National Park Service

Alaska Region Science Strategy

2006 and Beyond

Integrating science to enhance resource management
in a changing world.

March 2006

"Though the world has changed profoundly since the first national parks were created more than a century ago, the national park idea continues to provide benefits of fundamental importance to the nation…In looking to the future we must see to it as a nation and as a people that the National Park System and the national park idea continue to flourish."

John Hope Franklin, Chair
National Park Service Advisory Board (2004)

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National Park Service
Alaska Region Science Strategy

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Preface

At a meeting held in May 2004, the National Park Service Alaska Leadership Council (Alaska Regional Directorate and park superintendents, ALC) reaffirmed the Alaska Region mission statement (NPS 2004):

We care for those special places in Alaska saved by the American people as a part of a national system of parks so that all may experience our heritage. We serve residents and visitors who seek inspiration, recreation, and education, as well as those who come for traditional activities, subsistence and scientific study. We cooperate with local communities, tribes and others to protect the natural and cultural resources in these special places for this and future generations.

To align work and budgets, the following priority focus areas were identified:

- protect the integrity of each unit's natural and cultural resources and values;
- improve public understanding and enjoyment of our units, including the provision of appropriate services and access;
- improve community relations;
- develop a sustainable budget strategy for the Alaska Region;
- acknowledge the achievements of all the region's talented and dedicated staff and develop in-house training and programs that provide employees with the tools and knowledge they need to succeed in Alaska.

To achieve these priorities and ensure that regional resource strategies are current, the ALC formally recognized that a multi-disciplinary Alaska Region Science Strategy was needed. The science strategy was intended to facilitate ecosystem-scale thinking and scientific investigations, support decision-making, and achieve NPS mandates. Although specifically included under the first priority for protecting natural and cultural resources and values, an effective science strategy implemented in Alaska will have significant value in achieving all five of the Region's priority focus areas.

- To protect the integrity of resources and values, it is important to understand what those resources are, and how they are likely vulnerable, not only today but 50 years and more from today.
- To improve public understanding and enjoyment, facilities developed for public use should provide services and access that do not immediately or ultimately destroy the very values that visitors come to experience, while presenting to visitors a defendable scientific rationale for why services and access are so designed.
- Improving community relations through outreach and listening can lead to better science planning and reap the benefits of traditional knowledge. Science so linked will provide information that supports management decisions, especially important when making hard choices about balancing protection, development and use.

- To ensure that the information necessary to make hard but defendable choices is available to managers will require targeted scientific research that answers relevant questions for making those choices. Enabling this research will require tough budgetary decisions and commitment to long term baseline data collection.
- Such commitment will demonstrate to the region's talented and dedicated staff working on these issues within the parks and regional office a renewed confidence in their value to the organization.

This document is intended to provide the first step in a multi-part effort to create and implement an integrative, multi-disciplinary scientific research strategy for the National Park Service Alaska Region. The strategy was developed through existing documents, input from and National Park Service management and staff and external partners. Outreach included federal and state partners, Tribes, communities and other interested parties.

"…to conserve the scenery and the natural and historic objects and wild life…by such means as will leave them unimpaired for the enjoyment of future generations." Organic Act of 1916

Executive Summary

In 1998, Congress passed the National Parks Omnibus Management Act (NPOMA) that gave superintendents and managers specific legal authority to conduct and support science in parks. The National Park Service (NPS) Alaska Region presents this science strategy to meet the intention of NPOMA and set the course for implementing proactive scientific investigations that allow NPS to better understand and effectively respond to anticipated and unanticipated changes in the world over the next ten to fifty years and beyond.

The NPS Science Strategy was shaped using the three primary elements of strategies: (1) the *end* goals and objectives to be achieved; (2) the *way* or process to achieve the desired end; and (3) the *means*, or array of financial, logistical and intellectual assets available to achieve results. The NPS Science Strategy is presented in three parts: Part I provides the *context* for the strategy; Part II presents the strategic *framework*; and Part III offers an *implementation plan*. As a strategy, this document is not "how to" guidance. Appendices and references are provided that offer guidance for the proposed framework. During implementation, the NPS can generate lessons learned to create detailed guidance for NPS staff.

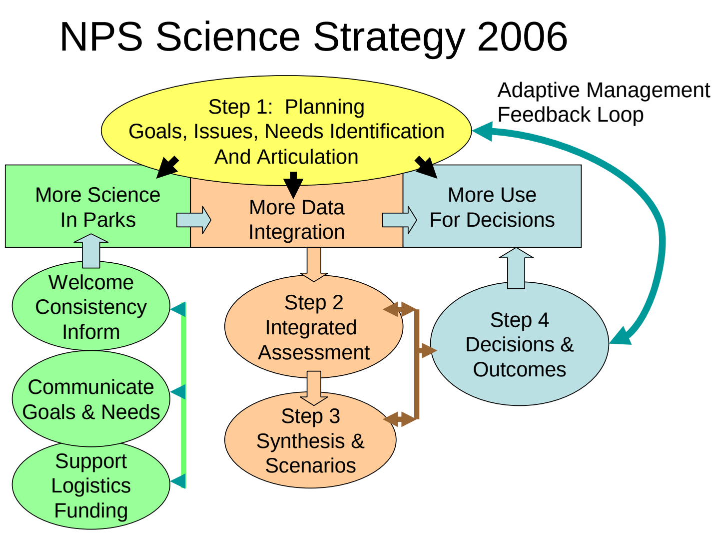
To develop the strategy, existing documents were examined and input was solicited from NPS leadership and technical staff, partner agency staff, research scientists and other interested parties. Two primary questions were asked during feedback sessions: 1) what would a successful integrated science strategy look like, and 2) what key issues are of principal concern. Three primary needs were identified by respondents for the strategy to fulfill. First, scientific data should guide management decisions for preserving NPS core values in each park. Second, an overarching conceptual framework should be used to create scientific questions relevant for Alaska park needs. Third, the strategy should provide pathways to ensure that more science occurs in parks, and that better integration, interpretation and communication of scientific results enhances resource management and decision-making. Of concern were five top environmental stressors impacting Alaska's parks: (a) climate change (b) increasing human use, (c) development within and surrounding parks, (d) global and local contaminants, and (e) exotic species. The most challenging problem identified for science-based decision-making was diminished NPS scientific capacity; managers must make decisions on complex issues without adequate data and science staff support.

The NPS Alaska Region has existing scientific and partnership assets available that can be aligned to implement the science strategy. With a cadre of professional staff, and park-based, regional and national NPS funds, science is currently conducted in support of natural, cultural and subsistence programs. The passage of NPOMA set the agenda for natural resource sciences in parks and in 1999, the Service launched a new science initiative, called the Natural Resource Challenge (NRC). In response, the Inventory and Monitoring Program was funded with NRC national funds, and Cooperative Ecosystem Studies Units and two Science and Research Learning Centers were funded in Alaska by the Regional Office and individual parks. An array of cultural resource programs are

supported via NPS national funds allocated across the Alaska Region. NPS also provides funds for partnership protection activities. Park base funds support park specific monitoring, restoration, resource management, and research and serve as the backbone of resource assessment in parks. Alaska NPS Advisory groups have planned and implemented resource management and science in parks specific to natural, subsistence and cultural disciplines, as well as interpretive and educational programs. NPS also benefits from an array of partnerships with federal and state agencies and non-governmental organizations.

Science is conducted in Alaska parks for three purposes under NPOMA: (1) "Science for Parks" is issue- or decision-driven science, (2) "Parks for Science" encourages curiosity-based science, and (3) "Parks for Learning" enhances communication of science for decision-making and public stewardship. NPS science is to support the Organic Act of 1916 and be consistent with The Department of the Interior GPRA Goals to (a) protect the environment and preserve our nation's natural and cultural resources and (b) provide recreation for America.

Based on legislative goals, GPRA goals and staff input, the NPS Alaska Region Science Strategy's overarching vision and desired **end** is to: *generate scientific questions and collect and process data to identify the sustainable balance between preservation and park use to support adaptive management.* The **way** to achieve the overarching vision is shaped by three strategy objectives in the framework: 1) enhance scientific research in, and knowledge about national park resources and stressors (*more science*); 2) create a framework to guide interdisciplinary research, data integration and synthesis for identifying sustainable balance (*better integration*), and 3) deliver data in a format designed to inform decision-making, promote adaptive management, and educate the public (*better use*). Finally, the implementation plan offers suggested actions and **means** for aligning existing NPS assets to enhance data collection, integration, and use for decision making. An overall illustration of the three strategy objectives and their relationship to implementation are provided in the following figure and described below.



In the figure at left, the three strategy objectives are shown in rectangles. Under each of the objectives, actions for implementation are shown. The arrows represent the flow of information, although in every element, the processes are inherently iterative and interactive. More scientific research feeds into the integration of data, which in turn influences the decisions made for adaptive management. Step 1, while primarily discussed in the strategy framework, is shown above the objectives because planning influences every aspect of the strategy.

To encourage more science in parks, it is important to understand what limits scientific activity. NPS staff and partner scientists were asked to identify limiting factors. Issues identified that currently inhibit park-based research included philosophical differences among NPS personnel and research scientists on what kind of scientific research is valuable, important, and appropriate for park settings, how welcoming park personnel are to scientists, how understanding and responsive scientists are to NPS mission requirements, what support NPS offers, and the ease in which scientists can obtain research permits with necessary parameters for research success. Based on these results a primary recommendation under the strategy is that NPS offer targeted opportunities for scientists and park personnel to exchange ideas in facilitated brainstorm sessions for problem solving, aligning understanding, and improving relations. The implementation plan includes a matrix for guiding NPS-scientist facilitated discussions to seek low cost, high value alternatives for NPS logistical and other support. Specific suggestions are included for nurturing science partnerships, developing scientist welcome information packets, improving the permit process, creating consistency in park access among all users, and providing guidance on what kinds of research questions and activities are encouraged and restricted. It is important for NPS to generate and provide clear, succinct NPS goals and objectives for individual parks with particular emphasis on issues where a sustainable balance between use and preservation is most challenging, and link funding opportunities directly and clearly to the NPS mission and goals.

To better integrate and use science, the strategy offers a four step framework for goal setting, data integration, synthesis, and decision making. Each step is founded on existing guidance and protocols that are readily available. The framework and four step process is fully iterative rather than linear; any step within the process may be revisited when new information makes it valuable or necessary. Step 1 clearly links manager needs to scientific inquiry, steps 2 and 3 provide rigorous processes for integrating interdisciplinary and interagency data and interpreting results within the context of resource management issues, and steps 1, 2, and 3 directly support Step 4, better use of science in managing resources through informed decision-making.

During step 1 manager-scientist dialogues are facilitated to identify value-based goals and science questions clearly linked to management issues and resource concerns. To implement the strategy it is recommended that an inclusive management team in each park conduct outreach to interested parties and meet in facilitated sessions to update and refine goals by revisiting existing legislation, General Management Plan resource goals, and current and anticipated resource changes and management challenges. Step 1 is used to establish value-based goals for natural, cultural and subsistence resources and visitor experiences that are *operationally defined* for a place such as a park. A summary document of results will then be made available to NPS staff, outside scientists, partner agencies and the public.

Step 2 is a process to formally integrate and convert diverse data into useful information for resource managers. Integrated assessments are used to systematically incorporate existing interdisciplinary data and information from all possible sources to evaluate resource vulnerability and sensitivities, and evaluate possible cause-effect relationships between stressors and effects on park resources. Specific products completed during Step

2 include: conceptual formulation, analysis of exposure, effects and vulnerabilities, and characterization of response and risk. Implementation of Step 2 can emerge from existing activities for natural, cultural and subsistence resources ongoing within parks and under the I&M program. Suggested actions for implementation include generating three demonstration projects in selected parks or sub-regions that are different in character, values and issues of concern (e.g., GLBA, WRST and Serpentine Hot Springs). The demonstration assessments should be selected to solve current and future issues in parks and in so doing, inform a management challenge while training a cadre of NPS experts in the process. The demonstration projects should be closed out in brainstorming discussions among the teams to generate a lessons learned summary for documenting the process and developing NPS guidance.

Step 3 is scenario development and synthesis. System dynamics is a recommended approach for synthesizing results of integrated assessments where additional evaluation is needed to support management decisions using alternative scenarios of potential outcomes. This may be needed under more complex or uncertain circumstances. Specific products of synthesis include: defined management options/outcomes described for evaluation, specific interactive parameters used for building the scenarios, and model results. Again, demonstration projects are the best option for implementing and learning the process (e.g., expand the recently completed Glacier Bay Environmental Impact Statement; generate early evaluations of Wrangell-St. Elias community growth). On completion, facilitated discussions should be held to determine the value of the analysis, lessons learned, and opportunities for tailoring to NPS. NPS guidance should be generated from lessons learned.

Step 4 is management decision-making, a re-evaluation of current management strategies and the formulation of new resource management directions, adjustments or specific management decisions (decisions), as influenced by results of the first three steps. This step provides a process to transform results from steps 2 and 3 into information that supports adaptive management. Assessment results presented by the assessment team to the management team include management options evaluated within the context of vulnerability and risk. Specific products from step 4 include: a summary of goals, integrated assessment, and synthesis, the array of factors considered in the decision process, a summary of management decisions with supporting rationale, and guidance for monitoring impacts of the management decision. For implementation of step 4 it is recommended that the case studies completed for steps 2 and 3 be summarized for supporting decisions and the results be presented to the relevant management team for critique and improvement during facilitated sessions. Based on input, lessons learned and a standardized format for reporting should be generated for NPS guidance. Follow up monitoring should be defined and then implemented to evaluate the success of management action.

To ensure effective implementation over the next two years, the following priorities are recommended: (1) conduct manager-scientist-cultural consultant-community member focal discussions in each park, (2) complete a demonstration project in a selected park for implementing the science strategy, (3) define and develop a prototype welcome packet and guidance for enhancing science in parks, and (4) fund a “request for proposal” that requires integration of two or more disciplines, has an applied management element, and is implemented and reported using the science strategy framework process. Other recommendations are included for implementation over the next ten years.

Implementation of the science strategy will depend on senior management commitment that may require some restructuring of budgets to support integrating science across disciplines. It is important that NPS staff investment in science strategy implementation be recognized as an essential component of job performance. With an implementation priority in place, the opportunity to conduct a demonstration project will help develop staff knowledge and experience in integrated assessment and synthesis and form the basis for generating written guidance specific to application in NPS. The goal is to create highly useable guidance and a cadre of staff with direct experience in integrated assessment and synthesis within the NPS Alaska Region able to capitalize on results from increased park-based research as well as applicable data collected elsewhere.

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Glossary

Asset: The collection of legislative acts, management documents, professional staff, institutional knowledge, available data, partners, national, regional and park based funding, and any other values that can be used to implement a science strategy.

Assessment endpoint: An explicit expression of a value that is to be protected, operationally defined by an ecological, cultural or human entity and its attributes. For example, Dall sheep are valued ecological entities; reproduction and age class structure are some of their important attributes. Together "Dall sheep reproduction and age class" form an assessment endpoint.

Ecological risk assessment: A process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors

Conceptual model: A conceptual model in conceptual formulation is a written description and visual representation of predicted relationships among ecological, cultural and park user entities and the stressors to which they may be exposed.

Integrated assessment: A process of interrelating multiple ecological, cultural and socioeconomic assessments and conceptual models integrated across disciplines, processes, systems and data types. It may combine ecological and human health risk assessments, ecosystem and cultural vulnerability assessments and socioeconomic evaluations.

Management goal: Management goals are statements about the desired condition of ecological, cultural and human values of concern.

Response Characterization: An evaluation of all lines of evidence concerning how values described in management goals and operationally defined by assessment endpoints are likely to be vulnerable and respond to stressors to which they are exposed.

Strategy: A three part approach for achieving desired outcomes or results that includes the end to be achieved, the way or process for achieving the end, and the means for implementation.

Stressor: Any physical, chemical or biological action or change that can induce an adverse response in a valued entity. Note that a stressor for one entity can be of benefit to another.

Sustainability: to sustain is to keep in existence, maintain, or prolong; sustainability must be operationally defined and interpreted for a "place" with clearly defined goals for the ecological, cultural and human resources there, linked to the processes and values that retain the biotic diversity, carrying capacity and resiliency of natural and cultural systems.

System dynamics: A process for evaluating the fundamental dynamic patterns of systems using dynamic mathematical models that assist in thinking about how a system changes over time based on growth, decay and oscillation.

Vulnerability assessment: A process to identify those ecosystems and cultural values most vulnerable to being lost or permanently harmed in the future, and which stressors are likely to cause the greatest risk.

Vital sign: Set of measurements that represent the overall health or condition of park resources as represented by composition, structure and function of the larger ecosystem and, known or hypothesized effects of stressors, or elements that have important human values.

Abbreviations

ACF	Alaska Conservation Foundation
ACIA	Arctic Climate Impact Assessment
ADFG	Alaska Department of Fish and Game
AK	Alaska
AKRO	Alaska Regional Office
ALC	National Park Service Alaska Leadership Council
AMAP	Arctic Monitoring and Assessment Programme
ANILCA	Alaska National Interest Lands Conservation Act
ANSC	Alaska Native Science Commission
AOOS	Alaska Ocean Observing System
ASLC	Alaska Sea Life Center
ASMIS	Archeological Sites Management Information System
AVO	Alaska Volcano Observatory
BLM	Bureau of Land Management
CESU	Cooperative Ecosystem Studies Units
CRAC	Cultural Resources Advisory Council
EAG	Educational Advisory Group
EIS	Environmental Impact Assessment
EVOS	Exxon Valdez Oil Spill Trustee Council
FSB	Federal Subsistence Board
GEM	Gulf Ecosystem Monitoring Program
GPRA	Government Performance and Review Act
I&M	NPS Inventory and Monitoring Program
IPY	International Polar Year
MSLC	Murie Science and Learning Center
NANA	An Alaska Native-owned regional corporation
NEPA	National Environmental Protection Act
NGO’s	Non-governmental organizations
NPRB	North Pacific Research Board
NPOMA	National Parks Omnibus Management Act of 1998 (Public Law 105-391)
NPS	National Park Service
NRC	Natural Resource Challenge
NRPP-NRM	Natural Resource Preservation Program-Natural Resource Management
NRAC	Natural Resources Advisory Council
NRCS	Natural Resource Conservation Service
NSSI	North Slope Science Initiative
NWS	National Weather Service
OASLC	Ocean Alaska Science and Learning Center
PMIS	Project Management Information System
RFP	Request for Proposal
RLC	Science and Research Learning Centers
SAC	Subsistence Advisory Council
SAIP	Archeological Resources Inventory
SCC	Service-Wide Comprehensive Call

TNC	The Nature Conservancy
UAA	University of Alaska Anchorage
UAF	University of Alaska Fairbanks
USAF	United States Air Force
USC	United States Code
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WACAP	Western Airborne Contaminants Assessment Project

Alaska National Parks and Preserves

ALWR	Alagnak Wild River
ANIA	Aniakchak National Monument and Preserve
BELA	Bering Land Bridge National Preserve
CAKR	Cape Krusenstern National Monument
DENA	Denali National Park and Preserve
GAAR	Gates of the Arctic National Park and Preserve
GLBA	Glacier Bay National Park and Preserve
KATM	Katmai National Park and Preserve
KEFJ	Kenai Fjords National Park
KLGO	Klondike Gold Rush National Historic Park
KOVA	Kobuk Valley National Park
LACL	Lake Clark National Park and Preserve
NOAT	Noatak National Preserve
SITK	Sitka National Historic Park
WRST	Wrangell-St. Elias National Park and Preserve
YUCH	Yukon Charlie National Park and Preserve

Alaska Regional Inventory and Monitoring Networks

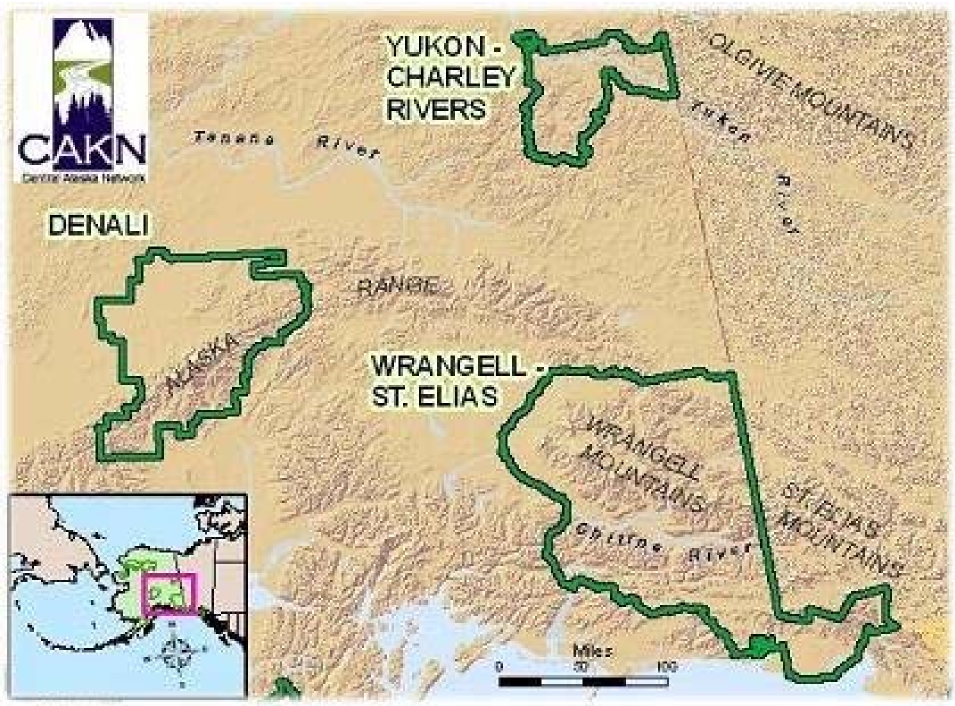
The Inventory and Monitoring program was established in 1992 to provide consistent databases of information about natural resources, including their current condition and how they change over time. Inventories are multi-year, finite projects. Under the I&M program, there are four area networks including the Arctic Network (ARCN), Central Alaska Network (CAKN), Southeast Alaska Network (SEAN), and Southwest Alaska Network (SWAN).

ARCN Arctic Network

The Arctic Network contains five major public lands including Bering Land Bridge National Preserve (BELA), Cape Krusenstern National Monument (CAKR), Noatak National Preserve (NOAT), Kobuk Valley National Park (KOVA) and Gates of the Arctic National Park and Preserve (GAAR).

CAKN Central Alaska Network

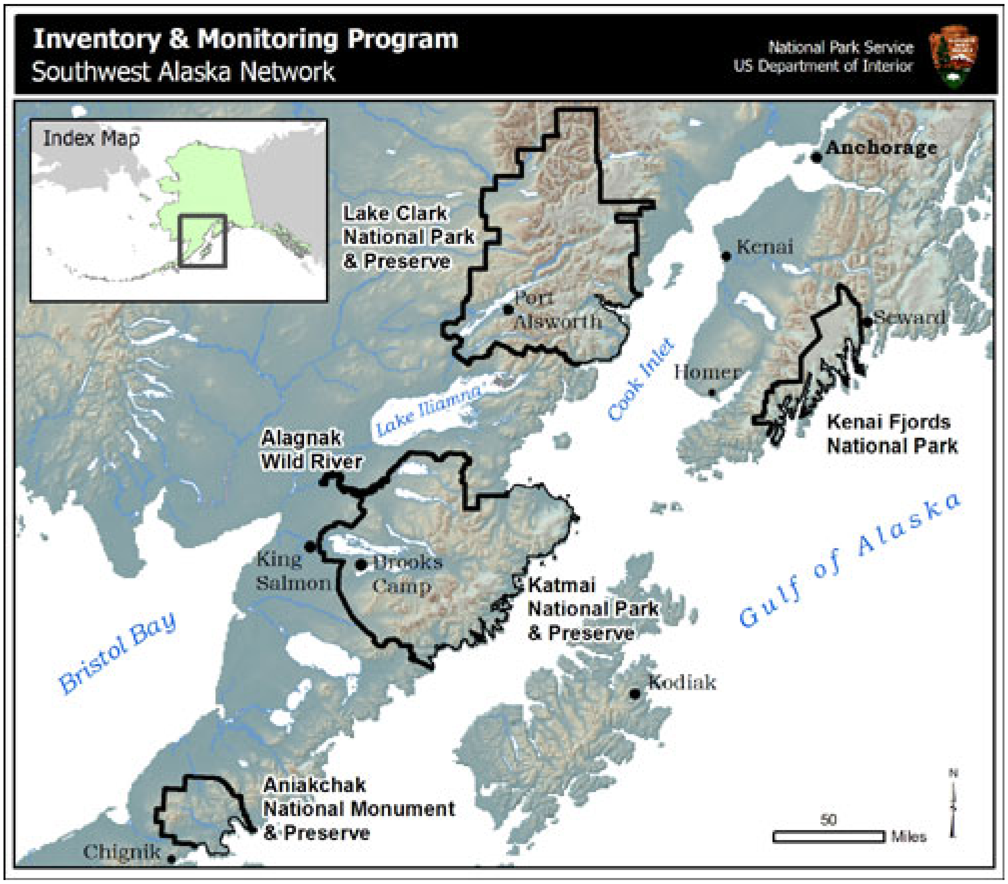
The Central Alaska Network is part of the National Park Service Inventory and Monitoring Program. It is composed of three national park units: Wrangell-St. Elias National Park and Preserve (WRST), Denali National Park and Preserve (DENA), and Yukon-Charley Rivers National Preserve (YUCH).



The Central Alaska Network is vast: its three parks together contain over 8.8 million hectares (21.7 million acres) and span an area that is 650 km from east to west and 650 km from north to south. Based on area, the Central Alaska Network represents 25% of all the land in the National Park Service system. These parks provide the space and the time to see and understand natural processes that are occurring at great spatial and temporal scales. The network is currently conducting baseline inventories of selected resources, and is developing and prioritizing a list of “vital signs” for long-term monitoring.

SWAN Southwest Alaska Network

The Southwest Alaska Network (SWAN) includes five units of the National Park Service (NPS): Alagnak Wild River (ALWR), Aniakchak National Monument and Preserve (ANIA), Katmai National Park and Preserve (KATM), Kenai Fjords National Park (KEFJ), and Lake Clark National Park and Preserve (LACL). Collectively these units comprise 9.4 million acres, 11.6 percent of the land managed by the NPS, and 2 percent of the Alaska landmass. Network parks encompass climatic conditions, geologic features, pristine ecosystems, natural biodiversity, freshwater, and marine resources equaled in few places in North America.



SEAN: Southeast Alaska Network

SEAN contains the Sitka National Historic Park (SITK), Klondike Gold Rush National Historic Park (KLGO), and Glacier Bay National Park and Preserve (GLBA). Vital signs monitoring will involve permanent programs and operate under a model of sharing resources and expertise.

Scidmore Bay in Glacier Bay National Parkand Preserve (NPS Photo Blain Anderson)

Department of the Interior

National Park Service, Alaska Region
Science Strategy 2006

Introduction

The National Park Service (NPS) Alaska Region presents this science strategy to set the course for the next five to ten years and more. It is designed for implementing proactive scientific investigations that will aid park managers in responding to anticipated and unanticipated changes in natural and cultural resources and human pressures over the next ten to fifty years and beyond. It is supported by existing NPS strategic plans for natural, cultural and subsistence resources, inventory and monitoring programs, research activities and partnerships, park resource management efforts, and interpretive educational materials. The science strategy adds value by providing an overarching framework for science in Alaska's parks, defining ways to increase the number of, and benefits from scientific investigations, and presenting a process for integrating disciplines and data types in a format designed to inform decision-makers. The Science Strategy is presented in three parts:

- **Part I** provides the *context* for the strategy. Included is background information on the NPS mission and legislative authority for conducting science in parks, a summary of input provided by NPS staff and others on what the underlying rationale for the strategy should be and what it should accomplish, as well as a description of existing NPS scientific assets that are essential to implementation.

- **Part II** presents the *framework* for the strategy. Included are an overarching goal statement and three principal objectives that form the strategy. These are supported by options to enhance scientific investigations, and a four-step iterative process designed to integrate scientific data and information consistent with resource manager needs, and to communicate results in a format that informs the decision process.

- **Part III** presents the *implementation plan.* Here specific actions are suggested that if implemented will successfully bring the science strategy into mainstream use in the Alaska Region and provide a proactive capability for decision making in parks. The action items create a pathway for transforming concept into action. It is anticipated that full implementation for all parks will require 10 years of effort, and that each park could achieve implementation within a two to three year window. The strategy is founded on the principles of ecosystem-based adaptive management where scientific information is integrated, interpreted and used to influence decision-making, coupled with follow up assessments to evaluate success. Both decision-based and curiosity-based scientific investigations are recognized as valuable and critical to successful implementation of the strategy.

Part I Context for the Science Strategy

The National Park Service is committed to using scientific information to improve the management of the natural, cultural and subsistence resources in national parks, monuments, preserves, historic sites, affiliated areas and associated programs (parks). This commitment has led to interest in expanding the quality and quantity of science conducted within parks as well as using available scientific information more effectively. The following provides background information on legislative authority for conducting science in parks, the rationale for why a science strategy is needed to achieve NPS goals, and existing NPS assets that will help make success possible.

1.0. Mission

The National Park Service (NPS, Service) has been charged with preserving an astounding wealth of this nation's natural and cultural resources since its creation under the Organic Act in 1916. The key management provision of the Organic Act is: *"…to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations*" (16 USC).

1.1. Historical Perspective

To meet the mission for the Service throughout most of the 20th century, NPS practiced a combination of active management and passive acceptance of natural systems and processes while becoming a superb visitor services agency (Natural Resource Challenge (NRC) 1999). Throughout this tenure, scientific understanding was not a central focus for decision-making (Sellars, 1997). The use of science by the Service has recently been a topic of considerable interest (e.g., NRC 1992, NPS 1992, and NPSSAB 2001). It is now recognized that management based on scientific understanding will be needed to ensure the continued preservation of our natural and cultural resources in parks. As noted by Soukup (2004), while "…intuitive decision-making may have sufficed in the 20th century, it certainly will not ensure that the natural systems (the wildlife and scenery) of national parks will be maintained unimpaired throughout the 21st century."

1.2. Authorities and Legal Framework for Enhancing Science:

In 1998, Congress passed a research mandate for the U.S. National Park System (Congress 1998). It is contained in Title II of the National Parks Omnibus Management Act of 1998, Public Law 105-391 (NPOMA). This mandate gives superintendents and managers the legal authority to conduct various scientific programs in parks, i.e., "Science for Parks", and to authorize the use of parks for scientific study, i.e., "Parks for Science."

Under NPOMA, the purposes are to (1) more effectively achieve the mission of the National Park Service; (2) enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; (3) ensure appropriate documentation of resource conditions in the National Park System; (4) encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value, where such study is consistent with the Organic Act; and (5) encourage the publication and dissemination of information derived from studies in the National Park System. A more complete summary of legal authorities for science in national parks is provided in Appendix A. For information on the operational framework for NPS in implementing these authorities, see NPS Management Policies (NPS 2001, in revision).

2.0. Rationale for Developing a Science Strategy.

A strategic approach to science is a positive avenue for ensuring that data collected today informs decisions needed in a different world tomorrow. This is particularly important as parks become "increasingly crowded remnants of primitive America in a fragmented landscape, threatened by invasions of nonnative species, pollution from near and far, and incompatible uses of resources in and around parks…Protection of these natural resources now requires active and informed management to a degree unimaginable in 1916" (NRC 1999).

2.1. Increasing Pressures

For many, the specter of parks becoming "crowded remnants" may seem far in the future within the context of the vast expanse of Alaska where NPS Alaska Region holds trusteeship over 54 million acres of public land, nearly two thirds of the 84 million acres total within NPS. NPS Alaska Region is in the enviable position of having stewardship over some of the most intact ecosystems, cultural sites, and living cultures that exist in the world today. However the globe is undergoing a profound transition in which human populations are more crowded, more consuming, highly connected and increasingly more diverse than at any time in history. Current projections envisage human populations reaching around 9 billion in 2050 and 11 to 12 billion by 2100, nearly double the population at the turn of this century (National Research Council 1999). While most of this future growth is anticipated in developing countries of Africa, Asia and Latin America, current research pointedly indicates that the human ecological footprint exceeded the global carrying capacity around 1990; indicators of this "overshoot" are climate change, global contamination, and diminishing biodiversity (Meadows, et al 2004). This holds true locally as well. Use and enjoyment, when exceeding the resiliency of natural systems or cultural resources can lead to degradation and loss of the very values the American people wish to enjoy and use in parks.

Alaska along with the entire arctic region is on the front line of change from global processes influenced by human actions. Remoteness and current low human populations will not buffer Alaska's parks from significant ongoing climate change (ACIA 2004), increasing levels of long range transported contaminants (AMAP 2002, 2004 a, b), accelerating population growth http://www.censusscope.org/us/s2/chart_popl.html and continued focus on resource extraction, fisheries and tourism as primary industries http://www.labor.state.alaska.us With this population comes increased mechanized access to remote areas, commercial fishing, mining, oil and gas development and other consumptive uses, subsistence activities, introduction of exotic species, encroaching development outside park boundaries and within private in-holdings, and increasing air and boat traffic. All of these pressures will place natural and cultural resources under NPS jurisdiction at potential risk in ways for which we have little precedent for coping. Placing a "virtual fence" around park lands will not protect their values (e.g., Pringle 2000), nor given legislative mandates (e.g., Alaska National Interest Lands Conservation Act (ANILCA) 1980) is this possible or desirable.

2.2. Challenges Associated with Conducting Science in Alaska

Scientific research in field locations is normally challenging; nowhere is this greater than within the remote expanses of Alaska's national parks. Logistical difficulties related to few field laboratories, lodging or transportation options mean that it frequently is impossible to implement studies that in other locations would be straightforward. In addition, complex regulations, overlapping authorities for wildlife, fisheries, marine resource management and air and water quality protection complicates permitting and logistics. Shared ownership of land, private in-holdings that include mineral land claims, and unique legal requirements for subsistence access under ANILCA (1980) add to the complexity. Given that 80% of the nation's designated wilderness areas are in Alaska, conventional modes of travel are unavailable or prohibited within much of Alaska's park areas. These alone are daunting obstacles even in an environment where resources are plentiful and resource managers encouraging. However resources are limited and the historical culture of NPS resource managers has not fully embraced scientific work in parks (Sellars 1997).

2.3. Financial Limitations

The NPS continues to face challenges associated with a limited budget. Despite the infusion of funds through the Natural Resource Challenge (NRC 1999, see section 4.1), inflation continues to erode NPS scientific capacity, and NPS budget limitations make it difficult at best and impossible in many cases to significantly invest in scientific research and support. Creating innovative approaches for promoting and facilitating scientific work, as well as using available scientific information more effectively must be a primary focus for the NPS science program and central to the strategy.

3.0. NPS Staff Input to Science Strategy Development

To create a strategy responsive to regional needs it was critical to combine NPS policy with substantial input provided by managers and staff within the National Park Service Alaska Region, those most directly concerned and central to implementation. Interviews of leadership and technical staff were conducted between November 2004 and June 2005 for the science strategy framework, and with NPS, partner scientists and interested parties between May 2005 and Dec 2005 for the implementation plan, (see Appendix B). To shape the strategy, two principle questions were asked:

- What would a successful integrated NPS science strategy look like?
- What key issues are of principal concern for Alaska's parks?

Although these open ended questions resulted in a rich array of input, main themes were remarkably consistent across disciplines, and staff roles as summarized below. Additional input was provided by scientists and interested parties on the challenges and opportunities of doing research in parks. A complete summary of interview results are provided in Appendix C.

3.1. Key Results from NPS Interviews

NPS interviews resulted in three key guidelines which directly shaped the science strategy.

1. First, there is a need to use science to help sustain NPS core values in each park within the context of ongoing natural change and increasing human pressures.
2. Second, an overarching conceptual framework for science in Alaska's parks is necessary to provide a unified rationale for scientific investigations by NPS and partners, and establish effective questions for interdisciplinary research.
3. Third, there was a clear imperative among managers, scientists, interpretive staff, and others concerning the need for more and better interpretation, communication and exchange of scientific results to ensure their use for more effective resource management and decision-making.

3.2. Issues of Concern

Environmental, social and administrative issues were raised during discussions of stressors impacting Alaska's national parks. The primary issues NPS science should address included the following, selected from a broader range of issues (see Appendix C):

1. The top environmental stressors impacting parks included: (a) climate change (b) increasing human use, (c) development within and surrounding parks (d) global and local contaminants, and (e) exotic species.
2. The most challenging problem facing NPS science is a diminishing scientific capacity, even with recent improvements under the NRC (1999). Too few staff, and a limited range of disciplinary expertise are available to fulfill basic needs and track information, yet enormous staff effort is required to compete for remarkably limited research funds.
3. Managers must make decisions on challenging issues without adequate information and staff. In addition, high turnover of leadership and continuing erosion of staff numbers and range of expertise are resulting in a significant loss of institutional knowledge.

3.3. Internal and External Factors Shaping the Science Strategy

Based on NPS staff input, the science strategy had to be designed to respond to an array of limitations while adding power to science and science-based decision-making. The following characterizes existing factors that shaped the goals of the science strategy.

- Data and information on Alaska's natural and cultural resources are exceptionally limited (e.g., NRPP-NRM and I&M, see memo 2005), and information about park resources is not only far from complete, it can never be complete,
- Despite the serious lack of knowledge about natural and cultural resources in Alaska's parks, management decisions are regularly needed, many of which are highly controversial and politically charged.
- The NPS was designed as a resource management agency, not a research organization. While scientific understanding can be a key component for balancing use and protection, science initiatives are modestly funded and career-track scientists are few.
- Research projects completed on park lands have not consistently been available to, interpreted for, or used by NPS resource managers in decision-making.
- The exceptionally large and remote tracts of land in Alaska requiring NPS oversight and protection are beyond ready understanding by those making budgetary decisions at the national level. The task of inventorying, monitoring and conducting research within the Alaska parklands is enormous, and well exceeds existing capabilities and funds.
- Given existing realities of budget, this science strategy cannot be contingent on an infusion of additional funds and more staff for research. Rather, it should provide a positive pathway for science within the current administrative environment.

4.0. Existing NPS Assets for Strategy Implementation

Program priorities are currently guided by the NPS Legacy Initiative and 4-Year Plan: "Doing Business in the 21st Century (NPS 2005) that includes key goals and objectives relevant to science (e.g., continue and enhance partnerships, build and sustain institutional memory, coordinate with other land management agencies, states and local governments in the overall stewardship of natural and cultural resources, build youth programs to enhance resource stewardship, knowledge and relevancy; please see Appendix D). The NPS Alaska Region has a cadre of professional staff, and park-based, regional and national NPS funds that are essential to the conduct of science in and for national parks that support natural, cultural and subsistence programs. The Legacy Goals, combined with existing programs provide vital assets for implementation of science in parks. What follows is a brief overview of existing programs and funding sources. For additional information please see referenced documents and Internet sites.

4.1. Natural Resources Research and Program Funding

The passage by Congress of the National Parks Omnibus Management Act of 1998 (NPOMA) set a new agenda for natural resource sciences in parks. In 1999, the Service launched a new science initiative, called the Natural Resource Challenge (NRC 1999) which provided NPS a significant infusion of funding for science and natural resource management that has increased every year since FY 2000. By 2005 the funding base for

NPS natural resource and science reached $78 million above levels prior to the NRC (NPS 2004).

The goals of the NRC are to identify and document park resources, determine their condition and trends, assess the implications of natural or human influenced changes, and convey findings to managers, scientists, and the public. To provide direction for implementation, the Alaska Region Natural Resource Advisory Council (NRAC) published a strategic plan that included four regional priorities and eleven focus areas (see table 1 taken from NPS 2000a). An implementation plan was also produced (NPS 2002).

Consistent with NRC goals, three new programs were implemented in the Alaska region: the Inventory and Monitoring Program (I&M) funded with NRC national funds, and Cooperative Ecosystem Studies Units (CESU) and Science and Research Learning Centers (RLC), funded in Alaska by the Regional Office and individual parks.

Table 1: NRAC Regional Priorities

1. **Preserving Alaska's Ecosystems**
   - State of the Park Resources
   - Backcountry and Wilderness Resources
   - Coastal Resources
   - Partnerships across Boundaries
2. **Visitation and Access**
   - Visitor Use
   - Transportation and Access
3. **Balancing Preservation and Consumption**
   - Subsistence and Sport Harvest
   - Non-Federal Ownership
4. **A Scientific Foundation for Park Management**
   - Living Laboratories
   - Bringing Information Resources into the 21st Century
   - Fostering Professionalism

4.1.1. Inventory and Monitoring Program

The Inventory and Monitoring Program (I&M) has been a focal program for collecting natural resource data to provide information to park managers about resource status and trends. In Alaska, work ongoing under I&M is a foundation element of the science strategy. Of particular note is the selection of vital signs, and development of ecosystem conceptual models for parks within the four regional networks. Research implemented under I&M is already producing valuable results and increasing understanding of park resources. This is the primary program funded under NRC at this time. For additional information see http://science.nature.nps.gov/im/index.htm

4.1.2. Cooperative Ecosystem Studies Units

NPS partnered with 12 other federal agencies to create a national network of university-based Cooperative Ecosystem Studies Units (CESU). Two of these include the Alaska Region as partners: the North and West Alaska Cooperative Ecosystems Studies Unit (NWA CESU) http://www.uaf.edu/snras/cesu/about.htm, and the Pacific Northwest CESU (PNW CESU) http://www.cfr.washington.edu/research.cesu/. The CESUs foster partnerships in research, education, and technical assistance. The NPS supports numerous park-oriented research and technical projects in the biological, physical, cultural, and social sciences by university faculty and graduate students through the CESUs. Alaska park resources are being used to fund a research coordinator to participate in the NWA CESU, while the Pacific West Region supports the PNW CESU.

4.1.3. Science and Research Learning Centers

The NRC included a vision for a national system of field laboratory facilities, with capabilities for temporary lodging, computer and Internet access, logistical support, research grants, opportunities for collaboration, and other benefits to the scientific community. Science and research learning centers have now been established in two parks in Alaska, both funded through their sponsoring parks and each with unique capacities. The Ocean Alaska Science & Learning Center (OASLC), located at Kenai Fjords National Park, is focused on coastal and marine ecosystems research (see http://www.oceanalaska.org/). The Murie Science and Learning Center (MSLC), established in Denali National Park and Preserve in 2004, is oriented toward Alaska's inland parks. The MSLC partnered with the Denali Institute to provide science-based learning opportunities for park visitors (see http://www.alaskanha.org/murie-science-learning-center.htm).

4.1.4. Other Natural Resource Research Programs

An array of programs and funding sources are available to NPS science and resource personnel to complete research in parks. In several cases there is cross-over between these programs and the I&M program. For an overview of a variety of research programs funded through NPS see http://www.nature.nps.gov/scienceresearch/index.cfm

Service-wide Comprehensive Call A Service-wide Comprehensive Call (SCC) for research proposals at the national level provides funds for research by national park personnel and partners. These research proposals undergo a rigorous winnowing process within Alaska and, for most funding categories, those selected subsequently compete again at the national level. A diverse array of research and resource management projects has been funded in Alaska.

Exotic Species NPS has initiated a national effort to assess the range, abundance and affects of non-indigenous plants and animals and to map, control and eradicate exotic plants. In Alaska it will be difficult to ascertain the presence of exotics without knowledge of native species, work that is underway under the I&M program. As those data are collected, efforts are being directed toward processing available data on invasive and exotic species from outside the parks and to create and maintain databases for invasive plants and animals that will populate an informational web site.

Park Air and Water Quality A consistent approach established at the national level for assessing water and air quality is being evaluated for application in Alaska. Both national programs are important to establishing baseline condition and identifying trends for these key natural resources. In Alaska the enormity of uncounted lakes, rivers, glaciers, estuaries and other surface and subsurface waters presents a particular challenge for assessing existing water quality. Alaska's air is considered the cleanest in the country, yet contaminants from around the globe are being transported to the Arctic where unique processes are increasing levels of mercury and persistent organic pollutants (AMAP 2002). NPS is developing a monitoring plan for Alaska consistent with parameters established in the NRC Air Quality Action Plan.

4.2. Cultural Resource Programs

NPS Alaska Region supports the cultural sciences for identifying, evaluating and preserving a rich human history across the Alaska landscape. An array of cultural resources programs in Alaska are funded through NPS national funds, and allocated within the Region based on identified needs. NPS also provides funds for partnership protection activities. For information on funding opportunities see: http://www.cr.nps.gov/helpyou.htm.

An existing cultural resource strategic plan is currently being updated by the Alaska Region Cultural Resources Advisory Council (CRAC). The updated strategic plan priorities for enhancing the protection and appreciation of cultural resources include:

- Protect the integrity of each unit's natural and cultural resources and values
- Improve public understanding and enjoyment of our units, including providing appropriate services and access; and
- Improve community relations in Alaska

Cultural resource projects support the NPS Strategic Plan for cultural resource long term goals and address park resources listed in or eligible for listing in the National Register of Historic Places, or address archeological resources, museum collections or ethnographic material. A substantial portion of the Cultural Resource funding is directed toward documentation and preservation of cultural resources through an array of programs as briefly described below.

The Cultural Resources Preservation Program supports inventory, evaluation, documentation, research and stabilization of park resources. The NPS Systemwide Archeological Resources Inventory (SAIP) funds archeological overview and assessments, identification and evaluation studies, and database documentation using the Archeological Sites Management Information System (ASMIS). The Cultural Landscapes Inventory program funds landscape inventories**.** The Historic Resource Studies Program provides funds for parks recently established that have not completed their inventory, evaluation and registration of park cultural resources. The Historic Structures Inventory provides an update on the "List of Classified Structures" that provides information on the use and condition of existing structures. The Historic Structures Stabilization program funds repair and rehabilitation of these structures and the Cultural Cyclic Maintenance is used for repair of historic property and protection and prevention of erosion at archeological sites. The Museum Collections Backlog Cataloging and Preservation and Protection Programs manage museum collections to ensure proper cataloging of un-cataloged objects and to correct deficiencies. Ethnography Projects are funded for study of the cultural landscapes, natural resource use and traditional resource users. The Park Native American Graves Protection Projects provides funding for cultural affiliation and lineal descendent studies, repatriation, and consultations on inadvertent discoveries, planned excavations and modifications.

4.3. The Beringia International Heritage Program: integration across natural and cultural disciplines.

In 1990, after many years behind-the-scenes planning by scientists and officials in two countries, U.S. President Bush and Soviet President Gorbachev announced their intention to establish a *Beringian International Heritage Park* to celebrate contemporary, historic, and prehistoric linkages between both sides of the Bering Straight. This launched what today is the Beringia Program. The Program supports a diverse suite of international scientific, cultural, and educational projects, and holds alternating annual conferences in Anchorage, Alaska and Anadyr, Chukotka to present project results. The program has been a major success in establishing a strong link between the landscape and cultural change across the Bering Sea, and is a testament to the value of partnerships through close cooperation with Native people. Additional information may be obtained at: http://www.nps.gov/akso/beringia/beringiaprogram.htm.

4.4. Park Base Funding of Science and Resource Management.

Park base funds support park specific monitoring, restoration, resource management, and research and serve as the backbone of resource assessment in parks. Park and regional professional natural and cultural resource staff are on the front line for implementation of science and resource management in parks. Their direct knowledge of park natural and cultural resources is the guiding force behind setting priorities and identifying research and management needs.

4.5. Advisory Groups and NPS Science and Strategic Plans.

Alaska NPS personnel have invested heavily in planning for and implementing resource management, subsistence, and science in parks. Advisory groups have generated strategic plans specific to their area of concern. The Alaska Region Natural Resource Programs Strategy for the Future (see 4.1 above, NPS 2000) represents about 10 years of work by many NPS staff, and was published by NRAC. The accompanying implementation plan is designed to achieve regional priorities and focus areas under the strategy, integrate the I&M program with other aspects of the overall Natural Resources Management Program, and institutionalize the NRC. Other advisory groups include the CRAC (see 4.2 above), and the Subsistence Advisory Council (SAC), both currently updating their strategic plans. The Education Advisory Group (EAG) generated three regional themes for NPS outreach: (1) Alaska's national parks preserve large, intact natural systems including geological and hydrological processes and biological diversity, the foundations of life on earth, (2) Alaska's national parks provide access to a collective heritage where human activity remains integrated with natural processes, and (3) Alaska's national parks and their compelling stories enrich our lives by providing opportunities that help us make connections with ideas and meanings larger than ourselves (NPS, 2003). In additional to regional activity, specific parks may generate park-specific science plans to meet park needs (e.g., Glacier Bay Integrated Science Plan).

4.6. Partnerships

NPS benefits significantly from an array of partnerships with federal and state agencies and non-governmental organizations both within and in addition to partnerships established under the CESUs (see 4.1.2.). Some of these partnerships are formally established, such as that with the US Geological Survey, particularly the Biological Resources Division. Others may occur through serendipity.

There are three general levels of partnership from which NPS benefits. Different organizations at different times may move among recognizable categories. How NPS invests in different partnerships is based on how great and what kind of investment is possible.

1. *Direct shared resources and joint investigations*: these are the top level partnerships possible. The CESUs provide a platform for conducting these with universities. The most direct partnership NPS has is with the US Geological Survey which serves as the science arm for the Department of the Interior.
2. *Direct exchange and tracking of investigations*: this is the next level of partnership. Here NPS may participate in workshops and symposia, offer comments on science plans, and closely track and influence the work of other organizations (e.g., North Slope Science Initiative).
3. *Access to data and information collected by other scientists and organizations*: This third level of partnership can be much more valuable than may be believed, as data already collected can be very cost effective when used in integrated assessments (North Pacific Research Board, Gulf Ecosystem Management-GEM program).

5.0 Conclusions

The mission of the NPS, supplemented by recent legislation, provides the political foundation for increasing scientific research in parks, as well as using existing and new scientific data to guide management decision-making. While research is inherently challenging throughout Alaska, and particularly so in those Alaska national parks containing designated wilderness, NPS is poised to augment existing NPS scientific activity. NPS staff expertise, budgetary assets, research programs, logistical assets and partnerships offer the means for implementing a science strategy. Based on input from NPS personnel, partners and other interested parties, there is a need for more science, and even greater needs for interpreting science within an interdisciplinary context, and in a way that enhances the value to resource managers. The following science strategy framework was formulated based on these conclusions.

Part II Strategy Framework

The NPS Alaska Region desired a science strategy that would create a pathway to meet future resource management needs within the context of current realities. The NPS science strategy framework presented here uses the NPS priorities for park science as the foundation for meeting perceived needs for science. Section 6.0 provides a brief description of NPS categories for science in parks. Section 7.0 provides an overview of the characteristics of a strategy followed by the NPS strategy framework. Note that the strategy is not "how to" guidance. Rather the strategic framework includes appendices and references to existing guidance that will enhance an understanding of the process and support implementation.

6.0. NPS Priorities for Park Science

Underlying the Omnibus Act (1998) and the NRC (1999) was the recognition that national parks provide an excellent opportunity for understanding the natural and cultural systems that make up our national heritage, and that science should be conducted within parks, both for seeking essential knowledge to improve resource management, and deeper knowledge about the very nature of ecosystems as well as our global and cultural heritage. Alaska's parks are natural laboratories for understanding ecological and global processes, cultural links to landscapes, and stressors increasingly causing change.
Fig. 1 represents an overall framework for NPS science (see also sections 6.1., 6.2, and 6.3) founded on three goals presented in the NRC (1999): Science for Parks, Parks for Science, Parks for Learning.

6.1. Science for Parks, Parks for Science: Initiating Science in Parks

Scientific research may be initiated because of an identified information need (issue based) or a specific management decision that requires information (decision-based) both of which focus on science with a defined relationship to NPS needs (science for parks). Scientific research may also be initiated because there is a question about how the world works or is changing (curiosity-based) that leads to new scientific understanding; direct application to park management may not be obvious (parks for science). All three are appropriate and valuable reasons for conducting science in parks. At the same time, regardless of whether connection to a known NPS management concern is recognized or not, all research done in parks should be incorporated into the NPS knowledge base. It is normal for important discoveries to emerge through serendipity, or findings that at first seem unrelated to an issue, but later become key sources of understanding for old or new management problems.

6.2. Parks for Learning: Using Science for Management and Education

A significant portion of science in parks should help to ensure effective management of park resources while promoting public stewardship through better education. The application of scientific research to a specific management decision (e.g., NEPA) or management objective will, to a certain extent, depend on why the study was initiated.

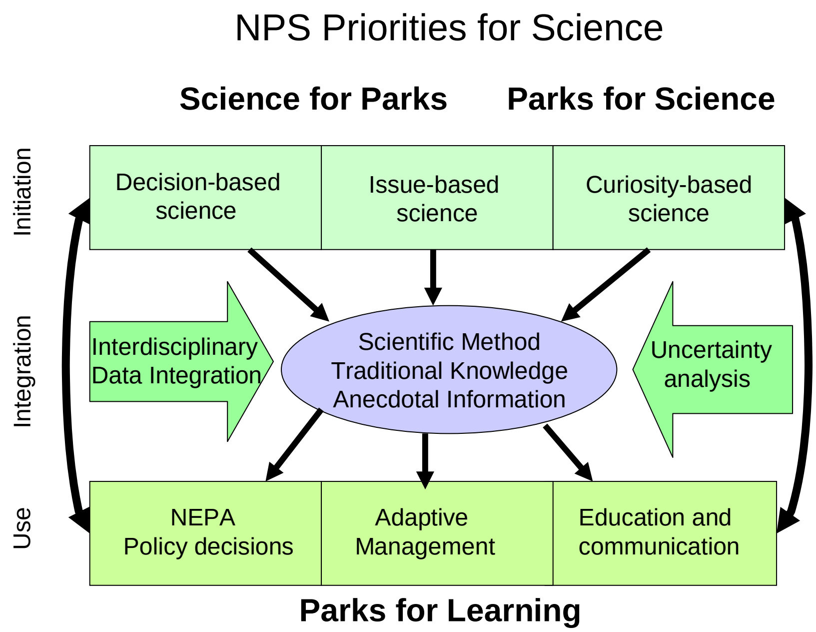


Fig 1: The overall framework for NPS Science: Science for Parks, Parks for Science and Parks for Learning.

Even though scientific data are critical to better understanding, more data alone do not, *a priori*, result in the use of data in decision-making, or necessarily better inform the public. A direct connection between management goals, data processing, and the integration and presentation of results must be made for that purpose regardless of the reason for initiating studies.

6.3. Integration of Data for Management

Implied but not explicit within the parks for science, science for parks and parks for learning framework, is the need to transform scientific data into useful information for resource management and public education. Not unique to the Service, there is a consistent and long standing dilemma within many organizations using science in the decision process in making the connection between available data and decision needs. At the core of a solution are the interpretation, synthesis and communication of data consistent with management needs for information. This requires a process designed to integrate diverse types and sources of data that may span multiple disciplines and sources; in a data-limited environment, maximum use of available information is essential to success.

6.3.1. Diverse Types of Data

Information is derived in many ways, from rigorous data collection protocol to casual observation. The quality of this information is of primary concern to decision-makers and scientists working in national parks. In the strictest sense, quality science must satisfy the requirements of the scientific method (e.g., Kuhn 1970, Popper, 1959, 2002). The empirical sciences are based on hypothesis testing and the systematic collection of empirical data. When applied, the scientific method is effective in more precisely measuring relationships among selected variables and reducing uncertainty about those relationships. Anecdotal accounts and traditional knowledge, although collected using different approaches and rigor, can also be important sources of information in a science program. Anecdotal accounts often provide initial insights to relationships that trigger scientific inquiry and further assessment. Traditional knowledge is founded on repeated and often long standing observations of natural relationships and cultural mores. How these alternative types of data are used determines scientific rigor, not whether they are used. Regardless of origin, all data sources should be subject to uncertainty analysis. To provide the level of confidence generally desired for management action, knowledge gained through traditional ways and anecdotal accounts may require verification through the systematic empirical observations that satisfy the rigors of the scientific method.

6.3.2. Alternative sources of data

Since NPS resources are managed within the context of complex natural systems, rich cultural history, and limited data, the use and integration of interdisciplinary data and diverse data types and sources is appropriate and necessary. NPS must depend to a significant degree on using data collected by other federal and state agencies, independent scientists, community observers and others. To ensure scientific excellence, formal evaluation of uncertainty will be required when integrating interdisciplinary data collected by multiple agents using different approaches. The following science strategy framework is structured to integrate and synthesize diverse types and sources of data into useful information linked to manager needs.

7.0 Elements of the NPS Science Strategy

There are three elements that, when working together, create the framework for achieving strategic visions; these include clearly defined ends, ways and means (Lykke 1989, Taylor 1990, Jablonsky 1992; **see fig 2**).

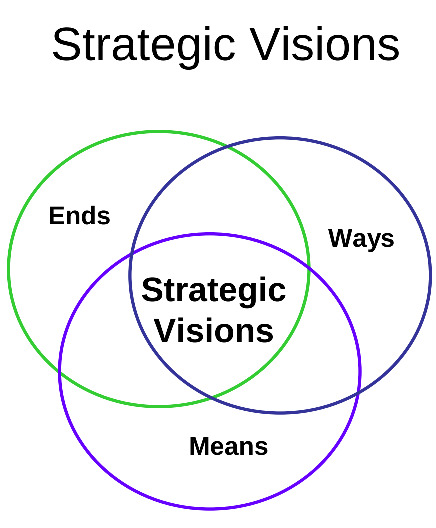


Fig 2: Strategies include three basic elements: the end to be achieved, the way or process for achieving the end and the means such as staff, funding, expertise for implementation.

- The *end* includes the goal and objectives to be achieved. These may be defined by policy, legislation, organizational goals, and local community and other interested party needs. Central to success for NPS Alaska will be the transformation of policy goals into place-based outcomes for the resources under NPS management.

- The *way* is the process used to achieve the desired end. The process incorporates the concepts that guide implementation; the underlying framework of understanding and approach that is used. By defining a clear process, available means may be aligned more effectively.

- The *means* are the array of financial, logistical and intellectual assets available to focus on tasks designed to achieve desired end results. The more focused the goals and process to achieve them, the more effective allocation of assets can become.

The end-ways-means structure is used for the NPS science strategy. The strategy includes the overall strategic vision, ways to encourage more science and a process for linking science to management and integrating data in a way that fosters informed resource management and good stewardship, and alignment of available resources. The format for the strategy emerged from existing legislation, policy, NPS strategic plans, and direct input from NPS Alaska personnel, partners and interested parties.

7.1. NPS Science Strategic Vision and Goal: The "End"

Consistent with the Organic Act (1916, see section 1.0) the NPS translated the Act's key management provisions into two primary GPRA Goals: DOI Goal I: Protect the environment and preserve our nation's natural and cultural resources, and DOI Goal II: provide recreation for America. Both goals are core to the NPS mission, yet they may often come in conflict because overuse of park natural and cultural resources can lead to their degradation. As well, inadequate knowledge about this relationship can lead to management mistakes. Recognizing that science can provide for more informed decision-making the new science priority established under the *National Parks Omnibus Act of 1998*, directed NPS to "assure that management of units of the National Park System is enhanced by the availability and utilization of a broad program of the highest quality science and information" and to "…assure the full and proper utilization of the results of scientific study for park management decisions."

Based on legislative goals, GPRA goals and staff input, the NPS Alaska Region Science Strategy's overarching vision and desired end is to: *generate scientific questions and collect and process data to identify the sustainable balance between preservation and park use to support adaptive management.* Thus when future research projects are being developed, scientific questions should be shaped in part by asking how the proposed work helps identify this balance.

To determine which "sustainable balance to protect," sustainability must be operationally defined (see Appendix E) and a clear description must be generated of those natural, cultural and subsistence resources to be maintained. This may be done at the Alaska Region level for some issues, at the park level for ecosystem assessment, or for some other definable "place." It is not the purview of the science strategy to do this. However it is an essential part of the strategy recommendation for manager-scientist interfaces necessary to achieve the strategic vision (see Section 7.2.2.1). In short, the desired "sustainable balance" must be operationally defined for each "place" for the overarching strategic vision to be useful. This is particularly relevant to operationally defining key terms such as natural, health, and unimpaired that serve as the goal for NPS management (see Appendix F).

7.2. Enhancing Science in Alaska's National Parks: The "Way"

To enhance science in Alaska parks, the strategy has three priorities which together form a solid foundation for advancing the value of science for parks (see fig. 3). These include:

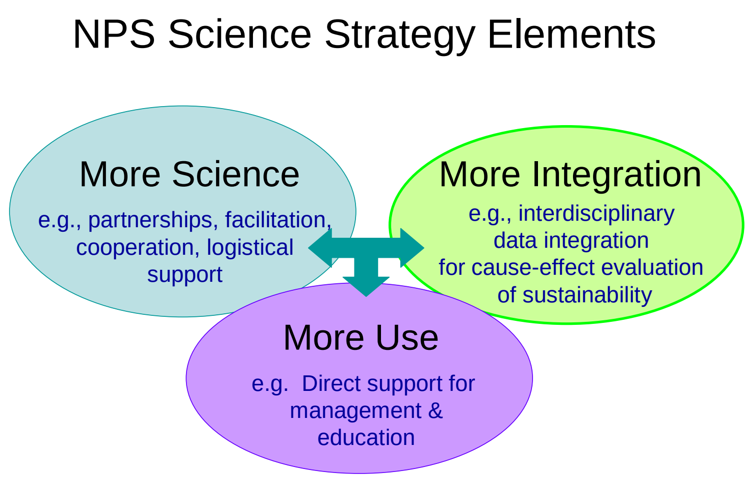


Fig. 3
The strategy includes three priority elements that together create a basis for enhancing and using science to make informed decisions that allow NPS to achieve a sustainable balance between preservation and use of NPS resource values.

1. Enhance scientific research in, and knowledge about national park values, resources, and stressors;
2. Guide interdisciplinary research and data integration to better understand the links between natural and cultural values within the context of a changing human and natural environment; and
3. Synthesize and deliver data in a format designed to inform resource management decision-making, promote adaptive management, and educate the public.

Each of these priorities is expanded on below including the rationale for inclusion and the relationship to the other priorities.

7.2.1. More Science: Expanding Scientific Research in Parks

Alaska's parks are rapidly becoming enclaves of natural and cultural landscapes with relatively minor impacts from industrial development. Parks represent a national treasure for both our national heritage as traditionally viewed, as well as a treasure trove for understanding natural and cultural resources and processes that are disappearing across the global landscape. Their importance to the scientific community for helping us understand natural processes, cultural mores and ecosystem services is highly significant.

At the same time, several factors present challenges to park staff and scientists in finding common ground for supporting science. Successful implementation of the science strategy requires overcoming the following issues that park staff and scientists have identified as currently limiting park-based research. Ways to address existing challenges are discussed in the implementation plan (see Part III).

7.2.1.1. Overcoming Philosophical Differences

Fostering partnerships for science, data processing, and problem solving for protecting resources is an essential part of existing capabilities within CESUs. For these and other partnerships to be fully effective however, scientists must feel welcome in parks, confident that they can complete their work within expected timeframes and budget, and obtain data that will pass scrutiny under peer review. The NPS task is to embrace and encourage the study of park resources; the challenge is to determine how to increase the use of parks for science without impairing public use and enjoyment, or the natural and cultural values that may be impacted by scientific study. Staff perceptions of potential impacts and impairment are linked to a strong cultural history within the Service about the use of parks for science. Scientist's perceptions are also strongly held cultural views. Both perspectives must be better understood and clearly articulated to find common ground for the development of effective guidance for park staff and scientists. Success can be fostered through communication tools, and ease relating to the application process, permitting and funding opportunities.

7.2.1.2. Consistency Regarding Park Access

Access in parks is limited to protect natural and cultural resources as well as visitor experience. These are important restrictions designed to ensure the dual mission of the NPS is met. However, there perceived inconsistencies concerning who is considered a legitimate user or visitor. Activities and access allowed for members of the public are sometimes not allowed for scientists trying to work in backcountry locations. This type of inconsistency sends a powerful negative message to researchers and can seriously compromise their research. Guidance, that includes consistent parameters and clear rationale for limitations and opportunities, is needed so that all understand opportunities and restrictions and why they exist, regardless of whether they are members of the general public, hunters, guides, concessionaires or scientists. This will streamline permitting and help prevent acrimony.

7.2.1.3. Defining Appropriate Research

A key issue for park managers as well as scientists conducting research in parks is defining the type of research appropriate for a particular park, as well as unique areas within a park (e.g., wilderness). Some types of research are just not appropriate in the park environment. In other cases however, mitigation measures are possible to create a scientific opportunity that is consistent with the park mission. A greater understanding by park managers and scientists concerning inherent limitations and needs from each other's perspective will help to ensure that research applications respect the NPS mission while meeting necessary requirements for quality science. NPS guidance developed in partnership with scientists could help articulate those types of activities most suited for parks.

In addition, knowing the type of research most needed in a park can help trigger scientific interest. Scientists tend to be curiosity-driven when asking scientific questions. However, issues of concern and top questions about changes occurring within park resources can help set the stage for top quality scientific endeavors with a direct link to park needs. Sharing research questions and needs with the scientific community, anecdotal accounts that appear unusual, traditional knowledge that is challenging to understand can all elicit excellent scientific research. The goal of determining how to sustain natural and cultural resources in the face of rapid global change presents one of the most challenging scientific issues today. This is more directly addressed in section 7.2.2.1 below.

7.2.1.4. Enhancing Support in a Resource Limited Environment.

Even when scientists are welcomed and scientific studies encouraged, the logistical challenges of conducting research in national parks can be daunting both for NPS and independent scientists. Strategies for streamlining logistical support, transport opportunities, and support services to meet park personnel and researchers' needs are required to create win-win opportunities. This must be accomplished in an environment where resources are sometimes so limited that NPS cannot meet basic staffing requirements. Recognition of this by scientists seeking logistical support is important for understanding inherent limitations. NPS and scientists need to work together to identify high value but low cost support alternatives.

7.2.1.5. Encouraging Interdisciplinary Research

A core goal for the science strategy is to enhance interdisciplinary research and integration. Parks in Alaska have astounding natural and cultural resources that have been interwoven over centuries and cannot be fully understood unless within an integrated interdisciplinary context. The original founding research conducted under the Beringia Program provides a role model for future work for natural and cultural integration, whether done for ancient or modern day relationships. Existing NPS Alaska strategic plans also highlight this important connection.

The administrative framework at NPS separates natural, cultural, and subsistence programs and funding. If NPS is to achieve the goal for interdisciplinary research and integration, programmatic and targeted financial support is needed to foster interdisciplinary research and follow up integration and synthesis. This is also addressed in section 7.2.2.2 below.

7.2.1.6. Encouraging NPS Scientific Excellence

NPS personnel have significant knowledge and scientific capabilities that are key assets to the Service. However substantial time by technical and scientific staff is spent on administrative duties, many of which are related to a complex process of competing for limited NPS research dollars at the national level. In addition, NPS personnel are limited by travel budget and historical culture in their professional engagement with the larger scientific community. While NPS will remain primarily a resource management organization, professional development of resource staff is an important pathway for improving scientific excellence within NPS.

7.2.2. More Integration: Issues and Science, Disciplines, Data Synthesis and Evaluation

Scientific investigations are essential to our understanding of ecological and cultural processes. However integration across disciplines and diverse data types requires a deliberate process beyond typical scientific investigations. To address the sustainable balance between preservation and use, NPS needs tools to evaluate cause and effect relationships including: 1) a set of scientific questions concerning the sustainability of values of concern in parks, 2) an integrative process that evaluates relationships between values and stressors affecting them, and 3) a process for synthesizing results for delivery to managers. These are the first three in a four step process for meeting the needs of adaptive management to sustain NPS values. This process is presented in fig. 4 and an overview of each step is provided below.

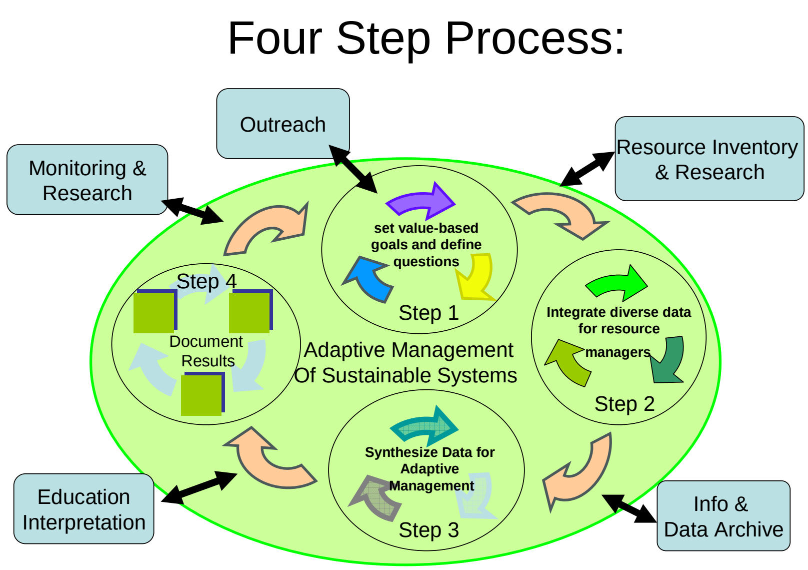


Fig. 4
The four-step process is iterative within each step, and iterative among all four steps. Step 1, outreach, is the interface of managers, scientists, cultural consultants, and community members, for defining key issues and setting value based goals. Step 2 is the integration of data and information from all available sources for interpretation. Step 3 is the synthesis of information into possible outcomes that may arise from management decisions. Step 4 is the documentation of decisions with rationale. Each step provides needed support for planning science, storing and using data, and identifying monitoring and research needs.

7.2.2.1. Step 1: Set value-based goals for resources to sustain and define management relevant science questions.

The most important step toward managing for a sustainable balance between preservation and use is to define what those values are for resources in a specified location and determining the kinds of scientific, traditional and cultural knowledge that will help managers sustain them. Thus, goals for natural, cultural and subsistence resources and visitor experiences must be *operationally defined* for a place (e.g., region wide, park wide, watershed, or specific species in a given area). This includes a description of desired characteristics, conditions or experiences (e.g., operationally defining existing legislation and management plans for a place, and terms such as natural, healthy, and unimpaired (see Appendix F). These goals are essential because the effectiveness of scientific data for use in resource management is founded on the collection and translation of data into useful information pertinent to the managers' issues of concern.

For scientists to be responsive to decision-makers needs, a planning dialogue among managers, scientists and other interested parties is the beginning of a necessary interface.

During planning dialogues, managers, science staff and interested parties revisit founding legislation and other policy documents for the park or region. Using available updated information, original goals are affirmed or clarified for the key values that are to be sustained, and their potential vulnerability is considered.

Specific products from Step 1 include:

1. Clearly articulated management goals based on the identification or updated reaffirmation of critical resource values and key management concerns;
2. Characterization of management needs and decisions required within the context of the goals and concerns,
3. Identification of specific information needs; these may or may not be available. If not available, then this information can inform research priority development.
4. Agreement on the scope, complexity and focus for scientific inquiry and data processing to integrate diverse available data to address the management concern. This should also include the expected outcome of an assessment and the technical and financial assets available to complete it.

By knowing the values to be sustained, scientists can generate questions that are both intellectually interesting and relevant to management concerns. For example, if a manager needs to know what is causing harbor seal declines, climate change scientists may cogently argue that their research is a high priority because climate change may be a significant factor in that decline. However, general climate change research may be of little or no value to the manager trying to protect harbor seals since harbor seals are influenced by many factors in the environment, not just climate. In addition, climate change researchers are more likely to form their questions within the context of physical processes. If science questions about climate change are formed within the context of harbor seal vulnerability, then the research is more likely to address managers' needs.

In Fig 4, the arrows leading from step 1 indicate results that provide guidance for moving to step 2 where data integration occurs, and also provides guidance for new research and monitoring activity to fill identified research needs.

7.2.2.2. Step 2: Integrating diverse data into useful information for resource managers

Goal setting provides guidance for generating new scientific questions as well as new research to fill data gaps. However management decisions are needed on a regular basis, regardless of the state of the science. Under these circumstances it is essential to use available data in a highly effective way to meet immediate needs when new data may not be available for five or more years. A process is needed that can systematically integrate available information from relevant data on system characteristics, targeted resources and stressors and translate it into results easily communicated to resource managements. It should include an evaluation of resource vulnerability and sensitivities and provide a way to use existing data from all relevant disciplines, as well as relevant data within parks and from other locations.

Such an integrated approach can be applied under the science strategy using existing guidelines, appropriately modified and expanded for NPS application. The process can be used to evaluate the likelihood that sufficient natural or cultural changes will occur as a result of exposure to one or more natural or human-based stressors to alter resource sustainability. The process combines regional vulnerability assessment (www.epa.gov, see Appendix G) and ecological risk assessment (USEPA 1992, 1998; see also Appendix H) except that it is designed to inform managers about factors needed to sustain a valued resource, and human based or natural forces (stressors) that may impact their sustainability because of inherent sensitivity and vulnerability to those stressors. The NPS integrative process is not *a priori* concerned about adverse consequences. Rather it is designed to identify pathways for sustaining valued resources, consistent with the dual mission of the park service to protect natural and cultural resources while ensuring their use in perpetuity, and in light of regional and global, human-based and natural environmental forces (see Appendix I).

Specific products of the NPS integrative process include:

1. *Conceptual formulation*: During conceptual formulation management goals are translated into specific operationally defined endpoints for scientific study and conceptual models are constructed that includes both a written description and visual representation of predicted relationships among ecological, cultural and park user entities and the stressors to which they may be exposed. This is a powerful process that promotes data integration across data types and sources of information (e.g., data collected using the scientific method, traditional ways of knowing, anecdotal accounts). Also included is the assessment plan for data analysis.
2. *Analysis*: Analysis of exposure, effects and vulnerabilities of key values of management concern in response to defined stressors or anticipated change to generate stress-response relationships.
3. *Response characterization*: Characterization of response and risk of values to anticipated changes or pressures and opportunities for sustainable balance between dual goals.

Inherent in these products is the summary of results with scientific evidence for use by managers, educators and the public plus documentation of supporting data for archive. A preponderance of evidence approach is used with uncertainty analysis to provide managers the information they need for more informed decision making, and offers educators and interpreters key information to share with the public. In fig 4, arrows leading from data integration show a ready-made format for archiving existing data, as well as incorporating new data as it comes available.

Products from step 2 may provide the information needed to make management decisions at the close of the assessment. In this case, step 3 is eliminated and step 4 is begun. Under more complex or uncertain circumstances, results can also be used to form alternative scenarios of potential outcomes given different management alternatives. Either way, data integration offers products to enhance the use of science for decision-making. The process is specifically designed to translate scientific data into useful information for use by decision makers.

7.2.2.3. Step 3: Synthesize Data and Process Scenarios.

For most place-based assessments, multiple values and many stressors are operating within a complex ecological and socio-cultural system. Complex assessments may be required to address the diversity of forces and array of values of concern, and more than one management option will likely be under consideration to satisfy competing interests and to find the best course for achieving resource sustainability. In this case a formal evaluation of possible management options and scenarios of potential outcomes is a useful, though optional exercise. Here potential maintenance or corrective actions are more thoroughly evaluated to determine the best to retain or bring apparent conditions toward the desired condition (e.g., adaptive management, see Appendix J).

Scenario development, as used here, is the synthesis of integrated assessments within the context of a formal evaluation of management options and their potential outcomes using conceptual and simulation models. The foundation for scenario development is derived from the field of system dynamics (Forrester, 1961, Ford 1990, see also Appendix K). One of the most widely known applications of systems dynamics relates to global environmental responses to human influences (Meadows et al 1972, 1992, 2004). While it is not anticipated that the NPS will invest significantly in running mathematical computer models as part of the science strategy, the value of approaching alternative management options with the same rigor used in system dynamics would be of great value. While these models are not predictive, they are instruments to support strategic thinking, group discussion and learning. The models are generated by giving values, positive or negative, to different relationships and projecting outcomes over multiple years. While not predictive, these models can identify possible outcomes that can be highly informative.

Specific products of synthesis include:

1. Defined management options/outcomes described for evaluation.
2. The specific interactive parameters used for building the scenarios
3. Results of synthesis interpreted for managers

As shown with arrows in fig. 4, the results of synthesis coupled with the integrated assessment are particularly effective in providing useful information with direct links to management issues and decision-making, as well as providing interpretations of value to interpreters, educators and the public.

7.2.3. More Use: Step 4: Effective Use of Data for Adaptive Management

Good planning and data integration described in Steps 1 and 2 supports the synthesis and delivery of data in a format designed to inform resource management decision-making, promote adaptive management, and educate the public. To accomplish this, the third and fourth steps in the four step process, shown in fig 4., link scientific interpretations to resource management concerns.

7.2.3.1. Communicate results

A crucial and often ill defined step is to communicate scientific results to managers in a format that will inform their decisions. Much more is required than presenting results of individual scientific studies in publications or presentations. However, if the first steps of the above process are completed, they provide the organization and key content for this important step. A review of each of the first two or three steps will offer the information managers need to respond effectively in a management arena, with objective and scientifically based options among which to choose for the best management decision. Presentation of assessment results by the assessment team to the management team would include management options evaluated within the context of vulnerability and risk.

7.2.3.2. Document Management Direction and Assess Outcomes. Following communication, the manager can review and re-evaluate current management strategies in light of new information, and where appropriate generate new resource management directions, adjustments, or specific management decisions (decisions), as supported by steps 1, 2 and 3. Assessment results may lead to a refinement of decision options. However, the final decision would be based on scientific understanding in conjunction with the suite of policy issues and other decision factors influencing the decision process. Specific products from step 4 include:

1. Summary of Goals, Integrated Assessment and Synthesis
2. Array of factors considered in the decision process
3. Summary of decision with rationale
4. Guidance for monitoring impacts of decision and success of management action.

The science-management team completes a final science-management decision summary that documents scientific evidence and other considerations used to make the decision, along with a projection of the intended outcome of implementation of the management action. Using this outcome-based approach, a monitoring plan can easily be designed to measure the success of the decision in achieving the desired end, originally articulated during planning, and refined during the decision process.

Once a management decision is made and implementation begins, the four-step process ends. However the results of the process continue to guide monitoring and research priorities, particularly targeting significant uncertainties identified. As new data come available that could alter conclusions reached in the integrated assessment, or a new management issue emerges that requires evaluation, the planning process is re-visited. Such evaluation can lead to adjustments and new directions for management within an adaptive management framework (**see** Appendix J). Follow-on assessments are generally significantly less labor intensive because of available documentation from previous assessments.

7.2.4. Summary of Science Strategy Framework

The three part framework: more science, more integration, more use, provides a process specifically designed meet the needs expressed by NPS and partners. These include:

- An overarching theme for NPS research
- The strong desire for science to inform resource management decisions

- The need to better translate scientific data into information for education, interpretation and to foster public stewardship
- The need for more data on, and greater understanding of park resources
- A greater value placed on scientists conducting work in parks demonstrated by easier access, better information, effective permitting, and greater support.
- Emphasis on scientific excellence
- An effective process for establishing priorities for science and streamlining competition for funding
- The need to more effectively archive data, information and decisions

The proposed framework addresses these needs directly to enable data to be collected and transformed into useful information for resource management. Data alone tend to be of limited value in serving the needs of managers facing difficult decisions. When scientific data are presented in a form that includes integration, synthesis and interpretation of results within the context of resource management issues, coupled with an explicit treatment of uncertainty that describes the level of confidence scientists have in the conclusions they present, managers have information directly applicable to the decision process. As such, this four step process will facilitate better use of science in park management.

The four step process is fully iterative; each step produces a specific set of outcomes that feed into the next step, and any step may be revisited during the process when new information makes it valuable or necessary. In addition, each step within the process is iterative. The inputs shown in fig. 4 (e.g., outreach, resource inventory and research, data archive, education, monitoring) are top priority needs that were identified by NPS managers and staff as essential for a science strategy; these are an integral part and products of the four-step process.

The process is designed for place-based application, provides a rigorous framework for defining system characteristics to be sustained, and adds power to the integration of interdisciplinary data. The approach is applicable and appropriate for addressing watershed level, regional or global processes influencing change in parks, both natural and human induced, that may be anticipated over decades. However the process is also appropriately applied for more immediate and specific management issues.

Although aspects of the framework are similar to the National Environmental Protection Act (NEPA) process, there are important differences. Under the framework, a specific government action is not a necessary driver of the process. Public outreach can be general rather than specific, and be forward looking to problems either NPS or partners and the public see in the future. In addition, no specific decisions need to be drivers although identified concerns generally shape the assessment. A general place-based assessment completed under the framework, such as for a park, can be subsequently used for many small and some large decisions without a formal new assessment. The framework also introduces vulnerability and cause effect evaluations on a rigorous scale coupled with uncertainty analysis. The framework is designed to support a deliberative decision process and helps move away from reactive decision making.

Part III of the science strategy provides a set of actions to transform the framework into implementation to fulfill identified NPS needs.

Part III Implementation Plan: The Strategic "Means"

The implementation plan represents an organized structure for using NPS "means" for the science strategy. Existing programs, budgets, staff and partners are assets that can be used to implement the strategic vision for more science, better integration and better use of science for the adaptive management of sustained park values. Innovative approaches will be needed to streamline and augment current activities, and define a stepwise pathway that leads to full implementation of the strategy over time.

The most successful implementation plan provides specific actions in a time line with outcomes that are measurable, achievable and realistic. The following recommendations are a first cut of action items that must be evaluated using these criteria. It is anticipated that after initial implementation, NPS will revisit goals, assess preliminary outcomes and revise the implementation plans to be responsive to results and future change.

Based on the three primary objectives of the science strategy, general implementation objectives include the following.

- Enhance scientific research in, and knowledge about national park values, resources, and stressors:
    - Identify, communicate and focus efforts on priority scientific needs. Advertise needs, research goals and offer guidance to prospective scientists.
    - Attract and implement appropriate scientific studies in parks through clear statement of goals, clear permitting guidance, joint funding opportunities, and logistical support.
    - Develop effective partnerships: expand range of partners, improve connection, and offer partnership opportunities.
    - Improve opportunities for future research and discovery by preserving long term research and monitoring sites, providing enduring access to study sites, and systematically archiving baseline data and museum collections
- Guide interdisciplinary research and data integration to better understand the links between natural and cultural values and social and environmental goals within the context of a changing human and natural environment
    - Prioritize parks for assessments and identify specific park issues requiring clear balance between natural and cultural values to ensure sustainability.
    - Conduct integrated assessments at specified scales (e.g., watershed, park, region).
    - Generate interdisciplinary research agendas for parks; conduct a cross walk among existing strategic plans to identify areas of overlap.
- Synthesize and deliver data in a format designed to inform resource management decision-making, promote adaptive management, and educate the public.

- Create integrated conceptual models for each park and region that shows the combined natural, cultural and social processes influencing park values and their vulnerabilities
- Use scientific guidance and streamline programmatic requirements to reduce administrative burdens for science staff.

Specific action items are provided below selected to start the implementation process. They are not comprehensive to meet all identified needs. Rather, they were selected as those of greatest value for early implementation of the strategy either because of their great importance for building a platform for implementation, or immediate potential for having a positive impact with relatively little investment. These were generated based on feedback provided by NPS personnel, partners, scientists, and the public.

For successful implementation of any and all of the following recommendations, it is essential to incorporate science strategy implementation into current funding processes, including PMIS. This will enable the allocation of funds through national and regional programs for funding facilitated focus group sessions, and other identified activities essential for strategy implementation. In addition, NPS staff need time spent on implementing aspects of the strategy to be recognized as an essential component of their job performance.

8.0 Integrate Existing NPS Assets

Existing NPS assets, as shown in fig. 5 are the foundation for increasing and enhancing the value of science within parks. Fully linking these assets and identifying ways to improve and expand support is a primary need for encouraging more science in parks.

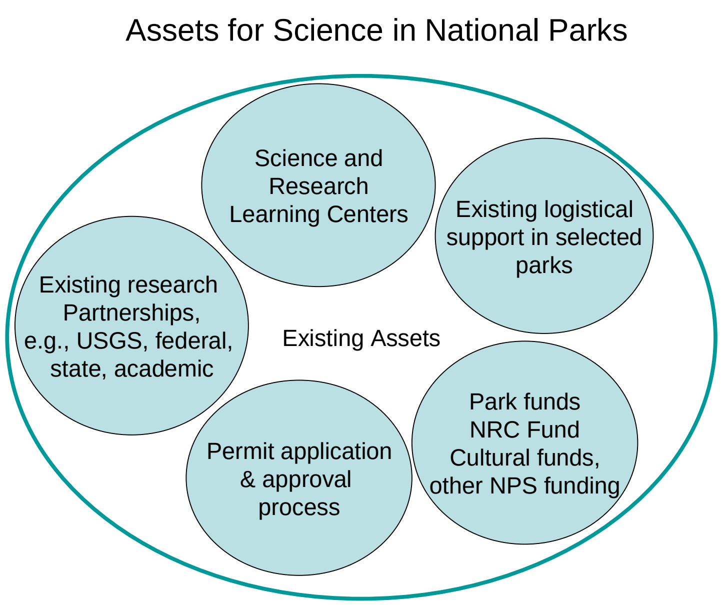


Fig. 5
National Parks in the Alaska Region have a variety of assets currently supporting scientific research. These vary among parks but include research partnerships supported in part through CESUs, logistical support, a permitting process and funding. In two parks Science and Research Learning Centers have been established.

NPS assets currently are administered under an array of Headquarters and Regional goals and focus areas, individual programs, funding opportunities, oversight groups and managers (see fig 6). This organizational structure presents some challenges for scientific integration.

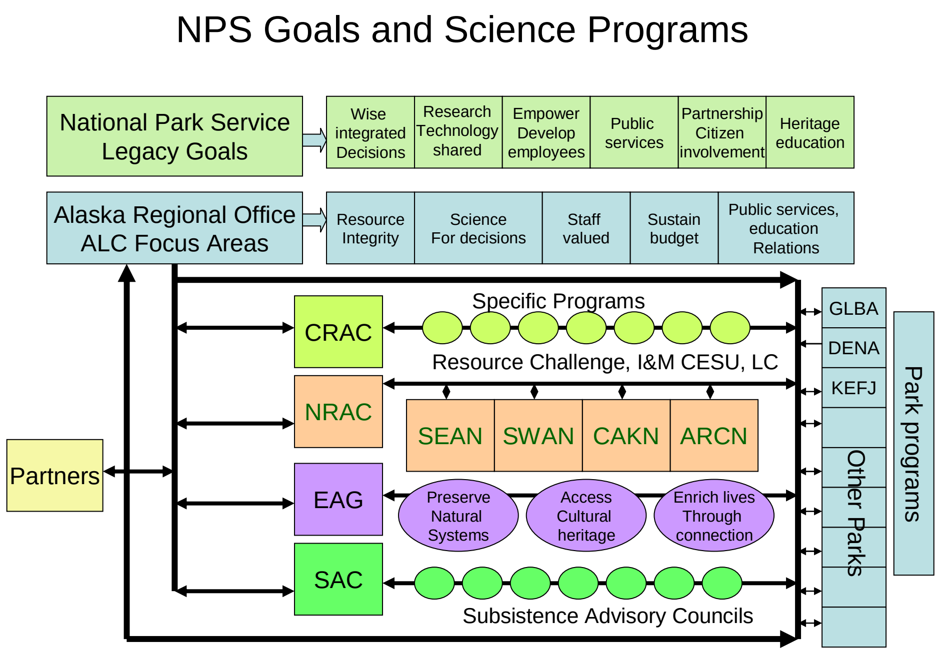


Fig. 6 NPS Alaska Region Programs

Alaska Regional assets are significant and form a solid foundation for implementation of the science strategy. The challenge lies in integrating these assets which currently tend to include self contained and independently funded operations divided by discipline and activity. By using the four step framework of the strategy, information across disciplines and programs can be used effectively to create strategic science.

Aligning scientific work within the science strategy framework however, will allow for direct integration of information and identification of contributions from each program and activities as illustrated in fig. 7, which shows where current activities align with specific steps. For example, most NPS assets contribute to the up-front planning process (step 1), including founding legislation and existing park specific general management plans. In addition, the I&M planning process includes scientist-manager dialogues. Data mining and data archiving completed under the I&M program are key assets to interdisciplinary integrated assessments (step 2), as well as ongoing and completed research and monitoring activities. Of particular note are the I&M ecosystem level conceptual models for network areas. The Beringia Program has a history of integrating cultural and natural resources in a place that is of significant value for moving toward integrated assessments for other regions. While NPS staff may have more limited experience with scenario development (step 3), similar processes are implemented through NEPA although narrower in purpose. The final summary process (step 4) will benefit from the decision history in parks, and regular meetings with communities concerning subsistence and other community based interactions. The I&M monitoring program will be central to generating monitoring strategies for follow-up to enable adaptive management.

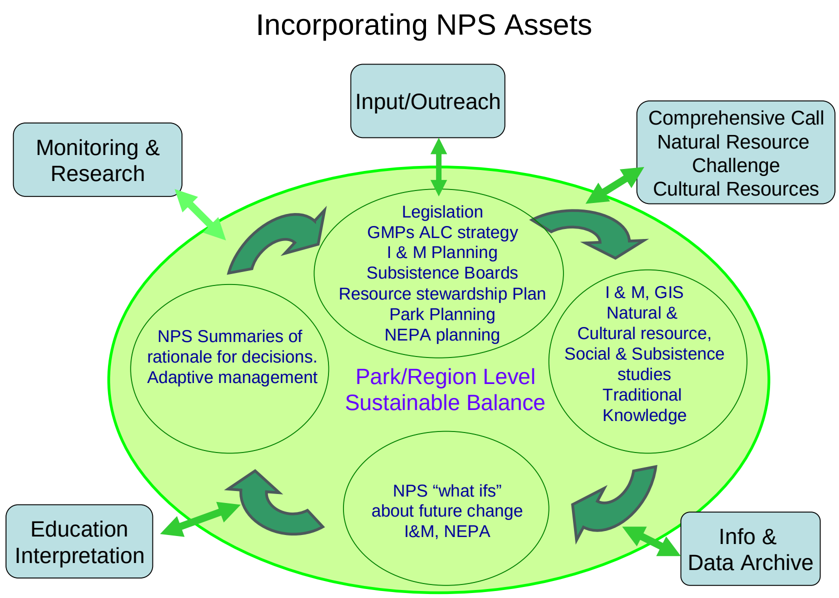


Fig. 7
The National Park Service has a significant array of existing assets for defining and supporting scientific research in Alaska's Parks. These are arranged here relative to the four steps of the science strategy to show how these assets fit within the framework. The framework provides a defined process that fully incorporates and integrates these assets.

Based on these assets and the identification of existing challenges by NPS managers and staff, as well as scientists interested in, or already conducting science in parks, the following action items under the implementation plan are outlined to meet science strategy objectives for the NPS Alaska Region. In some cases suggested actions are already being implemented. They are included as part of the overall plan, and there may be an opportunity to enhance the existing asset. For some suggestions, action may be needed at the national level, while others can be implemented by the Alaska Region or individual parks.

8.1. Encourage More Science in Parks

To encourage more science in parks a number of issues raised that now limit science need to be addressed. These include such diverse variables as logistical support, access and NPS welcome, and effective permitting. The grid presented in fig. 8 offers a systematic way to identify and categorize potential opportunities for encouraging and supporting more science in parks. Examples are included in the grid for illustration. There are many possible options that could be identified.

Note that cost and value in the grid must be considered carefully and are multi-varied. Cost can be related to funding and staff time required, or the potential for adverse impact on park values. In addition, something of high value to scientists may be of minimal value to park management, and something of high value to parks may be of little interest to scientists. Or even with high scientific value, the cost may be prohibitive.

Investment Opportunities

Resource Cost \ Value	High	Medium	Low
High	Airplane, boat use Logistical support	Ready Lodging NPS Staff guidance and support	Not cost effective
Medium	Office Space Telephone access	Quick processing of applications and permits; Research opportunities	Not cost effective
Low	Easy, online permit applications Welcoming spirit Info sharing	Internet information Guidance for Appropriate research	Not cost effective

Fig. 8
Opportunities for Investment
A systematic evaluation of values and costs related to conducting scientific research in parks is needed. This will help generate ideas, mutual understanding, and open opportunities to increase the value, and reduce cost of research. Value and cost are relative and can relate to values of the research, importance to park management, the resources, or visitor experience. Cost can be in terms of the funding required or potential degradation of a resource or visitor experience.

For implementing the science strategy, suggestions are needed most where the benefit is moderate to high but the cost is relatively low, such as:

- NPS Guidance on research needs and priorities
- Processes and SOPs for ensuring non-NPS science teams are connected with NPS staff to help with permit applications, logistics and other challenges.
- Infrastructure is made available and easily accessed to aid scientists in accomplishing their work (i.e., see Pringle, 2004).
- Partnership opportunities are enhanced with outreach and communication.

Even with full commitment to science by park managers, it is important for visiting scientists to be sensitive to NPS costs associated with logistics and accommodations. NPS management must support base operations as a first priority and resources are limited. Scientists need to apply for sufficient research support through granting agencies. The action items recommended to generate more opportunities for logistical support for science are to:

- Conduct facilitated focus group sessions among NPS staff and research scientists to find high value low cost opportunities for better support within budget limitations. Plan sessions at each scientist meeting where NPS partner research is presented (e.g., I&M research workshops).
- Generate a summary of regional and park-specific opportunities to prioritize and implement. Create a "lessons learned" compendium for adjusting NPS response.
- Create an implementation strategy based on results and include time line.

8.1.1. Nurture partnerships

In Alaska, partnerships are central to successful implementation of science programs to fill information gaps. With both funding and information scarce and logistics challenging, NPS must capitalize on existing data and planned investigations by organizations conducting research that may be applicable to NPS resources. In addition to enhancing connections through the CESU's and with the US Geological Survey (USGS), outreach to an array of organizations is essential, and background data mining valuable. For example, research supported by the Exxon Valdez Oil Spill Trustee Council Gulf Ecosystem Monitoring Program (EVOS-GEM) can contribute data on resource conditions in SWAN and SEAN parks, especially KEFJ, KATM, LACL, and GLBA. The Alaska Department of Fish and Game (ADFG) collects important data across the state on wildlife and fish populations, habitat and changes resulting from sport, subsistence and commercial activities. The US Fish and Wildlife Service (USFWS) staff evaluates change in threatened and endangered species in Alaska, many of which find refugia in national park areas. Examples of federal, state, NGO and Native organizations that are or could be collaborators at different levels (see discussion in section 4.6.) are shown in fig. 9.

Partnership Opportunities

Direct Collaboration	Research Planning & Data Exchange	Data/information Sharing
ADFG USFWS USGS NRCS UAF (CESU) TNC USEPA Federal Subsistence Board	EVOS IPY USFWS NRCS USFS BLM USEPA WACAP NANA NSSI	USAF WACAP NGO's EVOS GEM AOOS Tourism Industry Native Corps.
Level 1	Level 2	Level 3

Fig. 9 Partnership Opportunities

NPS has many potential collaborators for research activities and support. By capitalizing on these, the power of research for all agencies and organizations is increased. The level of partnership will vary among organizations. It can also vary at different times and under different circumstances with partner organization (note that the same organization may be listed under different levels).

Weather monitoring conducted by the National Weather Service (NWS) is important for river flow and flood forecasting. Partnership organizations like the North Slope Science Initiative (NSSI) provide opportunities for NPS to influence as well as benefit from data collected by partners, and the North Pacific Research Board (NRPB) offers funding opportunities. Other organizations presenting partnership opportunities include the US Forest Service and Bureau of Land Management, the Alaska Volcano Observatory (AVC), Alaska Ocean Observing System (AOOS), US Air Force, US Environmental Protection Agency (EPA), and the Western Airborne Contaminants Assessment Project (WACAP). Partnerships could also be strengthened with Tribes, the Alaska Native Science Commission (ANSC) and Native Corporations, as well as an array of non-governmental organizations like the Alaska Conservation Foundation (ACF). Additional partnership opportunities are possible with programs and researchers within the University of Alaska (UA). The International Polar Year (IPY) is likely to offer many opportunities. These and other partnerships will enable all agencies to expand their research opportunities and help fill gaps in NPS data.

To nurture partnerships:

- Find common ground for science. Explore mission and goals among NPS and potential partners in facilitated workshops to determine where and how partnerships can be more fruitful.

- Give frame to partnership discussions by eliciting intellectual exchange using conceptual models of cause and effect relationships that are generated for particular parks or the region.
- Share management issues to help target science questions for partner agencies to discover data and information that may already be available, or may be planned (create a focus group or arrange a session for brainstorming at a scheduled science meeting).
- Encourage partners to conduct research in parks (see following sections).

In efforts to nurture partnerships, it is also important to consolidate outreach so that the main vision for park-based science receives priority attention. Too many partners in too many directions that are not cohesive will tend to diffuse available resources and diminish products.

8.1.2. Encourage Scientists to Conduct Research in Parks

A key concern expressed by both NPS staff and scientists was a communication breakdown linked to differences in philosophy about the value and risks of science in national parks, what kinds of research are appropriate in parks, and the level of support that should be provided. While philosophical differences may only be moderately changed within individuals, actions can be taken to increase understanding and flexibility through better communication. To enhance good relations and increase scientist's understanding of park action the following are suggested

- Make scientists feel welcome. Create welcome information packets for each park that include: (1) a note of welcome and encouragement, (2) a mission statement that describes goals, desired ends for park resources, overarching theme for sustainable values with specifics for park, key issues and research needs (ideally from implementing step 1 of the framework), (3) a description of how park managers see research impacting the park (positive and negative), (4) guidance on the types of science appropriate for the park or in different regions within the park, (5) a description of the types of logistical support that is available and what is not available, plus other helpful information. These packets should be advertised and available on the Internet and easily sent by e-mail as attachments to inquiring scientists (see sample welcome packet for GLBA in Appendix L).
- Recommend to interested scientists specific NPS staff contacts for discussing research ideas prior to the writing or submission of proposals. This can help ensure requirements are met through up-front guidance to minimize revision and streamline the permitting process.
- Make it easier for scientists to apply for permits: (1) modify the Internet application site to allow applications to be saved, worked on off-line, and then entered into the system, (2) provide a succinct description of what type of activity is allowed and not allowed in different areas of a park (e.g., transportation, animal marking, plot layout) with the rationale for opportunities and limitations, (3) provide clear guidance on the full process and timelines required (e.g., general permit application process plus unique Superintendent requirements for an individual park), and (4) include specific park staff as point(s) of contact for questions and assistance.

- Offer multi-year permits with the stipulation that permit restrictions and reporting requirements must be met to ensure renewal. Show commitment to long term monitoring sites through special permit availability.
- Designate areas in parks now for long term monitoring opportunities and ensure protection of those sites for monitoring activity (ideally through implementing steps 1, 2, and 3 of the framework for a given park).
- Provide timely announcements of funding opportunities with reasonable deadlines. In addition, provide an annual timeline for all targets of opportunity for research funding so that scientists can plan accordingly. Deliver by Internet, and by E-mail as appropriate, a description of the request for proposal.
- Build a master E-mail list of research organizations and scientists across the nation to broadcast timely announcements (e.g., with three or more months lead time).

8.1.3. Establish consistency regarding park access

Visitors entering and enjoying parks are considered a top priority in the NPS. This has been the primary focus since the first park was established in 1916. There is a perception by scientists that access for research is a second-class activity burdened by restrictions greater than those placed on guides, concessionaires, hunters and tourists. It is recommended that NPS:

- Establish clear access guidance for activity types that include time, duration, limitations, and logistics
- Ensure consistency in access such that scientists are viewed by park personnel as legitimate users of parks.
- Work with scientists to create a modus operand for finding workable solutions to eliminate what could be considered conflicting use. Couple this with guidance on what is and is not allowed in a park, ensuring that if the activity is not allowed for scientists, the same standards are applied to other users of parks. At the same time, scientists can self regulate to avoid requesting activities that are in conflict with guidance for reasonable access.

8.1.4. Provide logistical support for scientists and science

A key issue for parks and scientists to overcome is the logistical challenge of conducting research in park areas. Generally remote, few amenities are available in parks, are very expensive to import, and there are often restrictions on using some amenities even if made available. It is important to think carefully and communicate well the opportunities and limitations for both park managers and visiting scientists. This is perhaps one of the greatest impediments on conducting science in parks. It is strongly recommended that the grid presented in fig. 7 section 7.1. provide a framework for brainstorming in order to:

- Conduct facilitated focus groups among NPS, organizational partners and individual scientists to identify main issues, opportunities and solutions; use scheduled scientist meetings as targets of opportunity to conduct meetings.
- Generate logistical partnerships that maximize available resources
- Increase recognition and use of lower cost logistical alternatives

8.1.5. Define parameters for research appropriate in national parks

There are two dimensions to defining research for parks. One relates to helping scientists design the correct type of research for a park to allow the activity to be permitted. The other is to encourage scientists to initiate research on issues where parks need information to meet management goals. To address these:

- In partnership with scientists, generate NPS guidance on what are appropriate opportunities and necessary limitations on research in parks (e.g., passive observation vice manipulation, working through the NPS Minimum Requirements Decision Guide). Scientists will be willing partners and self regulate if fully informed and part of the process.
- Generate and provide clear succinct NPS goals and objectives for individual parks with particular emphasis on issues where a sustainable balance between use and preservation is most challenging. When done in a group where NPS staff and scientists explore together in facilitated discussion sessions the threats to NPS goals, interesting science questions will emerge that are relevant to NPS needs.

8.1.6. Encourage interdisciplinary research

Interdisciplinary research will likely require not only partnership building but also funding to solicit interdisciplinary work. It is recommended that NPS:

- Conduct outreach to funding agencies like the National Science Foundation and National Park Association to define interdisciplinary funding opportunities that target NPS issues.
- Offer interdisciplinary “request for proposal” opportunities that provide seed funding and logistical support.
- Link these opportunities directly and clearly to the NPS mission and goals for sustainable natural and cultural resources, and park use and enjoyment.

8.1.7. Encourage NPS scientific excellence

NPS staff would benefit from streamlined processes for selecting research topics and prioritizing projects and funding to reduce administrative requirements; this would provide more quality time for science. Current processes, though consolidated, still require extensive staff time and are burdensome, and particularly so given the levels of available funding. In addition, little time and funding are available for NPS staff to participate in scientific meetings and research. It is recommended that NPS:

- Provide professional development opportunities for NPS staff on a bi-annual schedule for study, attending scientific meetings or other opportunities
- Include scientific activity in performance plans
- Using current computer assisted tracking (e.g., PMIS) preview proposals prior to entry to evaluate alignment with NPS priority needs.
- Designate funding specific for interdisciplinary research
- Provide small grants to young researchers and incorporate science into education and outreach to build the next generation of scientists

8.2. Using Science More Effectively: Implementing the Strategy Framework for Goal Setting, Data Integration, Synthesis, and Decision Making

The value of increasing the amount of scientific research conducted in parks will depend to a significant degree on how well resulting data are converted to information of use to park managers. Park managers will use *accessible* data to make informed resource management decisions to meet the needs of the future. While it is important to encourage basic scientific study within parks as discussed previously, it is at the same time critical that a significant portion of scientific research conducted in parks help park managers determine how to balance preservation with human use of park resources. This question presents a significant challenge and goes to the core of understanding ecosystem and cultural processes. In short, we need data and interpretations that answer resource and subsistence managers' questions. Implementation of the science strategy should help encourage and trigger the curiosity of leading research scientists in academia, government agencies, non-profit organizations and others to propose research questions applicable to park issues. At the same time, to ensure that data and information flow through to management decision-making, a deliberate process to integrate scientific results and to connect conclusions to decisions and policy is needed. The following (see fig. 10) provides a defined process for ensuring this connection to achieve the second and third goals of the science strategy: better integration and better use.

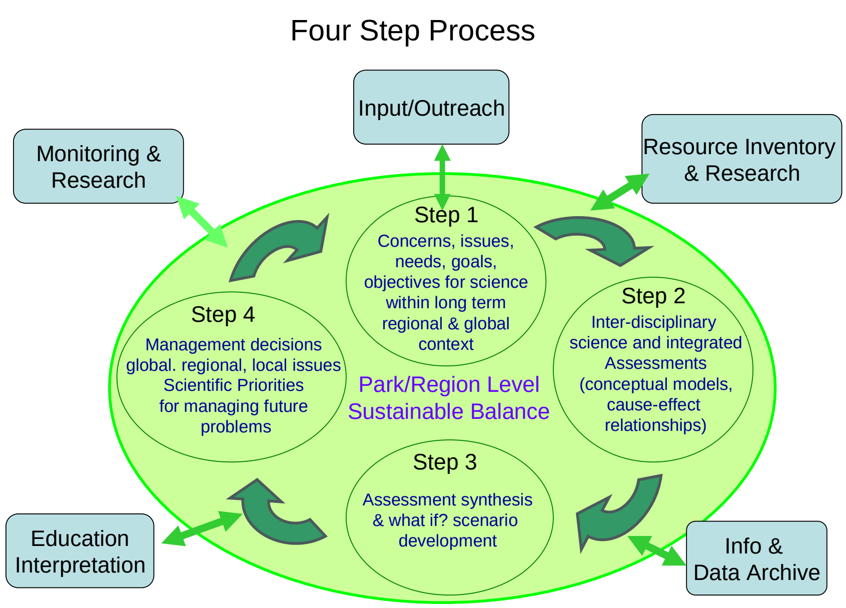


Fig. 10: Four Step Process
The four steps in the framework include Step 1: defining goals and planning; Step 2: conceptual formulation and data integration; Step 3: synthesis and scenario development and Step 4: the decision process including documentation and assessing outcomes. Each step provides information for use in the following step, but the entire process is iterative. Essential NPS needs are provided by each step as noted in blue boxes

As discussed previously, there are four steps in the strategy framework designed to link scientific investigations to management needs and the decision process. Each step is iterative and intended to accomplish a specific set of outcomes that feed into other steps. These include actions to:

1. Set value-based goals and define scientific questions to promote science and set the course for interdisciplinary integrated assessments
2. Integrate interdisciplinary data and information to link key values and stressors, and assess the vulnerability and susceptibility of value-based goals to be sustained
3. Systematically evaluate potential outcomes of an array of management options
4. Document resource management decisions and monitor the impact of their implementation

The process is most effectively implemented in a place (e.g., specific watershed, park, or the Alaska region) which creates boundaries for defining system characteristics to be sustained, and adds power to the integration of interdisciplinary data. The process is linked to existing inventory and research efforts (e.g., NRC, I&M). Ongoing monitoring activities provide an in-place and developing process for evaluating the outcomes of management decisions, creating a feedback loop for adaptive management and the entry point for incorporating and integrating new data as it comes available.

8.2.1. Implementing Step 1: Setting value-based goals and defining science questions based on issues and concerns (planning)

The effectiveness of scientific data for use in resource management is founded on the collection and translation of data into useful information pertinent to the managers' issues of concern. In order for science and scientists to be responsive to these management needs, a planning dialogue among managers, scientists and other interested parties is the beginning of a necessary interface, and coupled with previously documented goals.

Currently most Alaska parks' enacting legislation and GMPs were written before or during 1980, representing a 25+ year span in a period of rapid global change. As such, updating goals, objectives, concerns and issues are current needs for parks in Alaska, and a key component for implementing the science strategy. Actions recommended for science strategy implementation in each park within the Alaska Region include:

- Establish a management team for implementing the science strategy in each park that includes the Superintendent, natural and cultural resource and subsistence managers ("resource managers") required to make decisions about sustaining vulnerable resources, and NPS staff and scientists who will be collecting and processing data and implementing management decisions. Also include NPS interpreters/educators in discussions to obtain their input, and enhance their understanding and later communication of issues and results. Existing teams, with slight adjustments, may be appropriate for this purpose.
- Conduct outreach to outside interests including federal and state partners, local communities and members of the public. Those with direct interests in NPS resources will provide important input during early dialogues.
- In facilitated sessions, revisit existing legislation, General Management Plans and current and anticipated resource and management changes, to update and refine goals, evaluate existing issues, and identify future risks to, and opportunities for parks' resource values. This planning process is critical to, but separate from the scientific conduct of assessments.

Note that outreach for the science strategy is less likely to be adversarial than that linked to NEPA decisions and similar government actions. As such this process can open communication pathways of significant value to the NPS for multiple applications. Early involvement enhances public commitment to, and acceptance of outcomes from the process. The level of involvement of interested parties depends on the purpose for the assessment, regulatory requirements, and the characteristics of the management issue.

To implement step 1, facilitated dialogues are essential. These are best done in a step-wise fashion, first among park leadership and personnel, and then partners, users of park resources, local community members, and outside professionals with interest in science or commercial development. The products of dialogues are to:

- Re-clarify common ground on valued resources (entities and their attributes, e.g., harbor seal recruitment) in the park (e.g., some values may have changed appreciably because of climate change)
- Summarize the suite of concerns recognized by park staff and interested parties.
- Identify alternative perspectives on how to best approach managing these resources in the face of existing problems and anticipated changes.
- Agree on the scope, complexity and focus of potential assessments, including the expected outcome and the technical and financial support available to complete them.

It is important to note that these dialogues can be conducted during part of regularly scheduled meetings and do not require substantial funding, time or travel. As such they add minimal burden to already extended staff, while providing important products. However, focused facilitation is necessary to ensure the results are obtained in a positive sharing environment and captured for direct use. Table 2 provides a list of steps for planning.

Table 2: Planning elements for Step 1

- Identify suite of interested parties, those normally participating and those not. Include in the dialogue, resource managers, interested parties, scientists who would proceed with the integrated assessment, educator/interpreters.
- Develop communication strategy for obtaining the appropriate level of input
- Conduct outreach activity geared to the particular audience.
- Summarize and publish results of input with defined terms and areas of disagreement and alignment.
- Identify range of decisions needed now and likely needed within the next 10 to 20 years based on anticipated human population shifts and use patterns, and environmental factors.
- Begin integrated assessment to document current or identify future benefits and risks to park values to frame adaptive management opportunities.

Since a specific decision is not a driver for these exchanges (e.g., unlike NEPA), open exchange and information gathering is more achievable. Outreach format for planning depends on the level of controversy surrounding issues of park management and the level of decision to be made (e.g., NEPA action linked to Environmental Impact Statements (EIS) requires more extensive outreach than a day-to-day decision). Where fully successful, the planning process will set the stage for most decisions likely to be needed within a 10+ year projection so that results can be referred to on a regular basis and extra time investment is unnecessary. Thus, with effective initial investment, time and effort overall is reduced and the quality and scientific support for decisions is increased.

A sample of dialogue outcome for Wrangell St. Elias National Park and Preserve (WRST), obtained from dialogues held in September 2005 among the WRST management team at Copper Center, and at the Subsistence Management Council meeting held in Tok AK are provided in Appendix M. Results represent a total of four hours of group input.

When immediate or future decisions are needed or being considered, an integrated assessment can be defined. For example, to be proactive about planning for anticipated rural and urban growth around WRST, park managers could use an integrated assessment to assess potential risks and to proactively identify options for handling anticipated community growth and visitor use issues.

8.2.2. Implementing Step 2: Integrated Assessments to identify stress-response relationships and sustainable balance

Once key values and goals are identified or confirmed during Step 1, information is available to support step 2. The purpose for step 2 is to assemble and process available data for exploring the sustainable balance between the preservation and use of identified values in a particular place such as a park. The assessment step is used to systematically evaluate and organize data, information, assumptions and uncertainties in order to help understand and predict the relationships between natural and human forces and their effects on natural, cultural and subsistence resources (cause and effect relationships). The process can be used to evaluate the likelihood of future vulnerability and risk, or positive change (prospective), or evaluate the likelihood that observed changes are caused by past actions or stressors (retrospective). In most place-based assessments both are likely to be relevant. The assessment is founded on the identification of the sensitivities, or inherent properties that predispose an organism, ecological system, cultural site or artifacts to effects from exposure to human based and natural stressors (vulnerability), and the analysis of data and characterization of risk or benefit from exposure to these stressors in a place (e.g., park watershed) using three major elements: characterization of vulnerabilities, characterization of exposure and characterization of effects.

There are three main phases of integrated assessments: (1) conceptual formulation, (2) analysis, and (3) characterization of sustainability (see fig. 11). During conceptual formulation management goals are translated into specific operationally defined endpoints for scientific study and conceptual models are constructed that includes both a written description and visual representation of predicted relationships among ecological, cultural and park user entities and the stressors to which they may be exposed. This is a powerful process that promotes data integration across data types and sources of information (e.g., data collected using the scientific method, traditional ways of knowing, anecdotal accounts). Also included is the assessment plan for data analysis.

Conceptual formulation involves the generation of conceptual models that are structured around the management goals and related endpoints selected for scientific evaluation. The process of translating management goals into scientific endpoints is critical. Using values and related goals selected during step 1, scientists then ask what must be true in a place for those goals to be met. For example if there are to be natural reproducing populations of salmon in a place, conditions must exist that include unpolluted freshwater streams with gravel bottoms, riparian cover, sufficient escapement of spawning salmon,

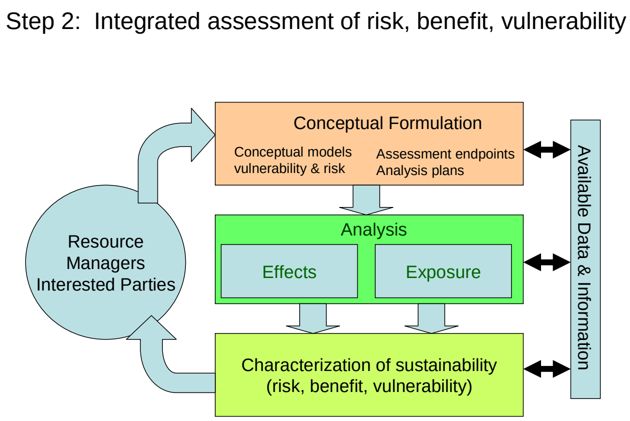


Fig. 11 The integrated assessment of risk, benefit and vulnerability

The three phases of the assessment include conceptual formulation, analysis and characterization of benefit, risk and vulnerability. This is an iterative process. Each stage can influence the others, and all can benefit from available and new data as it comes available.
The process is directly influenced by the needs of managers and interested parties (as shown on the left) and generates information appropriate for direct communication to them.

water flow, forage for fry and so forth. These requirements are based on the natural history of salmon and must be reflected in related conceptual models. A key product of Step 2 are endpoints that can be measured directly or indirectly (these are likely to overlap some with the I&M vital signs) and create the direct linkage between management goals and the assessment of vulnerability, risk and benefit. Final products during this phase include conceptual models, specific measurable variables or endpoints linked to management goals, and a plan for analyzing data (see USEPA 1998 for more detailed guidance for this and other phases of the assessment; see also vulnerability www.epa.gov/reva/).

During analysis, the second phase of the assessment, data on changes occurring that influence park values are processed to evaluate links between adverse or positive stressors and their effects on key values to generate stress-response relationships (see fig. 12).

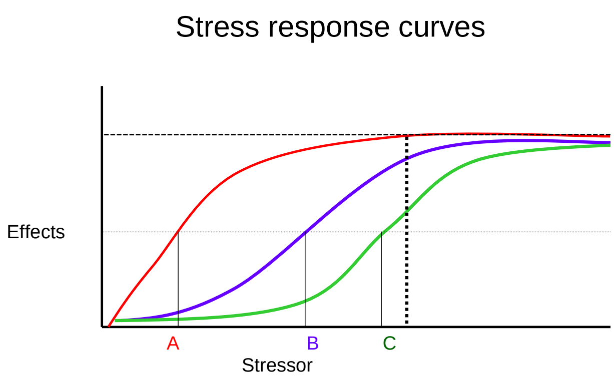


Fig. 12 Stress response curves
A goal for decision makers is to know how best to balance competing interests and needs between preservation of resources and actions that may result in impairment. Science based stress response curves can provide valuable feedback for understanding this relationship. For example, species **A** may respond more strongly to a stressor than **B** or **C**. The mid horizontal line may indicate first evidence of an effect, the top horizontal line may represent elimination of a species. In this example, species **A** may drive the decision process because of its greater susceptibility (sensitivity and likelihood of exposure). For each curve there are error bounds that also provide guidance to decision makers.

The last phase, characterization of sustainability, provides interpretation of data analysis for communicating to resource managers, local communities, scientists and other interested parties with a focus on how to successfully balance preservation and use of resources.

These three phases are inherently iterative with feedback loops among any of the phases. If new data are identified or questions arise during analysis for example, the conceptual formulation can be revisited and adjusted accordingly. If essential data are identified as missing during the course of the assessment, the team may stop until those data are collected before resuming. Feedback from each phase of the assessment can and should be used to improve interpretation. This process is patterned closely with the USEPA process for ecosystem level risk assessment (USEPA 1998, Marcy 1996) but with changes more aligned with the National Park Service dual mission. The assessment is not *a priori* concerned about adverse consequences.

Implementation of Step 2 can emerge from existing activities ongoing within parks and under the I&M program. Suggested actions for implementation include the following.

- Generate demonstration projects to solve real-world issues in parks and train a cadre of NPS experts in the process. Obtain assistance from a leader/facilitator with expertise in benefit and risk assessment to guide the development of demonstration projects. Establish a support team to be trained by soliciting interested support staff from both natural and cultural disciplines in AKRO and Parks to participate in the demonstration projects (see fig. 13).

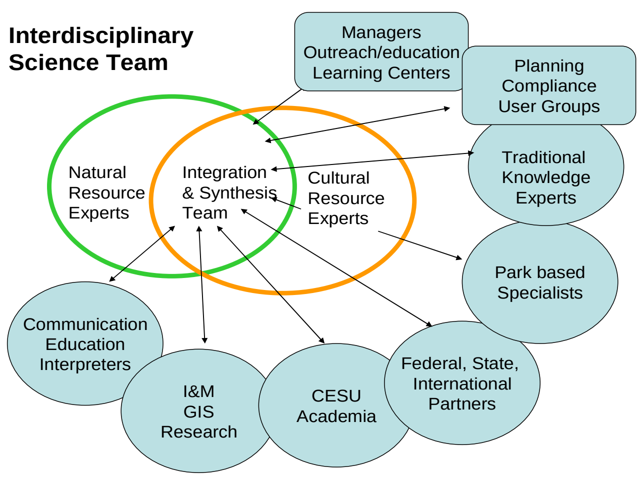


Fig. 13: Interdisciplinary Science Teams
NPS integration and synthesis teams would form and disband for assessments as needed. A cadre of trained leaders within NPS could assemble teams by recruiting experts from within and outside NPS to contribute essential knowledge and capabilities. The teams can remain flexible and be tailored to changing needs.

- Select parks or sub-regions to feature for demonstration projects that are different in character, values and key issues to address. Three areas are suggested for NPS development to illustrate the process: WRST (subsistence, climate change, community growth), GLBA (visitor type and access route, increased demand for use, climate change), Beringia Serpentine Hot Springs (cultural spiritual values, subsistence, visitor access, environmental values).

- Three potential approaches to completing demonstration projects are proposed: (1) create the above integration and synthesis team within NPS Alaska Region Headquarters and draw on experts from all available sources to complete an assessment; (2) expand current I&M teams to include cultural expertise and mainstream this approach within existing structure; (3) offer a grant opportunity and advertise a request for proposal that specifically requires the investigator(s) to use the science strategy framework to create final synthesis of research.
- Each proposed approach can offer an alternative way for achieving success and will provide added experience and learning. At the same time each approach has limitations such that implementing more than one approach is of value.
    - Creating a support integration team has great potential for building a cadre of expertise at the Alaska Region Headquarters, which can assist individual park staff to complete assessments within each park. Ultimately this would provide the greatest support for science strategy implementation over the long term.
    - Expanding I&M activities in each region and park by including natural and cultural staff within an interdisciplinary assessment team will allow the integration of ecological and cultural disciplines. For example staff in the Southwest Area Network (SWAN) have completed an evaluation of available ecological data within parks in the region and generated Venn diagram conceptual models of the ecosystems for the region. Using these evaluations as a starting point, the next steps would be for NPS cultural staff as well as invited partner experts to add necessary cultural and stressor expertise to evaluate the models within the context of stressors and expanded set of values.
    - Offering grant opportunities will expand partnerships and create the opportunity for synergy and independent exploration which can offer substantial insights to NPS. The degree to which NPS personnel are involved will determine the level of learning that takes place. It would be important to end a project with a lessons learned brainstorming opportunity.
- Based on demonstration project evaluations, NPS can generate system wide conceptual models that feature relationship pathways and interactions among variables (e.g., see sample generic model in fig. 14). Using these models, NPS can explore individual pathways more completely (e.g., fig. 15) using relevant data collected within Alaska parks, collected in other areas of Alaska and from areas outside Alaska, including relevant laboratory research.
- Structure processing and exploration of the conceptual model and analysis by asking questions about vulnerable areas, susceptible species and cultural sites, vulnerable communities and human values, and areas of exposure to potential stressors (e.g., development, population increase, introduction of exotic species, increasing visitor use). In particular focus on comparisons where human use and enjoyment is likely to conflict with preservation of natural and cultural values.

Fig. 14 Generic conceptual model

At the top of the model general activities and sub activities are shown that impact parks. The center boxes are potential stressors from those activities. At the bottom are park values at potential risk. Note that multiple activities can be shown to create a common stressor, and that multiple stressors can be shown to impact one value.

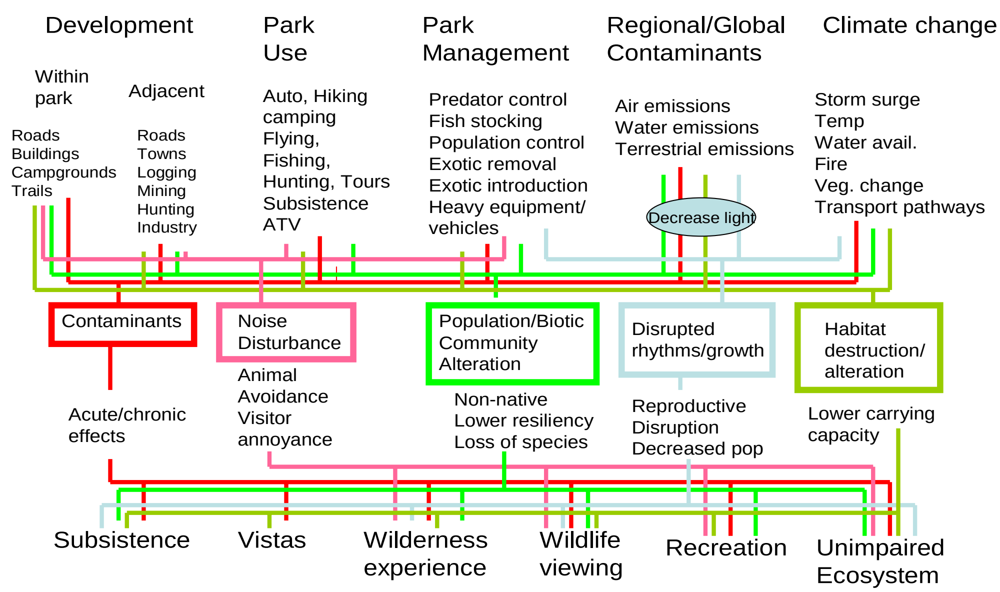
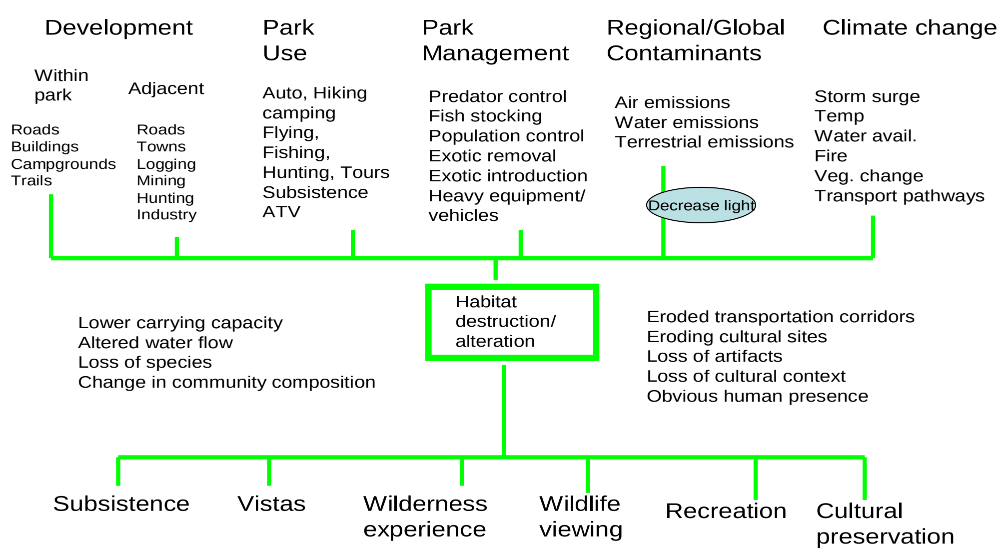


Fig. 15 Single pathway model

By focusing on one stressor at a time (as shown) or on one specific value (e.g., vistas; an alternative approach), all available information can be gathered and used to create a detailed model of one pathway. As individual models are completed, they can then be integrated with, and related to, the larger ecosystem model constructed for a defined area, location, or issue. An individual conceptual model should be expanded for the habitat pathway based on the types of issues listed.



- Document results of these evaluations and obtain expert assistance in generating stress-response curves and vulnerability assessments using gathered information to generate the final characterization of results with discussions of uncertainty and relationship to management concerns.
- Through facilitated discussions, close out the demonstration projects with a summary document presented to the management team for each project, and a brainstorm discussion among the teams to generate a lessons learned summary for documenting the process and developing NPS guidance. Share guidance across NPS.

Within a given park, which was established through social and political processes as well as recognition of natural and cultural features, there will be a number of different ecosystem types, ecoregions, and other ecological, geological, and cultural characteristics that must be considered in the development of conceptual models. For example there may be distinct watersheds within a park with significant differences that require individualized conceptual models. It is important and appropriate to consider these areas independently for part of the analysis. At the same time it is important and appropriate to combine results of assessments for these areas into a park wide interpretation for cross cutting issues and goal achievement.

8.2.3. Step 3: Scenario Development and Synthesis

For most place-based assessments, multiple values and many stressors are operating within a complex ecological and socio-cultural system. Complex assessments will be required to address the diversity of forces and array of values of concern, and more than one management option will likely be under consideration to satisfy competing interests and to find the best course for achieving resource sustainability. In this case a formal evaluation of possible management options and scenarios of potential outcomes is a useful exercise.

Scenario development, as used here, is the synthesis of integrated assessments within the context of a formal evaluation of management options and their potential outcomes using conceptual and simulation models. The foundation for scenario development proposed here is derived from the field of system dynamics (Forrester, 1969; see Appendix K). One of the most widely known environmental applications of systems dynamics relates to global environmental responses to human influences (Meadows et al 1972, 1992, 2004).

System dynamics is based on identifying dynamic patterns, such as growth, decay and oscillations, that are the fundamental dynamic patterns of systems (e.g., dynamic models help in understanding why some systems oscillate over time such as those typical of predator and prey populations). The value of approaching alternative management options with the same rigor used in system dynamics or other equally tested, structured and rigorous process would be of great value. Scenarios capture results and provide frameworks that filter and organize knowledge. While these models are not predictive, they are instruments to support strategic thinking, group discussion and learning. Guidance for their development is readily available (e.g., see Ford, 1998).

During this last phase, scenarios of potential outcomes using a range of management options (e.g., no management intervention, moderate intervention and strong intervention of varying types) could be used to evaluate multiple impacts, cumulative effects, and resource vulnerabilities. Using the results of this evaluation, a synthesis summary is generated and communicated to the management team for consideration (see fig 8, Communicate results). At this juncture, the scientific information would be available in a form accessible to multiple audiences, provide the foundation for informed and defendable decision-making, and be particularly useful for education and interpretation. Depending on the decisions and projected changes, Step 3 may or may not be needed for moving foreword to decision making.

Suggestions for implementation include the following.

- Based on the Glacier Bay Environmental Impact Statement completed in 2003, use the six options and existing data to assign plus (+) and minus (-) input values for number of boats, noise, disturbance, enjoyment of visitors in boats or backcountry, reaction of key species and so forth and run simple models to evaluate trajectories over 20 to 50 years (see fig. 16). Explore multiple types of scenerios within the six options to better understand the influences of each + and – value. On completion, present results to the management team for a facilitated discussion on the value of the analysis, lessons learned, and opportunities for tailoring process for NPS to improve outcome.
- Conduct preliminary assessments for WRST to directly address scenarios of community population increase, rural and subsistence use, and climate change variables for a 20 to 50 year trajectory. Complete as for GLBA.
- Generate NPS guidance from lessons learned.

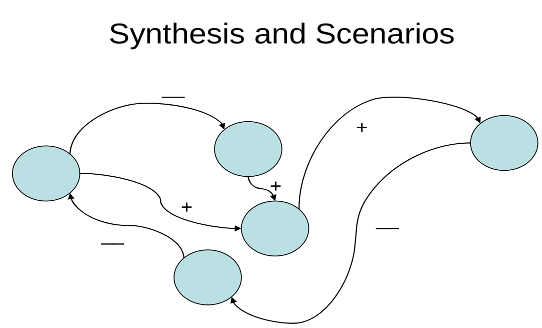


Fig. 16: Synthesis and Scenarios using system dynamics
By assigning different plus and minus values to variables for different management scenarios and running simple models over relevant time frames (e.g., 20-50 years), scientists and managers can explore the potential outcomes of different decisions.

8.2.4. Step 4: Management Decision Making

The fourth step is a re-evaluation of current management strategies and the formulation of new resource management directions, adjustments or specific management decisions (decisions), as influenced by results of the first three steps. Presentation of assessment results by the assessment team to the management team would include management options evaluated within the context of vulnerability and risk. Assessment results may lead to a refinement of decision options. However, the final decision would be based on scientific understanding in conjunction with the suite of policy issues and other decision factors influencing the decision process (see fig. 17).

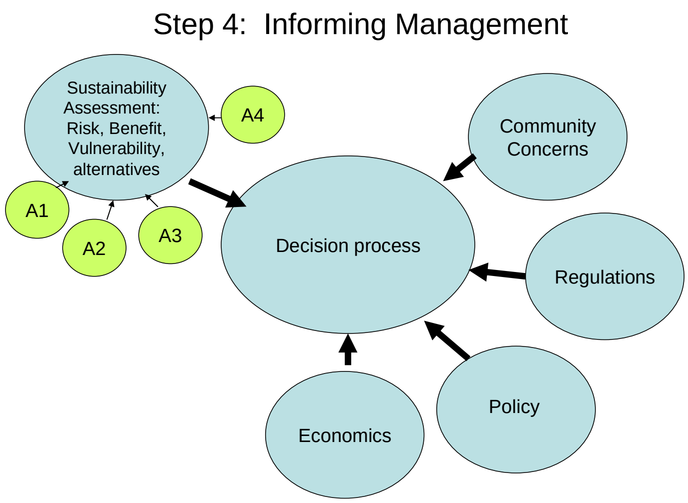


Fig. 17 Informing the Decision Process
Managers must integrate and respond to multiple sources of input for making informed and reasoned resource management decisions. Science is only one of many sources of input. However, by using scientifically defendable integrated assessments with uncertainty analysis, and generating scenarios for alternative management outcomes (e.g., A1, A2, A3, A4), the power of the scientific input increases and can better influence the final decision.

The final decision summary is completed to document scientific evidence and the array of other considerations used to make the decision, along with a projection of the intended outcome of implementation of the management action. Using this outcome-based approach, a monitoring plan could easily be designed to measure the success of the decision in achieving the desired end, originally articulated during planning, and refined during the decision process.

Once a management decision is made and implementation begins, the assessment closes. However the results of the assessment guide monitoring and research priorities, particularly targeting significant uncertainties identified in the assessment. As new data come available that could alter conclusions reached in the sustainability assessment, or a new management issue emerges that requires evaluation, the planning process would be re-initiated. Such evaluation can lead to adjustments and new directions for management within an adaptive management framework. Because of the previous assessment, following assessments are likely to be significantly less labor intensive because of available documentation.

For implementation of step 4 it is recommended that the case studies completed for steps 2 and 3 be summarized for supporting decisions and the results be presented to the relevant management team for critique and improvement during facilitated sessions. Based on input, lessons learned and a standardized format for reported be generated for NPS guidance.

8.3. Priorities for Implementation

Given the challenges presented by the science strategy it is valuable to consider how best to approach implementation. The following bullets highlight the array of highest priority actions that will move implementation forward.

- Conduct manager-scientist focal discussions in each park (beginning with those identified as having the greatest opportunity to be completed within two years) to refine and agree on goals, needs and issues (i.e., demonstrate and document open communication pathways to link management needs with science);
- Complete a demonstration project in a selected park for implementing the science strategy (i.e., learn the value of the process while learning to do it);
- Define and develop welcome packet and guidance for enhancing science in parks
- Fund a "request for proposal" that requires integration of two or more disciplines that has an applied management element (i.e., create the opportunity for cross discipline exchange, integration, and management use) that uses the science strategy framework process.

Implementation of the science strategy will depend on senior management commitment that may require some restructuring of budgets to support integrating science across disciplines. With an implementation priority in place, the opportunity to conduct a demonstration project will help develop staff knowledge and experience in integrated assessment and synthesis and form the basis for generating written guidance specific to application in NPS. The goal is to create highly useable guidance and a cadre of staff with direct experience in integrated assessment and synthesis within the NPS Alaska Region to implement the strategy. Implementation will help NPS achieve multiple benefits that include:

- Clear and transparent links between management needs, scientific research, and interpretations;
- Streamlined information processing for reporting, research priority setting, and competing for funds that reduces staff administration burdens;
- Enhanced archiving of data coupled with rationales for management direction and decisions for parks; enhanced retention of institutional knowledge despite change in personnel.
- Effective transfer of scientific information in a format useful to scientists, senior managers, educators, interpreters, and the public;
- Science-based resource management that is defensible, clear and transparent.

8.4. Timeline for Implementation

At this juncture is it not possible to generate a detailed timeline for implementation of the science strategy. Priority setting should be done in a facilitated group setting among members of Alaska regional and park leadership and advisory councils. The following are suggestions for high priority opportunities to begin implementation within a time context that should be achievable given time and funding restraints.

2006-2007: Generate packets for scientists for Alaska parks and put online this year, supplement by generating individualized guidance for each park the following year.

2006-2008: Conduct facilitated discussions to update each park's general management plan goals to support step 1 of the framework. Process these into linked assessment endpoints to guide development of step 2. Fund and advertise an RFP for conducting park or issue-based scientific assessment that uses the strategy framework.

2007-2010: Form one, preferably two or three interdisciplinary teams to process and expand existing I&M ecosystem models in separate regions where different systems and issues must be addressed. Conduct step 2. Document results and capture lessons learned for future guidance for scientists and establish RFP for integrated research.

2010-2015 Use experienced teams to apply the framework process to all parks in Alaska. Once established, the goals could be revisited and updated once every five years, and the integrated assessments reevaluated every 10 years to incorporate new data and integrate with I&M research results (this would become part of regular updates on data-partnerships among NRAC, CRAC, EAG, SAC and the I&M team).

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Web Links for NPS Programs:

Beringia International Heritage Program: http://165.83.62.205/Rd/Beringia/beringia2.htm

Cooperative Ecosystem Studies Units

National Program: http://www.cesu.org/cesu/introduction/introduction.html

North and West Alaska: http://www.uaf.edu/snras/cesu/

Pacific Northwest: http://www.cfr.washington.edu/research.cesu/

Inventory and Monitoring Program

National Program: http://www1.nature.nps.gov/protectiongrestoring/im/inventoryandmonitoring.cfm

Alaska Networks: http://www.nature.nps.gov/im/units/AKRO/index.htm

National databases; http://science.nature.nps.gov/im/apps.htm

Research Learning Centers

National Program: http://www.nature.nps.gov/learningcenters/index.html

Ocean Alaska Science & Learning Center: http://www.oceanalaska.org/

Murie Science & Learning Center: http://www.alaskanha.org/murie-science-learning-center.htm).

Appendix A
History, Authorities, and Legal Framework

The NPS has engaged in a number of internal attempts to professionalize its resource staffs and encourage a scientific attitude in the management of the National Parks. Starting with George Wright in the 1930's, at least a dozen blue-ribbon panels, including the Leopold Committee, have recommended a scientific based approach to NPS resource management, and urged the Congress to confer a legal mandate for science on the NPS. In 1992 the National Research Council issued *Science and the National Parks*, urging an adequate science and technology program. This was followed up in 1995 by a task force that wrote *Science and the National Parks II*, again urging a legal mandate. In 1998, Congress passed a Research Mandate for the U.S. National Park System (Congress 1998). It is contained in Title II of the National Parks Omnibus Management Act of 1998, also known as the "Thomas Bill" after Senator Craig Thomas of Wyoming, its sponsor. This mandate gives superintendents and managers the legal authority to both conduct various scientific programs in parks "Science for Parks", and to authorize the use of parks for scientific study, "Parks for Science".

Section 205 addresses use and approval of NPS lands for research by others, "Parks for Science". Ultimate responsibility for implementation of this section is assigned to Regional Directors. The NPS revamped its research and collecting permitting system so that there is a uniform permit and consistent set of requirements for research in all parks. The Research Permitting and Reporting System is available on the Web at: http://science.nature.nps.gov/permits/index.html

Public Law 105-391: National Parks Omnibus Management Act of 1998.

Title II – NATIONAL PARK SYSTEM RESOURCE INVENTORY AND MANAGEMENT

Sec. 201. PURPOSES. The purposes of this title are (1) to more effectively achieve the mission of the National Park Service; (2) to enhance management and protection of national park resources by providing clear authority and direction for the conduct of scientific study in the National Park System and to use the information gathered for management purposes; (3) to ensure appropriate documentation of resource conditions in the National Park System; (4) to encourage others to use the National Park System for study to the benefit of park management as well as broader scientific value, where such study is consistent with the Act of August 25, 1916 (commonly known as the National Park Service Organic Act, 16 U.S.C. 1 et seq.); and (5) to encourage the publication and dissemination of information derived from studies in the National Park System.

Sec. 202. RESEARCH MANDATE. The Secretary [of the Interior] is authorized and directed to assure that management of units of the National Park System is enhanced by the availability and utilization of a broad program of the highest quality science and information.

Sec. 203. COOPERATIVE AGREEMENTS. (a) COOPERATIVE STUDY UNITS -The Secretary is authorized and directed to enter into cooperative agreements with colleges and universities, including but not limited to land grant schools, in partnership with other Federal and State agencies, to establish cooperative study units to conduct multi- disciplinary research and develop integrated information products on the resources of the National Park System, or the larger region of which parks are a part. (b) REPORT . --Within one year of the date of enactment of this title, the Secretary shall report to the Committee on Energy and Natural Resources of the United States Senate and the Committee on Resources of the House of Representatives on progress in the establishment of a comprehensive network of such college and university based cooperative study units as will provide full geo- graphic and topical coverage for research on the resources contained in units of the National Park System and their larger regions.

Sec. 204. INVENTORY AND MONITORING PROGRAM. The Secretary shall undertake a program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources. The monitoring program shall be developed in cooperation with other Federal monitoring and information collection efforts to ensure a cost-effective approach.

Sec. 205. AVAILABILITY FOR SCIENTIFIC STUDY. (a) IN GENERAL .-The Secretary may solicit, receive, and consider requests from Federal or non-Federal public or private agencies, organizations, individuals, or other entities for the use of any unit of the National Park System for purposes of scientific study. (b) CRITERIA .-A request for use of a unit of the National Park System under subsection (a) may only be approved if the Secretary determines that the proposed study- (1) is consistent with applicable laws and National Park Service management policies; and (2) will be conducted in a manner as to pose no threat to park resources or public enjoyment derived from those resources. (c) FEE WAIVER .-The Secretary may waive any park admission or recreational use fee in order to facilitate the conduct of scientific study under this section.(d) NEGOTIATIONS .-The Secretary may enter into negotiations with the research community and private industry for equitable, efficient benefits-sharing arrangements.

Sec. 206. INTEGRATION OF STUDY RESULTS INTO MANAGEMENT DECISIONS. The Secretary shall take such measures as are necessary to assure the full and proper utilization of the results of scientific study for park management decisions. In each case in which an action undertaken by the National Park Service may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which unit resource studies have been considered. The trend in the condition of resources of the National Park System shall be a significant factor in the annual performance evaluation of each superintendent of a unit of the National Park System.

> **Sec. 207. CONFIDENTIALITY OF INFORMATION.** Information concerning the nature and specific location of a **N**ational Park System resource which is endangered, threatened, rare, or commercially valuable, of mineral or paleontological objects within units of the National Park System, or of objects of cultural patrimony within units of the National Park System, may be withheld from the public in response to a request under section 552 of title 5, United States Code, unless the Secretary determines that- (1) disclosure of the information would further the purposes of the unit of the National Park System in which the resource or object is located and would not create an unreasonable risk of harm, theft, or destruction of the resource or object, including individual organic or inorganic specimens; and (2) disclosure is consistent with other applicable laws protecting the resource or object.

MANAGEMENT POLICIES 2001: Management Policies 2001 (NPS 2001a, currently in revision) provides specific guidance regarding appropriate activities in National Park Service areas. Relevant excerpts from Management Policies 2001 (NPS 2001a), Director's Order #24 (NPS 2000a), and the NPS Museum Handbook (NPS 2000b) are reproduced below for convenience. Readers are directed to the original documents for the complete text.

> **1.7.1 INFORMATION SHARING.** The Service is committed to the widest possible sharing and availability of knowledge, and to fostering discussion about the national park system, America's natural and cultural heritage found in national parks, and the national experiences and values they represent. Most information shared with the public is presumed to be in the "public domain," and therefore available to anyone who is interested. The only exception to information sharing is where disclosure could jeopardize specific park resources or donor agreements, or violate legal or confidentiality requirements.

> **2.1.2 SCIENTIFIC, TECHNICAL, AND SCHOLARLY ANALYSIS.**
> Decisions regarding the treatment and use of park resources will utilize scientific, technical, and scholarly analysis. Analysis will be interdisciplinary and tiered, focusing first on the park as a whole (including its global, national, and regional contexts) and then on site-specific details.

> **4.1.2 NATURAL RESOURCE INFORMATION.** Pursuant to provisions of the National Parks Omnibus Management Act, the Service will withhold information about the nature and specific location of sensitive park natural resources – specifically mineral, paleontological, endangered, threatened, rare, or commercially valuable resources-unless the Service determines, in writing, that disclosure of the information would further the purposes of the park, would not create an unreasonable risk of harm, theft, or destruction of resources, and would be consistent with other applicable laws.

> **4.2 STUDIES AND COLLECTIONS.** The Service will promote cooperative relationships with educational and scientific institutions and qualified individuals offering expertise that can assist the Service in obtaining information, and when the opportunity for research and study in the parks offers the cooperators a significant

benefit to their programs. NPS facilities and assistance may be made available to qualified cooperators who are conducting NPS-authorized studies.

Studies in parks will be preceded by (1) an approved scope of work, proposal, or other detailed written description of the work to be performed; and (2) a written statement of environmental and cultural resource compliance appropriate to the proposed methodology and study site.

4.2.1 NPS-CONDUCTED OR –SPONSORED INVENTORY, MONITORING, AND RESEARCH STUDIES. With or without an NPS permit, Service staff will comply appropriately with professional standards and with general and park-specific research and collecting permit conditions. All research and data and specimen collection conducted by NPS employees will be appropriately documented and carried out in accordance with all laws, regulations, policies, and professional standards pertaining to survey, inventory, monitoring, and research. Service staff will be expected to make their findings available to the public, such as by publication in professional journals or presentation in interpretive programs.

4.2.2 INDEPENDENT STUDIES. Non-NPS studies conducted in parks are not required to address specifically identified NPS management issues or information needs. However, these studies, including data and specimen collection, require an NPS scientific research and collecting permit. The studies must conform to National Park Service policies and guidelines regarding the collection and publication of data, the conduct of studies, wilderness restrictions, and park-specific requirements identified in the terms and conditions of the permit.

Park Service scientific research and collecting permits may include requirements that permittees provide for parks, within agree-upon time frames, copies of appropriate field notes, cataloging and other data, information about the data, progress reports, interim and final reports, and publications derived from the permitted activities.

4.2.3 NATURAL RESOURCE COLLECTIONS. Specimens that are not authorized for consumptive analysis will be labeled and cataloged into an appropriate cataloging system in accordance with applicable regulations (36 CFR 2.5).

5.1.1 NATIONAL PARK SERVICE RESEARCH. A written scope of work, research design, project agreement, proposal, or other description of work to be performed will be prepared and approved before any research is conducted.

Research conducted by NPS personnel, contractors, and cooperative researchers will be subjected to peer review both inside and outside the Service, to ensure that it meets professional standards, reflects current scholarship, and adheres to the principles of conduct for the appropriate discipline.

Certain research data may be withheld from public disclosure to protect sensitive or confidential information about archaeological, historic, or other NPS resources when doing so would be consistent with FOIA.

5.1.2 INDEPENDENT RESEARCH. The National Park Service will promote relationships with individuals and organizations qualified to perform research, and encourage them to direct their research toward park management objectives and the broader contexts within which park resources exist.

Research that includes taking plants, fish, wildlife, rocks, or minerals must comply with permit requirements of 36 CFR 2.5. Independent researchers will be authorized to conduct archaeological research on park lands only through the issuance of an ARPA or Antiquities Act permit by the appropriate regional director. This permitting authority cannot be further delegated. NPS facilities, collections, and assistance will be made available to qualified scholars conducting NPS- authorized research, as long as park operations are not substantially impeded or park resources adversely impacted thereby.

6.3.6 SCIENTIFIC ACTIVITIES IN WILDERNESS. The statutory purposes of wilderness include scientific activities, and these activities are encouraged and permitted when consistent with the Service's responsibilities to preserve and manage wilderness.

6.3.6.1 GENERAL POLICY. Scientific activities are to be encouraged in wilderness. Even those scientific activities (including inventory, monitoring, and research) that involve a potential impact to wilderness resources or values (including access, ground disturbance, use of equipment, and animal welfare) should be allowed when the benefits of what can be learned outweigh the impacts on wilderness resources or values. However, all such activities must also be evaluated using the minimum requirement concept and include documented compliance that assesses impacts against benefits to wilderness.

7.5.3 RESOURCE ISSUE INTERPRETATION AND EDUCATION. Resource issue interpretation should be integrated into both on- and off-site programs, as well as into printed and electronic media whenever appropriate.

7.5.4 RESEARCH. Interpretive and educational programs will be based on current scholarship and research about the history, science, and condition of park resources, and on research about the needs, expectation, and behavior of visitors.

8.10. NATURAL AND CULTURAL STUDIES RESEARCH AND COLLECTION ACTIVITIES. Studies, research, and collection activities by non-NPS personnel involving natural and cultural resources will be encouraged and facilitated when they otherwise comport with NPS polices. Scientific activities that involve field work or specimen collection, or have the potential to disturb resources, the visitor experience, or park operations, require a permit issued by the superintendent that prescribes appropriate conditions for protecting park resources, visitors, and operations.

8.11.1 GENERAL. The National Park Service will facilitate social science studies that support the NPS mission by providing an understanding of park visitors, the non-visiting public, gateway communities and regions, and human interactions with park resources.

Investigators will be encouraged to use the parks for scientific studies whenever such use is consistent with Service policies that recognize the scientific value of parks as laboratories.

8.11.2 NPS-SUPPORTED STUDIES. Superintendents may authorize park staff to carry out routine duties without requiring a research/collecting permit. NPS-supported research will rely on high-quality methods, and undergo peer review. NPS-supported scientists will be expected to publish their findings in refereed journals, among other outlets.

8.11.3 INDEPENDENT AND COMMERCIAL STUDIES. Non-NPS social science studies conducted in parks are not required to address specifically identified NPS management issues or information needs.

NPS MUSEUM HANDBOOK, PART II.

SECTION V. B. 2. WHEN IS CONSUMPTIVE USE ACCEPTABLE?
Destructive or scientific analysis is a legitimate use of museum collections for approved research purposes. The research purpose must be based on a professional research design that clearly documents the need for the analysis. Note: New and developing non-invasive technologies for analysis are preferable to analysis that destroys or alters all or part of any object or specimen.

DIRECTOR'S ORDER #24. NPS MUSEUM COLLECTIONS MANAGEMENT.

Park superintendents, center managers, and other who manage collections (with the assistance of museum management staff) have the following responsibilities:

4.3.25 PRESERVATION VS. DESTRUCTIVE USE: Manage objects to preserve their condition, including using reproduction when originals may be damaged by use. Authorize in writing destructive analysis of collections, except for rare or highly significant objects, specimens, and archival materials. Obtain regional director approval for destructive analysis of rare or highly significant objects, specimens, and archival materials and for any consumptive use of collections.

References:

Congress. 1998. Public Law 105-391. National Parks Omnibus Management Act of 1998. http://lcweb2.loc.gov/law/usa/us050391.pdf

National Park Service (NPS). 2000a. National Park Service Director's order #24: NPS Museum Collections Management. http://www.nps.gov/policy/DOrders/DOrder24.html

National Park Service (NPS). 2000b. National Park Service Museum Handbook. http://www.cr.nps.gov/museum/publications/index.htm

National Park Service (NPS). 2001a. Management Policies 2001. 137 pp. http://www.nps.gov/policy/mp/policies.pdf

National Park Service (NPS). 2001b. Handbook for Environmental Impact Analysis. 125 pp. http://www.nps.gov/policy/DOrders/RM12.pdf

United States Department of the Interior (USDI). 2002. Title 36-Parks, forest, and public property. Chapter I-National Park Service, Department of the Interior Part 2 -Resource protection, public use and recreation-Table of Contents Sec. 2.5 Research specimens. http://www.access.gpo.gov/nara/cfr/waisidx_02/36cfr2_02.html

Appendix B
Interviewees for the Science Strategy

Alaska Regional Leadership (5)

Marcia Blaszak	Regional Director
Vic Knox	Dep. Reg. Dir.
Ralph Tingey	Assoc. Reg. Dir.
Judy Gottlieb	Assoc. Reg. Dir.
Bob Winfree	Science Advisor

Park Superintendents (12)

Linda Cook	AFAR
Tom Heinlein	BELA
Jeff Mow	KEFJ
Paul Anderson	DENA
Tomie Lee	GLBA
Joe Fowler	KATM
Jim Corless	KLGO
Joel Hard	LACL
Greg Dudgeon	SITK
Julie Hopkins	WEAR
Jed Davis	WRST
Dave Mills	YUGA

Natural Resources Advisory Council (11 attending)

Geoffry Smith	SITR
Meg Hahr	KLGO
Judy Putera	LACL
Sara Wesser	AKRO
Devi Sharp	WRST
Tom Heinlein	WEAR
Joan Darnell	AKRO
Troy Hamon	KATM
Guy Adema	DENA
George Dickison	AKRO
Russ Kucinski	AKRO

Cultural Resources Advisory Council (11 attending)

Michele Jesperson	WRST
Bob Gal	WEAR
Rachel Mason	AKRO
Wayne Howell	GLBA
Ted Birkedal	AKRO
Susan Boudreau	GLBA
Stephanie Stephens	AKRO Curator
Ann Kain	DENA
Jeanne Schaaf	LACL
Shelley Hall	KEFJ
Theresa Thibault	KLGO

Subsistence Advisory Council (4)

Sandy Rabinowitch	AKRO
Don Callaway	AKRO
Mary McBurney	LACL
Clarence Summers	AKRO

Beringia (2)

Bob Gerhard	AKRO
Peter Richter	AKRO

Education Advisory Group (14)

Joanne Welch	AAPLIC
John Morris	AKRO
Jim Ireland	KEFJ
Kris Nemeth	GLBA
Smitty Parratt	WRST
Don Pendergrast	GAAR
Mary Ann Porter	WEAR
Ken Grant	GLBA
Michele Simmons	SITK
Sandy Snell-Dobert	KLGO
Blanca Stransky	DENA
Roy Wood	KATM
Glenn Hart	WRST
Nancy Stimson	AKRO

Alaska Regional Team Managers (6)

Russ Kucinski	NR Team Lead
Ted Birkedal	CR Team Lead
George Dickison	GIS Team Lead
Joan Darnell	RER Team Lead
Jay Liggett	EPR Team Lead
Bob Gerhard	BER Team Lead

Natural Resource Staff AKRO (8)
Linda Stromquist
Judy Alderson
Page Spencer
Kevin Meyer
Lynn Griffiths
Terry DeBruyn
Bruce Giffen
Jim Halloran

Inventory and Monitoring Staff (4)

Sara Wesser	AKRO
Diane Sanzone	ARCN
Alan Bennett	SWAN
Chiska Derr	SEAN

Additional NPS Staff (21)

Lois Dalle-Molle	NWA-CESU
Philip Hooge	DENA
Peter Armato	KEFJ/OASLC
Christina Kriedman	KEFJ
Jim Pfeiffenberger	KEFJ/OASLC
Mike Tetreau	KEFJ
Allison Banks	GLBA
Chad Soiseth	GLBA
Whitney Rapp	GLBA
Lewis Sharman	GLBA
Chris Gabriele	GLBA
Mark Thompson	WRST
Barbara Cellarius	WRST
Eric Veach	WRST
Vicki Snitzler	WRST
Molly McCormick	WRST
Smitty Parratt	WRST
Will Tipton	WRST
Steve Hunt	WRST
Mason Reid	WRST
Dave Nelson	WRST

Subsistence Resource Commission (3)

Bert Adams	Yakutat
Robert Marshal	Tazlina
Chuck Miller	Dow Lake

Non-NPS Researchers (10)

Jesse Ford	OSU
Dixon Landers	US EPA
Ann Hoover-Miller	ASLC
Bruce Molnia	USGS
Sue Hazlatt	USGS
Linda Leiberman	USGS
Denny Capps	USGS
Lynda Lancaster	USGS
Alexander Milner	UAF
Carl Hild	UAA

Other Interested Parties (14)

Earl Laska	Inholder DENA
Vince Mathews	USFWS
Gail Collins	Tok
Tom Taube	ADFG
Mike Koskey	ADFG
Elaine Sinyan	Galena
Joeneal Hicks	Galena
Helen Geisert	Chitina
Roy Fensy	Copper Center
Connie Friend	Tok
Gloria Stickwa	Copper Center
Chuck Miller	Dot Lake
Roy Tansy	Copper Center
Irene Tansy	Copper Center

Appendix C
NPS Leadership and Staff Input to Strategy Development

Guidance for developing a region wide integrated science strategy in Alaska was derived from NPS policy documents as well as substantial input provided by managers and staff within the National Park Service Alaska Region as well as interested parties. Interviews of NPS leadership and technical staff were conducted between November 2004 and June 2005 (see Appendix B). The focus of input centered on responses to two principle questions:

- What would a successful integrated NPS science strategy look like?
- What key issues are of principal concern for Alaska's park lands?

Although these open ended questions resulted in a rich array of input, main themes were remarkably consistent across disciplines, staff roles, and outside interests, with important nuances that distinguished the variety of perspectives of natural and cultural resource staff, park leadership, education/interpretation staff and others. Since the questions were deliberately open-ended, characterization of responses is qualitative rather than quantitative. What follows is a summary of major points that emerged from input, recognizing that the actual input was richer than can be represented here.

1.0. Vision and Goals

Input was offered by a broad array of respondents on the desired end results of both management of park resources, and the implementation of a science strategy. In addition, factors that will influence the ability to meet these goals were also highlighted. The following summarizes key points.

1.1. Planning for parks must take on a global perspective. Global issues were seen as playing an ever increasing role in the impacts on and management of park resources, on most of which park managers have little say. Climate change, contaminants and development will impact the sustainability of parks. When planning within parks, NPS thinking must be on a global level.

1.2. Parks are ecosystems and subject to constant change, some natural, others human induced. Managing for sustainable park resources must be done within the framework of ongoing change. Park resources are characterized by natural variability with trajectories of change as part of natural cycles and influences. Ecosystems in parks are rapidly changing and will continue to change over the next 10-50 years and beyond. To sustain park resources, we need to manage for key values using a scientific understanding of natural ecosystem cycles and accept natural change rather than attempt to force consistency or to manage for individual species. At the same time, we need to understand these processes so we can distinguish between natural change and human induced impacts. This will help with resource management and in influencing public expectations.

1.3. The goal for Alaska's parks is to achieve a sustainable balance between preserving natural and cultural resources in perpetuity and ensuring public use, subsistence use, and study. Implementation of the science strategy should result in a better understanding about where the sustainable balance is between these two goals. This was viewed as particularly important in relation to identifying coming changes in human population and development. Substantial changes to state demographics in the next 50 years will likely place significant pressures on parks. Help is needed to understand what pressures are likely to increase, what is sustainable and how to sustain values, and where goals are unattainable or conflicting without a change in management.

2.0. Science Strategy Themes

Within the abundant and diverse input obtained, key themes for the Science Strategy were consistently voiced during group sessions and individual interviews across multiple disciplines and roles within and outside the organization. These themes directly shaped the framework for the strategy. Based on input, the strategy should be designed to:

2.1. Provide an overarching conceptual framework for NPS science. Consistent with the "Parks for Science" and "Science for Park" framework, data collected by an entire array of scientists from multiple organizations should be prioritized, integrated with and incorporated into NPS scientific interpretations based on an overarching concept aligned with the dual mission of the NPS. Scientific questions should emerge from the overarching concept.

2.2. Ensure NPS science is recognized for its excellence. This message was both explicit and implicit in multiple comments from a wide variety of respondents. NPS science would be explicitly defined and recognized as rigorous, pass intense internal and external peer review, and the results and interpretation be accepted as scientifically sound by federal, state, academic and international partners.

2.3. Effectively integrate data across disciplines and data types. Multiple sources and types of data are available and should be solicited by NPS in the interpretation of science for park management. Recognizing the importance of understanding the inter-relationship and co-evolution of natural and cultural processes, these data should be combined as appropriate to enhance our understanding of each discipline. In addition, both scientific studies using the scientific method, and knowledge gain through traditional ways of knowing were recognized as important to NPS scientific interpretations. Many sources of data are also available outside of NPS that are essential to understanding natural and cultural processes and were collected by many organizations using differing data collection techniques. The Science Strategy should be formulated so as to successfully use and integrate all types and origins of data.

2.4. Target problems and prioritize research to obtain knowledge most needed to achieve the NPS mission. The Science Strategy should facilitate issue-based research that addresses the most pressing problems facing park management, promotes investigations on how and why changes are occurring in Parks, and to seek understanding about cause and effect relationships. The Inventory and Monitoring Program is an essential program for NPS to establish knowledge about the existence and trends in resources within parks. To be proactive in protecting NPS resources we also need to know the causes for change and the effects of stress on valued resources.

2.5. **Synthesize and translate scientific data into useful information that influences management decisions.** NPS science would be designed to answer key questions about NPS resources and address practical problems in a way that will inform complex issues and support park decision-making needs. Research supported by NPS and encouraged in partnerships would target the highest priority concerns of resource managers. The scientific process would include open planning with resource managers, should include scientific design, data analysis and interpretation that is clear and transparent, and a process to ensure final results are communicated effectively to park managers to inform and support management decisions as well as partners and the public.

2.6. **Ensure that NPS science creates a knowledge base that is easily communicated, permanently stored and readily retrieved.** A consistent concern expressed by many respondents is that research relevant to parks has been completed but not published and/or integrated into the Service information base. Too often when NPS personnel leave a park or the Service their institutional knowledge is lost. As such, the science strategy should create a systematic process for ensuring useful deliverables from scientific studies that are fully integrated into the NPS knowledge base. As data are collected by NPS and others, these data would be systematically gathered to create a reference library for NPS and others; a place for data mining and information dissemination. In addition data would be synthesized into useful information and stored in a format useful to other scientists, resource managers, interpreters and the public.

2.7. **Engage the larger community in partnerships, data collection, interpretation, and communication, to foster stewardship for sustainable systems in parks.** It was recognized that NPS, as a resource management agency, does not have the research capabilities of a science organization. As such NPS must rely on partnerships to obtain sufficient data and information to achieve the clear mandate to use quality science in its resource management decisions. It was also emphasized that parks cannot achieve their mission as islands, but must encourage stewardship outside park boundaries. The need for an open process of data sharing, outreach to other agencies collecting relevant data on issues of concern, and communication about stewardship concerns were voiced.

2.8. **Implementation of the strategy will help NPS achieve its mission and goals for sustainable natural and cultural resources as well as public use.** The challenge of balancing the needs of public use and protection of natural and cultural resources in perpetuity was recognized by a wide cross section of respondents. Finding the sustainable balance with the help of the NPS science strategy was a high priority, particularly among park managers and interested parties.

3.0. Issues of Concern

During these discussions, issues of significant concern were also raised. Major themes included stressors impacting park resources now and in the future, administrative and communication challenges, and financial constraints.

3.1. Stressors

Concern was raised about both natural and human induced stressors impacting park resources, with the recognition that this distinction is blurred in many cases. Specific stressors of concern voiced in common by a wide variety of respondents included

3.1.1. Climate change Climate change is changing habitats, use of areas, accessibility, biotic communities, diseases and causing other effects that will change the characteristics of parks as well as the type of management action required to maintain park values and mission.

3.1.2. Increasing human use. As human population continues to expand exponentially and Alaska parks become an increasing target of visitor enjoyment, subsistence and hunter use, potential impacts on natural and cultural resources increase.

3.1.3. Development within and surrounding parks. Park ecosystems are directly linked to surrounding areas around park boundaries. Fragmentation, contamination, loss of habitat and overuse are likely to increase.

3.1.4. Global and local contaminants. Long range atmospheric and oceanic transport is bringing contaminants to parks with potential direct impacts on the viability of park resources, and the value of subsistence harvest. Local contaminants are being introduced through development of natural resources (e.g., mining) and use of park resources with industrial based transportation and activities (e.g., development, ATVs, boats, vehicles, hover craft).

3.1.5. Exotic species. Coupled with climate change and increasing use of parks, exotic species are increasingly transported to, and able to thrive in areas where they did not exist previously. This has significant impacts on natural communities.

3.2. Communication and Exchange

Inadequate communication was a repeated theme by respondents, although the set of communicators targeted was often very different. The follow characterizes key themes.

3.2.1. **Managers** expressed frustration in trying to make good decisions without sufficient scientific information in a format they could use in the decision process.

3.2.2. S**cience staff** expressed frustration in trying to communicate with managers who have minimal or no understanding of basic ecological principles, and the perceived lack of connection between scientific knowledge communicated and management decisions made. They also perceived a lack of management support for external exchange and visibility of NPS science and scientists in academic, state, federal and NGO circles.

3.2.3. **Educators and interpreters** expressed frustration that scientific results were not better processed and communicated so as to influence and educate the public.

3.2.4. **All categories of respondents** focused on the need for better communication for building partnerships and solid community support to achieve park sustainability.

3.3. Financial constraints

A universal concern expressed by NPS personnel was the diminishing capability to accomplish the NPS mission because recent gains in scientific capacity, achieved through NRC, are again being eroded by rising costs and shrinking budgets. Managers make decisions on challenging issues with inadequate information and staff. Personnel face heavy administrative duties that prevent effective use of their capability and expertise. Specific themes included:

3.3.1. **Insufficient funds** to meet park administrative needs and scientific support.

3.3.2. **Enormous staff effort** at many levels is required to compete for extremely limited research funds.

3.3.3. **Insufficient staff** and range of expertise to fulfill basic needs and track available information.

3.3.4. **High turnover** of leadership coupled with continuing erosion of staff numbers and expertise resulting in loss of institutional knowledge.

Appendix D: Legacy Goals

The National Park Service established updated goals and objectives to guide work over the next four years. The following goals and objectives are relevant to and guide the science strategy.

Goal: Management Excellence

- Continue partnerships with CESU's, universities and other research institutions as an efficient and effective way to meet NPS science and research needs.

Goal: Sustainability

- Build effective and sustainable partnerships that fulfill the NPS core mission.
- Retain and make readily available the knowledge and experience of staff and partners to build and sustain an institutional memory to improve decision-making
- Increase awareness and public knowledge of NPS cultural resource programs. Build support and understanding for the use and preservation of our cultural heritage

Goal: Conservation

- Restore natural character to disturbed lands and waters through pioneering ecological restoration practices
- Build coalitions to implement the Ocean Stewardship Strategy
- Continue implementation of the Natural Resource Challenge
- Coordinate with other land management agencies in the overall stewardship of natural and cultural resources and visitor protection.
- Coordinate with states and local governments in the overall stewardship of natural and cultural resources and visitor protection
- Implement the NPS Wilderness Action Plan

Goal: 21st Century Relevancy

- Build youth programs to enhance resource stewardship, knowledge and relevancy
- Ensure that the NPS assesses opportunities to work with educational institutions, communities, Tribes, and others so our programs, parks and visitors reflect the diversity of America
- Use innovative techniques to deliver interpretation.

Appendix E
Science to support sustainable systems management

Sustainability as a management goal.

To sustain is to keep in existence, maintain, or prolong. The world society is still trying to comprehend the concept of sustainability in the context of the environment as coined by the Brundtland Commission (World Commission on Environment and Development, 1987). Yet this term can be very useful as a guiding principle for developing management goals, and implementing resource protection and scientific evaluation. Sustainability has been used effectively as a management goal in a variety of settings (e.g., USEPA 1995).

Science for Sustainable Management as an NPS goal

NPS is charged with the overall mission of preserving natural and cultural resources within parks while ensuring their use and enjoyment. This dual mission can be a challenge to implement since use and enjoyment, when exceeding the resiliency of natural systems or cultural resources, can lead to degradation and loss of the very values the American people wish to enjoy. As such, there must be a sustainable balance between these goals.

Effective use in goal setting and scientific evaluation requires that sustainability be operationally defined and interpreted for a “place” (e.g., ecosystem, national park, or watershed). To do this, key questions need to be addressed (e.g., what does sustainability or integrity mean for a particular ecosystem or archeological site; what must be protected to meet sustainable goals or system integrity; which ecological resources and processes or cultural artifacts are to be sustained and why; how will we know we have achieved sustainability?). Answers to these questions serve to clarify the goals for the particular place and the ecological and cultural resources there.

For national park resources, ecological and cultural values are intimately interrelated such that cultural values and norms can only be understood within the context of the ecosystem in which they evolved. How the ecosystem evolved over time provides clues for changes in biotic and human communities. In this light it becomes clear that sustainability is not a static concept. Systems evolve or change in response to natural and human influences. The challenge is to determine what processes and values must be sustained to retain the biotic diversity, carrying capacity and resiliency of natural and cultural systems, and what human and natural influences will maintain or compromise those values to be sustained. Thus there is no “perfect collection of species” to sustain. Rather there are characteristics of systems that are desirable for functional and aesthetic reasons. It is here that the dynamic tension between the dual and potentially conflicting goals of the National Park Service must be fully evaluated.

Terms established by mandate from the Organic Act, Wilderness Act and under ANILCA provide the foundation for operationally defining sustainability for the science strategy;

these include “natural, healthy and unimpaired” (see also Appendix E). Such goal terms when operationally defined for the place, are available for interpretation into specific objectives about what must be true in a place in order for the goal to be achieved. Identification of ecological and cultural values that can be measured or estimated in the system of concern paves the way for scientific assessments and informed decision-making (USEPA 1998). Translating national goals into explicit and transparent management goals and objectives for each park will provide the basis for designing effective science planning that supports defensible decision making.

Appendix F
Natural, Healthy, Unimpaired

"Natural, healthy, and unimpaired" are three terms used in ANILCA that established policy guidance for the management of many of Alaska's parks. Terms such as natural and healthy are intuitively understood by most people. In the dictionary, "natural" is defined as something that exists within or is formed by nature or pertaining to nature. People are in general agreement that an old growth forest, Pacific salmon, or rain is natural, and a car is not part of nature, but was invented by humans. In the dictionary, "healthy" is defined as being free from disease or ailment. People also can generally agree that animals and animal populations that are physical strong, abundant, reproducing and without parasites and illness are healthy. To determine whether an individual animal or plant, or a population, or species is healthy, however, would require greater evaluation if the ill effects of "unhealthy" were not immediately obvious. Here, the realm of management becomes somewhat more challenging. The most difficult term to define is "impaired," which means to make worse, weaken, or damage. These terms continue to present a challenge to resource managers because, while providing intuitive understanding, the continuing discussion remains within the policy context. To date operational definitions for these terms have not been established.

While existing policy continues to guide NPS resource management, it is possible and desirable under the science strategy, to begin work that can establish operational definitions for these terms founded on basic precepts of what these terms mean, combined with empirical evaluation of little impacted natural, cultural and subsistence resources in parks. The purpose is to create benchmarks for defining these terms. The current advantage in Alaska is that there are many resources that are little impacted when compared to other areas of the nation. However, all systems around the globe, including those considered remote, are now impacted by human induced global processes and will become increasingly so in the future from global, regional and local industrial-based human activities. This presents some urgency for establishing empirical definitions for natural, healthy and unimpaired in Alaska's parks.

It is important to be cognizant that impairment of natural, cultural and subsistence resources can easily go unrecognized without the benefit of baseline criteria or benchmark data, until significant effects have been realized. It is remarkably easy for resource degradation to go unnoticed and very difficult to document subtle but critical impairments. This is true for several reasons.

First, available data are very limited about Alaska's resources. Without data collected before and after impacts, an understanding of change and impairment is unlikely. The timing of study of a resource or area determines the baseline for condition. "Present condition" will become the baseline criterion for intact systems because previous condition is unknown. This is true regardless of how much the system may have been impaired before it was studied. This problem of recognition of impairment is exacerbated by high turnover among park management and staff. When new staff arrive in a park, their observations start at "present condition" without the benefit of a personal historical perspective on what conditions were like prior to their arrival. Thus, long term impairment from incremental changes can occur without recognition by those most intimately concerned with managing the resources.

Second, the sensitivity of our scientific measures is limited such that real change leading to impairment can occur without the ability to document it, even when data are collected. It is important to emphasize that measures of effect are often the most difficult to collect because they require strict protocols that are a challenge to implement in natural systems. Thus, when effects are recognized and documented, impairment is often significant.

Third, the absence of documented impairment does not constitute confirmation that there is no impairment. As noted previously, adverse effects are the most challenging to observe and measure in the field. Confirmation of “no impairment” is not possible without a benchmark and strict protocols for comparison. On the other side, when adverse effects are observed, the impairment can be much greater than data may suggest. Observable effects may constitute major degradation and irreversible loss of essential resources.

Finally, individual human perspectives strongly influence what impaired might represent in Alaska’s national parks. What one person believes is impaired, another may view as improved. These are policy based issues that are best addressed within policy forums. However science can inform the policy debate by providing data about the sustainability of the array of natural, cultural and subsistence resources influenced by change that would constitute impairment because of the unsustainable nature of the change.

Natural, healthy and unimpaired can be operationally defined using data being generated through the Inventory & Monitoring Program as well as other research conducted in parks. However, without processing these data for this purpose, the debate will continue while the resources are subject to ever increasing human pressures that could result in permanent loss without viable scientific understanding.

Appendix G: Vulnerability Assessment

Vulnerability assessment is a process to identify those ecosystems and cultural values most vulnerable to being lost or permanently harmed over the next 5 or more years and to determine which stressors are likely to cause the greatest risk. These are not predictive assessments; rather they are used to identify undesirable environmental changes that may be expected over the coming years. For application in parks, current GIS and I&M activities will provide a foundation for evaluation.

Examples of a regional approach are being implemented through EPA's Regional Vulnerability Assessment (ReVA) program, a regional scale, priority-setting assessment process developed by EPA's Office of Research and Development (ORD) through pilot assessments (for process description and updates see www.epa.gov/reva/). ReVA is expanding cooperation and integrating research on human and environmental health, eco-restoration, landscape analysis, regional exposure and process modeling, problem formulation, and ecological risk guidelines.

The program is part of the Integrated Science for Ecosystem Challenges Initiative for FY 2000 sponsored by the White House Committee on the Environment and Natural Resources (CENR). As such, the scope of ReVA is to conduct pilot assessments that focus on one geographic region that is well characterized biologically. The ReVA program is responsible for the collection, management, and analysis of multiple data sources to evaluate environmental conditions and known stressors within the Mid-Atlantic region.

To date, extensive effort has been made to evaluate environmental condition and known stressors within the Mid-Atlantic region, but predicting future environmental risk to prioritize efforts to protect and restore environmental quality efficiently and effectively is still difficult. ReVA is being developed to identify those ecosystems most vulnerable to being lost or permanently harmed in the next 5 to 25 years and to determine which stressors are likely to cause the greatest risk. The goal of ReVA is to identify undesirable environmental changes expected over the coming years. The ReVA program will extend environmental assessments for the region by using integrative technologies to predict future environmental risk and support informed proactive decision-making, and prioritization of issues for risk management.

Appendix H
Ecological Risk Assessment

Excerpted from the USEPA *Guidelines for Ecological Risk Assessment* 1998

Ecological risk assessment is a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors (USEPA 1992, 1998; for a copy of the EPA Ecological Risk Assessment Guidelines go to http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12460). The process is used to systematically evaluate and organize data, information, assumptions, and uncertainties in order to help understand and predict the relationships between stressors and ecological effects in a way that is useful for environmental decision making. An assessment may involve chemical, physical, or biological stressors, and one stressor or many stressors may be considered.

Ecological risk assessments are developed within a risk management context to evaluate human-induced changes that are considered undesirable. As a result, these Guidelines focus on stressors and adverse effects generated or influenced by anthropogenic activity. Defining adversity is important because a stressor may cause adverse effects on one ecosystem component but be neutral or even beneficial to other components. Changes often considered undesirable are those that alter important structural or functional characteristics or components of ecosystems. An evaluation of adversity may include a consideration of the type, intensity, and scale of the effect as well as the potential for recovery. The acceptability of adverse effects is determined by risk managers. Although intended to evaluate adverse effects, the ecological risk assessment process can be adapted to predict beneficial changes or risk from natural events.

Descriptions of the likelihood of adverse effects may range from qualitative judgments to quantitative probabilities. Although risk assessments may include quantitative risk estimates, quantization of risks is not always possible. It is better to convey conclusions (and associated uncertainties) qualitatively than to ignore them because they are not easily understood or estimated.

Ecological risk assessments can be used to predict the likelihood of future adverse effects (prospective) or evaluate the likelihood that effects are caused by post exposure to stressors (retrospective). In many cases, both approaches are included in a single risk assessment. For example, a retrospective risk assessment designed to evaluate the cause for amphibian population declines may also be used to predict the effects of future management actions. Combined retrospective and prospective risk assessments are typical in situations where ecosystems have a history of previous impacts and the potential for future effects from multiple chemical, physical or biological stressors.

The Ecological Risk Assessment Process

The ecological risk assessment process is based on two major elements: Characterization of effects and characterization of exposure. These provide the focus for conducting the three phases of risk assessment: problem formulation, analysis and risk characterization.

The overall ecological risk assessment process was presented in the 1992 report *Framework for Ecological Risk Assessment* (referred to as the Framework Report. The format remained consistent with the diagram. However, the process and products within each phase have been refined, and these changes are detailed in fig 1-2 below. The three phases of risk assessment are enclosed by a dark solid line. Boxes outside this line identify critical activities that influence why and how a risk assessment is conducted and how it will be used.

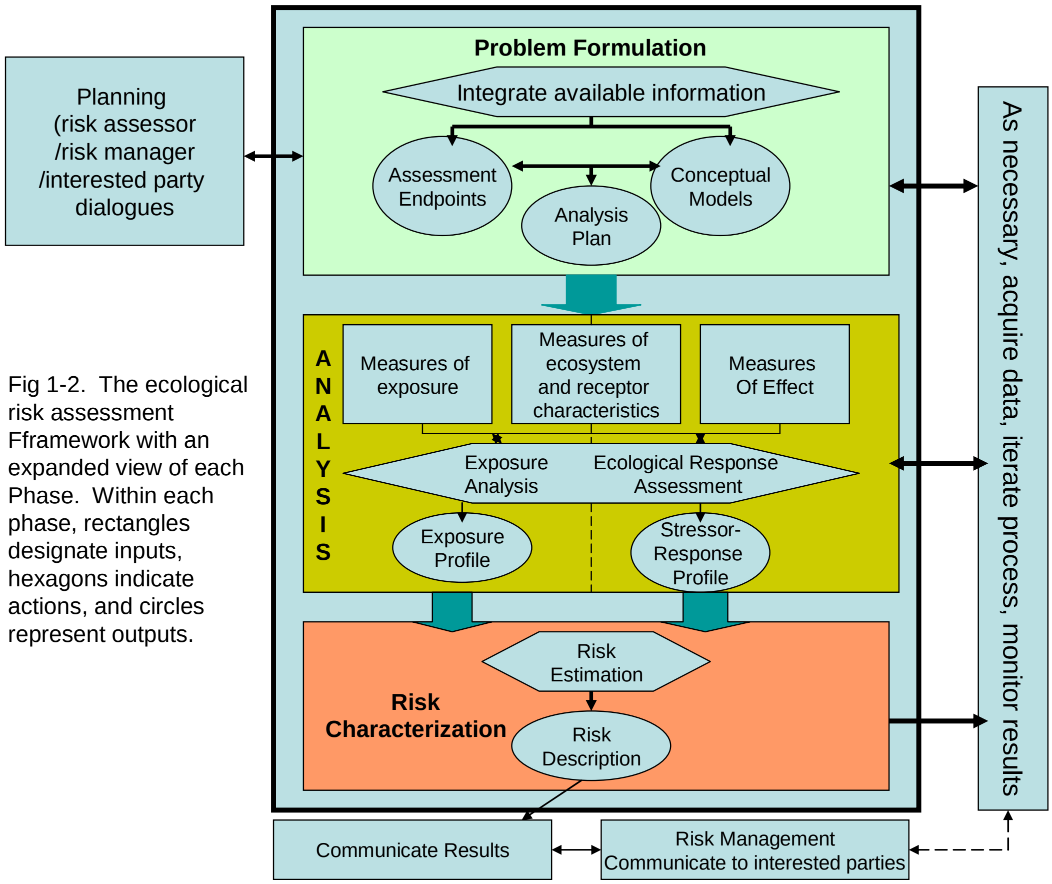


Fig 1-2. The ecological risk assessment Fframework with an expanded view of each Phase. Within each phase, rectangles designate inputs, hexagons indicate actions, and circles represent outputs.

Problem formulation, the first phase is shown at the top. In problem formulation, the purpose for the assessment is articulated, the problem is defined, and a plan for analyzing and characterizing risk is determined. Initial work in problem formulation includes the integration of available information on sources, stressors, effects, and ecosystem and receptor characteristics. From this information two products are generated: assessment endpoints and conceptual models. Either product may be generated first (the order depends on the type of risk assessment), but both are needed to complete an analysis plan, the final product of problem formulation.

Analysis, shown in the middle box, is directed by the products of problem formulation. During the analysis phase, data are evaluated to determine how exposure to stressors is likely to occur (characterization of exposure) and, given this exposure, the potential and type of ecological effects that can be expected (characterization of ecological effects).

The first step in analysis is to determine the strengths and limitations of data on exposure, effects, and ecosystem and receptor characteristics. Data are then analyzed to characterize the nature of potential or actual exposure and the ecological responses under the circumstances defined in the conceptual model(s). The products from these analyses are two profiles, one for exposure and one for stressor response. These products provide the basis for risk characterization.

During risk characterization, shown in the third box, the exposure and stressor-response profiles are integrated through the risk estimation process. Risk characterization includes a summary of assumptions, scientific uncertainties, and strengths and limitations of the analysis. The final product is a risk description in which the results of the integration are presented, including an interpretation of ecological adversity and descriptions of uncertainty and lines of evidence.

Although problem formulation, analysis and risk characterization are presented sequentially, ecological risk assessments are frequently iterative. Something learned during analysis or risk characterization can lead to a reevaluation of problem formulation or new data collection and analysis…

Interactions among risk assessors, risk managers, and other interested parties are shown in two places in the diagram. The side box on the upper left represents planning, where agreements are made about the management goals, the purpose for the risk assessments, and the resources available to conduct the work. The box following risk characterization represents when the results of the risk assessment are formally communicated by risk assessors to risk managers. Risk managers generally communicate risk assessment results to interested parties. These activities are shown outside the ecological risk assessment process diagram to emphasize that risk assessment and risk management are two distinct activities. The former involves the evaluation of the likelihood of adverse effects, while the latter involves the selection of a course of action in response to an identified risk that is based on many factors (e.g., social, legal, political economic) in addition to the risk assessment results.

The bar along the right side of figure 1-2 highlights data acquisition, iteration, and monitoring. Monitoring data provide important input to all phases of risk assessment. They can provide the impetus for a risk assessment by identifying changes in ecological condition. They can also be used to evaluate a risk assessment's predictions. For example, follow-up studies could determine whether mitigation efforts were effective, help verify whether source reduction was effective, or determine the extent and nature of ecological recovery. It is important for risk assessors and risk managers to use monitoring results to evaluate risk assessment predictions so they can gain experience and help improve the risk assessment and risk management process (Commission on Risk Assessment and Risk Management, 1997).

Even though the risk assessment focuses on data analysis and interpretation, acquiring the appropriate quantity and quality of data for use in the process is critical. If data are unavailable, the risk assessment may stop until data are obtained. The process is more often iterative than linear, since the evaluation of new data or information may require revisiting a part of the process or conducting a new assessment… The dotted line between the side bar and the risk management box indicates that additional data acquisition, iteration, or monitoring, while important, are not always required.

Appendix I
NPS Integrated Assessment

The following description of the process is an overview and not intended as guidance. Guidance for specific elements in the multi-step process described here is readily available and was developed for related applications. In the course of implementation of the NPS science strategy through demonstration projects, NPS can refine and document the process to generate NPS guidance and application.

Conceptual Formulation

The first phase of the assessment is the identification of sensitive and robust areas, species, cultural sites and natural processes in a park, place or region, and the evaluation of the problem, concern, or opportunity (conceptual formulation). There are three products of conceptual formulation: evaluation of vulnerabilities, assessment endpoints, conceptual models, and the analysis plan. Assessment endpoints emerge from converting management goals into operationally defined endpoints for a specific place (e.g., park) that are measurable.

Work completed under the I&M program on vital signs, ecosystem conceptual models, and evaluation of available data forms the cornerstone for the natural resource assessment and is directly applicable during this phase. More explicit work on stressors and effects expands the assessment to connect ecological information to the management issues to be addressed, as well as the addition of relevant cultural and subsistence concerns. Note that the results of conceptual formulation, while qualitative in nature, may be sufficiently compelling to support specific management action without additional assessment. If this is the case, the assessment would be summarized and communicated to the management team for decision making. If not, the next phase of the assessment becomes applicable.

Analysis

The second phase is the analysis of data to determine the potential for exposure of key natural and cultural resources to identifiable forces or stressors, and the likely positive or negative effects of exposure. During this phase, data and information concerning the location of resources, proximity to stressors, timing of exposure and other relevant information are used to clarify vulnerability and create stress-response profiles. Data of particular relevance during this phase include GIS information on land formations, vegetation, animal populations and other spatial data superimposed with human activities, natural stressors and other factors that may influence them. In addition, inventory, baseline and experimental research data and traditional knowledge about sensitivities of resources to different stressors, whether collected in parks or elsewhere by NPS, partners or independent scientists, provide essential information for developing stress-response profiles.

Characterization of vulnerability

The final phase of the assessment is a description of the results of Phase 1 and Phase 2, integrated across natural and cultural issues and including an explicit treatment of uncertainty about the relationships identified. The summary describes how key resources will likely respond to identified stressors based on evaluations of vulnerability, and risk or benefit of exposure on the array of targeted park values. This characterization of sustainability gives resource managers information designed to help them evaluate where results are most robust, what lines of evidence support the conclusion, and information on sources of error and uncertainty.

The characterization of park resource sustainability is communicated to the resource managers at the end of the assessment. The final process of information sharing among managers, scientists and interested parties may provide sufficient information to support management decisions. In addition the conceptual models, descriptive information and response profiles provide a synthesized interpretation of a wide array of data that is documented with references, analytical results and conclusions, all of which provide the basis for long term archive, easy retrieval and use, and a ready framework for sorting and incorporating new data and information as it is collected.

Depending on the complexity of the issues, or in situations where many management options are on the table for debate, a further scientific evaluation of potential outcomes of different decision options may be warranted. This would lead to step 3: scenario development.

Appendix J

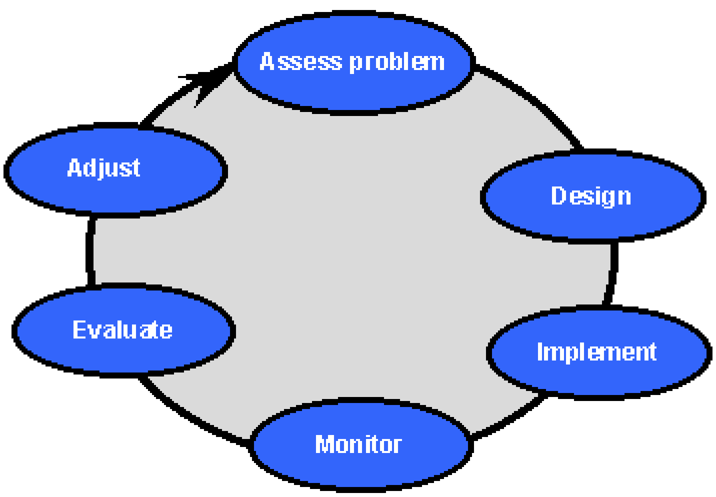
Adaptive Management

This information was obtained from the BC Forest Service use of adaptive management found at http://www.for.gov.bc.ca/hfp/amhome/AMDEFS.HTM

Adaptive management has been defined in various ways since its development in the early 1970s. It is recognized that different people and organizations continue to have differing views about the best definition for their purposes. In order to bring some consistency and clarity to what is meant by "adaptive management," the working definition for the term is:

Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. In its most effective form–"active" adaptive management–employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed.

We often portray the adaptive management process a six-step cycle, and emphasize that successful adaptive management requires managers to complete all six steps:



Some of the differentiating characteristics of adaptive management are to:

1. acknowledge uncertainty about what policy or practice is "best" for the particular management issue,
2. thoughtfully select policies or practices to be applied (the assessment and design stages of the cycle),
3. carefully implement a plan of action designed to reveal the critical knowledge that is currently lacking,
4. monitor key response indicators,

5. analyze the management outcomes in consideration of the original objectives, and
6. Incorporate results into future decisions.

<u>Some other definitions</u>

Bormann et al. 1994, p. 1: "...is 'learning to manage by managing to learn'..."

Halbert, C.L. 1993, p. 261-262: "...is an innovative technique that uses scientific information to help formulate management strategies in order to 'learn' from programs so that subsequent improvements can be made in formulating both successful policy and improved management programs."

Lee, K.N., 1993, p. 9: AM..."...embodies a simple imperative: policies are experiments; *learn from them*." (italics are the author's).

Lee K. N. and J. Lawrence, 1986, p 435: "...is a policy framework that recognizes biological uncertainty, while accepting the congressional mandate to proceed on the basis of the 'best *available* scientific knowledge'. An adaptive policy treats the program as a set of experiments designed to test and extend the scientific basis of fish and wildlife management."

Scientific Panel for Sustainable Forest Practices in Clayoquot Sound, 1995, p. 271: "The rigorous combination of management, research, and monitoring so that credible information is gained and management activities can be modified by experience. Adaptive policy acknowledges institutional barriers to change and designs means to overcome them."

<u>Sources</u>

Bormann, B.T., P.G. Cunningham, M.H. Brookes, V.W. Manning, and M.W. Collopy. 1993. Adaptive ecosystem management in the Pacific Northwest. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-341. 22 pages.

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Appendix K
System Dynamics

The field of system dynamics originated in the 1960's with the work of Jay Forrester and colleagues at the Sloan School of Management at the Massachusetts Institute of Technology. Forrester and his colleagues developed the initial ideas by applying concepts from feedback control theory to the study of industrial systems. Their early ideas are described in Forrester's *Industrial Dynamics* (1961). One of the best-known applications of the new ideas during the 1960s was Forrester's *Urban Dynamics* (1969) which highlighted the field's expansion beyond the industrial arena. One of the most widely know applications of system dynamics appeared a few years later in a best-selling book entitled *The Limits to Growth* (Meadows et al. 1972). The *Limits* study examined the prospects for growth in human population and industrial production in the global system over the next century using a computer model which simulated resource production, food supply needed to keep pace with growth, as well as the accumulation of pollutants. The authors concluded that the world system could not support existing rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology. The *Limits* study, recently updated (Meadows et. al 1992, 2004) is not about doom and gloom, but about making deliberate choices about the future. The authors argue that "it is possible to alter these growth trends and to establish a condition of ecological and economic stability that is sustainable far into the future" (Meadows et al. 1972, 24).

System dynamics is based on dynamic mathematical models that assist in identifying dynamic patterns, such as growth, decay and oscillations, that are the fundamental dynamic patterns of systems (e.g., dynamic models help in understanding why some systems oscillate over time such as those typical of predator and prey populations). Both human and ecological systems exhibit highly complex patterns of behavior that evade our ability to understand them without assistance. Models are most useful when they lead to counterintuitive results which force planners and scientists to reexamine their understanding of a system (Ford 1999). To model the dynamic behavior of a system, results of an integrated assessment could be used to generate four hierarchies of structure: (1) boundary area, (2) feedback loops, (3) "state" variables, and (4) rate (flow) variables representing activity within the feedback (adapted from Forrester, 1969).

Scenarios emerging from modeling would capture results and provide frameworks that filter and organize knowledge. While these models are not predictive, they are instruments to support strategic thinking, group discussion and learning.

Appendix L
Glacier Bay National Park and Preserve (Draft Sample)
Science in the Park Welcome Packet

This is a sample draft. Specific sections must be filled in by each park to apply to that park. General boilerplate language should be consistent across parks. Glacier Bay personnel have not yet reviewed this draft.

Welcome
We are very pleased with your interest in research opportunities within Glacier Bay National Park and Preserve (GLBA). This packet provides information to help you successfully initiate and complete research in the park. We strongly encourage you to read through the packet, and open and print the online permit application form before preparing research proposals and contacting NPS staff in parks. With this information in hand, you will be better prepared to apply for research funding from granting organizations with the assurance that your work can be successfully implemented in the park.

Background
The National Park Service (NPS) is dedicated to using scientific understanding to improve resource management (Omnibus Act 1998, NPS Alaska Region Science Strategy 2006). To encourage scientific activity with parks, NPS outlined three primary science-based goals: *Science for Parks* (encouraging and designing research with direct application to management), *Parks for Science* (encouraging and benefiting from curiosity-driven science) and *Parks for Learning* (translating science into useful information for all) (NPS 1999).

Since NPS is a management agency rather than a research institution, NPS research funding is very limited. Thus, to ensure we meet the terms of the Omnibus Act of 1998 by making management decisions informed by science, NPS funded research must be supplemented through partnerships with other federal agencies, the state, international partners, and independent researchers. We consider you an important partner in meeting our research goals.

What the Welcome Packet Contains
This welcome packet includes GLBA management goals and research needs to both inform and encourage you to conduct research and test interesting hypotheses likely to generate important scientific results, while providing data that helps us meet our management mandate. Also included is more practical guidance such as information on the permit application process, what activities can and cannot be permitted, and how to prepare for work in the field. It is particularly important for researchers not familiar with the NPS mission and Glacier Bay to review this material to ensure their proposed research activity will not come in conflict with the mission of NPS and the park. We hope you find the information packet useful. Feel free to offer suggestions for improving this packet, or our process of partnering with scientists conducting research in the park.

Glacier Bay National Park and Preserve: The Place

GLBA is an extraordinary natural environment for studying climate change, boat-tourist-wildlife interactions, or determining factors influencing ecology and wildlife community characteristics and many other important areas of scientific inquiry. Glacier Bay includes…(map).

This unique area offers a landscape with visual change as you move into the bay toward the glaciers. It is a prime location to study the co-evolution of landscapes, ecosystems and culture.

Management Goals

NPS management goals are to preserve the natural and cultural resources within Glacier Bay, and ensure their enjoyment by visitors. The park includes a significant complement of physical, biological and human values.

The most significant physical aspect of GLBA is that it is a recently deglaciated fjord and contains active tidewater glaciers in retreat. The bay's shoreline and coastal environments are characterized by a structure that changes at the mouth from more fine grain beaches to those less mature with cobble/boulder beaches in the north toward the terminus of the glaciers. At the terminus, exposed bedrock overlain by fine sediment predominates, due to recent glacial activity. The park's natural soundscape includes sounds of wind, water, wildlife, and glaciers, and air and water quality is high, all values to be preserved.

Biological resources include marine mammals (humpback whale, Steller sea lion, minke whale, harbor porpoise, killer whale, harbor seal, and sea otter), a variety of marine birds and raptors typical of SE Alaska (colonial nesting marine birds, murrelets, molting waterfowl, raptors, shorebirds, and sea ducks), and marine fishes including four pelagic fish (capelin, walleye pollock, Pacific herring and northern lampfish), demersal (bottom) fishes (skates, sculpins, and flatfishes) and five species of salmon and steelhead trout. Vegetation at the mouth of the bay is typical to the region and becomes sparse as you move into the bay toward the glaciers. Near the terminus, only hardy pioneer species are evident. In general, community diversity is low on land and in rocky intertidal communities close to tidewater glaciers.

The cultural resources include archaeological finds such as petroglyphs and petrographs, culturally modified trees, rock shelters, villages, forts, fishing sites and weirs, hunting and gathering sites, stone cairn formations, mining camps, canneries, trading posts, log cabins, trails, horticulture sites, burial sites, major/multi-component sites, cemeteries or burials. Based on a preliminary assessment, ethnographic resources include 15 sites that may qualify as traditional cultural properties. The Park Service compiled Cultural Landscapes Inventories in the park for Bartlett Cove and Dundas Bay. Both areas may be eligible for listing in the National Register for Historic Places, as important components of a larger ethnographic landscape.

Visitor experience is a key value and the second of two primary management goals. In Glacier Bay five major visitor groups are identified: cruise ship passengers, tour vessel passengers, charter vessel passengers, private vessel visitors, and backcountry users. In 2001 nearly 383,000 visitors traveled through Glacier Bay aboard vessels, 85% as cruise ship passengers.

Management Issues

Several management issues are of immediate concern. With the publication of the 2003 EIS, specific numbers of vessels are now defined for the foreseeable future, but much is not known about the effects of vessel traffic on key species of concern. For example, the most prevalent human sounds come primarily from motorized vessels. Noise is most prevalent under and over water and along the coastline. Air and water quality while high is impacted by a variety of emission and discharge sources from park operations, vehicles, boats and cruise vessels. These may impact protected species such as two of Glacier Bay's marine mammal species listed as threatened and endangered (humpback whales and Steller sea lions) and other species that are in decline (e.g., harbor seal). A number of marine birds are particularly sensitive to vessel disturbance including colonial nesting marine birds, murrelets, molting waterfowl, raptors, shorebirds, and seaducks. Marbled murrelets are present throughout the park and though not currently listed in Alaska are listed as threatened along the west coast of the US. Kittlitz's murrelets are currently a potential candidate for listing under ESA.

Critical to all resource protection is the regulation of vessel use in GLBA. It is recommended that scientists review Chapter 1.0 of the GLBA EIS, and particularly section 1.5 to better understand current management issues. In addition, since the EIS was specific to tour vessel use, many other issues have not been addressed, and are listed in section 1.5.2 of the EIS. Resources and stressors in the terrestrial environment are relatively unstudied.

Observed Changes and Stressors

Glaciers are retreating in GLBA. This alone presents a host of opportunities for understanding the responses of glaciers to climate change, the progression of succession in plant communities, the response of wildlife and fish to changing environments, and offers the potential for discovering cultural artifacts and sites, among many other research questions and opportunities. In addition to natural change, human induced impacts are of potential concern. At center is the increase in user days and numbers, particularly the strong interest in increasing the number of boats entering Glacier Bay. These boats introduce physical, noise and pollutant disturbances. The recent GLBA Environmental Impact Assessment (2003, EIS) focused on defining the best balance for boat traffic. While decisions have been made on the best available science, there is much that still requires investigation as defined in the recently completed GLBA Science Plan (2005). Even less is known about changes likely to occur in terrestrial and glacial environments and how these changes link back to preservation and use of natural and cultural park resources. These are areas of research that NPS GLBA strongly encourages.

Research Questions

The landscape, wildlife, and human use of GLBA are changing. Some of these are ecological processes, like climate change, and are coupled with the ever increasing numbers of visitors in GLBA. The potential for degradation of wilderness values and conflicts between natural ecosystem function, cultural integrity and visitor use are real. GLBA park personnel are seeking better scientific understanding of the sustainable balance between these two missions to continue to protect the wilderness aspects of GLBA, and the cultural values, while keeping the region accessible. NPS needs scientifically verified answers for overarching questions such as: (a) what stressors are placing the natural and cultural values at greatest risk, (b) what combined and cumulative effects are altering those values, (c) what mitigation measures are possible, and (d) what balance can be found to ensure that the incredible values of Glacier Bay are sustained without compromising their enjoyment by visitors. Questions of particular interest to GLBA managers include but are not limited to: (1) how vessel traffic influences the behavior, location and reproductive success of sensitive marine mammals and birds, (2) how harvest of marine species affects trophic levels and top predators, (3) how humans are impacting the ecological, cultural values and visitor experience in marine and terrestrial areas, (4) how glacial retreat, climate change and human pressures are interacting to change the ecosystem and cultural values of Glacier Bay. An area of inquiry relatively unexplored is how climatic factors are changing the terrestrial environment in GLBA. Scientific understanding of environmental change and declines observed in many important species is the first step toward effective action.

GLBA welcomes active exchange among scientists and staff to identify those questions of greatest mutual scientific interest, and explore how researchers' interests will lead to greater understanding of the dynamic system of Glacier Bay.

Appropriate Research in Parks

The mission of the NPS is to preserve and protect the natural and cultural values on park lands while providing opportunities for appropriate use and enjoyment. Scientific research activities must be in conformance with this mission. We ask scientists working in parks to recognize these limitations, the most important of which is to *do no harm*. With this in mind the following general guidelines may be helpful:

- Observational research is desirable; manipulation of the environment, resources, or animals is discouraged or restricted and subject to permitting parameters. (Note that the park environment can provide the control in experimental or comparative studies. In addition predictions and hypothesis testing are still possible within these limitations)

- Use of boats and aircraft is allowed with permits, helicopter access in designated wilderness areas is prohibited except under a minimum requirement determination.
- Most coastal and bay areas are accessible by boat. There are several areas however, that are restricted to motorized boat traffic for resource protection. These are marked on park maps.
- Plan ahead to gain boat access; there are limitations on total boat traffic into the bay
- Installation of permanent structures is generally not allowed

GLBA is working toward establishing long term research sites to promote longitudinal studies in the park. Research pertaining to glacial retreat, succession, climate change, animal and plant population shifts and the like are better addressed where there is continuity in research location. Suggestions from the research community for establishing long term sites are welcome.

Permit Requirements:
It is important to recognize that you are not guaranteed access to park areas; permits are required. Thus, BEFORE submitting your grant application, check the guidelines and contact our Research Permit Coordinator to ensure your proposed work is consistent with the park mission. Submit your permit application at least three months ahead of your intended field season, preferably longer. If possible, discuss your proposed with NPS prior to writing grant proposals; NPS can often provide a letter of support with your funding request.

- Online applications can be found a…..t: It may be convenient to print out the form, create your application offline, and then cut and paste text into the form online for submission.
- Specific requirements for obtaining a research permit in GLBA include:…
- Scientists holding permits for conducting research in any national park are expected to follow their research plan as closely as possible, to comply with permit limits and park regulations, and to provide a short annual report (on-line form) on how the research season went.
- Upon closeout of the research activity, scientists are required to provide a summary of the research project for NPS permanent records. Included is a summary of research results, lessons learned, and benefits and limitations of doing research in the park. Scientists are particularly encouraged to relate their research results to the management issues of importance to park managers. A form and sample report are attached to illustrate what is expected (to be developed).
- Multi-year permits can be granted, with a simple renewable process occurring on an annual basis. The renewal review ensures NPS-scientist communication, and includes confirmation that the scientist complied with permit guidelines, and an annual report was submitted to NPS (see attached annual report form-to be developed).

- When developing your research plan, research parameters should align with requirements to avoid actual or potential need for exceptions to policy. We have many scientists conducting work. If each scientist requests one or more exceptions, park resources and visitor experiences may not be protected.
- Remember that research practices that are commonly used in non-park areas may not be appropriate in parks (e.g., some animal and plot marking protocols, use of helicopters for access). Make certain your approach is fully described and approved by NPS personnel BEFORE your arrival at the park.

NPS Support that may be available:
GLBA park personnel wish to provide you as much support as possible. Our greatest asset is the outstanding natural environment of GLBA in which to do research. Unfortunately, budgets and logistical assets are very limited and NPS must meet its primary mission first. Thus you are responsible for ensuring you have the necessary assets available to you while in GLBA to complete your work. You will be assigned to an NPS research coordinator to help you plan ahead, and help with information needs upon arrival. In addition, depending on the season and timing, the following assets may be available to you but they are not guaranteed, nor should you depend on their availability.

- Limited telephone and Internet access at GLBA headquarters in Bartlett Cove
- Temporary housing for lease
- Some backup outdoor gear and radios

NPS is seeking ways to offer high value, low cost support services. Your ideas and suggestions are very welcome.

What it is like to work in GLBA
GLBA is wilderness. It is difficult for those unaccustomed to working in the wilderness to understand the enormity of GLBA, its remoteness, the cost and difficulty of access and the resource intensity of working in this vast and often forbidding environment. Researchers MUST be knowledgeable and prepared for wilderness survival if working in remote regions. Rescue is ***not*** guaranteed if you get into trouble. We suggest you read … to prepare. What you can expect:

- Weather
- Water conditions
- Temperatures
- Ice

What you should bring:

- Gear guide?

Transportation to the Park:

- Airplane to Gustavus
- Boats and ferry to Bartlett Cove

Lodging

- Lodge
- Camping
- NPS cabins

Transportation in the Park

- Tour vessel
- Kayak
- Small boats for lease
- Air charters

What will ensure your work goes well:
- Research protocols fully vetted with staff before arrival
- Permits in hand before arrival
- Sufficient grant funds and transportation contracts established before arrival to ensure field access
- Proper equipment for field work
- Minimal or no unplanned logistic support needs on site

What will likely cause problems:
- The reverse of those above and…

What you need to bring with you or ensure you have:
- Appropriate camping and survival gear for Alaska maritime environment
- Marine band radio and extra batteries (GPS also highly recommended)
- Detailed maps of the region
- Food and first aid supplies
- Contracts for boat or airplane transportation to reach research sites

Review of Process

On an annual basis, NPS staff review input provided by scientists on how well NPS is encouraging science in parks. We invite you to fill out the attached questionnaire during any part of this process to offer input so we can update our welcome packet and improve our responsiveness to scientists' needs.

References

NPS (2003) *Final Environmental Impact Statement: Glacier Bay National Park and Preserve, Alaska, Vessel Quotas and Operating Requirements.* National Park Service Glacier Bay National Park and Preserve, Alaska, United States Department of the Interior, P.O. Box 140, Gustavus AK 99826-0140.

NPS (2005) Glacier Bay Science Plan

Appendix M
Wrangell-St. Elias National Park and Preserve
(WRST) Management Goal Setting Linked to Assessment Endpoints

This draft has not been reviewed by WRST staff or community members

In this example, the original values protected in a park are reviewed by park management and communities in light of ongoing changes that influence the preservation and use of park resources. Based on the updates, some values can be identified as at risk, and assessment endpoints may be generated to focus research and data integration efforts, consistent with the strategy framework. The following provides a brief look at the logic behind linking park values to protect with assessment endpoints used for the integrated assessment.

The Park

Wrangell-St. Elias National Park and Preserved (WRST) was established and designated wilderness on the 2nd of Dec 1980 under the Alaska National Interest Lands Claim Act (ANILCA). Prior to this the park was proclaimed as Wrangell-St. Elias National Monument on 01 Dec 1978, and designated as a World Heritage Site on the 24th of Oct 1979.

WRST encompasses almost 11,000,000 acres of land in south Alaska and is the largest unit of the National Park Service. WRST sits adjacent to the Canadian border and is contiguous with Canada's Kluane National Park. The two parks together form the largest area of protected land in the world.

The implementing language for the 1978 Monument called for preservation of areas with significant geological, ecological, biological, archeological and historic features, among others. The general language of ANILCA echoes the 1978 proclamation. The specific implementing language in ANILCA for WRST says that the park and preserve shall be managed to *"maintain unimpaired the scenic beauty and quality of high mountain peaks, foothills, glacial systems, lakes, and streams, valleys and coastal landscapes in their natural state; to protect habitat for and populations of, fish and wildlife including but not limited to caribou, brown/grizzly bears, Dall sheep, moose, wolves, trumpeter swans and other waterfowl, and marine mammals; and to provide continued opportunities including reasonable access for mountain climbing, mountaineering and other wilderness recreational activities. Subsistence uses by local residents shall be permitted in the park, where such uses are traditional in accordance with the provisions of title VIII."* General provisions under ANILCA also provide specific language about what is to be preserved for the benefit, use, education and inspiration of future generations.

WRST is one of the most accessible parks in the Alaska Region. The Alaska Highway and the Richardson Highway provide road access to the north and west boundaries of the park while the Glenn Highway provides access from Anchorage. Two rough roads provide access into areas of the park. One, the McCarthy Road (which follows an old railroad bed), runs 60 miles into the southern preserve to the small town of McCarthy and the Kennecott mine and town. The other road, the Nabesna Road, in the northern preserve and 46 miles long, runs to the small village of Nabesna. Access to more remote areas is by small plane, foot and occasionally by pack train. The western boundary roughly follows the Copper River and the eastern boundary is the international border. The far southeastern boundary stretches to the Malaspina Forelands and Yakutat Bay of the Gulf of Alaska. (Summary taken from http://www.wrangell.st.elias.national-park.com/info.htm#est.

Process to Update Goals and Issues

A facilitated four hour meeting was held at WRST NPS headquarters in Copper Center, AK, in September 2005 with the WRST management team. During the session, the team evaluated current legislative goals relative to changes occurring in the park. To encourage discussion, questions asked of participants included: what is your vision of WRST in the future; what key values must be protected in WRST; and what places these values at risk now and in the future? An additional one hour facilitated session was held at a regularly scheduled Subsistence Advisory Council meeting held in Tok, AK September 2005. The summarized results below are offered as a brief case study example to illustrate the process and value of step 1 of the framework. *Staff Time Required*: five hours in group meetings; an additional five hours processing of information by facilitator; one hour review by staff.

Vision for WRST (NPS input for management goals)

- WRST is the largest park in the NPS and has the largest designated wilderness area in the U.S. WRST provides the best unconfined recreational opportunities in the nation, perhaps the world, with outstanding opportunities for solitude and wilderness experience. Conclusion: WRST is the biggest and most untrammeled park in the nation.
- WRST offers unparalleled scenic vistas of mountains, rivers, glaciers, landscape
- WRST provides protection for naturally functioning ecosystems and communities of wildlife, fish, and plant life.
- WRST provides for consumptive use without impairment, including plentiful subsistence harvest for Native and rural residents on the park and preserve, and unrivaled sport hunting and fishing on the preserve, with healthy and abundant populations of desired species such as Dall sheep and burbot fish.
- WRST protects and provides for living native cultures.

NPS and Community Concerns (summary of input)

- WRST is experiencing increasing hunting and subsistence pressures as human populations increase in surrounding communities. Subsistence users are increasingly concerned about local depletions of subsistence species where they hunt along corridors of access (e.g., there are so many hunters in Unit 13 that it’s too crowded; ATVs are going half way up the mountains where they never used to go before; private trespass is becoming a real problem).

- As tourism increases, current air corridors for flight seeing will show increased traffic and alternative routes will likely be used which will decrease wilderness experience because of the wide ranging impact of over flights. As well, wildlife disturbance will increase.
- Climate change impacts are increasing and will likely stress existing populations of wildlife, fish and plant communities. Food availability for certain species may change, displacement of desired subsistence and sport species may occur, reproductive success may be impacted and populations may decline.
- Climate change impacts species locations and influence subsistence take (e.g., in 2005 the weather was so warm that moose moved elsewhere; took caribou instead).
- Species are shifting their location, migration, reproduction in response to climate change, but the federal bureaucracy has fixed hunting and fishing times that are not equally responsive, making subsistence difficult (e.g., sockeye went up the warm waters of the Chilkoot River in December in 2005, geese are leaving earlier). We should use traditional knowledge to help with management
- ATV use is causing impacts, including high erosion in access areas and must be addressed (e.g., location, timing, frequency, potential hardening of high traffic areas).
- Closures in high use hunting, fishing and subsistence areas outside of WRST lead to displacement of commercial and recreational takes that cause local depletions (e.g., King salmon in WRST were taken in high numbers by charter boats during past Kenai closure and king runs have not recovered).
- Pressures to open new roads in the park will increase access and promote local development.
- Community growth in larger towns (e.g., Tok) may reach sufficient size to be labeled urban and local subsistence users will lose rights for subsistence take in the park.
- New cultural way is not working. Young people are not learning to hunt the same. We need more elders involved and to use traditional ways of knowing that see all species together (e.g., "when I see a certain bird, I know it is time to fish-I look at the system and not single species"). When an elder dies, 20 to 50 years or more of knowledge disappears.
- Hunters and tourists from lower 48 show lack of awareness and recognition of local issues. They come for sport or short term visit or job and return south without the stewardship ethic affecting behavior.
- We need to come together to create common understanding and interests to balance what one person wants relative to another. One individual's value can be in conflict with another (e.g., a natural predator may catch what a subsistence user wants to eat, a tourist wants to photograph, and a big game hunter wants to hang on the wall). How much can be sustained?
- We need a balance between trail use and impact on animals.
- How do we get tribal communities involved? Building relationships takes years. We need ways to get elders and young people involved.
- We need public meetings that are open forums for exchange and broader in scope than subsistence council meetings to share ideas and find solutions.

- To know a good system for managing wildlife, we should evaluate management and use 100 years ago to understand how to do it well.
- Influx of people is leading to trash build-up along road system.

Potential Assessment Endpoints
These are samples of potential endpoints that include an entity and important attributes that are measurable. In each case they directly relate to a defined value under founding legislation, and reflect modern concerns.

- Protected Species as listed under ANILCA that represent different aspects of the system (e.g., ungulate, predator, small mammal, nesting bird, subsistence species, fish in natural healthy populations measured by abundance, distribution, reproduction, recruitment.
- Subsistence access and take consistent with pre-1980 abundance
- Open vistas of natural ecosystems free of air pollution, ATV tracks, human structures, debris, and modified landscape
- Wilderness experience as defined by natural sounds, no evidence of human presence (sight, sound, scent), and observable wildlife
- Plant community composition, abundance and distribution in different habitats

Data Needs
Based on these assessment endpoints, suggested data needs (inside NPS and by outside researches in Alaska or outside of Alaska) include but are not limited to the following:

- Protected species life history characteristics and needs: home range, food (trophic web, type, location, seasonality, abundance, access), energetics, predator pressures (including human), disease vectors, birth and death rate, disturbance tolerance, weather and temperature sensitivities and range, reproductive needs
- Animal population estimates
- Subsistence users' annual take with location, species, sex-age, historic and current
- Sport hunter annual take with location, species, sex-age, historic and current
- Fisher annual take with location, species, historic and current
- Current and projected visitor rates by type and use pattern
- Wilderness traveler use patterns
- Mode of access to park, location, transportation means, frequency, purpose
- Frequency, route and duration of tour and other over-flights
- ATV use patterns: locations, frequency, duration, damage, historic and current

Integrated Assessment and Conceptual Models
To conduct an integrated assessment, existing data and best professional judgment are used to create conceptual models of relationships among system variables. In this case it may be of value to create an illustrative conceptual model surrounding the interactions of a subsistence species like caribou, which are hunted by wolves, subsistence users, hunters, and eat forage directly impacted by ATVs, small mammals and climate change. Insofar as fish are used by predators (animal and human) this could influence the take of caribou at different times, and should be considered. All sources of data should be used

(scientific research: past and current; and traditional knowledge: historic and current) to create the conceptual model and compare conclusions. This suggested model would be only one of many conceptual models that can be generated, and then combined into larger more interactive models. By going through this process, insights are frequently made about relationships not previously considered, missing data that are needed, and opportunities to use existing data differently.

Some data under suggested needs will be readily available, other may be available but require assembly, and still other data may need to be collected. By linking assessment endpoints with goals, the integrated assessment is directly responsive to decision needs. The following example for Dall Sheep provides a simple illustration of this selection process. To do this, scientists ask: what must be true in this place to achieve a particular goal.

- Goal: WRST provides protection for naturally functioning ecosystems and communities of wildlife, fish, and plant life.
- Objective: Natural and healthy populations and communities of species
- One species endpoint: Dall sheep abundance, distribution, and recruitment.
- Essential needs of Dall sheep:
    - sufficient forage (type, location, availability, competition)
    - death rate from all sources balanced by birth rate
    - Survival of offspring to reproductive age
    - uncontaminated environment
    - low disease frequency
    - balanced natural and human predator abundance and distribution
    - access to undisturbed natural habitat of sufficient size, type and appropriate location

Other large mammalian species are likely to have the same essential needs and one set of requirements may be generalized. Other species will have different needs (e.g., tundra vegetation will be subject to consumer rates, trampling, changes in water regimes, temperature and so forth). To consider community effects, it is then appropriate to look at the interdependency of large mammal forage and vegetation sensitivities, and build from there, especially where vegetation is dependent on small animal and insect distribution and abundance for nutrient delivery, pollination and other life history needs. The list of species needs above provides a clear set of data needs as well. Selection of data priorities can be determined by comparing the array of assessment endpoints to look for overlap, where one data set will provide insights for more than one endpoint, such as Dall sheep may provide for other ungulates in the park.

Check In With Management

Once assessment endpoints are selected and defined, they should be presented to management and other interested parties to ensure they are considered sufficiently reflective of management goals. Once approval is obtained, the assessment can move forward.