol.4, Issue 1. National Park Service, Alaska Regional Office. Anchorage, Alaska.

Sousanes, P. J. 2004a. DRAFT Climate monitoring protocol for the Central Alaska Network: Denali National Park and Preserve, Yukon-Charley Rivers National Preserve, and Wrangell-St. Elias National Park and Preserve. Central Alaska Inventory and Monitoring Network, Fairbanks, AK.

Sousanes, P.J., 2004b. Climate Monitoring Site Evaluation 2004. Central Alaska Inventory and Monitoring Network, National Park Service. Fairbanks, AK. 89 pp.

Sousanes, P.J. 2004c. DRAFT Snowpack monitoring protocol for the Central Alaska Network Denali National Park and Preserve, Yukon-Charley Rivers National Preserve, and Wrangell-St. Elias National Park and Preserve. Central Alaska Inventory and Monitoring Network, Fairbanks, AK.

Sousanes, Pamela J. 2006. Annual Climate Monitoring Report for Denali National Park and Preserve, Wrangell-St-Elias National Park and Preserve and Yukon-Charley Rivers National Preserve. NPS/AKCAKN/NRTR-2006/xx. National Park Service. Denali Park, AK. 75 pp.

Stahlnecker, K. 1995. Dall sheep survey, Denali National Park and Preserve. Report. National Park Service, Denali Park, AK.

Stickney, A. A. 1981. Subsistence Resource Utilization: Nikolai and Telida. Interim Report II. Technical Paper 20. Juneau: Alaska Department of Fish and Game Division of Subsistence.

Stokes, J. 1985. Natural Resource Utilization of Four Upper Kuskokwim Communities. Technical Paper 86. Alaska Department of Fish and Game, Division of Subsistence, Juneau.

Stokes, J. W. and E. Andrews. 1982. Subsistence Hunting of Moose in the Upper Kuskokwim Controlled Use Area, 1981. Technical Paper 22. Juneau: Alaska Department of Fish and Game, Division of Subsistence.

Stottlemyer, R. 1992. Nitrogen mineralization and streamwater chemistry, Rock Creek watershed, Denali National Park, Alaska, U.S.A. Arctic Alpine Research 24(4):291-303.

Stottlemyer, R., and K.McLoone. 1990. Natural regulation of headwater stream chemistry by geological substrata, soils, and vegetation, Denali National Park and Preserve. Draft final report. Dept of Biological Sciences, Michigan Technological University, Houghton, MI. GLARSU Research Rept. 43. 58 pp.

Stroud, George S. 1985. History of the Concession at Denali National Park (Formerly Mount McKinley National Park). National Park Service, Anchorage.

Students and Teachers of Minchumina Community School. 2000. Lake Minchumina Past and Present. Denali National Park and Preserve.

Swanson, J.E., M.E. Vande Kamp, D.R. Johnson, R.E. Manning, S.R. Lawson 2002. A Survey of Overnight Backcountry Visitors to Denali National Park and Preserve. Cascadia Field Station USGS/BRD/FRESC, College of Forest Resources, University of Washington. Technical Report NPS/CCSOUW/NRTR-2002-04 NPS D-318.

Swem, T., C. McIntyre, R.J. Ritchie, P.J. Bente and D.G. Roseneau. 1994. Distribution, abundance, and notes on the breeding biology of gyrfalcons *Falco rusticolus* in Alaska. pp. 437-444. *In* B.-U. Meyburg and R.D. Chancellor [eds.] Raptor Conservation Today. Pica Press, London. Proceedings of the IV World Conference on birds of prey and owls, Berlin, Germany, May 10-17, 1992. (World Working Group on Birds of Prey and Owls).

Taylor, D., J. Dalle-Molle, and J. Van Horn. 1988. Survey of Dall sheep, Denali National Park and Preserve-1987. NPS, Alaska Region, Natural Resource Survey and Inventory Report, AR-88/13.

Thorson, R. M. 1986. Late Cenozoic Glaciation of the Northern Nenana Valley *In* Hamilton, Reed, and Thorson, Glaciation in Alaska: The Geologic Record, Alaska Geologic Society.

Thorsteinson, L.K., and D.L. Taylor. 1997. A watershed approach to ecosystem monitoring in Denali National Park and Preserve, Alaska. Journal of the American Water Resources Assn. 33(4):795-810.

Troyer, W. 1974. Winter moose census, Mt. McKinley National Park, 1974. National Park Service, Anchorage. 3 pp.

Troyer, W, and M. Grosnick. 1978. Annual Dall's sheep census, Mt. McKinley National Park, 1977. National Park Service, Anchorage, AK.

Troyer, W, and M. Grosnick. 1979. Annual Dall's sheep census, Mt. McKinley National Park, 1978. National Park Service, Anchorage, AK.

Tyrrell, L.E. 2005. Winter road users and their perceptions of the Aufeis Removal Project at Denali National Park and Preserve. National Park Service.

U. S. Census Bureau, 2000.

U.S. Department of the Interior. Bureau of Land Management. Alaska Fire Service. 2007. Alaska Fire Service GIS Database. Fairbanks, Alaska.

U.S. Department of the Interior. National Park Service. 1999. Park Research and Intensive Monitoring of Ecosystems Network (PRIMENet), First Annual Report, 1999. National Park Service, Denver, Colorado. 68 pp.

U.S. Department of the Interior, National Park Service. 2003. Environmental Assessment for a Gravel Acquisition Plan, Denali National Park and Preserve, Alaska, 172pp. + 5 Appendices.

U.S. Department of the Interior. 1992. NPS Alaska Region. Archives. Alaska Regional Office. Anchorage, Alaska.

U.S. Department of the Interior. 2004. National Park Service. Denali National Park and Preserve Fire Management Plan. Denali National Park and Preserve, Alaska.

U.S. Department of the Interior. 2007a. NPS Alaska Region. Denali National Park and Preserve Fire Report Archive. Denali National Park and Preserve. Alaska.

U.S. Department of the Interior. 2007b. NPS Alaska Western Area Fire Management Archives. Denali National Park and Preserve, Alaska.

U.S. Department of the Interior. 2007c. NPS Alaska Region. Alaska Regional GIS Database. Alaska Regional Office. Anchorage, Alaska.

U.S. Department of the Interior. 2008. NPS Alaska Western Area Fire Management Archives. Denali National Park and Preserve, Alaska.

U.S. Department of Agriculture. 2004. Natural Resources Conservation Service. Soil Survey Geographic (SSURGO) database for Denali National Park Area, Alaska.

U.S. Department of Agriculture. 2006. USFS Pacific Wildland Fire Science Laboratory. Fuels Characteristics Classification System. Seattle, Washington.

U.S. Department of Agriculture. 2007. USFS Remote Sensing Application Center. MODIS Imagery Archives. Salt Lake City, Utah.

Van Ballenberghe, V. 2004. In the company of moose. Stackpole books, Mechanicsburg PA 122 pp.

Van Ballenberghe, V., and D. G. Miquelle. 1990. Activity of moose during spring and summer in interior Alaska. Journal of Wildlife Management 54: 391-396.

Van Maanen, J.L. and G.L. Solin. 1988. Hydraulic and channel characteristics of selected streams in the Kantishna Hills area, Denali National Park and Preserve, Alaska, 1982-1984. U.S. Geological Survey Open-file report 88-325. Anchorage, AK. 105 pp.

Ver Hoef, J. M. 2000. Sampling and geostatistics for spatial data. Ecoscience 9:152-161.

Weddle, Larry 2005. Moose Browse Utilization - Post Burn. Alaska Western Area Fire Management. Denali National Park and Preserve, Alaska.

West, F. H. 1965. Excavations at two sites on the Teklanika River, Mount McKinley National Park, Alaska. Report to the National Park Service, University of Alaska, College.

West, F. H. 1996. Teklanika West pages 332-341 *in* American Beginnings: The prehistory and paleoecology of Beringia. University of Chicago Press.

West, R.L., and N.A. Deschu. 1984. Kantishna Hills heavy metals investigations, Denali National Park, 1983. From USFWS/NPS Interagency agreement no. 14-16-007-82-5524. On file at National Park Service, Alaska System Support Office, Anchorage, AK. 104 pp.

Western Region Climate Center (WRCC). Reno, Nevada. http://www.wrcc.dri.edu/

Wilbor, S. L. 1996. Reproductive performance, nesting habitat, and prey of taiga merlins in Denali National Park and Preserve, Alaska. M. S. Thesis. University of Alaska.

Williams, Liz, Chelsea Venechuk, Davin Holen, and William Simeone 2005. Lake Minchumina, Telida, Nikolai, and Cantwell Subsistence Community Use Profiles and Traditional Fisheries Use. Technical Paper 295. Juneau: Alaska Department of Fish and Game Division of Subsistence.

Withers, Jared. 2006. Denali National Park and Preserve Soundscape [draft] Annual Report. 2006. Denali National Park and Preserve, Denali Park, Alaska. Unpublished report. 85pp.

Wolfe, David F.G. 1994. History of Vegetation Surveys in Denali National Park, Alaska U.S. Department of the Interior, National Park Service.

Womble, P. 1979. Survey of backcountry users in Mount McKinley National Park, Alaska: A report for management (No. CPSU/UW S-79-8): National Park Service, Cooperative Park Studies Unit, College of Forest Resources, University of Washington, Box 352100, Seattle, WA 98195-2100.

Wygal, Brian. 2007. Cultural resource exploration in Denali National Park and Preserve: 2007 Annual Report. Denali National Park and Preserve, Cultural Resources Division. 67 pp.

Wygal, Brian. 2008. Cultural resource exploration in Denali National Park and Preserve: 2008 Annual Report. Denali National Park and Preserve, Cultural Resources Division. 336 pp.

Wygal, Brian, and Kathryn Krasinski. 2009. Draft Cultural Resource Exploration in Denali National Park and Preserve: 2006-2009 Final Report.

Zarnke, R. L. 1983. Serologic survey for selected microbial pathogens in Alaskan wildlife. Journal of Wildlife Diseases 19: 324-329

Appendices

Appendix A: ***Interdisciplinary Team and Stakeholders***

Appendix B: ***Indices Identified and Used – Cultural Resources***

Appendix C-1: ***Resource Assets and Current Conditions – Cultural Resources (Structures and Cultural Landscapes)***

Appendix C-2: ***Resource Assets and Current Conditions – Cultural Resources (Museum Objects)***

Appendix D: ***Resources Attributes, Current Conditions, and References – Natural Resources***

Appendix E: ***Public Involvement and Expert Review Response***

Appendix F: ***Appendix F: Additional Employee Needs, Line Items for Construction, Funding Sources, and Project Prioritization***

Appendix A: Interdisciplinary Team and Stakeholders

Interdisciplinary Planning Team

Philip Hooge	Overall project coordination
Charlie Loeb	Planning and public involvement; team meetings
Lucy Tyrrell	Project logistics; Document compiling, editing, and design
Guy Adema	Project management; physical resources
Tom Meier	Biological resources
Ann Kain	Cultural resources
Amy Craver	Cultural and subsistence resources
Dan Warthin	Fire Management
Ingrid Nixon	Interpretation
Christie Anastasia	Murie Science and Learning Center education
Joe Van Horn	Wilderness and ranger protection
Dutch Scholten	Maintenance

Subject Matter Leads

Guy Adema	Physical resources
Tom Meier	Biological resources
Ann Kain	Cultural resources
Amy Craver	Cultural and subsistence resources
Larry Weddle	Fire Management
Charlie Loeb	Social science

Resources Staff, Center for Resources, Science, and Learning

Guy Adema, Andrea Blakesley, Bridget Borg, Phil Brease, Jane Bryant, Bonni Burnell, Amy Craver, Nikki DeMers, Philip Hooge, Pati Jones, Ann Kain, Jeremy Karchut, Jane Lakeman, Rob Liebermann, Carol McIntyre, Wendy Mahovlic, Tom Meier, Morgan Miller, Susanna Nancarrow, Pat Owen, Jon Paynter, Laura Phillips, Charlier Reynar, Carl Roland, Pam Sousanes, Sarah Stehn, Lucy Tyrrell, James Walton, Dan Warthin, Larry Weddle, Jared Withers, Brian Wygal, Larissa Yocum

Consultation and Expert Review

Aldo Leopold Wilderness Research Institute (Alan Watson), Alaska Department of Fish and Game, Denali Citizens Council, Denali Education Center, National Parks Conservation Association, U. S. Geological Survey, University of Alaska Fairbanks (Peter Fix), University of Vermont (Robert Manning)

Stakeholder and Researcher Meetings

Public meetings to inform stakeholders, and specifically researchers, about the preparation of the RSS were held in Anchorage (January 9, 2007), Denali Park – Healy – McKinley Village (January 11, 2007), Fairbanks (February 7, 2007), and Susitna Valley - Talkeetna (January 8, 2007).

Appendix B: Indices Identified and Used – Cultural Resources

Existing indices were employed to provide a measure of resource condition, but it was recognized that some attributes may require more than one index of condition to fully describe desired and current conditions.

Archeological Sites Management Information System, ASMIS

This index has over 200 data fields, most of which are not relevant for RSS purposes. The field for Site Condition describes the existence of threats and impacts to the archeological resources. An absence of threat, and/or removal of impact to the resources is a desired condition. The field for Depositional Integrity concerns the degree to which an archeological deposit is intact or complete, or the degree to which the original deposit is preserved. Additionally, consideration of whether a park-wide inventory has been completed was added as a field of assessment.

Annual and Comprehensive Inspection for Facility Management Software System, FMSS inspection

The FMSS inspections are intended as a maintenance tool. Therefore, not all inspected attributes on the inspection sheet apply to the RSS purpose of determining current condition and describing future condition. The inspection factors are separately listed for each resource or group of resources in Appendix D.

Automated Museum Checklist, AMC

The checklist is an extensive and comprehensive list that covers condition of the resource and conditions in which it is housed. It is more detailed than what is required to determine current condition or define desired condition. A subset of checklist categories exists for each location of collections and within that subset some standards do not apply to the location and are given a status of NA, not applicable. Targets for desired condition were established as a percent compliance with all applicable standards.

Cultural Landscape Inventory, CLI assessment

The CLI is an evaluated inventory of all cultural landscapes (landscapes, component landscapes, landscape features, and component landscape features) having historical significance in which the NPS has or plans to acquire legal interest. The CLI provides the baseline information for a cultural landscape. As such, the CLI assists park managers and cultural resource specialists in planning, programming, and recording treatment and management of listed landscapes. Prescriptive recommendations from the CLI suggest treatments that will allow the cultural landscape to attain the desired condition. These desired conditions are largely a product of the Cultural Landscape Report. Therefore, the 1995 Cultural Landscape Report will continue to act as a detailed description of desired condition, when consistent with statements within the GMP.

List of Classified Structures, LCS assessment

The LCS is an evaluated inventory of all historic and prehistoric structures that have historical, architectural, and/or engineering significance within parks of the National Park System in which the NPS has, or plans to acquire, any legally enforceable interest. The assignment of condition should be based on the goal of maintaining the character, material, and stability of the structure as acquired, excavated, or existing. The assessments, as presented in the LCS, are an appropriate, although not comprehensive, description of current condition. The LCS also assesses impact levels of an agent or series of agents having a negative effect on the significant characteristics or

integrity of a structure, and for which some form of mitigation or preventative action is possible. This aspect of the assessment was not employed in the RSS, but could be considered for future use or as a secondary step in determining a course of action to attain desired condition.

Appendix C-1: Resource Assets and Current Conditions – Cultural Resources (Structures and Cultural Landscapes)

Current condition for structures (e.g., buildings, outhouses, doghouses, bridges, graves) as given by LCS, FMSS, and ASMIS, and for cultural landscapes as given by CLI.

The terms and definitions of condition (Good, Fair, Poor, Serious, etc) varies from program to program. Thus, the condition for a structure may be different depending on whether the assessment of condition was made in LCS, FMSS, and AMSIS.

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
1	Pearson Cabin	4	1073	Fair	2006	18650	Poor	Good	
2	Upper Toklat Ranger Station	24	1074	Good	2006	38020	Serious	Good	
3	Dog Feed Cache & Sled Storage - HQ	105	1075	Good	2005	1505	Serious		
4	Upper Windy Patrol Cabin	7	5222	Good	2006	18651	Serious	Good	
5	Lower Savage Patrol Cabin	8	5223	Good	2007	18652	Poor	Fair	
6	Lower East Fork Patrol Cabin	9	5224	Good	2007	18653	Good	Good	
7	Wonder Lake Ranger Station	14	5225	Good	2007	18699	Good		
8	Lower Windy Shelter Cabin	15	5226	Good	2006	18700	Serious		
9	Sushana Patrol Cabin	17	5227	Good	2007	18701	Serious	Good	
10	Lower Toklat Patrol Cabin	18	5228	Good	2007	18702	Serious	Fair	
11	Moose Creek Shelter Cabin	19	5229	Good	2007	18703	Good	Good	
12	Riley Creek Patrol Cabin	20	5230	Good	2006	18704	Serious	Good	
13	Igloo Creek Patrol Cabin	25	5231	Good	2006	18708	Serious	Good	
14	Upper East Fork Patrol Cabin	29	5232	Good	2006	18709	Serious	Good	
15	Upper Savage Patrol Cabin	30	5233	Good	2006	18710	Serious	Good	
16	Sanctuary Patrol Cabin	31	5234	Good	2006	18711	Serious	Good	
17	Administration Building, HQ	21	5235	Fair	2004	1514	Poor		
18	Residence/Old Museum, HQ	22	5236	Fair	2004	1519	Poor		
19	Superintendent's Residence, HQ	23	5237	Good	2004	1526	Serious		
20	Interp/Museum, HQ	101	5238	Good	2007	1511	Good		

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
21	Ranger Office/Upthere, HQ	103	5239	Good	2007	1512	Good		
22	Old Sign Shop, HQ	106	5240	Good	2004	1502	Serious		
23	Plumbing Shop, HQ	107	5241	Good	2004	1528	Good		
24	Engineer Office, HQ	110	5242	Good	2004	1499	Serious		
25	Residence/Old Superintendent's Garage, HQ	111	5243	Good	2008	1518	Serious		
26	"John House", HQ	112	5244	Good	2005	1523	Poor		
27	Carpenter Shop, HQ	102	35000	Good	2004	1510	Good		
28	Employee Residence - Apartments, HQ	12	35001	Good	2005	1521	Good		
29	Employee Residence - Apartments, HQ	13	35002	Good	2006	1522	Good		
30	Moose Creek Shelter Cabin Cache	00019A	36500	Good	2007				
31	Moose Creek Shelter Cabin Dog Houses	00019B	36501	Poor	2007				
32	Messhall - CCC Camp	121	36502	Good	2004	1557	Good		
33	Dog Houses - HQ	00105A	36503	Good	2004				
34	Dog Kennels - HQ	00105B	36504	Good	2004				
35	Retaining Wall, HQ	00111A	36505	Fair	2004				
36	Hotel Heat & Power House	140	36506	Fair	2007	18902	Poor		
37	McKinley Airfield	AIRH	36507	Good	2004				
38	McKinley Park Road - Rt. 1	RIP	36508	Good	2004				
39	McKinley Park Road - Rt. 1	RIA	36509	Good	2004				
40	McKinley Park Road - Rt. 1	RIB	36510	Good	2004				
41	McKinley Park Road - Rt. 1	RIC	36511	Good	2004				
42	Moose Creek Fish Camp Cabin	MMK-011	36512	Poor	2003			Fair	
43	Quigley Residence	42	36514	Good	2006	18714	Poor	Good	
44	Quigley Shed	00042A	36515	Good	2006				
45	Quigley Outhouse	00042B	36516	Poor	2006				
46	Upper Caribou Creek Cabin	MMK-00023	36517	Poor	2008			Fair	
47	Upper Caribou Creek Shed	MMK-00023A	36518	Poor	2008				
48	Taylor Cabin	MMK-040	36519	Fair	2007			Fair	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
49	Caribou Creek Camp Cabin	MMK-044	36520	Poor	2008			Fair	
50	Caribou Creek Camp Shed	MMK-044A	36521	Fair	2008				
51	Last Chance Creek Cabin	MMK-046	36522	Fair	2003			Fair	
52	Last Chance Creek Shed	MMK-046A	36523	Fair	2003				
53	Glacier Creek Cabin	MMK-055	36524	Poor	2007			Poor	
54	Glacier Creek Shed	MMK-055A	36525	Poor	2007				
55	Glacier Creek Dragline Bunkhouse	MMK-00056	36526	Poor	2008			Fair	
56	Glacier Creek Dragline Shed	MMK-00056A	36527	Poor	2008				
57	Little Annie Mine Cabin	MMK-061	36528	Fair	2007			Good	
58	Little Annie Mine Portal	MMK-061B	36529	Poor	2007				
59	Little Annie Mine Tailings Pile	MMK-061C	36530	Good	2007				
60	Glen Creek Cabin	MMK-063	36531	Poor	2007			Fair	
61	Thorofare River Patrol Cabin	1	36532	Good	2008				
62	Glacier Peak Rock Shelter	MMK-079	36533	Good	2007			Poor	
63	Skookona Prospect Tailings Piles	MMK-080	36534	Good	2008			Good	
64	Skookona Prospect Hand-Stacked Tailings Piles	MMK-080A	36535	Good	2004				
65	Skookona Prospect Claims Marker	MMK-080B	36536	Good	2004				
66	Nelson Cabin	MMK-086	36537	Poor	2008			Good	
67	Quigley Ridge Cabin	MMK-00089	36538	Poor	2008			Good	
68	Kantishna Hydraulic Co. Dam	MMK-019A	36539	Poor	2007				
69	Kantishna Hydraulic Co. Ditch	MMK-00019	36540	Poor	2006			Good	
70	Alpha Ridge Mine Cabin	MMK-091	36541	Poor	2008			Good	
71	Alpha Ridge Mine Shed	MMK-091A	36542	Poor	2008				
72	Carlson Lake Cabin	MMK-029	36543	Poor	2007			Good	
73	Lower Toklat Patrol Cabin Dog Houses	00018C	36544	Poor	2007				
74	Carlson's Birch Creek Cabin	MMK-00115	36546	Poor	2005			Good	
75	Carlson's Birch Creek Dog Houses	MMK-00115A	36547	Poor	2005				
76	Slippery Creek Mine Cabin	MMK-116	36548	Poor	2007			Fair	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
77	Slippery Creek Mine Cold Storage Box	MMK-116A	36549	Fair	2007				
78	Upper Savage Patrol Cabin Dog House Ruins	00030A	36550	Poor	2006				
79	Parker Cabin	DENA040	36551	Good	2007	18926	Serious		
80	Parker Cabin Cache	DENA040A	36552	Good	2007				
81	Parker Cabin Sauna	DENA040B	36553	Good	2007				
82	Jauhola's Moose Creek Cabin	DENA165	36554	Fair	2006	18924	Serious		
83	Jauhola's Glacier Creek Cabin	DENA058	36555	Good	2008				
84	Kantishna Roadhouse	40	36556	Poor	2008				
85	Eureka Creek Hand-Stacked Tailings Piles	MMK-126A	36557	Good	2004				
86	Fourth Of July Creek Cabin	TAL-063	36558	Poor	2007				
87	Fish Lake Cabin	DENA167	36559	Poor	2007				
88	Lower East Fork Patrol Cabin Dog House	00009A	36560	Poor	2006				
89	Colorado Creek Cabin #1	MMK-228	36561	Poor	2007				
90	Colorado Creek Cabin #2	MMK-228A	36562	Poor	2007				
91	Colorado Creek Outhouse	MMK-228B	36563	Fair	2007				
92	Colorado Creek Bridge	MMK-228C	36564	Poor	2007				
93	Caribou Creek Hydraulic System	MMK-00042	36570	Poor	2007			Fair	
94	Caribou Creek Header Boxes	MMK-00041	36571	Poor	2007			Fair	
95	Stampede Mine Mill Building	MMK-016	36572	Poor	2003			Unknown	
96	Stampede Mine Messhall	MMK-016A	36573	Fair	2003				
97	Stampede Mine Privy	MMK-016B	36574	Poor	2003				
98	Stampede Mine Bunkhouse	MMK-016C	36575	Fair	2003				
99	Stampede Mine Privy #2	MMK-016D	36576	Poor	2003				
100	Stampede Mine Bridge	MMK-016F	36578	Fair	2003				
101	Stampede Mine Power House/Shop	MMK-016G	36579	Fair	2003				
102	Stampede Mine Warehouse	MMK-016H	36580	Poor	2003				
103	Stampede Mine Cache	MMK-016I	36581	Fair	2003				
104	Stampede Mine Pilgrim Cabin	MMK-016J	36582	Fair	2003				

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
105	Stampede Mine Weather Station	MMK-016K	36583	Poor	2003				
106	Stampede Mine Greenhouse	MMK-016L	36584	Poor	2003				
107	Stampede Mine Warehouse #2	MMK-016M	36585	Poor	2003				
108	Lower Windy Shelter Cabin Dog Houses	00015A	36587	Poor	2006				
109	Lower Windy Shelter Cabin Outhouse	00015B	36588	Fair	2006				
110	Lower Windy Shelter Storage Cabin	00015C	36589	Fair	2006	61921	Poor		
111	Pearson Cabin Cache	00004A	36590	Poor	2006				
112	Pearson Cabin Dog Houses	00004B	36591	Poor	2006				
113	Crooked Creek Cabin	MMK-120	36593	Poor	2007			Fair	
114	Crooked Creek Cache	MMK-120A	36594	Poor	2007				
115	Morino Grave	HEA-00280	36595	Good	2005			Fair	
116	McClarty Grave	HEA-00282	36596	Good	2005			Fair	
117	Smith Grave	HEA-282A	36597	Fair	2005			Fair	
118	Glacier City Main Cabin/Office	MMK-00003H	36598	Poor	2006			Fair	
119	Glacier City Cabin	MMK-00003A	36599	Poor	2006			Fair	
120	Glacier City "Scow"	MMK-00003B	36600	Poor	2006			Fair	
121	Glacier City Cabin #2	MMK-00003D	36602	Poor	2006			Fair	
122	Glacier City Barn	MMK-00003E	36603	Poor	2006			Fair	
123	Glacier City Blacksmith Shop	MMK-00003F	36604	Poor	2006			Fair	
124	Roosevelt Cabin	DENA087A	36606	Fair	2007			Unknown	
125	Roosevelt Cabin Storage Shed	DENA087B	36608	Fair	2007				
126	Roosevelt Cabin Sauna	DENA087C	36609	Poor	2007				
127	Roosevelt Cabin Outhouse	DENA087D	36610	Poor	2007				
128	Roosevelt Cabin Doghouses	DENA087E	36611	Poor	2007				
129	Castle Rocks Lake Cabin	DENA020	36613	Fair	2005				
130	Roosevelt Cabin Cache	DENA087F	36615	Fair	2007				
131	Upper Savage Patrol Cabin Dog House	00030B	565203	Good	2006				
132	Busia Cabin	MMK-00017	599769	Good	2008	93699	Serious	Good	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
133	Residence #27	27	600925	Good	2007				
134	Residence #26	26	600951	Fair	2007				
135	Residence #28	28	600959	Fair	2007				
136	Residence #34	34	600966	Good	2007				
137	Teklanika West	HEA-00001						Good	
138	Teklanika East	HEA-00002						Good	
139		HEA-00023						Fair	
140		HEA-00024						Fair	
141	C. Lester Plumb Cabin Site	HEA-00040						Poor	
142	Ski Hut Site	HEA-00041						Unknown	
143	Cabin Site	HEA-00043						Fair	
144		HEA-00044						Fair	
145		HEA-00045						Fair	
146	Yanert	HEA-00053						Unknown	
147	Morino Roadhouse Site	HEA-00059						Fair	
148	Windy	HEA-00071						Unknown	
149	Clear Creek RR Bridge	HEA-00072						Good	
150	Carlo	HEA-00073						Unknown	
151	Riley Creek RR Bridge	HEA-00074						Good	
152	McKinley Park Station	HEA-00075						Poor	
153	Teklanika Archeological District	HEA-00085						Good	
154	Stampede Trail	HEA-00091						Fair	
155	Historic Cabin	HEA-00094						Fair	
156	Teklanika Bridge Crossing	HEA-00105						Fair	
157		HEA-00107						Fair	
158	Cabin	HEA-00108						Fair	
159		HEA-00114						Good	
160	Thompson/Stubbs Complex	HEA_00132						Good	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
161	Riley Creek Lithic Scatter	HEA-00133						Fair	
162	First Park HQ	HEA-00134						No Data	
163		HEA-00135						Fair	
164		HEA-00136						Fair	
165	Hotel Overlook Site	HEA-00143						Fair	
166	Reservoir Hill Site	HEA-00144						Good	
167	Morino Hill Site	HEA-00145						Fair	
168		HEA=00146						Unknown	
169	Mt. McKinley NP HQ	HEA-00147						Good	
170		HEA-00148						Good	
171		HEA-00149						Unknown	
172		HEA-00150						Fair	
173		HEA-00151						Fair	
174		HEA-00152						Good	
175		HEA-00153						Unknown	
176		HEA-00154						Unknown	
177		HEA-00155						Unknown	
178		HEA-00156						Unknown	
179		HEA-00157						Unknown	
180		HEA-00158						No Data	
181		HEA-00159						Unknown	
182		HEA-00160						Poor	
183		HEA-00161						Unknown	
184		HEA-00162						Unknown	
185		HEA-00163						Fair	
186		HEA-00164						Unknown	
187		HEA-00165						Fair	
188		HEA-00166						No Data	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
189		HEA-00167						Unknown	
190		HEA-00168						Fair	
191		HEA-00169						Unknown	
192		HEA-00170						Unknown	
193		HEA-00171						Unknown	
194		HEA-00173						No Data	
195		HEA-00192						Unknown	
196		HEA-00193						Unknown	
197	Worker's Cabins	HEA-00208						Unknown	
198	Hotel Intake Dam Structures	HEA-00209						No Data	
199		HEA-00227						Poor	
200		HEA-00228						Good	
201		HEA-00229						Poor	
202	West Fork Chulitna River Bridge	HEA-00230						Unknown	
203		HEA-00231						Fair	
204		HEA-00232						Good	
205		HEA-00255						Good	
206		HEA-00256						Fair	
207		HEA-00257						Fair	
208		HEA-00258						Fair	
209		HEA-00259						Fair	
210		HEA-00260						Fair	
211		HEA-00261						Fair	
212		HEA-00262						Poor	
213		HEA-00263						Good	
214		HEA-00264						Fair	
215		HEA-00265						Good	
216	CCC Camp at Teklanika	HEA-00276						Fair	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
217	CCC Camp	HEA-00277						Fair	
218	ARC Vehicle & Machine Dump	HEA-00278						Fair	
219	Large Can Dump	HEA-00279						No Data	
220	Northwest "Meadows" Dump	HEA-00281						No Data	
221	Historic Cabin	HEA-00283						Fair	
222	Kennedy Cabin Foundation	HEA-00284						Good	
223	W.A. Baker Cabin Ruins	HEA-00285						Poor	
224	Nenana Canyon Roadhouse	HEA-00293						Poor	
225		HEA-00313						Fair	
226	Diamond	MMK-00001						Good	
227	Kantishna	MMK-00002						Fair	
228		MMK-00015						Unknown	
229	Banjo Mill	MMK-00022						Fair	
230	Kantishna Roadhouse	MMK-00018						Fair	
231		MMK-00024						Fair	
232		MMK-00025						Poor	
233	Rainy Creek Overlook	MMK-00027						Fair	
234		MMK-00026						Fair	
235		MMK-00029						Good	
236	Birch Creek Cemetery & Settlement	MMK-00031						Good	
237		MMK-00034						Good	
238		MMK-00035						Fair	
239		MMK-00036						Fair	
240		MMK-00037						Fair	
241		MMK-00038						Fair	
242		MMK-00039						Fair	
243		MMK-00043						Unknown	
244		MMK-00045						Poor	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
245		MMK-00047						Poor	
246		MMK-00048						Fair	
247		MMK-00049						Fair	
248		MMK-00050						Poor	
249		MMK-00051						Fair	
250		MMK-00052						Fair	
251		MMK-00053						Fair	
252		MMK-00054						Fair	
253		MMK-00057						Fair	
254		MMK-00058						Fair	
255		MMK-00059						Fair	
256		MMK-00060						Fair	
257		MMK-00062						Fair	
258		MMK-00064						Fair	
259		MMK-00065						Good	
260		MMK-00066						Fair	
261		MMK-00067						Good	
262		MMK-00068						Fair	
263		MMK-00069						Fair	
264		MMK-00070						Unknown	
265		MMK-00071						Good	
266		MMK-00072						Fair	
267	Taylor Mine	MMK-00077						Fair	
268		MMK-00078						Good	
269	Glacier Peak Summit	MMK-00079						Poor	
270	Humbolt Prospect	MMK-00081						Poor	
271	McGonagal Claims	MMK-00082						Poor	
272	Busia Grave	MMK-00083						Good	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
273		MMK-00084						Good	
275	Pollock Homestead	MMK-00085						Unknown	
276		MMK-00087						Fair	
277		MMK-00088						Fair	
278	Galena Lode Claim	MMK-00090						Good	
279	Never Sweat Lode Claim	MMK-00092						Poor	
280	Lower Moose Creek Sawmill	MMK-00093						Good	
281	Cache Creek Base Camp	MMK-00094						Fair	
282	Stampede Trail	MMK-00095						No Data	
283		MMK-00096						Fair	
284		MMK-00097						Fair	
285		MMK-00098						Good	
286	Eureka	MMK-00099						Good	
287		MMK-00100						Poor	
288		MMK-00101						Good	
289		MMK-00102						Good	
290		MMK-00103						Fair	
291		MMK-00104						Unknown	
292		MMK-00105						Poor	
293		MMK-00106						Unknown	
294		MMK-00107						Good	
295		MMK-00108						Good	
297		MMK-00109						Good	
298		MMK-00110						Unknown	
299		MMK-00111						Unknown	
300		MMK-00112						Fair	
301		MMK-00113						Fair	
302		MMK-00117						Fair	

	Structure Name	Structure/Site Number	LCS ID	(I) Latest LCS Condition	Latest Year LCS Assessment	FMSS Number	(II) FMSS Condition 1	(III) ASMIS Condition 1	(IV) Cultural Landscape Condition 1
303		MMK-00118						Fair	
304		MMK-00119						Fair	
305	CCC Camp (WLRS)	MMK-00121						Fair	
306		MMK-00122						Good	
307		MMK-00123						Poor	
308		MMK-00124						Poor	
309	Copper Mountain Mining Camp	MMK-00125						Fair	
310		MMK-00127						Good	
311		MMK-00128						Good	
312		MMK-00129						Fair	
313	Live Trap Lake Cabin	MMK-00131						Poor	
314	Willow Creek Overlook	MMK-00028						Unknown	
	Cultural Landscapes:								
	Teklanika								No Assessment
	Road Corridor								No Assessment
	Wonder Lake Ranger Station								No Assessment
	Kantishna Mining District								No Assessment
	Park Headquarters								Fair

Appendix C-2: Resource Assets and Current Conditions – Cultural Resources (Museum Objects)

The current condition of objects in the Denali National park and Preserve museum collection as summarized for archives, cultural resources, and natural history objects.

Condition	Objects/Specimens		
	Archives	Cultural Resources	Natural History
Excellent	16800	11838	474
Good	65760	11837	7351
Fair	0	6079	55
Poor	0	66	11
No Condition Assigned	0	2485	2150
TOTAL	82560	27277	10041

Appendix D: Resources Attributes, Current Conditions, and References – Natural Resources

This table lists the attributes, indicators, current condition, and source of information (reference) for 120 indicators being used to assess the condition of Denali's natural resources. Additional cultural indicators are listed here (between D-71 and D-72) but the condition assessment for these indicators is provided in Appendices B, C-1 and C-2. For a more complete treatment of the indicators listed, see Tables 8-10 (see column 5 for letter-number combination that corresponds to that listed in column 1 of this table (e.g., AppD-1 means Appendix D, row D-1).

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
Wildlife Populations, Habitat, Ecosystems (Parkwide)				
D-1	No Anthropogenic Changes in Species Composition	# Native animal species lost	None to date	NPS Performance Management Data System (PMDS) Goal Ia2B Report 2007
D-2	No Anthropogenic Changes in Species Composition	# Exotic animal species	None to date	PMDS Goal Ia2B Report 2007
D-3	Natural Regulation of Animal #s, Distribution	Caribou	Slow increase	Adams and Roffler 2008
D-4	Natural Regulation of Animal #s, Distribution	Moose	Slight decrease	Owen and Meier 2006
D-5	Natural Regulation of Animal #s, Distribution	Dall's sheep	Unknown	Putera and Keay 1998
D-6	Natural Regulation of Animal #s, Distribution	Beavers	Unknown	Arp, unpublished data
D-7	Natural Regulation of Animal #s, Distribution	Snowshoe hares	At peak	McIntyre, unpub. data
D-8	Natural Regulation of Animal #s, Distribution	Arctic ground squirrels	Unknown	McIntyre, pers. comm.
D-9	Natural Regulation of Animal #s, Distribution	Small mammals	Unknown	Oakley 2003
D-10	Natural Regulation of Animal #s, Distribution	Trumpeter Swans	Increasing	McIntyre 2006
D-11	Natural Regulation of Animal #s, Distribution	Willow Ptarmigan	Unknown	McIntyre, pers. comm.
D-12	Natural Regulation of Animal #s, Distribution	Passerine birds	Unknown	Roland and McIntyre 2006
D-13	Natural Predator-Prey Function	Wolves	Stable	Meier et al. 2006
D-14	Natural Predator-Prey Function	Grizzly bears	Unknown	Keay 1999
D-15	Natural Predator-Prey Function	Golden Eagles	Stable	McIntyre and Adams 1999

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
D-16	Natural Animal Behavior	# Bear-human interactions (BHIMS)	Stable	Denali BHIMS database
D-17	Natural Animal Behavior	# Human-wildlife interactions	Stable	Denali BHIMS database
D-18	Natural Animal Behavior	Wildlife damage to property	Stable	Denali BHIMS database
D-19	Natural Animal Behavior	Wildlife obtaining human food	Decreasing	Denali BHIMS database
D-20	Wetland Function	Acres of functional wetland lost	None	USFWS NHD
D-21	Wetland Function	Wetland plant communities	Unknown	Roland et al. 2004
D-22	Natural Fish Movement	New restrictions to fish movement	Unknown	Karle 2007b
D-23	Lake Ecosystem Function	Acreage of lakes >1 acre	Stable	USGS NHD
D-24	Lake Ecosystem Function	# Lakes > 1 acre	Stable	USGS NHD
D-25	Lake Ecosystem Function	Limnological measurements of ecosystem function	Stable	Larsen and others Brabets and Arp, pers. comm.
D-26	Anthropogenic Contaminants	Indicators to be determined	Unknown	WACAP final report (in press)
D-27	Aquatic Communities	Aquatic species communities	None known	Larson, unpublished data
D-28	Aquatic Communities	% Native aquatic invertebrates	None known	
D-29	Aquatic Communities	# Salmon entering park	Unknown	U. S. National Park Service, 2001
D-30	Aquatic Communities	Nonanadromous fish communities	Unknown	Markis et al. 2004
D-31	Water Quality	Water chemistry	Some known stable, some unknown	Mangi 2005
D-32	Water Quality	Contaminants in aquifers	High nitrate and visible sheen in some; some unknown	Mangi 2005
D-33	Water Quality	Presence of organchlorines	Unknown	Karle 2007b
D-34	Water Quality	Presence of *E. coli*	Unknown	Karle 2007b
D-35	Soil / Water Interface	Effects of CaCl	Unknown	Karle 2007b
D-36	Water Quality	Turbidity, heavy metals in streams	Unknown	Mangi 2005

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
D-37	Water Quality	% of unimpaired streams and lakes	Unknown	Alaska DEC, Mangi 2005
D-38	Water Quality	# Water quality violations	None	Alaska DEC
D-39	Water Quality – Potential Influences	Effects of coalbed methane	None	Karle 2007b
D-40	Water Quality – Potential Influences	Effects of north access road	None	Karle in press
D-41	Functional Stream Morphology	Floodplain morphology near roads	Stable	Karle 2007b
D-42	Functional Stream Morphology	Placer-mined stream morphology	Largely recovered to non-functional	Karle 2007b
D-43	Functional Stream Morphology	Floodplain delineations	Limited	Karle 2007b
D-44	Functional Stream Morphology	Effects of potential north access	None	Karle in press
D-45	Functional Stream Morphology	Hydrologic regime and climate	Unknown	Karle 2007b
D-46	Functional Stream Morphology	% Mined riparian acres restored	Improving	Karle 2007b
D-47	Major Ecosystem Processes (Plants)	Plant species composition	Unknown	Roland 2004
D-48	Major Ecosystem Processes (Plants)	# Native plant species lost	None known	Roland 2004
D-49	Major Ecosystem Processes (Plants)	Exotic plant species	Developed areas	Roland 2004
D-50	Major Ecosystem Processes (Plants)	Anthropogenic effects	Not widespread	Roland 2004
D-51	Major Ecosystem Processes (Fire)	# Acres burned per year	Not analyzed	DOI 1202 Fire reports
D-52	Major Ecosystem Processes (Fire)	# Natural fire starts per year	Not analyzed	DOI 1202 Fire reports
D-53	Major Ecosystem Processes (Fire)	Total duration of incidents	Not analyzed	DOI 1202 Fire reports
D-54	Major Ecosystem Processes (Fire)	Fire season duration and timing	Unknown	Unpublished AWAFM Data
D-55	Major Ecosystem Processes (Fire)	Percent burns by severity class	Unknown	AK Regional Geospatial Database
D-56	Major Ecosystem Processes (Fire)	Actions that deviate (Limited)	None	DENA fire files
Scenic and Geological Values Preserved (Parkwide)				
D-57	Glaciers	Total glaciated area	Decreasing	Adema 2007

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
D-58	Glaciers	Extent, volume of selected glaciers	Decreasing	Arendt et al. 2002, Adema 2007
D-59	Rare Geological Features	Inventory of features	None	Brease, Clark, pers. com
D-60	Rare Geological Features	Condition of defined features	Unknown	Brease, pers. com
D-61	Surface Processes	# Interrupted major processes	Unknown	Brease/Adema, pers. com
D-62	Natural Viewshed	Acres where development visible	Unknown	Brease/Adema, pers. com
D-63	Soil (including frozen soil)	# Acres thermokarst	Unknown	Brease/Adema, pers. com
D-64	Soil (including frozen soil)	Carbon balance	Unknown	Schuur and Vogel 2007
D-65	Soil (including frozen soil)	Soil temperature	Unknown	Sousanes 2004a, Osterkamp 2005
D-66	Soil (including frozen soil)	Acreage degraded	Unknown	Brease/Adema, pers. com
D-67	Climate Change (see also ecosystem processes)	Climate variables	Unknown	Sousanes, pers. com
D-68	Climate Change (see also ecosystem processes)	Damage from floods, landslides	Unknown	Brease/Adema, pers. com
D-69	Climate Change (see also ecosystem processes)	Insect outbreaks (acres)	Unknown	Owen, pers. com
D-70	Natural Lightscapes	# Acres with impaired lightscape	Unknown	Tranel, pers. com
D-71	Natural Lightscapes	Starlight magnitude	Unknown	Brease, pers. com
Historical, Archaeological, Ethnographic Resources (Parkwide)				
	Historic Structures Integrity, Condition	% structures in good condition (LCS)	36%	See Appendix B, C
	Site Integrity, Condition	% sites in good condition (ASMIS)	28%	See Appendix B, C
	Landscape Integrity and Condition	% landscapes in good condition (CLI)	0%	See Appendix B, C
	Condition of Museum Objects	% in good condition (ANCS+)	75%	See Appendix B, C
	Condition of Ethnographic Resources	% in good condition (ANCS+)	Unknown	See Appendix B, C
	Condition of Museum Objects	# of objects identified	75%	See Appendix B, C
	Native Peoples: Ethnographic Resources	% in good condition (ASMIS)	28%	See Appendix B, C
	Native Peoples: Ethnographic Resources	% in good condtion (CLI)	0%	See Appendix B, C
	Native Peoples: Ethnographic Resources	# and condition listed for resources	Unknown	See Appendix B, C
Air Quality,Class I Airshed (Parkwide)				
D-72	Air Quality, Chemical Composition	Ground-level ozone	Stable	PMDS Goal Ia3 Report 2006

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
D-73	Air Quality, Chemical Composition	Sulfur in precipitation	Stable	PMDS Goal Ia3 Report 2006
D-74	Air Quality, Chemical Composition	Nitrogen in precipitation	Slightly degrading	PMDS Goal Ia3 Report 2006
D-75	Air Quality, Chemical Composition	Lichen community structure	Unknown parkwide	Roland, pers. comm.
D-76	Visibility	IMPROVE visibility measures	Improving (clearest days) and stable (haziest days)	PMDS Goal Ia3 Report 2006
Paleontological Resources Unimpaired (Parkwide)				
D-77	Paleontological Sites and Environments	% Sites protected by paleo plan	0%	Brease, unpublished data
D-78	Paleontological Sites and Environments	% Sites with good rating	Unknown	Brease, unpublished data
D-79	Paleontological Sites and Environments	Paleontological inventory	Incomplete	Brease, unpublished data
Wildlife Populations, Habitat, Ecosystems (Old Park / Wilderness Area)				
D-80	Wildlife Viewing Opportunities Maintained	% bus trips with sightings	Stable	NPS unpublished data
D-81	Wildlife Viewing Opportunities Maintained	Shorebird nesting density	Unknown	McIntyre, pers. comm..
D-82	Highest Standard of Wildlife protection	Adjacent lands: harvest	Unknown	National Parks Cons. Assoc. (NPCA) 2006
D-83	Highest Standard of Wildlife protection	Demography of populations	Some known	Owen and Meier 2006, Adams and Roffler 2008
D-84	Highest Standard of Wildlife protection	Traffic effects on migration	Unknown	Putera and Keay 1998
Wildlife Populations, Habitat, and Ecosystems (Park Additions and Preserve)				
D-85	Natural Wildlife Populations (new park only)	Harvested species: numbers	Unknown	NPCA 2006
D-86	Natural Wildlife Populations (new park only)	Harvested species: sex ratios	Unknown	NPCA 2006
D-87	Natural Wildlife Populations (new park only)	Harvested species: age distribution	Unknown	NPCA 2006
D-88	Healthy Wildlife Populations	Harvested species: numbers	Unknown	NPCA 2006
D-89	Healthy Wildlife Populations	Human-introduced diseases	None known	Beckmen 2005
Subsistence Resources and Opportunities (Park Additions and Preserve)				
D-90	Opportunities for Harvesting Firewood	% of firewood cutters w/o permit	Unknown	DENA records
D-91	Opportunities for Harvesting Firewood	Density, distribution of timber	Unknown	Roland, unpublished data

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
D-92	Opportunities for Harvesting Firewood	% who want firewood, who can cut	Unknown	
D-93	Opportunities for Harvesting Cabin Logs	% of cabin log cutters w/o permit	Unknown	
D-94	Opportunities for Harvesting Cabin Logs	Density, distribution of timber	Unknown	Roland, unpublished data
D-95	Opportunities for Harvesting Cabin Logs	% who want logs, who can harvest	Poor	Craver, pers. comm.
D-96	Subsistence Trapping	% of trappers who are intergenerational	Unknown	
D-97	Subsistence Trapping: Customs, Traditions	% of trapping demand that trap	Moderate	Craver, pers. comm.
D-98	Trapping: Sustainability of Populations	Furbearer density, distribution	Decline	Trapper reports, ADF&G
D-99	Subsistence Hunting Opportunities	% of subsistence hunters who hunt	Unknown	
D-100	Subsistence Hunting Opportunities	% of hunting demand that hunt	Unknown	
D-101	Subsistence Fishing Opportunities	% of fishers who are active	Unknown	
D-102	Subsistence Fishing Opportunities	Density/distribution of fish	Decline	ADF&G, pers. comm.
D-103	Subsistence Fishing Opportunities	% of fishing demand that fish	Poor	Craver, pers. comm.
Wilderness Resource Values, Wilderness Recreational Opportunities (Parkwide)				
D-104	Opportunity for Solitude: Privacy, Isolation	# Encounters with humans	Standards met in Old Park, unknown elsewhere	Swanson et al. (2002)
D-105	Opportunity for Solitude: Privacy, Isolation	% Campers who can camp out of sight, sound	Standards met in Old Park, unknown elsewhere	Swanson et al. (2002)

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
D-106	Opportunity for Solitude: Natural Soundscape	Max % of time motor noise heard	Meets standards some zones, fails in others	Denali Annual Soundscape Report (e.g., Withers 2006)
D-107	Opportunity for Solitude: Natural Soundscape	Max # of loud motor noises per day	Meets standards some zones, fails in others	Denali Annual Soundscape Report (e.g., Withers 2006)
D-108	Opportunity for Solitude: Natural Soundscape	Max loudness (dBA) of motor noise	Meets standards some zones, fails in others	Denali Annual Soundscape Report (e.g., Withers 2006)
D-109	Lack of Human Imprint on the Landscape	Social trails, # Campsites	Unknown	
D-110	Lack of Human Imprint on the Landscape	# Encounters with litter, waste	Not met, Old Park	Swanson et al. 2002
D-111	Lack of Human Imprint on the Landscape	# Encounters with signs of use	Unknown	
Park Development Zone - Park Road				
D-112	Satisfaction with Wildlife Observations	% Visitors satisfied w/ sightings	Study underway	Phillips et al. 2007
D-113	Satisfaction with Wildlife Observations	% Visitors w/ sightings of 4 or more species	Study underway	Phillips et al. 2007
D-114	Lack of Crowding on Park Road	# Visitors reporting crowding	Study underway	Phillips et al. 2007
D-115	Wilderness Character	Area of visible structures (sq ft)	Unknown	Denali GIS database
D-116	Wilderness Character	% Visitors who feel they traveled through wilderness	Study underway	Phillips et al. 2007
D-117	Comfort During Bus Rides	% Visitors reporting discomfort	Study underway	Phillips et al. 2007

#	ATTRIBUTE	INDICATOR	CURRENT CONDITION	REFERENCE
D-118	Quality of the Education Experience (Bus)	% Visitors satisfied w/ driver	Unknown	Phillips et al. 2007
D-119	Quality of the Education Experience (Bus)	% Visitors who understand park purpose	Unknown	Phillips et al. 2007

Appendix E: Public Involvement and Expert Review Response

Public Involvement

Public involvement in developing a park's Resource Stewardship Strategy (RSS) is designed to:
1) Keep the public informed about the strategy and its implications, and
2) Welcome ideas and information from the general public.

The RSS is intended as a scientifically credible internal management document that is formally reviewed by credentialed scientists (expert review) rather than generally reviewed by the public.

Opportunities for public involvement were as follows:

Timeline	Purpose	Method
RSS Phase 1: September 2006	Engage scientists to 1) inform about the RSS 2) gather information on potential attributes and indicators for resource values	• Workshop following the Alaska Park Science Symposium held at Denali, September 2006
RSS Phase 1: Early 2007	Engage public, including scientists to 1) provide information about the RSS 2) get feedback on resource issues of concern that need to be addressed by the RSS 3) brainstorm indicators that would reflect success in achieving desired conditions described in the park's General Management Plan 4) assemble mailing list of those who wish to be kept informed	• Print fact sheet about the RSS and post on Denali's Web site • Hold informational meetings with stakeholders (scientists) ✓ Fairbanks, Anchorage • Hold general public meetings ✓ Fairbanks, Anchorage, Denali, and Talkeetna
RSS Phase 2: Early Summer 2007	Engage scientists to 1) review strategies or projects No public involvement planned	• Consult scientists as needed by phone or email
RSS Phase 3: Spring 2008 – Summer 2009	Engage public, including scientists to 1) inform of the draft RSS 2) welcome additional information or ideas This is not a formal comment period, but for information-sharing only.	• Issue press release indicating draft RSS is being reviewed by experts and is available for viewing via the Web or email • Alert individuals who indicated an interest by attending meetings about draft RSS • Distribute complete draft upon request and provide on park Web site
Phase 4: Fall 2009	Finalize RSS (main document) Develop RSS Summary for general readership	• Provide documents electronically on Denali Web site; mail copies of RSS Summary to those who request them

Response to Expert Review

Reviewer Comment:
The comprehensive strategies shown on Table 1 in the Executive Summary are a nice compilation, especially because it fits on one page…It would be helpful to have these strategies organized into some kind of hierarchy to indicate which strategies are most important.

Response:
Denali staff agrees that the table of strategies is useful and we have included it in the *RSS Summary*. Because each strategy includes from one to 21 projects, and because the range of projects within a strategy can be so diverse, it was impractical to compare strategies for prioritization. Rather, it is the project, which is the "lowest common denominator" that we could compare through a ranking process. The 99 projects were prioritized (see Appendix F). However, if one wanted to get a general sense of the priority given to each strategy, one could view Appendix F, and note how many highest-band projects occur in each strategy.

Reviewer Comment:
…the most interesting and vital pages in the draft RSS for Denali is found in Appendix F…It is unclear to me why such an important part of the document is relegated to an appendix. In the end, without priorities, the stewardship strategy ends up being, however well thought out, just a list of projects. My suggestion would be for the RSS to include a specific section to address prioritization within the annual cycle of funding and project planning that occurs within NPS. Priorities will likely shift over various time scales, but if you made prioritization an explicit part of your strategy, it seems like the strategy will have a better chance of being effective.

Response:
Denali park staff agrees with this reviewer's comments. Priorities are very important to the effective implementation of Denali's RSS. The template and instructions for the RSS provided from the Midwest Region (Herbert Hoover RSS) did not make any provision for prioritizing projects. Denali's RSS team had some discussions about by what process we should prioritize projects, and how we could incorporate project priorities into the document. In the end, we put the prioritization of projects into an appendix, as a compromise between not including them at all (direction received from the national RSS effort with the template document and instructions) and putting them in the main document (to give proper emphasis to the priorities). We would recommend that the service-wide RSS group consider incorporating project prioritization as an integral part of any RSS. We considered the prioritized list important enough to be explained and included in Denali's *RSS Summary*. The prioritization methods have also been used at Denali for a parkwide priorization of projects for funding and to integrate project priorities across divisions.

Reviewer Comment:
The document is a vast improvement over previous RMPs, but still needs a stronger link to the process of annual decision-making.

Response:
The RSS was the principal driver in developing Denali's resources 5-year plan, which is used for annual decision-making. Denali's resources 5-year plan is fully integrated into Denali's 5-year plan,

the source of annual decision making parkwide. We envision the RSS being a living document which is evaluate periodically every few years. We are looking into how to best incorporate updates.

Reviewer Comment:
While I believe that it is possible for necessary information to be gained for park management with each project, what will really determine that is the sample design used for each project. If the sample design for any of those projects does not take into account the spatial or temporal objectives of the project, the data collected have the potential to be useless. In my opinion this fundamental information is well understood by the Natural Resources team of the park, and thus should not be an issue. However, in the interest of the longevity of the RSS as a document, perhaps subsequent plans, etc. could explicitly incorporate information on sample design of the studies.

Response:
Denali's Resource Management plan (the previous NPS servicewide planning paradigm) did include sample designs and the equivalent of study plans for each project. The inclusion of these protocols was problematic in that study plans quickly became outdated if conditions or project emphasis areas changed. The inclusion of protocols also made the document too long. It was a specific strategic shift on the part of NPS servicewide to not include protocols in the development of resource stewardship strategies. As projects are implemented, Denali staff will write study plans (or develop protocols if the project is also an Inventory & Monitoring vital sign) and perform compliance review.

Appendix F: Additional Employee Needs, Line Items for Construction, Funding Sources, and Project Prioritization

Additional Employee Needs

The park has deficiencies in several key positions needed to implement the Resource Stewardship Strategy. All of these positions are dedicated in their entirety to implementation of the RSS, with costs included in ONPS (base) needs.

- MSLC Research Coordinator
- MSLC Webmaster
- MSLC Education Coordinator (change funding source to give additional funding options to programs)
- Social Scientist (from term subject to furlough, to permanent subject to furlough)
- Data Manager
- Natural Resource Specialist (Sound)
- Cultural (Historian) to Cultural (Archeologist), no budgetary effect
- Cultural Resource Specialist (Museum), from 4-month furlough to full-time

Line Item (Construction)

Costs for line item construction for the following buildings were not included in the RSS.

- Emergency Services Fire Management Building ($3,600K)

  This building will house both emergency services, and fire management staff. The ESFMB is scheduled for completion in 2011.

- Science Center

  The Science Center has not yet been sent forward by the Region for line item. The Science Center will provide sufficient permanent offices for all resource management staff.

- MSLC Residential Facility

  The MSLC Residential Facility is currently planned as a partnership program, developed through donations.

Funding Sources

"Project" Funding

Project funding to implement the Resource Stewardship Strategy includes the Service-Wide Comprehensive Call, Concessions Franchise Fees (CFF), and Federal Lands Recreational Enhancement Act (FLREA) funding.

Operation of the National Park Service (Base) Funding

Denali's Operation of the National Park Service (ONPS) or base funding to implement the Resource Stewardship Strategy includes all base Resource Management costs; Maintenance costs associated with historical restoration or stabilization; Interpretation Division costs dedicated to the resource education costs of the Murie Science and Learning Center; and the Protection (Ranger) costs associated with resource protection (i.e., excluding visitor protection costs).

Inventory and Monitoring (I&M) Program Funding

In the presentation of budget figures by funding source, project costs and the salaries associated with the Central Alaska Network I&M Program were listed as a separate funding source, even though they are a base funding.

Centennial Challenge Funding

In the presentation of budget figures by funding source, Centennial Challenge projects were listed as a separate funding source, even though they are a flexible base funding.

Project Prioritization

The prioritization of projects within the Resource Stewardship Strategy (RSS) is very important to its role as a strategic document. Suggested criteria for ranking were solicited from all interested park staff. The subject matter and project leads for the RSS met to select the final criteria and collaboratively rank the projects. The 5 criteria chosen, along with the three possible scores for each criterion, are as follows:

1. Is there a legal or programmatic obligation or commitment to the project?
    1. Legal obligation
    2. Programmatic commitment
    3. No legal obligation or programmatic commitment

2. How strong is the linkage to a desired resource condition?
    1. Strong linkage to a desired condition of one or more resources or values
    2. Moderate linkage to a desired condition of one or more resources or values
    3. Weak or no linkage to desired conditions

3. Is there a peril to the resource or urgency to address the resource issue?
    1. Peril/urgency is imminent and substantial
    2. Some peril/urgency exists or is anticipated
    3. No peril or urgency

4. Is there public or political interest in the project?
    1. Substantial political or public interest
    2. Moderate political or public interest
    3. No political or public interest

5. Is the project cost-effective? Are there potential synergies with other projects?
    1. Very cost-effective
    2. Reasonably cost-effective
    3. Not cost-effective

For each project, the sum of the scores for all 5 criteria became the project score. Lower project scores indicate higher project priority. The projects were then ordered into three tiers of priority – Highest, Medium, and Lowest. Within each tier, projects are arranged by total score, then by project number.

All ranking systems are imperfect, and the three priority tiers are more meaningful than small differences between total scores. All projects that appear in the table are considered to have value and the National Park Service intends to accomplish them. The prioritization simply describes how important they are for the near-term, as opposed to the long-term, in the implementation of the RSS. And, as a reminder, the RSS does not include every proposed project that would benefit Denali's resources.

Resource Stewardship Strategy Projects listed in ranked tiers (Highest, Medium, Lowest) and in order of total score (lower score is higher priority), and project number within equal scores.

Priority	Strategy	Project #	Project Title	Total Score	Legal/ Program	Linkage to Desired Condition	Peril/ Urgency	Public Interest	Cost-Effective-ness
HIGHEST	I	61	Bear Habituation Management	5	1	1	1	1	1
	B	16	Weather, Indices, and Fire Behavior	6	1	1	1	1	2
	B	18	Wildland Fire Return Intervals	6	1	1	1	1	2
	D	25	Air Quality Monitoring	6	2	1	1	1	1
	I	62	Wolf Habituation Management	6	1	1	2	1	1
	J	67	Wildlife Diseases Monitoring	6	1	1	2	1	1
	K	69	Fuel Treatments and Wildland Fire Risk	6	1	1	1	1	2
	M	78	Wildlife and State Game Regulations	6	2	1	1	1	1
	N	80	Harry Karstens Protection Initiative	6	1	1	1	1	2
	A	2	Paleontological Resources Inventory	7	2	1	2	1	1
	A	7	Wildland Fire History Prior to 1950	7	3	1	1	1	1
	B	14	Biological Effects of Climate Change	7	2	1	1	1	2
	C	24	National Register Nominations	7	1	1	2	2	1
	D	26	Monitoring Climate and Snowpack	7	2	2	1	1	1
	D	27	Glacier Monitoring	7	2	1	1	1	2
	D	32	Monitoring Passerine Birds	7	2	1	2	1	1
	D	34	Golden Eagles and Peregrine Falcons	7	2	1	2	1	1
	D	39	Dall's Sheep Monitoring	7	2	1	2	1	1
	D	44	Soundscape Monitoring	7	2	1	1	1	2
	E	47	Documentation of Wildland Fires	7	2	2	1	1	1
	G	54	OHV Trails Rehabilitation	7	1	1	1	1	3
	G	55	OHV Impacts Monitoring	7	2	1	1	1	2
	H	56	Integrated Study of Park Road Capacity	7	2	1	1	1	2
	I	63	Wildlife Habituation Management	7	1	1	2	2	1
	M	75	Timber Resources Management	7	2	1	1	2	1
	M	77	Wildlife Population and Harvest Data	7	2	1	1	1	2
	A	4	Rare and Endemic Flora	8	1	1	1	2	3
	A	8	Inventory of Smoke Conditions	8	1	1	3	1	2
	A	13	Inventory of Cultural Landscapes	8	1	1	2	2	2
	D	29	Water Quality Monitoring	8	1	1	2	2	2

Priority	Strategy	Project #	Project Title	Total Score	Legal/ Program	Linkage to Desired Condition	Peril/ Urgency	Public Interest	Cost-Effective-ness
	D	30	Stream Morphology Monitoring	8	2	1	2	2	1
	D	33	Trumpeter Swan Monitoring	8	2	1	2	2	1
	D	37	Caribou Monitoring	8	2	1	2	1	2
	D	38	Moose Monitoring	8	2	1	3	1	1
	D	41	Grizzly Bear Monitoring	8	2	1	2	1	2
	F	48	Paleontological Resources Plan	8	2	1	3	1	1
	F	51	Waterway Navigability	8	1	3	1	2	1
	G	53	Park Gravel Acquisition Operations	8	1	2	2	2	1
	H	57	Backcountry Monitoring	8	2	1	2	2	1
	J	65	Exotic Plant Species Monitoring	8	2	1	1	2	2
	L	71	Digitizing the Museum Collection	8	1	1	1	3	2
	M	79	Subsistence Customs and Traditions	8	3	1	1	1	2
MEDIUM	A	10	Archeological Survey	9	1	1	3	2	2
	A	11	Native Place Names Archeological Survey	9	1	1	3	2	2
	B	17	Ecological Impacts of Wildland Fires	9	2	1	2	2	2
	C	23	Trapping History	9	3	1	1	3	1
	D	40	Wolf Monitoring	9	2	1	3	1	2
	D	42	Vegetation Structure and Composition	9	2	1	2	2	2
	D	43	Landcover Monitoring	9	2	1	2	2	2
	D	45	Plant and Landscape Phenology	9	2	1	2	3	1
	G	52	Restoration of Mined Sites in Kantishna	9	1	1	3	2	2
	H	59	Entrance Area Indicators and Standards	9	2	1	2	2	2
	M	76	Furbearer Trapping Management	9	2	1	2	3	1
	O	84	Visitation Model	9	2	2	1	2	2
	Q	89	Cultural Resources Data Management	9	2	2	1	3	1
	A	5	Inventory of Bird Status and Distribution	10	3	1	2	1	3
	A	9	Burn Severity	10	2	1	3	3	1
	B	15	Physical Effects of Climate Change	10	3	2	2	1	2
	C	20	Mountaineering History	10	3	1	3	2	1
	D	28	Permafrost Monitoring	10	2	2	1	3	2
	D	31	Fish Monitoring	10	2	1	2	2	3
	F	49	Cultural Sites Monitoring Plan	10	2	1	2	2	3
	H	58	Trail and Campsite Impacts Monitoring	10	2	1	3	2	2
	J	66	Exotic Animal Species Monitoring	10	3	1	3	2	1

Priority	Strategy	Project #	Project Title	Total Score	Legal/ Program	Linkage to Desired Condition	Peril/ Urgency	Public Interest	Cost-Effective-ness
	J	68	Integrated Pest Management	10	2	2	3	2	1
	L	70	Improving Collections Standards	10	2	1	3	3	1
	L	72	Addressing Catalog Backlog	10	1	1	3	3	2
	N	81	Boundary Marking	10	3	2	2	2	1
	O	83	Day-Hiker Inventory	10	3	2	2	2	1
	Q	88	GIS Database	10	2	3	1	3	1
	Q	90	Natural Resources Data Management	10	3	2	1	3	1
	Q	91	Data Dissemination and Availability	10	3	2	3	1	1
	R	92	Science-rich Media	10	3	1	3	2	1
	R	96	Research and Community Connections	10	3	1	3	2	1
LOWEST	A	3	Nonvascular Plant Inventory	11	3	1	3	3	1
	A	12	Native Place Names Map	11	3	1	3	2	2
	C	19	Mining History	11	3	1	3	2	2
	C	22	History of the Park Road	11	3	1	3	3	1
	D	35	Monitoring Important Herbivore Species	11	2	1	3	3	2
	D	36	Small Mammal Monitoring	11	2	1	3	3	2
	E	46	Assessment of Geohazards	11	3	2	3	2	1
	J	64	Anthropogenic Contaminants	11	3	2	2	1	3
	R	95	Science-based Education Seminars	11	3	1	3	2	2
	S	98	MSLC Staffing	11	3	1	3	3	1
	A	1	Special Geologic Features Inventory	12	3	1	3	2	3
	C	21	Scientific Legacy	12	3	1	3	3	2
	L	73	Finding Aids for Archival Collections	12	3	2	3	2	2
	P	85	Human Populations Monitoring	12	2	3	3	3	1
	P	86	Community Survey	12	3	3	3	2	1
	R	93	Trans-disciplinary Communication	12	3	2	3	3	1
	R	94	Researchers-in-Residence	12	3	2	3	3	1
	F	50	Natural Lightscapes Monitoring Plan	13	3	3	3	3	1
	H	60	South Denali Indicators and Standards	13	3	3	2	3	2
	P	87	Economic Impact Model	13	3	3	3	2	2
	O	82	Dispersed Entry Visitation	14	3	2	3	3	3
	S	99	MSLC Facilities Development	14	3	2	3	3	3
	A	6	All Taxa Biodiversity Inventory	15	3	3	3	3	3