Science in Northwest Alaska:
Research Needs and Opportunities on Federally Protected Lands

compiled and edited by

D. M. Hopkins, W. H. Arundale, and C. W. Slaughter

Alaska Quaternary Center
University of Alaska Museum
Occasional Paper #3
University of Alaska Fairbanks
Fairbanks, Alaska

SCIENCE IN NORTHWEST ALASKA

RESEARCH NEEDS AND OPPORTUNITIES ON FEDERALLY PROTECTED LANDS

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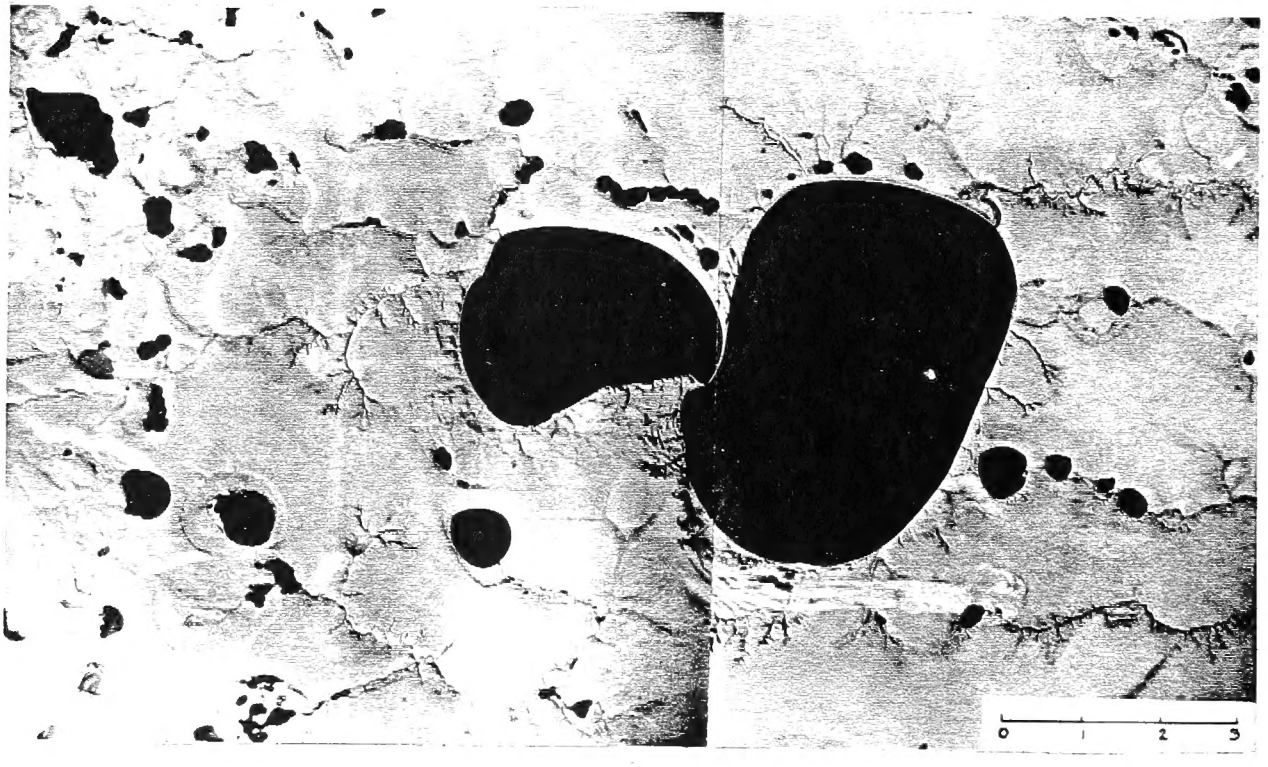


North and South Devil Mountain lakes, Seward Peninsula. These maar lakes, created by volcanic eruptions, should yield valuable information on volcanism in cold climates and on the history of volcanism and tectonic movements in Beringia. Many landscape features of northwest Alaska offer valuable research opportunities.

SCIENCE IN NORTHWEST ALASKA
RESEARCH NEEDS AND OPPORTUNITIES ON FEDERALLY PROTECTED LANDS

EXECUTIVE SUMMARY

Passage of the Alaska National Interest Land Conservation Act in 1980 created a mosaic of national parks, preserves, monuments and wildlife refuges. Federal lands now occupy more than half of northwest Alaska. Growing concern for wise management of these federal lands and increasing awareness of the region's potential research value led to organization of a symposium and workshop entitled "Research in Federally Reserved Lands in Northwest Alaska: Needs, Opportunities, Constraints," held in Anchorage on September 26-27, 1987. The conference attracted more than 100 scientists, land managers, and Native participants. Conference discussions focused both on general cross-cutting issues and on topics specific to particular disciplines or research areas.

CROSSCUTTING ISSUES

** Baseline data are inadequate for almost every resource on federally reserved lands in northwest Alaska. Good baseline data, important for assessing the condition of existing resources and for measuring the changes brought about by natural and human-induced processes, are essential to both sound management and effective research. Because baseline data acquisition is both urgent and expensive, economical ways of gathering new data and better ways of using existing data must be found.

** Sustained, long-term funding is a key requirement for an effective research program. Valuable information has been lost due to curtailment of long-term projects before completion, or failure to support the analysis and reporting phases of field-oriented research. The need applies to the social, biological and physical sciences. New sources of funding must be accompanied by careful and coordinated research planning.

** Better coordination of research efforts; better exchange of information concerning work planned, in progress, or recently completed; and more incentives for cooperation among agencies, universities, and local people could help maximize our return on existing research dollars. A framework should be developed in northwest Alaska to facilitate continuing interaction among all interested parties to provide a firm base of financial, technical, and logistical support for research. The UNESCO Man and the Biosphere (MAB) Program could help in reaching this goal; MAB's Northern Sciences Network is an established vehicle for international communication concerning research in the circumpolar north. MAB has the potential to offer assistance in the planning and implementation of inventory, monitoring, and related research.

** Efforts to establish an international cultural and ecological preserve in the Bering Strait Region should receive strong support.

** Increased support for research and resource centers within the region would benefit northwest Alaskan research in many ways. UIC-NARL already exists at Barrow. Establishing an additional center in one or more of northwest Alaska's other large communities is desirable. The center(s) would encourage interdisciplinary research, minimize duplication of effort by fostering interagency communication and coordination, support and facilitate local involvement in the planning, conduct, and utilization of research in northwest Alaska, and provide housing, laboratory, and warehouse space for transient researchers as well as logistic support for long-term monitoring and shorter-term research. The center(s) could also serve an educational function for the communities of the region, and inform scientists concerning the interests, needs, and aspirations of local people.

DETAILED RECOMMENDATIONS: SOME EXAMPLES

** Climate data for northwest Alaska are sparse and inadequate. Establishing additional local weather stations in villages, at both coastal and inland sites, and using Wyoming snow gages to measure snowfall are just two steps that would help address this problem.

** Northwest Alaska is largely unaffected at present by industrial, urban or agricultural development, but the landscape is very sensitive to the effects of possible global climatic changes. The Noatak River watershed offers an outstanding opportunity for research and monitoring to detect and understand global change in the north.

** Unique processes related to the presence of permafrost and intense frost action shape the landscapes of northwest Alaska. These landscape processes are of intrinsic scientific interest, and also must be understood by planners and developers to avoid costly mistakes and environmental hazards.

** The effects of fire on range quality are inadequately understood. The juxtaposition of forest and tundra and the variety of herbivores present in northwest Alaska provide attractive opportunities for investigating the interaction of wildfire and range quality.

** Subsistence-related studies must take into account the historical changes that have occurred over the past decades and centuries. Contemporary studies must be sufficiently long-term to encompass year-to-year variability.

** Remotely sensed imagery and data should be used more extensively as an aid to inventorying nonrenewable resources in northwest Alaska. More effort should be devoted to making the resulting information available to local planners and users.

** Contamination of groundwater and surface water systems by petroleum products, mine wastes, other toxic chemicals, sewage, and biological toxins creates health hazards for fauna, flora and humans. Although groundwater circulation is limited in most permafrost situations, water appears to move freely through carbonate rocks and through some areas underlain by gravel. Better studies of the groundwater regime and more effective monitoring of surface and groundwater quality are urgently needed.

** The tourism industry, along with many other groups in the region, could benefit from cross-cultural comparisons of how people work in both Native and western society. Studies should focus on sources of labor supply; the culture of work, including values, ethics, work environments, time use, and status valuation; and other factors that either attract or alienate workers.

** An expanded effort to record, preserve, transcribe, and translate Native oral history is urgently needed.

** Because many of northwest Alaska's archaeological resources are concentrated in highly erosional environments along rivers, lakes, and ocean shores, these areas urgently need archaeological study before important resources disappear. Associated studies of coastal retreat and riverbank and lakeshore erosion are needed to guide this research.

** Incentives are needed to stem the information loss resulting from excessive reliance on 'gray literature' as a means of publication.

LOCAL INVOLVEMENT

** Knowledgeable Native people, especially elders, have a wealth of traditional information and wisdom. They know a great deal about the flora, fauna, landscape processes, weather, travel conditions, and other phenomena that can greatly enhance and extend our brief and sketchily written western scientific record for the region. By consulting with the elders in an atmosphere of mutual respect, scientists and managers can learn much that would benefit their work.

** Scientists and managers need encouragement and incentives to devote time and energy to programs that will improve science education for local people, provide more science-related jobs in the near term, and eventually help train a cadre of Native scientists who can work in the region.

** Some scientists and managers need better training in cross-cultural skills and better knowledge of the region's cultural and social context so they can work with local people more effectively.

** Northwest Alaska's Native people depend heavily on the region's natural resources for their physical and cultural survival. An increasing number of restrictions resulting from federal management related to these resources has led to growing resentment among local residents. Many of the region's Native leaders feel that research on federal lands is likely to bring additional regulations. Without

increased, meaningful local involvement in research and management, the resentment generated by this situation may have negative consequences for science.

** The people of northwest Alaska have a serious interest in and commitment to scientific research, clearly demonstrated by their thoughtful contributions at the conference and by the financial support for this report provided by the NANA Regional Corporation and the North Slope Borough. We must continue working together to foster this interest and commitment.

Clearing a hole in the sea ice near Nome for tomcod fishing.
A subsistence lifestyle remains necessary for many northwest Alaska residents.

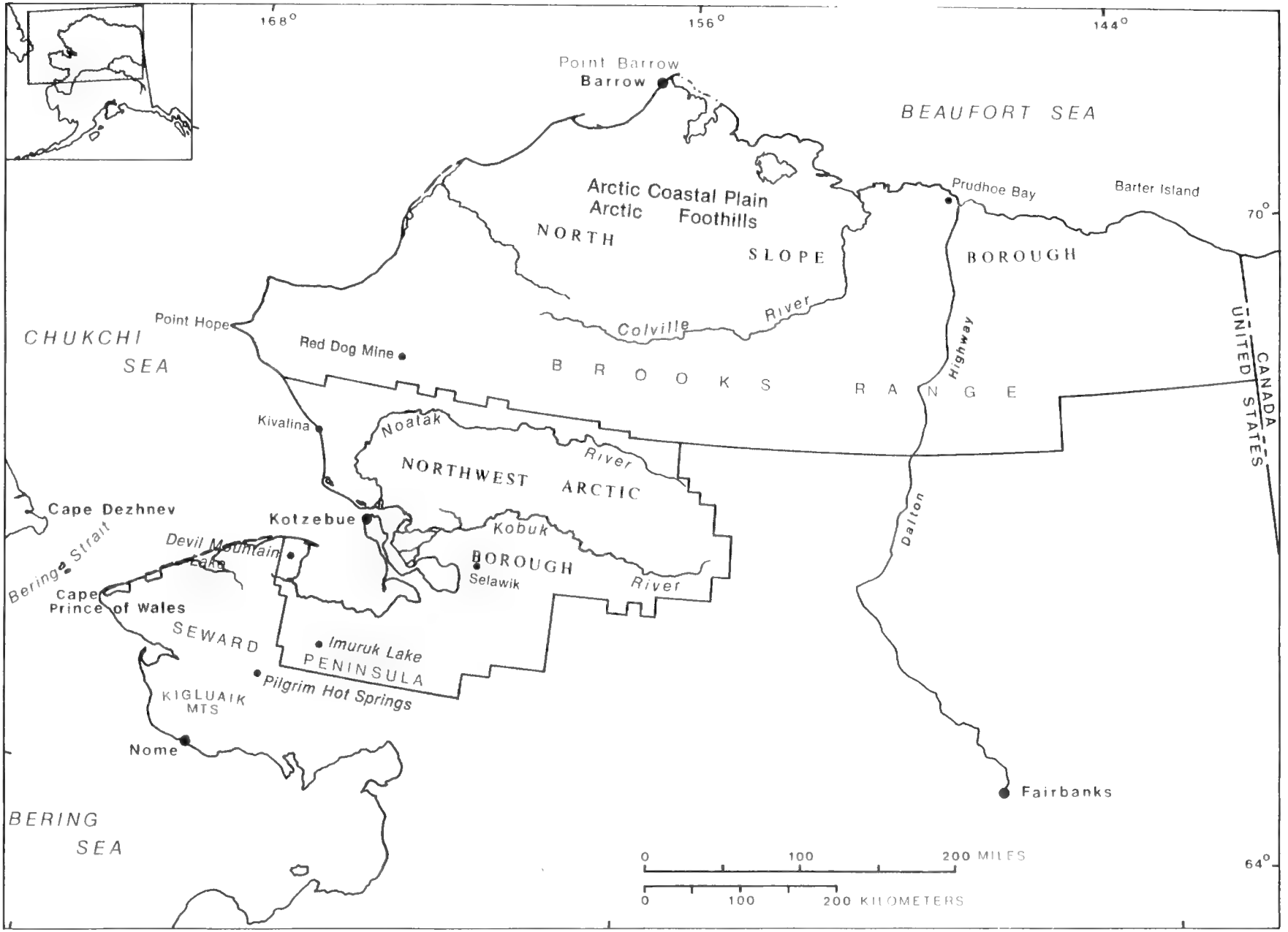


Figure 1. Location map for northwest Alaska.

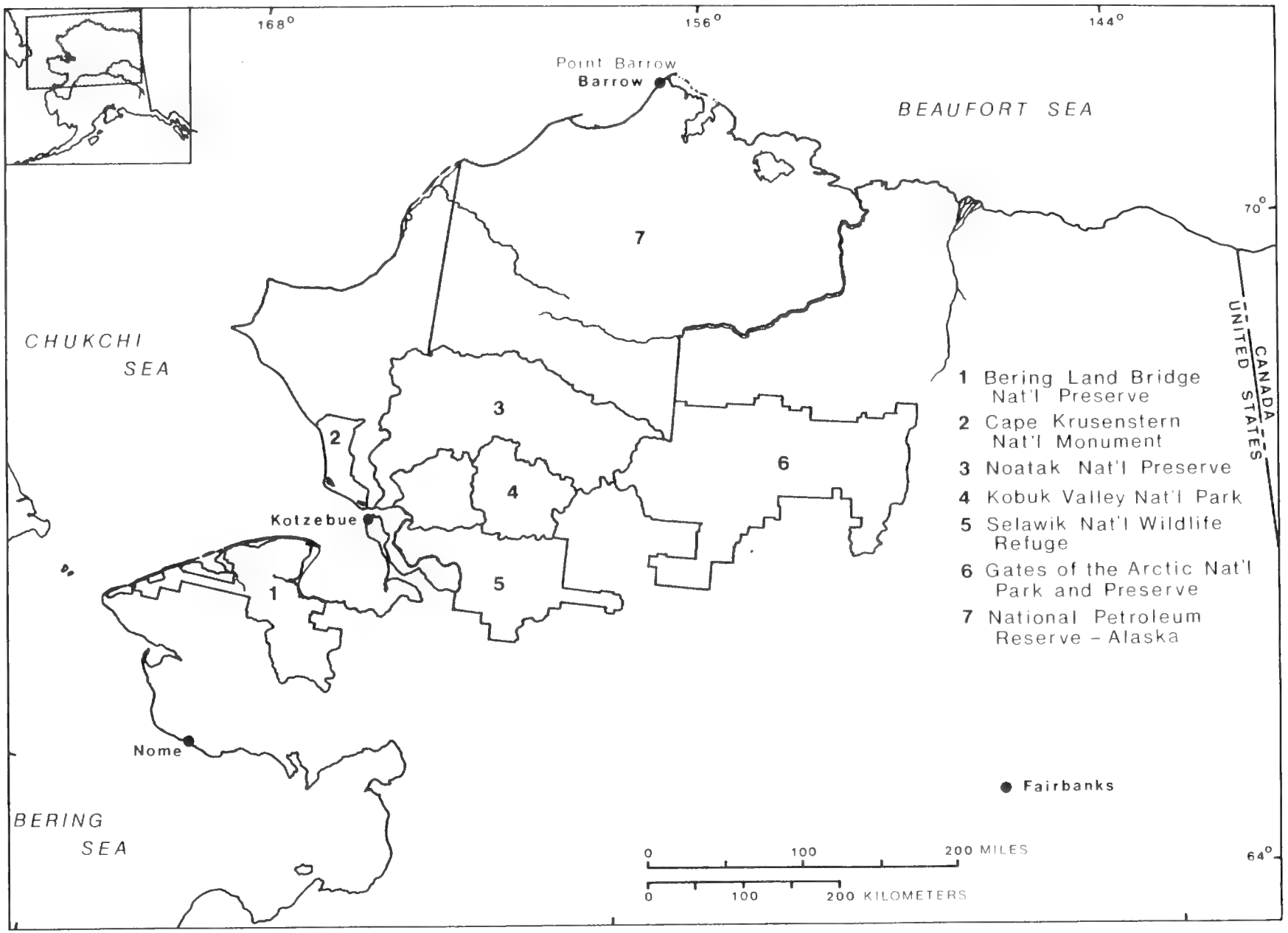


Figure 2. Federally protected lands in northwest Alaska west of the Dalton Highway.

CHAPTER 1

INTRODUCTION

Background

Approximately 60% of the land in northwest Alaska is now in federal ownership. Passage of the Alaska National Interest Lands and Conservation Act (ANILCA) (PL 96-487) on December 2, 1980, established new national parks, national preserves, national monuments, and national wildlife refuges encompassing about 90,000 square kilometers north of the Bering Sea and west of the Dalton Highway (Figure 1). Within this region, the National Petroleum Reserve-Alaska (NPR-A) covers an additional 93,000 square kilometers. Except for NPR-A, which may be opened to future coal and petroleum development, these lands will never undergo urbanization and are unlikely to see extensive development of extractive industries such as mining and logging. Large sectors of this highly diverse region will thus remain untouched by industrialization, and available as a valuable subsistence resource for local people, as a viably functioning ecosystem for scientific study, and as a beautiful and unspoiled landscape for all Americans.

For the federal agencies concerned, this sudden deluge of new lands has presented a significant challenge. New Alaskan national parks, preserves, and monuments, for example, more than doubled the total land area under National Park Service jurisdiction. From the outset, responsibility for administering these new federal lands raised many questions and engendered an immediate need for scientific information. What is the size and distribution of the resources for which the agencies are now responsible? What resources are critically endangered? What levels of subsistence harvest can biological populations tolerate? What levels of sport and recreational activities can be sustained? Much of the previous scientific study has been reconnaissance in nature, with only limited relevance to current management needs. Fortunately, the language of ANILCA makes clear that Congress places a high value on scientific research on the new federally reserved lands.

Viewed from a slightly different perspective, the federally reserved lands in northwest Alaska are an important national and international scientific resource. For example, mounting concern about global climate change is especially focused on the Arctic, because its effects are likely to be felt earliest and most strongly there (Office for Interdisciplinary Earth Science, 1988). The upper Noatak River watershed, located in the Noatak National Preserve and in the Gates of the Arctic National Park and Preserve, has therefore been proposed as a potential site for long-term environmental monitoring (Wiersma et al., 1986; Slaughter and Wiersma, 1988; Sandberg and Bell, 1989), and the 1989 biennial revision of the U.S. Arctic Research Plan identifies the Noatak basin as a region for long-term ecological research (IARPC, 1989). Such proposals fit well with the call by the U.S. Arctic Research Plan for increased scientific attention to arctic phenomena and increased research in arctic and subarctic areas such as northwest Alaska.

Other perspectives on these lands also deserve consideration. Although distant observers may view much of northwest Alaska as empty country, ideally suited for research and wilderness recreation, the newly designated federal reserves are by no means unoccupied. To the contrary, these lands have supported

subsistence activity--hunting, fishing, gathering--for 10,000 years or more. As "front yard and back yard" for many of northwest Alaska's residents, the land continues to provide habitat for essential subsistence resources and pasturage for managed reindeer herds. Furthermore, subsistence activities yield vital cultural and spiritual nourishment in a time of rapid social and economic change.

When these lands were transformed into national parks, monuments, preserves, and refuges, the Native people of northwest Alaska experienced a loss of local control that sometimes came as a painful surprise. Some supported passage of ANILCA, believing it would help preserve their subsistence lifeways, only to find themselves further constrained by federal regulations. It is not surprising that interaction between federal land managers and local people has sometimes been marred by antagonism and misunderstanding.

Congress was aware of the unique relationship between Native people and these lands, and in ANILCA provided that federally reserved status need not invoke the management patterns typical of national parks, monuments, and wildlife refuges in other states, where, for example, hunting is generally forbidden. But working out management policies that balance local needs and federal mandates is not an easy job. The new federally reserved lands pose both new opportunities and new problems for federal land managers and Native people alike.

The Conference

All these factors formed the background for conversations among planning officers at the National Science Foundation and the National Park Service in late 1986. They wanted a forum that would allow both scientists and local people to provide input and guidance to federal managers of northwest Alaska's lands. The Alaska Quaternary Center of the University of Alaska Fairbanks subsequently proposed coordinating a conference toward this goal. A symposium and workshop, "Research on Federally Reserved Lands in Northwest Alaska: Needs, Opportunities, and Constraints," was convened in Anchorage, Alaska, September 26-27, 1987. More than 100 scientists, land managers, and Native residents participated (see Appendices I,II, and III).

In the symposium, invited speakers and discussants delivered prepared talks designed to stimulate discussion in the workshop on the following day. Invited presentations spanned a broad range of disciplines (archeology, biology, geology, resource management, and others) and topics (baseline studies, fire ecology, subsistence, availability of published resources) and reflected a broad range of viewpoints (scientist, land manager, Native leader, environmentalist, northwest Alaska resident). Nine workshop discussion groups developed ideas and recommendations for presentation to the larger gathering. A panel discussion on local involvement in research and management rounded out workshop activities.

This report presents ideas and conclusions that emerged during the conference. A preliminary version was circulated for comment in May 1989. W. Arundale solicited additional discussion and comments from interested people in Barrow by phone and in Kotzebue and Nome during a visit in November 1989. Although the federal lands of northwest Alaska are our primary focus, we believe much that is said here also applies to other parts of arctic Alaska and perhaps to

other arctic and subarctic areas as well. If successful, this document will help focus the energies and discussions of the many different people who can influence planning for research and management in Alaska during the 1990s.

Northwest Alaska's Important Scientific Values

Early scientific travelers such as E. de K. Leffingwell (1919) and P.S. Smith and J.B. Mertie (1930) recognized the important scientific values of northwest Alaska. Subsequently, U.S. Geological Survey parties have conducted geologic mapping and vegetation surveys in parts of the region. Archaeologists have surveyed a few areas in some depth, gaining insights into the life of earlier inhabitants (for example, Davis et al., 1981; Giddings, 1952; Giddings and Anderson, 1986; Hall and Gal, 1982). Three cycles of petroleum resource exploration in NPR-A in the 1920s, the 1940s and the 1970s (Reed, 1958; Schindler, 1983; Gryc, 1985) produced new knowledge of the vegetation and the surficial deposits, and greatly heightened understanding of the geology of the Paleozoic and Mesozoic rocks.

The Naval Arctic Research Laboratory (NARL), established near Point Barrow in 1947 and active until 1981 (Reed and Ronhovde, 1971; Laursen and Kelley, 1979, 1980), supported a wide range of research in arctic Alaska. The Atomic Energy Commission's Project Chariot near Cape Thompson (Wilimovsky and Wolfe, 1966; O'Neill, 1989) and other major research efforts, such as the International Biological Program (IBP) studies near Barrow (Brown, 1975; Brown et al., 1980; Tieszen, 1978; Hobbie, 1980) and near Prudhoe Bay (Walker et al., 1980), the Outer Continental Shelf Environmental Assessment Program (OCSEAP) (Anonymous, 1988a), and many smaller projects, have added greatly to our knowledge of the region. Both NARL and Project Chariot were crucial in introducing Native people to the potential importance, value, and local impact of scientific research.

Northwest Alaska's scientific values are further enhanced both by characteristics that are pan-arctic and by attributes that are unique. The diversified landscapes can be viewed as a microcosm of the circumpolar Arctic. Topographically, the region includes the major mountain groups comprising the western Brooks Range which culminate in several peaks higher than 2,000 m. Smaller and lower ranges, such as the Kigluaik Mountains of the Seward Peninsula, are almost equally spectacular. The region also includes extensive rolling uplands and inland basins as well as the vast lake district of the outer arctic coastal plain. This diverse topography supports a highly varied vegetation (Figure 2). The forest-tundra ecotone lies within the southern part of the region. Low arctic tundra, covering most of the western and northern part of the region, gives way to small areas of mid-arctic tundra near Bering Strait and Point Barrow.

A unique aspect of northwest Alaska is its position at the crossroads of a land dispersal route between Asia and North America and a sea dispersal route between the Pacific, the Arctic, and the Atlantic oceans. Cape Dezhnev, Asia's eastern tip, lies within clear view across Bering Strait from Cape Prince of Wales. Bering Strait is a major avenue through which annually migrating fish and marine mammals pass back and forth between the warm seas to the south and the Arctic Ocean to the north. During times of low sea level, northwest Alaska was the gateway to the Bering Land Bridge, a major avenue of faunal, floral and human interchange between Asia and the Americas (Hopkins et al., 1982; Fitzhugh

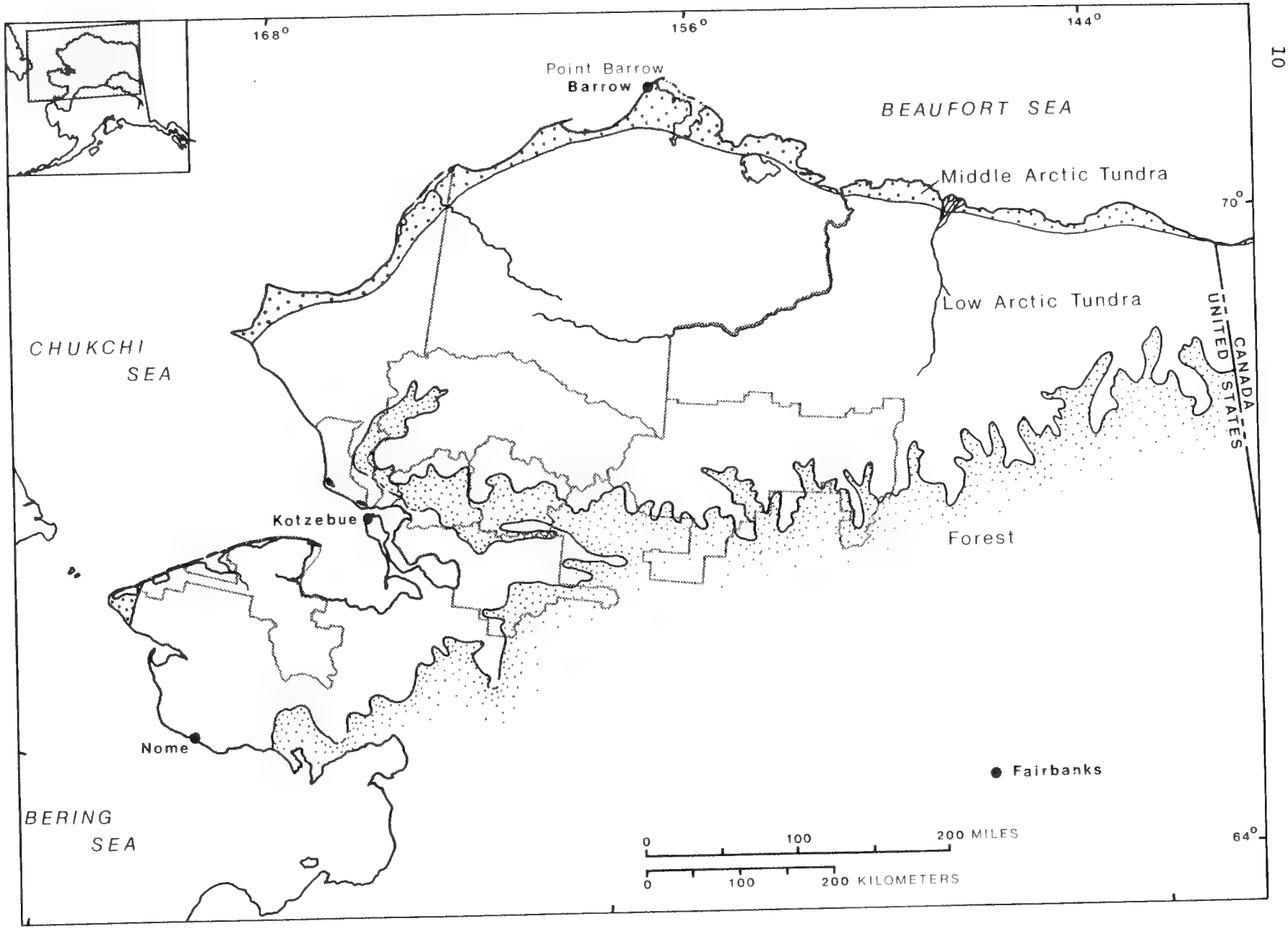


Figure 3. Vegetation distribution in northwest Alaska west of the Dalton Highway.

and Crowell, 1988). Several species of migratory birds continue to flock annually between the continents across this narrow water barrier. Records of ancient faunal and floral dispersals across the land bridge can still be discerned in the living biota of northwest Alaska and in the rich fossil record preserved in the frozen permafrost of the region.

Finally, northwest Alaska is in a unique position to contribute to scientific issues of broad social and economic concern. The unique geographic position of northwest Alaska, at the junction of two continents separated by a fluctuating and intermittently ice-covered sea, renders the region especially sensitive to both short- and long-term climatic change. Contemporary global climate change should be monitored in northwest Alaska. Small changes in solar radiation and modest changes in global sea level have brought about major changes in the distribution of land and sea, in the former extent of glaciers, and in the vegetation and animal life. The region is also a significant place in which to evaluate the extent and the effects of past climatic changes.

A rich two-million-year record of changing climates is preserved in widespread glacial deposits and in shelly marine beds laid down near the coasts of northern Bering Sea, Kotzebue Sound, and the Chukchi and Beaufort seas. Lake sediments preserve a more detailed record of climatic fluctuations during the past few tens of thousands of years. Annual growth rings from timberline trees, ground temperatures in permafrost, and oral history related by Native elders can combine to provide a basis for reconstructing highly detailed records of climatic fluctuations during the past few centuries. Rich records of past climates, exceptional modern-day climatic sensitivity, and large areas of federally protected land present an unparalleled and highly significant opportunity for long-term environmental and climatic monitoring in northwest Alaska. Northwest Alaska thus provides a major opportunity to detect warning signs of global atmospheric pollution and climate modification.

Research Context

To maximize the advantages offered by these significant scientific values, researchers must also concern themselves with the geographical, cultural, and political context of their research at the local, regional, state, national and even international levels. These contextual elements can impose constraints on research; permit requirements imposed by government agencies are one example. But more often, valuable research opportunities appear, as national and international science initiatives offer new avenues for funding or cooperative research.

Northwest Alaska's geography is an immediate aspect of this research context. Nome (population 3,208) , Kotzebue (population 2,636), and Barrow (population 3,052) (1986 population figures; Alaska Department of Labor, 1989) comprise the regional administrative and trade centers (Figure 3). Smaller villages are scattered along the rivers and the coasts of the Bering and Chukchi seas The region is essentially roadless except for the Dalton Highway, which connects Fairbanks with Prudhoe Bay and forms the eastern boundary of the region. A 95-km road connects the Red Dog mine with a port near Kivalina, and several hundred kilometers of roads radiate from Nome to points on the Seward Peninsula. Seagoing tug and barge operations provide a summer supply line to coastal towns and villages, and river tugs move fuel and supplies to villages on the Kobuk and lower Noatak rivers. Commercial air service, however, is the

principal means of public transport. Residents rely heavily on their own boats, snow machines, and all-terrain vehicles for subsistence activities and intervillage travel.

Northwest Alaska has a distinctive social, cultural, and political context. Native Alaskans, mostly Inupiaq Eskimos but including some Yupik Eskimos and Athabaskan Indians, make up about 80 percent of the population. For many years, Native people throughout Alaska have struggled to deal with the economic and social dislocations resulting from imposition of a western economy, value system, and lifestyle. Important in this process have been the regional Native corporations mandated by the 1971 Alaska Native Claims Settlement Act (ANCSA). Regional corporations in northwest Alaska include the Bering Straits Native Corporation (BSNC) based in Nome, the NANA Corporation based in Kotzebue, and the Arctic Slope Regional Corporation based in Barrow. Also important are the regional non-profit corporations: Kaweruk, Inc., based in Nome, Maniilaq Association, based in Kotzebue, and the Inupiat Community of the Arctic Slope, based in Barrow. Village corporations mandated by ANCSA also play a role. IRAs--tribal governments organized under the Indian Reorganization Act--have become active in the region. Many communities also have a municipal council or a city government.

Of growing importance in the 1980s have been the Native-controlled regional governments: the North Slope Borough, founded in 1972 and based in Barrow, and the relatively new Northwest Arctic Borough founded in 1986 and based in Kotzebue. These boroughs represent a significant advance in regional self-government (McBeath and Morehouse, 1980). Through the boroughs, Native people have sought substantial concessions from large multi-national corporations wishing to develop natural resources in the region. The income from development has brought support for regional government, some jobs and job training, and improvements in such important amenities as housing and health care. Nevertheless, serious social concerns remain.

Efforts by Native people to gain more control of their own affairs include several initiatives toward gathering scientific information, to help them gain a credible voice in the management of renewable resources and in the planning efforts arising from the Arctic Research and Policy Act. Activities of the Science Advisory Committee of the North Slope Borough (1985), the Alaskan Eskimo Whaling Commission, the Eskimo Walrus Commission, and the Alaska and Inuvialuit Beluga Whale Committee (1989), and formulation of a Regional Conservation Strategy by the Inuit Circumpolar Conference (Inuit Circumpolar Conference, 1986, 1987) are examples. Residents of northwest Alaska have demonstrated that they intend to participate actively in all aspects of regional affairs affecting their lives and livelihood, including research.

With implementation of ANILCA, the federal land managing agencies have become an increasingly important aspect of the region's research context. Kotzebue is headquarters for Noatak National Park and Preserve, Kobuk Valley National Park, and Cape Krusenstern National Monument of the National Park Service (NPS), and the Selawik National Wildlife Refuge of the U. S. Fish and Wildlife Service. Headquarters for the Bering Land Bridge National Preserve (NPS) are in Nome. Gates of the Arctic National Park and Preserve (NPS) and the National Petroleum Reserve-Alaska (U.S. Bureau of Land Management) are managed from Fairbanks. Other agencies with important research and resource management interests in

northwest Alaska include the U.S. Geological Survey, the U.S. Minerals Management Service, and the Alaska State Department of Fish and Game.

Agency land managers in northwest Alaska face some difficult problems that both directly and indirectly affect northern science. Few land managers arrive with much knowledge of local and regional issues, and even fewer are native to the region. Most have sound scientific training and work hard to learn about the region, at least as it relates directly to their jobs. Some go far beyond that point, striving to learn local lifestyles and to integrate themselves and their families into the local community. Unfortunately, career development policies may result in land managers transferring out of the region just when they have begun to acquire a useful understanding of the local situation. Issues related to pay differentials, housing, benefits, and the quality of local schools may also influence an agency employee's decision to transfer. Despite the best intentions, these factors can work against development of good local knowledge, local involvement, and local agency credibility, and tend to result in long-term institutional memory loss.

Federal managers must respond to congressional mandates expressed in federal law, regulations, and policy. They must respond, however, in the context of diverse local and regional needs expressed by a variety of interest groups concerned with environmental and development issues, Native economic and cultural questions, and conduct of scientific research, among others. Potentially conflicting pressures may also come from within agencies in the form of written or unwritten rules, policies, and practices. For example, those actions most likely to lead to advancement within the agency may not always be those most likely to maintain good relationships with local people. State of Alaska resource managers sometimes face similar problems.

Another facet of the regional research context, especially on federal lands, is the issue of defining relationships between research and management. In an ideal situation, scientists conduct their research and promptly make their results known to both the managers and the people affected. Managers then work with the public to develop management decisions based not only on the scientists' findings, but also on public policy and local needs. In reality the process is often much less clearly defined. Some managers are active scientists who carry out research. Some scientists advise managers or conduct research at their request. Management requirements may shape or limit research problems and techniques. Both scientists and managers need to be very clear about their objectives and the rationale for their objectives. They also need to communicate clearly with the public concerning these issues. If management policies are controversial and the impact of management policies is confused with the impact of research, the results can be negative, even for research projects only indirectly related to management.

Finally, economic and political aspects of the larger scientific world strongly influence the research context of northwest Alaska. Because science in this region has much in common with science in other high-latitude settings (U.S. Arctic Research Commission, 1986), it will be beneficial to participate in state, national, and international science initiatives such as the programs of the Alaska Science and Technology Foundation, the U.S. Arctic Research Plan, the UNESCO Man and the Biosphere Program, and the International Geosphere-Biosphere Program. Funding, logistical support, communication with scientists addressing similar problems in other regions, and ultimately better scientific

understanding are among the benefits that will flow to research endeavors involved or coordinated with these larger programs. To be successful, however, these larger science initiatives must be placed in the local and regional perspective, the real world of northwest Alaska. The scientists who will conduct the research, the land managers who must interpret and apply the results, and the local people who must live with the results and consequences must all participate (Freeman and Slaughter, 1986).

The research context in northwest Alaska involves exciting scientific values and opportunities coupled with rapidly changing geographic, social, cultural, and political factors. Failure to acknowledge and give weight to these factors will restrict the opportunities available to scientists and managers, and will limit the value of their results. Conversely, those who fully acknowledge these factors should find enhanced opportunities and see more widespread and fruitful application of their findings. In northwest Alaska, the possibilities exist and the time is ripe for rewarding interaction among scientists, land managers, and Native people. We must look for every available chance to take advantage of these emerging opportunities.

Polygonal ground, an important landscape feature in lowland areas of northwest Alaska, indicates presence of ice-rich permafrost.

CHAPTER 2

CROSSCUTTING ISSUES

Several important themes or issues recurred throughout symposium and workshop discussions. These crosscutting issues, important for planning and implementing improved research and management in northwest Alaska, have key implications for federal and nonfederal lands alike.

Increased Local Involvement

Increased local involvement in planning and conducting research, coupled with improved sharing of research results with local people, is essential to future research success in the region. This need applies to research in disciplines ranging from social anthropology and archaeology to wildlife biology and geomorphology. Whether the topic is landscape dynamics, ecosystem disturbance and rehabilitation, subsistence resource use, or global change, improved local resident participation is imperative.

Pragmatically, involving residents who have pertinent local knowledge and local perspectives can often facilitate field research and enhance its results. Ethically, the indigenous residents are those most directly affected by ongoing processes. Shifts in wildlife populations, landscape changes that alter stream water quality, and disturbances to cultural sites, for example, all affect local people in very personal and sometimes long-lasting ways. It is the indigenous people who must live daily with management decisions concerning federal lands--decisions on wildlife management, transportation mechanisms and corridors, harvest seasons and methods, and land and resource allocations. A more detailed discussion of this issue is found in Chapter 4.

Baseline Data

Baseline data are inadequate for almost every attribute of federally reserved lands in northwest Alaska. This problem applies to resources ranging from biological populations to cultural values, from nonrenewable energy and mineral resources to local and regional ecological systems. Our lack of data is particularly critical because this region is experiencing rapid change along many dimensions. Apart from portions of NPR-A, most of the baseline data gathering so far has been preliminary. Much more work is needed.

ANILCA's mandates, like those of any rational long-term management program, require planning based on sound information. Baseline data are essential for assessing the condition of existing resources, for prioritizing conservation and management efforts, and for measuring change brought about by either natural factors or human actions. To develop sound, sustainable management strategies, federal and state agencies, regional corporations, boroughs, and local governmental entities all must understand regional environmental attributes and processes.

Acquiring baseline data is both urgent and expensive, so economical ways of gathering new data and better ways of using existing data must be sought. Here are just two examples: remote sensing techniques should be exploited more fully and applied to both existing and new imagery; oral history should be consulted as a valuable source of useful information on historic climate,

vegetation, and wildlife. The value of baseline data increases considerably if the form in which it is gathered is compatible with the theoretical and methodological frameworks employed in contemporary research.

Sustained Long-Term Funding

Sustained and consistent long-term research funding is badly needed, particularly for studies dependent on time-series data. The value of many agency-funded field surveys and projects has been seriously compromised by the failure to provide funds for regular and continuous measurements, follow-up analysis, and report preparation and publication. Examples include hydrological, climatological, and other environmental monitoring; ethnographic and archeological field surveys; and mission-oriented studies conducted in-house by agencies or by contractors in almost every discipline.

New sources of funding, however, must be accompanied by careful research planning. Optimal use of new long-term funding sources will require better, more inclusive ways of prioritizing research and assuring that project quality remains high. Research planning must consider not only long-term projects, but also those data needs best met by shorter-term and even crisis-oriented research. Long-term projects can best be protected by concurrently providing reasonable funding for shorter-term and urgent priority research.

The recent burgeoning of contacts, agreements, and joint projects between U.S. and Soviet research institutions focused on the North provides a good example of a sudden shift in the demand for research funding. Many of the proposed projects involve paired studies to be conducted in northwest Alaska and northeast Siberia on subjects relevant to research and regional planning in both areas. If these agreements are to be carried out, new funding sources will be needed. The National Science Foundation is moving to provide some funds; the American Association for the Advancement of Science may also be helpful, but the longer-term funding question remains unanswered. How can we systematically provide for and integrate such new needs with existing long-term programs?

The social sciences, in particular, need increased support. Several workshop groups noted the disparity between funding for the natural and the social sciences. For example, anticipated NSF expenditures for arctic research in all disciplines for fiscal year 1988 totaled $21,597,000, but only $62,000 of this amount was budgeted for the social sciences (Committee on Arctic Social Sciences, 1989). Because so many of the important issues in northwest Alaska have a social dimension, inadequate support for social science research is a source of serious concern. [In response to this concern, NSF recently announced plans for an Arctic Social Sciences program beginning in 1991 to be funded at ca. $1,000,000.]

Sustained funding is a long-term objective, but one measure could be taken immediately. We propose that a directory be compiled and widely distributed listing all funding sources available for high-latitude research. The current annual summary of NSF-funded projects in the Arctic could provide a useful starting point. Publications such as the University of Alaska Fairbanks' UAF Research Report News, which reports information about agency programs and deadlines, can serve as models. Such a directory would help researchers make

fuller and more effective use of existing sources and would highlight important areas where funding is lacking.

International Cultural and Ecological Preserve in the Bering Strait Region

An exciting example of new U.S.-U.S.S.R. initiatives is the proposal for an international cultural and ecological preserve in the Bering Straits area. By the end of 1989, a newly appointed joint planning team, including U.S. National Park Service officials and their Soviet counterparts, had visited both Alaska's Seward Peninsula and Siberia's Chukchi Peninsula (International Park Program, 1989). When Congress established the Bering Land Bridge National Preserve on the Seward Peninsula, it acknowledged the value and uniqueness of this important area. Presumably the Bering Land Bridge National Preserve, and perhaps parts of other units of the National Park System in northwest Alaska, will be building blocks in this proposed international preserve.

We support and endorse plans for an international park in the Bering Strait region. At the same time, we support the Native leaders of northwest Alaska who insist that the many questions and concerns of the region's residents must be addressed. Northwest Alaska's Native people are already uncomfortable with the level of regulation associated with the existing parks. Will the formation of an international park mean additional regulations and restrictions? In what way and to what extent will local people be involved in decision-making? Will education and employment opportunities for Native people result? Will research concerns of particular interest to the Native community be addressed? For example, are there plans for comparative studies of Soviet and American Native subsistence practices? How will scientific work be set up so that villagers can participate comfortably without feeling as though they are living in a fishbowl?

Better Coordination and Cooperation

Improved coordination of research efforts and better exchange of information on planned research, work in progress, and completed projects would help researchers make more effective use of existing resources and avoid duplication of effort. The logistical difficulties involved in working in northwest Alaska and higher transportation and living costs compared to "the lower 48 states" also make developing mechanisms for sharing facilities and logistical efforts more urgent. We propose several specific measures:

** Establish and widely disseminate an interdisciplinary newsletter listing both planned research and recently completed reports and publications, including information on the organizations and individuals involved, and the topical and geographic areas covered. The strengths and weaknesses of earlier efforts such as Current Research Profiles, formerly produced by the Alaska Environmental Information and Data Center (AEIDC), should be considered in selecting the newsletter format.

** Publish a journal with broad appeal modeled after the National Science Foundation's Antarctic Journal carrying short (maximum 1,000 word), non-refereed reports written in a style understandable to the layperson. The intended audience would explicitly include northern residents and institutions.

** Organize periodic, topically oriented, interdisciplinary meetings in Kotzebue, Nome, or Barrow, ideally in cooperation with the regional research and resource centers discussed below. Agencies and individuals would outline research plans, review research results, and solicit local views on research needs, approaches, and local/regional participation. All appropriate regional organizations and individuals must be involved.

** Create incentives for agencies to pool resources for work on important problems that are high on general priority lists, but not sufficiently important to any single agency's mission or too expensive to be funded by a single agency working alone.

** Develop one or more computer bulletin boards to distribute information about grants, programs, and projects to interested researchers, agency personnel, and local people in, for example, fire ecology, subsistence research, or cultural resources. Such bulletin boards might make available in electronic form the newsletter and journal proposed above.

** Encourage increased interdisciplinary efforts. Ideas emerging from workshop discussions ranged from suggesting that geological survey parties include researchers from other disciplines, such as botany and archaeology, to organizing tightly knit research programs combining disciplines such as paleontology and archaeology.

** Increase contacts and coordination between managers and scientists. A surprising number of investigators leave the region after carrying out their research without ever contacting local resource managers or reporting to them the results of their studies. Managers, like local residents, can often save researchers time and money by providing useful information on local conditions. Similarly, scientists, during even a casual visit, can often supply managers with information useful for resource conservation and management. Safety considerations are also served when researchers inform local managers of their plans and itineraries. Most important, such contacts build mutual trust among people who often share at least some, often many, closely related objectives. They demonstrate courtesy and respect for professionals who live and work in rural areas, factors important in continuing to attract highly qualified people to these positions.

** Analyze different stewardship strategies on federal lands. Each major land managing agency has a unique mandate, and to some extent, a unique management style. Over time, it will be worthwhile to examine these different stewardship strategies to see what is and is not successful. Additionally, different stewardship strategies will have different "spill-over" impacts on adjacent state, Native, and other private lands. Whether positive or negative, these impacts also need careful analysis.

** Strengthen regional, statewide, and national coordination of research and related educational activities. A framework is needed for enhancing interaction among agencies representing the science, conservation, and economic development sectors; universities and research institutions; and local communities to establish research objectives and to provide a firm base of financial, technical, and logistical support for research.

** Link increased regional, statewide, and national coordination to the growing international interest in the region. Even the conference recommendations for increased international cooperation, developed in 1987, did not foresee the recent exponential growth in social, economic and scientific contacts with the Soviet Union. Particularly needed is a means of communicating rapidly with Soviet collaborators about the growing number of Soviet contacts and joint efforts to encourage individual and organizational initiatives but reduce duplication of effort.

** Develop cooperative agency-university educational arrangements that will enhance Native people's ability to work toward higher levels of professional involvement in science. For example, with proper supervision, volunteers working with the Alaska and Inuvialuit Beluga Whale Commission might receive community college credit for the instruction they receive and the data gathering they carry out on the commission's behalf.

Because the Noatak River watershed, in the Noatak National Peserve and Gates of the Arctic National Park and Preserve, has been designated as an International Biosphere Preserve (Risser and Cornelison, 1979), the UNESCO Man and the Biosphere (MAB) Program may be a suitable vehicle for institutionalizing some of the desired cooperation. The U.S. National Committee for MAB encourages cooperative programs in those regions where biosphere reserves provide a permanent hub for long-term interdisciplinary basic research, applied research, and demonstration projects that support ecosystem management and encourage sustainable, culturally appropriate economic uses. As a designated biosphere reserve, the Noatak watershed permanently links northwest Alaska with MAB's international network of ecosystem research sites. Additionally, MAB's Northern Sciences Network (Roots, 1985) is now an established vehicle for information exchange and coordination of research in the circumpolar North.

Research projects involving radio-collaring and tracking wildlife such as sheep, caribou, and bear provide opportunities for cooperation among agencies.

These recommendations for increased cooperation and coordination sound positive, but realistically, will people follow them and make them work? Several workshop participants quietly voiced skepticism and their awareness of conflicts that complicate and inhibit even the most well-intentioned cooperative efforts. Although the conflicts were mentioned primarily in terms of intra- and interagency concerns, they exist among and within agencies, academic institutions, and Native organizations as well.

Internally contradictory values and institutional structures play a significant role in some of these conflicts. If we look, for example, at how the academic reward system is structured, we see one such conflict. Despite the educational mandate of universities, publication requirements for tenure and promotion may give university scientists little incentive to spend time training Native students, making and maintaining contacts with managers, or communicating their results to local people--all valuable educational undertakings with positive long-term benefits for research.

Regional Research and Resource Centers

Scientists and Native leaders attending the conference reached near consensus concerning the desirability of establishing a regional research and resource center in Kotzebue or Nome, or both, and of strengthening the existing research and resource center at the former Naval Arctic Research Laboratory (NARL) in Barrow. With good communication local people's interest is awakened and involvement of the local community is heightened by a strong scientific presence (Anonymous, 1988b; Albert, 1989). The former NARL facility is now owned and operated by the Ukpeagvik Village Native Corporation as a multiple-use facility, designated UIC-NARL. Experience at NARL has shown that the objectives of interdisciplinary and interagency coordination and cooperation are generally well served when researchers work through a central support facility, as are the needs of local political entities for scientific information.

The level of local interest in having such a center is high. In 1986 the Northwest Arctic Borough passed an ordinance (Appendix IV) strongly endorsing construction of such a facility in Kotzebue. The borough even drew up preliminary plans and hired a consultant to make preliminary cost estimates (Anonymous, 1988b). Such actions clearly attest to local support for such a center and to a valid concern that Native people have a meaningful role in its operation.

We endorse the need to strengthen and expand regional research and resource centers in northwest Alaska. Table 1 indicates the facilities that such a center might have and the functions it might serve. As an early step, the Chukchi and Northwest campuses of the University of Alaska Fairbanks might be encouraged to provide a venue where researchers passing through Kotzebue and Nome, respectively, could interact with one another and with local people and perhaps offer seminars and lectures. The rural campuses might also host periodic interdisciplinary science meetings.

We acknowledge some valid concerns about developing one or more such centers. Their costs may consume resources that could be put toward more research. Some kinds of research might not benefit directly from such a center, but would benefit significantly from additional funding. A center can artificially

concentrate research in a few areas to the possible detriment of research quality or diversity of research undertaken. We believe, however, that the advantages of local research and resource centers outweigh their disadvantages, especially if they are part of a carefully thought out regional research plan.

For scientists coming from outside the region, research in northwest Alaska seems costly, because the region is distant from major population centers. Public accommodations may be more expensive than in other parts of the U.S., and are available only in the largest towns. Surface transportation other than along natural waterways is almost completely lacking. Researchers at the conference repeatedly emphasized how much a regional center would help with this problem.

Local residents of the region, however, sometimes see the situation differently. It is helpful to appreciate their perspectives. Because they see scientists who work for oil companies or consulting firms with quite generous funding, they sometimes do not understand that university and agency scientists commonly must operate with more restrictive budgets. Additionally, since local people must live with high transportation and living costs, they resent outsiders who come into the area to work but seem to make little contribution to a local economy starved for cash income and jobs. They also worry that a center that provides meals and lodging might take income and jobs from local hotels and restaurants. On balance, however, a regional research and resource center is likely to bring more scientists, and hence more jobs and cash income into a community. For example, as a step toward addressing these concerns centers should look for efficient ways to support the local economy, by hiring locally whenever possible and providing referrals for economical transient board and housing in the community.

We want to make three final points relating to the research and resource center(s):

** The research and resource center(s) should be developed with independent funding. An equitable and broadly acceptable method for allocating center resources will be necessary, almost certainly involving charges for the use of facilities. Some operating subsidies will probably be required, however, because these charges must be kept modest or researchers will seek other options, obviating some of the center's important goals.

** Those planning and developing the center(s) should carefully examine the record at NARL and at other northern science and support centers to see what has and has not worked.

** The planning and development process must involve local people, university and government scientists, and agency managers working together so that the resulting center(s) will serve the needs of all three groups.

TABLE 1

DESIGN ELEMENTS FOR A REGIONAL RESEARCH AND RESOURCE CENTER

Facilities

--Laboratory and office facilities for one or two resident scientists.
--Laboratory and office facilities for visiting scientists.
--A small auditorium or conference room for presentations and meetings.
--Secure storage for boats, outboards, and other field equipment.
--Dormitory, cooking, and eating space for visiting and transient scientists.
--A small library that would be a repository for the most complete collection possible of scientific literature, including the "gray literature" on the surrounding region.
--Display space for exhibits on current research.
--A community museum.

Staff

--A regional scientific liaison to facilitate cooperation and coordination, local contacts, and long-term planning.
--An expediter/interpreter.
--Additional support staff as needed.

Functions and objectives

--Furnish facilities and support for conducting research, including laboratory, office, warehouse, and housing space for transient researchers.
--Support local involvement in the planning and conduct of research and dissemination of the results.
--Facilitate communication and cooperation among researchers, managers, agencies, and research institutions.
--Promote interdisciplinary research efforts.
--Encourage scientists conducting year-round or long-term studies to remain in residence.
--House museum collections important to the local community.
--Provide educational opportunities for members of the community through classes, training programs, and interpretive work in the local schools.
--Educate researchers about the local area, including Native culture, and the interests, needs, and aspirations of local people.
--Serve as a communications node for disseminating information about research results and scientific issues of statewide and national significance.

CHAPTER 3

DETAILED DISCUSSION AND RECOMMENDATIONS

Section 1

Inventory and Monitoring

Background

Scientists and managers alike are concerned with the quality of our information concerning the environment and biota of northwest Alaska, and with our ability to detect important natural or anthropogenic changes as they occur. Inventory involves describing and cataloging components of the present climate, landscape, and biota. Examples include topographic and geologic mapping, wildlife population censuses, and catalogs of the flora and the fauna. Monitoring is concerned with environmental change, rates of change and processes. Examples include stream gauging, collection of climatic and weather data, long-term observation of precipitation chemistry, changes in trace elements in leaves of a given plant species, and changes in plant productivity on established plots.

The major objectives of inventory and monitoring are to acquire a better knowledge of the resources, to identify potential environmental hazards such as flooding and thermokarst collapse, to furnish early warning of large-scale environmental changes, and to provide a framework for hypothesis formulation and testing. Inventory and monitoring efforts are prerequisite to understanding the environmental systems, processes, and resources of northwest Alaska and to developing appropriate research and management programs.

Inventory Needs

Inventory needs in northwest Alaska are only partially met. Maps at scale 1:250,000 or larger are a basic necessity. Most of the area is covered by U.S. Geological Survey topographic maps at scales 1:63,360 and 1:250,000 (one and four miles to the inch, respectively), scales that are adequate for most research and management needs. Coverage by more specialized maps, however, is incomplete. U.S. Geological Survey maps defining the bedrock geology at scale 1:250,000 cover most parts of northwest Alaska, but larger scale geologic maps are almost entirely lacking. U.S. Geological Survey maps of surficial deposits (soils and loose sediments) at a scale of 1:250,000 cover parts of the Arctic Coastal Plain, parts of the Brooks Range, and most parts of the Seward Peninsula, but surficial deposits in much of the region remain unmapped. Surficial geologic maps at a scale of at least 1:250,000 delineating, for example, areas of volcanic deposits, glacial drift, wind-blown sand, loess, alluvium, and other loose materials at the surface should be prepared as soon as possible for unmapped parts of northwestern Alaska.

More directly useful to land managers are specialized interpretive maps, largely derived from surficial and bedrock geologic maps, showing, for example, the distribution of potential construction materials, areas of ice-rich permafrost susceptible to thermokarst collapse, areas subject to seasonal flooding, areas vulnerable to river-bank and coastal erosion, areas where disturbance of the vegetation may result in gullying or wind deflation, and

areas sensitive to landsliding and avalanching. Such maps are largely unavailable for northwest Alaska.

Vegetation maps at scale 1:63,360 based primarily on air photo interpretation have been published for parts of Alaska by the Alaska Environmental Information and Data Center, the U.S. Bureau of Land Management, and the U.S. Fish and Wildlife Service. Preparation of vegetation maps for all of the federally reserved lands of northwest Alaska at a scale no smaller than 1:250,000 should receive high priority. Fire history maps would be a valuable tool for improving our understanding of the dynamics of northwest Alaskan vegetation.

Limited inventories of the flora, mammals, birds, fish, and archaeological resources have been carried out on most U.S. National Park Service lands. Extensive archaeological surveys and reconnaissance vegetation mapping have been conducted on NPR-A. More complete faunal and floral inventories are needed on all of northwest Alaska's lands. More complete cultural resource inventories will also be required for virtually all areas; the Selawik National Wildlife Refuge should receive priority attention, because only limited cultural resource survey work has been done there to date.

Inventories of invertebrate faunas and limnological resources are inadequate. Terrestrial and aquatic invertebrates are significant parts of the food chain, and better inventories are needed to understand their dietary role for both subsistence and commercial fish species. Better knowledge of invertebrate stocks is needed, for example, to understand the relationships between Selawik pike and sheefish populations.

Reconstructions of Quaternary history are important for gaining a historical framework for understanding modern landscapes. Paleoecological data can be linked with monitoring of contemporary processes and dynamics to better hypothesize future change in landscapes and ecosystems. Heavily sclerotized (hardened) insects, such as beetles, commonly appear in Pleistocene sediments and are thus potential sources of paleoclimatic and paleoenvironmental information. The conditions in which they occur today can provide important clues about past climates. For this reason, we recommend more effort to collect information on terrestrial and aquatic beetles and the environments in which they occur.

Lakes of various sizes cover large parts of lowland areas. Lakes are also numerous within areas glaciated during the late Pleistocene. Lakes are important as nesting and feeding habitat for migratory birds, and play an important role in the life history of some fish species used extensively as sport and subsistence resources. Lake sediments are a major source of paleoenvironmental and paleoclimatic information, because they incorporate remains of pollen, diatoms, ostracodes, and aquatic insects. For these reasons, we recommend studies of the physical and chemical limnology of the several types of large and small arctic lakes. Inventories are especially needed for the diatom floras and mollusk and ostracode faunas in arctic lakes, so that we can better understand the significance of populations of these organisms recovered from ancient lake sediments.

Weather and climate data for northwest Alaska are sparse and inadequate. Long-term weather records are a critical requirement for understanding past and present interactions between atmosphere, landscape, and biotic processes, and

are absolutely essential if we are to monitor the effects of global change. Subsistence resources are directly and immediately affected by short- and long-term environmental variability. Relatively long-term weather records are available for Nome, Kotzebue, and Barrow. Unfortunately, Barter Island, a former first-order station in northeastern Alaska, now reports only three times daily, and precipitation and maximum/minimum temperatures are no longer reported there. We are very concerned that one or more of the three remaining first-order stations may fall victim to federal budget cuts.

The lack of representative long-term weather data poses serious difficulties for planning environmental protection in connection with large-scale industrial developments away from the coast. For example, the design capacity for the settling pond intended to remove heavy metals from mine wastes at the Red Dog Mine (located at 300 m. elevation) was necessarily based upon sea-level precipitation records obtained at Kotzebue, 125 km to the south. An unexpectedly (but probably not unusual) wet summer in 1989 was followed by high, perhaps above average, snowfall during the 1989-90 winter; in March 1990 snowmelt runoff exceeded the settling pond capacity and forced the unscheduled release of pollutants into the Wulik River (Hulen, 1990).

The existing first-order stations do not, in any case, provide a good representation of northwest Alaska's climate. The Nome, Kotzebue, and Barrow stations are all coastal, and conditions a few kilometers inland are quite different. Short and often discontinuous records have been and continue to be kept at several other communities, also mostly coastal, in support of weather forecasting for air traffic. Unfortunately, most of these data are difficult to access, if archived at all, and environmentally critical parameters such as precipitation are often not recorded. A major problem with existing data is consistent under-estimation of precipitation received as snowfall

The requirement for better, more representative weather data could be satisfied in part by establishing small local weather stations in the villages, staffed through local hire programs. Placing Wyoming snow gages near several coastal and inland settlements would greatly improve knowledge of the time, amount, and distribution of snowfall. In addition to standard weather observations, local observers should monitor phenology of vegetation, timing of spring break-up and fall freeze up, and at coastal stations, timing and height of storm surges.

Long-Term Monitoring

The rapidly emerging issue of global climatic change and its consequences for the landscape and the biota (Office of Interdisciplinary Studies, 1988) lend urgency to calls for initiating a well-designed long-term environmental monitoring (LTEM) program in Alaska. Because of northwest Alaska's high-latitude setting and widespread permafrost, the forest-tundra ecotone and, in fact, the entire biotic system is highly sensitive to climatic alteration. An LTEM installation in northwest Alaska would be a valuable early warning site for regional, national, and circumpolar global change research.

The Noatak River watershed offers an ideal site for a major monitoring effort (National Park Service, 1974; Young, 1974). Advantages include varied topography, a diversity of landscapes and terrestrial and aquatic ecosystems, and the administrative protection provided by two National Park Service units (Noatak National Preserve and Gates of the Arctic National Park and Preserve)

and its status as an International Biosphere Reserve. The Noatak watershed has been proposed as the North American component of a US-USSR bilateral biosphere research program, to be paired with an as-yet unnamed high-latitude biosphere preserve within the Soviet Union (Krugman and Puzachenko, 1988).

In a recent feasibility study Wiersma et al. (1986) conducted reconnaissance level environmental monitoring in the Noatak National Preserve with several objectives: (1) establishing reference levels for pollutants that already exhibited global contamination; (2) establishing baseline measurements of ecosystem parameters that permit comparison with more impacted areas; and (3) providing an early warning system for detecting hazardous pollutants and changes in ecosystem processes. The researchers acquired data concerning chemical constituents of surface water, soils, and plant materials. They established permanent plots for repetitive analysis of above-ground vegetation, community structure, and biomass distribution. Fresh water sources were analyzed for periphyton populations, and an algal species list was prepared. Wiersma et al. (1986) also recommended specific sites for a long-term comprehensive environmental monitoring program.

The scale of future monitoring may range from activities on a few small plots to larger studies involving entire watersheds or landscape elements and even to studies involving an entire Biosphere Reserve: Laughlin (1988) presents a list of key arctic environmental variables to be monitored for understanding global change (Table 2). The optimal spatial scale, temporal scale, and precision of measurement for monitoring depend upon project objectives and upon the fiscal, technological, and personnel resources available. Monitoring tools may range from in situ instruments and data loggers, through field surveys, to satellite-based remote sensing.

The design of a long-term monitoring program must be based on our current understanding of ecosystem structure and function, but the design also must be flexible enough to accommodate an evolving and improving understanding of ecosystems. Long-term monitoring requires, above all, a commitment to continuity of effort, adequate logistic support, sustained quality assurance, scientific credibility, physical site security, and continuity of policies in the face of changing administrative personnel.

Though they did not develop a specific monitoring program, the Inventory and Monitoring workshop group proposed a regional long-term monitoring strategy based on experience gained in ecosystem research and monitoring in other regions and on the particular needs of northwest Alaska. Inventory and monitoring on federally reserved lands in northwest Alaska should capitalize on approaches taken previously in UNESCO-MAB Biosphere Reserves. Monitoring projects should be interdisciplinary and multi-media, integrating physical and biological components of environmental systems. They should emphasize involving local residents, and fully utilizing and acknowledging local and traditional knowledge. They should also emphasize support for local and regional economic development, but with concern for maintaining ecosystem integrity and for concomitant to environmental conservation measures. Thus, monitoring should serve the interests of six distinct but intertwined sectors: local residents and users; federal land managers; the resource development community; the conservation community; the scientific community; and those concerned with global change.

Table 2. Arctic environmental variables important for monitoring global change (Laughlin, 1988)

I. ATMOSPHERE

Variable	Importance to Global Change	Past Data Base	Technical Systems
CO_2	* *	~15 yrs, plus ice cores	Flask samples
CH_4	* *	~10 yrs, plus ice cores	Flask samples
Strat. O_3	* *	Limited (~10 yrs)	Dobsons, satellites Ozone sondes
Halocarbons	*	Short record, not all sampled routinely	
Trop. O_3	*	Limited (~10 yrs)	
Trop. Aerosols (Arctic Haze)	*	~10 yrs, expeditionary + surface stations	Aircraft expeditions + surface stations
Profiles of Temp., Humidity, Wind	*	Limited network of radiosondes in Arctic	Radiosondes, rockets, satellites (problems)
Cloud Cover (amt., height, type)	* *	Limited pre-satellite, few surface stations	Satellites
Precipitation	* *	Inadequate, problems with snow gauges	Gauges, stations
Surface Pressure	* *	Open network in Arctic	Buoys, stations
Surface Temperature	* *	~50 yrs, satellite data over larger area, proxy: tree rings, varves, cores	Stations, satellites Proxy data methods
Radiation Budget	* *	Very few stations, (many expeditionary) Satellites (ground truth essential)	Stations, satellites

II. OCEAN

Variable	Importance to Global Change	Past Data Base	Technical Systems
Surface Temperature	* *	Limited pre-satellite	Satellites, ships, buoys
Sea Ice (ext., thickn., comp.)	* *	Historical: natives, whalers Iceland: 1000 yrs. satellites	Satellites, aircraft (Ice Patrol), sonars
Sea Level	*	Limited tide gauge data	Tide gauges
Deep Water Formation	* *	Very limited	Tracers
Biochem. Fluxes Ocean CO_2	* *	Limited Ship data	Ships, ice stations
Salinity	* *	Reasonable data base	CTDs, buoys
Ice Motion	*	Buoys (~10 yrs), exped. data, limited satellite data	Buoys, satellites, ice stations, shore radars

* * Essential * High

III. HYDROSPHERE

Variable	Importance to Global Change	Past Data Base	Technical Systems
Snow Cover (ext., thickn., H_2O cont.)	* *	Ocean ice: non-exist. Land: spot data only except extent by satellite	Satellite potential (needs ground truth), snow courses
Glacier / Ice Sheet Mass Balance	* *	Poor coverage: index glaciers only	Altimeter potential (need ground truth)
Permafrost Temp.	*	Limited number of boreholes and soil sites	Borehole thermometry
Depth of Active Layer	*	Expeditionary data base	Radar potential (needs ground truth)
River / Lake Freeze-Up and Breakup Dates	*	Noisy, but long-term record; satellite data	Satellites
River Runoff	*	Poor in Arctic	Gauges satellite-interrogated

IV. BIOSPHERE

Variable	Importance to Global Change	Past Data Base	Technical Systems
Carbon balance	* *	Limited data	
Index of Vegetation	* *	Adequate data, maps (Geogr. Info. Systems)	Satellites, but ground truth essential
Primary Productivity			
• Ocean	* *	Good data base	Satellites: chlorophyll
• Land	*	Spotty data	
Toxins in Indicator Species (incl. humans)	* *	Variable, eg. DDT, radionuclides, etc.)	
Ice Habitats (Leads, polynyas, ice type)	*	Post-satellite: good	Satellites
Population Estimates and Distribution	* *	Data set fairly good	

V. SOLID EARTH

Variable	Importance to Global Change	Past Data Base	Technical Systems
Volcanic Emissions	* *	Limited in Alaska, Kamchatka, better in Iceland	Seismic network, satellites
Geomorphology (climate-related)	*	Coastal Erosion data good Other data sets exist (e.g. frost action)	Aerial photography

* * Essential * High

A rational monitoring strategy must be founded on clearly specified objectives. Objectives for an LTEM program in northwest Alaska should include:

** Collecting inventory data to provide benchmarks for determining future change.

** Determining the directions and rates of change of physical, chemical and biological ecosystem parameters.

** Determining spatial and temporal patterns of change (local vs. regional vs. circumpolar; transient vs. ephemeral vs. annual vs. decadal vs. solar-cyclical vs. secular or long-lasting)

Environmental monitoring programs are sometimes seen as mundane, pedestrian, routine, or less-than-cutting-edge activities in science. Establishing and maintaining scientific credibility in a monitoring program for northwest Alaska is therefore essential and will entail several factors. Foremost is competence and rigor in program design and execution. Protocols and procedures must be developed and carried out according to the various standard methods for analysis of specific parameters, such as water quality. These include standards now being applied in national and international activities such as the National Acid Precipitation Assessment Program (Interagency Task Force, 1983), the National Atmospheric Deposition Program (Technical Committee NADP, n.d.), the Global Environmental Monitoring System (GEMS) (Wiersma, 1987), the NSF Long-term Ecological Research Program (LTER), International Hydrological Program (IHP) (UNESCO, 1984), the UNESCO-MAB Biosphere Reserve Program (Batisse, 1982), and the International Geosphere-Biosphere Program (Dyer et al., 1987).

Monitoring should not be conducted in isolation, but should be linked to ongoing research. For example, reconstructions of Quaternary history are important in gaining a historical framework to understand modern landscapes and to anticipate future effects. Paleoecological data can be linked with results from monitoring contemporary processes and dynamics to improve hypotheses about future change. Thus, monitoring should be closely tied to hypothesis formulation and testing, to ensure that information is acquired within the framework of current theoretical and experimental studies. A model for this approach is found in the current LTER program.

An integrated monitoring and research design is essential. The program should be designed to disaggregate systems and isolate critical factors and processes important for specific monitoring objectives (Dyer et al., 1987). The unifying concepts for integrated monitoring can be found in a major landscape unit such as a watershed, which integrates and processes input (solar radiation, atmospheric contributions) and for which processes, rates, and outputs (mass, energy, nutrients) can be quantified. A watershed on the scale of the Noatak River basin can be viewed at the top or regional scale by techniques such as satellite-based imagery, and at the same time split up into constituent third-, second- and first-order catchments for more specific, detailed, and higher-resolution measurement and monitoring. Catchments can be divided, in turn, into smaller landscape units such as slopes, terraces, stream channels, or vegetation communities appropriate for high-resolution measurement and monitoring. A conceptual parallel in biology might be found in moving from ecosystem to community to species to specific habitat. This continuum concept

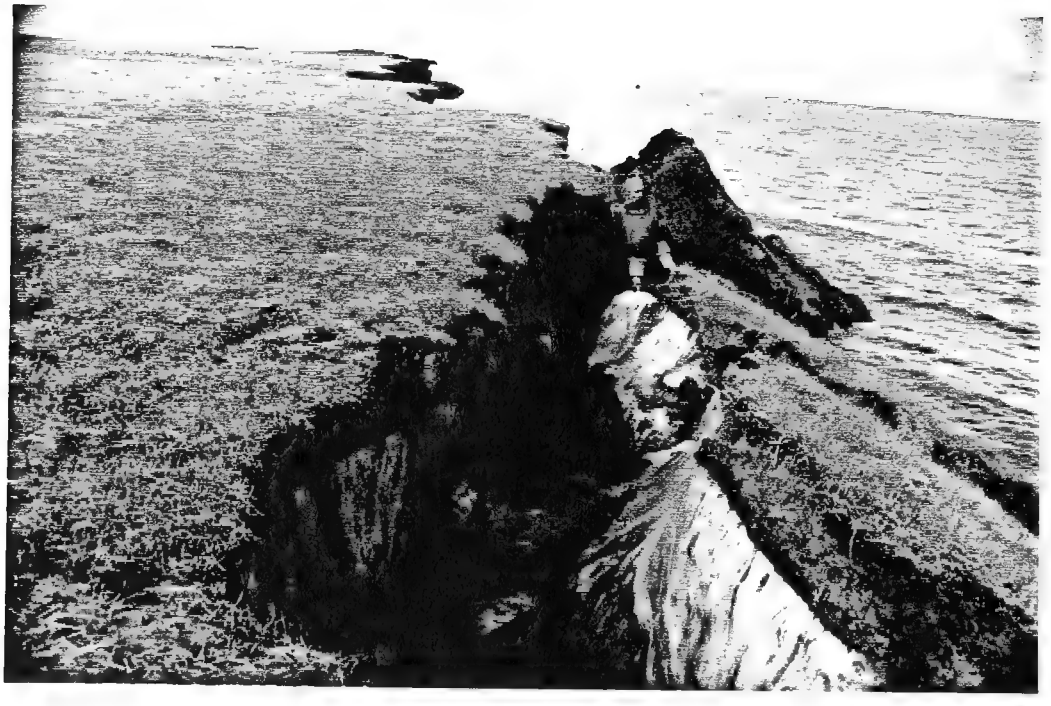
is also useful in considering the relationship between spatial and temporal scales in monitoring (Dyer et al., 1987).

Sites selected for monitoring programs must have both physical and administrative security. The value of data such as meteorological and hydrological observations that involve stochastic (randomly varying) elements increases with length of record. Thus, monitoring locations must have security not only from physical disturbance (flood, erosion, industrial development, vandalism), but also from administrative disruption (ownership transfer, change in land-use policies). Monitoring biological and landscape processes necessarily entails data acquisition over a span of decades or even centuries. Installing a properly designed monitoring program is costly both in equipment and personnel investment, and protecting that investment requires close attention to site security.

Successful operation and maintenance of a properly-designed monitoring program depends on management's commitment to continuing administrative and fiscal support by the federal agencies that control the land base and the fiscal resources. One-time funding for establishing a monitoring program is of limited value unless accompanied by the continuing fiscal and managerial support essential to building the required long-term records. Management commitment can best be ensured with multi-year funding, as is now being applied to the Long-Term Ecological Research program of the National Science Foundation (Brenneman and Blinn, 1987). Strengthening and broadening the linkages between local, state, federal, and international entities will help and may be required to broaden the support base and reduce the potential impacts of reductions in support by individual participants.

Finally, scientific credibility requires dedicated and technically competent personnel, employed on a continuing basis throughout the stages of planning, data acquisition, data archiving, and analysis. A corollary is that a monitoring program in northwest Alaska should be conducted by qualified personnel living and working in the region. Residents should receive training and become responsible for the monitoring program as early as is feasible.

A "Wyoming shield" precipitation gauge provides more accurate measurement of precipitation than does a conventional rain gauge in windy conditions.



Rapid coastal erosion involves wind, waves, thawing of ice-rich permafrost, and collapse of blocks bounded by frost cracks at the centers of ice wedges.

Section 2

Landscape Dynamics and the Climate-Landscape System

Background

Landscapes are dynamic systems, subject to natural alteration and change at time scales ranging from millennial to almost instant. Landscape change is driven by tectonic processes (volcanism, uplift or subsidence of the land, with or without faulting), by climate, and by human activity. This discussion is concerned with the natural changes in the landscape and the evolution of northwest Alaskan landscapes driven by tectonic processes and climate. The more rapid changes in the landscape and biota caused by human activities are discussed under Section 5, Human-Induced Environmental Alteration. The slower, climate-driven changes in the vegetation and landscape of northwest Alaska are susceptible to analysis and should be studied so that we can better assess the probable results of environmental changes, both human-induced and natural, now in progress.

Landscape stability in upland areas of northwest Alaska is affected mainly by fluvial processes and by mass-movement due to frost-creep and solifluction. Stream deposition, erosion, and lateral migration are important, especially in some lowland areas. Away from streams, however, periglacial processes involving permafrost, cycles of freezing and thawing, growth of ice wedges, development and drainage of thermokarst lakes, and formation and degradation of peat are the most important landscape processes.

Glaciers were much more extensive in the past. Half a million years ago, they covered part of the present Arctic National Wildlife Range and most of Gates of the Arctic, Noatak, and Kobuk Valley Parks and Preserves and Selawik National Wildlife Refuge. Large areas of southern and western Seward Peninsula, including parts of Bering Land Bridge Preserve, were also glaciated. Late Pleistocene glacial deposits are largely restricted to the Brooks Range and the Kigluaik Mountains of the Seward Peninsula. Today, numerous small glaciers persist in the Brooks Range, and a few remain in the Kigluaik Mountains.

Basaltic volcanism has been active in the southern part of northwest Alaska throughout the past several million years. Basaltic cinder cones and maars (volcanic explosion craters) are found on the Selawik National Wildlife Refuge and in the Bering Land Bridge National Preserve. The most recent eruptions took place at the Lost Jim cinder cone in the Imuruk Lake area about 1,600 years ago and at North Devil Mountain Lake maar about 7,200 years ago. Faulting and crustal warping have also had dramatic effects in the volcanic area around Imuruk Lake, and active faults are known in several other parts of northwest Alaska.

Several large active inland dune tracts are found in the Kobuk Valley National Park, and active dunes adjoin sandy coastal beaches. Wind was a much more important geologic agent during the late Pleistocene when the climate was drier and the vegetation cover much thinner. Wind-transported sand formed dunes and sand sheets on the arctic coastal plain, throughout much of the Kobuk Valley and over most of the northern coastal plain of the Seward Peninsula. Loess (wind-blown dust), mostly deposited during late Pleistocene time, mantles many lowland and upland areas that were not reached by the wind-blown sand.

Although the wind-blown sand and loess are now largely stabilized by vegetation, the sand is susceptible to renewed movement and the loess is vulnerable to gullying and thermokarst collapse wherever the vegetation cover is broken.

Arctic coastal processes are unique because of the interaction of wind, waves, sea ice, and ground ice in the coastal bluffs. Wave erosion, sea-ice override, and less commonly, shoreline progradation are important processes in coastal areas. All of these forces (water, wind, waves, frost, and biotic activity) interact in spectacularly dynamic ways to make northwest Alaska a particularly challenging region for geomorphic analysis.

Northwest Alaska abounds in materials that preserve a record of the plants and animals and the changing climates of the past. The cold climate and permafrost have kept bones and plant remains in Pleistocene sediments well-preserved. Study of pollen recovered from the bottom sediments of northwest Alaskan lakes has produced a rich and valuable record of past vegetation and past climate. Imuruk Lake, a large, shallow lake in the Bering Land Bridge National Preserve, has yielded a continuous pollen record that extends back for at least 150,000 years, providing the longest continuous pollen record yet discovered in Alaska. Remains of a variety of aquatic organisms, including ostracodes and diatoms, are also preserved in northwest Alaskan lake sediments but thus far have received little study.

Research Needs and Opportunities

Although assessments of rates of coastal progradation and retreat have been completed for most of the Beaufort Sea coast (Reimnitz et al., 1988) and parts of the Bering Land Bridge Preserve (Mason, 1990; Jordan, 1990), more studies of coastal dynamics are needed. Encroaching erosion threatens several coastal communities, including Kotzebue, Barrow, Point Hope, and Shishmaref. Northwest Alaskan archaeological sites tend to be concentrated along the coasts, so knowledge of coastal processes is also needed for cultural resource planning and management. Northwest Alaskan barrier islands are important and productive migratory bird habitat, and the dynamic processes responsible for their unique characteristics are of interest to wildlife biologists. Studies of arctic coastal processes provide an opportunity to obtain new insights into the unique interactions of snow, ice, waves, wind, and sediments. For all of these reasons, studies of coastal processes should continue, and estimates of rates of erosion or progradation should be made for all of the low-lying and rapidly changing northwest Alaskan coasts. Research now in progress concerning the evolution of barrier islands and beach ridge complexes, the interaction of ice, waves, and sediment on arctic beaches, and coastal sediment budgets should be continued and extended.

Data are needed on erosion rates and sediment yields for upland landscapes. Watershed sediment production is integrally related to sedimentation on downstream floodplains, estuaries, and lagoons. Studies of nutrient and energy flux on terrestrial landscapes and through terrestrial/aquatic ecotones to stream systems and estuaries can address important research questions.

The basaltic lava flow complexes on and near the Seward Peninsula offer opportunities for detailed studies that hold general interest for an understanding of high latitude landscape processes, of volcanism in cold

climates, and of the history of volcanism and tectonic movements in Beringia. For example, study of potassium-argon dated lava flows and cinder cones can provide a basis for estimates of rates of rock breakdown and slope denudation under arctic climatic conditions.

Interaction of wind-drifted sand, snow, permafrost, and a high groundwater table make arctic sand dune areas unique. Research concerning the dynamics of wind-drifted sand in the Great Kobuk Sand Dunes of Kobuk National Park has been completed (Koster and Dijkmans, 1988). Mason (1990) and Jordan (1990) have conducted research on dune/blow-out systems in the Bering Land Bridge National Preserve. These studies should be continued and extended to other parts of northwest Alaska. Much more knowledge is needed concerning the extent of stabilized dunes and sand sheets.

Peat accumulates readily in poorly drained areas in cold-dominated environments, but degrades and disappears just as readily when the surface is flooded. Deltas, coastal marshes, and some beach-ridge areas are mosaics of accumulating fresh peat, deteriorating peat, and expanding shallow ponds, landscapes that result from the interaction of peat growth and bacterial degradation. Peat presently constitutes a major sink or storage for fixed carbon, and may play an important role in the exchange of greenhouse gases between landscape and atmosphere (Post, 1989). Because of their importance as nesting habitat for migratory birds, their occasional use as reindeer/caribou grazing habitat, and their widespread occurrence in arctic landscapes, the Alaskan coastal peatlands and their shallow lakes should receive special study.

Northwest Alaskan lowlands are a mosaic of thermokarst lakes and basins of drained lakes. Recent studies have shown that the lakes are more diverse in morphology and limnology than had been previously recognized. Studies of ancient thaw lake deposits establish that the lakes contained a rich and diverse fauna and flora and were significantly productive. These deposits include remarkably well-preserved records of the vegetation that surrounded them, making them excellent sources of paleoecological information. As indicated earlier, we urge that studies of the limnology, morphology, and dynamics of modern thaw lakes be extended. We also recommend studies of pollen and macrofossils in ancient thaw-lake deposits as a part of the paleoclimatic and paleoecological studies proposed below.

Studies of the history of environmental change are needed to learn more about the origin and stability of the present climate-landscape system and to anticipate the consequences of the human-induced climatic changes expected in the near future. Several approaches should be used:

** An important source of information on climatic and landscape events during recent centuries comes from oral history obtained from interviews with Native and other local elders. Information may be gained concerning climatic change, changes in coastal shorelines, erosion and changes in river channel morphology, and the periodicity of large storm events. Data on variation in plant and animal populations, and expansions and contractions of animal and plant ranges may also be provided. Syntheses of oral history accounts should be supplemented by the analysis of the books, articles, journals, field notes, and other written accounts of early European explorers in northwest Alaska.

** Following a long period during which spruce limits were stable, recent evidence indicates that spruce and cottonwood trees, alder shrubs, and perhaps tall willows have colonized areas where they were previously unknown. Detailed dendrochronological, ecological, and phytogeographical studies of the forest-tundra ecotone are required, accompanied by a review of written and oral history materials to establish the rate, extent, and geographic distribution of this vegetation change, to determine what species are involved, and to discover when it began. These vegetation changes are having profound effects on the distribution of moose and beaver. What other mammalian species are affected and to what extent?

** By studying the sediments of the many lakes of northwest Alaska and the organic remains they contain, longer paleoclimatic records can be obtained. Some of the lakes are relatively ephemeral, having existed on the landscape for only a few centuries, but others have been present for tens of thousands or even hundreds of thousands of years. Studies of fossil pollen sequences in these lakes have been a major source of information on the climatic and vegetation history of northwest Alaska south of the Brooks Range, but very little palynological data has been obtained north of the mountain crest. A concerted effort should be made to identify lakes that will provide improved and extended pollen records from northwest and arctic Alaska.

** In other parts of the world, fossil diatoms and ostracodes preserved in lake sediments have provided valuable supplemental information on past climates, past environments, and changes in lake productivity. Yet studies of fossil diatoms and ostracodes are almost nonexistent in northwest Alaska. Future paleoclimatic and paleoecological studies should be expanded to include consideration of these important organisms.

** Glaciers are sensitive to climatic change, and traces of former glaciers can persist on the landscape for many thousands of years. The small existing glaciers in northern Alaska have been shrinking steadily during most of the past century, presumably in response to climatic warming. The dynamics and history of the small active glaciers in northwest Alaska have been fairly well documented, and the extent of the former (late Pleistocene) large glaciers has also been mapped. The causes, the extent, and the dating of the vastly more extensive early and middle Pleistocene glaciations are currently under study. This research should be continued and extended.

Section 3

Fire

Background

Terrestrial ecosystems of northwest Alaska have evolved with wildfire as a recurrent environmental factor. Most northwest Alaska vegetation is adapted to fire to some degree. In the short term, wildfire may produce abrupt, locally important changes in ecosystem structure and in the abundance of various biotic components. The research base specific to northwest Alaska concerning wildfire and its consequences is limited. Extensive research has been conducted, however, in other sectors of subarctic and arctic Alaska, Canada, Fennoscandinavia, and the Soviet Union on many aspects of fire in relation to northern lands (Viereck and Schandelmeier, 1980). Information at least partially applicable to northwest Alaskan landscapes is available concerning short- and long-term effects of fire on soils, vegetation community composition and succession, habitat and forage productivity for wildlife, and landscape stability, especially in permafrost-underlain settings. Forested lands are more susceptible to wildfire than are tundra landscapes and have thus received more attention (e.g. Slaughter et al., 1971; Foote, 1976; Viereck, 1973; Viereck and Dyrness, 1979; Viereck, et al, 1979). Lightning-caused fires have been documented in tundra regions (Wein, 1976), particularly on the Seward Peninsula (Melchior, 1974; Racine, 1979).

Wildfire management plans have been developed and implemented for much of northwest Alaska. Interagency plans call for a graded control response to wildfires, depending on values at risk. High-value sites are accorded maximum protection, while modified management responses ranging from "limited action" to simple monitoring are planned for remote or lower-hazard areas. This graded set of responses incorporates a time element for specific land areas, taking account of fire history and frequency, and changes in land and resource use over time. Fire management plans are reviewed annually, with opportunities for residents to participate in that review.

Some workshop participants suggested that implementing fire management planning has had an unanticipated effect--a de facto lessening of interest or support for research into fire behavior and fire ecology; other attendees disputed this suggestion. In a similar vein, there were suggestions, disputed by some, that fire management plans have not always taken proper account of reindeer forage (lichen) needs. Although scientific knowledge of relationships of fire with reindeer and caribou range has been growing over the past several decades, there is certainly a need for additional information and more widespread dissemination of that information in northwest Alaska.

Research Needs and Opportunities

Additional research is needed into the effects of fire upon range quality for all browsing and grazing species. Although successional post-fire changes in vegetation are fairly well understood for some specific settings, we have a much poorer grasp of the effects upon quality of grazing and browsing for various herbivores. We have even less understanding of what may control the nutritional or range quality in various types of tundra and forest. The

widespread interfingering of forest and tundra and the variety of herbivores present in northwest Alaska provide attractive opportunities for investigating the interaction of wildfires and range quality.

We need an improved understanding of spatial and temporal fire patterns and of fire frequencies. If historical fire frequencies can be reconstructed at individual sites, the networking of many sites scattered over a wide area and representing diverse vegetation types would offer a particularly powerful analytical tool. Several derivative questions could then be addressed:

** Are there geographic gradients (perhaps controlled by topography or local climates) in fire frequency in northwest Alaska?

** Is there a definable relationship between fire frequency and intensity on the one hand, and regional or global climate changes on the other?

** Is there an inverse relationship between frequency and intensity of wildfires?

** What significance does fire have for the position of latitudinal and elevational tree line?

** What are the relationships between fire frequency, fire intensity, and caribou and reindeer range quality in specific landscape settings?

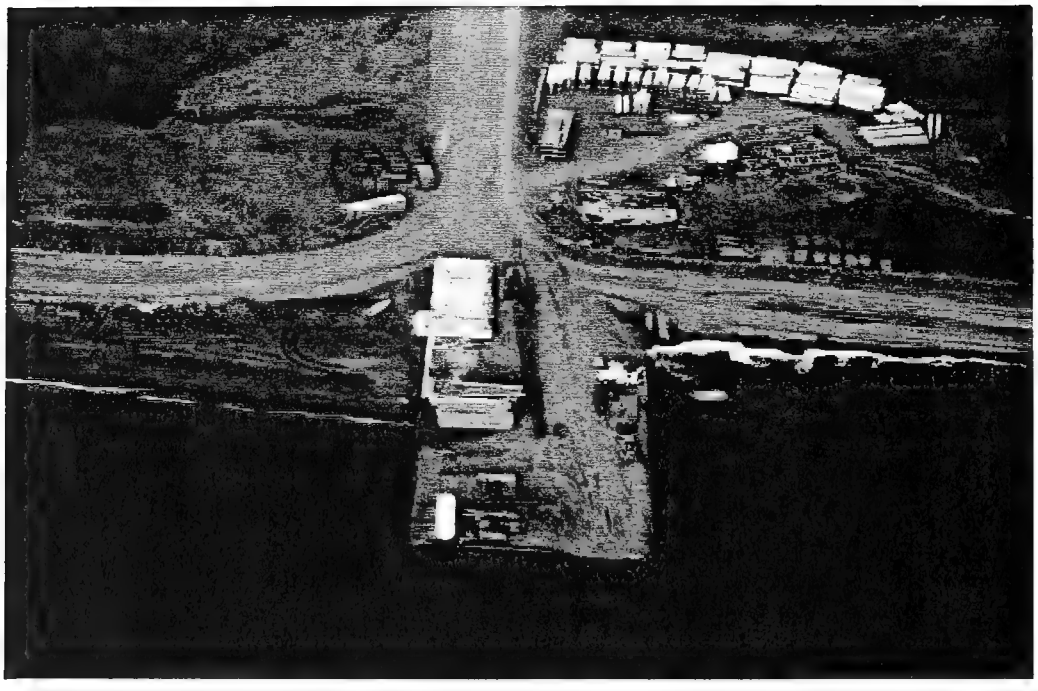
** What impacts do wildfire have on furbearers in specific regions?

** What are the relationships between wildfire and aquatic systems: streams, riparian zones, wetlands, and estuaries?

** What implications do the answers to these questions hold for fire management planning?

A serious problem is the lack of sustained funding. There was consensus that wildfire research has tended to run out of money at the point of conducting survey and inventory work. If process studies could be coupled to inventory analyses, considerably more information of direct benefit to management decisions could be derived. The lack of sustained funding has affected both the quantity and quality of wildfire research.

Wildfire is an important phenomenon affecting vegetation distribution and ecological relationships in northwest Alaska.



A newly-constructed port facility on the Chukchi Sea coast serving Red Dog Mine, 145 km north of Kotzebue.

Section 4

Minerals and Non-Renewable Resources

Background

Discussion of issues concerning minerals and other nonrenewable resources was handicapped because members of the mining and petroleum exploration and development communities were almost completely absent. Consequently, our recommendations on these subjects are probably less complete and less comprehensive than they might be. This lack of representation should be corrected in future science planning exercises for northwest Alaska.

Northwest Alaska is geologically complex and holds large reserves of valuable minerals, rare earths, fuels, and industrial materials. Nonrenewable resources known to be present include copper, lead, zinc, gold, coal, oil, gas, oil shale, jade, gravel, and possibly soapstone. Groundwater is present in abundance in some places but unavailable in others. The nonrenewable resources are potentially of great importance because many are exportable and, properly managed, could bring jobs and economic development to the region. Local people have used some of these resources for millennia, and gold and jade mining have proceeded on a small scale for several decades. Large-scale mining, however, is just beginning.

The National Petroleum Reserve-Alaska was set aside by Congress as a future petroleum resource. Mining its large coal reserves is also contemplated, when justified by economic circumstances. In general, the national parks, preserves, and monuments are not open to mining although preexisting claims in Gates of the Arctic National Park, Bering Land Bridge Preserve, and Cape Krusenstern National Monument may be worked. The Selawik National Wildlife Refuge is essentially closed to mineral entry.

A systematic review of the level of permissible and prohibited exploration methods on federally protected lands is needed. Remote sensing, geologic mapping, geophysical surveys, surface excavation, and drilling are a graded series of successively more intrusive exploration techniques. Where should they stop? If mineral and petroleum discoveries are made, then pressure to change the status of protected lands will develop. As a representative of the mining industry pointed out, nonrenewable resources represent one of the few bases for generating wealth within the region. Furthermore, knowledge of resource availability seems necessary in case of grave national emergency.

Research Needs and Opportunities

Baseline and inventory information are essential first steps for developing wise public policy and for planning rational development and environmental protection. To the extent that tracts of federally protected lands might be opened in the future for mining or oil extraction, inventories are needed to locate and evaluate the resources present. Extensive exploration has already been devoted to the petroleum potential of NPR-A, but the coal resources are still inadequately inventoried.

Several agencies, including NOAA and NASA, acquire remotely sensed imagery and data in great volume. It should be used more extensively as an aid to

inventorying nonrenewable resources in northwest Alaska. Much of this information is archived at the University of Alaska Fairbanks, but some potential local users seem unaware of its availability or do not know how to use it effectively.

Gravel, sand, and rock suitable for use as crushed rock or riprap should be inventoried to locate resources that can be safely used to satisfy anticipated construction needs in towns and villages and in any administrative, visitor, development, or research facilities built on federally protected lands. The region's three large towns and several of its villages have a continuing requirement for gravel and sand for docks, roads, airfields, and building foundations, crushed rock for concrete, and coarse rip-rap to stabilize beaches and reduce river-bank erosion. These materials will certainly be needed for drill pads, airfields, and access roads on NPR-A. Extracting sand and gravel from nearby beaches is likely to result in accelerated coastal retreat and may lead to disastrous losses of residences, installations, and archaeological sites along previously stable parts of the coast. Poorly planned sand and gravel extraction from river channels can accelerate bed or bank erosion or degrade spawning or over-wintering habitat for aquatic organisms.

Hot springs and basaltic volcanoes located in several places on the Seward Peninsula and in other southern parts of northwest Alaska indicate high geothermal heat flow. The Pilgrim Hot Springs on the Seward Peninsula have been evaluated as a potential source of geothermal energy. Other known hot springs should be evaluated, and the possibility explored that still unrecorded hot springs may exist. Local people, especially elders, are the best source of information concerning otherwise undetected hot springs. Any plans for developing hot springs should be sensitive to their importance for the Native people of the region. At least five of the known hot springs on the Seward Peninsula are visited for emotional, spiritual, and physical healing.

Groundwater circulation in permafrost environments is generally understood (Williams, 1970; Williams and van Everdingen, 1973), but requires much more investigation in specific geologic and geomorphic settings. Groundwater movement is more active and extensive in permafrost terrain than is commonly recognized, especially in carbonate terrains and some areas underlain by thick sheets of gravel. In these terrains significant, even large, quantities of groundwater may be available. Industrial and mining activity or residential settlement in these areas may result in serious contamination of both groundwater and surface water downstream from points where the groundwater emerges. Research is needed concerning the dynamics of groundwater circulation in carbonate and gravel terrains in northwest Alaska.

Recent studies indicate that gold is soluble in groundwater charged with organic compounds (Teller and Bressler, 1989; Teller, 1990). Evidence of both leaching and overgrowths have been found on gold grains in certain placer deposits. During the freezing process, concentrations of solutes in soil solutions are greatly increased, and this process may play some role in heightening the mobility of gold in permafrost. What is the extent and economic importance of gold redistribution in soil solutions and shallow groundwater? Several placer districts in northwest Alaska offer useful sites for studying the dynamics of this process and evaluating its potential economic importance.

Exposed mineral deposits, with their unusual chemistry, provide an opportunity to examine natural situations that may be quite analogous to human disturbance. For example, to what extent do large exposed ore bodies like the deposit at Red Dog Mine contribute dissolved metals and sulphur to streams? How far downstream are the toxic effects of such chemical loading felt? To what extent does it affect the biota, and how has the biota adapted? Similar questions might be explored at natural oil seeps, such as those at Cape Simpson, and at exposed coal seams in the arctic foothills.

The effects of exploration, development, and extraction of nonrenewable resources must be monitored throughout the life of any project. Experience indicates that plans for large projects often underestimate the seriousness of environmental problems unique to the Arctic. Because it is a relatively new development, northwest Alaskan residents have been particularly concerned about the adequacy of plans for environmental protection at the Red Dog Mine (145 km north of Kotzebue). Those concerns seem well founded; heavy snowfall during the first year of operation resulted in flooding by meltwater of the settling pond that removes heavy metal contaminants from mine discharge waters. Larger than anticipated spring runoff in 1990 led the Alaska Department of Environmental Conservation to grant permission for the release of a large volume of water containing elevated levels of zinc, lead, cadmium and cyanide into streams tributary to the Wulik River, a stream renowned for its Arctic char population (Hulen, 1990). Long-term oversight and stringent enforcement are required to insure that mitigation stipulations are met and to deal adequately with unanticipated environmental effects associated with major resource development projects.

Wherever extraction of non-renewable resources is permitted in northwest Alaska, consideration should be given to diverting part of the production for local use. This policy should apply to fuels (coal, petroleum, gas), as well as to construction materials and groundwater. As an example, we note that Barrow's energy and heating needs are satisfied by tapping nearby gas fields.

Thermokarst collapse and ponding mark a formerly-used winter road near Prudhoe Bay.

Section 5

Human-Induced Environmental Alteration

Background

Concerns about environmental alteration in northwest Alaska are representative of concerns throughout much of the circumpolar North. Global greenhouse warming, for example, may be especially intense at high latitudes, and the delicate balance among snow, water, wind, frost, and biotic agents makes northwest Alaska especially responsive to global climatic change. Predicted greenhouse climatic warming will affect ground temperatures, thaw permafrost, and increase landscape instability. It will have a profound effect on the vegetation, and ultimately, on vertebrate and invertebrate faunas. It may cause an increase in the extent of exposed soil on slopes, leading to accelerated erosion, greater sediment yield, and degradation of surface water quality due to increased leaching of soils. Warming may also lead to heightened biological productivity, peat accumulation, and development of the patterned bogs so common in more southern parts of Alaska.

Research Needs and Opportunities

Most of the federally reserved lands in northwest Alaska are at present minimally affected by development activities. These lands offer many opportunities to measure, through long-term monitoring and research, the secular changes that occur in natural environments. By comparing these changes with the effects of development, scientists and managers should be in a better position to evaluate the impacts of specific practices and specific pollutant sources in the future.

Detecting changes in the landscape and biota caused by human influences and by climatic changes should be one of the objectives of long-term environmental monitoring efforts in northwest Alaska. Acid precipitation and arctic haze may be particularly discernible and deleterious in northwest Alaska. Many of the region's plant and animal species live under conditions of environmental stress at or near their range limits. The additional stress posed by degradation of air or water quality may exceed the environmental tolerance of important biotic components. The dangers posed by radioactive fallout for Alaskan food chains have long been recognized and should be monitored. The lichen-reindeer association seems to have an especially high potential for concentrating radionuclides in top consumers, including humans. Thus, long-term monitoring efforts should be specifically designed to detect the possible effects upon landscape, soils, and biota of anthropogenic acid rain, arctic haze, radioactive fallout, and other pollutants.

Landscape alteration as a consequence of local human activities is also an important concern. Disturbance or removal of vegetation due to construction, logging, agricultural activities, or off-road vehicle traffic, for example, is likely to result in accelerated thawing of permafrost, gullying on slopes, and serious wind erosion in areas of ancient sand dunes.

Some of the areas at risk for these potential alterations are the various transportation corridors that have been proposed to connect mineral development sites with ports or railheads. These include a corridor to connect the Ambler

Mining District with Fairbanks, a surface route to connect future northwest Alaska mineral developments with the Red Dog mine site and road, and perhaps in the more distant future, corridors for accessing coal reserves. The Dalton Highway has provided a case study for the important environmental effects associated with northern transportation corridors (Brown, 1980).

Snow machines and light all-terrain vehicles (ATVs) are used widely for subsistence and recreational purposes in northwest Alaska. Their effects on the vegetation and the landscape are generally known (Brown, 1976; Slaughter et al., 1990), but need additional study in specific landscape settings. In the Barrow area, past use of tracked vehicles (often by scientists) has resulted in thermokarst collapse and extensive vegetation change (Abele et al., 1984). Because snow machines and ATVs have become increasingly important for subsistence activities, the results of further research will be of special concern to local people; their involvement in those studies would be particularly appropriate.

Contamination of groundwater systems by petroleum products and other toxic chemicals or by sewage and other biological toxins creates hazards to health and to the well-being of fauna, flora, and people. Studies of groundwater circulation are an urgent requirement in areas where planned development has the potential for contaminating groundwater.

Solid waste disposal is a related topic needing attention. Vast amounts of solid waste have begun to accumulate as a result of increasing population growth, concentration of the population in communities at transportation hubs, and increasing adoption of western consumption and disposal habits; yet this region has few appropriate disposal options. Much of the land is unsuitable for landfills. Leaching of contaminants often occurs because workable containment measures are not readily available. High transportation costs prevent most recycling options from being feasible. Creative research to devise better disposal methods is urgently needed.

Section 6

Recreation and Tourism

Background

The statewide trend toward an increase in tourism is expected to continue through the 1990's, and its effects are bound to be felt in northwest Alaska. Tour operators have long extolled the exotic character of places like Nome, Kotzebue, and Barrow. The region has much natural beauty, and the creation of new national parks and preserves is already attracting more recreational visitors seeking a "wilderness experience." Support of such visitation is implicit in the mandate of the U.S. National Park Service and the Refuge Division of the U. S. Fish and Wildlife Service. These services are expected to accommodate reasonable numbers of users. Further, planners in northwest Alaska believe that local demand for recreational opportunities will also increase during the next decade.

Given the acute shortage of jobs in northwest Alaska, an increase in tourism and recreational use would seem an attractive development option. The tourist industry, with proper management, should bring substantial economic gains to the region. If sensitively developed, it can also have other positive benefits by increasing tourists' understanding of Native culture and Native people's pride in their own heritage. Recreation and tourism seem at first glance to be relatively clean, non-polluting, low-impact land uses.

Nevertheless, this industry is not a purely nonconsumptive economic panacea. The extent to which recreation and tourism will consume resources and affect the land and local people depends upon the kind and numbers of users, the areas visited, the attitudes of tour operators, and a host of similar factors. These effects are not limited to such tangible resources as wildlife and available campsites but extend to less tangible quality-of-life issues, as well. What is the impact, for example, of tourists roaming a small community in search of Native people to photograph wearing picturesque dress or engaged in subsistence activities? Here, especially, research should be community based and directed toward increasing local involvement, benefit, and control.

Needs and Opportunities

Managers will soon need information concerning the capacity of public lands and waters to accomodate recreation and tourism. Inventory studies, proposed elsewhere in this report for dealing with soils, landscape processes, vegetation, wildlife populations, and archeological sites, should be the basis for determining when human impact begins to have an undesirable effect.

Another important early step would be to prepare a history of recreation and tourism in northwest Alaska. What happened, where, and when? Who were the key personalities and what were their roles? This analysis would provide a background and an overview for looking constructively at contemporary tourism in northwest Alaska. It would help all concerned to detect important long-term trends and would suggest questions and issues for additional research.

A literature review of the impact of tourism upon other comparable undeveloped or rural northern areas would be helpful. Drawing upon such a data base,

researchers could isolate the particular environmental and social effects that might be expected in northwest Alaska.

A regional baseline study of values and attitudes toward recreation and tourism would provide a clearer view of the local perspective. Important intraregional differences in attitudes toward tourism should be taken into account. For example, because of their long association with gold mining, some communities in the Nome area are more interested in having tourists visit than are some other northwest villages. A baseline study could establish what kinds, levels, and locations of activities are acceptable or desirable. Responses should be drawn from selected communities (as many as possible) and could be used to predict and possibly aid development of tourism. This baseline would also be useful for evaluating changes in values and attitudes as tourism develops in northwest Alaska.

Long-term longitudinal studies should be conducted of selected villages where some forms of tourism are already established. Such studies would help to identify impacts and the conditions determining their effects in particular communities. Villages that are not currently tourism oriented should also be included as controls.

Research to evaluate the effectiveness of local tourist attractions could be a real asset. What factors make local museums, cultural centers, and other community resources successes or failures as attractions for tourists?

For the new federally reserved lands, in particular, studies are needed to identify and document the timing, location, and duration of activities of all users. From these data, managers can determine incompatible uses by tourists, recreational users, and other interests and regulate accordingly. For example, the local need to carry out subsistence harvesting may make it necessary to limit access to some critical areas at certain times of year. We have already called attention to the problem of competition for resources between subsistence and recreational users in Section 7, Biological Aspects of Harvest by Humans.

If local people are to gain and maintain some measure of involvement in, benefit from, and control of tourism, they will need an understanding of the structure and dynamics of this industry. We must look beyond Alaska to understand the larger economic forces controlling much of the tourist business and the inner workings of the major national and international companies that dominate it.

Finally, we recommend a cross-cultural study of how people are put to work in both Native and Western society. The study should focus on sources of labor supply; the culture of work, including values, ethics, work environments, time use, and status valuation; and other factors that either attract or alienate workers. Among its other virtues, this study would suggest better designs for effective local hire programs, and provide the basis for planning employment situations that would not only attract, but also keep, local employees.

Tourism is growing in importance as a source of jobs and income in northwest Alaska.

Biologist Fred Decicco, of the Division of Sport Fish, Alaska Department of Fish and Game, measures sheefish at Josephine and Wesley Woods' camp on the Kobuk River. Two of the Woods' grandchildren look on.

Section 7

Biological Aspects of Harvesting by Humans

Background

Hunting, fishing and gathering have been basic to human life in northwest Alaska since the region was settled thousands of years ago. They remain so today. It is impossible to understand human life there without knowing what has been and still is involved in human subsistence activities. As federal and state agencies seek to manage the lands, sometimes by limiting access to the land and its resources, local people become increasingly fearful of the consequences for their subsistence lifeway and economy. As a result, subsistence has become perhaps the most controversial and sensitive research topic in northwest Alaska.

The term subsistence has become a problem. Legal attempts to define the term engender debate over whether the laws governing the harvest of natural resources should give special preferences or allowances to particular groups on the basis of ethnicity, economic status, or place of residence. The debate raises an important public policy question: should persons who have an adequate cash income and who harvest resources for recreational purposes have the same access rights as those with no surplus cash, who depend on subsistence resources for part of their living? Many Native Alaskans see the outcome of this debate as having a direct impact on their very physical and cultural survival. Because it has such strong emotional overtones, subsistence has become a symbolic and political issue of great significance. Amidst such controversy, some Native people prefer not to use the term "subsistence" at all, instead referring to the activities as a lifestyle or a lifeway.

Research Needs and Opportunities

General Issues. Several important issues affect this topic. The historical dimension is critical and must not be ignored. Dramatic changes have taken place in harvest methods, times of harvest, amounts gathered, and in the resources themselves. Yet, researchers and managers tend to look at contemporary or relatively short-term patterns and assume they have always been that way. There have been important changes, both subtle and dramatic, over the past centuries and even over the past several decades. If our understanding of subsistence is be accurate and provide an adequate basis for management, it must take full account of these historical changes. Data from ethnohistory, oral history, and archaeology can contribute valuable insights on the fluctuations and changes in the abundance and distribution of resources and their harvest in the past.

Researchers should conduct long-term, longitudinal studies of subsistence-related phenomena in contemporary rural society. Two- to five-year harvest studies, for example, are a minimum requirement. Comparative studies are needed to acquire longitudinal harvest data in several communities, preferably in differing geographic and ecological settings, gathered at the same time and using a common set of methods. Harvest studies should be accompanied by detailed distribution studies in which the harvest is tracked from its entry into the village until its ultimate consumption. Such tracking is necessary to reveal important social and economic aspects of subsistence, such as sharing.

Studies should not be restricted to federally reserved lands. The flora and fauna do not observe these boundaries; if scientists are constrained by them, the value of research results is likely to be constrained as well.

Although the results of subsistence research are relevant to policy issues, the research itself should avoid the tendency to be policy driven. Research that can distance itself to some degree from this policy environment is much more likely to be relevant to other regions. Objective research is also more likely to permit the generalization and broad comparability that we expect of rigorous scientific investigation.

Assess the Resource Base and Obtain Better Harvest Data. Scientists, managers, and local people alike urgently need a better assessment of the resource base. Questions needing immediate study in the Seward Peninsula area include: What is the status and welfare of the grizzly bear population? What is the status of the wolverine and other furbearer populations? What new and better census techniques can we develop for these assessments? What is the moose carrying capacity? Why is recent recruitment low? What is the status of the wolf population? What factors limit its growth? Similar questions could be asked in other areas. Studies should not be limited to animal resources. Fish and plant resources such as berries, wood and bark for housing, implements and handicrafts, and particularly firewood, are very important to survival in rural Alaska. Managers would find these kinds of data useful in preparing more effective management plans.

Harvest data are important to supplement resource assessments, but must be accurate and species-specific. Studies of harvest levels are difficult and expensive, and the harvest data biologists acquire are not always accurate. Although numerical counts are the traditional measure used by western science to estimate factors such as carrying capacity and sustainable yields, we should also seek alternative ways of documenting the status of biological populations. Both biological and behavioral factors may serve as indicators.

Subsistence hunters often observe evidence of population status. One key to tapping informal user information is to develop more and better ways to translate into management terms the broad array of informal information already potentially available. An important aspect of this process is mutual trust; managers wishing to use this approach must overcome the sometimes realistic fear by Native hunters of prosecution or harassment. Native people also need reasonable assurances that the data they provide will not be used to support policies or actions contrary to their welfare. Such assurances would remove most motivations for inaccurate user reporting.

The Alaska Eskimo Whaling Commission (AEWC) is recognized as an indigenous group well-known for honest harvest reporting and for its concern with questions of population health. Interestingly, the AEWC is much more than a channel for reporting harvest statistics. It recognizes traditional structures of authority and has a significant research and management role. As we note below, there is growing interest in traditional management strategies; research concerning the social and political attributes that make this group successful might help in developing similar groups that are effective and respected by Native people, researchers, and managers alike.

Evaluate Management Techniques. Some past and current approaches to managing subsistence resources falsely assume that there was no management and no need for management before western wildlife managers came on the scene. One symposium participant pointed out that people in northwest Alaska traditionally did have concepts of resource conservation. A Native person from the region added that local policing occurred traditionally and continues to occur today through internal disapproval and censure of over-harvesting. He argued that through groups like the Alaska Eskimo Whaling Commission and the Eskimo Walrus Commission, self-imposed quotas can be made to work. The newly formed Alaska and Inuvialuit Beluga Whale Committee (1989) represents still another group in which users have come together with managers who recognize the value of traditional Native knowledge and approaches to decision-making, in order to understand and manage an important resource. This approach, sometimes called co-management, is starting to appear in other resource management groups in Alaska such as the Yukon-Kuskokwim Fisheries Task Force.

Native cultures are undergoing change, and managers wonder whether traditional means of harvest control can continue to be effective. Nevertheless, managers also realize that some western approaches do not work well. Quotas, for example, may force people to take animals they do not immediately need, because if they don't use all their quota one year, they may be assigned a smaller quota the next year. Increasingly, problems such as these are showing that successful management must involve local users and must find ways to incorporate traditional values and ways of managing. Careful studies are needed of conventional western, traditional Native, and newly developing "hybrid" management techniques to determine which aspects of each approach are the most effective, and under what circumstances.

Competition and Allocation of Resources among Subsistence, Commercial, and Recreational Users. What are the effects of competition among subsistence, commercial and recreational users for resources held in common? Fish probably represent the most significant resource involved in this conflict. Several species are taken for both subsistence and commercial purposes, sometimes by the same individuals. When salmon populations, for example, start to decline, should restrictions be placed on subsistence users to allow commercial fishing to continue? Commercial harvesting can also have a secondary effect on other species taken primarily for subsistence or recreational purposes. For example, what is the effect of the herring fishery on the seal harvest? How does the pollock fishery affect seabird and marine mammal populations?

Recreational users represent still another potential source of competition for resources such as fish, game, berries, firewood, and campsites. More knowledge is needed about these and many other unstudied interactions that may force difficult allocation decisions in years to come. Further, these studies and subsequent allocation decisions must also take into account the effects of distant actions, such as interception of fish on the high seas, the impact of development on resting and wintering areas for migratory waterfowl, and the consequences of toxic pollutants such as acid rain and arctic haze in northwest Alaska.

Studies of competition and allocation policies need to focus on the effects of regulation not only on the resource, but also on the users. Studies of commercial and recreational users must be coupled with research on subsistence users. How do recently instituted regulations affect what local people take,

how much, when, and how? What are the economic and nutritional impacts? How are resource allocation decisions made by one agency "spilling over" to affect the lands of another agency or of adjacent private owners such as the Native corporations?

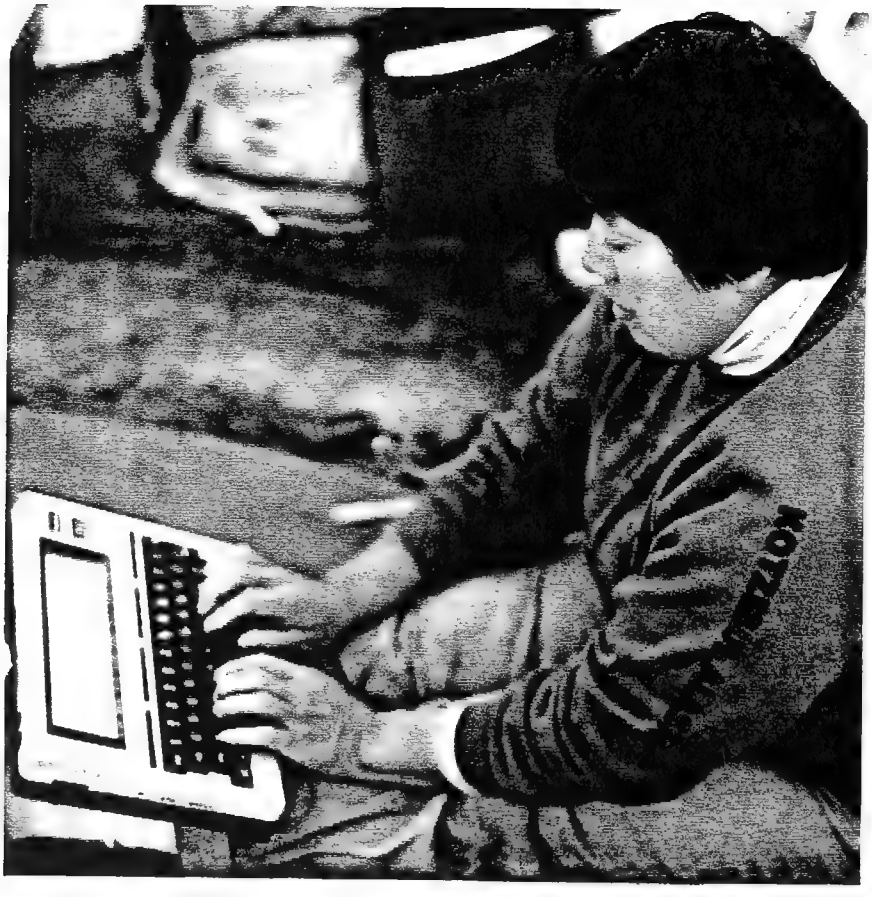
Other Issues. Caribou and reindeer interactions are particularly important in northwest Alaska. We need to know more about the respective habitat requirements and limitations of these two animals. How much are caribou encroaching on reindeer habitat, and to what extent does this affect subsistence dependence on caribou juxtaposed with economic dependence on reindeer? We need to know more about exchange of disease and parasites between the two. What is the best way to deal with wolves who follow caribou into a grazing allotment and then prey upon the more vulnerable reindeer? What reindeer herding techniques are most successful when caribou are also present? Cooperation among the Bureau of Land Management, the National Park Service, and the Alaska Department of Fish and Game on these issues has helped make individual agency efforts more fruitful. Recent research in which radio collared animals are tracked by aircraft may be particularly useful in answering some of these questions.

Several of northwest Alaska's vertebrate herbivores--hare, beaver, ptarmigan, and muskoxen--have undergone major population or range changes during the past 50 years. What are the vegetational responses to these changes in herbivore distribution? The distribution of moose has expanded dramatically northward and westward, and beaver have recently expanded into territories where they had never been seen before. Willows are an important food source for both of these species. Research is needed concerning the response of the vegetation to new herbivores, while separating the effects of herbivory from the effects of changing climate. At the same time, we need to examine the effect of new competitors on the arctic hare, an herbivore species indigenous to some of these areas.

More detailed analyses of the nutritional content of game foods are needed. Information is inadequate concerning, for example, the distribution within the animal of essential fatty acids, amino acids, and vitamins, and concerning seasonal and regional variability in these nutrients. Even though subsistence foods may account for only half the calories in the local diet, they may provide a much larger percentage of the nutritional needs for vitamins, minerals, and other dietary requirements. This knowledge is essential to assessing how well regional human nutritional needs are being met. It also could have important ramifications for subsistence-related management decisions.

Good planning information is essential for wise future management of subsistence resources. Answers or estimates are needed in response to several questions. How much is the human population of northwest Alaska likely to increase over the next ten years? Where are new communities or population concentrations likely to develop? How great an impact are they likely to have on subsistence resources? How are new technologies affecting subsistence resources and their use? Where is new economic development likely to take place? How will subsistence resources be affected and what conflicts with users might we anticipate?

Subsistence resources will remain essential to northwest Alaska's residents for the foreseeable future. In the 1960s and 1970s, the belief was widespread that the emphasis in northern local economies would shift within 20 years or less, making subsistence relatively unimportant. That belief was wrong because it overlooked both basic economic and cultural factors. Even as commercial foods have become more available, subsistence activities have taken on an increasingly important symbolic as well as economic dimension. The population is growing, but the region's ability to provide subsistence resources is finite. Thus, capable subsistence-related research will continue to be crucial to northwest Alaska's economic and cultural viability.



Hannah Loon, a resident of northwest Alaska and employee of the Subsistence Division, Alaska Department of Fish and Game, uses a laptop computer to record notes after a day in the field on the Noatak River.

Section 8

Archaeology and Oral History

Background

Too often in the past, researchers in the natural sciences have ignored the cultural history of the land. Yet, that history may be crucial to understanding anthropogenic processes and their influence on the landscape. Archaeology and oral history provide key information for comprehending not only how the people and the land have interacted in the past, but also how they interact in the present and are likely to interact in the future.

A noteworthy tradition of archaeological and ethnographic research by academic researchers in northwest Alaska has, since passage of ANILCA, been augmented by archaeological surveys, traditional land use surveys, and the collection of oral history data by various federal agencies and such regional organizations as the North Slope Borough, Maniilaq Association, and Kawerak, Inc. During the past several years the National Park Service has made a special effort to document and rescue archaeological sites in active erosional environments. Current National Park Service efforts to fund archaeological research in the Bering Land Bridge National Preserve and ethnographic and ethnohistoric research in Cape Krusenstern National Monument, the Kobuk Valley National Park, and the Noatak National Preserve will help to rescue important oral history information that otherwise would be lost. Additionally, from 1977 to 1982 the National Park Service (Davis et al, 1981), Bureau of Land Management and Geological Survey carried out extensive archaeological surveys and mitigation work on NPR-A (Hall and Gal, 1982).

Terminology should be clarified at this point. In recent years activities covered by legal mandates dealing with archaeological sites and their associated cultural, historical, and architectural information have come under the rubric 'cultural resource management.' The term 'cultural resources,' used later in this section, includes archaeological resources but also encompasses other types of data, such as oral history.

Needs--Protection of Endangered Resources

Oral History. The most obvious endangered resource is oral history, because the northwest Alaskan Native community is rapidly loosing older members with first-hand knowledge of local history and cultural lore acquired in the traditional way. Although there will always be elders, we have no more than ten or fifteen years left before the current generation of elders is gone and with them their unique storehouse of knowledge about traditional culture and lifeways. In many cases, for the material collected to be truly valuable it must be gathered in the elder's Native language by researchers possessing in-depth knowledge of the region and having either fluency in the Native language or the services of a fluent bilingual collaborator. We endorse earlier recommendations (for example, IARPC, 1987) that place the highest priority on collection and translation of oral histories.

Prehistory. Valuable portions of the region's prehistoric resources are also endangered. The coasts and river valleys of northwest Alaska have long been the region's most attractive environments for human habitation and use. But

these zones also include the areas where erosion is most active, threatening and destroying many archaeological sites. The problem is not limited to federally protected lands but exists throughout northwest Alaska. Many coastal and river segments have never been surveyed, and valuable unrecorded sites are almost certainly being washed away before we can study them.

Archaeological surveys completed or in progress should be extended at an early date to ensure that all vulnerable segments of coasts and river valleys are surveyed. A thorough survey of the archaeological resources of the Selawik Wildlife Refuge is an especially urgent need. Archaeologists need a system for pinpointing the most vulnerable areas and sites and for directing the limited excavation and research funds available to the most promising of the threatened sites. Symposium speakers and workshop participants, following Workman (1985), emphasized that such work must be planned and carried out within a framework of regional synthesis and a regionally based research design. Members of the Alaskan archaeological community reached a similar conclusion at a meeting organized by the Alaska State Office of History and Archaeology in April, 1988 to gather public input for Alaska's statewide historic preservation plan.

Needs--Conservation of the Existing Data Base

Oral History. Closely allied with preserving endangered resources is the need to conserve the existing data base. The need is perhaps most obvious for oral history. Kawerak, Inc. in Nome, Maniilaq Association in Kotzebue, and the North Slope Borough in Barrow as well as school districts in all three towns have extensive collections of tapes. However, few of these tapes have been adequately curated. Curation of tapes involves accessioning; cataloging by interviewer, interviewee(s), language, subject, and other factors; and storage in a safe, systematic, and retrievable manner. Because of lack of funds, many tapes have not even been duplicated with duplicate copies placed in separate, safe depositories. Fire or other catastrophe could erase large segments of recorded cultural memory!

Adequate curation will require accessioning and indexing existing tape collections. Choosing appropriate categories for indexing is always a problem. We suggest an indexing plan that includes categories of local interest as well as the categories used by the Oral History Program of Rasmuson Library, University of Alaska Fairbanks. In that way, collections from northwest Alaska can be indexed in the statewide Oral History Index, making the data much more widely useful and accessible. Curating these collections will also require concern and protection for individual and cultural privacy. Some tapes contain material that should not be widely disseminated; whoever curates and manages this material must be sensitive to these important matters of ethics and trust.

Translation is also an urgent need. Ideally, all existing tapes should be translated completely in the very near future, but this goal is not immediately feasible so careful choices must be made. Many tapes, including some of those most important for future research, were made in a Native language, and competent curation will require good bilingual skills, including knowledge of older forms and terms. The current elders are probably the best Native language speakers that will ever be available, and their help in translation would be invaluable.

Unfortunately, there are only a limited number of skilled bilingual speakers in most Alaskan communities, and competition for their services can be keen. Other community functions with high priority, such as education and health care, may already employ them full time. This shortage points to a continuing need to train local people in these important skills. More high quality bilingual training would benefit not only oral history translation and interviewing, but also prepare local people to work with scientists from a variety of disciplines and to qualify for other jobs as well.

A centralized data base, locating and indexing transcripts of all translated oral history materials (with appropriate restrictions on sensitive materials), would be extremely helpful. One workshop participant suggested that individual researchers should find a way to pay for the translation and transcription required by their research, then make this material available to both local people and other researchers through one or more central depositories keyed to the database.

Prehistory. Considerable archaeological field work has been accomplished in northwest Alaska since the enactment of ANILCA, mostly by federal agencies, but large portions of it remain unreported or reported only in the 'gray literature'. Moreover, many of the collections resulting from this field work remain unstudied, even though most have been placed in suitable archaeological depositories. We call for prompt and adequate publication of the results from these agency sponsored archaeological surveys and excavations including thorough analysis of the collections.

More complete and up-to-date regional and topical syntheses are also badly needed. Such overviews would make future work in northwest Alaska much more productive by providing a better contextual framework within which to frame research questions. Archaeologists need, for example, to understand better the various site types that occur in northwest Alaska and how these site types should be integrated into regional subsistence and settlement patterns.

Careful examination of the literature also shows that many questions of regional chronology remain unsettled, making investigation of more complex cultural process questions very difficult. For example, some important sites and components have never been adequately radiocarbon dated. Recently, a few researchers have begun systematic efforts to calibrate some series of radiocarbon dates for the effects of variations in the solar flux and to make such corrections as are necessary for reservoir effect (primarily old carbon in sea water) so that these radiocarbon dates can be converted to sidereal (calendar) years (Gerlach and Mason, 1990). These efforts should be continued and extended.

Opportunities--Interdisciplinary Topics

It is probable that the earliest late Pleistocene immigrants to North America passed through northwest Alaska, but the region has thus far yielded few traces of their passage. Directed searches for late Pleistocene archaeological sites in Alaska have been relatively unsuccessful, and sites known from northwest Alaska were discovered incidental to other archaeological projects. Most archaeologists agree that scarce research funds should not be devoted to looking for new early man sites. Instead, the search should continue, informed by Quaternary environmental reconstruction, as an incidental part of larger

projects directed toward other goals. Once the logistic costs of putting a team in the field are covered, limited time spent searching for early sites may become cost effective.

One of the key problems for people living in northwest Alaska, both past and present, is adjusting to changes in the availability of animal resources. How do people respond to resource depletions or surpluses? How can researchers mesh our knowledge about biological cycles with what we observe in the archaeological and historical record? How did individuals, families, and larger social groups respond? What changes in subsistence and settlement patterns resulted?

These questions could best be addressed through an interdisciplinary effort involving archaeology, oral history, biology, and paleoclimatology, focused on the late prehistoric and historic periods between 1200 A.D. and the present. This period has the best data base, since relevant archaeological, ethnographic, historic, and oral history data are abundant and readily available; this period is of great relevance and interest to northwest Alaskan residents; and archaeological sites dating from this period run the greatest risks of destruction by land owners, pot hunters, and natural processes. Interdisciplinary studies focusing on this period could yield some excellent anthropological lessons relevant to culture change, economic development, land management, and the economic factors that enhance or detract from the quality of life. Of all periods, this one can best provide useful lessons to planners. Studies of changes in land use during this 800-year time span may demonstrate, for example, the effects of long-term cyclicity of resources and the geographic extent of regions affected by these cycles.

Interdisciplinary analyses can teach us much about trade routes and the impact of trade during the late prehistoric and historic period. We already have some information on the extensive prehistoric trade network that linked northeast Asia with Alaska through key trading nodes, such as Kotzebue, then extended throughout arctic and interior Alaska. Studies of trade networks generally require interdisciplinary approaches involving archaeology, ethnohistory, regional analysis, trace element analysis, and sometimes other disciplines as well. To give a specific example of a trade-related question, during the late 1800's there were wealthy traders in the Selawik area; yet, within a 10 or 15 year period, these big traders disappeared. What happened in the system at that time to change the dynamics of trading so dramatically?

Constraints

The single most important constraining factor is the lack of adequate, sustained funding for federal agency and university-based research. Of the agencies working in northwest Alaska, the cultural resources program of the National Park Service comes the closest to having adequate staff and funding. The NPS cultural resources staff is, however, located in the Anchorage headquarters. Local involvement might be enhanced considerably by locating at least one archaeologist in northwest Alaska. And the National Park Service, along with all the other agencies, must give continuing attention to improving cooperation and communication between agency archaeologists and academics working in the region.

By contrast, funding and staffing for cultural resources by the U.S. Fish and Wildlife Service are woefully inadequate. Because prime fish and wildlife habitats have long been attractive for settlement and subsistence exploitation, these lands include many known (and probably more unknown) important historic and prehistoric archaeological sites. The National Historic Preservation Act, the Archaeological Resources Protection Act, and their recent amendments require all federal agencies, including the Fish and Wildlife Service, to inventory and protect significant historic and prehistoric sites on their lands. For comparison, in FY88 the National Park Service, responsible for approximately 56,000,000 acres in Alaska, spent about $1,600,000 (not including its National Register Program) and employed 13 full-time archaeologists and historians as well as three project professionals and 20 seasonal employees to take care of cultural resources on their lands. For the same period, the USFWS, responsible for approximately 77,000,000 acres, or about 11% of all federal lands in the nation, spent less than $75,000 and had one full-time employee.

For nonagency research, small amounts of additional federally mandated funds that are not presently being tapped may be available through provisions such as Section 13. 18 of ANILCA. Some of the oral history curation and shorter-term archaeological funding could come from the National Endowment for the Humanities, the National Archives, and other smaller granting sources, including some at the state level. In the past, the region's nonprofit Native corporations and the North Slope Borough have funded oral history and settlement pattern studies. Given the current economic situation in northwest Alaska, however, community-based governments are unlikely to provide the sustained funding that is needed. The National Science Foundation has recently added a Program Director for Arctic Social Sciences within the Division of Polar Programs. We applaud this step. It should be most helpful for increasing the visibility of the social sciences, and better meeting the need for sustained funding of archaeological and oral history research.

An oral history recording session at the historic site of Pigniq. From left to right are Kathy Itta, Otis Ahkivgak, Shirley Phillips, William Schneider, and Freda Brower Frantz.

Section 9

Publication, Curation, and Archiving

Background

Publications, curated collections, and archived data represent the end products of scientific research. If these final steps are neglected, much of the value of the original effort is lost. Products of research are much like capital in a banking system: to have value, they must be traceable and retrievable. Failure to make research results available, traceable, and retrievable is wasteful and unethical. Solutions to the problems discussed in this section are more likely to be effective if conceived and implemented in the context of regional research planning.

Information loss from research is a major problem in northwestern Alaska. Information is lost through failure to publish research findings in traceable literature and through failure to adequately archive data and curate scientific collections.

One cause of information loss is excessive reliance by many individuals and many agencies upon publication in the so-called "gray literature." Examples of gray literature include agency reports that receive only limited distribution and are unavailable in libraries, and equally unavailable privately circulated manuscripts of lectures given at local scientific meetings--a practice that seems to be especially favored by anthropologists and archaeologists. One consequence of relying on gray literature as a medium of publication is very short or selective institutional memory in many state and federal agencies. With rapid personnel turnover, a sponsoring agency may effectively forget what has already been accomplished; research may be repeated, sometimes just a few years after the original study.

Curation and archiving present a different set of problems. Curation (the care and supervision of collections) and archiving (document and information filing and storage) constitute significant obligations. The collections and information involved are unique, often irreplaceable, were costly to obtain, and demand proper stewardship. We emphasize that these obligations are long-term, may be costly to discharge, and must go beyond simple storage of information.

The question of where and how to archive and provide stewardship for research materials is widely debated, especially in the case of historic and prehistoric artifactual material. Some sectors insist upon local community stewardship. At the other extreme, some suggest that nothing short of a national repository such as the Smithsonian Institution can provide adequate long-term care and protection of scientific records and specimens. Local communities often lack the resources and the expertise to protect objects from decay, fire, flood, theft, or vandalism. Conversely, total reliance upon a national repository such as the Smithsonian Institution has the appearance of "cultural imperialism," exporting the regional cultural and natural resource heritage out to a southerly, "higher" place. A reasonable middle ground would, in many cases, be placement of materials in a regional facility such as the University of Alaska Museum or the Alaska and Polar Regions Department Archives of the University of Alaska's Rasmuson Library. Another approach involves application

of modern and emerging technology that permits reproduction of specimens and information so faithfully that the needs of both local and national depositories can be met.

Scientists and investigators working in the North have a clear obligation to ensure that their results are made available--not only to the sponsoring agencies and to their professional colleagues through normal peer review and publication, but also to the indigenous people resident in the region where the research was conducted and to the resident resource managers.

Research Needs and Opportunities

To realize the goals of responsible publication, curation, and archiving, we must do more than pay lip service to these activities. Funds must be included in initial research budgets to ensure that the end products of research are properly managed. Funds should always be allocated to support publication in the open literature. Every research project likely to produce materials requiring costly stewardship should plan and budget to ensure that curation and archiving responsibilities will also be met.

Researchers and their institutions have, at best, an uneven record in the matter of communicating their findings to the communities in the region where research is done. Mechanisms must be put in place to encourage and facilitate the prompt conveyance of research results to local residents. This set of mechanisms should be planned from the outset. Information products specifically tailored to use in local schools and communities should be encouraged. These could include photos, films, tapes, summary reports, lecture presentations, and other non-traditional media.

We recommend that libraries and repositories for collections be established within northwest Alaska according to a carefully conceived regional research plan. We recommend that computer-aided communication and database systems now available or under development be implemented to link repositories, communities within the region, and researchers wherever they reside. Education and training are naturally linked to the functions of publication, curation, and archiving. Thus, development of a repository system and a regional research catalogue should logically be associated with educational institutions--Alaska's universities and community colleges. We note that rural Alaska already has an enviable information system partially in place through the University of Alaska's Rural College system (Creed, 1987).

A thorough review of prior studies is an essential first step in any multi-agency and multidisciplinary research planning effort. To facilitate planning efforts, a regional research catalogue is needed. The catalogue should indicate what publications, reports, notebooks, and collections exist and where they are located. To create such a catalogue, a network encompassing the local, regional, state, and national repositories must be developed. The system adopted must be a truly interactive network, so that traceability and retrievability can be achieved.

CHAPTER 4

LOCAL INVOLVEMENT

A recurring theme throughout the symposium and workshop was the need and the desire of local people, particularly the Native community in northwest Alaska, for greater involvement in research. Symposium presenters, panel members, discussants, and most workshop groups returned repeatedly to this issue (see also, Albert, 1989; Bielawski, 1986; Committee on Arctic Social Sciences, 1989; IARPC, 1987; O'Neill, 1989).

The Problem

For much too long it has been much too easy for scientists and land managers working in the Arctic to virtually ignore the local people, especially the Native people, at best acting as though there were no need to consult them on research or management issues--even issues directly affecting their everyday lives. All too often, scientists and managers have seen a requirement to consult local people as a time-consuming, stressful, and inconvenient exercise, necessary only to fulfill permitting requirements and to "keep the local people happy." In recent years, however, scientists and managers have become increasingly aware of their obligation to involve themselves more than superficially with local communities. One achievement of the conference was a heightened awareness of both the need for and the value of local involvement.

In an earlier section we delineated differing perspectives among scientists, land managers, and Native people, and discussed some difficulties in communication and sources of conflict. We also noted recent initiatives demonstrating commitment by the Native community to participate in science planning and to share in the results of scientific research. Here we discuss additional concerns and perceptions of scientists, resource managers, and Native people. Mutual understanding of these issues will be required if we are to work together effectively.

Despite intensive western contact, traditional culture and lifeways still play an important role in the lives of Alaska's Native people. Native people feel a tremendous economic and cultural stake in the land, the sea, and the resources that they yield. Their physical and cultural survival depends on these resources; yet, Native people generally feel denied any meaningful role in the research on these resources, or for that matter, their management.

The problem is exacerbated when words like "remote," "isolated," "frontier," or "pristine wilderness" are used to characterize the federally protected lands of Alaska. Native people bristle when they hear their homeland thus described, because it seems to deny their long history in the region. For the Native community, northwest Alaska is a familiar place where most mountains, valleys, streams, lakes, and other landmarks are well known and have traditional Inupiaq, Yupik, or Athabaskan place names. Every sector of northwest Alaska has been used by Native people for many thousands of years.

Native knowledge of natural history is undervalued and under-utilized by scientists and land managers, another recurrent source of resentment and a lost opportunity for both research and management. In a region where most written history extends less than a century into the past, oral tradition has much to

tell the scientist concerning episodic events and processes such as floods, storm surges, sea ice over-rides, fires, earthquakes, and volcanic eruptions. Information concerning less dramatic changes in climate, vegetation, and abundance and distribution of game animals and fish is also available. Native hunters and fishermen are acute observers of the life histories and behavior of fish and wildlife. The botanist conducting an inventory of the flora, the geologist interested in fossil or mineral deposits, the hydrologist studying springs, and the planner examining changes in resource use areas will each find knowledgeable individuals among the Native people who can contribute to his or her study. Ethnoscience can contribute to both science and management.

There is a widespread sense within the Native community that local control is rapidly eroding. This feeling contributes to alienation, hopelessness, and low self-esteem for individuals, and serious social problems for communities. One aspect of this feeling is a perception, sometimes quite accurate, that members of the Native community have little chance to make known their research information needs or to influence research priorities and guidelines according to these needs. Opportunities to participate in the research process are minimal, and local people are not routinely informed of research results, even findings that may affect them dramatically. Such conditions can produce resentment that is likely to be directed at scientists.

Native people frequently perceive scientists as exploiting both the land and the community, using them as research materials to enhance personal stature and income while returning little of value to the community or region. There is widespread fear that federal and state fish and wildlife management agencies, or external interest groups such as sport hunters and fishermen, may use the results of management-oriented research to deny local people continued access to the land and its resources. Native leaders in northwest Alaska widely share the view that research on federal lands is very likely to lead to additional restrictions on the use of those lands by local people. Thus, awareness of research being planned and research in progress as well as prompt access to research results is very important to these leaders.

One final circumstance contributing to misunderstanding is a fundamental difference in world view. The western-science-based training of many managers and scientists emphasizes the value of knowledge gained through observation and contemplation rather than activity, and skill in writing and saying rather than doing and making. In smaller societies with strong oral traditions, such as those of northwest Alaska, the emphasis is just the opposite. These societies emphasize the development of knowledge as an integrating social activity, with work and communication as major contexts for its expression (E. Bielawski, personal communication; Sayer 1984). Without an appreciation of these very basic differences in world view, communication regarding traditional knowledge or local concerns about how research is conducted, may be much more difficult. With such an appreciation, scientific and traditional knowledge can complement one another, increasing the power and value of both.

Scientists working throughout the North have become increasingly aware of their social and moral obligation to work with local people and with locally-based resource managers. At the same time, scientists retain valid concerns about the problems and potential conflicts greater local involvement may entail.

The cost of logistics in northwest Alaska seems very high. Budgetary concerns push scientists to operate as self-sufficiently as possible, even to the point of avoiding purchase of housing, food, supplies, or labor in the region. Because a stay in one of the larger towns may seem disproportionately expensive, these fiscal concerns tend to discourage many scientists from allocating time to make contact with local agencies or to work with local people or local schools. Often the result is a "fly in our own field camp, fly it back out" mode of operation in which no more than a few hours are spent in the community while the research party shifts from airline to charter service, making no contact with the local people.

Other concerns of scientists include perceived threats to continued research freedom and to access to the land. Scientists worry that the Native community, through political or community organizations, or land managers through their control of access permits, may impose restrictions that limit scientists' ability to conduct their work effectively, an especially serious concern for projects involving long-term observations.

Land managers share with scientists some of these same concerns while facing additional issues and considerations. Most share a general philosophy of stewardship over the land and its resources and feel strongly about agency mandates to conserve, preserve, and protect these resources. Their concepts of conservation and preservation are, however, often shaped by cultural values that originate outside the region and that may conflict in important ways with those of Native people. Further, agency land managers are under pressure to show results in forms such as written plans, reports, publications, number of miles travelled or villages visited. Institutional concerns about agency power and growth may also conflict with concerns about the land, its resources, and the indigenous people.

Increasing Local Involvement in Research

Making Contact. Whenever one talks about local involvement, the complaint almost inevitably emerges, "... but how can we get more local involvement when people don't seem interested? We held a meeting/hearing in _____ and only three people showed up!" Assuming a lack of interest because of a poor turnout, however, may be unwarranted. The meeting may have been poorly publicized. It may have conflicted with other important community or subsistence events. Or people may simply be "meetinged out" by too many such demands. Making a formal presentation or simply attending a key meeting sponsored by a local or regional Native organization can sometimes be quite effective. Too often, however, scientists and managers rely solely on the formal meeting process for local involvement.

Informal contacts are often a better way to start. One can begin by identifying the important elders and leaders in a community, then visiting with them informally, one on one. Telephoning ahead to make a mutually convenient appointment saves time and is a mark of courtesy. A call or word of introduction from a respected official in a regional Native organization with whom you are working can lend credibility to a visit. Being accompanied by a Native collaborator can also help build trust.

Visiting is an important activity in rural Alaska, and often a good way to learn about local concerns and achieve greater local involvement. Visits are

much more likely to be successful if visitors know the local subsistence schedule and avoid times of intense subsistence activity. Follow-up visits are also extremely important. They help show a genuine interest in involvement and avoid the impression that one simply wants to manipulate. Spontaneous informal conversation at the grocery store or the local basketball game can also help build relationships between scientists and local people and pass useful information and ideas in both directions.

Many Native elders are knowledgeable and well-spoken concerning critical issues such as, for example, subsistence and education. Visiting and speaking, both formally and informally, with people at the Senior Citizens Center can often be helpful. Elders' Conferences are a forum in which views on important issues are often expressed publicly. Local and regional subsistence user's groups may also provide an appropriate venue for an exchange of views and constructive contributions to research planning.

Planning and Setting Priorities. We follow Albert (1989) in recommending more involvement of Native people in setting research priorities that have local applications. Areas of particular urgency include subsistence and subsistence-related issues, anthropology, ethnology, archaeology, health, social science research, and any other area likely to be used as the basis for public policy decisions or resource development analyses. One panelist from northwest Alaska remarked that Eskimo people have been studied intensively and sometimes quite intrusively, but feel that these intrusions have brought few results beneficial to them as individuals, to their communities, or to their regions. At the same time, local people have important needs that research could and should address. A good example of a project in which local consultation should take place in the initial planning stages is the proposed MAB-sponsored long term environmental research and monitoring effort (Wiersma et al., 1986) in the Noatak drainage.

We also endorse local efforts to initiate and carry out research that meets local and regional needs when these projects are conducted in a rigorous and scientifically sound manner. We cite, as an example, the Norton Sound Mercury/Human Health Study initiated by the Norton Sound Health Corporation in conjunction with Kawerak, the Nome Eskimo Community, Sitnasuak Native Corporation, and the Nome Village Corporation. With funding from a variety of sources, the goal of the study is to locate the sources of pollutants, especially mercury, emerging from the sites of mining activities around Nome and to assess their impact on human health, particularly as they affect the local water supply.

Research Design and Data Gathering. Local people sometimes provide researchers with essential logistical and travel assistance. Many Native people know their local environment in impressive detail. Local people can often tell the researchers where to find what they want to see, and will do so if the community has been consulted and supports the research. The scientist, however, must listen carefully at the right time and treat the information given with respect. Local involvement, however, needs to extend beyond this level of assistance.

We recommend Native participation in research design and planning for data acquisition, particularly of subsistence-related and social science research. Local input will be most effective when one or more Native people are involved

as co-workers, ideally from the very outset. This step can be important in securing local cooperation and can help ensure that valuable time and energy are not wasted on unworkable research designs. A Native collaborator can alert researchers to cultural pitfalls or environmentally sensitive locations of which they may not be aware. Research procedures that accord with, rather than violate, Native cultural norms and environmental concerns are much more likely to succeed.

Local people can also be helpful to researchers in designing data-gathering tools. A Native collaborator, for example, can help researchers develop clearly phrased questions that avoid ambiguity and embarrassment in the Native cultural context. One workshop panelist from northwest Alaska recalled participating in a survey in which the investigator asked questions about the family. "Family" meant nuclear family to the researcher but extended family to the respondents. If unrecognized, such ambiguities can dramatically affect the validity and quality of research results, and can be damaging to an accurate understanding of the people of northwest Alaska. For many of these same reasons, a good translator is also very important.

These benefits are not limited to social science research. For example, one regional leader pointed out how a workshop held in Nome to write sections of the Eskimo Walrus Commission manual on counting animals and taking tissue samples improved these sections by giving local people an immediate opportunity to comment on the proposed procedures. Thus, local participation in designing research strategy and data acquisition tools should be considered whenever the research topic is of interest to the local community. Further, the scientist or manager should avoid assuming that he or she knows what is and is not of interest to local people without consulting them.

Reporting Results. Consideration should be given to involving Native people in production of the final report(s). One northwest Native leader noted that reports can change in quite startling ways when a researcher suddenly learns it will be reviewed by local people. If Native people are not actually involved as collaborators in writing the report, researchers should consider reviewing all or relevant parts of a penultimate draft with interested community members. Some technical topics may not be understood or of interest, but with adequate communication with local people, determining what material is appropriate to review with them should be easier. The researcher should also consider providing feedback to local reviewers, showing how review comments and ideas affected the final product. Local people may well catch errors of fact or interpretation, improving the report and saving the researcher from misrepresentation, embarrassment, or both. Involvement in review will also ensure that at least some local people are familiar with the outcome and implications of the research.

We strongly recommend that researchers report their results to the local community in a form that local people can readily use. Films, photographs, audio and video tapes, radio broadcasts, live slide presentations, school demonstrations, and perhaps best of all, personal face-to-face interactions all help to convey research results more effectively than the usual technical scientific report.

Education and Training

For Natives. A significant key to local involvement is education and training. A major goal should be to train a group of indigenous scientists to work in the Arctic. An even earlier task is to provide education and training opportunities in connection with research projects in the region. Improved educational opportunities can be provided in several ways:

** A program should be developed to identify promising young people from the region and to match them with research projects where they can gain skills and experience. Such a program could aid recruitment and help make "hands on" work experiences successful.

** Research projects should incorporate opportunities for local people to learn about science and gain valuable job skills at the same time. Funds to support student participation on NSF research grants, especially by Native students, are available from the National Science Foundation.

** When promising Native young people are found, a program should be developed to pull them into the research/educational system. The program could provide opportunities to work as field assistants, then go to school at the university sponsoring the research, and eventually move up to project leadership positions.

** Scientists planning research in northwest Alaska should work with the school districts, UAF Rural Campuses, and the Barrow Higher Education Center to improve science training and train local field assistants. Short courses and workshops are two of the avenues through which scientists could become involved with local students.

** Field school programs directed specifically at local people should be supported as an excellent way to involve young people in scientific research while teaching them valuable skills. Field schools have been successful elsewhere in the North (see, for example, Bielawaski, 1984, 1986; Hanks and Pokotylo, 1989). Successful field school programs in archaeology and oral history have also been conducted in cooperation with the North Slope Borough (Gerlach et al., 1985) and through the Chukchi Rural Campus.

** Upward Bound and the Rural Alaska Honors Institute (RAHI) of University of Alaska Fairbanks deserve continuing support as programs designed to introduce rural Alaskan high school students to the possibilities and value of a university education, and for some, a career in science. Greater participation in these and similar programs by scientists interested in northwest Alaska could provide useful contacts, role models, and mentors for future Native scientists.

A closely related issue is the quality of education in rural Alaska, including preparation in science. Limitations in this educational process for rural students, beginning with the primary level and extending through the university, are widely recognized as restricting access to science information and science and technology based careers (N. Murphy, personal communication).

Some potentially helpful programs are developing which deserve the support and participation of scientists, managers, and Native people alike. Examples include:

** At the primary and middle school levels (kindergarten through 8th grade) an Alaska-wide science consortium to assist teachers has been started. The consortium's goals are to improve science teaching by (a) teaching **science as inquiry** with active student involvement, (b) teaching the **processes of science**, and (c) teaching **science content that is locally relevant**. The program will work through summer institutes, in-service training, a newsletter, electronic mail contacts, and cooperative student projects to which students from different schools contribute data.

** At the secondary level, the Department of Education, University of Alaska Fairbanks, has developed a mentoring program whereby rural high school teachers participate in special workshops, then spend a month working on a research project with an established scientist. Teachers working on projects in mariculture, animal parasite studies, and nutrition have then been able return to their home schools and continue some of their research with their students.

** The Native Alaskan Action for Access to Science Program at University of Alaska Fairbanks provides several mechanisms to help Native students: summer workshops and a Scientist-in-Residence Program for precollege students; help for postsecondary students in the form of special orientations, a scholarship data base, and special introductory math and science courses; and internship, work-study and mentorship programs.

One Kotzebue elder shared with us an important insight concerning western education. She noted that young Native people who choose to follow traditional lifeways gain frequent support and reinforcement for that choice from all the traditional celebrations tied to the subsistence cycle. There are no similar celebrations and reinforcements for academic progress. Perhaps her observation can help us appreciate one reason why so few Native students choose science. It also suggests an additional dimension that programs to remedy this problem should consider.

Improvements in rural science education will pay off in several ways. Ultimately, they will produce Native scientists. Meanwhile, the improvements will create a reservoir of Native people who possess greater competency in western science and can better understand and interpret for others the goals and methods of researchers who come to their region. They will also better equip local people to participate in management decisions with a significant scientific component. They will create a larger pool of potential Native collaborators and research assistants for future projects. And they will also upgrade job skills for nonresearch employment in a region where jobs and job-training are a crucial need.

"Yes," one conference attendee was heard to grumble, "but it's unrealistic to expect someone to participate in these kinds of programs on top of a full field season." Certainly few active scientists or managers can participate in more than one such project at a time. Several conference participants pointed out,

however, that an "expedition" approach to fieldwork is no longer appropriate. We must continue to move toward a perspective that values activities such as these not as an "add on," but as an integral part of any "full field season."

For Scientists. Some scientists and managers lack the cross-cultural knowledge and skills to communicate effectively with Native people. Although training is needed to acquire those skills, they worry that time spent acquiring them will be costly and unrewarding. Yet, without effective cross-cultural contact, scientists as well as resource managers are likely to remain so unaware of the social context of their work that they fail to appreciate the cultural and social impacts of their presence and their actions.

Many scientists and managers would benefit from formalized opportunities to learn about Native culture and lifestyles. A series of cross-cultural workshops held by the Alaska Department of Fish and Game in 1986-87 illustrate what might be done. We strongly recommend that appropriate funding agencies assist the Rural Campuses, the Barrow Higher Education Center, and the Native community in producing intensive seminars or short courses designed to familiarize researchers and managers with northwest Alaska and its people.

Other Suggestions

** Local or regional governments should consider collaborating with the National Science Foundation, the Sea Grant Program of the National Oceanographic and Atmospheric Administration, other agencies, and the State of Alaska to fund a scientific liaison officer. The North Slope Borough took this step nearly a decade ago and found it beneficial. A liaison officer works with scientists and land managers to facilitate communication on research matters. He or she can assist in developing more extensive local involvement and more effective management decisions. The liaison officer might also help to attract and coordinate research projects, funding, and attendant local job opportunities.

** Scientists and Native people should work together to prepare a document providing ethical guidelines. Ethical Principles for the Conduct of Research in the North (MAB Working Group of Canada, 1977) and the section on Scientific Research Issues in Draft Principles for an Arctic Policy (Inuit Circumpolar Conference, 1986) could serve as useful source documents. We note that the Social Sciences Task Force of the U.S. Interagency Arctic Research Policy Committee is currently preparing a statement of principles and guidelines for conduct of Arctic research; we assume that this is being undertaken in consultation with Native leaders..

** Scientists and Native people should also collaborate in preparation of a handbook on research protocol as a step toward increasing local involvement. Needed is a practical guide, supportive and encouraging in tone, specifically directed toward conducting research in northwest Alaska. The handbook should list names, addresses and phone numbers of local government agencies, Native groups, and contacts in each community. A newsletter supplement could keep handbook information up to date.

** By compiling case studies of projects having extensive local involvement in other high-latitude regions, we could learn valuable lessons about appropriate and inappropriate ways to integrate research, management, and

local people. One model clearly deserving consideration is the community-based research approach exemplified by the study of reindeer management at Sanikiluaq (Belcher Islands, NWT, Canada) conducted jointly by the local Hunters and Trapper Association and the University of Alberta (M. Freeman, personal communication).

** Universities and agencies should provide increased incentives for scientists doing research in the region to become at least temporary residents, remaining at least six months to a year. Although some agency researchers, including several conference participants, are already permanent residents, more resident scientists would be beneficial. Resident scientists generally get to know the region and the local people better than their itinerant colleagues. Their daily contacts allow more of the personal communication about research that is particularly effective.

** The process begun at the 1987 Anchorage symposium and workshop should be extended and continued in the form of a series of periodic, perhaps even annual or biennial, topically oriented interdisciplinary workshops to be held in the regional centers of Kotzebue, Barrow, and Nome. Such gatherings seem a most promising mechanism for bringing together scientists, managers, and local people and for developing local input. Associated preconference workshops could discuss detailed results of particularly important studies, or present background information on new and unfamiliar research areas. Ultimately, such meetings could become important vehicles for regional research planning.

The late Raymond Mendenhall, Kotzebue area elder. Native elders are extremely observant and knowledgeable; they can contribute significantly to the body of scientific information concerning northwest Alaska.

CHAPTER 5

CONCLUSIONS

More than 100 scientists, land managers, and native leaders convened in Anchorage on September 26-27, 1987, to discuss research needs and opportunities and the constraints on research in the national parks, preserves and wildlife refuges of northwest Alaska. Although discussion focused primarily upon northwestern Alaska, much of the symposium and workshop was relevant to research planning throughout arctic Alaska. The need for increased involvement of Native people in the planning and conduct of scientific research received special attention. The obligation on the part of investigators to ensure that the results of their studies are communicated to local communities where the work is accomplished, in a form that local people can understand and use, was emphasized. This symposium and workshop developed specific recommendations for research in northwest Alaska, and identified a number of "crosscutting" issues applying to all aspects of research in the region.

Specific recommendations

Northwest Alaska now shows few effects of local industrial, urban, or agricultural development. Major mineral development now commencing at the Red Dog Mine may well be the precursor to more widespread regional industrial development. The landscape of this region is sensitive to the effects of local or global climatic alterations, and some effects of climate warming may already be observed. We recommend undertaking a long-term environmental monitoring program to detect and measure changes in the composition of the biota and in air, water, and soil quality of northwest Alaska. The Noatak National Park and Preserve is recognized as an international Biosphere Reserve, and should be strongly considered for a major, sustained monitoring effort.

Studies of contemporary landscape processes related to frost action and to the presence of permafrost, and studies of the history of past environmental changes, are needed to gain better understanding of the origin and stability of the present climate-landscape system, and to anticipate the consequences of climatic changes expected in the future. Study of pollen in lake cores has already provided a considerable body of data, but several other resources have yet to be fully utilized. Historical records, oral history, and studies of plant macrofossils, diatoms and ostracodes from lake cores should be used to enhance the quality of the paleoclimatic record.

Northwest Alaska is geologically complex and holds large reserves of valuable minerals, rare earths, fuels, and industrial materials. A systematic review of the level of permissible and prohibited mineral resource exploration methods on federally protected lands is needed. To what extent and by what means should non-renewable resources be inventoried? Under what circumstances, if any, might extraction of non-renewable resources be allowed on the various federally reserved lands? To what extent may development of groundwater and geothermal energy be permitted? If discoveries are made, then pressure to change the status of protected lands will develop. Balanced against this possibility is the need for knowledge of resource availability in the event of urgent local need or grave national emergency.

The effects of exploration and development of nonrenewable resources must be monitored throughout the life of any project. Environmental degradation and pollution are of particular concern. Contamination of groundwater systems can create health hazards for flora, fauna, and humans. Improved understanding of groundwater recharge and movement, and of chemical and biological contamination of surface and groundwater resources, is needed.

The wildfire regime and its effects on biological productivity are not sufficiently understood in northwest Alaska. More research is needed to provide a basis for improving integration of fire ecology into resource management activities, and to support formulation of appropriate fire management policies.

Appropriate tourism development, sensitive to local concerns and needs, is acknowledged as an emerging regional industry. Tourism is a sector that could particularly benefit from cross-cultural studies of the culture of work in Native and western social settings in northwest Alasaka.

Subsistence activities are very important to the economy of northwest Alaska. Studies of subsistence harvest and resources must take into account the historical changes which have taken place over the past several centuries, and especially during recent decades. Contemporary subsistence research must encompass year-to-year variability in the resource base and in subsistence needs and harvests. Subsistence research should also address competition and allocation decisions involving subsistence, commercial, and recreational uses of common resources.

Oral history is a seriously endangered resource. The population of Native elders having first-hand knowledge of traditional life is rapidly dwindling. Meanwhile, the integrity of the existing recorded oral history data base is in a precarious state because funds are lacking to copy, index, transcribe and translate important tape collections. An organized and well-funded effort should be made to collect additional information and to make the existing data base more secure and more accessible.

Comprehensive and current regional and topical syntheses of northwest Alaska's prehistory are needed. Interdisciplinary investigations of questions related to the initial arrival of early man, adaptation to environmental change, and development of trade practices are similarly needed. Northwest Alaska's prehistoric cultural resources are largely concentrated along the shores of rivers, lakes, and seas--dynamic environments subject to wave- and river-bank erosion. Studies of coastal retreat have been completed for most of the Beaufort Sea coast and for parts of the Bering Land Bridge National Preserve. This research should be extended to the remaining parts of the coast, and similar studies should be undertaken along major river systems and lakes in order to guide prioritization of archaeological efforts and protection measures for sites that are at risk.

Results of research conducted in northwest Alaska are not always adequately reported or disseminated. Incentives are needed to stem the information loss resulting from excessive reliance on 'gray literature' as a means of publication. Greater concern for proper archiving and curation of research data, specimens, and artifacts is also necessary.

We support and endorse efforts to establish an international Beringia park in the Bering Strait region. We encourage designation of a land unit in northeastern U.S.S.R. as a counterpart to those federally reserved lands in northwest Alaska that constitute the U.S. sector of the international Beringia park. We urge federal managers to address concerns of Native leaders and residents about resource management and use of the lands included in this international park.

Crosscutting issues

We urge greatly increased involvement of Native people in the planning and conduct of research and in sharing the benefits of research in northwest Alaska. Areas of particular interest and concern include subsistence-related issues, anthropology, ethnology, archaeology, and health, and other social science research. Native people, especially elders, possess extensive traditional knowledge about the region--its flora, fauna, weather, ice conditions, landscape processes, and other phenomena--knowledge that can significantly improve our collective understanding of northwest Alaska. We particularly recommend that Native participants be involved in design and planning of subsistence-related and social science studies, and other research where local interest is significant. Researchers must faithfully ensure that copies of their reports reach the communities in the region where research is conducted. Researchers should report their results in forms more readily understandable to a nonscientific audience.

Educational opportunities can be developed in collaboration with research programs and must be encouraged, with the specific objectives of improving local understanding of science and providing a broader pool of Native scientists and technical science support personnel. Research projects should incorporate opportunities for local people to learn about science while gaining useful job skills. As an important step toward enhancing Native involvement, we recommend preparation and wide distribution of a statement of ethical guidelines for conduct of research in northwest Alaska.

Inventory and baseline data, urgently needed for planning purposes by federal, state, and local governments, are inadequate for almost every resource on federally reserved lands in northwest Alaska. Inventories of flora, fish, birds, mammals, key invertebrates, and cultural resources should be completed. Improved maps of mineral resources, surficial geology, and energy resources should be prepared for all the federally reserved lands. Inventory and analysis of the physical, chemical, and biological characteristics of the very extensive freshwater resources--lakes, streams, estuaries--of northwest Alaska are required. A more comprehensive and regionally representative network of long-term climatic data stations is sorely needed.

Research in northwest Alaska is seriously constrained by a lack of sustained, dependable long-term funding. Sustained funding accompanied by coordinated planning is especially crucial for reseOrch involving time-series data acquisition. Climatic and hydrologic records, base-line environmental monitoring, and long-term physical and biological research require a sustained and dependable long-term funding base to be fully effective. Further, many important policy issues concerning physical resources and biological systems have major social consequences, and many research questions have a social

dimension; development of funding adequate to support comprehensive research in the social sciences is a serious concern.

Regional coordination of research in northwest Alaska must be greatly strengthened to minimize duplication of effort and to maximize effective use of resources. There is need to develop a framework, building on current efforts of the U.S. Arctic Research Commission and the Interagency Arctic Research Policy Committee, for continuing and improving interaction among the federal agencies that represent the science, conservation, and economic development sectors, the universities and independent research institutions, local government, and regional and village corporations. Among the mechanisms suggested were publication of an interdisciplinary newsletter, and organization of biennial interdisciplinary meetings in the larger communities of Northwest Alaska.

As a designated Biosphere Reserve, the Noatak watershed links northwest Alaska with an international Man and the Biosphere (MAB) network of ecosystem research sites. Biosphere Reserves can provide a permanent basis for long-term interdisciplinary research and demonstration projects to support ecosystem management and to encourage sustainable, culturally appropriate economic uses. The circumpolar MAB Northern Science Network exists to facilitate communication and cooperation among northern countries. MAB should be a useful and suitable vehicle for institutionalizing improved cooperation among agencies and groups conducting research in northwest Alaska,

We support the establishment of regional research and resource centers. We emphasize the potential value of the existing regional research and resource center (the former Naval Arctic Research Laboratory) operated by the Ukpeagvik Inupiat Corporation at Barrow, and the proposed Consortium Library/Research/ Cultural Center to be operated by the Northwest Arctic Borough. These centers can provide mechanisms to support interdisciplinary research, minimize duplication of effort by encouraging agency cooperation, and promote local involvement in the planning, conduct, and utilization of research in northwest Alaska. Regional centers can also facilitate research by providing housing, laboratory, and warehouse space for transient researchers, and supplying logistic support for long-term monitoring and shorter-term research in remote areas. Regional centers can also serve an educational function, informing residents about ongoing research while concurrently educating scientists concerning the needs, interests, and aspirations of the local community.

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APPENDIX I

SYMPOSIUM PROGRAM

INTRODUCTION:	David M. Hopkins Alaska Quaternary Center
OPPORTUNITIES--LANDSCAPE HISTORY:	
Past and Present Landscape Processes	Thomas D. Hamilton U.S. Geological Survey
The Changing Lansdcape of Northwest Alaska	Patricia M. Anderson University of Washington
Discussant:	David M. Hopkins
OPPORTUNITIES--PREHISTORY:	
Major Archaeological Problems in Northwest Alaska	Douglas D. Anderson Brown University
Discussant:	Robert Gal U.S. Bureau of Land Management
OPPORTUNITIES--BIOLOGY:	
Some Notes on Vegetation and Ecology	Steven Young Center for Northern Studies
Long-term Ecological Work in Northwest Alaska	Francis S.L. Williamson University of Alaska Fbks
Discussant:	Patrick J. Webber National Science Foundation
LONG-TERM MONITORING:	
Long-Term Studies Within Arctic Ecosystems	Mel I. Dyer UNESCO, Paris
Discussant:	William Gregg U.S. National Park Service

APPENDIX II

WORKSHOP GROUPS AND PANELS

Group 1: Baseline Information

Leader: William Gregg, U.S. National Park Service

Recorder: Mel Dyer, UNESCO

Group 2: Fire, Erosion, and Landscape Dynamics

Leader: Leslie A. Viereck, USDA Forest Service

Recorder: Kaye R. Everett, Ohio State University

Group 3: Biological Aspects of Subsistence Research

Leader: Robert White, University of Alaska Fairbanks

Recorder: Kathy Frost, Alaska Department of Fish and Game

Group 4: Mineral and Nonrenewable Resources

Leader: Tom Albert, North Slope Borough

Recorder: Rosa Meehan, U.S. Fish and Wildlife Service

Group 5: Human-induced Alteration

Leader: Steve Young, Center for Northern Studies

Recorder: Kate Roney, U.S. National Park Service

Group 6: Nonconsumptive Uses: Tourism and Recreation

Leader: David R. Cline, National Audubon Society

Recorder: Ken Atkinson, U.S. National Park Service

Group 7: The Climate-Landscape System: Present, Past, and Future

Leader: Patricia M. Anderson, University of Washington

Recorder: L. David Carter, U.S. Geological Survey

Group 8: Prehistory and Oral History

Leader: Robert Gal, U.S. Bureau of Land Management

Recorder: Craig Gerlach, University of Alaska Fairbanks

Group 9: Publication, Curation, and Archiving

Leader: Ron Inouye, University of Alaska Fairbanks

Recorder: Eugene West, University of Alaska Fairbanks

Panel Discussion: Communication, Education, and Ethics of Research

Leaders: Rosita Worl, State of Alaska Governor's Office
Milton Freeman, University of Alberta
Perry Mendenhall, Nome Eskimo Community
Eileen Norbert, Kaweruk, Inc.
Leona Okakuk, North Slope Borough
Jerry Stroebele, U.S. Fish and Wildlife Service

Closing Panel: Summary and Review

Leaders: Boyd Evison, U.S. National Park Service
David Klein, Alaska Cooperative Wildlife Research Unit
Perry Mendenhall, Nome Eskimo Community

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APPENDIX IV

NORTHWEST ARCTIC BOROUGH RESOLUTION 86-14

A RESOLUTION RECOMMENDING THE ESTABLISHMENT OF REGIONAL ARCTIC RESEARCH CENTERS.

WHEREAS, the interest and concerns of the people of the Northwest Arctic Borough are very much focused on any activities of individuals, agencies or governments as they involve the Arctic; and

WHEREAS, the Arctic Research and Policy Act of 1984 requires that the United States government develop a five (5) year plan for research in the U.S. Arctic; and

WHEREAS, the National Science Foundation, in conjunction with the Northwest Arctic Borough has provided a formal opportunity for review of the proposed five year plan for Arctic research at the UIC-NARL facility in Barrow, on October 22 and 23, 1986;

NOW THEREFORE BE IT RESOLVED:

1. that the Northwest Arctic Borough Assembly urges all participants at the review session work to their utmost ability in assuring that the interest of the U.S. Arctic are protected, and that such residents are given every reasonable opportunity to participate in both the planning and conduct of research in the U.S. Arctic.

2. that several sites within the U.S. Arctic be designated as regional Arctic Research Centers and that these centers be focal points for: 1) the conduct of Arctic Research, 2) the logistical support for Arctic research, and 3) for educational activities that maximize the transfer of knowledge to and from residents for the U.S. Arctic.

3. that at least a portion of the former Naval Arctic Research Laboratory in Barrow, Alaska be designated as one of these regional Arctic Research Centers.

4. that a center be considered in the Northwest Arctic Borough.

5. that the Northwest Arctic Borough Assembly urges that the National Science Foundation be designated the federal agency to be responsible to fund and oversee the management of such Arctic Research Centers.

Resolution 86-14

PASSED AND ADOPTED this 5th day of November, 1986.

Borough Clerk

ATTEST:

SIGNED AND APPROVED this 5th day of November, 1986.

Mayor