NORTH SLOPE SCIENCE INITIATIVE

A STRATEGY FOR INVENTORY, MONITORING, AND RESEARCH

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May 2005

CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

Alaska's North Slope extends from the crest of the Brooks Range to the Arctic Ocean and from the Canadian border on the east to the Chukchi Sea on the west. It includes the continental shelf and coastal water, flat coastal tundra, undulating foothills, rivers, lakes, and mountain slopes. The area provides important habitat for four caribou herds; is an important production and staging area for migratory birds; provides important ocean and estuarine habitat for marine mammals, migratory birds, and fish; and is vital to Alaska Natives and their communities. Oil fields on land and off the coast of Alaska's North Slope produced about 14 billion barrels (bbl) of crude oil through the end of 2002. North Slope oil has averaged about 20% of U.S. domestic production since 1977, and it currently provides about 11% of annual domestic production of approximately 3.3 billion bbl and 5% of the annual domestic consumption of 7 billion bbl. As much as 20 billion additional bbl of oil could be extracted from the area, if all lands within the North Slope boundaries were open to exploration and development.

Exploration and extraction will continue on the North Slope and expand into areas of the North Slope ecosystem that until now have not been influenced by industrial activity. Even though the residents of Alaska and other states have benefited from oil and gas production on the North Slope, industrial development has had social and environmental costs. Although research and monitoring has been carried out on the North Slope during the past several decades to understand the effects of oil and gas exploration, development, and production, an integrated, comprehensive assessment of those effects is not possible because of the lack of critical long-term data sets. Understanding the nature, extent, and causes of both the benefits and costs is an essential component of effective, long-term decision making about resource management of the North Slope.

The North Slope Science Initiative (NSSI) was formally established in 2004 to develop a science-based program that integrates inventory, monitoring, and research activities to support resource-management decisions on the North Slope of Alaska. NSSI member organizations include Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, National Marine Fisheries Service, Minerals Management Service, U.S. Geological Service, Alaska Department of Natural Resources, Alaska Department of Fish and Game, Arctic Slope Regional Corporation, and the North Slope Borough. The NSSI provides a means to ensure that inventory, monitoring, and research activities are systematically integrated across disciplines and individual projects or programs. The NSSI adopts a strategic framework to provide natural resource managers with the data and analyses they need to evaluate multiple simultaneous goals and objectives related to land stewardship and legislative mandates for energy resource exploration and development on the North Slope. The NSSI will utilize and complement the information produced under other North Slope science programs, where appropriate. The NSSI also provides a strategy in which information sharing can occur among agencies, non-governmental organizations, industry, academia, and members of the public to increase communication and reduce redundancy among science programs.

GOAL AND OBJECTIVES

The goal of the NSSI is to enhance the quality and quantity of the scientific information available for aquatic, terrestrial, and marine environments on the North Slope and to make this information available to decision-makers, governmental agencies, industry, and the public. This goal will be accomplished through a coordinated and integrated approach to conducting inventory, monitoring and research activities on the North Slope. Science based decisions are essential to managing development in concert with protection of the environment.

To support this goal, the primary objectives of the NSSI include:

- Develop an understanding of informational needs for regulatory and land management agencies, local governments, and the public;

- Identify and prioritize informational needs for inventory, monitoring, and research activities to address the impacts of past, ongoing, and anticipated developmental activities on the North Slope;

- Coordinate ongoing and future inventory, monitoring, and research activities to minimize duplication of effort, share financial resources and expertise, and assure the collection of high-quality information;

- Identify priority informational needs not addressed by existing agency science programs, and develop a funding strategy to address those needs;

- Maintain and improve public and agency access to accumulated and ongoing research and to contemporary traditional and local knowledge; and

- Ensure, through appropriate peer review, that the science conducted under the oversight of the NSSI and by participating NSSI agencies and organizations is of the highest technical quality.

The NSSI science strategy, described in this report, identifies an overall framework to guide the development of inventory, monitoring, and research activities on the North Slope. It is one part of the overall NSSI, and guides identification and implementation of scientific activities that will support resource-management decisions. The primary audience for this science strategy is the NSSI Executive Director and Oversight Group, but it also provides important direction and context for the NSSI Science Technical Group, members of the public, and other stakeholders.

SCOPE

While several arctic research institutions and organizations exist, the NSSI differs from those by serving a specific niche in arctic research. NSSI supports applied inventorying, monitoring, and research programs focused on the effects of developments at both the local and landscape level on the North Slope. The NSSI will improve the understanding of North Slope terrestrial, aquatic, and near-shore marine ecosystem dynamics and enhance the ability to

forecast and respond to the effects of natural and anthropogenic change on the basis of a scientific understanding of causal relationships. NSSI investigations will focus on developing an understanding of the effects of human decisions and actions (particularly, resource-development decisions) on North Slope resources.

IDENTIFYING INVENTORY, MONITORING, AND RESEARCH PROJECTS

To be effective, the NSSI program must be able to identify and prioritize topical areas for further study from a very broad set of possible topics. The NSSI will use a system-based conceptual framework to select North Slope natural and anthropogenic attributes that will be the subject of inventory, monitoring, and research projects. The framework involves a careful examination of interactions between system elements (drivers and receptors) and their position within a system hierarchy consisting of the following levels of increasing complexity: populations, communities, ecosystem processes, landscape patterns, and human systems. The system-based framework ensures consideration of how resource-development actions affect the North Slope as a system of interrelated components. Hierarchical levels capture relevant phenomena at several temporal and spatial scales.

The process to identify NSSI inventory, monitoring, and research projects includes: (1) identifying and prioritizing resource management issues and associated activities; (2) identifying and prioritizing drivers that affect resources; (3) identifying and prioritizing the receptors affected by drivers; and (4) determining the measurement endpoints for each of the driver-receptor interactions.

Setting issue priorities for the NSSI will require extensive communication and interaction with stakeholders and other science programs on the North Slope. Participating NSSI agencies and organizations will initiate the process of defining priorities for inventory, monitoring, and research projects by providing a clear statement of resource-management responsibilities, associated development actions, and likely development scenarios. Topical areas of interest to several agencies or stakeholders may be given higher priority than those applicable to only one or a few.

Important North Slope receptors are those natural and human attributes that (1) reflect the social and cultural values of North Slope communities, (2) define natural conditions valued by society or that are critical to human welfare and economic conditions, or (3) are elements of essential ecological or human system functions. Drivers, which may affect surface resources or sociocultural systems, can be both "natural" or human caused. Natural drivers can be either abiotic (climate, permafrost, offshore, coastal erosion, etc.) or biotic (predation, plant community distribution, insect harassment, etc. Anthropocentric drivers might include hunting pressures, traditional land uses, winter exploration activities, etc. When considering affects of drivers on receptors, it is helpful to define the spatial and temporal zone of impact of developmental activities. Environmental and human attributes (receptors) are potentially "at-risk" when they fall within a specific zone of impact. The zone of impact includes the geographic extent (impact zone) and the time span of individual activities on the North Slope is an essential component of the NSSI program. The potential zone of influence of an action is a function of both the nature of the action and associated disturbances and the response to the disturbance.

Conceptual models can be useful tools for identifying relationships between drivers and important receptors and for prioritizing those linkages that should be subjects for inventory, monitoring, and research. Development of conceptual models for the NSSI will require input from subject experts (both from within and outside of resource-management agencies) and other stakeholders. Models can be developed in a workshop or other collaborative setting. Well-constructed models will help identify the spatial and temporal scales at which data should be collected, the strength of relationships, existing data, ongoing programs addressing relationships, and data gaps. Conceptual models should be treated as hypotheses subject to testing via monitoring and research data, and are refined as data are collected and analyzed using an adaptive management process.

DATA ISSUES

The NSSI provides a unique opportunity to catalog and evaluate data requirements for inventory, monitoring and research directed at resource management issues across the North Slope. The development of data requirements will be based on a number of factors: (1) hypothesis development and experimental design, (2) exploratory studies of very large data sets (e.g., remote sensing data), (3) monitoring to support resource management decision-making, (4) partnerships with other research programs, (5) agency mandates and requirements, and (6) public participation and recommendation from workshops.

The NSSI will conduct its activities in a coordinated manner that recognizes that all information must be developed and utilized to reflect the context of the resource management issue or specific inventory, monitoring, or research project. Data protocols and collection must be developed within the context of a conceptual model that explicitly recognizes specific resource management decisions, such as, mitigation actions, the potential for adaptive management in response to new information, or the long-term data collection of animal population parameters under control and experimental conditions.

Much of the existing data for the North Slope is available in Geographic Information System (GIS) databases maintained by federal, state, university, nonprofit research organizations, industry, and local government agencies who conduct resource management and/or resource development programs or maintain spatial databases for ongoing research projects. Currently, there is no standard GIS system for the North Slope. Access to the varied systems now available requires in-depth knowledge of many different programs: a task that hinders information sharing among North Slope researchers and resource managers. A key priority of the NSSI program will be the development and implementation of a North Slope GIS database that allows current spatial data to be captured under the "umbrella" of the NSSI data system and encourages new information to meet NSSI spatial data standards.

For many NSSI investigations, developing correlations of driver-receptor interactions must include the recognition of possible confounding factors introduced by other natural and human forces. Clearly, any studies to determine driver effects will need to utilize rigorous statistical approaches that include, as appropriate, control and treatment areas, random samples,

repeated measures, and adequate sample sizes. Trend analyses may have to be used to determine cause and effect when control areas cannot be reasonably assigned and, in general, to examine temporal effects.

Examining development issues on the North Slope may not always be suited to a standard experimental approach, and it may not always be possible to establish direct cause-and-effect relationships. However, uncertainties can be reduced by: (1) maximizing statistical approaches that can capture levels of significance, (2) designing control for major confounding factors, and (3) for confounding factors that remain, directly analyzing whether they could explain the findings and, if so, quantifying the strength of that relationship. Statistical power can be gained by using (1) large sample sizes, (2) data gathered over large areas (landscape-scale studies), (3) studies conducted over multiple but similar regions, (4) studies conducted with multiple species that focus on only one driver, (5) selecting receptors without a priori knowledge of changes to minimize sample bias, and (6) conducting long-term monitoring to gain evidence from trend analysis.

In addition to statistics and study designs, data quality objectives must be developed for all inventory, monitoring, and research activities conducted under the NSSI. The scientific credibility of the NSSI and resulting inventory, monitoring, and research efforts will depend on following strict state-of-the-art protocols.

Decisions related to resource management rely on information that contains an element of uncertainty. Uncertainty can be a natural component of the system (e.g., biological variability, such as population fluctuations) or related to the quality or type of information available to a decision maker (e.g., sampling issues or model error). Recognizing that uncertainty is present in any resource-management decision provides the incentive to incorporate an adaptive-management approach that allows new information to be incorporated into management actions and provides for an experimental approach to specifically test uncertainties.

Alaska Native traditional and local ecological knowledge (TEK) holds a vast store of information about the North Slope environment and its relationship to human welfare. This information can provide critical ecological and natural history baseline data for NSSI studies and insight into potential effects of development on natural, cultural, and social environments. The NSSI will emphasize the collection and application of TEK to resource-management decisions. In addition, the NSSI will follow established guidelines for the conduct of research in the Arctic. These guidelines remind researchers that they have an ethical responsibility to conduct work in the Arctic that respects the people living in the North, their culture, and their environment.

The NSSI program will require a method to share and disseminate information among agency participants, the scientific community, and the public. It will be necessary to design and implement an information system that can accommodate a wide variety of information types, including spatial data, inventory and monitoring results, and traditional knowledge. The system will be robust and transparent to all users with a minimum of bureaucratic constraints. The system will embrace a broad user community and adhere to standard data quality procedures including the use of metadata (data about the data). The development of an NSSI information-sharing system will be coordinated with other data-management programs operating on the North

Slope. The NSSI system must be able to serve a wide variety of data, including traditional and local knowledge, industry data, gray literature, and peer-reviewed science. In addition, the system must use a quality-assurance procedure and data-ownership protocols, and determine the types of information that are useful to resource scientists and decision makers.

PROGRAM IMPLEMENTATION

Successful implementation of any science program requires sound leadership. Program management must ensure that the program stays on track and continues to address the overall goals and objectives of the program over a long period of implementation. Yet it must be able to adapt to new information and changing conditions in a way that does not compromise the overall integrity of the program. Such a structure also ensures that studies are funded in a fair and equitable manner.

Resource-management agencies whose administrative and legal responsibilities include management and stewardship of North Slope resources comprise the member organizations of the NSSI. These agencies have been involved in the formation of the NSSI and will provide direction and input throughout the life of the initiative. Two groups—the North Slope Science Oversight Group (Oversight Group) and the North Slope Science Technical Group (Science Group)—will provide direction and coordination of the work of the NSSI. The work of the Oversight Group and Science Group and the NSSI in general will be supported by an Executive Director with overall responsibility for NSSI management.

An implementation plan will be developed to provide program guidance, develop specific proposal areas and budget priorities, and serve as the business plan for the NSSI. The implementation plan will be drafted by the Executive Director and NSSI staff, based on input provided by the Science Group. It is the primary source of program guidance and review the Science Group provides. It will be updated on an annual basis to reflect changes in priorities, program direction, and information gained from NSSI field activities.

NSSI stakeholders include a variety of agencies, organizations, and members of the public. Agencies with resource-management responsibilities on the North Slope are obviously stakeholders in the NSSI and are responsible for overseeing and funding NSSI activities. Other stakeholders whose participation will be vital to successful completion of NSSI activities include: (1) other Federal agencies; (2) other State agencies; (3) North Slope communities; (4) Alaska Native organizations; (5) non-governmental organizations (including environmental groups and resource conservation groups); (6) academic researchers; (7) the energy industry; and (8) members of the public from both inside and outside of Alaska.

By its nature, the NSSI is a long-term activity that will require a stable funding source. Monitoring is effective only if conducted over a sufficiently long period of time to capture temporal variability in resource conditions and to separate anthropogenic effects from the effects of natural cycles and stochastic events. A program such as the NSSI that relies on an adaptive-management framework to inform decision making depends on critical, often long-term experiments to address uncertainties, and these require a stable commitment of resources. In

addition, the NSSI will facilitate development of an information-sharing system that will serve a core contingency and associated scientific and stakeholder organizations, and this system will require a stable, long-term commitment of resources.

RECOMMENDATIONS

The NSSI is in its early stages, and a number of important next steps lie ahead for the initiative. A phased, integrated approach will be needed to fully establish the NSSI as the premier science program to address resource-management information needs on the North Slope. An implementation plan will be developed that maps out NSSI activities over time. This plan will provide program guidance, develop specific proposal areas and budget priorities, and serve as the business plan for the NSSI. It will be updated on a periodic basis to reflect changes in priorities, program direction, and information gained from NSSI field activities.

Identification and prioritization of inventory, monitoring, and research projects is the most important first step to be considered in the implementation plan for the NSSI. An initial examination of data availability and information needs was conducted. While this effort was useful, it serves only as a survey (admittedly incomplete) of existing information rather than a comparison of data availability to data needs. Workshop participants identified several key inventory, monitoring, and research areas that should be considered by the NSSI.

The Research and Monitoring Team (RMT), charged with developing a monitoring program for the NPR-A, is further along in identifying and prioritizing projects than is the NSSI. The NSSI will capitalize on the work already performed by the RMT and consider use of the "issue areas" and conceptual models of the RMT as a starting point.

The desired characteristics of the NSSI information-sharing system is the second priority of the NSSI. Early establishment of the system will ensure that existing data are considered when NSSI inventory, monitoring, and research projects are identified. This information-sharing system will necessarily evolve as the NSSI evolves. A first-start, which could be useful in the initial planning phase of NSSI activities, is the North Slope web portal (http://www.northslope.org), which serves to identify important NSSI participants and activities.

Data interpretation and decision making will benefit from standardization of data collection methodologies, data collection protocols, and data-quality objectives. The NSSI will look to other agencies that have undertaken such a process for lessons learned and guidance. Currently, there is no standard GIS system for the North Slope and access to the varied systems now available requires in-depth knowledge of many different programs—a task that hinders information sharing among North Slope researchers and resource managers. A key priority of the NSSI program will be the development and implementation of a North Slope GIS data base that allows current spatial data to be captured under the "umbrella" of the NSSI data system and encourages new information to meet NSSI spatial data standards. Traditional knowledge has been used by other agencies on the North Slope, in other parts of Alaska, and elsewhere and these past efforts should be studied to determine their applicability to the NSSI and to provide initial guidance for its use. The effort to establish these data standards will benefit from the NSSI

information-sharing system because comparisons will be possible among similar data sets and the usefulness of different types of data will become apparent.

To be most effective, the NSSI must be able to provide data that are valuable for resource managers over the long term. Inventory, monitoring, and research projects must be chosen now but with forward thinking that not only provides for the information needs of today but also anticipates those of the next several decades. Some adjustment and evolution of the program will be necessary and healthy as new information is collected, interpretations change, and understanding unfolds. With careful planning and active involvement of member agencies and other stakeholders, the NSSI will become and continue to be an important influence on the scientific integrity of resource management on the North Slope.

NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this report.

ABBREVIATIONS

ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
ANCSA	Alaska Native Claims Settlement Act of 1971
ASC	Alaska Science Center
ASRC	Arctic Slope Regional Corporation
BLM	U.S. Bureau of Land Management
NSB	North Slope Borough
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DQO	data quality objective
FACA	Federal Advisory Committee Act
FLPMA	Federal Land Policy Management Act
FWS	U.S. Fish and Wildlife Service
GIS	Geographic Information System
MMS	Minerals Management Service
NAS	National Academy of Sciences
NGO	non-governmental organization
NMFS	National Marine Fisheries Service
NPR-A	Naval Petroleum Reserve-Alaska
NPRPA	Naval Petroleum Reserves Production Act of 1976
NPS	National Park Service
NSSI	North Slope Science Initiative
OCS	Outer Continental Shelf
Oversight Group	North Slope Science Initiative Oversight Group
RMT	Research and Monitoring Team
Science Group	North Slope Science Initiative Science Technical Group
SDSS	spatial decision support system
TEK	traditional and local ecological knowledge
USGS	U.S. Geological Survey

UNITS OF MEASUREMENT

ac	acre(s)
bbl	barrel(s)
cm	centimeter(s)
ºC	degrees Centigrade
ºF	degrees Fahrenheit
ha	hectare(s)
in.	inch(es)
km	kilometer(s)
m^3	cubic meter(s)
mi	mile(s)

NORTH SLOPE SCIENCE INITIATIVE

A STRATEGY FOR INVENTORY, MONITORING, AND RESEARCH

1 INTRODUCTION

Alaska's North Slope extends from the crest of the Brooks Range to the Arctic Ocean and from the Canadian border on the east to the Chukchi Sea on the west (Figure 1; see Appendix A for a brief overview description of the human and natural environment of the North Slope). It includes the continental shelf and coastal waters, flat coastal tundra, undulating foothills, rivers, lakes, and mountain slopes. The area provides important habitat for four caribou herds; is an important production and staging area for migratory birds; provides important ocean and estuarine habitat for marine mammals, migratory birds, and fish; and is vital to Alaska Natives and their communities. Oil fields on land and off the coast of Alaska's North Slope produced about 14 billion barrels (bbl) of crude oil through the end of 2002. North Slope oil has averaged about 20% of U.S. domestic production since 1977, and it currently provides about 11% of annual domestic production of approximately 3.3 billion bbl and 5% of the annual domestic consumption of 7 billion bbl (NAS 2003). As much as 20 billion additional bbl of oil could be extracted from the area, if all lands within the North Slope boundaries were open to exploration and development (Bird and Houseknecht 2002; Bird and Houseknecht 2005). When production of the large reserves of natural gas and coal in the region becomes economically feasible, the strategic and economic importance of the North Slope's hydrocarbon energy resources will be even greater.

The continuation of exploration and extraction on the North Slope will expand industrial activitiy into areas of the North Slope that until now have not been influenced by industrial activity. Even though the residents of Alaska and other states have benefited from oil and gas production on the North Slope, industrial development has had social and environmental costs. Substantial research and monitoring has been carried out on the North Slope during the past several decades to understand the effects of oil and gas exploration, development, and production. Understanding the nature, extent, and causes of both the benefits and costs is an essential component of effective, long-term decision making about resource management of the North Slope.

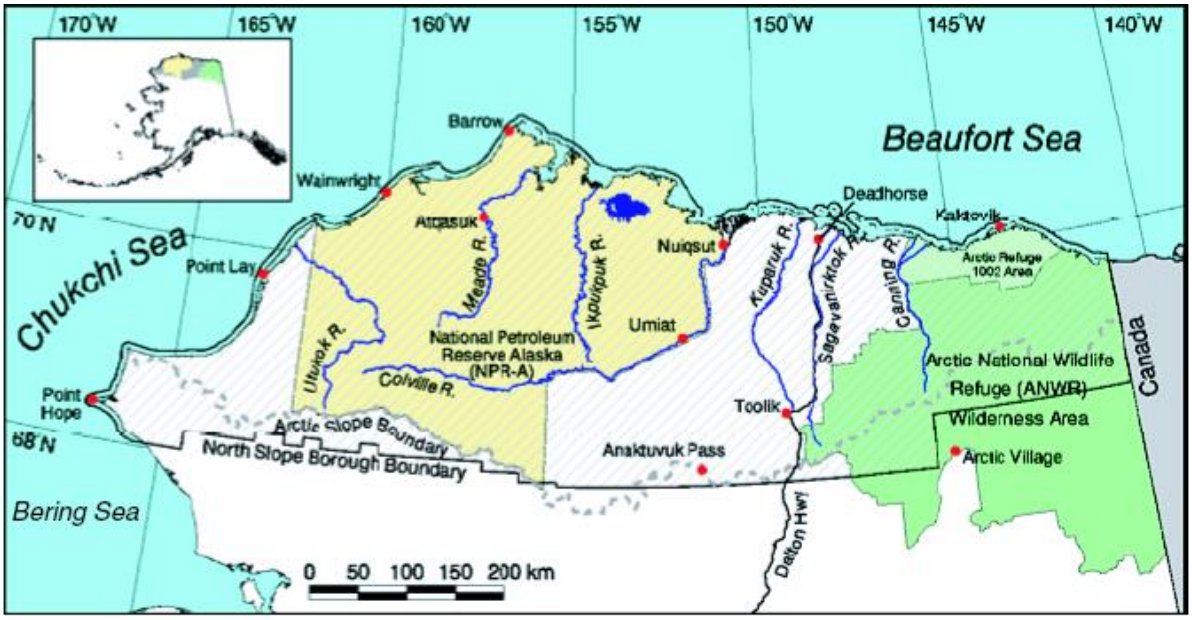

FIGURE 1 North Slope of Alaska (Source NAS 2003)

Decisions regarding where, when, and under what conditions industrial activities are permitted on the North Slope are made by many Federal, State, municipal, and other agencies or entities (Box 1). Decisions generally have been made on a case-by-case basis, without a comprehensive strategy that identifies the scope, intensity, direction, and consequences of industrial activities judged appropriate and desirable.

BOX 1 NSSI Member Organizations

- Bureau of Land Management
- U.S. Fish and Wildlife Service
- National Park Service
- National Marine Fisheries Service
- Minerals Management Service
- Alaska Department of Natural Resources
- Alaska Department of Fish and Game
- Arctic Slope Regional Corporation
- North Slope Borough
- U.S. Geological Survey

Resource-development decisions on the North Slope have relied on mitigation actions to protect natural systems (see Box 2). To ensure defensibility, decisions must be based on information generated through well-designed integrated studies that have examined context and systems connections for specific actions under consideration. A useful inventory program is statistically robust, adequately describes the current status of important resources, and serves as a basis for change detection. Similarly, any monitoring program must be designed to detect changes in resources of concern and clearly identify factors that have produced change. Useful research addresses key questions related to

BOX 2 NSSI Definitions

The NSSI provides a framework to determine the inventory, monitoring, and research needed to support decision making on the North Slope. The following definitions apply:

- ***Inventory:*** Determination of the current status of important resources on the North Slope.
- ***Monitoring:*** Determination of changes in conditions or resources through time.
- ***Research:*** Focused studies to address informational needs.

cause, effect, and relationships. Efficiencies can be gained by integrating these activities across disciplines.

Most ecological studies in the North Slope region have been local, and ecosystem-level research and monitoring largely have been lacking. Climate changes during the past several decades on the North Slope have been unusually rapid. These changes complicate and confound the assessment and isolation of the effects of oil and gas activities on the North Slope. If natural resource managers are to make informed, science-based decisions on future North Slope developments, the nature and extent of undesirable effects likely to accompany future activities must be fully acknowledged and incorporated into regulatory strategies and decision-making. Therefore, it is paramount that natural resource agencies collectively develop and implement a cooperative program to provide the scientific information necessary to address these impacts and to separate these impacts from those caused by other environmental changes.

The North Slope Science Initiative (NSSI) was established to provide direction to and oversight of inventory, monitoring, and research activities conducted on the North Slope by resource agencies (Box 2) to ensure that these activities provide the information needed to make informed decisions that protect natural and human systems while exploration and resource development proceed. This report provides a description of the overall strategy for the development of this science program. Its primary audience is the NSSI Executive Director and Oversight Group, but it also provides important direction and context for the NSSI Science Technical Group, members of the public, and other stakeholders.

BOX 3 NSSI Goal and Objectives

Goal:

To enhance the quality and quantity of the scientific information available for aquatic, terrestrial, and marine environments on the North Slope and make this information available to decision-makers, governmental agencies, industry, and the public.

Objectives:

- Develop an understanding of informational needs for regulatory and land-management agencies, local governments, and the public.
- Identify and prioritize informational needs to address the impacts of past, ongoing, and anticipated development activities on the North Slope.
- Coordinate ongoing and future inventory, monitoring, and research activities.
- Identify priority needs not addressed by existing science programs and develop a funding strategy to meet these needs.
- Maintain and improve public and agency access to accumulated and ongoing research and to contemporary traditional and local knowledge.
- Ensure that the science conducted under the NSSI is of the highest technical quality.

1.1 NSSI GOAL AND OBJECTIVES

The goals and objectives of the NSSI are presented in Box 3. The NSSI provides a means to ensure that inventory, monitoring, and research activities are systematically integrated across disciplines and individual projects or programs. To achieve the objectives of the NSSI, an active adaptive-management framework will be applied that provides natural-resource managers with the data and analyses they need to evaluate multiple simultaneous goals and objectives related to land stewardship and legislative mandates for energy-resource exploration and development on the North Slope. The NSSI will also provide a framework in which information sharing can occur among agencies, non-governmental organizations (NGOs),

industry, academia, and members of the public to increase communication and reduce redundancy among science programs.

The NSSI is not intended to serve as an umbrella program for all science activities on the North Slope. Rather, it is specifically intended to serve the needs of resource managers and decision makers as development-related decisions are made on the North Slope. Properly implemented, the NSSI will provide for long-term, unbiased inventory, monitoring, and research data on the interaction between natural and human systems as related to use and management of North Slope resources.

1.2 DESIRED CHARACTERISTICS OF AN NSSI SCIENCE STRATEGY

The NSSI science strategy identifies an overall framework to guide the development of inventory, monitoring, and research activities on the North Slope. This science strategy was developed in large part by utilizing the guidance provided by the National Research Council to the North Pacific Research Board in their development of their science plan. The science strategy is one part of the overall NSSI, and it guides identification and implementation of scientific activities that will support resource-management decisions. The following elements will contribute to a successful science strategy:

- Clearly defined scientific goals that recognize the needs for ecological modeling, integrated physical and biological monitoring, social and economic studies, and sampling on the wide range of space-time scales that affect the ecosystems of interest;
- Clearly defined program-management policies that provide for a stable funding base and management infrastructure, allow for flexibility in program design and periodic program review, and outline fair and consistent review and grant award procedures;
- An effective data-management and dissemination strategy;
- Coordination with existing programs;
- Development of applications that are useful to decision makers and stakeholders; and
- Recognition of the importance of public interaction, community involvement, and the use of traditional and local knowledge (NAS 2004) .

Development of the NSSI science strategy required input and recommendations on its scope and content. Facilitated workshops were held in January 2004 in Anchorage, Fairbanks, and Barrow to gather this information from stakeholders and interested parties and to begin developing key questions and priority informational needs. The results of this workshop were presented in a workshop summary report (Krummel et al. 2004). Workshop participants provided feedback and information on issues, information, data, and models that are used by agencies, NGOs, academia, industry, and the public. In addition, workshop participants provided ideas on establishing communication with stakeholders and developing roles and responsibilities for agencies and the research community. Workshop participants indicated the following:

- The NSSI should support resource-management decision making. A coordinated program that effectively integrates the needs of State, Federal, and Borough natural resource

agencies would add value by increasing cooperative efforts and providing long-term focus and direction. Because of the number and breadth of ongoing programs, participants suggested that NSSI activities be effectively coordinated with ongoing programs.

- The NSSI science strategy should utilize a conceptual scientific framework. The conceptual framework would clearly delineate the major system phenomena on the North Slope and show how resource-management issues link to these system phenomena. The conceptual framework would define phenomena important to resource managers and also illustrate how the NSSI science program would be integrated with other science programs on the North Slope.

- Species-specific information should be considered in an ecosystem or landscape context to ensure that results of inventory, monitoring, and research projects can be shared, merged, and linked to other projects. Context provides the foundation for effective development of cause-effect relationships.

- NSSI-funded science projects should be conducted at all scales (local, ecosystem, and landscape), depending on the type of factors or issues being considered. Appropriate temporal and spatial scales fundamentally are driven by the nature of the problem that defines a project or program.

1.3 NSSI SCOPE AND RELATIONSHIP TO OTHER SCIENCE PROGRAMS

The NSSI focuses entirely on the inventory, monitoring, and research needed to inform the resource-management decisions of member agencies on the North Slope (Table 1). The NSSI is an applied science program with a very specific niche among the array of science programs relevant to the North Slope (see Appendix B for an incomplete list of other science programs being conducted on the North Slope). The NSSI will utilize and complement the information produced under other North Slope science programs where appropriate. The NSSI, with other science programs relevant to the North Slope, will improve the understanding of North Slope terrestrial, aquatic, and near-shore marine ecosystem dynamics and enhance the ability to forecast and respond to the effects of natural and anthropogenic change on the basis of a scientific understanding of causal relationships. NSSI investigations will focus on developing an understanding of the effects of human decisions and actions (particularly, resource-development decisions) on North Slope resources. Only actions that physically take place on the North Slope and in adjacent waters are considered within the scope of NSSI activities. However, to fully understand the effects of these actions and decisions, it will be important to consider the effects of other factors and influences on the resources of concern (e.g., effects on migratory species in areas of their range outside of the North Slope). These confounding factors must be considered by the NSSI, but will not be the focus of the initiative. Rather, other science programs, either under way or planned, will be relied on to provide that information, where possible.

TABLE 1 Overview of NSSI Member Agency Missions

Agency	Mission
Bureau of Land Management	Collaboratively manage its Alaska lands and its uses on the North Slope to promote healthy and productive ecosystems for present and future generations, in accordance with the Federal Land Policy Management Act (FLPMA) and the Naval Petroleum Reserves Production Act of 1976 (NPRPA). The NPRPA encourages oil and gas leasing in the NPR-A while requiring protection of important surface resources and uses, including any activities related to the protection of environment, fish and wildlife, and historical or scenic values.
U.S. Fish and Wildlife Service	Work with others to conserve, protect, and enhance the fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The FWS manages the Arctic National Wildlife Refuge, and has primary management authority for migratory birds, certain threatened and endangered species, polar bear, and Pacific walrus. The FWS also cooperates with other Federal and State agencies and various industries to minimize the effects of development on fish and wildlife resources.
National Park Service	Preserve the natural and cultural resources and values of the land within the National Park System for the enjoyment, education, and inspiration of this and future generations. NPS cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.
National Marine Fisheries Service	Provide stewardship of living marine resources through science-based conservation and management and the promotion of healthy ecosystems. NMFS provides regulatory oversight of development activities and other actions potentially affecting marine resources.
Minerals Management Service	Manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues. MMS oversees exploration and production of U.S. offshore natural gas, oil, and other mineral resources for safety and environmental soundness.
Alaska Department of Fish and Game	Protect, maintain, and improve the fish and game resources of the State and manage their use and development for the maximum benefit of the people of the State, consistent with sustained yield principles.
Alaska Department of Natural Resources	Develop, conserve, and enhance natural resources for present and future Alaskans. Lead resource-development agency for the State of Alaska.
Arctic Slope Regional Corporation	Represent the Inupiat Eskimos of Alaska's North Slope. The shareholders of ASRC own surface and subsurface title to more than four million acres of North Slope lands, and, therefore, represents the largest private landowner on the North Slope.
North Slope Borough	Help North Slope Borough employees, residents, and other stakeholders work together to transition successfully in changing times. This includes administering planning, zoning, and permitting; managing coastal and wildlife resources with a focus on subsistence; and supporting for the traditional culture of the North Slope.
U.S. Geological Survey	Provide reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. USGS provide scientific leadership and accurate, objective,

	and timely data, information, and research findings about the earth and its flora and fauna to Federal and State resource managers and policy makers, local government, and the public to support sound decision making regarding natural resources, natural hazards, and ecosystems in Alaska and circumpolar regions.

Many science programs on the North Slope are directed at large-scale phenomena such as global climate attributes and change, and a number are directed at marine systems. Studies conducted under these programs may provide useful data to the NSSI on factors that may affect resources of concern to NSSI agencies. Consideration of global climate change and its effects on North Slope resources must be an essential aspect of the NSSI, because without such consideration, interpreting observed changes in resources will be difficult. The NSSI will benefit from establishing relationships with these other science programs and ensuring that data collected are shared and considered when interpreting findings from NSSI inventory, monitoring, and research activities. Chapter 3 outlines key components of a system to allow sharing of data, reports, and other information.

In addition to these science programs, Federal, State, and North Slope Borough (NSB) agencies and organizations, as well as the oil and gas industry, are actively conducting scientific studies on the North Slope. A Research and Monitoring Team (RMT) advises the Bureau of Land Management (BLM) in assessing the effectiveness and appropriateness of mitigation stipulations established in recent Records of Decision for the Northeast and Northwest Naval Petroleum Reserve-Alaska (NPR-A) Environmental Impact Statements (BLM 1998, 2004). The intended outcome is the adaptive management of the NPR-A. The RMT focuses on assessing NPR-A research and monitoring needs, developing and recommending research priorities, and applying improved technology and operating practices to oil and gas exploration and development in the NPR-A. The RMT is comprised of members from resource management agencies (BLM, Minerals Management Service [MMS], U.S. Department of Energy [DOE], U.S. Fish and Wildlife Service [FWS], Alaska Department of Fish and Game, and the U.S. Geological Survey [USGS]), NSB, the oil and gas industry, environmental and conservation organizations, academia, and members of the public. A Subsistence Advisory Panel advises the BLM on how subsistence resources, uses, and users may be impacted by oil and gas exploration and development in the NPR-A.

Issues and indicators being considered by the RMT for future projects include: (1) impacts on suitability of calving habitat, insect relief habitat, herd distribution and movements, and caribou harvest levels by North Slope residents on the Teshepuk and Western Arctic caribou herds; (2) habitat, distribution, behavior, nutritional status, and survival of molting geese; (3) degradation of fish habitats (e.g., dewatering, blocking of movement); (4) alteration of predator/prey relationships; (5) effects of oil and gas activities on endangered species; (6) environmental contaminants resulting from oil and gas activities and hydrocarbon oil spills; (7) change in access to subsistence resources; (8) impact of oil and gas activities on social-cultural systems; (9) effects on cliff-nesting raptor species; and (10) effects of oil and gas activities on migrating bowhead whales during the autumn.

RMT activities and other agency and industry programs have been important in addressing specific informational needs related to ongoing and planned activities and decision making. These activities are most closely related to the NSSI in terms of their objectives and focus. The NSSI will help to ensure coordination among these activities, identify additional informational needs, and help set priorities for inventory, monitoring, and research; thus reducing redundancy and providing focus to these programs to ensure that they effectively address priority informational needs.

2 IDENTIFYING INVENTORY, MONITORING, AND RESEARCH PROJECTS

The NSSI program will identify and prioritize topical areas for further study from a very broad set of possible topics. Investigation of all possible topics would quickly sap the resources available to the NSSI and ultimately would be ineffective in providing the type of scientific information that would be most valuable in informing good decisions. Identification and prioritization of topical areas for inventory, monitoring, and research are critical considerations for the NSSI and require a conceptual framework to guide the process. Stakeholder input into the identification and prioritization of development issues will facilitate consensus building and allow the NSSI to function cooperatively in the context of other North Slope science programs.

BOX 4 Important Components of the NSSI Conceptual Framework

Drivers: the activities or factors that produce (drive) change in an environmental system. Drivers can be anthropogenic or natural in origin. Examples include specific development actions, climate change, and recreational activities.

Receptors: the entities or factors affected by drivers. Examples include vegetation distribution, water runoff patterns, and subsistence harvest patterns.

System hierarchy: organization levels (levels of complexity) for receptors within an environmental system that defines the nature of driver effects. The NSSI uses five hierarchical levels for examination of effect (populations, communities, ecosystem processes, landscape patterns, and human systems).

Populations: individuals of a species in a specific geographic area that interbreed.

Communities: associations of species in a geographic area.

Ecosystem processes: interactions among components of ecological systems (e.g., competition, predation, nutrient and energy transfers, hydrologic cycles).

Landscape patterns: characteristics of an area or region including the distribution of ecological components.

Human systems: all aspects of human populations including socio-cultural attributes, exploitation patterns, and interactions with environmental systems.

The NSSI will use a system-based conceptual framework to select North Slope natural and human attributes that will be the subject of inventory, monitoring, and research projects (Box 4). The framework involves a careful examination of interactions between system elements (drivers and receptors) and their position within a system hierarchy consisting of the following levels of increasing complexity: populations, communities, ecosystem processes, landscape patterns, and human systems.

By encouraging consideration of the drivers associated with resource management activities and the effects of those drivers on different elements of the system hierarchy, the conceptual framework provides methodological rigor to the process of identifying projects to be performed under the NSSI program. The framework ensures consideration of effects at all levels of the system hierarchy rather than the hierarchical levels that typically get the greatest emphasis (e.g., populations). Because of the varied spatial and temporal patterns of resource development across the North Slope, the NSSI must address issues that can simultaneously affect a number of different ecological and human system components. A system hierarchy and its components provide a means to classify and organize simultaneous driver-receptor interactions within an integrated framework (Box 5).

BOX 5 A System Hierarchy as the Conceptual Framework for the NSSI

A system hierarchy can provide assistance in organizing driver-receptor interactions that occur at a number of spatial and temporal scales, some simultaneously. A system hierarchy assists in defining and bounding issues areas, including the relevant system interactions and dynamics (O'Neill et al. 1986, Salthe 1985). For the NSSI, a system hierarchy uses five organizational levels (populations, communities, ecosystem processes, landscape patterns, and human systems) to categorize the relationship between resource management and North Slope natural and human attributes. The potential for a management action or decision to influence one or more hierarchical levels simultaneously (e.g., one action affecting both population and community attributes) can guide the NSSI program to explicitly address multiple system interactions that are all directly relevant to resource management.

A system hierarchy also assists in the development of conceptual models by showing the potential linkages between development actions and potentially affected North Slope attributes. These conceptual models can be useful heuristic devices to communicate NSSI program elements to stakeholders, public, and decision-makers, especially elected officials. The use of a system hierarchy to guide the selection of relevant driver-receptor assessment areas also makes no a priori assumptions about "required" interactions and allows maximum program flexibility and adaptability to changing resource-management issues.

The organizational levels of the system hierarchy provide a method to categorize sets of resource-management actions as these may affect an associated set of environmental attributes. For any resource management action, especially those associated with resource development (e.g., energy exploration and road construction), one can define one or more activities or factors that would affect the North Slope environment and its components. These resource development activities are called *drivers* because they can force change in North Slope attributes by moving attributes to different conditions or states than existed prior to the action of a driver. A North Slope attribute that could be directly affected by a driver is defined as a *receptor*. Using the system hierarchy, all receptors can be mapped to one or more hierarchical levels and specific linkages can be drawn between drivers and associated receptors. Evaluating these driver-receptor interactions is an essential task area under the NSSI program.

The system-based framework also ensures consideration of how resource development actions affect the North Slope as a set of interrelated components. Hierarchical levels capture relevant phenomena at several temporal and spatial scales. By categorizing driver-receptor interactions across the hierarchical levels, clear sets of assessment areas can emerge that capture phenomena of interest for resource management. The use of a system hierarchy provides a general framework that allows the NSSI program to examine how an individual development action and its associated drivers can simultaneously influence one or more natural or human receptors. In addition, a system hierarchy can be used to construct conceptual models that develop the linkages between development and its potential spatial and temporal effects on North Slope natural and human attributes (see Section 2.2).

Figure 2 presents steps and considerations for identifying inventory, monitoring, and research projects for the NSSI using the system-based framework. Table 2 presents examples of various elements of the NSSI framework.

Step 1. Identify Resource Management Issues and Associated Activities

- Identify problems or questions of interest
  - Resource-management responsibilities; decisions to be made
  - Associated development actions; types of activities
  - Development scenarios and plans
- Prioritize problems or questions for further consideration
  - Agency mandates
  - Applicability to multiple agencies or decisions
  - Regulatory requirements
  - Public concern

Step 2. Identify Drivers that Affect Resources

- Identify drivers associated with each high-priority resource-management issue
  - Changes brought about by driver (e.g., land disturbance, disruption of runoff)
- Prioritize drivers for further consideration
  - Commonality among resource issues
  - Dominant effects
  - Regulatory requirements

Step 3. Identify Receptors Affected by Drivers

- Identify receptors at each system hierarchical level as appropriate
  - Resources in project areas
  - Resources in areas affected by drivers outside of project area
  - Resources sensitive to drivers associated with project activities
  - Conceptual model of linkages between drivers and receptors
- Prioritize receptors for further consideration
  - Sensitivity to environmental change
  - Affected by multiple drivers
  - Regulatory requirements
  - Keystone species
  - Important subsistence species or resources
  - Monitoring efficiency
  - Indicators of change
- Select receptors for inventory, monitoring, and research
  - Inventory: need for baseline information
  - Monitoring: tracking change
  - Research: answering of essential questions for understanding

Step 4. Determine Measurement Endpoints

- Identify appropriate variables for quantification
  - Reflect effect of driver on receptor
- Prioritize measurement endpoints
  - Ease of collection
  - Statistical confidence
  - Cost
  - Ability to compare with data collected elsewhere
- Select measurement endpoints for inventory, monitoring, and research
  - Inventory
  - Monitoring
  - Research

FIGURE 2 Process and Considerations to Identify Inventory, Monitoring, and Research Projects for the NSSI

TABLE 2 Examples for Various Elements of the NSSI Framework

NSSI Element	Examples				
Agency Decisions	Leasing, facility locations, road and corridor location, tundra travel, stipulations				
Drivers	Land disturbance, noise, human activity, air emissions, erosion, spills, increased access				
Hierarchical Level	Populations	Communities	Ecological Processes	Landscape Patterns	Human Systems
Receptors	• Demes • Metapopulations • Life stages	• Species associations • Species relationships	• Energy transfers • Nutrient cycling • Hydrologic cycling	• Topography • Vegetation cover • Watersheds • Surface water	• Subsistence • Recreation • Aesthetics • Cultural integrity
Measurement endpoints	• Birth and death rates • Recruitment • Immigration and emigration rates • Age structure • Sex ratio	• Relative importance • Diversity • Predator-prey relationships	• Net primary productivity • Net secondary productivity • Transfer rates • Flow patterns	• Seasonal movement patterns • Species distributions • Patch size • Habitat connectivity • Corridors	• Caribou movement patterns • Road density • Noise level monitoring • Alaska Native employment in energy industry

2.1 IDENTIFICATION OF DRIVERS AND RECEPTORS

A clear statement of resource-management responsibilities, associated development actions, and likely development scenarios initiates the process of defining priorities for inventory, monitoring, and research projects. Topical areas of interest to several agencies or stakeholders may be given higher priority than those applicable to only one or a few. Thus, setting issue priorities for the NSSI may require extensive communication and interaction with stakeholders and other science programs on the North Slope.

Defining the spatial and temporal zone of impact of developmental activities can help locate environmental and human attributes (receptors) potentially "at-risk" when these fall within a specific zone of impact. The potential zone of influence of an action is a function of both the nature of the action and associated disturbances and the response to the disturbance. Defining the geographic extent (impact zone) and the time span of individual activities on the North Slope is an essential component of the NSSI program.

Any project or development scenario will have a wide variety of associated drivers (see Table C-1 in Appendix C), and these drivers must be well defined before a zone of impact and associated receptors can be identified. For a gravel-mining operation, for example, drivers could include surface disturbance, erosion, sedimentation, noise, and human activities. It is important to recognize that the zone of impact can extend well beyond the "footprint" of a project, i.e., that area directly affected by the physical presence of an action (e.g., the area under a building). In addition, the area affected by each driver and the duration of the impact will vary among drivers (e.g., noise effects will have a shorter duration and affect a different area than sedimentation). Often the zones of impact for drivers are not well understood, and the NAS has identified this as an important knowledge gap on the North Slope requiring further research (NAS 2003).

Important North Slope receptors are those natural and human attributes that (1) reflect the social and cultural values of North Slope communities, (2) define natural conditions valued by society or that are critical to human welfare and economic conditions, or (3) are elements of essential ecological or human system functions. Examples of some North Slope receptors are presented in Table C-2 in Appendix C. Many of the receptors on the North Slope are directly related to specific agency resource-management and stewardship missions or activities and are being studied by those agencies. These agencies often have valuable information on their status. The NSSI program is not intended to duplicate agency missions. Rather, by forming agency and stakeholder partnerships, the NSSI provides an opportunity to systematically address driver-receptor interactions that can benefit a number of agencies.

2.2 CONCEPTUAL MODELS

Conceptual models identify relationships or linkages among elements of a system. They are a visual representation (usually a flow, network, or web diagram) that depicts our understanding of how a system functions. Conceptual models can be useful tools for identifying relationships between drivers and important receptors and for prioritizing those linkages that should be subjects for inventory, monitoring, and research (Maddox et al. 1999). Conceptual

models provide heuristic devices to guide researchers toward hypothesis development. Many North Slope science programs utilize conceptual models as bases for identifying subjects for research.

Conceptual models serve resource managers by:

- Articulating important processes and variables;
- Contributing to understanding interactions between ecosystem processes and dynamics by identifying key links between drivers, stressors, and system responses;
- Facilitating selection and justification of monitoring variables;
- Assisting in the evaluation of data from the monitoring program; and
- Communicating dynamic processes to technical and non-technical audiences (Gross 2003).

Development of conceptual models for the NSSI will require input from subject experts (both from within and outside of resource-management agencies) and other stakeholders. They can be developed in a workshop or other collaborative setting. Well-constructed models will help identify the spatial and temporal scales at which data should be collected, the strength of relationships, existing data, ongoing programs addressing relationships, and data gaps. Conceptual models should be treated as hypotheses subject to testing via monitoring and research data, and are refined as data are collected and analyzed using an adaptive management process.

The RMT uses a conceptual modeling approach for developing their monitoring program. They have developed a series of models for each of the issue areas being considered for the program. Figure 3 presents the conceptual model developed for the Teshekpuk caribou herd. Thorough documentation of conceptual models is essential for making the models valuable tools for identifying inventory, monitoring, and research projects. Descriptions of processes by which drivers affect receptors, existing study programs, sources of data, strength of relationships, confidence in the validity of relationships, and levels of variability are a few of the subjects that should be provided with conceptual model documentation.

2.3 SETTING PRIORITIES

An important task of the NSSI is to filter through the rather long list of potential drivers and receptors and identify those considered most important or that could serve as indicators of system change. Clearly, the list of receptors provided in Table C-2, although certainly not comprehensive, would require a large commitment of finances, staff effort, and time to study adequately. As described in Section 2.2, development of a conceptual model is an important first step in setting priorities. Considerations in identifying priorities are presented in Figure 2 and include, but are not limited to:

- Drivers that affect multiple resources,
- Drivers with dominant effects,
- Drivers and receptors that have associated regulatory requirements (e.g., endangered species, marine mammals, wetlands),
- Sensitivity of receptors to environmental change,
- Receptors that are affected by multiple drivers,
- Keystone species,
- Important subsistence species or resources,
- Receptors and drivers that can be studied efficiently, and
- Receptors that are known to be indicators of change.

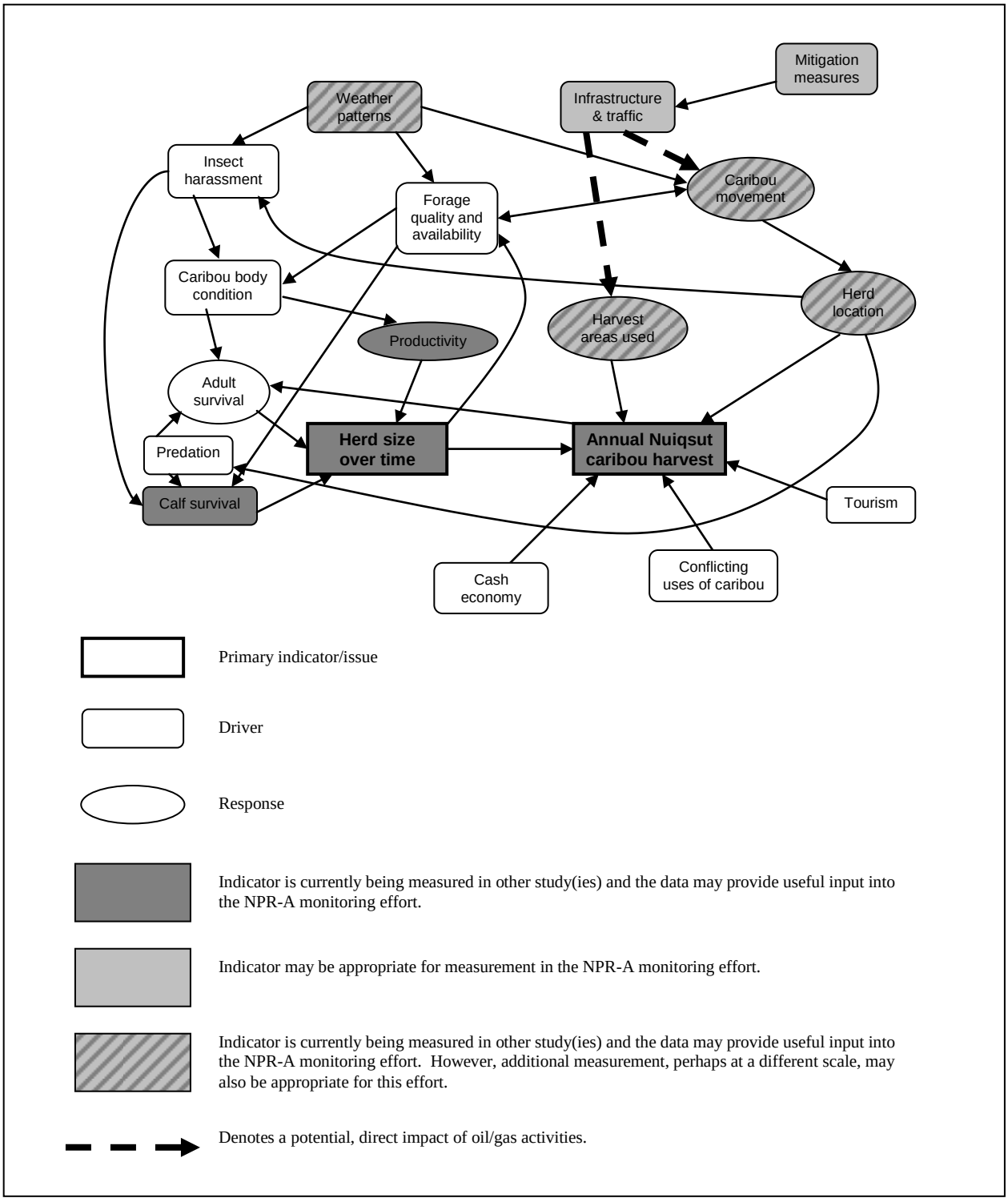

FIGURE 3 Conceptual Model of Drivers Affecting the Teshekpuk Caribou Herd (Source Research and Monitoring Team)

3 STUDY DESIGN AND DATA CONSIDERATIONS

The systematic evaluation of driver-receptor linkages, conceptual models, and measurement endpoints ultimately will lead to a series of study designs and data-collection protocols. Data and results derived from these studies will provide the quantitative information necessary to make informed resource management decisions. The development and use of data within the NSSI program must be accomplished using hypothesis testing, robust experimental designs, and statistically valid analytical methods that withstand rigorous peer review. Many programs and projects are now collecting information on the North Slope systems, and the NSSI must develop procedures to share information with these other science endeavors.

3.1 EXPLORATORY ANALYSIS AND HYPOTHESIS TESTING

It is likely that the some of the funding within the NSSI program will be used to conduct exploratory analyses that seek to derive patterns and information from large and complex data sets (e.g., surface hydrology from high resolution digital terrain data or vegetation change from satellite sensor data). Other NSSI studies will develop experimental designs appropriate for the hypothesis testing using statistical analysis of control and experiment data sets. Both exploratory analyses and data derived from experimental designs will yield new insights on how resource development affects North Slope natural systems.

Exploratory analyses are likely to complement and assist in developing hypotheses suitable for well-developed experimental designs and statistical evaluation. Well-developed experimental designs can be used to test null hypotheses on the effectiveness of various mitigation strategies and potential remediation approaches. For example, effective remediation will require control and experimental plots that evaluate plant species mix, soil amendments, and natural versus managed plant succession rates. In addition, it is entirely possible to conduct experimental manipulations of infrastructure development activities (e.g., noise levels, vegetation disturbance) that will allow researchers to more closely control key variables and parameters. The NSSI provides an opportunity to develop a set of questions that can poised to the research community who can, in turn, develop testable hypotheses and experimental approaches.

Some example issues that are suitable to hypothesis development and experimental testing include:

- Construction disturbance and bird nesting patterns and/or reproductive success rates,
- Culvert design (and placement) and surface runoff,
- Remediation and reclamation of unneeded infrastructure,
- Surface travel and tundra protection, and
- Zones of influence from infrastructure development.

A clear statement of resource-management responsibilities, associated development actions, and likely development scenarios initiates the process of defining hypotheses for

inventory, monitoring, and research projects. Topical areas of interest to several agencies or stakeholders may be given higher priority than those applicable to only one or a few. Thus, setting issue priorities for the NSSI will require extensive communication and interaction with stakeholders and other science programs on the North Slope. Table 3 lists some of the issue areas developed by the NSSI member organizations that could serve as a basis to develop program hypotheses that could be used to develop long-term experiments and robust statistical analysis.

Many of the largest projects and activities on the North Slope are related to energy exploration, development, and production (NAS 2003). These projects or activities can be subdivided into specific sets of activities that directly or indirectly alter environmental attributes of the North Slope. Indeed, while major resource-development issues capture headlines and public attention, scientific inquiry requires parsing the developmental issue into small pieces suitable for measurement and hypothesis testing. For example, leasing decisions lead to a number of activities, including exploratory well development, seismic surveys, and the construction of facilities. From each activity, one can define a specific disturbance or perturbation (e.g., tundra travel, pad construction, and gravel mining).

3.2 IDENTIFYING INFORMATION AND DATA NEEDS

The NSSI program provides a unique opportunity to catalog and evaluate data requirements for inventory, monitoring, and research directed at resource management issues across the North Slope. The development of data requirements will be based on a number of factors:

- Agency mandates and requirements,
- Monitoring to support resource management decision-making,
- Partnerships with other research programs,
- Exploratory studies of very large data sets (e.g., remote sensing data),
- Hypothesis development and experimental design, and
- Public participation and recommendations.

TABLE 3 Issue Areas Identified by NSSI Member Agencies Relative to North Slope Resource Development and Management Decisions

Informational Needs

Inventory

- Baseline contaminant levels in many North Slope species including those used by subsistence hunters and fishermen.
- Information on salmon populations on the North Slope including the relative numbers of fish and the distribution of spawning fish.
- Good hydrologic information for use in designing infrastructure including several years of data during spring break-up.

Monitoring

- Effects of offshore development and activities on the nearshore marine environment.
- Effects of infrastructure (e.g., pipelines, roads, airstrips) on the distribution, abundance, and fitness of caribou, muskoxen, tundra-nesting birds, waterfowl, overwintering fish, and denning polar bears.
- Effects of water and gravel extraction on overwintering fish and aquatic and riparian communities (including their avian and mammalian components).
- Effects of enhanced human access on fish and wildlife populations.
- Effects of contaminants (including spilled oil), dust, and other "additives" on tundra environments and their components.
- Document and understand the hydrologic changes to tundra, wetlands, riparian, streams, rivers, and coastal habitats.
- An independent technical review of the fish work conducted in the Beaufort relative to the impacts of causeways and the effects of breaching the West Dock and Endicott causeways.
- Impacts of industrial activities and associated development on animal populations (reproduction, calving, age structure).
- Changes in air quality (smoke, particulate, nitrogen, sulfur, metals, organics).
- Contaminant loading from point, regional, and global sources (e.g., persistent organic pollutants, and sulfur and nitrogen from trans-polar Arctic haze).
- Impacts of increased non-point source organic pollutants from motorized sources.
- Effects of noise and light pollution.
- Impacts of industrial development and associated development on invasive and exotic species.

Research

- Restoration techniques to use in Alaska oilfields.
- Cost-effective means to reduce collisions of migratory birds with human structures.
- Improved slopewide habitat classification/mapping technique that would be useful both at the landscape level and the project level.
- Life-history information on many poorly known fish and wildlife species in the Arctic.
- Better understanding of predator-prey relationships on the North Slope and the influences of humans on fox, gull, and raven populations.
- Criteria for establishing opening and closing dates for tundra travel.
- Determination of the options for habitat improvement in oil-field development, abandonment, and reclamation.
- Methodology for collecting and compiling traditional and local knowledge.

It is clear that information and data requirements will not be developed in an ad hoc manner. As stated in Section 2, the NSSI will conduct its activities in a coordinated manner that recognizes that all information must be developed and utilized to reflect the context (system dynamics) of the resource management issue or specific inventory, monitoring, or research project. Data protocols and collection must be developed within the context of a conceptual model that explicitly recognizes specific resource management decisions, such as, mitigation actions, the potential for adaptive management in response to new information, or the long-term data collection of animal population parameters under control and experimental conditions.

The NSSI workshop (Krummel et al 2004) identified a number of spatial data sets, available remote sensing information, and a network of scientific programs that have developed information on North Slope landscapes, vegetation, ecosystem functions, animal populations, subsistence activities, climate change, and oil and gas development activities. It will be critical to the success of the NSSI program to systematically evaluate and prioritize the information available from current and past inventory, monitoring and research for three reasons: (1) maximize integration with past and ongoing programs and projects (partnerships must be developed), (2) benchmark best-in-class inventory, monitoring and research programs that could provide guidance to the NSSI data collection efforts, and (3) begin the process of developing data sharing protocols and information management systems to support NSSI activities.

Much of the existing data for the North Slope is available in Geographic Information System (GIS) databases maintained by federal, state, university, nonprofit research organizations, industry, and local government agencies who conduct resource management and/or resource development programs or maintain spatial databases for ongoing research projects (Krummel et al 2004). This spatial information can be used to construct a baseline status of key physical, biological, and infrastructure attributes that could be made available to the community of organizations that participate in the NSSI program. Currently, there is no standard GIS system for the North Slope and access to the varied systems now available requires in-depth knowledge of many different programs—a task that hinders information sharing among North Slope researchers and resource managers (Krummel et al 2004). A key priority of the NSSI program will be the development and implementation of a North Slope GIS database that allows current spatial data to be captured under the "umbrella" of the NSSI data system and encourages new information to meet NSSI spatial data standards.

3.3 DATA QUALITY

For many NSSI investigations, developing correlations of driver-receptor interactions must include the recognition of possible confounding factors introduced by other natural and human forces. Clearly, any studies to determine driver effects will need to utilize rigorous statistical approaches that include, as appropriate, control and treatment areas, random samples, repeated measures, and adequate sample sizes. Trend analyses may have to be used to determine cause and effect when control areas cannot be reasonably assigned and, in general, to examine temporal effects.

Monitoring studies and some research that relate observed changes in receptors to large-scale perturbations are usually correlational (IPCC 2001). Examining development issues on the North Slope may not always be suited to a standard experimental approach, so direct cause-and-effect relationships cannot be established. However, uncertainties can be reduced by:

- Maximizing statistical approaches that can capture levels of significance,
- Designing control for major confounding factors, and
- For confounding factors that remain, directly analyzing whether they could explain the findings and, if so, quantifying the strength of that relationship.

Statistical power is gained by using:

- Large sample sizes,
- Data gathered over large areas (landscape-scale studies),
- Studies conducted over multiple but similar regions,
- Studies conducted with multiple species that focus on only one driver,
- Selecting receptors without a priori knowledge of changes to minimize sample bias,
- Conducting long-term monitoring to gain evidence from trend analysis.

In addition to statistics and study designs, data quality objectives (DQOs) must be developed for all inventory, monitoring, and research activities conducted under the NSSI. The scientific credibility of the NSSI and resulting inventory, monitoring, and research efforts will depend on following strict state-of-the-art protocols. The DQO process develops a procedure (EPA 2000) that assists investigators in developing proposals and projects plans, especially in the area of potentially expensive and time-consuming data collection. The steps involve:

- Describing the project goal(s) and objective(s),
- Identifying the type of data needed,
- Identifying constraints to data collection,
- Determining the quality of the data needed,
- Determining the quantity of the data needed,
- Describing how, when, and where the data will be obtained,
- Specifying quality assurance and quality control activities to assess the quality performance criteria, and
- Describing methods for data analysis, evaluation, and assessment against the intended use of the data and the quality performance criteria.

By explicitly requiring all researchers to develop DQO plans, the NSSI will provide the scientific community with high-quality information collected under stringent hypotheses testing and quality control oversight.

3.4 ADDRESSING UNCERTAINTY AND ADAPTIVE MANAGEMENT

One of the important aspects of the NSSI is the recognition that decisions related to resource management rely on information that contains an element of uncertainty. Uncertainty can be a natural component of the system (e.g., biological variability, such as population fluctuations) or related to the quality or type of information available to a decision maker (e.g., sampling issues or model error). Recognizing that uncertainty is present in any resource-management decision provides the incentive to incorporate an adaptive-management approach that allows new information to be incorporated into management actions and provides for an experimental approach to be employed to specifically test uncertainties. In the classic use of adaptive management, decisions and actions are taken with the explicit understanding that the collection of new information can be used to alter the decision or modify the implementation of an action. In a regulatory framework, active adaptive management must be clearly supported by all parties to a decision and adequate funding must be made available to support a well-developed research and monitoring program. Since the NSSI is not a regulatory endeavor, adaptive management would be used to address uncertainty and develop inventory, monitoring, and research programs to understand the role of uncertainty in resource management.

The foundation of adaptive management is the use of monitoring to track environmental conditions and research to address cause-effect relationships. For the NSSI, monitoring information will be obtained to examine how measurement endpoints change over time in response to driver-receptor interactions. It is expected that monitoring will be required for a number of phenomena that occur at the population, community, ecosystem, landscape, or human system levels in the system hierarchy. Monitoring programs will be designed to link to other ongoing monitoring on the North Slope, especially those programs that are measuring rates of change in North Slope systems in response to yearly and seasonal temperature changes. Monitoring programs under the NSSI may not explicitly address specific management decisions (that is generally the responsibility of each agency and is considered part of an adaptive-management framework in the NEPA context). However, monitoring will be integral to tracking measurement endpoints that are developed within the NSSI program.

3.5 TRADITIONAL KNOWLEDGE

One research subject that warrants special emphasis by the NSSI program is traditional knowledge (TK), a relatively new focus of applied social science research that strives to document indigenous science as a counterpart to western science, with the ultimate objective being fully-informed decision making by agencies or entities that are responsible for all aspects of environmental management. The field of study that is TK arose from both the anthropological subdiscipline of ethnoscience and the debate over whether indigenous groups practiced self-regulated resource management. In 1993 in Canada, this debate, as well as pressure from the First Nations, resulted in policy changes by the Canadian national government, including the requirement that TK be incorporated into environmental assessment and resource management considerations (Usher 2000). Since that time, discussion about TK has mostly focused on what exactly TK is, how to effectively integrate TK with western science, and the use of TK in land and resource management decisions throughout North America.

Definitions

Traditional Ecological Knowledge (TEK), also referred to as Traditional Environmental Knowledge, is a growing area of study that seeks to document the specialized body of knowledge held by indigenous peoples and tested by way of hundreds, perhaps thousands, of years experience living in and adapting to their environment. The actual definition of TEK—what it is—is dependent upon who you ask. Defined etically, or from an outside perspective such as western science, TEK is shared and agreed upon knowledge based on experience and passed from generation to generation, that is integrated within a community at the cultural level. Defined emically, or from an insiders perspective, TEK is what you need to know and do (practically and spiritually), in order to be a real person. Historically within western science, TEK refers only to those concrete observations about the environment that can be verified, tested and either proved or refuted, following the scientific method.

TK, also referred to as Indigenous Knowledge, and frequently considered synonymous to TEK, is characterized by western science as TEK without the stringent requirement that the information relate to ecology or the environment, per se, and therefore not necessarily be location- or region-specific. Instead, TK could be about technology, such as the best tools to use for a given task; about cosmology, such as creation stories or other aspects about the nature of the universe; or theology, such as knowledge and values acquired through spiritual teaching. For most indigenous peoples there is no disconnect between TEK and TK—the two are the same—and this creates much consternation on the part of the western-science researcher or land manager, in that "spiritual" or abstract knowledge is frequently given in conjunction with concrete or experiential knowledge, resulting in an overall uncertainty by the land manager as to the reliability and usefulness of the information received.

Local Knowledge (LK), when contrasted to TK, represents recent experiences shared by a group or community that have yet to be integrated culturally. In this way, LK can be considered those hypotheses that still need testing and positive correlation before they can truly become "traditional." LK becomes TK when there is a majority consensus, and when it is actively taught to subsequent generations as "the way it is." User knowledge is the direct experience of an individual (or one thing experienced by a group), that, when experienced by others, correlated, and shared through word-of-mouth, becomes local knowledge. One aspect of user knowledge that is consistently integrated into environmental documents in Alaska is what could be termed Issue-Driven Knowledge—or those comments and concerns that are given by individuals, and frequently agreed upon by others (and could therefore be considered local knowledge), that is elicited as part of a meeting, hearing, or workshop about a specific topic or issue.

Methods

NSSI will strive to mandate research methods that are consistent with those used throughout the State of Alaska, and are considered the standard for TK. In addition, NSSI will mandate the use of methods to present TK that are useful to all interested parties. A development of a common data format for TEK will be investigated to facilitate use by scientific, decision-making, and Native communities alike.

Research Methods

The primary research methodology for eliciting TK corresponds to a combination of methods developed from within the field of cultural anthropology—interviewing, mapping, and participant-observation. Interviewing—whether it is individuals or groups of people—can be accomplished in a variety of ways. Structured interviews are those where a list of specific questions are asked of every participant. Unstructured interviews are basically conversations that may begin with a generic question, but ultimately cover a range of topics that follow the whims of the interviewee (i.e., whatever memories or topics come to mind during the course of the conversation). The most useful format for documenting TK is the Semi-structured or Semi-directive interview—where the interviewer compiles a list of topics to be discussed, then begins the interview asking the informant about the topics, making sure to direct the conversation back to the topic(s) of interest should the interview get off-track. All interviews should be recorded, and notes should be taken by the interviewer.

Mapping is an effective tool for eliciting TK, especially TEK, which is usually region or area specific. Mapping consists of using base maps to record information about specific locations, resources types, habitat, spawning or calving areas, harvest areas, and a multitude of other information useful for the environmental manager. Maps have the benefit of providing the informant a visual representation of the landscape, and help remind or direct interviewees to specific places.

Participant-observation consists of the researcher actively participating with the informant in the activity in question. For example, research about the TEK of whitefish in a given community may involve the researcher accompanying the informant to their customary fishing hole. There, the researcher will not only help in the catching of fish, but will also be able to observe this activity taking place. It is usually the case on any given TK research project that all three methods will be utilized by the researcher.

Useful sources of information:

- *Observations on the Utility of the Semi-directive Interview for Documenting Traditional Ecological Knowledge* by Henry P. Huntington, in Arctic, Vol. 51, No. 3 pgs. 237-242.
- *Chief Kerry's Moose: A Guidebook to Land Use and Occupancy Mapping, Research Design and Data Collection* by Terry N. Tobias, a joint publication of the Union of BC Indians and Ecotrust Canada.

TK Data Storage and Presentation

Once information has been collected it must be stored in such a way that allows for its effective use. Most TK interviews are recorded, and frequently, these sound recording are archived at an educational repository, such as the local library or university. Transcripts of interviews are also useful, but it can be cumbersome to weed through pages of text to find information about individual topics.

In recent years, TK information has been successfully compiled into computer databases, making the data accessible to a wide variety of end-users as long as they have a computer. These databases are query-able, in that specific questions or topics can be asked of the information,

making it easy to compile information on specific topics or by specific informants. Other digital media, such as the Project Jukebox listed below, are useful for readily accessing stored information on particular subjects.

Spatial databases that link GIS data to databases containing topical information are currently being developed and may prove extremely useful for TEK research. The goal in this type of application is to have a map of a region whereby various locations can be selected and information pertaining to those locations accessed.

Useful sources of information:

- **Project Jukebox** (http://uaf-db.uaf.edu/Jukebox/PJWeb/pjhome.htm) is an interactive, multi-media computer-based system designed to access oral histories and their associated photographs, maps, and text. The digitized recordings provide rapid access to specific segments of each recording.
- *From Neqa to Tepa: A Database with Traditional Knowledge about the Fish of Bristol Bay and the Northern Alaska Peninsula* available from the US Fish and Wildlife Service, Office of Subsistence Management, Anchorage, Alaska.
- *Exxon Valdez Oil Spill Traditional Ecological Knowledge Database* located on the web at http://www.subsistence.adfg.state.ak.us/geninfo/publctns/askinst.cfm

Community Involvement and Participation

Any aspect of TK, whether research, input regarding a given environmental document (EIS, or Land Use Plan), or advice regarding activity on public lands requires local community involvement. For one, the residents of the local community are the possessors of TK—this information would not exist without them. Partnerships with local community organizations, including Heritage Groups, Tribal Governments, or local or municipal governments with similar missions and goals of the NSSI, are integral to effectively capturing and using TK in the decision-making process.

Useful sources of information:

- *Guidelines for Improved Cooperation between Arctic Researchers and Northern Communities* prepared by the National Science Foundation, Office of Polar Programs, Arctic Sciences Section and the Barrow Arctic Science Consortium.
- *Best Practices on Indigenous Knowledge*, a joint publication of the Management of Social Transformations Programme and the Centre for International Research and Advisory Networks (http://www.unesco.org/most/bpikpub.htm)
- Guidelines for Research, by the Alaska Federation of Natives (http://www.ankn.uaf.edu/afnguide.html)

3.6 ETHICAL CONSIDERATIONS

Guidelines for the conduct of research in the Arctic have been developed by several entities, including the Alaska Federation of Natives, the U.S. Interagency Arctic Research Policy Committee, the National Science Foundation, the International Arctic Sciences Committee and others. These guidelines remind researchers that they have an ethical responsibility to conduct

work in the Arctic that respects the people living in the North, their culture, and their environment. The NSSI endorses the following guidelines which have been compiled from the above sources:

- NSSI researchers will inform appropriate community authorities of planned inventory, monitoring, and research activities on lands and waters used by or occupied by North Slope residents. The researchers will clearly identify the purposes of the studies, goals, time frames, and areas that will be part of the study. The researchers will summarize the techniques that will be used and the probable positive and negative implications and impacts of the research.
- NSSI researchers should consult with and, where applicable, include communities in project planning and implementation. Reasonable opportunities should be provided for the communities to express their interests and to participate in the research. NSSI researchers will incorporate, whenever possible, local and traditional knowledge and experience when formulating study designs and plans.
- NSSI researchers will provide copies of the reports and findings of studies to the local communities, including summaries that clearly explain in non-technical terms what the results might mean to the local community.
- The collection of traditional and local knowledge will always involve the informed consent of all individuals providing such information. In cases where individuals or groups provide information identified as confidential in nature, their anonymity must be guaranteed in both the original use of data and in its deposition for future use.
- NSSI researchers will acknowledge the contributions of the communities and individuals in their reports.

3.7 INFORMATION SHARING

The NSSI program will require a method to share and disseminate information among agency participants, the scientific community, and the public. It will be necessary to design and implement an information system that can accommodate a wide variety of information types, including spatial data, inventory and monitoring results, and traditional knowledge. The system should be robust and transparent to all users with a minimum of bureaucratic constraints. The system should embrace a broad user community and adhere to standard data quality procedures including the use of metadata (data about the data).

An NSSI information system is best referred to as a shared information system rather than a decision-support system. The spatial nature of the initiative demands that GIS play a major role in storing data. However, GIS can provide only rudimentary support for decision making, and more sophisticated methods are often required to address individual problems or decisions. Developing a shared information system will be among the tasks undertaken by the NSSI and will require substantial discussion with user groups, needs, and design analysis, and in-depth proposal development. Presented here are some general considerations for the form of the data-system architecture, how it should be operated (constructed, accessed, and maintained), and how extensions of this system might be used to support the NSSI and its participants.

The development of an NSSI information-sharing system will be coordinated with other data-management programs operating on the North Slope. The coordination will primarily address the need to serve results and data to resource managers. Participants at an NSSI workshop (Krummel et al. 2004) identified numerous and varied ongoing projects and programs now implemented on the North Slope. Many of these projects are not well known by researchers and managers on the North Slope who could benefit from the results or methods. The NSSI will establish connections to current data houses, including agencies, academia, and industry. This is especially important to benchmark best-in-class data-management activities that could be incorporated by the NSSI.

The NSSI shared-information system must be able to serve a wide variety of data, including traditional and local knowledge, industry data, gray literature, and peer-reviewed science. In addition, the system must develop a quality-assurance procedure and data-ownership protocols, and determine the types of information that are useful to resource scientists and decision makers. Table 4 presents desirable characteristics of an information-sharing system identified during the January 2004 NSSI workshops.

The NSSI information system should address the following structural elements:

- The system should use modern enterprise architecture to reflect the organization, processes, interrelationships, and activities of the NSSI and the resource-management agencies who will use the system. The term enterprise architecture refers to a structure that reflects the working operation, including the end users, of the information system. The enterprise architecture should include a cohesive and practical approach that enables the NSSI organization to define and understand its operational requirements, organizational structure, and inventory, monitoring, and research strategies. The enterprise architecture would define the framework for how the proposed software, computing, storage, and networking systems should integrate and operate to meet the changing needs of the NSSI and its capability to support resource-management activities and needs.
- A data warehouse should be a key element of the proposed enterprise architecture structure. The data warehouse should be able to store a number of data types such that complex data queries can be made of all stored data under design considerations of rapid retrieval and maximum search flexibility.
- The NSSI should seek proposals on data-warehouse design and construction. The proposals should address a broad category of applications and technologies for gathering, storing, analyzing, and providing access to data to help organizations make better decisions.
- It should be recognized from the beginning of the design process that numerous spatial decision support systems (SDSS) will reside as applications attached to the larger shared information system, to address specific difficult and complex decisions. By maintaining flexible warehouse design considerations, the NSSI can avoid development of an unwieldy and most likely ineffective decision-support system.

TABLE 4 Some Desirable Attributes of a North Slope Information-Sharing System

General Architecture

- Infrastructure that insures connectivity
- System should be scalable, adaptable, expandable
- Simple robust system
- Single point of entry on one website; links to other agencies
- Enterprise-level capability with 24-7 operation
- Standard connectivity protocol
- Spatial data in GIS format
- Non-spatial data presented as metadata with links to data (Alaska Geospatial Data Clearinghouse could be used as a model)
- Ability to process and query data from a single environment
- Good search (keyword) capability
- Good suite of metadata tools (metadata service used to find data; ESRI metadata explorer)
- Easy and intuitive to access, simple link to data, keyword search, geographic search

Standards

- Disaggregated data needs to be digested to be usable (hard copy data reports)
- Include metadata (document the data collection techniques; FGDC metadata standards for mapping/imagery; use a standard metadata vocabulary to obtain data)
- Consider international standards
- Consider standard data formatting
- Compatibility and communication with other systems
- NSSI should be responsible for setting criteria
- Include data collected under lower or inconsistent standards so as not to lose information, but quality of data should be indicated
- Avoid data "sanitization" and censoring

Quality Assurance

- Retain metadata and publish to determine reliability of the data
- Include data-quality categories in metadata to aid usability (e.g., code data or reports to indicate level of review)
- Should be the responsibility of the scientist or contributor
- Retain control over the integrity of the metadata
- Principal investigator should be responsible for quality assurance and quality control of data and reports
- Ensure data from disparate sources can be made to work synergistically will require much communication

Content

- DEM with area SAR data
- Imagery
- Habitat maps
- Vegetation maps
- Elevation and hydrology
- Species distribution (especially species of special concern)
- Political boundaries
- Snowfall
- Climatological data (or links to it)
- Human activity, infrastructure, subsistence use
- Monitoring stations, stream gauges, etc.

TABLE 4 (Cont.)

Content (Cont.)
• Mineral potential, oil, gas, coal
• Comprehensive metadata
• Data from all final reports
• List available reports and data and how to access them
• Forum for presenting implications of research findings; include links to original publications; explanation of spatial/ temporal scales of data
• Need for consistent datasets
• Store data in most disaggregated form possible so that it can be aggregated later
• Database of who is doing what and contacts
• Traditional knowledge in a database
• Public testimonies
• University of Alaska's archives

Source: Krummel et al. (2004)

The NSSI will develop a clear description of the enterprise architecture that includes details related to how the NSSI information system will function and how it will connect to the data systems of other science programs. In one form, enterprise architecture is a conceptual tool that will assist the NSSI with understanding its set of required activities. It provides a roadmap of the workings of the NSSI information system and is a route planner for mission activities and technology change. The evaluation process spans the planning, organizational, systems, data, and technical divisions of the organization. It can offer a guide to remaining adaptive and responsive to rapid changes.

The design goal of the NSSI shared information system will be to turn large amounts of data and other information into useful accessible information. This will not be reached immediately, but will remain a long-term objective of the NSSI agencies. The primary objective is getting enough of the right information in a timely manner and usable form and analyzing it so that it can have a positive impact on new organizational efforts, routine operations, and decisions.

4 PROGRAM IMPLEMENTATION

A key objective of the NSSI is to enhance coordination among the member's existing science and assessment programs and build consensus on new inventory, monitoring, and research priorities. By implementing a systems framework and active adaptive management, the NSSI should facilitate better integration of results derived from multiple studies. The NSSI will employ accepted peer-review and data quality standards so that NSSI results will be accepted by the general scientific community into the decision-making process. The NSSI will be a dynamic program that will annually seek input on priority inventory, monitoring and research issues required for effective resource management decision-making. The NSSI plans to sponsor public workshops and presentations to seek public input on future planned activities and present progress reports on current activities. As the NSSI develops over the next several years, targeted focus group workshops will be also used to gather further information on key scientific and

operational issues. This section discusses the approach to be used in implementing the work of the NSSI.

4.1 ORGANIZATIONAL STRUCTURE

Resource-management agencies whose purview includes resources of the North Slope comprise the member organizations of the NSSI. These agencies have been involved in the formation of the NSSI and will provide direction and input throughout the life of the initiative. Two groups—the North Slope Science Oversight Group (Oversight Group) and the North Slope Science Technical Group (Science Group)—will provide direction and coordination of the work of the NSSI. Charters have been developed for each of these groups that define roles and responsibilities, as well, as general operational considerations. The work of the Oversight Group and Science Group and the NSSI in general will be overseen by an Executive Director. The Executive Director is responsible for providing managerial guidance and executive oversight for the development and implementation of the NSSI; provides advice and consultation to governmental agencies, scientific and academic institutions, and other interest parties; and coordinates and ensures the integration of science-based activities for the North Slope.

4.2 NSSI OVERSIGHT AND MEMBER ORGANIZATIONS

Activities of the NSSI are directed by an Oversight Group that is composed of Federal, State, and Borough land managers. The Oversight Group consists of the following member agencies with voting privileges: the State Director of BLM; the Regional Directors of the FWS, National Park Service (NPS), National Marine Fisheries Service (NMFS), and the Minerals Management Service (MMS), the U.S. Geological Survey (USGS); the Commissioners of the Alaska Department of Natural Resources (ADNR) and the Alaska Department of Fish and Game (ADFG); the Arctic Slope Regional Corporation (ASRC) President; and the Mayor of the NSB. These are the principal entities at the regional, State, and Federal levels with management responsibilities for public and private lands and minerals; fish, wildlife and habitats on the North Slope. In addition, the Department of Energy (DOE), and the U.S. Arctic Research Commission (USARC) participate in the Oversight Group as advisory agencies on science issues related to the North Slope.

The stated mission of the Oversight Group is to "enhance the quality and quantity of the scientific information available for aquatic, terrestrial, and marine environments on the North Slope and to make this information available to decision makers, governmental agencies, industry, and the public. This mission will be accomplished through a coordinated and integrated approach to conducting inventory, monitoring, and research activities on the North Slope." To accomplish this, the Oversight Group directs and facilitates information gathering and analysis on the North Slope. Specific objectives of the Oversight Group include:

- Developing an understanding of informational needs for regulatory and land management agencies, local governments, and the public;

- Identifying and prioritizing informational needs for inventory, monitoring, and research activities;
- Coordinating ongoing and future inventory, monitoring, and research activities to minimize duplication of effort, share financial resources and expertise, and assure the collection of high-quality information;
- Identifying priority needs not addressed by existing agency science programs and developing a funding strategy to meet these needs;
- Maintaining and improving public and agency access to past and ongoing research and to traditional and local knowledge; and
- Ensuring the technical quality of NSSI scientific activities.

The Oversight Group may establish other ad hoc and standing committees, as considered necessary, and would specify the purpose and duration of each committee. Any committees established would automatically expire upon completion of their assignment. The Oversight Group also will establish a standing staff-level committee composed of one member from each member agency or organization. Committee members would advise their respective Oversight Group members on issues prior to each Oversight Group meeting and will provide assistance to the NSSI Executive Director, as appropriate.

The Oversight Group will meet a minimum of two times per year—once in Anchorage and once in Barrow. Oversight Group meetings will be open to the public and shall provide an opportunity for public comment. The Oversight Group may close meetings on matters pertaining to confidential personnel issues, litigation, confidential information such as archaeological information, and other matters included under applicable State and Federal laws and Borough ordinances. Summaries of key decisions will be posted on the NSSI website. Hard copies will be available upon request.

4.3 NORTH SLOPE SCIENCE TECHNICAL GROUP

The Science Group is a Federal Advisory Committee Act (FACA)-charted committee that provides the Oversight Group and Executive Director with advice and guidance on the implementation of the NSSI. Specifically, the role of the Science Group is to assist in identifying and prioritizing inventory, monitoring, and research needs and provide other scientific advice as requested by the Oversight Group. The Science Group is a key program component of the NSSI and provides the primary conduit for stakeholder and science guidance on issues, projects, program direction, quality assurance (peer review), proposal review, and technical assistance to the Executive Director and the Oversight Group. Because the Science Group is established under a FACA charter, the members of this group are subject to a number of ethical and procedural rules that have been developed to ensure full public accountability (see Appendix D).

The duties of the Science Group are solely advisory to the Oversight Group. The Oversight Group and the Executive Director will give direction to the Science Group regarding priorities for decisions needed for agencies' management. These duties include:

- Advising the Oversight Group on science planning and relevant research and monitoring projects;
- Advising the Oversight Group on scientific information relevant to the Oversight Group's mission;
- Reviewing selected reports to advise the Oversight Group on their content and relevance;
- Advising the Oversight Group on how to ensure that scientific products generated through NSSI activities are of the highest technical quality;
- Reviewing ongoing scientific programs of NSSI member organizations on the North Slope at the request of the member organizations;
- Periodically reviewing the North Slope Science Plan and providing recommendations for changes to the Oversight Group;
- Providing recommendations for proposed NSSI-funded inventory, monitoring, and research activities;
- Providing other scientific advice as requested by the Oversight Group; and
- Coordinating with groups and committees appointed or requested by the Oversight Group to provide science advice, as needed.

While the role of the Science Group is advisory, the work of this group is critical to ensuring that the NSSI develops a long-term culture of quality inventory, monitoring, and research programs that is relevant to resource management. The Science Group will provide a State-wide and national perspective to the NSSI and develop relationships with other science programs on the North Slope. In addition, the Science Group will provide a sounding board for the Executive Director and NSSI staff to assist in the management of the NSSI.

The Science Group will meet as often as necessary to fulfill its responsibilities, taking into consideration time and budget constraints. The Science Group will attempt to operate by consensus; however, recommendations can be made by majority vote. All Science Group meetings will be open to the general public and representatives of the news media.

4.4 STAKEHOLDER INVOLVEMENT

NSSI stakeholders include a variety of agencies, organizations, and members of the public. Agencies with resource-management responsibilities on the North Slope are obviously stakeholders in the NSSI, and, as discussed above, are responsible for overseeing and funding NSSI activities. Other stakeholders whose participation will be vital to successful completion of NSSI activities include: (1) other Federal agencies (i.e., those without resource-management responsibilities on the North Slope); (2) other State agencies; (3) North Slope communities; (4) Alaska Native organizations; (5) NGOs (including environmental groups and resource conservation groups); (6) academic North Slope and Arctic researchers; (7) the oil and gas industry; and (8) members of the public from both inside and outside of Alaska.

Active participation by stakeholders will ensure that the NSSI becomes a respected national program that has the support of elected officials and the general public. A proactive stakeholder participation plan will be developed by the Executive Director that outlines how the NSSI will communicate with stakeholders. Elements of such a plan include:

- A clear statement of the role of stakeholders in the NSSI;
- Development of an NSSI website that disseminates information and provides opportunities for input;
- Regularly scheduled meetings and workshops;
- Communication with the media;
- Development of an e-mail notification system (part of the website design);
- Development of a semiannual newsletter; and
- Notification process for public meetings.

The stakeholder participation plan will be approved by the Oversight Group and made available to the public. The plan will be updated as necessary.

4.5 FUNDING SOURCES

By its nature, the NSSI is a long-term activity that will require a stable funding source. Monitoring is effective only if conducted over a sufficiently long period of time to capture temporal variability in resource conditions and to separate anthropogenic effects from the effects of natural cycles and stochastic events. A program such as the NSSI, which relies on an adaptive-management framework to inform decision making, depends on critical, often long-term experiments to address uncertainties, and these require a stable commitment of resources. In addition, the NSSI will facilitate development of an information-sharing system that will serve a core contingency and associated scientific and stakeholder organizations; this system will require a stable, long-term commitment of resources.

Thus, it will be imperative for the NSSI to develop funding sources that will support projects that could have lifetimes of 25 to 50 years. Because of the extensive energy resources on the North Slope and the value of those resources to the Federal, State, and Alaska Native organizations, the NSSI agencies will seek Congressional and State approval for an annual budget that is obtained from derived directly or indirectly from lease payments, royalties, settlements or other income resulting from oil and gas activities.

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APPENDIX A

HUMAN AND NATURAL ENVIRONMENT OF THE NORTH SLOPE

`HUMAN AND NATURAL ENVIRONMENT OF THE NORTH SLOPE

The North Slope of Alaska is the area of Alaska north of the crest of the Brooks Range that extends from the Chukchi Sea on the west, the Beaufort Sea to the north, and the Canadian border to the east (Figure 1). The North Slope is approximately the size of the State of Minnesota and occupies 230,000 km^2 (89,000 mi^2). It encompasses three ecoregions—the Arctic Coastal Plain, Arctic Foothills, and the Brooks Range (Figure A-1). Each ecoregion has unique environmental characteristics and consequently supports different species complexes and human uses. Descriptions of the North Slope environment and its component parts are to be found in a number of publications (e.g., Gallant et al. 1995; Truett and Johnston 2000; and NAS 2003). A brief overview of the North Slope environment is presented in this chapter as background information and is derived from these major sources.

A.1 PHYSICAL ENVIRONMENT OF THE NORTH SLOPE

The harsh climate of the North Slope is the dominant force shaping its ecological and human systems. It is characterized by very low mean annual temperatures and very low annual precipitation. Daily minimum temperatures average –30°C (–22°F) in winter and 1°C (34°F) in summer. Average daily maximum temperatures are –21°C (–6°F) in winter and 8°C (46°F) in summer. Continuous dark around the winter solstice and continuous light around the summer solstice reduce the amount of within-day temperature fluctuations. Annual precipitation ranges from 12 to 20 cm (5 to 8 in.) in low elevation areas and up to 100 cm (40 in.) in the highest elevations of the Brooks Range.

Terrain varies among the ecoregions of the North Slope. The Arctic Coastal Plain is predominantly flat with a very gradual slope from the Arctic Ocean towards the foothills of the Brooks Range (Arctic Foothills ecoregion). The coastal plain is about 150 km (93 mi) wide just south of Barrow and narrows toward the east. The Arctic Foothills ecoregion is about 50 to 100 km (30 to 60 mi) wide, and consists of broad, rounded east-west trending ridges and mesas with elevations less than 800 m (2,600 ft). The Brooks Range ecoregion features steep, rugged

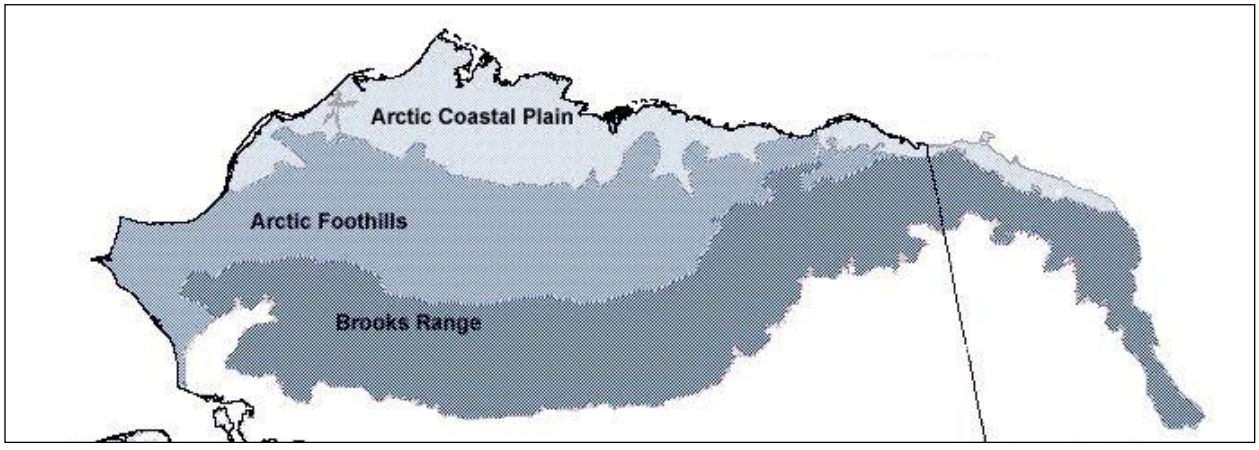

FIGURE A-1 Ecoregions of the North Slope (Source: Nowacki et al. 2001)

mountains with elevations that range from 500 m (1,600 ft) in the lower valleys to 2,400 m (7,900 ft) on the highest peaks.

Surface soils throughout the North Slope remain frozen and snow-covered for most of the year. Permafrost is soil material that remains frozen year-round. On the North Slope, the permafrost layer extends to depths of up to 650 m (2,000 ft). Permafrost is separated from surface layers by an "active layer" that thaws each summer, and which is subject to continuous change. Disruptions of the active layer can result in differential thawing, settling, and loss of strength that creates thaw pits, ponds, and other thermokarst features. Permafrost-related features are common on the landscape and include extensive networks of ice-wedge polygons, thaw lakes, peat ridges, frost boils, and pingos on the coastal plain; pingos, gelifluction lobes, ice-wedge polygons, and beaded drainages in the foothills; and gelifluction lobes, ice-push ridges, polygons, stripes, and circular frost scars in the Brooks Range. Vegetation patterns are strongly influenced by these features.

Surface water is abundant across the North Slope. The Arctic Coastal Plain is very poorly drained as a result of the limited topographic relief and underlying permafrost. About 20 to 50% of the area of the coastal plain is occupied by thaw lakes. Streams tend to be sluggish, meandering to the west of the Colville River and more braided to the east. In the foothills, streams originating in the Brooks Range tend to be swift, but portions may be braided across gravel flats. Spring snowmelt and ice breakup often result in flooding and channel shifting and produce very dynamic systems. Channel shifts produce oxbow lakes, which are the most common type of lake in this ecoregion. In the Brooks Range, streams have a trellis drainage pattern, and extensive alluvial fans form in broad valleys at the base of streams. Lakes in the Brooks Range ecoregion are sparse and occur primarily in rock basins at the mouths of large glaciated valleys and within the floodplains of larger streams.

A.2 ECOLOGICAL RESOURCES OF THE NORTH SLOPE

Vegetation community patterns on the North Slope are strongly affected by topography, climate, and soils. Vegetation communities of the North Slope grade from predominantly wetland communities on the Arctic Coastal Plain to more mesic communities in the Arctic Foothills and Brooks Range (Figure A-2). Still, the three ecoregions share many of the same dominant species.

Vegetation distribution and community patterns on the coastal plain are strongly affected by permafrost conditions and effects on topography and drainage patterns. Poor drainage and abundant surface water typical of the ecoregion favor an abundance of wetland community types largely dominated by grasses and sedges such as *Dupontia fischeri*, *Alopecurus alpinus*, *Carex aquatilis* and *Eriophorum angustifolium*. Slight differences in topography can favor species less tolerant of saturated soil conditions; better drained sites often support dwarf scrub communities dominated by mountain avens (*Dryas integrifolia*), mountain cranberry (*Vaccinium vitis-idaea*), bearberry (*Arctostaphylos alpina*), and willows (*Salix* spp.).

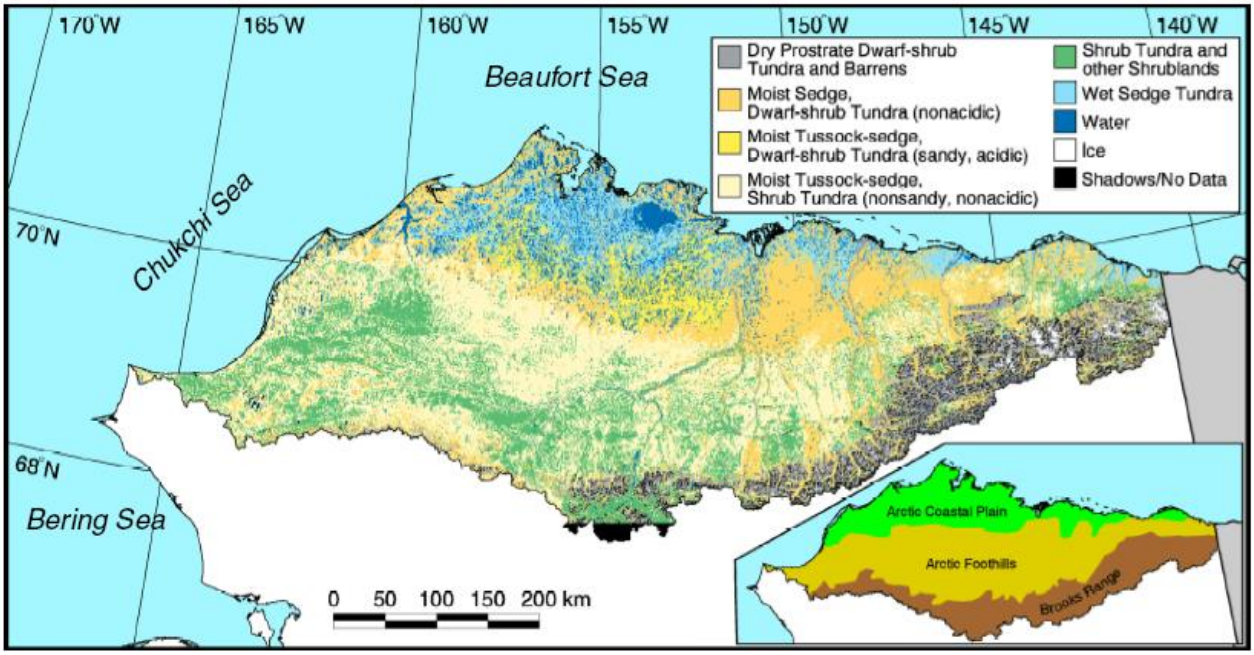

FIGURE A-2 Major Vegetation Communities of the North Slope (Source: NAS 2003)

The Arctic Foothills ecoregion supports vegetation communities that are more characteristic of mesic soil conditions. Sedge-dominated tussocks are common and often support *Eriophorum vaginatum* and *Carex bigelowii*. Intermixed are low shrubs such as dwarf Arctic birch (*Betula nana*), crowberry (*Empetrum nigrum*), Labrador-tea (*Ledum decumbens*), and mountain cranberry. Mosses and lichens occur between tussocks. Dwarf scrub communities are dominated by mountain avens and various species of *Vaccinium* and willows. Scrub communities dominated by alders (*Alnus crispus*) and willows are found along drainages. Forest habitats, dominated by white spruce (*Picea glauca*) and balsam poplar (*Populus balsamifera*), are found only along the terraces of the Noatak River and its tributaries in the western portion of the ecoregion.

Vegetation cover is sparse in the Brook Range, because of the relatively harsher climatic and edaphic conditions, and generally limited to valleys and the lower portions of slopes. Dwarf scrub communities occupy drier sites of this ecoregion, while mesic herbaceous communities dominate wet and mesic sites. Dwarf scrub communities are dominated by many of the same species found in the coastal plain and foothills. Herbaceous species and lichens occur frequently with shrubs. Sedges, willows, and mosses dominate mesic herbaceous communities of the Brooks Range.

The North Slope supports a wide variety and abundance of animal species. While there is some distinction between the animal communities occurring in the three ecoregions of the North Slope, many species occur throughout the entire area. Species can be grouped into the following broad types: invertebrates, freshwater fishes, anadromous fishes, waterbirds, terrestrial birds, herbivorous mammals, and carnivorous mammals.

Freshwater fishes of the North Slope occur further inland than anadromous species. Exclusively freshwater species include Arctic grayling (*Thymallus arcticus*) and ninespine stickleback (*Pungitius pungitius*). These species are widespread on the North Slope and occur in lakes, streams, and rivers of the region and overwinter in the deepest portions of lakes and rivers where the water does not freeze. Several species, including the broad whitefish (*Coregonus nasus*), least cisco (*C. sardinella*), and Dolly Varden (*Salvinellus malma*), are largely freshwater species but range seasonally into brackish or marine waters. Strongly anadromous species include humpback whitefish (*C. pidschian*) and Arctic cisco (*C. autumnalis*). Arctic cisco spawn in the Mackenzie River of Canada, and juveniles are transported by westerly currents into the Beaufort Sea. This species is very abundant in marine waters of the North Slope and is the most important subsistence fish species.

About 240 species of birds use the North Slope for at least a portion of their life cycle. Most of these species (about 180) occur in the area only during the breeding season and winter elsewhere. Waterfowl that regularly breed on the North Slope include tundra swans (*Cygnus columbianus*), brant (*Branta bernicla*), snow geese (*Chen caerulescens*), Canada geese (*B. canadensis*), white-fronted geese (*Anser albifrons*), long-tailed duck (*Clangula hyemalis*), common eiders (*Somateria mollisima*), king eider (*S. spectabilis*), spectacled eider (*S. fischeri*), and Pacific loon (*Gavia pacifica*). The barrier islands, reefs, spits, beaches, and shallow lagoons along the coast provide shelter to thousands of molting birds (e.g., long-tailed duck, eiders, scaup [*Aythya* spp.], and brant) and nesting sites for gulls, eiders, terns, shorebirds, and passerines. Molting areas are critical to the life history of many North Slope species.

The Arctic Coastal Plain is an important breeding area for many species of shorebirds. At least 18 species breed in the Arctic Coastal Plain between the Colville and Canning Rivers, and approximately 20 other species occur as migrants or vagrants. The most common shorebird species that nest in the area are the American golden plover (*Pluvialis squatarola*), black-bellied plover (*P. dominica*), dunlin (*Calidris alpina*), pectoral sandpiper (*C. melanotos*), semipalmated sandpiper (*C. pusilla*), red phalarope (*Phalaropus fulicaria*), and red-necked phalarope (*P. lobatus*). These species nest on tundra habitats.

Herbivorous mammals of the North Slope range in size from small rodents such as lemmings (*Lemmus sibericus* and *Dicrostonyx* spp.) and Arctic ground squirrels (*Spermophilus parryi*), to large ungulates such as caribou (*Rangifer tarandus*), moose (*Alces alces*), and muskox (*Ovibus moschatus*). Small mammals have important impacts on vegetation communities and are important components of the food base of many predators. Caribou can be considered a keystone species on the North Slope because of their important influence on the functioning of terrestrial ecosystems. Four caribou herds occur across the North Slope: the Western Arctic herd, the Teshekpuk Lake herd, the Central Arctic herd, and the Porcupine herd. These herds have distinct calving areas (mostly within 48 km [30 mi] of the coast), but sometimes overlap during certain times of the year. Caribou often wander great distances during seasonal migrations. Generally, the winter ranges for all four herds include the northern foothills of the Brooks Range.

The polar bear (*Ursus maritimus*), brown bear (*Ursus arctos*), wolf (*Canis lupus*), and Arctic fox (*Alopex lagopus*) are the dominant mammalian predators of the North Slope. Polar bears are present year-round and are widely distributed, occurring on land, fast ice, and pack ice.

Polar bears do not hibernate, but are active all winter. Brown bears were uncommon on the North Slope before oil-field development, but have increased at least in part in response to the availability of human waste (Shideler and Hechtel 2000). Arctic foxes are abundant and found throughout the North Slope. They have adapted to human development and are important predators of waterfowl. Wolves are relatively uncommon on the North Slope.

A.3 HUMAN SYSTEMS OF THE NORTH SLOPE

Human occupation and use of the North Slope has persisted for as many as 12,000 years. Alaska Natives continue to occupy and use their traditional lands, maintaining many traditions in social organization, cultural beliefs, and religious activities into the 21st century. It is thought that North Slope Inupiat have occupied the Arctic coastline for 700 or more years. European and American contact with Alaska Natives was driven by the exploitation of resources such as fur, whales, gold, and salmon. Intensive contact generally was local or regional through the late 19th century. Many Alaska Natives continue to live in rural communities that consist largely of Alaska Natives, rely heavily on harvesting available resources for subsistence, and maintain their identity in traditional sociocultural heritage.

The North Slope Borough (NSB) encompasses the human communities of the entire North Slope. Approximately 70% of Borough residents are native Inupiat. Eights communities (Anaktuvuk Pass, Atqasuk, Barrow, Kaktovik, Nuiqsut, Point Hope, Point Lay, and Wainwright) exist within the Borough, and none are connected to each other or the rest of the State by road or to the rest of the State by highway (Figure 1). Barrow is the largest of these communities and supports about 5,000 of the 8,000 Borough residents. Most of the travel on the North Slope is by air, snow machine (winter), or water (summer). A barge travels to Barrow once in late summer to deliver supplies.

Subsistence activities are important to Alaska Native communities of the North Slope. Residents of coastal villages have traditionally depended on marine mammals such as bowhead whales (*Balaena mysticetus*), beluga whales (*Delphinapterus leucas*), walrus (*Odobenus rosmarus*), and seals for food and supplies. Bowhead is the most important of these and represents a unique and powerful aspect of the culture. Caribou, birds, fish, and plants also are valuable subsistence resources. In inland Arctic Alaska (e.g., Anaktuvuk Pass), caribou are the most important subsistence resource, although moose, bear, snowshoe hare (*Lepus americanus*), ground squirrels, ptarmigan (*Lagopus* spp.), and fish are also taken. Many Alaska Natives maintain strong cultural and spiritual ties to the resources, so that disruption of subsistence activities has profound sociological effects.

The discovery of oil at Prudhoe Bay brought major change to human communities of the North Slope. Passage of the Alaska Native Claims Settlement Act in 1971 established the Arctic Slope Regional Corporation and village corporations and led to the founding of the North Slope Borough in 1972. The Borough receives tax revenue from oil and gas facilities and provides for education and a variety of other services and utilities for residents.

The Prudhoe Bay oil field was established in 1968 and began production in 1977. Since then, a number of other producing oil fields have been established, and several more are in the planning stages of development. Development is centered on Prudhoe Bay and extends west into the NPR-A and east towards the Arctic National Wildlife Refuge. Almost all oil development on the North Slope occurs on the Arctic Coastal Plain. Oil-field development has resulted in land disturbance (up to about 9,000 ha, or 22,000 ac) and the creation of an extensive infrastructure including support buildings, gravel pads, roads, air fields, and pipelines. The most significant of these are the Dalton Highway, which connects the Prudhoe Bay oil field to Fairbanks, and the Trans-Alaska Pipeline System, which delivers oil to Prince William Sound. All lands currently used for oil and gas production are leased from the State of Alaska.

A.4 REFERENCES

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APPENDIX B

SCIENTIFIC PROGRAMS AND INSTITUTIONS RELEVANT TO THE NORTH SLOPE

TABLE B-1 Scientific Programs and Institutions Relevant to the North Slope

Program Name	Sponsor Organization	Topical Area	Geographic Scope
Arctic and Subarctic Ocean Fluxes (ASOF)	NSF through ARCSS	Oceanic interactions and the effects on ocean circulation and climate	Global
Arctic Climate Impact Assessment	International Arctic Science Committee, Arctic Council through AMAP	Evaluates and synthesizes climate knowledge	Pan-Arctic
Arctic Climate System Study (ACSYS)	World Climate Research Programme, Norwegian Polar Institute	Climate research	Pan-Arctic
Arctic Data Collection Center (ADCC)	NSF through ARCSS	Clearinghouse of Arctic research data	Pan-Arctic
Arctic Monitoring and Assessment Programme (AMAP)	Arctic Council	Pollutants and their effects on ecosystems	Pan-Arctic
Arctic Research Consortium of the United States (ARCUS)	NSF	Global climate change	Pan-Arctic
Arctic System Science (ARCSS)	NSF through ARCUS	Global change and ecosystems	Pan-Arctic
Arctic Transitions in the Land-Atmosphere System (ATLAS)	NSF through LAII	Climate change and its effect on vegetation	Arctic Slope
Atqasuk Research Center	NSF through BASC	Global change and its effects	North Slope
Barrow Arctic Science Consortium (BASC)	NSF	Sponsors and encourages a wide range of research programs	Alaskan Arctic
Barrow Area Information Database	NSF through BASC	Facilitates the study of the North Slope region	North Slope
Bering Climate	NOAA	Climate, atmosphere, ocean, fishery, biology	Pacific Arctic
Bering Ecosystem Study (BEST)	NSF	Study ecosystem of Bering Sea	Pacific Arctic
Center for Global Change and Arctic System Research	University of Alaska–Fairbanks (UAF)	Global climate change	Pan-Arctic and Subarctic
Cooperative Institute for Arctic Research (CIFAR)	NOAA through UAF	Climate change and its effects	Pacific Arctic
Environmental Studies Program Information System	MMS	Searchable database with various topical studies, scientific and economic	North Slope

Table B-1 (Cont.)

Program Name	Sponsor Organization	Topical Area	Geographic Scope
Feedbacks on Arctic Terrestrial Systems (FATE)	International Arctic Science Committee	Circumpolar fluxes and terrestrial biodiversity	Pan-Arctic
Gulf of Alaska Ecosystem Monitoring and Research Program (GEM)	*Exxon Valdez* Oil Spill Trustee Council	Plan examines and monitors biological and physical components of ecosystem	Gulf of Alaska
High Latitude Dynamics Program	NSF, NOAA, ONR, MMS, PSC at University of Washington (UW)	Studies the physics of high-latitude oceans and its role in climate	Pan-Arctic
Human Aspects of the Arctic System (HARC)	NSF	Initiative to study human dimensions of Arctic system	Pan-Arctic
IASC Pacific Arctic Group (PAG)	International Arctic Science Committee	Climate, contaminants, human dimensions, ecosystem	Pacific Arctic
Integrated Assessment of the Impacts of Climate Variability on the Alaskan North Slope Coastal Region	NSF through HARC, University of Colorado	Climate change and its effect on decision-making processes	North Slope
International Arctic Buoy Programme (IABP)	National Ice Center	Oceanographic and meteorological measurements	Pan-Arctic
International Arctic Research Center	UAF	Climate change	Pan-Arctic
International Tundra Experiment	NSF through LAII	Biological effect of climate change in cold climates	Global
Land-Atmosphere-Ice Interactions (LAII)	NSF through ARCSS	Interactions among components to contribute to an understanding of climate change	Pan-Arctic
National Snow and Ice Data Center (NSIDC)	NOAA, NASA, University of Colorado	Manages various cryospheric studies	Global
North Pacific Research Board	Environmental Improvement and Restoration Fund	Ecosystems and fisheries	Pacific Arctic
Ocean-Atmosphere-Ice Interactions (OAII)	NSF through ARCSS	Marine interactions to contribute to understanding climate change	Pan-Arctic
Ocean-Atmosphere-Sea Ice-Snowpack Interactions Program (OASIS)	NSF	Interactions among various elements and the effects on the Arctic environment	Pan-Arctic
Polar Science Center (PSC)	NOAA, NSF, NASA, UW	Multidisciplinary studies of the Arctic Region, particularly climate	Pan-Arctic

Table B-1 (Cont.)

Program Name	Sponsor Organization	Topical Area	Geographic Scope
Regional, Integrated Monitoring System for the Hydrology of the Pan-Arctic Land Mass	NSF, NASA through NSIDC	Pan-Arctic terrestrial water cycle, monitoring program	Pan-Arctic
Russian-American Initiative on Shelf-Land Environments	NSF through LAII	Climate change	Eurasian and Alaskan Arctic
Study of Environmental Arctic Change (SEARCH)	NOAA, NSF, NASA, DOD, DOI, DOE, PSC at UW	Recent changes in the Arctic	Pan-Arctic
Synthesis, Integration, and Modeling (SIMS)	NSF through ARCSS	Integrates data into models, takes a system focus	Pan-Arctic
Unaami Arctic Data Collection	NSF, NOAA	Climate change in the Arctic, related to SEARCH	Pan-Arctic
Western Arctic Shelf Basin Interactions (SBI)	NSF	Impact of global change on biological, geochemical, physical elements	North Slope
Yukon North Slope Long-term Research and Monitoring Plan	Northwest Territories Wildlife Management Advisory Council	Identifies research and monitoring issues on Yukon North Slope	Yukon North Slope
Yukon North Slope Wildlife Conservation and Management Plan	Northwest Territories Wildlife Management Advisory Council	Reconcile factors affecting the conservation of wildlife, habitat, and traditional native use	Yukon North Slope

APPENDIX C

EXAMPLES OF DRIVERS AND RECEPTORS RELEVANT TO THE NSSI

TABLE C-1 Examples of Anthropogenic and Natural Drivers that May Affect Receptors on the North Slope

Anthropogenic	Natural
1. Oil and gas development • seismic surveys (terrestrial and marine) • gravel extraction • gravel pads • coastal facilities (docks, causeways) • price of oil • human access • dust • road construction/ice-covered roads • human population levels • wildlife disturbance • probability of finding oil and gas • water withdrawal • water injection • habitat loss • wildlife access to habitat • contaminants (air, water, land) • precipitation chemistry • vehicle traffic (aircraft, boat, snowmobiles, other) • pipeline construction • thermokarsting • power lines • access by hunters • changes in technology • scientific activity • garbage/waste • location of hunting and fishing • predator attraction • influx of drugs and alcohol • enhancement of cash economy/affluence • culvert design and placement • national security/funding of projects • artificial nesting structures • habitat fragmentation • habitat disturbance that leads to invasive species • oil spills (terrestrial, aquatic, marine) • loss of wilderness values 2. Transportation • fuels spills • air pollution • culvert design and placement • thermokarsting • vehicle traffic (aircraft, boat, snowmobiles, other)	1. Climate change • temperature • coastal erosion • phenology • precipitation • evapotranspiration • ice cover • successional patterns • fire frequency • increased climate variability • changes in species distribution • snow cover • longer ice-free season • changes in decomposition/CO_2 release • hydrological change • storm frequency • rate of solar insulation (clouds) • degree days • changes in sea ice • thermokarsting 2. Weather variation • Arctic oscillation • floods • snowpack • river/lake/sea ice • freeze-up • break-up • storms • dust 3. Animal population changes • natural variation • trophic interactions • competitive interactions • disease/parasite interaction 4. Natural catastrophes • earthquakes • volcanoes 5. Atmospheric deposition patterns 6. Resource abundance and distribution

Table C-1 (Cont.)

Anthropogenic	Natural
2. Transportation (Cont.) • facilitates secondary developments • barrier to movement • creating new habitat • gravel needs • wildlife disturbance • habituation of wildlife • human access • infrastructure	
3. Tourism/recreation • economic benefits • garbage/waste • wildlife disturbance • human access • development of service sector • cultural conflicts • aesthetic	
4. Urbanization • pressure on buildable land • off-road vehicle use • wildlife disturbance • human access • human population increase • subsistence implications • human health issues • pollution/air/soil/waste • industrial development • crime	
5. Subsistence • use of motorized vehicles • use of modern firearms • changes in traditional subsistence areas • harvest rates	
6. Other factors • changes in resource – economic conditions • climate change • state/national/international public policies • historic contamination (old landfills) • circumpolar economic situation/industrial development (international) • pollution and long-range transport • global energy use patterns • regulatory regimes and resource-agency decisions	

Source: Krummel et al. (2004)

TABLE C-2. Examples of Biological, Physical, and Human Receptors on the North Slope

Biological	Physical	Human
1. Vegetation (vascular and nonvascular) • plant communities as indicator of ecosystem change • successional patterns • rate of green-up • rare plants • barrier islands • riparian areas	1. Air quality • local air patterns • emissions	1. Subsistence use patterns • opportunity as a cultural value
2. Biological communities • species composition • sustainability • migrants • residents • abundance	2. Water quality	2. Community economy • subsistence • jobs • transfer payments
3. Biological processes • food webs • biological controls over productivity	3. Hydrology • break-up • water quantity • lake depth • channelization • watershed • lagoon	3. Recreation, wilderness, tourism • hunting/fishing/other
4. Caribou • population dynamics and productivity • insect relief habitat • calving habitat • distribution	4. Weather patterns and seasonal cycling • Arctic oscillation	4. Economic value of ecosystem services • nonuse values (non-local interests) • use values (non-local interests)
5. Birds • waterfowl • molting concentrations of geese in the Teshekpuk Lake area • nest disturbance • raptors • passerines • shorebirds • loons and other waterbirds • rare and threatened birds	5. Permafrost/active layer soil moisture • change in thermal regime	5. Physical land/marine access
	6. Snow cover and chemistry	6. Infrastructure placement • Teshekpuk Lake
	7. Erosion and deposition • coastal integrity	7. Human ecosystem • health and pollution • human waste disposal
	8. Climate	8. Oil and gas development • leases • landfills • waste • air and water quality
	9. Sea ice	9. Cultural sustainability
	10. Ocean • circulation • productivity	10. Population dynamics/change • changes in a community due to non-migration
	11. Viewshed and landform	11. Cultural and paleontological resources
	12. Noise levels	
	13. Chemical cycling/transfer	
	14. Topography	

Table C-2 (Cont.)

Biological	Physical	Human Dimension
6. Fish • seasonal fish migration • population abundance • overwintering habitat 7. Marine mammals • cetaceans and pinnipeds 8. Aquatic habitats • near-shore • freshwater • overwintering fish habitat • energetic inputs (peat) • marine algae • boulder patch • lagoons 9. Mammalian predators • bear (denning habitat) • wolverines • fox • wolves • polar bears 10. Other wildlife • game/non-game species • small mammals • other ungulates • muskox 11. Aquatic invertebrates • seasonal dynamics • benthic communities • ice-associated zooplankton 12. Microbial community 13. Other invertebrates • parasites • insects 14. Feedback to climate change	15. Geology and soils • gravel resources • paleontological resources • oil reserves • gas • coal • geomorphic processes	12. Education 13. Regional economy 14. Social well-being 15. Non-hydrocarbon development

Source: Krummel et al. (2004)

APPENDIX D

NSSI CHARTERS

NORTH SLOPE SCIENCE INITIATIVE
DEPARTMENT OF THE INTERIOR, STATE OF ALASKA,
ARCTIC SLOPE REGIONAL CORPORATION, AND NORTH SLOPE BOROUGH

CHARTER

NORTH SLOPE SCIENCE OVERSIGHT GROUP

Official Designation: North Slope Science Initiative, North Slope Science Oversight Group (hereafter the Oversight Group).

Background and Need: Alaska's North Slope provides important terrestrial, marine, and estuarine habitat for thousands of migratory birds, caribou, and other terrestrial mammals, marine mammals, and fish, and is culturally important to many Alaska Natives and their communities. Its petroleum resources are vital to the Nation, and it currently provides about 11% of annual domestic oil production. When production of the large reserves of natural gas and coal in the region becomes economically feasible, the strategic and economic importance of the North Slope's hydrocarbon energy resources will be even greater. Past oil and gas activities have impacted habitats, but those impacts have been difficult to measure. It is essential that State, Federal, and North Slope Borough and Arctic Slope Regional Corporation natural resource agencies collectively develop and implement cooperative North Slope-wide inventory, monitoring, and research programs to provide the scientific information necessary to address developmental impacts, and to differentiate these impacts from those caused by natural processes.

Mission: The mission of the Oversight Group is to enhance the quality and quantity of the scientific information available for aquatic, terrestrial, and marine environments on the North Slope and to make this information available to decision makers, governmental agencies, industry, and the public. This mission will be accomplished through a coordinated and integrated approach to conducting inventory, monitoring, and research activities on the North Slope.

Goals: The Oversight Group directs and facilitates a coordinated approach to information gathering and analysis on the North Slope and its associated marine environment, including the integration of contemporary and traditional local knowledge. Specifically, the Oversight Group will:

- Develop an understanding of informational needs for regulatory and land management agencies, local governments, and the public;
- Identify and prioritize informational needs for inventory, monitoring, and research activities to address the impacts of past, ongoing, and anticipated development activities on the North Slope;
- Coordinate ongoing and future inventory, monitoring, and research activities to minimize duplication of effort, share financial resources and expertise, and assure the collection of quality information;
- Identify priority needs not addressed by existing agency science programs, and develop a funding strategy to meet these needs;

- Maintain and improve public and agency access to accumulated and ongoing research, and to contemporary and traditional local knowledge; and
- Ensure through appropriate peer review that the science conducted under the oversight of the NSSI and by participating NSSI agencies and organizations is of the highest technical quality.

Membership: The Oversight Group consists of the following member agencies with voting privileges: the State Director of the Bureau of Land Management; the Regional Directors of the U.S. Fish and Wildlife Service, National Park Service, National Marine Fisheries Service, and the Minerals Management Service; the Commissioners of the Alaska Department of Natural Resources and the Alaska Department of Fish and Game; the Arctic Slope Regional Corporation President; and the Mayor of the North Slope Borough. These agencies represent the principal governmental agencies at the regional, State, and Federal levels with management responsibilities for public lands, fish, and wildlife on the North Slope. In addition, the U.S. Geological Survey and the U.S. Department of Energy will participate on the Oversight Group as the primary advisory agencies on science issues related to the North Slope, but will not have voting privileges.

Summary of Agency Missions and Roles:

A. Federal

1. Bureau of Land Management collaboratively manages its Alaska lands and its uses on the North Slope to promote healthy and productive ecosystems for present and future generations, in accordance with the Federal Land Policy Management Act (FLPMA) and the Naval Petroleum Reserves Production Act of 1976 (NPRPA). The NPRPA encourages oil and gas leasing in the National Petroleum Reserve Alaska (NPR-A), while requiring protection of important surface resources and uses, including any activities related to the protection of environmental, fish and wildlife, and historical or scenic values.

2. U.S. Fish and Wildlife Service is one of the primary natural resource-management agencies on the North Slope. The mission of the Fish and Wildlife Service is to work with others to conserve, protect, and enhance the fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The Fish and Wildlife Service manages the 19 million acre Arctic National Wildlife Refuge in northeast Alaska and has primary management authority for migratory birds, certain threatened and endangered species, polar bear, and Pacific walrus. The Service also cooperates with other Federal and State agencies and various industries to minimize the effects of development on fish and wildlife resources. To accomplish this mission, the Service is involved in a variety of research, monitoring, and management projects on the North Slope and in the adjacent coastal waters of the Beaufort Sea.

3. Minerals Management Service manages the mineral resources located on the Nation's Outer Continental Shelf, collects revenue from the federal OCS and onshore Federal and Indian lands, and distributes those revenues. The MMS Offshore Minerals Management Program administers the OCS competitive leasing program and oversees exploration and production of our Nation's offshore natural gas, oil, and

other mineral resources for safety and environmental soundness. MMS is also responsible for oil spill response reviews for all platforms off the Nation's coasts. MMS funds environmental and technology studies for ocean energy and minerals. The prime laws for the MMS Offshore Program are the Outer Continental Shelf Lands Act and the Oil Pollution Act.

4. National Park Service preserves the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. The Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

5. U.S. Geological Survey serves the Nation as the Department of Interior's lead science agency by providing scientific expertise responsive to important natural resources issues and natural hazards assessments. The mission of the USGS Alaska Science Center (ASC) is to provide scientific leadership and accurate, objective, and timely data, information, and research findings about the earth and its flora and fauna to Federal and State resource managers and policy makers, local government, and the public to support sound decision making regarding natural resources, natural hazards, and ecosystems in Alaska and circumpolar regions. To meet the specific information needs of resource-management agencies for the marine and terrestrial ecosystems of the North Slope of Alaska, the ASC will combine and enhance the Center's diverse science programs, capabilities, and talents with capabilities of USGS from across the nation to strengthen its scientific capacity and contribution to the resolution of the complex natural resource issues associated with change within the North Slope region.

6. NOAA/National Marine Fisheries Service provides stewardship of living marine resources through science-based conservation and management and the promotion of healthy ecosystems. National Oceanic and Atmospheric Administration (NOAA) activities on Alaska's North Slope include consultation and coordination regarding Federal water development projects under the Fish and Wildlife Coordination Act and other laws, consultation regarding Federal actions under the Endangered Species Act, and regulation of small take authorizations under the Marine Mammal Protection Act. Under this program, NOAA issues regulations or Incidental Harassment Authorizations for the unintentional take of small numbers of marine mammals. The authorizations often require monitoring and research to quantify the extent of take and to reduce harmful effects to marine mammals. NOAA also performs research concerning marine mammals under NOAA jurisdiction, including whales and seals. NOAA is especially involved with bowhead whales and whaling, including research, funding/grant work for the Alaska Eskimo Whaling Commission, and staffing for the U.S. delegation to the International Whaling Commission.

7. U.S. Department of Energy seeks to protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy. To tackle our immediate need for oil and gas, the DOE continues to develop and promote technologies that can lower the costs of oil and natural gas exploration and development, maximize the efficiency and stability of America's oil and gas production and supply, and protect the environment. The Department's

research activities are closely coordinated with, and synergistic to, the activities of other Federal agencies including the U.S. Environmental Protection Agency and various branches of the Department of the Interior. DOE recently established the Arctic Energy Office in Fairbanks and is sponsoring numerous research efforts regarding the Alaska North Slope through that office and other DOE programs.

B. State of Alaska

1. Department of Fish and Game protects, maintains, and improves the fish and game resources of the State, and manages their use and development for the maximum benefit of the people of the State, consistent with the sustained yield principle. The Alaska Department of Fish and Game has a responsibility to collect biological information necessary to evaluate land-development activities, present this information to decision makers so they can make informed decisions, and provide options for development activities that will minimize or mitigate negative impacts of development.

2. Department of Natural Resources is the lead resource-development agency for the State of Alaska. Its mission is to develop, conserve, and enhance natural resources for present and future Alaskans. Several divisions in DNR have major responsibilities regarding North Slope developments.

   (a) The Division of Oil and Gas develops and manages the State's oil and gas leasing programs. The division staff identifies prospective lease areas; performs geologic, economic, environmental, and social analyses; develops a five-year leasing schedule; and conducts public review of proposed sales. The division conducts competitive oil and gas lease sales and monitors collection of all funds resulting from its programs.

   (b) The Division of Geological and Geophysical Surveys (DGGS) generates, analyzes, and interprets data on geologic resources and natural conditions and maps and inventories mineral and energy resources on State land for use by government, private industry, scientists, educators, and the public.

   (c) The Division of Mining, Land, and Water is the primary manager of Alaska's land holdings. Responsibilities include ensuring the State's title; preparing land-use plans and easement atlases; classifying land; leasing and permitting State land for commercial and industrial uses; and coordinating needed authorizations for major developments on the North Slope. The division allocates and manages the State's water resources on all lands in Alaska, adjudicates water rights, provides technical hydrologic support, and assures dam safety.

   (d) The Office of Habitat Management and Permitting fulfills specific statutory responsibilities for protecting freshwater anadromous fish habitat under the Anadromous Fish Act and providing free passage of anadromous and resident fish in fresh waterbodies. This office also coordinates positions taken by the State of Alaska on resource-development issues.

   (e) The Office of Project Management and Permitting administers the Alaska Coastal Management Program, which provides stewardship for Alaska's rich and diverse

coastal resources to ensure a healthy and vibrant Alaskan coast that efficiently sustains long-term economic and environmental productivity. It also administers the State of Alaska's Large Project teams responsible for coordinating State agency participation on major resource-development projects throughout Alaska.

C. Arctic Slope Regional Corporation (ASRC)

The ASRC is the Alaska Native-owned regional corporation representing more than nine thousand Inupiat Eskimos of Alaska's North Slope. The shareholders of ASRC own surface and subsurface title to more than four million acres of North Slope lands. By virtue of this title, the ASRC represents the largest private landowner on the North Slope. The ASRC ownership stems from an earlier claim of aboriginal title, covering the entire Alaskan North Slope, that was eventually settled in part by the Alaska Native Claims Settlement Act of 1971 (ANCSA). The mission of ASRC includes actively managing its lands and resources in order to enhance Inupiat cultural and economic freedoms. ASRC is involved with a number of North Slope resource-development activities, and has a variety of subsidiary companies that are active in North Slope resource development and other sectors.

D. North Slope Borough

The North Slope Borough's responsibilities include planning, zoning, and permitting; coastal management; wildlife research with a focus on subsistence; and support for the traditional culture of the North Slope. The Borough's planning and zoning authority through its Home Rule Charter mandates active land use management across Federal, State, Native and municipal lands. The Borough has a coastal management plan and participates in ACMP consistency reviews, stressing the health, safety, and cultural welfare of NSB residents and compliance with environmental policies of local concern. The Borough monitors and conducts scientific research on marine and wildlife resources to ensure healthy population levels and to sustain a continued subsistence harvest for its residents.

All of the Borough's planning and research activities are conducted in part to guarantee strong local input into subsistence resource management, with a special emphasis on the blending of contemporary and traditional local knowledge as a mechanism to sustain the resources and the local indigenous culture.

Officers and Organization

Chair and Vice Chair: The Oversight Group shall designate a Chair and Vice Chair. The Chair shall alternate annually between Federal and non-Federal voting members. The Chair may participate in discussion and debate at the meetings and may vote on all questions before the Oversight Group. The Vice Chair shall assume the responsibilities of the Chair in the event of the Chair's absence. The Vice Chair shall be the Chair Elect for the annual rotation.

Designees: Oversight Group members may appoint designees to act on their behalf in their absence.

Advisory Groups: The Oversight Group may recommend to the Secretary of the Interior the establishment of formal advisory groups, such as the North Slope Science Technical Advisory Group, as appropriate. Charters for any advisory group must be reviewed and approved by the Oversight Group and forwarded to the Secretary of the Interior following the guidance provided by the Federal Advisory Committee Act.

Staffing and Budget: Staffing and budget will be provided through an Interagency Agreement. The Bureau of Land Management will develop and manage the Interagency Agreement. An Executive Director and support staff will report programmatically to the Chair and Vice Chair of the Oversight Group.

Committees: The Oversight Group may establish other ad hoc and standing committees as deemed necessary, and will specify the purpose and duration of each committee. Any ad hoc committees established would automatically expire upon completion of their committee assignment. The Oversight Group will establish a standing staff-level committee composed of one member from each representative Oversight Group member agency or organization. Staff committee members will advise their respective Oversight Group members on issues prior to each Oversight Group meeting, and will provide assistance to the Executive Director of NSSI, as appropriate.

Oversight Group Meetings and Procedures

A. Notice of Meetings: Reserved.

B. Conduct of Meetings: Oversight Group meetings will be open to the public and will be generally conducted according to *Roberts Rules of Order*. The Oversight Group shall provide a reasonable opportunity for public comment.

C. Voting Procedures: A quorum of Oversight Group members, or their designees, shall be convened prior to any voting (a quorum shall consist of at least three Federal members and two non-Federal members). All decisions shall be made by the voting members by consensus. Oversight Group members may participate by telephone or teleconference. The U.S. Geological Survey and U.S. Department of Energy will not have voting privileges. The use of a proxy by voting members is not permitted.

D. Recusal: Oversight Group members may recuse themselves from voting, if necessary to avoid a conflict of interest.

E. Records: Summary of key decisions will be posted on the NSSI website. Hard copies will be available upon request.

F. Closed Meetings (Executive Sessions): The Oversight Group may close meetings on matters pertaining to confidential personnel issues, litigation, confidential information such as archaeological information, and other matters included under applicable State and Federal laws and Borough ordinances.

G. Frequency and Location of Meetings: The Oversight Group will meet a minimum of two times per year—once in Anchorage and once in Barrow.

H. Expenses for Oversight Group: Expenses related to travel, lodging, and per diem for Oversight Group meetings shall be borne by the representatives' respective member agencies.

Availability of Funds: This agreement shall not be construed as a commitment by any Federal agency signatory to expend funds in excess of available appropriations.

SIGNATURE AUTHORITY:

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John Goll Date
Regional Director
Minerals Management Service

_____

Rowan Gould Date
Regional Director
U.S. Fish and Wildlife Service

_____

Marcia Blaszak Date
Regional Director
National Park Service, Alaska Region

_____

James W. Balsiger Date
Administrator, Alaska Region
NOAA / National Marine Fisheries Service

_____

John D. Buffington Date
Regional Director, Western Region
U.S. Geological Survey

_____

Henri Bisson Date
State Director, Alaska State Office
Bureau of Land Management

_____

Rita A. Bajura Date
Director, National Energy Technology Laboratory
U.S. Department of Energy

_____

Tom Irwin Date
Commissioner
Alaska Department of Natural Resources

_____

Kevin C. Duffy Date
Commissioner
Alaska Department of Fish and Game

_____

George N. Ahmaogak Sr. Date
Mayor
North Slope Borough

_____

Jacob Adams Date
President
Arctic Slope Regional Corporation

NORTH SLOPE SCIENCE INITIATIVE
DEPARTMENT OF THE INTERIOR, STATE OF ALASKA, AND NORTH SLOPE BOROUGH

CHARTER

NORTH SLOPE SCIENCE TECHNICAL GROUP

Official Designation: North Slope Science Technical Group (The Science Group).

Scope and Objectives: The purpose of the North Slope Science Technical Group is to advise the North Slope Science Oversight Group on issues such as identifying and prioritizing inventory, monitoring, and research needs, and providing other scientific advice as requested by the Oversight Group.

Duration: The need for the Science Group is expected to continue indefinitely. In accordance with the Federal Advisory Committee Act (FACA), the Science Group will be rechartered every 2 years by the Secretary of the Interior (Secretary).

Agency or Official to Whom the Science Group Reports: The Science Group reports to the Oversight Group through the Secretary's designee who shall serve as the Designated Federal Official of the Science Group.

Bureau Responsible for Providing Necessary Support: Administrative support and funding for activities of the Science Group will be provided by the Bureau of Land Management.

Estimated Annual Operating Costs: The annual operating costs associated with supporting the Science Group's functions are estimated to be $45,000/year plus .5 man years.

Description of Duties: The duties of the Science Group are solely advisory to the Oversight Group; which will give direction to the Science Group regarding priorities for decisions needed for Agencies' management. Duties could include the following:

a. Advise the Oversight Group on science planning and relevant research and monitoring projects;
b. Advise the Oversight Group on scientific information relevant to the Oversight Group's mission;
c. Review selected reports to advise the Oversight Group on their content and relevance;
d. Review ongoing scientific programs of North Slope Science Initiative (NSSI) member organizations on the North Slope at the request of the member organizations to promote compatibility in methodologies and compilation of data;
e. Advise the Oversight Group on how to ensure that scientific products generated through NSSI activities are of the highest technical quality;
f. Periodically review the North Slope Science Plan and provide recommendations for changes to the Oversight Group;

g. Provide recommendations for proposed NSSI funded inventory, monitoring and research activities.
h. Provide other scientific advice as requested by the Oversight Group; and
i. Coordinate with groups and committees appointed or requested by the Oversight Group to provide science advice, as needed.

Allowances for Science Group Members: Members of the Science Group will receive no compensation as members. Members shall, however, be allowed travel expenses, including per diem, when engaged in actual performance of Science Group duties, in the same manner, as persons employed intermittently in Government service are allowed such expenses under 5 U.S.C. 5703.

Frequency of Meetings: The Science Group will normally meet from two to four times annually, but in no case less than once. Additional meetings may be called as deemed necessary.

Group Membership: The Group will consist of not more than 15 members, appointed by the Secretary. The members will be selected from among, but not limited to the following disciplines: expertise in North Slope traditional and local knowledge, landscape ecology, petroleum engineering, civil engineering, petroleum geology, botany, hydrology, limnology, habitat biology, wildlife biology, marine ecology, biometrics, sociology, cultural anthropology, economics, ornithology, oceanography, civil engineering, fisheries biology, and climatology.

Ethics and Responsibilities of Members: All members will comply with applicable ethics, rules, and regulations. The Department of Interior will provide materials to those members appointed as Special Government Employees, explaining the ethical obligations which the members should be familiar. Consistent with the ethics requirements, members will endeavor to avoid any actions that would cause the public to question the integrity of the Commission's operations, activities, or advice. The provisions of this paragraph do not affect any other statutory or regulatory ethical obligations to which a member may be subject.

Subgroups: The Science Group may establish such workgroups or subgroups as it deems necessary for the purposes of compiling information or conducting research. However, such workgroups may not conduct business and must report to the full Group.

Termination Date: The Science Group Charter will expire 2 years from the date the Charter is filed, unless prior to that date it is renewed by the Secretary in accordance with FACA, 5 U.S.C. Appendix (1988). The Science Group shall not meet or perform any functions without a valid current charter.

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Secretary of the Interior Date Signed

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Date Charter Filed