Merged With
A.R.L.I.S.
ANCHORAGE, ALASKA
Est. 1997
ALASKA RESOURCES LIBRARY
Bureau of Land Management
FILE COPY

LGL ALASKA

ecological research associates

ASSESSMENT OF THE KNOWLEDGE OF POTENTIAL EFFECTS OF THE NORTHWEST ALASKAN PIPELINE PROJECT ON MAMMALS: LITERATURE REVIEW AND AGENCY INPUT

Final Report

Prepared for

Northwest Alaskan Pipeline Company, Agent and Operator for
Alaskan Natural Gas Transportation Company

under

Contract No. 478085-9-K071

Prepared by

LGL Ecological Research Associates, Inc.
Richard J. Douglass
John M. Wright
Steve G. Fancy

and

University of Alaska
Erich H. Follmann
John L. Hechtel

June 1980

ALASKA RESOURCES LIBRARY
Bureau of Land Management

Merged With
A.R.L.I.S.
ANCHORAGE, ALASKA
Est. 1997

TD
195
.P5
A88
1980

ASSESSMENT OF THE KNOWLEDGE OF POTENTIAL EFFECTS OF THE NORTHWEST ALASKAN PIPELINE PROJECT ON MAMMALS: LITERATURE REVIEW AND AGENCY INPUT

Final Report

RECEIVED
JUN 25 1980
Central Receiving Group

Prepared for

Northwest Alaskan Pipeline Company, Agent and Operator for
Alaskan Natural Gas Transportation Company

under

Contract No. 478085-9-K071

3 3755 001 09233 7

Prepared by

LGL Ecological Research Associates, Inc.
Richard J. Douglass
John M. Wright
Steve G. Fancy

and

University of Alaska
Erich H. Follmann
John L. Hechtel

June 1980

ARLIS
Alaska Resources Library & Information Services
Library Building, Suite 111
3211 Providence Drive
Anchorage, AK 99508-4614

460085-9-K07-5-0

TABLE OF CONTENTS

LIST OF TABLES

APPENDICES

INTRODUCTION

Short History of Project

The construction of a large diameter natural gas pipeline through arctic and subarctic regions of Alaska may cause adverse impacts to mammals and their habitat. In recognition of this, Fluor Engineers and Constructors, Inc. (Fluor), acting as agents for Northwest Alaskan Pipeline Company (NWA), initiated a program of mammal studies that will lead to the design and construction of a pipeline in a manner that creates the least possible impact on mammals. This report represents the initial step towards obtaining this goal.

The proposed NWA pipeline system in conjunction with other systems is intended to transport natural gas from the Prudhoe Bay oil fields to markets in the midwestern and western United States. The route proposed for the pipeline is parallel the Alyeska oil pipeline from Prudhoe Bay to Delta Junction. From Delta Junction the NWA pipeline will follow the Alaska Highway to the Canadian border. From the Canadian border to the western U.S. the gas will be transported through the Foothills pipeline system. The pipeline will be buried the entire length except at compressor stations and metering stations and will be 122cm (48 inches) in diameter. The right of way for the pipeline will be 37m (120 feet) wide and will be revegetated as soon as possible after construction of the pipeline. To maintain the integrity of the permafrost, the gas will be transported in a chilled (below 0° C) condition. Besides the pipeline right of way several associated facilities will be constructed including construction camps, material sites, compressor stations, assembly yards, access roads and various types of maintenance facilities.

Three primary objectives must be satisfied in order to construct a pipeline that will have the least possible impact on mammals:

1. Adequate baseline data on mammals and mammal habitat along the NWA corridor must be collected for facility design preconstruction

planning, locating facilities and alignment, construction scheduling, protection of sustained human uses, etc., and to minimize or avoid adverse impacts.

2. Measures to mitigate adverse impacts to mammals and their habitat during construction and operation of the NWA project must be assessed and recommended.

3. Assistance in preparation of the 1980 Federal Energy Regulatory Commission (FERC) filing, and continuous consultation on construction and post-construction monitoring efforts.

To satisfy these primary objectives, a three-phase approach has been initiated. Phase I (the subject of this report) of this approach provides the initial input to the overall development of a mammal program. Phase I is based primarily on a literature search and on interviews with appropriate government personnel. Baseline studies (Phase II) will be based on the results of the Phase I literature review. An additional literature (Phase III) review is being conducted on human-carnivore interactions.

Specific tasks that were performed during Phase I of the mammal program and are reported on in this report are:

1. Published and unpublished data on selected mammals relevant to the NWA project were reviewed.

2. Current government regulations and proposed stipulations for the grant right of way for the NWA project as they relate to the protection of mammals were reviewed.

3. State and federal personnel associated with the project were interviewed for current agency objectives related to mammal protection and interaction associated with the NWA project.

4. Proposals that were previously submitted to NWA by agencies, and NWA responses to these proposals, were reviewed.

5. An attempt was made to identify and summarize current and future (planned and funded) agency studies of mammals that may be potentially affected by the NWA project.

6. Spring studies that will provide adequate baseline data on mammals and their habitats along the NWA corridor were recommended.

7. Overall studies (including all seasons) that will provide adequate baseline data on mammals and their habitat along the NWA corridor were recommended.

METHODS

Literature Review

Matrices were used to direct the literature search and to limit the search to relevant material. Two types of matrices were constructed. The contact matrix (Appendix I) was designed to help determine the adequacy of information that described whether habitats of specific mammals contacted the proposed pipeline and related facilities. Matrices were constructed for all ungulates and large carnivores for each of four segments of the pipeline corridor. The segments were Prudhoe Bay to the crest of the Brooks Range, the crest of the Brooks Range to the Yukon River, the Yukon River to Delta Junction, and from Delta Junction to the Alaska/Yukon border. Only one matrix was constructed for each of the small carnivores and other furbearing mammals. No matrices were constructed for small rodents and insectivores.

The second type of matrix, impact matrix (Appendix 2), was designed to aid in determining the adequacy of data concerning impact of the pipeline project on mammals. Major groups of pipeline activities considered in the contact matrix were preconstruction, construction, operation, and abandonment. The literature search was directed toward determining what is known about the impacts (e.g., barriers to movement, direct mortality, habitat modification, etc.) these activities may have on mammals.

Adequacy of data for both matrices was judged on several levels. The first and most obvious was whether there were any data available; the second was whether the data were qualitative (anecdotal) or quantitative. If the data were quantitative, they were further judged for completeness, consistency, and relevancy. Symbols were placed on matrices indicating the adequacy of data for each contact and possible impact.

Information sources included published journals, books, Alaska Department of Fish and Game reports, Canadian Wildlife Service publications, Joint State/Federal Fish and Wildlife Advisory Team (JFWAT) special reports, consultant reports, Alaska Department of Fish and Game files, JFWAT files and various other government documents. The literature review also included a review of draft Department of the Interior and State of Alaska stipulations relating to pipeline-mammal interactions and a review of proposals prepared by various agencies. A literature review sheet was completed for each document we reviewed. These literature review sheets are on file in the LGL Fairbanks office.

Agency Interviews

Personnel from government agencies and the University of Alaska were interviewed for input into the design of a mammal program related to the proposed gas pipeline. Agency personnel were selected for interviews if they had responsibilities related to the pipeline or had special knowledge (e.g., experience with the Alyeska oil pipeline or a particular mammal species). A standard series of questions was asked during all interviews and, when appropriate, special questions were asked. Other agency personnel were contacted occasionally for technical imput (especially for specific sampling methods) but were not asked the standard questions. Responses were recorded on standard forms and are in the LGL Alaska files. The following questions were asked during interviews:

1. Do you feel that present data are adequate to predict, mitigate and monitor impacts of the gasline on mammals?

2. What are major data gaps?

3. How would you fill the gaps?

4. Have there been changes in distribution since ALYESKA?

5. Can any of these gaps be filled from present agency programs?

RESULTS AND DISCUSSION

Evaluation of Stipulations

Stipulations received by Northwest Alaskan Pipeline Company on 7 January 1980 from the Department of the Interior (DOI) were examined for specific stipulations related to mammals. These stipulations are being considered for adoption by the State of Alaska and, for the time being, are to be considered as being official State of Alaska stipulations (Al Ott, personal communication February 1980). Other federal and state regulations relating to mammals were also reviewed.

At the outset, mammals are protected by these stipulations in a general way. The stipulations state under "principles" that the company (Northwest Alaskan Pipeline Company) shall employ all practical means and measures to preserve and protect the environment and that the company shall balance environmental amenities and values with economic and technical considerations so as to be consistent with national policies. In doing so the company and the Federal Inspector must consider the benefit or detriment to the environment that may be anticipated to result from pipeline-related activities (DOI stipulations).

Under Stipulation 1.3.6 (Responsibilities), the company may be required to make modifications of the pipeline system to prevent significant damage to wildlife populations and their habitats.

Stipulation 1.6.1 requires the company to submit comprehensive plans and/or programs on several topics to the Federal Inspector. Topics which are relevant to mammals, especially carnivores, include blasting, camps, environmental briefings, liquid waste management, quality assurance/quality control, solid waste management, and surveillance and maintenance. In order for the plans and programs submitted by NWA to comply with this stipulation, they should include information on measures to avoid, minimize, and/or mitigate encounters with mammals along the pipeline corridor.

In the Notice to Proceed Section there are two stipulations relating to mammals. In Stipulation 1.7.3 all applications for notices to proceed must be accompanied by all applicable reports and results of environmental studies. In Stipulation 1.7.7 the Federal Inspector may revoke any notice to proceed in order to control or prevent significant damage to the environment including wildlife populations and their habitats.

The quality assurance and control stipulations (1.8.2.1.c.2) requires that at a minimum the company must provide procedures for the detection and prompt abatement of actual or potential procedures, events, or conditions of a serious nature that may cause significant damage to wildlife populations or their habitats. Under Stipulation 1.8.2.2 other procedures are required to provide for the restocking of wildlife populations and the re-establishment of their habitats if they are seriously damaged or destroyed by pipeline-associated activities.

Stipulation 1.8.2.8 calls for a field survey and inspection plan. The quality assurance program that is developed for the project must include the procedures for inspection that will be used to ensure adherence to commitments to protect carnivores along the pipeline corridor.

In Stipulation 1.9.1 the company is required to conduct pipeline system operations in a manner that will ensure protection of the environment. The company is also required to immediately notify the Federal Inspector of any occurrence that in any way threatens to significantly harm the environment.

Section 1.10 (Surveillance and Maintenance) requires that a surveillance program be established to provide for public health and safety, and to control damage to wildlife resources. Stipulation 1.11.1 (Health and

Safety) also requires NWA to protect pipeline workers from dangerous encounters with mammals along the corridor. NWA must be prepared to deal with potential hazards as they occur.

The company is also required to provide an environmental briefing to employees (Stipulation 2.1). This program should expose pipeline workers to environmental conditions along the corridor. It should include warnings regarding the dangers of carnivores and the need to avoid attraction of these animals.

Section 2.2.4.1 requires that all waste generated by the company be removed or disposed of in a manner acceptable to the Federal Inspector. In relation to mammals this means in a manner that will not attract wolves (*Canis lupus*), red foxes (*Vulpes vulpes*; and arctic fox, *Alopex lagopus*), or bears (grizzly bear, *Ursus arctos*; and black bear, *Ursus americanus*).

Under Stipulation 2.5.5.1 the Federal Inspector may restrict activities of the company in key wildlife areas during breeding seasons, lambing and calving periods, overwintering, and during major migrations. The stipulation most specific to mammals is 2.5.6.1 This stipulation requires the company to "...design, construct and maintain both the buried and above-ground sections of the pipeline so as to assure free passage and movement of big game animals." Big game species which will encounter the pipeline are wolves, wolverine (*Gulo gulo*), grizzly bears, black bears, Dall sheep (*Ovis dalli*), bison (*Bison bison*), caribou (*Rangifer tarandus*), and moose (*Alces alces*).

Stipulation 2.6.2.1 requires that material site boundaries be shaped with the primary emphasis placed on prevention of destruction of wildlife habitat and other environmental factors. Stipulation 2.7.2.3 specifies that hand clearing where specified by the Federal Inspector must be used to minimize disruption of existing habitat conditions.

Without written approval of the Federal Inspector, blasting is prohibited within 0.25 miles of waterbodies containing wildlife resources (Stipulation 2.11.2). Stipulation 2.11.3 requires that "timing and location of blasting shall be approved by the Federal Inspector." The distribution of mammals carnivores and presence of concentration areas, movement zones, and critical habitats and phenological periods may be included as criteria for determining where and when blasting will not be permitted. Knowledge of these places and periods will aid NWA in incorporating this information into the early phases of the pipeline system design and construction planning. NWA is also required to inform all employees of all laws relating to hunting, fishing, and trapping (Stipulation 2.16.1).

Section 3.1.2.3 requires that maintenance needs be designed with minimal re-entrance requirements in order to protect environmentally sensitive areas. Stipulation 3.1.2.6 requires that all construction and other activities be conducted so as to avoid or minimize thermal changes which may jeopardize the surrounding environment.

Evaluation of State and Federal Laws

Several State and Federal laws and regulations apply to mammals along the pipeline corridor. State laws prohibit the disturbance or destruction of the dens of fur animals (5AAC 81.090), harassment of game by airplanes or other motorized vehicles (5AAC 81.120), and the feeding of certain carnivores or deliberately leaving food or garbage where it will attract bears, wolves, foxes or wolverine (5AAC 81.218).

State regulation 5AAC 81.375 allows the harassing and killing of an animal in the defense of life or property provided the necessity for taking is not brought about by the improper disposal of garbage or a similar attractive nuisance. Federal law 16 U.S.C. 742(a)754, Fish and Wildlife Service, prohibits harassment of birds, fish, and mammals from aircraft. In order for NWA to comply with State and Federal laws concerning harassment, key wildlife areas will have to be identified and strict regulations implemented to control harassment within these areas.

In order for NWA to comply with these stipulations regarding mammals, the company must 1) determine the locations of key wildlife areas and the timing of wildlife events within these areas (Stipulations 1.3.6, 1.7.3, 1.9.1, 2.5.5.1, 2.5.6.1, 2.6.2.1, and 3.1.2.3), 2) provide a means of monitoring or determining if impacts occur (Stipulations 1.7.7, 1.8.2.1.c.2, 1.9.1, and 1.10.1), and 3) provide some means of repairing damage once it has occurred (Stipulation 1.8.2.2). Some, but not all, of the key wildlife areas can be identified from existing information, but field investigations will be required to make these identifications realistic and useful. The following literature review describes the extent of existing material. The monitoring efforts can only be implemented through continued field investigations. Once impacts have been identified (item 2 above), methods for repairing damage will be developed from a review of literature and, if necessary, experimental procedures.

Agency Input

General

Of the persons interviewed (Table 1), most felt that present data were inadequate to predict, avoid, monitor, or mitigate pipeline-related impacts on any species or group of species of mammals. Several people indicated that under budgetary constraints, they would accept the current level of data adequacy for some species. During the interviews specific data gaps were identified and some ways of filling them were suggested. Some of the concerns related to all mammals were as follows:

1. Studies should be conducted that distinguish between the effects of the oil pipeline from those caused by the gas pipeline. These would be Phase III studies to measure impacts

Table 1. People Interviewed for Input Into the Development of an Overall Mammal Program Related to the Northwest Alaskan Natural Gas Pipeline.

Person Interviewed	Affiliation	Reason Interviewed
Ken Whitten	ADF&G	Dall sheep, caribou and wolves
Carl Yanagawa	ADF&G	General concerns
Ray Cameron	ADF&G	Caribou and wolves
Carl Markon	USFWS	Habitat mapping for all species
Tom Rothe	USFWS	Habitat mapping for all species
Nancy Hemming	ADF&G	General concerns and carnivores
Jim Glaspell	ADF&G	General concerns and carnivores
Vic Van Ballenberghe	USFS	Moose, furbearers and wolves
Dave Klein	UAF	All species
John Burns	ADF&G	Furbearers
Marilyn Sigman	ADF&G	Furbearers and all species
Dick Shideler	ADF&G	Furbearers and all species
Gary Milke	ADF&G	All species
Bob Larson	ADF&G	Bison and carnivores
William Gasaway	ADF&G	Moose
Wayne Heimer	ADF&G	Dall sheep
Harry Reynolds	ADF&G	Bears
Dave Kellyhouse	ADF&G	Carnivores, moose and caribou
John Coady	ADF&G	Carnivores and moose
Dave Johnson	ADF&G	Black bears
Bob Stephenson	ADF&G	Wolves
Tony Booth	USFWS	Carnivores
Al Crane	USFWS	Regulations
Al Ott	SPCO	Regulations
Jim Davis	ADF&G	Caribou

ADF&G = Alaska Department of Fish and Game
USFWS = U.S. Fish and Wildlife Service
USFS = U.S. Forest Service
UAF = University of Alaska, Fairbanks
SPCO = State Pipeline Coordinator's Office

so subsequent mitigative actions would be taken as requested in NWA original request for Quotation.

2. Studies to determine the effects of thermal erosion on mammals and mammal habitat should be initiated.

3. Long-term monitoring studies that clearly separate natural variation from variation due to the pipeline should be conducted from the preconstruction through the abandonment phases of pipeline operations.

Such studies would be extremely valuable to forming mitigative actions. Related to this, a concern was expressed that the lack of baseline data hampers all aspects of a biological program as it relates to the pipeline. A final comment concerning the agencies experience with Alyeska was that even when good biological data were available, it was very difficult to get them considered in engineering design.

Dall Sheep

The major concern expressed with Dall sheep was that data for sheep in the Brooks Range were outdated. Essentially the only concern for Dall sheep was in the Brooks Range because the agency people felt other herds were far enough removed from the corridor that they would not be affected. Specific data gaps were the lack of specific knowledge of critical wintering, lambing, and movement areas as they related to pipeline activities. A pipeline activity that was felt to be a particular problem was that of pipeline-related aircraft traffic in areas adjacent to the corridor.

Moose

Although moose are extremely important game mammals and considerable research has been performed on them, agency personnel felt that major data gaps existed. Among these are the lack of specific distributional data based on systematic surveys and the lack of relative habitat use data along the pipeline corridor. Related to this was a concern that no one has determined the importance of riparian willows to moose in areas north of tree line versus forested areas. It was felt that there may be a significant difference and that this difference would have a bearing on predicting and mitigating the effects of the pipeline on critical moose range. A final concern was that the effect of gravel mining for the oil pipeline on moose habitat was apparently much greater than predicted and that this effect should be considered in all moose studies.

Caribou

A major concern expressed by several biologists was that the current monitoring effort in the range of the Central Arctic Herd be continued. Biologists felt that this study was crucial to providing suitable baseline data and for monitoring possible impacts. Other concerns were that distributional data on southern herds were lacking but the chance of contact seemed remote. Also it was felt that caribou spending the winter between the crest of the Brooks Range and the Yukon River may be from the Western Arctic Herd or the Porcupine Herd. It was suggested that the herd identity of these animals be determined because if there are animals present from these herds the potential effects of the pipeline could occur over a much broader area than if the animals are from local herds. The habitat mapping people expressed a concern over the lack of relative habitat use data. An obvious data gap was the lack of good experimentally based information on the effects of pipeline-related disturbance on caribou.

Bison

Agency personnel felt that the distribution of bison and location of important ranges are adequately known but felt that migration routes between these areas are poorly known. It was felt that migration routes should be delineated so that construction can occur when bison are absent from construction areas.

Carnivores

Agency staff familiar with the construction of the TAPS project felt that the project had a major impact on wolves north of Atigun Pass. Wolves which were essentially undisturbed before construction of the haul road were attracted to the corridor area, apparently by the availability of food handouts from workers. A major reduction in the number of wolves resulted from shooting, presumably to collect the skins. It is unclear whether the shootings occurred from people in vehicles taking advantage of wolves on or near the haul road or whether they were taken by aerial hunters. However, it is generally felt that shooting from the road was the more important cause of mortality.

Wolves between Atigun Pass and the Yukon River were also attracted to the corridor, but it is not known if wolf numbers in that area were reduced. However, if most wolves on the North Slope were shot from the road, it seems reasonable that the population south of Atigun Pass was also reduced from pre-TAPS levels.

Wolf numbers south of the Yukon River have been reduced by trapping and by aerial hunting. The impact of the TAPS project and associated activities on wolves was quite clear, especially with regard to increased mortality. Impacts from the NWA project may be similar if the attraction of animals to the corridor by feeding and improper food storage and garbage disposal is not properly controlled. These various factors suggest to agency staff that wolf studies probably are not necessary.

Grizzly bear and black bear problems along the TAPS corridor were quite substantial, particularly in localized areas. Bears were attracted to camps and construction areas by feeding, and by improper food storage and garbage disposal. This attraction resulted in large numbers of bears being concentrated near certain camps. Although some mortality occurred due to this attraction, bear populations were not noticeably reduced during or after TAPS construction and problems will probably re-occur. Little is known about bears south of Atigun Pass, and there was a consensus among the people interviewed that bear studies should be conducted during the NWA project. Agency personnel felt that critical habitats and habitat use need to be identified and that information on alterations of distribution, movements, and behavior of bears resulting from pipeline construction should be obtained.

Foxes also were attracted to camps and construction sites during the TAPS project. Although not physically intimidating, they caused problems at camps and were potentially dangerous because they can transmit diseases, including rabies. The arctic fox has been studied fairly extensively in the area of Prudhoe Bay to determine the effects of development on their population. Additional work, therefore, is not considered necessary.

The red fox has not been studied at all except for one project north of Galbraith Lake. Little is known about the red fox in interior Alaska but there is evidence that populations are fairly high around Delta Junction. A red fox study to determine critical habitats, habitat use, and alteration of distribution, movements and behavior resulting from pipeline construction would be justified.

A concensus among personnel that were interviewed was that attraction of animals to camps and construction sites should be avoided. Determining the effectiveness of various deterrents and developing plans to implement them on the NWA project were considered important for study.

Little is known of the disease potentials and status in carnivores along the pipeline corridor. Since the various zoonotic diseases that occur in these carnivores are dangerous to man, disease surveys along the corridor were recommended.

Furbearers

All personnel interviewed felt that there were little or no data on which to base predictions of impacts or mitigative actions for furbearers. It was suggested that relative habitat preferences be determined for the most common species. Several people suggested looking at the effects of habitat modification on prey species and the resultant effects on carnivorous furbearers. The effects of the pipeline on fur trapping activities was mentioned as a potential problem. It was recommended that an initial step in furbearer studies would be to conduct a literature-based impact assessment of the pipeline, particularly in relation to the effects of hydrological modifications and gravel mining on aquatic furbearers.

Small Mammals

Although biologists felt that the least amount of data were available for small mammals, they felt that studies on small mammals by themselves were not justified. There was concern expressed for including small mammal studies in terrestrial furbearer studies. It was felt that understanding the effects of the pipeline on small mammals would be crucial to understanding the effects of the pipeline on most carnivores.

Agency Proposals

During 1978, the Interagency Fish and Wildlife Task Force (IFWTF) developed a series of proposals for NWA-related studies on fish and wildlife in 1978. These studies were considered necessary to provide environmental information to the NWA designers and construction planners. In November 1979, these proposals were updated within the context of the current NWA plans. Two projects related to mammals were included in the draft proposals (Second Revision) dated 29 November 1979. These proposals were entitled "Carnivore Studies Associated with Construction of the Gasline", and "Effects of the Trans-Alaska/Northwest Pipeline Corridor on the Distribution and Movements of Caribou".

The carnivore proposal poses broad objectives. It includes six species of mammals and the specific studies range from determining the effects of the NWA project on carnivore movements to disease investigations. The specific objectives are:

1. to determine the sex, age, and distribution of grizzly bears, black bears, wolves, foxes, and coyotes (*Canis latrans*) which frequent construction camps and areas of human activity along the NWA corridor;

2. to describe the influence of pipeline-related activities on the daily and seasonal movements of these carnivores;

3. to evaluate the dependence of carnivores on artificial sources of food and the effects of this conditioning on behavior patterns and food habits;

4. to develop and assess practical and effective means of minimizing carnivore-human contacts and confrontations; and

5. to identify the carrier status and zoonotic disease potential of carnivores within the gasline corridor and to document any abnormal incidence of disease resulting from increased contact with humans and/or other carnivores.

The justification for this study stems from the carnivore-related problems that occurred during construction of the Trans-Alaska Pipeline System (TAPS). Improper garbage disposal and animal feeding altered local distributions of animals, increased the potential for zoonotic disease transmittal, and reduced the health and safety conditions in the construction areas. The study proposed by IFWTF would aid in determining what designs and procedures should be implemented on the NWA project to greatly reduce the probability of their recurrence.

The Fairbanks office of ADF&G has no other current or planned projects with regard to bears and canids in the areas traversed by the NWA project. However, depending on snow conditions, some aerial surveys may be flown for wolves in conjunction with the wolf hunt in certain areas of Game Management Unit 20.

The U.S. Fish and Wildlife Service does not have any current or planned projects on bears or canids in areas traversed by the NWA project. The carnivore project seems relevant to problems associated with the NWA project. If all elements were implemented and successfully executed, the proposed project would provide much of the information required to measure and mitigate possible pipeline-related impacts on carnivores.

The caribou proposal includes investigations of the general ecology of the Central Arctic Caribou Herd and monitoring impacts of the transportation corridor (including the proposed NWA project). Specific objectives of this study are:

1. to monitor range occupancy, seasonal movements and productivity of the Central Arctic Herd (CAH);

2. to determine latitudinal distribution and sex/age composition of caribou within the Utility Corridor and to identify any local abnormalities by comparison with corresponding parameters obtained through aerial survey;

3. to determine the location, direction, and timing of caribou crossings of the Utility Corridor and to characterize the behavior of caribou which encounter the haul road, existing facilities, gasline system construction activities, and associated vehicular, aerial and human activity;

4. to evaluate the effects of the various components of the Utility Corridor on caribou movements with special interest in the effectiveness of present and future big game crossings; and

5. to describe the mechanisms by which movement patterns of caribou are established and subsequently sustained or altered.

This study is an extension of a study designed to measure the impacts of the TAPS pipeline and will continue to do so while including measurements of effects related to the NWA project. This study provides most of the information (baseline and monitoring) that will be required to develop plans to avoid and mitigate impacts on the Central Arctic Caribou Herd. As presented, the proposal does not suggest studies on caribou that may come in contact with the NWA pipeline in any area south of the crest of the Brooks Range.

The two proposals (carnivore and caribou) prepared by IFWTF present programs that are relevant to the NWA project and will provide appropriate data, but they do not account for the full range of potential problems relating to the NWA project. IFWTF felt that other studies would be identified through their "Status and Packaging of Available Information" project.

Game Management Plans and Related Studies

Draft proposals of the Alaska Wildlife Management Plans (ADF&G 1976) for Arctic and Interior Alaska were reviewed for information relevant to the Northwest Alaskan gas pipeline project. These plans present the Alaska Department of Fish and Game's management goals and guidelines for mammals, raptors, and waterfowl. Management problems and impacts of the game management plans are discussed for individual species in the management plans.

One concern expressed throughout the game management plans is that development, through alteration of habitat, will have detrimental effects on game populations. Another concern is that multiple utility corridors may compound the smaller impacts of single corridors, causing serious problems.

Moose

The ALaska Wildlife Management Plans recognize that resource exploitation and development will restrict moose habitat, and that efforts must be made to protect critical habitat and assure free passage to these habitats. The plans specifically suggest that development be regulated to minimize adverse impacts on moose in the arctic. In the Interior, the plans suggest that ADF&G should discourage development activities that adversely affect important moose habitat and should recommend actions that maintain the aesthetic appeal of the area.

Caribou

With respect to the caribou and development, the Alaska Management Plans are particularly concerned with barriers to migration and the division of ranges. The plans suggest that detrimental land use practices be discouraged. Regarding large construction projects, the plans specify that ADF&G should monitor herd movements and make recommendations on construction modes and project activities which would minimize adverse impacts.

Dall Sheep

The management plans state that Dall sheep may be adversely affected by alteration of important habitats or through disturbance of sheep use of critical areas. Mineral licks, winter ranges, lambing areas, and migration routes are particularly susceptible to damage or interference from certain activities, including construction in transportation and utility corridors. The plans state that critical habitats must be protected from alteration or undue disturbance.

Bison

Management guidelines for bison include encouragement of land use practices which enhance bison habitat, and the use of habitat improvement programs to improve the carrying capacity of selected areas for bison. Since year-round bison range is extremely limited in Interior Alaska, the loss of any component of existing range to human development would have adverse effects on the bison herd.

ADF&G Species Management Plans

Grizzly Bear

The grizzly bear occurs within all the game management units traversed by the proposed NWA pipeline. The concerns regarding potential impacts to grizzly bears are similar throughout. Land use practices that affect the "wild character" of an area and critical bear habitat, increased human access in grizzly bear habitat, and improper food storage and refuse disposal which will increase the number of human-bear encounters, are identified as potential problems that will affect bears as development continues in Alaska. It is recommended that ADF&G discourage development that will impact critical bear habitat and the "wild character" of an area and encourage proper storage and disposition of food and refuse.

Black Bear

The black bear occurs in all of the game management units south of the Brooks Range divide. The concerns expressed with regard to the black bear are the impacts on critical habitat and loss of the "wild character" of an area that are associated with development. The ease with which black bears become accustomed to garbage and handouts that often are associated with increased development are identified as additional concerns. The ADF&G recommendations for black bear management include discouragement of feeding and improper food storage and garbage disposal, protection of important habitats and maintenance of the "wild character" of affected areas.

Wolf

Wolves occur throughout the area traversed by the NWA pipeline. The only problem identified with wolves is the increased potential for human-wolf encounters as wolves become accustomed to the presence of people at camps and work sites. Where people are bitten, wolves are often destroyed so that the carcasses can be analyzed for rabies. Increased regulations pertaining to animal feeding, food storage and garbage disposal and adequate enforcement of regulations, are identified as potential solutions to this problem.

Coyote, Red Fox, and Arctic Fox

Red foxes occur throughout the pipeline route; arctic foxes are found regularly north of the Brooks Range and coyotes south of the Brooks Range. Loss of habitat is the only problem identified with regard to these furbearers. Important habitats should be identified in advance of development so that detrimental impacts can be minimized. One suggested approach to protecting habitat is to coordinate development activities with various conservation agencies.

During interviews with agency personnel, ongoing studies were discussed to determine if they would be useful to NWA project. Most projects (Table 2) would provide data that would not be directly applicable to the NWA project, but would provide some information.

Table 2 Agency studies that may produce data useful in planning the NWA pipeline.

AGENCY BISON STUDIES

Agency		Project	Location
ADF&G (Fiscal Year 1980)			
		Radio-telementry study to determine movements of herd groups.	Delta Jct.

AGENCY CARIBOU STUDIES

Agency		Project	Location
ADF&G (Fiscal Year 1980)			
	Research	Behavorial responses and seasonal distribution of caribou encountering the haul road in the Trans-Alaska Pipeline Corridor	Fairbanks
		Size, sex and age composition of the Porcupine Caribou Herd	Fairbanks
		Qualitative and quantative aspects of natural mortality of the Western Arctic Caribou Herd	Fairbanks
		Seasonal home range, social structure and habitat selection of the Western Arctic Caribou Herd	Fairbanks
		Calf Mortality in the Delta Caribou Herd	Fairbanks
	Management	Periodic composition and population counts (including a proposed aerial-photo census of the Fortymile Caribou Herd in summer 1980)	Fairbanks, Delta, Tok
USFWS		Caribou habitat use dynamics on the calving grounds of the Porcupine Caribou Herd in the Arctic National Wildlife Range	Denver (Kenai) - Fairbanks
BLM		Western Arctic Caribou Herd and reindeer winter range study in The Selawik-Buckland area	Fairbanks

Table 2 (cont.)

AGENCY MOOSE STUDIES

Agency		Project	Location
ADF&G (Fiscal Year 1980)			
	Research	Determination of sightability of moose during aerial census	Fairbanks
		Standardizition of moose census techniques	Fairbanks
		Sightability and movements of juvenile moose	Fairbanks
		Moose mineral lick studies	Fairbanks
		Moose management techniques development	Kenai
		Moose physiology, productivity and biotelemetry studies	Kenai
		Nelchina moose calf mortality studies	Glennallen
		Nelchina yearling moose mortality study	Glennallen
	Management	Periodic trend and composition counts	Fairbanks, Delta, Tok
USFWS		Moose Surveys in the Arctic National Wildlife Range (in conjunction with periodic ADF&G management surveys on the Arctic Slope)	Fairbanks
U of A /Alyeska		Evaluation of impact of cutting collection on existing moose habitat	Fairbanks

Table 2 (cont.)

AGENCY SHEEP STUDIES

Agency	Project	Location
ADF&G		
Research	Dynamics of high and low quality sheep populations. Lick observations and aerial surveys. Capture and collar sheep	Dry Creek, Sheep Creek

GENERAL AGENCY STUDIES

Agency	Project	Location
BLM	Sagwon Bluffs, Habitat Management - Peregrines and their prey (small mammals)	Fairbanks
	Central Brooks Range Habitat Management Plan - primarily concerned with Dall Sheep and their use of mineral licks	Fairbanks
	Fortymile Resource Area Range Use Plan (in preliminary stages)	Fairbanks
USFWS	Terrestrial and Aquatic Habitat Mapping	Anchorage
	AIMS	Anchorage
U of A /Museum Vertebrate Collection	Breeding birds and small mammal populations in the Delta area	Fairbanks

The ADF&G Division in Fairbanks has proposed a grizzly bear project in Interior Alaska. The study would be initiated during 1981 in an area of the Alaska Range between the Wood and Little Delta Rivers, and area remote from the pipeline corridor. A second study phase is planned for an area southeast of Tok, between the highway and the Canadian border. This project would not begin until 1983. This proposed grizzly bear project is designed to refine maximum harvest levels in these areas by studying bear density, home range size, reproductive biology and survival rages. Data from this study would perhaps yield some useful information regarding bears directly affected by the NWA pipeline. However, specific impact studies are not planned except in response to hunting pressure.

A second study proposed by the ADF&G Division is to study the reporductive tracts of black bears harvested in Inereior Alaska. It is not anticipated that this project will yeild data applicable to the NWA project.

The ADF&G is planning a wolf survey and removal program for Game Management Units 20B, 20C (Salcha and Goodpaster River area), and 20D (up to Robertson River) beginning in fall 1980 and continuing into spring 1981. There may be a wolf control program in the area farther east. There are no other current or planned projects with regard to bears or canids in the areas traversed by the NWA project.

Literature Review

Dall Sheep

Contact

For the purposes of this report, the NWA corridor will be considered to contact sheep ranges if the corridor occurs within two miles of known sheep ranges. This arbitrary distance was used because the boundaries of sheep ranges were accurately described in only a few areas, and because sheep may be more sensitive to some disturbances than are other large mammals (McCourt *et al.* 1974; Tracy 1977). The NWA corridor will contact Dall sheep ranges in several areas (Appendix 1). Contact with important Dall sheep habitat will occur in the Brooks Range between Cathedral Mountain (haul road Milepost 110) and Slope Mountain (MP 248) (Linderman 1972; Alaska Dept. Fish and Game 1974; Summerfield 1974; Hemming and Morehouse 1976). Pipeline construction will also occur within two miles of areas used by Dall sheep near Cathedral Rapids on Alignment Sheet 112. This area contains an important mineral lick at Sheep Creek (Heimer 1975) approximately five miles from the NWA corridor. Figure 1 contains a summary of the contact matrices for Dall sheep, bison, moose, and caribou. Five of the proposed compressor stations will be located within two miles of known sheep ranges, and three of these (at MP 113, 136, and 178) will be within two miles of lambing areas (Andersen 1971; Price 1972; Summerfield 1974; Hemming and Morehouse 1976). Five of the construction camps are located within five miles of sheep habitat in the Brooks Range.

Impact

The impact of intensified human activity on Dall sheep populations is not completely understood (Appendix 2). However, some general predictions can be made. Human disturbances can adversely affect the physiology, productivity, and ecology of sheep as well as their behavior (Geist 1971a). Harassment by aircraft or other means increases energy expenditure at the expense of body growth, development, and reproduction (Geist 1975, 1978). Ewes with lambs are particularly sensitive to disturbances (Murie 1944; Smith 1954; Jones *et al.* 1963).

Most studies dealing with human disturbances of mountain sheep have relied on overt behavioral responses to determine if the animals were affected by the disturbance. Recent work with bighorn sheep (*Ovis canadensis*) using heart rate telemetry found that most heart rate responses to disturbing stimuli preceded or occurred in the absence of overt behavioral reactions (MacArthur *et al.* 1979). Heart rate correlates reasonably well with energy expenditure in some ungulates (Webster 1967; Johnson and Gessaman 1973; Holter *et al.* 1976; Kautz 1978), and may provide a useful estimate of relative energy costs (MacArthur *et al.* 1979). Some disturbances may therefore affect the energy budget of an animal even though no overt behavioral response is shown.

Six studies have included observations on the response of Dall sheep to aircraft disturbances (Andersen 1971; Linderman 1972; Nichols 1972; Price 1972; Lenarz 1974; Summerfield 1974), although only one of these (Lenarz 1974) presented quantitative data. Helicopters usually evoked a greater response from sheep than did fixed-wing aircraft. This is possibly because helicopters fly slower and closer to the sheep and are generally more noisy (especially "rotor popping") (Andersen 1971; Linderman 1972; Price 1972). No studies have been conducted to determine the responses of mountain sheep to aircraft flying at different altitudes, as have been conducted with caribou and muskoxen (Klein 1973; McCourt *et al.* 1974; Calef *et al.* 1976; Surrendi and DeBock 1976; Miller and Gunn 1979). The reaction of Dall sheep to low-flying aircraft is apparently highly variable (Linderman 1972; Price 1972), although Linderman found that sheep always reacted nervously and assumed the alarm posture (Geist 1971b) until the disturbance had passed. Linderman also cautioned that aerial observations of sheep which appear undisturbed should not be considered as a demonstration of tolerance of aircraft. Lenarz (1974) found that "ewes" (including young rams not discernable from females) reacted more strongly to helicopters than did rams. Andersen (1971) and Price (1972) found that sheep were more easily disturbed by aircraft when congregated at mineral licks, which are usually located lower on slopes away from escape cover.

The effect of ground traffic and the presence of the haul road on Dall sheep distributions and movements is unknown. Tracy (1977) found that the Mt. McKinley National Park road inhibits the movements of some sheep, while others crossed while people and vehicles were nearby. The strength of reactions and the percentage of sheep showing visible reactions to buses and visitors in Mt. McKinley Park decreased with increasing distances between the sheep and the road (Tracy 1977). MacArthur *et al.* (1979) found that heart rates of bighorn sheep were positively correlated with the proximity of the sheep to a road traversing their range. However, as they approached the road, sheep became further separated from escape cover which in turn may have been stressful to the animals. Another explanation is that sheep experienced chronic stress through previous association of the road with human disturbance (MacArthur *et al.* 1979). Dall sheep crossing the haul road during migrations may experience similar stress because they would be well away from escape cover, and since most human disturbances would occur near the road.

Our knowledge of the response of Dall sheep to construction activities is limited to two anectodal observations, one of a ditching operation blocking passage of a group of sheep (JFWAT files), the other of sheep reacting to blasting 3.5 miles away (Lent and Summerfield 1974).

Two studies attempted to determine the effects of compressor station sounds on Dall sheep (McCourt *et al.* 1974; Reynolds 1974). The value of the data obtained during these studies is limited, however, since the results were contradictory, and only the compressor noise aspect of a compressor station was considered.

Sheep may habituate to harmless, frequently occurring disturbances (Geist 1971a, 1971b, 1975). There are several areas in Alaska where apparently healthy Dall sheep populations live in close proximity to intensive human disturbance, however, there is no scientific literature on these situations. Tracy (1977) noted that Dall sheep in Mt. McKinley National Park have habituated to humans climbing up slopes, yet reacted strongly to sudden loud noises. Geist (1978) suggested that big game animals can be taught to ignore human beings. There have been no studies, however, to determine if Dall sheep can be taught to tolerate construction activities, or how to habituate them to certain human disturbances.

To summarize, current information on Dall sheep distribution, movements, and productivity along the NWA corridor is not available. This information is necessary to help assess, avoid, or mitigate any impacts of NWA construction and operation on Dall sheep populations. There are no quantitative data available to recommend minimum aircraft flight altitudes over Dall sheep range at different times of the year. There are large data gaps concerning the impact of various construction activities on Dall sheep. Quantitative data on the short-term effects of human disturbances on Dall sheep are thus very limited, and nothing is known about the long-term effects of disturbance on Dall sheep populations.

Recommendations

The three primary objectives identified earlier call for baseline data on Dall sheep populations and habitats, monitoring studies which will identify adverse impacts of NWA construction and operation on sheep, and means to mitigate any adverse impacts. The haul road surveys initiated by LGL in spring 1980, if continued on a year-round basis over a period of several years, will provide much of the baseline data needed to satisfy government stipulations. Aerial surveys of sheep ranges adjacent to the corridor should be conducted once the snow melts to provide further baseline data on sheep distributions and the number of sheep using specific areas.

Data obtained during the haul road and aerial surveys will help to identify any changes in sheep distribution due to NWA construction and operation. The presence of compressor stations adjacent to lambing areas presents a potential adverse impact on sheep productivity. The haul road and aerial surveys will not detect changes in productivity of lambing areas. Detailed studies of the productivity of lambing areas located adjacent to and away from compressor stations should therefore be conducted for several years prior to and following compressor station operation to monitor the impact on sheep populations.

There is very little information available on the impact of specific construction activities on Dall sheep (Appendix 2), however, experiments to provide these data would probably cause more disturbance to sheep populations than would actual construction. Opportunistic studies of impacts could be conducted if there is cooperation between construction contractors and biologists. For example, the reaction of sheep to blasting might be studied during experimental blasting by construction engineers.

Several studies on Dall sheep populations in the Atigun Canyon were conducted prior to TAPS construction. The oil pipeline and haul road do not pass through this canyon; however, the canyon is used as an air corridor. Ground and aerial studies should be conducted in the Atigun Canyon for comparison to the data obtained in earlier studies. This comparison would help to identify any adverse impacts of aircraft disturbance over a longer term, and may also provide information on habituation of Dall sheep to aircraft disturbance.

Recommendations for mitigative measures are premature at this time. Data on Dall sheep which will be collected in these recommended studies need to be obtained before intelligent mitigative recommendations can be made.

Bison

Contact

The Delta bison herd, introduced near Delta Junction in 1928, is currently estimated at 280 animals. The bison herd migrates seasonally in several separate herd groups between summer and winter ranges. The major calving area and summer range of the bison herd is along the sandbars and west bank of the Delta River (Alaska Dept. of Fish and Game 1974; Hemming and Morehouse 1976; Burbank and Sigman 1979). Calving also occurs west of Healy Lake near the junction of the Tanana and

Gerstle rivers (Rausch 1962; Larson 1980 pers. comm.). There is little or no contact between the proposed NWA corridor and bison calving grounds or summer ranges (Appendix 1). The proposed compressor station sites and construction camps are also located in areas which receive little or no use by bison. Bison will contact the NWA corridor during the winter months, however, and major migration routes are intersected by the corridor (Burbank and Sigman 1979). The timing and routing of the movements of most herd groups between seasonal ranges is poorly known; however, one herd group uses the Haines gas pipeline right-of-way as a migration route between winter ranges near Healy Lake and summer ranges west of the Delta River (McIlroy 1972; Burbank and Sigman 1979).

Impact

Approximately seven bison are killed by vehicles along the Richardson and Alaska highways each year (Griffin 1968; Larson 1974, 1980 pers. comm.), and there is a potential for significant losses from road kills due to increased road traffic during construction of the gas pipeline. Studies in the reaction of bison to aircraft disturbance were conducted in Wood Buffalo National Park. These studies found that helicopters caused greater disturbance to bison than did fixed-wing aircraft, while a single fly-over by a fixed-wing aircraft caused moderate disturbance and often caused running at an altitude of 120 m (394 ft.). Multiple fly-overs at 120 m caused significant disturbance and intra-specific strife. A flight at an altitude of 300 m (984 ft.) created little or no disturbance to bison (Tempany *et al.* 1976). Quantitative data concerning the possible impact of other increased human contact on the bison herd is lacking (Appendix 2). There have been no studies to determine the effects of construction activities on bison. It is not known what effect the cleared or revegetated corridor will have on bison movements, although bison feeding on the revegetated oil pipeline right of way followed the right of way to areas outside their normal range (Larson 1980 pers. comm.). In summary, the only quantitative data available on the impact of human disturbances and construction activities on bison is for aircraft disturbance and the number of bison killed by vehicles along the highways. Information needed to assess, avoid, and mitigate any impacts of NWA construction on the Delta bison herd is severely lacking.

Recommendations

The three primary objectives which must be satisfied in order to construct a pipeline that will have the least possible impact on bison call for adequate baseline data on the movements and seasonal distribution of the bison herd, means for monitoring adverse impacts on the bison herd, and measures for mitigating impacts. The location of the main calving grounds, summer range, and some winter ranges for various herd groups is well known, however, the movements of individual animals for much of the year is poorly known. Very little information is available on the calving grounds and migrations of the Healy Lake herd group, which uses the proposed NWA corridor as a major migration route between summer and winter ranges. LGL initiated aerial and ground surveys of the bison range in spring 1980 to help determine the movements of some herd groups and to identify specific trails used by bison to cross the corridor. In order to provide accurate, detailed information on bison movements and use of specific areas, however, the approximately seven to nine lead cows should be radio-collared. A long-term study using radio-telemetry would be the least expensive means of obtaining the necessary baseline data on herd movements and would also provide a means of monitoring any adverse impacts of NWA construction on the bison herd.

There are no data available on the impact of construction activities on bison (Appendix 2); however, if NWA construction were conducted in the summer months, contact with bison would be minimal. If it is not possible to schedule construction during the summer, it may be necessary to conduct studies to determine the best means of construction such that the herd will be least affected. Further information on alignment, construction scheduling, and bison movements needs to be obtained before mitigative measures can be recommended.

Moose

Contact

Moose inhabit all of the regions along the NWA corridor (LeResche *et al.* 1974). The locations of moose concentration areas delineated by ADF&G (1974) and Hemming and Morehouse (1976) are often contradictory. Except for restricted areas where intensive studies have been conducted, the locations of concentration areas have been determined by chance observations or the 'educated opinions' of agency biologists. These opinions are based on local experience when possible but are often based upon knowledge of moose seasonal habitat preferences determined in other areas. The locations of concentration areas delineated in Hemming and Morehouse (1976) are based on more recent information than was available at the time that ADF&G (1974) distribution maps were compiled. The source of new data used by Hemming and Morehouse (1976) was primarily observations collected by JFWAT personnel during trips on the haul road.

The number of moose in the vicinity of the corridor may vary seasonally due to migrations and differences in seasonal habitat preferences. In the Interior (defined as the drainages of the Yukon and Kuskokwim rivers by LeResche *et al.* 1974, which encompasses all of the NWA route south of the crest of the Brooks Range), boggy lowlands are important calving and early summer ranges, low-shrub upland communities are selected later in summer and in fall, while tall shrub and forest habitats are most important in winter (Coady 1973, 1976; LeResche *et al.* 1974; Gasaway *et al.* 1979). On the Arctic Slope (the region north of the crest of the Brooks Range) moose are generally confined to riparian shrub communities along large rivers, but in summer may disperse to smaller tributaries and off-river areas (Mould 1977; Coady 1979). In all regions, tall willow shrub communities are capable of supporting the highest densities of resident moose, while unbroken expanses of northern coniferous forest ('taiga') support the lowest densities (LeResche *et al.* 1974).

In Alaska, individual moose traditionally re-use the same seasonal home ranges (LeResche 1974; Coady 1976; Van Ballenberghe 1977; Gasaway *et al.* 1979), and probably follow the same routes each year when moving between their ranges (LeResche 1974; Van Ballenberghe 1978). The length of migrations vary greatly; some individuals move only a few kilometers between seasonal home ranges while others move as far as 360 km (LeResche 1974; Coady 1976; Van Ballenberghe 1978). During years with shallow snow depths, migrations may be shortened (Van Ballenberghe 1977). The timing of migrations in any single area is variable within the spring and fall-winter movement periods. This is probably related to differences in the pattern of seasonal range use by segments of individual populations (Coady 1976) and environmental factors such as snow (Van Ballenberghe 1977). Moose are generally the least gregarious of North American cervids, but aggregations may form as a result of external factors such as limited forage, snow cover and topography, or because of breeding activities (Peek *et al.* 1974).

Impact

The impacts of buried-pipeline construction and operation upon moose are poorly documented (Appendix 2). The one study of moose undertaken in relation to TAPS focused on the effects of above-ground pipeline on moose movements (Van Ballenberghe 1978); only a few anecdotal observations of moose in relation to buried pipeline are available (Van Ballenberghe 1978; JFWAT files).

The effects on moose of site preparation activities, including surveying, road construction, development of support facilities, clearing of right of way, and material site use, are poorly understood. A few anecdotal references note moose response to power saws (Geist 1963) or to road construction (Denniston 1956). The clearing of vegetation from certain areas which serve as critical seasonal ranges could have serious effects on a great number of moose which annually range over a vast area (LeResche 1974). During construction of the oil pipeline, disturbances attributed to material sites affected almost twice the area anticipated during planning of the TAPS project (Pamplin 1979). Approximately half of the area impacted by material sites was riparian willow habitat (Pamplin 1979), the habitat capable of supporting the highest densities of moose (Le Resche *et al.* 1974).

Responses of moose to humans on foot have been described by several authors (McMillan 1954; Denniston 1956; Geist 1963; LeResche 1966; Mould 1977), though quantitative data are provided by only two sources (Altmann 1958; Tracy 1977). The reactions of moose to motor vehicles were described qualitatively by McMillan (1954) and quantitatively by Tracy (1977); in each instance studies were conducted within a national park. In winter, moose may use roadways to avoid deep snow (Van Ballenberghe and Peek 1971); and moose have been observed feeding on revegetation along the TAPS corridor (JFWAT files) and on willows growing on disturbed ground along a park road (Tracy 1977). LeResche *et al.* (1974) suggest that the greatest impact of development on moose will be to increase accidental mortality by attracting moose to transportation corridors. In Quebec, the number of moose killed by road traffic was positively correlated with the amount of vehicle traffic (Grenier 1973).

Air traffic appears to be less disturbing to moose than to other ungulates (Evans *et al.* 1966; LeResche 1966; Klein 1973a; McCourt *et al.* 1974; Mould 1977). Only one of these reports (McCourt *et al.* 1974) presents quantitative data, and it is based on a very small sample. As with other ungulates, moose cow/calf groups appear to be more sensitive to disturbance than bulls (Altmann 1958; Klein 1973a; Tracy 1977).

During construction of the TAPS pipeline, scattered observations indicated that moose movements were inhibited by open ditches (Van Ballenberghe 1978; JFWAT files), by pipe and strings placed on the ground with no openings between sections, and by pipe on cribbing during assembly (Van Ballenberghe 1978). The only available report of moose responses to construction activity (road building in Yellowstone National Park, Denniston 1956) suggests that moose avoid this type of disturbance. The effects of the presence of above-ground facilities (other than pipe) on moose are unknown, but stationary objects without associated sounds and smells are likely to be one of the least disturbing pipeline-associated stimuli as moose have been observed to respond most strongly to moving objects and objects associated with noises and smells (McMillan 1954; Altmann 1958; Tracy 1977).

Moose have apparently habituated to road traffic in two national parks (McMillan 1954; Tracy 1977), and it has been postulated that moose and other ungulates may learn to tolerate disturbing stimuli which are consistently harmless (McMillan 1954; Geist 1971a). Tracy (1977) suggests that the responses of moose to disturbance recorded by observers in the past have frequently underestimated the true reactions because of various factors of moose behavior. Geist (1971a, 1975) has stressed that the energetic costs of disturbance are virtually unknown for free-ranging wild ungulates and should be given greater consideration.

Summary and Conclusions

Construction of buried pipeline, from the time when ditches are opened to the time when the pipe is buried and the berm graded, will most likely inhibit moose movements. Present knowledge of the location and time of use of crossing areas or moose concentration areas is inadequate in some areas to schedule or align NWA activities so that minimal impact on moose will be assured.

Certain shrub communities may serve as irreplaceable wintering areas for moose populations and destruction of one of these areas will have drastic effects on the local population. The locations of these critical areas are not adequately known, especially from the crest of the Brooks Range to the Yukon River and from Delta Junction to the Alaska/Yukon border.

The majority of observations recorded on the response of moose to human disturbance are from national parks, where animals are not hunted; hunted moose will likely be more sensitive to disturbance (see Altmann 1958). No documentation is available on the response of moose to a great variety of stimuli which the NWA project will produce.

The response of moose to aerial disturbance has received little study, but observations indicate that flight altitudes recommended for caribou (300 m agl from November to April and 600 m agl from May to October, following Miller and Gunn 1979) will be adequate for moose.

Past observations of the reactions of moose to disturbances have underestimated overt responses and failed to measure energetic costs. The effects of disturbance caused by construction projects on moose population dynamics is unknown.

Increased accidental mortality may occur because of increased traffic and because moose are attracted to transportation corridors by forage or by the ease of travel on roads when snow is deep in surrounding areas.

Recommendations

The following studies are designed to meet the three primary objectives identified in the Introduction. To provide more precise baseline data on moose seasonal distribution and movements, radio-telemetry studies are necessary. Studies should be conducted in three areas: on the Arctic Slope, between Atigun Pass and the Yukon River, and between Delta Junction and the Alaska/Yukon border. These studies will supply: (1) unbiased data on habitat use, (2) accurate data on location and timing of movements and use of winter concentration areas (dependant upon frequent relocations and the collaring of an adequate sample of all population segments), (3) information on the response of moose to NWA activities and facilities, and (4) the potential for comparing the effects of the NWA alone (Delta Junction to Alaska/Yukon border) to the combined effects of the NWA and TAPS (Atigun Pass to Yukon River). To better separate the effects of these two projects, LGL recommends an additional radio-telemetry study in the Paxson to Glennallen region (the study area of Van Ballenberghe 1978), where only TAPS is present.

The habitat-preference study, using the pellet-group technique, proposed by LGL in spring 1980, would be redundant if adequate radio-telemetry studies are conducted. Therefore, when radio-telemetry studies begin we will discontinue the recommended pellet-group studies. But study of the activities of moose proposed in spring 1980 should continue.

Aerial surveys of the NWA pipeline corridor should be conducted in late fall and early winter to locate moose concentrations and crossing sites. Multivariate data will be collected on the ground at moose crossing attempts to identify which environmental factors are associated with successful and unsuccessful crossing attempts.

Detailed population censuses and productivity counts should be conducted annually in three areas (in the same regions suggested for radio-telemetry studies above). These censuses are necessary to monitor the long-term impacts assocated with the NWA project; and with data from the three areas (and from 'control' areas routinely surveyed by ADF&G), it may be possible to isolate the impacts of the NWA project.

Recommendations for mitigative measures would be premature at this time. More precise baseline data must be gathered before making suggestions for scheduling or alignment changes. As contacts between moose and the NWA project are identified, studies will be designed to measure responses of moose and to provide methods for mitigating impacts.

Caribou

Contact

Caribou are widely distributed in Alaska (Skoog 1968; Hemming 1971; Davis 1979); approximately two-thirds of the state is suitable caribou habitat (Skoog 1968). Davis (1979) currently recognizes 25 separate herds (i.e., subpopulations; the caribou in Alaska and the adjacent Yukon Territory are considered a single population, following Skoog 1968) in Alaska. The ranges of 10 herds - the Central Arctic, Western Arctic, Porcupine, Ray Mountains, Fortymile, Delta, Macomb, Nelchina, Mentasta and Chisana - overlap or come near the NWA corridor (Davis 1979). Only the Central Arctic (Cameron and Whitten 1979a), Western Arctic (Skoog 1968; Hemming 1971; Davis and Valkenburg 1979), Porcupine (ADF&G 1974; Foothills Pipe Lines (Yukon) 1978) and Fortymile (ADF&G files in Tok) herds are likely to contact the corridor (Appendix 1). It is uncertain whether the range of the Ray Mountains Herd, with a population estimated at 200 caribou (Davis 1979), overlaps the NWA corridor between Prospect Creek Camp and the Yukon River. Scattered sightings of caribou of the Macomb Herd have been reported along the Alaska Highway in the area between the Johnson and Robertson rivers. Caribou from the Delta, Nelchina, Mentasta, and Chisana herds have not recently come in contact with the NWA corridor (ADF&G files in Fairbanks).

All seasonal ranges of the Central Arctic Herd overlap the NWA corridor, while only the edges of summer and/or winter ranges of the Western Arctic, Porcupine, and Fortymile herds overlap the corridor (Appendix 1). Contact with caribou from these herds will be limited to times when peripheral portions of their ranges are used or when interherd movements occur. Interherd movements are unpredictable, yet they may be of great importance to the Alaska/Yukon caribou population as a whole (Skoog 1968; Walters *et al.* 1978).

Impact

During recent large-scale exploitation of northern resources, particular attention has been given to the response of caribou to obstructions (Klein 1971, 1979b; Miller *et al.* 1972; McCourt *et al.* 1974), especially to above-ground pipelines (Appendix 2) (Child 1973; Child and Lent 1973; Cameron and Whitten 1976, 1977, 1978, 1979b; Roby 1978; Cameron *et al.* 1979; Hemming undated). Cameron and Whitten (1977) found that the TAPS corridor is avoided by caribou of the Central Arctic Herd, particularly cows with calves, in areas with buried pipe as well as those with above-ground pipe. Cameron and Whitten (1978) and Roby (1978) suggest that haul road traffic and pipeline construction activity are responsible for the avoidance of the TAPS corridor by caribou, but no impact on the productivity of the Central Arctic Herd has been observed (Cameron and Whitten 1978). In above-ground pipeline simulation studies, caribou and reindeer (also *Rangifer tarandus*) generally altered the direction of their movements to pass around the simulation or reversed directions (Child 1973; Child and Lent 1973). On two occasions, caribou were observed as they encountered 48-inch pipe lying on the ground; in both cases movements were deflected (Cameron and Whitten 1976, 1977).

Another primary concern has been the reaction of caribou to increased air traffic (Geist 1971c; Thomson 1972; Klein 1973; McCourt and Horstmas 1974; McCourt *et al.* 1974; Calef *et al.* 1976; Surrendi and DeBock 1976; Davis and Valkenburg 1979; Miller and Gunn 1979). Only one observation (Hoffman 1975) suggests that migrations may be altered in response to air traffic. Adequate information on the overt reactions to single overflights by small aircraft are available, but knowledge of the impacts of disturbance by aircraft on caribou physiology, energetics and population dynamics is lacking (Geist 1975).

The behavioral responses of caribou to disturbances caused by site-preparation and construction activities are poorly documented. In contrast, the reaction of caribou to humans has frequently been described

(Lent 1964; Kelsall 1968; Thomson 1972; Bergerud 1974; Tracy 1977; Roby 1978), and many references relate the response of caribou to highway vehicles (Klein 1971; Bergerud 1974; Villmo 1975; Surrendi and DeBock 1976; Johnson and Todd 1977; Tracy 1977; Roby 1978). The responses of caribou to humans and vehicles are quite variable but certain aspects have been repeatedly noted. Cows, especially cows with young calves, are more wary than bulls. Caribou appear to be most sensitive during calving and least responsive to human disturbance during the mid-summer insect harassment season. Large aggregations of caribou are frequently less responsive to disturbances than small groups, probably because stimuli from outside the aggregation affects only a small proportion of the total aggregation and because the motion and noise produced by caribou within the aggregation dampens the impact of exogenous stimuli. Motor vehicles may be tolerated at a distance but heavy traffic can block movements across roads.

Specific studies were undertaken to determine the reactions of caribou to simulations of noises produced by a gasline compressor station (McCourt *et al.* 1974). Caribou avoided the immediate area around the noise simulator, but migrations were not blocked or deflected nor were local movements visibly altered. The studies failed to test the response of caribou to the combined stimuli (including visual and olfactory stimuli in addition to sound) which a real compressor station produces. Caribou are generally more sensitive to visual stimuli in conjunction with sounds or smells (Ericson 1972; Bergerud 1974; Tracy 1977; Roby 1978).

The effects of roads and clearings upon caribou movements are reviewed by Klein (1979b). Caribou apparently avoid high berms; they cross roads more frequently where berms do not restrict their vision (Surrendi and DeBock 1976; Cameron and Whitten 1978). Clearings or packed trails may influence local movements (Klein 1971), but it is unclear whether migrations are deflected (Miller *et al.* 1972; Banfield 1974; McCourt *et al.* 1974).

Summary and Conclusions

Haul road traffic and construction activities have apparently resulted in the avoidance of the TAPS corridor by caribou of the Central Arctic Herd on the Arctic Slope. Knowledge of crossing locations and areas of concentrated seasonal use have not yet been adequately documented in this region so that the effects of the NWA project can be avoided or minimized.

The response of caribou to ground traffic and construction activities in forested regions is not as well known as in tundra. The locations of caribou crossings and seasonal use areas along the NWA corridor south of the Brooks Range are not adequately known. Additional studies are needed to assure that the impacts associated with the NWA are minimized.

Sufficient effort has been expended on recording the behavioral reactions of caribou to single overflights by small aircraft. Information is lacking on the response of caribou to multiple flights and heavy aircraft, and on the physiological and energetic costs of disturbance by air traffic.

The behavioral responses of caribou to many NWA activities and facilities are poorly documented or unknown. The long-term impacts of construction projects and pipeline operation on caribou population dynamics are unknown.

Recommendations

The following studies are designed to satisfy the three primary objectives identified in the Introduction. LGL recommends that the Alaska Department of Fish and Game's on-going study of caribou range occupancy, seasonal movements, crossings, and population dynamics be continued on the Arctic Slope. In the region between TAPS Pump Station 4 and the Yukon River, a radio-telemetry study is recommended to determine the herd identity of caribou using this region, the timing and location of movements and seasonal range use, and to gather information on the response of caribou to the NWA project in a forested region. A similar radio-telemetry study is suggested in the section between Cathedral Rapids and the Alaska/Yukon border where caribou of the Fortymile Herd frequently winter. An additional radio-telemetry study of the Nelchina Herd in the area between Paxson and Glennallen is suggested because it would provide data on the response of caribou to TAPS alone for comparison with information gathered between TAPS Pump Station 4 and the Yukon River (TAPS and NWA), and Cathedral Rapids and the Alaska/Yukon border (NWA alone).

Periodic aerial surveys between TAPS Pump Station 4 and the Yukon River should be conducted when snow is on the ground to gather additional data on the distribution of caribou and crossing attempts. Aerial surveys of areas likely to be used by caribou of the Fortymile Herd between Cathedral Rapids and the Alaska/Yukon border will be conducted to monitor use of areas adjacent to the NWA corridor and to locate crossing attempts. Crossings of the corridor by caribou from the Macomb Herd will be monitored while flying or driving in the area between the Johnson and Robertson rivers. On-ground study of crossing attempts will provide data to evaluate which environmental variables are associated with successful and unsuccessful crossing attempts.

The long-term effects of the NWA project on caribou herds will be difficult to quantify. LGL recommends that censuses by the ADF&G on the Arctic Slope be continued to monitor the influences of development (NWA and TAPS) on the Central Arctic Herd. The Western Arctic, Porcupine, Macomb and Fortymile herds will only contact the pipeline at the periphery of their ranges or during interherd movements. Relating impacts of the NWA project to population changes in these herds will be difficult and at present no studies are suggested.

As contacts between caribou and the NWA project are identified, studies will be designed to measure the reactions of caribou and to provide methods for mitigating impacts. Recommendations for mitigative methods would be premature at this time.

Furbearers

Contact

Furbearers (i.e., mammals whose skins are commercially valuable) are distributed along the entire length of the NWA corridor (Appendix 1). The ranges of the carnivorous furbearers, lynx (*Felis lynx*), wolverine, marten (*Martes americana*), river otter (*Lutra canadensis*), mink (*Mustela vison*), ermine (*M. erminea*), and least weasel (*M. nivalis*) extends from the arctic coast south. Aquatic furbearers, muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) are found south of the Brooks Range. Although these species are wide-spread throughout Alaska, and are important for subsistence income and sport trapping, almost no quantitative data are available concerning key areas.

An attempt was made to identify key areas along the NWA corridor from ADF&G 'sealing documents' but only locations of captures were recorded. No estimate of trapping effort was included so that it was impossible to determine a capture rate or any other index to population density. Because the locations of captures in the 'sealing documents' were described so imprecisely, it was not even possible to identify important trapping areas along the NWA corridor.

Impact

There have been essentially no studies performed that quantified impact of development on furbearing mammals in northern environments (Appendix 2). However, during studies conducted for the Canadian Arctic Gas Pipeline, several furbearer studies were performed that identified potential problems. Studies of furbearers related to development in more southerly areas have also identified potential problems. A major concern for muskrat, beaver, river otter, and mink is associated with water level fluctuations caused by pipeline construction (Ruttan 1974; Wooley 1974a; Searing 1979). Concern for terrestrial furbearers is associated with habitat modification and increased trapper access. Habitat modification can make the habitat unsuitable for a given species directly (Soutiere 1979) or by modifying prey species composition and density (Wooley 1974b, 1974c). All species of furbearers may be affected by increased trapper access (Klein 1972; Ruttan and Wooley 1974). None of these impacts has been measured in northern areas so they remain essentially speculation at this time.

To summarize, the distributional data for furbearing mammals are such that key areas cannot be located and therefore cannot be avoided by pipeline structures and activities. Impacts, though postulated, have not been measured in a way that provides the information required to predict, avoid, or mitigate pipeline-related impacts on these species.

Recommendations

Obviously, providing all the predictive ecological data concerning furbearers is beyond the responsibility of Northwest Alaskan Pipeline Company, but there are several steps that seem appropriate. The following projects are recommended:

1. A literature-based impact assessment of pipeline and related structures and activities on furbearers. Primary emphasis should be placed on beaver and muskrat but the assessment should include terrestrial furbearers as well. The objectives of this assessment would be to clarify problems, determine possible field programs, and suggest mitigative actions.

2. Aerial surveys to locate concentrations of beaver and muskrats. These would constitute compliance with Department of the Interior stipulation 2.5.5.1 (avoidance of key wildlife areas). Key areas would be beaver lodges and muskrat feeding platforms. Emphasis of this survey would be to provide input so that material sites would be placed with minimum impact on these species. Beaver lodges would be located by surveying in the fall and muskrat feeding platforms in the spring.

3. A monitoring study to measure the impact of the Alyeska pipeline and related structures and to monitor the effects of the NWA on selected terrestrial furbearers. This would be more of a "systems" approach and would include measurements of disruption to the abiotic environment and the resultant impact to vegetation, prey species, and direct and indirect disturbance to the furbearers themselves. The determinations of Alyeska-related impacts would provide immediately-useful information that Northwest could use to avoid or mitigate impacts, and the monitoring of NWA structures and activities would provide an evaluation of the effectiveness of the mitigative actions and suggest steps to be taken if mitigation is unsuccessful.

Small Mammals

Contact

Small mammals are distributed along the entire length of the NWA corridor (Appendix 1) (Hall and Kelson 1959). Depending on the location and habitat, these may be shrews, bats, mice, voles, lemmings, squirrels, marmots, or hares. Although the distributions of these animals have been described, very little is known about the actual densities and habitat affinities of these animals along the corridor. The only specific data on densities and habitat affinities along the NWA corridor were collected by Brink (1978) on small mammals along the oil pipeline. Her data were collected during only one part of one season and are comprised of very small sample sizes. Data for densities and habitat affinities are available for other species in areas away from the pipeline, but because small mammal populations are extremely variable both spatially and temporally (Krebs and Meyers 1974), extrapolating to any given area along the NWA pipeline could be misleading.

Impact

Some effects of pipelines on small mammals have been described for species living north of the Brooks Range (Appendix 2). Populations of rodents were adversely affected by habitat modification resulting from modified drainage patterns, early snow melt, dust, revegetation operations (Brink 1978) and increased predation (Jansen and Eberhardt 1975). For areas south of the Brooks Range, no studies have been performed. In Canada, however, two studies were conducted on linear clearings in the boreal forest (seismic cut lines and winter roads). Linear clearings in the forest modified the species composition of the small mammal community (Bodner and Wooley 1974; Douglass 1977), lowered overall densities, modified the time periods during which animals were active (Douglass 1977), and limited home ranges of individuals of all species (Douglass 1976). In all of these studies the observed effects were related to habitat modifications similar to those that will be created by the NWA pipeline.

To summarize, data suggest that the NWA pipeline will affect small mammals in several ways through habitat modification, but the degree and extent of effects are unknown.

Recommendations

Although small mammals usually are not considered directly important to man, they do form integral components of ecosystems by providing food to predators, by modifying vegetation and soil, and by affecting nutrient cycling. Small mammals should be considered for inclusion in studies of other species of mammals and birds.

Small mammals, especially rodents, are primary prey items for almost every Alaskan carnivorous mammal, including ermine (Maher 1967), least weasels (MacLean *et al.* 1974), mink (Wilson 1954), wolverines (Macpherson 1969; Rausch and Pearson 1972), wolves (Mech 1970), red foxes (Carl 1971), arctic foxes (Rausch 1950; Chesemore 1968; Macpherson 1969), and grizzly bears (Carl 1971). Many raptorial birds, including golden eagles (*Aquila chrysaetos*) (Carl 1971) and rough-legged hawks (*Buteo lagopus*) (Swartz *et al.* 1975), prey on rodents. Snowy owls (*Nyctea scandiaca*), short-eared owls (*Asio flammeus*), and pomarine jaegers (*Stercorarius pomarinus*) are obligate microtine rodent predators (Pitelka *et al.* 1955; Batzli *et al.* 1975).

Small mammals can also have significant impacts on the plant communities in which they reside by modifying the plant species composition (Summerhayes 1941; Mueggler 1967; Batzli and Pitelka 1970; Frischknecht and Baker 1972), by reducing vegetative cover (Thompson 1955), and by significantly modifying soil building processes (Batzli *et al.* 1975).

In some parts of arctic ecosystems, rodents perform much of the nutrient cycling. Because of this, Batzli (1975) considered brown lemmings (*Lemmus sibiricus*) to be the most important vertebrate component of arctic ecosystems.

Because of the importance of small mammals in ecosystem function, it is recommended that small mammal studies be incorporated into studies of other mammals (especially carnivores) and vegetation. Specifically, small mammal studies should be included in the monitoring studies described earlier for furbearers.

Black and Grizzly Bears

Contact

Black bears and/or grizzly bears will come into contact with NWA pipeline activities along the entire route. Concentrations of black bears will be encountered from the Alaska/Yukon border north to approximately Wiseman. The northern limit of their distribution is approximately the Chandalar Shelf (Hemming and Morehouse 1976). Many black bear problems have occurred at both Alyeska's Five Mile Camp and Alaska Department of Transportation's Seven Mile Camp (Glaspell 1980 pers. comm.).

Grizzly bear range extends from the Alaska/Yukon border to the arctic coast (Alaska Department of Fish and Game 1974). South of Old Man Camp, grizzlies are more commonly found in upland habitats but coexist with black bears in other habitats (Kellyhouse 1980 pers. comm.). Major grizzly bear problems were experienced at camps north of Five Mile, particularly at Chandalar (Glaspell 1980 pers. comm.). Because of their overlapping ranges and similar niches the impacts on both grizzly and black bears will be discussed together and differences mentioned only when they are significant.

Impact

Activities associated with human development will affect bears inhabiting the area traversed by the pipeline (Appendix II). Although it is possible to speculate about some of the impacts of human activity and even to document others (Cowan 1972; Elgmork 1976, 1978), no quantitative work to assess the short-term or long-term effects of such impacts has been done. Although a rather large body of information on impacts exists, much of it is anecdotal and inconclusive and the effects of disturbance and harassment on bears are still poorly understood.

The reactions of bears to aircraft have been recorded in several studies (Quimby 1974; Ruttan 1974c; Harding 1976). Bears are reported as one of the more sensitive large mammals to aircraft disturbance (Klein 1974, Mc Court *et al.* 1974); however there is much individual variation in their reactions probably related in part to previous experience (Linderman 1974; Pearson 1975; Harding and Nagy 1977). Bears seem to react more strongly to helicopters than to fixed wing aircraft (Quimby 1974; Harding and Nagy 1977) and have abandoned dens due to helicopter disturbance (Reynolds *et al.* 1974).

Much variation in the reactions of bears to roads and the accompanying human activity has been noted (Tracy 1977). There is evidence that some grizzly bears may avoid the vicinity of roads (Elgmork 1976; Singer 1976; Tracy 1977) while others may habituate to, or even frequent roadsides (Tracy 1977; JFWAT files). In general, black bears habituate to developed areas more readily than grizzly bears (Barnes and Bray 1967; Singer 1976). Tracy (1977) studied the reactions of grizzy bears to human activity along the Mt. McKinley Park road, but circumstances in the park are not necessarily comparable to non-park situations and her data were inconclusive.

The mechanical and sensory effects of preconstruciton, construction and operational activities and facilities on bear movement, habitat use and behavior is unknown. However, large sections of pipe left on the ground or long open trenches could present barriers to movement. Bears not habituated to human activity are more likely to be disturbed by the presence of noise, traffic, and other human activity. This disturbance may cause stress and elicit avoidance behavior (Elgmork 1976, 1978; Tracy 1977). It is not known to what extent the oil pipeline project affected the avoidance or habituation behavior of bears contacting the pipeline corridor, or how great this effect was on the bear population. Specific information to assess the impacts of any of the NWA activities is unavailable.

One of the most serious problems encountered during TAPS construction resulted from the attraction of bears to areas of human activity. Bears quickly discover and utilize improperly handled food and garbage at camps, worksites or dumps (Barnes and Bray 1967; Craighead and Craighead 1972c; Meagher and Phillips 1980). Also, if bears are fed directly they soon lose their fear of humans and become incorrigible panhandlers (Eager and Pelton 1980). Having lost their fear of man they become even more dangerous (Craighead and Craighead 1972c; Mundy and Flook 1972; Herrero 1976). Once bears learn to seek food from human sources they apparently can retain this knowledge for periods up to 10 years (M. Meagher 1980 pers. comm.).

The most direct result of the juxtaposition of bears and humans is increased mortality of bears (Craighead and Craighead 1972c). Sources of this mortality include killing in 'defense of life and property' (Buchholtz 1977), control kills of nuisance animals by appointed agency or project personnel (Cole 1971), accidental deaths of bears during attempts to frighten or trap and transplant animals (McCaffrey *et al.* 1976), and increased hunting and poaching pressure resulting from improved access and higher numbers of people (Nagy and Russell 1968; Rogers *et al.* 1976; JFWAT files). In addition, road kills of bears can increase where bears are attracted to food sources along roads. Use of roadside areas by bears is often combined with poor driver visibility from dust, increasing the rate at which bears are struck and wounded or killed (JFWAT files). Accidental deaths of bears from blasting or destruction of dens, while less likely, still occur (JFWAT files). Human activities related to the TAPS project have resulted in a minimum of 11 grizzly and 30 black bear deaths (JFWAT files). The effects of bears concentrating at artificial sources of food such as dumps are not clearly understood. However, there is some evidence that higher cub mortality from predation by adults, and higher disease and parasite loads may result when bears are concentrated (Cole 1971).

Bears have some of the lowest reproductive rates of any land mammal in North America (Jonkel and Cowan 1971; Bunnell and Tait 1978). This, coupled with the large home range sizes and low densities of grizzly bears in most parts of their range, makes them vulnerable to sustained high levels of mortality (Craighead *et al.* 1974). Black bears with higher natality rates and densities are not as sensitive to similar mortality rates (Bunnell and Tait 1978).

In addition to the direct effects on bears, the NWA project may affect important prey species. Activities that affect the availability (density, distribution and vulnerability) of prey species such as moose, caribou, ground squirrels (*Spermophilus paryii*) and salmon will also affect the predators (including bears) that feed upon them.

Bears spend approximately six months (mid-October to mid-April) in dens. Destruction of dens or disturbance of bears in dens can have serious consequences (Harding and Nagy 1977). Abandonment of dens by bears can result from human activity near the den (Craighead and Craighead 1972a, 1972b; Harding 1976) or from disturbance caused by helicopters (Reynolds *et al.* 1974). Some denning studies of grizzly bears have been conducted on the North Slope (Reynolds *et al.* 1974) but nothing is known of bear den requirements in the interior of the state. Studies in some areas have shown that certain 'denning areas' are important (Pearson 1968). Well-drained, coarse soils in non-permafrost areas tend to be preferred sites for grizzly dens (Reynolds *et al.* 1974). These are also important areas for certain human structures such as borrow pits (Harding and Nagy 1977). Black bears in southern areas den in thick brush or in hollow logs and trees (Jonkel and Cowan 1971; Beecham *et al.* 1980). If this is also true along the NWA pipeline corridor it should be considered when clearing or slash disposal is contemplated. Human activity can also create artificial denning situations; bears have denned under buildings and culverts (Barnes and Bray 1966, 1967).

Whether other critical habitats besides denning areas exist for bears is not known. Bear studies elsewhere have shown the importance of localized habitat such as early spring feeding areas or mating areas (Hamer *et al.* 1979). In the Brooks Range and North Slope, grizzle bears concentrate in the spring (and to an extent in the fall) in river valleys - 68 percent of the bears observed in the spring by Curatolo and Moore (1975) were in river bar willow patches. These bears may be more vulnerable to harassment and hunting at these times (Curatolo and Moore 1975). Pamplin (1979) states that future demands for large quantities of gravel for other construction projects "can be expected to cause significant widespread damages to terrestrial wildlife habitats which are part of major river flood plains, particularly in arctic regions." Little is known about the ecological requirements of bears in the Interior.

In addition to the effects of human activity on bears, the problem of bear impacts on human activity must also be considered. These effects fall into the categories of safety, health, and economics.

Bears are powerful and unpredictable. When they feel threatened, they may attack, mauling or killing unsuspecting victims (Herrero 1970). Though fatal attacks are uncommon, they do occur, especially when human/bear contacts are increased due to the availability of artificial food sources and the presence of habituated bears (Craighead and Craighead 1972c; Hamer 1974; Herrero 1976). Females with young, very old bears, and habituated bears pose the most serious threats (McArthur 1979). Besides serious maulings, minor injuries such as bites and scratches frequently result from attempts to feed bears (Eager and Pelton 1980).

Bears are less likely to carry diseases transmissible to man than some of the other carnivores. However, bears do carry a number of parasites transmissible to man (Mundy and Flook 1972; Rogers and Rogers 1976). One of these, trichinosis, may cause aggressive behavior in bears leading to human attacks (Worley *et al.* 1980).

Economic impacts can be expected to occur when human activity occurs in areas frequented by bears. Property damage may occur in the form of damage to buildings, trailers, vehicles, and stored food (Bee and Hall 1956; Macpherson 1965; JFWAT files). During TAPS construction, for example, a grizzly popped windshields out of pickup trucks to obtain sack lunches left inside (JFWAT files). Work stoppages or slowdowns due to grizzly bear activity at the work sites also occurred during TAPS construction (Reynolds 1980 pers. comm.). Considerable expenses were incurred while crews sat idle as grizzly bears ransacked work sites in search of food.

Human activity in bear habitat poses important problems for both people and bears. Extremely serious bear/human conflicts occurred during the TAPS project (JFWAT files). However, almost all available information on bear/human problems does little more than document that they exist and are cause for concern. No studies provide the information necessary to assess the nature and extent of these impacts, and little information on the ecological requirements of Interior bears is available.

Wolves

Contact

Wolves are found along the entire NWA pipeline corridor from the Arctic Slope to the Alaska/Yukon border (Alaska Department of Fish and Game 1974). The ADF&G has fairly good information on wolves on the north slope along the pipeline corridor (Cameron 1980 pers. comm.) and also in portions of Game Management Unit 20. From the crest of the Brooks Range south to the Yukon River and from Delta Junction east to the Alaska/Yukon border relatively little information on wolves is available (Stephenson 1980 pers. comm.).

Impact

Various activities associated with the NWA project could potentially affect wolves (Appendix II). The main impacts of man and his activities on wolves fall into three general categories: direct effects on wolves, impacts on the prey populations, and impacts on critical habitat.

Man affects individual wolves and their populations in several ways. Disturbance and harassment are two forms of impact. Disturbances can result from nothing more than increased activity, such as construction or vehicular and air traffic. Any of these can elicit avoidance behavior (Carbyn 1974; Geist 1975), but wolves are capable of rapidly habituating to various forms of disturbances (Rausch 1967; Clark 1971; Grace 1976; Tracy 1977). Once habituated they may become attracted to and become nuisances in areas where humans are present (JFWAT files).

The reaction of wolves to aircraft is extremely variable - from fleeing in panic (Schweinsburg 1974) to ignoring the aircraft's presence (Mech 1966). Klein (1974) states that wolves appeared least disturbed of any of the large mammals. Wolves formerly subjected to aerial hunting will habituate to aircraft if the hunting and harassment ceases (Chapman 1977). However, certain individual animals may continue to exhibit strong reactions even after the other pack members have habituated (James 1980 pers. comm.).

Active harassment (e.g., making repeated low passes at wolves in order to better view or photograph them) causes more serious problems. There is evidence that aircraft flying at less than 100m will even frighten habituated wolves (Peterson 1974; Chapman 1977). Chasing wolves with vehicles or snow machines and throwing rocks also fall into the category of harassment. Harassment stresses even the habituated animals and can be especially serious at critical periods in the animals' lives (Geist 1975).

Inadequately stored food and improperly disposed of garbage can lure wolves into camps, worksites or dumps (Murie 1944; Van Ballenberghe *et al.* 1975; Grace 1976; Chapman 1977). Direct feeding of wolves by project personnel, discarding lunch sacks around the work sites, and littering also attract wolves (Geist 1975; Milke 1977). Artificial food supplies may result in less healthy and less efficient predators (Grace 1976; Milke 1977) or may maintain the wolf populations at an artificially high level to the detriment of prey species (Grace 1976).

Wolves used to seeking food (handouts, prey or carrion) along roads are prone to being hit by vehicles (Van Ballenberghe *et al.* 1975). Habituated wolves also cause injuries to humans, resulting in increased wolf mortality due to control of offending animals (Milke 1977; JFWAT files).

Wolves that have lost their fear of man become more susceptible to hunting and poaching pressure. The North Slope wolf population along the area traversed by the TAPS pipeline was reduced in the winter of 1977/1978 from 35 to 40 animals to only 3 or 4 by aerial trapping and poaching along the road (Cameron 1980 pers. comm.).

Indirect impacts on wolves that could have serious consequences include potential effects on major prey species. Careful attention must be paid to actions that will alter prey availability. Major prey species of the wolf in arctic and interior Alaska include caribou, moose, sheep and perhaps beaver (James 1980 pers. comm.). Impacts that change density, distribution or vulnerability of these prey will affect wolves (Chapman 1977).

Wolves have been observed hunting caribou along the road and even apparently using the road to stalk them (Murie 1944; Chapman 1977; Roby 1978). Road kills also provide an additional source of carrion for wolves (Van Ballenberghe *et al.* 1975).

The last major category of potential impacts on wolves is disturbance of critical habitat or critical sites. In general, if the habitat supports a prey population and man-caused mortality is not excessive the wolves should do well. There is, however, also a potential for human activity to affect wolves at critical sites such as den sites. Chapman (1977) reviews how disturbances may affect denning wolves. A wide range of responses of wolves at den sites ranging from a successful rearing of pups within a mile of Pump Station 4 (Whitten 1980 pers. comm.) to pups being abandoned for 118 hours after human disturbance (Chapman 1977) have been documented. Carbyn (1974) reports four instances of wolves moving den sites due to human disturbances. Murie (1944) actually crawled into a den and took one of the pups yet the wolves did not move. Stephenson (1974) states that prolonged human presence at distances less than two miles, or more than one visit to the den itself would be necessary to cause the wolves to move. Previous contacts the wolves have had with humans also are important. The responses of wolves to disturbances are extremely variable; even though wolves may abandon a den site, pup mortality has never been reported as a result of human disturbance and is unlikely to occur (Chapman 1976, 1977).

Another critical habitat for wolves might be winter travel routes, such as frozen rivers and lakes, barren ridges, roads and even highways (Mech 1970). The importance of these travel routes, or the impacts of disturbance on them, is not well documented; however, Peterson (1974) noted a decreased use of summer trails by wolves on Isle Royale after tourists began to use them.

Wolves that occupy areas traversed by the pipeline can cause a number of impacts on man and his activity. Human injuries result most often from the presence of habituated wolves in areas of human activity. While most instances of injuries during TAPS construction (JFWAT files) involved minor injuries (some bites not even breaking the skin), the potential for an animal as large and powerful as a wolf to inflict serious injuries on people is real (Milke 1977). However, there are no documented cases of fatal attacks on people by non-rabid wolves in North America (Mech 1970).

A number of zoonotic diseases are found in wolves. Increased numbers of wolf/human contacts could result in increased spread of disease. Although the wolf is not the primary vector species, rabies does occur in Alaskan wolves and the potential for transmission to man exists (Rausch 1972; Chapman 1978). Wolves also harbor brucellosis but the wolf's role as a reservoir and the significance of this disease is unknown (Rausch 1972).

Wolves (as well as coyotes and dogs) are definitive hosts of the parasitic tapeworm *Echinococcus granulosus*. Foxes (coyotes and dogs) are the definitive hosts of *Echinococcus multilocularis* (Leiby and Dyer 1971). Both tapeworms cause types of hydatid disease which poses 'a serious threat to human health wherever there is contact between man and infected carnivores' (Rausch 1952). Eggs of *Echinococcus* are passed in canid feces. Increased wolf/human contacts resulting from animals scavenging along the corridor could become an important source of human infection (Milke 1977).

Although some information gaps exist with regard to impact effects on wolf populations and individuals, at this time it is considered unnecessary to conduct impact related studies on wolves along the NWA pipeline corridor.

Coyotes

Contact

Coyotes may be distributed along the entire NWA corridor (Dufresne 1942; Bee and Hall 1956), but quantitative data concerning abundance and distribution are virtually non-existent. North of the Yukon River, coyotes are not abundant, and even south of the Yukon River where coyotes regularly occur, their numbers probably are not very high.

Impact

Coyotes are probably susceptible to the same types of impacts as the other canids (Appendix II). They are drawn into areas where carrion or garbage is available (Murie 1940; Ozoga 1963). Coyotes will habituate to the presence of humans and will frequent areas where they receive handouts, thus posing a potential hazard to people (Cornell and Cornely 1979). Frequently-fed coyotes may bite humans when frustrated in their attempts to obtain food (Murie 1940). It may become necessary to destroy these habituated coyotes.

Coyotes that do not lose their fear of humans may become extremely wary of certain human activities but still exploit the vicinity (Ozoga 1963). Studies have shown that even the presence of human tracks can cause such coyotes to alter their direction of travel or avoid a deer carcass (Ozoga 1963), yet they still successfully live with man (Gier 1975).

Increased impact-related mortality from road kills, control kills and poaching should not have a significant long-term effect on the population. Coyote populations have high turnover rates and good compensatory mechanisms which reduce the impacts of man-caused mortality (Connolly and Longhurst 1975). They are also extremely adaptable and adjust rapidly to changing conditions (Robinson and Grand 1958). It has been hypothesized that human activity might shift the competitive advantage of coyotes over foxes but the available data are inconclusive (Gier 1975; Murie 1944).

Very little is known about coyotes in Alaska or the impacts of disturbances on coyotes. Most previous research on coyotes has addressed the problem of coyote control. The intelligence, adaptability and high reproductive potential of the coyote will probably allow them to overcome serious negative impacts.

Coyotes are probably not very numerous along the corridor. In addition, they are probably able to cope with changes likely to result from NWA project activity. Approaches toward minimizing impacts on the red fox (see following section) should also be at least somewhat effective in protecting coyotes. Therefore, the ecological and impact-related data gaps on coyotes need not be addressed in a specific program.

Red Fox

Contact

The red fox is distributed along the entire NWA pipeline route (Dufresne 1942; Bee and Hall 1956), has high economic value for subsistence and recreational trappers (in some areas they are probably the mainstay for the trappers) (Larson 1980 pers. comm.), and is probably the most numerous canid along the corridor.

Impact

Little useful information on the effects of disturbance on the red fox exists (Appendix II). Tracy (1977) studied the red fox in relation to roads in Mt. McKinley National Park, and Allison (1971) studied fox behavior in the same location. However, data collected in a national park may not provide accurate predictions of the effects of NWA. A study of arctic and red foxes conducted on the North Slope (Eberhardt 1977) is useful for assessing the potential effects of the project on red foxes living north of the Brooks Range.

The three main areas of concern are the direct impacts on foxes, their food supply, and their habitat. Although red foxes are adaptable and capable of habituating to some kinds of disturbances, they are sensitive to others and their responses are variable. Eberhardt (1977) documented desertion of dens due to human disturbance but Allison (1971) and Tracy (1977) did not observe desertion of dens which were subjected to disturbances, or avoidance of the road by foxes. Other effects of disturbance on red foxes have not been documented.

Red foxes are sensitive to changes in food availability. Activities that adversely affect their major prey species will probably have negative impacts on the fox population (Englund 1970). However, red foxes are readily attracted to sources of unnatural food, such as garbage, litter and handouts (Milke 1977). Such unnatural food may maintain fox populations at abnormally high levels.

The effects of human activity on foxes need to be investigated. Acute fox problems were documented during the TAPS construction (Milke 1977) but no attempts were made to quantify the problem. However, the frequent association with humans and dependence on unnatural foods by foxes resulted in increased fox mortality, injuries and disease exposure for workers, and property damage (JFWAT files).

It has also been demonstrated that destruction of dens occurred as a result of human activities (Eberhardt 1977). The alteration of critical habitats, and the effects of human activity on habitat use has not been addressed for the Interior red fox population.

Arctic Fox

Contact

Arctic foxes are widely distributed on the North Slope. They are most commonly encountered on the coastal plain and range south into the Brooks Range (Bee and Hall 1956). Occasionally they are found south of the Brooks Range in the northern interior.

Impact

Arctic foxes are very mobile, opportunistic feeders with a high reproductive potential (Macpherson 1969; Chesemore 1975; Hanson and

Eberhardt 1978). Their realized productivity is directly related to microtine rodent abundance (Chesemore 1967; Macpherson 1969; Speller 1972). Arctic fox populations are able to recover from population crashes if the food supply is adequate (Macpherson 1969). Therefore, the population should be able to compensate for some increased mortality resulting from human activity, such as road kills, illegal kills, and trapper take (Eberhardt 1977; Hanson and Eberhardt 1978). Anecdotal observations on the reactions of arctic foxes to aircraft are inconclusive (Ruttan 1974).

Very significant impacts may be expected from changing food availability (Ruttan 1974). It is not known whether NWA activities would affect rodent populations severely enough to adversely affect foxes. Immediate problems would stem from developments that artificially increase the food supply (Eberhardt 1977; Brink 1978). Garbage, litter and handouts can maintain the fox population at a high density even as a natural prey abundance declines (Brink 1978; Hanson and Eberhardt 1978). Foxes quickly habituate to artificial food supplies even to the point of moving their pups into camps (Eberhardt 1977). This unnaturally high population of foxes in frequent contact with man represents a dangerous situation. There is a significant potential for transmission of diseases such as echinococcosis (Mike 1977) and rabies (Speller 1972). The propensity for arctic foxes to move hundreds of kilometers (Eberhardt and Hanson 1978) increases the potential to spread diseases over a large area.

In addition to transmitting disease, arctic foxes can cause economic losses through property damage (Brooks *et al.* 1971). Arctic foxes can chew through telephone wires and cables (Weeden and Klein 1971). Urquhart (1973) describes problems caused when arctic foxes 'removed the geophones from the cables and buried them after marking them with urine'.

Den sites are particularly susceptible to impacts. In some areas, den sites for arctic foxes might be a limiting resource (Brooks *et al.* 1971; Wooley 1976). Some dens are hundreds of years old and in some cases may be used traditionally (Macpherson 1969). Arctic foxes may abandon den sites when disturbed by humans (Eberhardt 1977) but there have been numerous observations of foxes denning in spite of disturbance (Ruttan 1974). Urquhart (1973) states that foxes may be most susceptible to harassment when natural food sources are low and that any type of disturbance that restricts hunting activity could lead to den abandonment. Destruction of den sites during construction activity (Ruttan 1974; Eberhardt 1977) can be a serious problem and, therefore, should be avoided. Certain features of camps and material sites can provide foxes with artificial den sites and cover. A pile of stored culverts, a pile of hay and a lumber pile have been used by arctic foxes as temporary den sites (Quimby and Snarski 1974; Eberhardt 1977). Foxes also used unskirted areas under buildings (Eberhardt 1977). This additional source of human/fox contact can affect both humans and foxes.

Some data gaps still exist but further work at this time seems unnecessary. The status and ecology of the arctic fox on the North Slope (Chesemore 1967; Burgess in prep.; Garrott in prep.) and the impacts of development on foxes (Eberhardt 1977; Hanson and Eberhardt 1978, 1979; Fine in prep.) have been examined by a number of researchers. These projects provide a fairly good framework of understanding for assessing the impacts of the NWA pipeline.

Dogs

Contact

Dogs (*Canis familiaris*) are the most widely distributed canid in Alaska, occurring almost everywhere people live and in some areas that people rarely visit (Gipson and Brainerd, in prep.). Free ranging domestic dogs are common around remote outposts, villages, and urban centers. Populations of feral dogs, living without direct dependence upon man, exist in at least 11 areas of Alaska according to a survey of biologists throughout the state conducted by Gipson and Brainerd. North of the Yukon River free ranging and/or feral dogs are uncommon adjacent to the route of the NWA pipeline, however, from Livengood to the Alaska/Yukon border, dogs are common and locally abundant, with wild populations occurring in some areas. Probably the highest concentration of feral and free ranging dogs occurs in the vicinity of Delta Junction where they have existed for at least 35 years. Gipson and co-workers presently have radio transmitters on 6 dogs in the area. These dogs forage and den between the Tanana River and the town of Delta Junction along the TAPS and the Haines military gas/pipeline routes.

Impact

Free ranging dogs are attracted to human activity and sources of food. There is likely to be frequent contact between workers and free ranging dogs at construction sites, camps and storage areas where dogs are attracted to food and garbage. Feral dogs behave much like coyotes or wolves, seeking supplemental food where possible, but generally remaining secretive unless a consistent source of garbage or food handouts is available. Many of the dogs that workers will contact will be potential sources of disease and injury. Wherever unconfined dogs concentrate they are likely to be a nuisance and pose a threat of damage to wild game and domestic livestock.

Ursids and Canids

Recommendations

The information gaps identified for ursids and canids in the previous section will limit the ability of NWA to design and plan the pipeline project with minimal effect on these animals. It will be necessary to obtain additional information to ensure their protection and the safety of pipeline workers. The NWA project stipulations provide additional rationale for these studies.

The recommended ursid and canid studies are as follows (these proposed projects are not ranked or prioritized):

1. Determine the status of zoonotic diseases in carnivores along the pipeline corridor. Ursids and canids have a high potential for being attracted to camps and construction areas. Because the probability for contact with pipeline workers is therefore increased, it is important to know the transmission potential for the various diseases associated with these species. A study should be developed to address this problem for carnivore species and other mammalian groups, as appropriate. This study should be developed in conjunction with other carnivore projects associated with the NWA mammal studies and in cooperation with other workers who may contact these animals (e.g., trappers and ADF&G personnel).

2. A review of information on methods to avoid and minimize contacts between humans and carnivores and on mitigation alternatives should be initiated immediately. This review will determine the state-of-the-art for the various deterrents used elsewhere for carnivores. Also, it will be instrumental in developing NWA plans to avoid and minimize human-carnivore encounters.

3. Seasonal surveys for bears, wolves, and red foxes should be conducted to aid in the identification of critical habitats, movements and concentration areas, critical phenological periods, and habitat use. These should be limited to the area south of the Brooks Range. Aerial surveys conducted during periods of snow cover would be most efficient. These should be supported by ground surveys including, perhaps, censusing

techniques that elicit vocal responses. Interviews with trappers, ADF&G, and the Department of Transportation (road kill data) would add additional information.

Surveys for red foxes and bears should include the entire route, whereas surveys for wolves should be concentrated in the area between the Brooks Range and the Yukon River and between Delta Junction and the Alaska/Yukon border. Specific studies should be conducted during each season through winter 1980-81. This effort will provide information for NWA's Environmental Master Guide.

4. A grizzly and black bear investigation should be initiated to determine habitat use, the presence of critical habitats, important phenological events, and movements. This project should be initiated before camps are constructed and/or refurbished, and continued through construction. This will aid in monitoring effects of the project on behavior, distribution, and movements. Information necessary to determine the effectiveness of the NWA provisions to avoid and minimize contact with bears will be obtained. Should the ADF&G human/bears-wolf mitigation study take place, the animals tagged for that project could be used for this additional work with little additional cost.

5. A red fox study should be conducted to determine habitat use, movements, and distribution in an interior Alaska area. The study should be initiated before construction begins and continue through the construction phase. This would allow determination of the project's effects on behavior, distribution, and movements. This study would also measure the effectiveness of various procedures used on the NWA project to avoid and minimize carnivore/human encounters. The red fox represents a good model for the canids and because of its relatively small home range compared to other canid species would be a good study animal.

6. The potential response of feral and free ranging dogs to the pipeline project should be considered for study. The potential for disease transmittal to workers on the project from dogs that frequent camps and construction sites requires that a plan developed for wild canids include this species. For efficiency, this study should be conducted near a community such as Delta Junction or Tok.

LITERATURE CITED

Alaska Department of Fish and Game. 1974. Alaska's wildlife and habitat. Vol. I. Anchorage, Alaska. 144 p.

Alaska Department of Fish and Game. 1978. Alaska's wildlife and habitat. Vol. II. Anchorage, Alaska.

Alaska Department of Fish and Game. Hunting regluations, No. 20. 73 p.

Alaska Department of Fish and Game. Files. Fairbanks, Alaska.

Alaska Department of Fish and Game. Files. Tok, Alaska.

Allison, L.M. 1971. Activity and behaviour of red foxes in central Alaska. M.S. thesis, Univ. Toronto, Ontario. 92 p.

Altmann, M. 1958. The flight distance in big game. Journal of Wildlife Management 22:207-209.

Andersen, R. 1971. Effect of human disturbance on Dall sheep. Alaska Cooperative Wildlife Research Unit Quarterly Rep. 23(3)23-27.

Banfield, A.W.F. 1974. The relationship of caribou migration behaviour to pipeline construction. In: V. Geist and F. Walther (eds.), The Behaviour of Ungulates and Its Relation to Management. IUCN Publ. New Series No. 24:797-804.

Barnes, V. and O. Bray. 1966. Black bears use drainage culverts for winter dens. Journal of Mammalogy 47:712-713.

Barnes, V. and O. Bray. 1967. Population characteristics and activities of black bears in Yellowstone National Park. Unpubl. final rep. to the National Park Service. 199 p.

Batzli, G.O. 1975. The role of small mammals in arctic ecosystems. In: F.B. Golley, K. Petrusewicz, and L. Ryzkowski (eds.), Small Mammals: Their Productivity and Population Dynamics. Cambridge Univ. Press, Cambridge, England. p. 243-268.

Batzli, G.O. and F.A. Pitelka. 1970. Influence of meadow mouse populations on California grassland. Ecology 51:1027-1039.

Bee, J.W. and E.R. Hall. 1956. Mammals of northern Alaska on the Arctic Slope. University of Kansas Museum of Natural History. Misc. Publ. No. 8. The Allen Press, Lawrence, Kansas. 309 p.

Beecham, J.J., D.G. Reynolds, and M.G. Hornocker. 1980 (in press). Denning ecology of the black bear in west-central Idaho. In: Fifth Internat. Conference on Bear Research and Management. Madison, Wisconsin.

Bellringer, E. 1974. Narrative surveillance report. November 12-25, 1974. JFWAT files. Anchorage. 4 p.

Bergerud, A.T. 1974. The role of the environment in the aggregation, movement, and disturbance behaviour of caribou. In: V. Geist and F. Walther (eds.), The Behaviour of Ungulates and Its Relation to Management. IUCN Publ. New Series No. 24:552-584.

Bliss, L.C. and E.B. Peterson. 1973. The ecological impact of northern petroleum development. In: Fifth Internat. Cong. Arctic Oil and Gas: Problems and Possibilities, LeHavre, France. p. 505-537.

Bodner, A. and D.R. Wooley. 1974. Population survey of small mammals. Chapter 1. In: R.D. Jakimchuk (ed.), Surveys of Mammals Along the Proposed Gas Pipeline in Alberta. Arctic Gas Biol. Rep. Ser., Vol. 25.

Brink, K.L. 1978. The effects of the Trans-Alaska Oil Pipeline on breeding bird and microtine rodent populations at Franklin Bluffs, Alaska. M.S. thesis, Univ. Montana, Missoula. 108 p.

Brooks, J.W., J.C. Bartonek, D.R. Klein, D.L. Spencer, and E.A. Thayer. 1971. Environmental influences of oil and gas development on the Arctic Slope and Beaufort Sea. Bur. Sports Fish and Wildl. USDI Res. Publ. 96. 24 p.

Buhholtz, M. 1977. Black bear survey - inventory progress report - 1975, Game Management Unit 20. In: R.A. Hinman (ed.), Annual report of survey - inventory activities Part II. Black bear, brown bear, polar bear, caribou. Fed. Aid in Wildl. Restor. Project W-17-8, Jobs No. 3, 4, 5, 17 and 22. ADFG, Juneau.

Bunnell, F.L. and D.E.N. Tait. 1978 (in press). Population dynamics of bears and their implications. International Conference on Population Dynamics of Large Mammals. Logan, Utah.

Burbank, D.C. and M. Sigman (compilers). 1979. Fish, wildlife, and habitat resources and the potential impacts of oil transportation: Alaska Highway (Delta Junction to Canadian Border). ADFG, Juneau.

Burgess, R. In prep. M.S. thesis, Univ. Alaska, Fairbanks.

Calef, G.W., E.A. DeBock, and G.M. Lortie. 1976. The reaction of barren-ground caribou to aircraft. Arctic 29:201-212.

Calef, G.W. and G.M. Lortie. 1973. Observations of the Porcupine caribou herd, 1972. Sect. 1., Appendix 1: Wildlife. In: Towards an Environmental Impact Assessment of the Portion of the MacKenzie Gas Pipeline from Alaska to Alberta. Environ. Protection Board, Interior Rep. No. 3.

Cameron, R. 1980. Personal communication. ADFG, Fairbanks.

Cameron, R.D. and K.R. Whitten. 1976. First interim report on the effects of the Trans-Alaska Pipeline on caribou movements. JFWAT, Spec. Rep. No. 2. 39 p.

Cameron, R.D. and K.R. Whitten. 1977. Second interim report on the effects of the Trans-Alaska Pipeline on caribou movements. JFWAT, Spec. Rep. No. 8. 11 p.

Cameron, R.D. and K.R. Whitten. 1978. Third interim report on the effects of the Trans-Alaska Pipeline on caribou movements. JFWAT, Spec. Rep. No. 22. 29 p.

Cameron, R.D. and K.R. Whitten. 1979a. Seasonal movements and sexual segregation of caribou determined by aerial survey. Journal of Wildlife Management 43:626-633.

Cameron, R.D. and K.R. Whitten. 1979b. Influence of the Trans-Alaska Pipeline corridor on the local distribution of caribou. Paper presented at the 2nd Internat. Reindeer/Caribou Symposium, Roros, Norway, 17-21 Sept. 1979.

Cameron, R.D., K.R. Whitten, W.T. Smith, and D.D. Roby. 1979. Caribou distribution and group composition associated with construction of the Trans-Alaska Pipeline. Canadian Field Naturalist 93:155-162.

Campbell, J. 1975. Narrative surveillance report: October 7-11, 1975, Glenallen; October 12-17, 1975, Valdez. JFWAT files. Anchorage.

Carbyn, L.N. 1975. Wolf population fluctuations in Jasper National Park, Alberta, Canada. Biological Conservation 6:94-101.

Carl, E.A. 1971. Population control in arctic ground squirrels. Ecology 52:395-413.

Chapman, R.C. 1977. The effects of human disturbance on wolves (*Canis lupus L.*). M.S. thesis, Univ. Alaska, Fairbanks. 209 p.

Chapman, R.C. 1976. Human distrubance at wolf dens - a management problem. In: First Conference on Scientific Research in the National Parks. New Orleans, Louisiana.

Chapman, R.C. 1978. Rabies: decimation of a wolf pack in Arctic Alaska. Science 201:365-367.

Chesemore, D.L. 1967. Ecology of the arctic fox in northern and western Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 148 p.

Chesemore, D.L. 1978. Notes on food habits of arctic foxes in northern Alaska. Canadian Journal of Zoology 46:1127-1130.

Chesemore, D.L. 1975. Ecology of the Arctic fox (*Alopex lagopus*) in North America - a review. In: M.W. Fox (ed.), The Wild Canids. VanNostrand Reinhold Co., New York.

Child, K.N. 1973. The reactions of barren-ground caribou (*Rangifer tarandus granti*) to simulated pipeline and pipeline crossing structures at Prudhoe Bay, Alaska. Completion Rep., Alaska Coop. Wildl. Res. Unit, Univ. Alaska, Fairbanks. 51 p.

Child, K.N. and P.C. Lent. 1973. The reactions of reindeer to a pipeline simulation at Penny River, Alaska. Interim report, Alaska Coop. Wildl. Res. Unit, Univ. Alaska, Fairbanks. 29 p.

Clark, K.R.F. 1971. Food habits and behavior of the tundra wolf on central Baffin Island. Ph.D. diss., Univ. Toronto, Ontario. 223 p.

Coady, J.W. 1973. Interior moose studies. Vol. I. Proj. Prog. Rep. Fed. Aid in Wildl. Restor. Projs. W-17-4, W-17-5. ADFG, Juneau.

Coady, J.W. 1974. Evaluation of moose range and habitat utilization in Interior Alaska. Proj. Prog. Rep. Fed. Aid in Wildl. Restor. Proj. W-17-6. ADFG, Juneau. 12 p.

Coady, J.W. 1976. Interior moose and moose disease studies. Vol. III. Proj. Prog. Rep., Fed. Aid in Wildl. Restor. Projs. W-17-6, W-17-7, W-17-8. ADFG, Juneau.

Coady, J.W. 1979. Surveys of moose on and adjacent to NPRA in 1977. In: Studies of Selected Wildlife and Fish and Their Use On and Adjacent to the National Petroleum Reserve in Alaska, 1977-1978. 105(C) Land Use Study, USDI, Anchorage. Vol. I:1-12.

Cole, G.F. 1971. Preservation and management of grizzly bears in Yellowstone National Park. BioScience 21:858-864.

Connolly, G. and G.W. Longhurst. 1975. The effects of control on coyote populations: a simulation model. Div. of Agric. Sci., Univ. Calif. Bull. No. 1872. 37 p.

Cornell, D. and J.E. Cornely. 1979. Aversive conditioning of campground coyotes in Joshua Tree National Monument. Wildlife Society Bulletin 7:129-131.

Cottam, G. and J.T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37:451-460.

Cowan, I.M. 1949. Rabies as a possible population control of arctic canidae. Journal of Mammalogy 30:396-398.

Cowan, I. McTaggart. 1972. The status and conservation of bears (*Ursidae*) of the world - 1970. In: Proceedings of the International Conference on Bear Research and Management. Calgary, Alberta. p. 343-367.

Craighead, F.C. Jr. and J.J. Craighead. 1972a. Data on grizzly bear denning acitivities and behavior obtained by using wildlife telementry. p. 84-106. In: Proceedings of the International Conference on Bear Research and Management. Calgary, Alberta.

Craighead, F.C. Jr. and Craighead. 1972b. Grizzly bear prehibernation and denning activities as determined by radiotracking. Wildlife Monograph No. 32. p. 35.

Craighead J.J. and F.C. Craighead. 1972c. Grizzly bear - major relationships in Yellowstone National Park. p. 304-333. In: Proceedings of the International Conference on Bear Research and Management. Calgary, Alberta.

Craighead, J.J., J.R. Varney and F.C. Craighead. 1974. A population analysis of the Yellowstone grizzly bears. Bulletin 40. Montana Forest and Conservation Experiment Station. University of Montana, Missoula. p. 20.

Curatolo, J.A. and G.D. Moore. 1975. Home range and population dynamics of grizzly bear (*Ursus arctos L.*) in the eastern Brooks Range, Alaska. Chapter 1. In: R.D. Jakimchuk (ed.), Studies of Large Mammals Along the Proposed Mackinzie Valley Gas Pipeline Route from Alaska to British Columbia. Arctic Gas Biology Report Ser., Vol. 32.

Davis, J.L. 1979. Distribution and status of *Rangifer terandus* in the U.S.A. Paper presented at the 2nd International Reindeer/Caribou Symposium. Roros, Norway. p. 17-21. September 1979.

Davis, J.L., R. Shideler, and R.E. LeResche. 1978. In: Movements and Distribution of the Forty mile Caribou Herd. Final Rep. (research). Fed. Aid in Wildlife Restoration Projects W-17-6 and W-17-7. ADFG, Juneau. p. 42.

Davis, J.L. and P. Valkenburg. 1979. Caribou distribution, population characteristics, mortality, and responses to disturbance in northwest Alaska. In: Studies of Selected Wildlife and Fish and Their Use of Habitats On and Adjacent to the National Petroleum Reserve in Alaska, 1977-1978. 105(C) Land Use Study, USDI, Anchorage. Vol 1:13-52.

Denniston, R.H. 1956. Ecology, behavior, and population dynamics of the Wyoming or Rocky Mountain moose. Zoologica 41:105-118.

Doll, D., W.P. McCrory and J.D. Feist. 1974. Observations of moose, wolf and grizzly bear in the northern Yukon Territor, Chapter III. In: K.H. McCourt and L.P. Horstman (eds.), Studies of Large Mammal Populations in Northern Alaska, Yukon and Northwest Territories, 1973. Arctic Gas Bio Rep Ser., Vol. 22.

Douglass, R.J. 1976. A study of the ecology of small mammals at Chick Lake Northwest Territories 1973-1975. Unpubl. manuscript submitted to Canadian Arctic Gas Study Ltd., Calgary, Alberta. 109 p.

Douglass, R.J. 1977. Effects of winter roads on small mammals. Journal of Applied Ecology 14:827-834.

Dufresne, F. 1942. Mammals and birds of Alaska. U.S. Fish and Wildlife Service, Circular No. 3. 37 p.

Eager, J.T. and M.R. Pelton. 1980 (in press). Human-bear interactions in the Smokey Mountains: focus on ursid aggression. In: Fifth Internat. Conference on Bear Research and Management. Madison, Wisconsin.

Eberhardt, L.E. and W.C. Hanson. 1978. Long-distance movements of arctic foxes tagged in northern Alaska. Canadian Field Naturalist 92:386-389.

Eberhardt, W.L. 1977. The biology of arctic and red foxes on the North Slope. M.S. thesis, Univ. Alaska, Fairbanks. 125 p.

Elgmork, K. 1976. A remnant brown bear population in southern Norway and problems of its conservation. In: Third Internat. Conference on Bear Research and Management. Binghamton, New York. p. 281-299.

Elgmork, K. 1978. Human impact on a brown bear population (*Ursus arctos* L.). Biological Conservation 13:81-103.

Englund, J. 1970. Population dynamics of the Swedish red fox (*Vulpes vulpes* L.). Uppsala. Almqvist and Wiksells, Boktryckeri AB. 10 p.

Ericson, C.A. 1972. Some preliminary observations on the acoustic behavior of semi-domestic reindeer (*Rangifer tarandus tarandus*) with emphasis on intraspecific communication and the mother-calf relationship. M.S. thesis, Univ. Alaska, Fairbanks. 121 p.

Espmark, Y. 1972. Behaviour reactions of reindeer exposed to sonic booms. Deer: Journal of the British Deer Society 2:800-802.

Evans, C.D., W.A. Troyer, and C.J. Lensink. 1966. Aerial census of moose by quadrat sampling units. Journal of Wildlife Management 30:767-776.

Fedeler, R. 1977. Letter to Mitre Corporation, Feb. 25, 1977. ADFG, Habitat Division files, Fairbanks.

Fine, H. In prep. M.S. tesis, University of Alaska, Fairbanks.

Foothills Pipe Lines (Yukon) Ltd. 1978. Winter distribution of the Porcupine Caribou Herd in relation to the proposed Demster Lateral Pipeline Route. Unpubl. rep. prepared by Renewable Resources Consulting Services, Ltd., Edmonton, Alberta. 92 p.

Frischknecht, N.C. and M.F. Baker. 1972. Voles can improve sage brush rangelands. Journal of Range Management 25:466-468.

Fuller, W.A. 1960. Behavior and social organization of the wild bison of Wood Buffalo National Park, Canada. Arctic 13:3-19.

Garrott, R.A. Undated. Prudhoe Bay Oil Reserves and the Arctic Fox. Unpubl. manuscript. 15 p.

Gasaway, W.C. and J.W. Coady. 1974. Review of energy requirements and rumen fermentation in moose and other ruminants. Naturaliste Canadien 101:227-262.

Gasaway, W.C., S.J. Harbo and S.D. DuBois. 1979. Moose survey procedures development. Vol. III, Proj. Prog. Rep., Fed. Aid in Wildl. Restor. Proj. W-17-11. ADFG, Juneau. 60 p.

Geist, V. 1963. On the behavior of the North American moose (*Alces alces andersoni* Peterson 1950) in British Columbia. Behaviour 20:377-416.

Geist, V. 1971a. A behavioral approach to the management of wild ungulates. In: E. Duffey and A.S. Watt (eds.), The Scientific Management of Animal and Plant Communities for Conservation. 11th Symp. British Ecol. Soc. Blackwell, Oxford. p. 413-424.

Geist, V. 1971b. Mountain Sheep: a study in behavior and evaluation. Univ. Chicago Press, Chicago. 383 p.

Geist, V. 1971c. Is big game harassment harmful? Oil Week 22(17):12-13.

Geist, V. 1975. Harassment of large mammals and birds. Unpubl. rep. to the Berger Comm. Univ. Calgary, Alberta. 62 p.

Geist, V. 1978. Behavior. In: J.L. Schmidt and D.L. Gilbert (eds.), Big Game of North America. Stackpole Books. Harrisburg, Pa. p. 283-296.

Gier, H.T. 1975. Ecology and social behavior of the coyote. In: M.W. Fox (ed.), The Wild Canids. VanNostrand Reinhold Co., New York. p. 247-263.

Gier, H.T. 1978. Parasites and diseases of coyotes. In: M. Beckoff (ed.), Coyotes Biology, Behavior, and Management. Academic Press, Inc., New York. p. 247-262.

Gipson, P.S. and S. Brainerd. Manuscrip in preparation. University of Alaska.

Glaspell, J. 1980. Personal communication. ADFG, Anchorage.

Grace, E.S. 1976. Interactions between men and wolves at an arctic outpost on Ellsmere Island. Canadian Field Naturalist 90:149-156.

Grenier, P. 1973. Moose killed on the highway in the Laurentides Park, Quebec, 1962 to 1972. North American Moose Conference and Workshop 9:155-194.

Griffin, W.H. 1968. Bison, elk, goat, and muskox studies. Fed. Aid in Wildl. Restor. Proj. W-15-R-3 and W-17-1, work plan Q. ADFG, Juneau.

Hall, E.R. and K.R. Kelson. 1959. Mammals of North America. Ronald Press Co. 1630 p.

Hamer, J. 1974. Distribution, abundance and management implications of the grizzly bear and mountain caribou in the mountain creek watershed of Glacier National Park, British Columbia. M.S. thesis, University of Calgary. p. 164.

Hamer, D., S. Herrero, R.T. Ogilvie, and T. Toth. 1979. Ecological studies of the grizzly bear. Parks Canada Contract WR96-78. Parks Canada Western Region. Calgary, Alberta. 86 p.

Hamilton, G.D. and P.D. Drysdale. 1975. Effects of cutover width on browse utilization by moose. North American Moose Conference and Workshop 11:5-25.

Hanson, W.C. 1972. Ecological studies of birds and mammals of the Gas Arctic/Northwest Project Prudhoe Bay Test Site, summers 1971 and 1972. Unpubl. Manuscript.

Hanson, W.C. and L.E. Eberhardt. 1977. Ecological consequences of North Slope oil development. In: D.F. Petersen and E.M. Sullivan (compilers), Biomedical and Environmental Research Program of the LASL Health Division, Jan-Dec. 1976. Los Alamos Scientific Lab. Report LA-6898-PR (1977). p. 58-60.

Hanson, W.C. and L.E. Eberhardt. 1978. Ecological consequences of petroleum developments in northern Alaska. In: D.F. Petersen and E.M. Sullivan (compilers), Biomedical and Environmental Research Program of the LASL Health Division, Jan.-Dec. 1977. Los Alamos Scientific Lab. Report LA-7254-PR (1978). p. 17-22.

Hanson, W.C. and L.L. Eberhardt. 1979. Ecological consequences of petroleum developments in northern Alaska. In: Pacific Northwest Laboratory Annual Report for 1978, Part 2, Supplement Ecological Sciences. Battelle Memorial Institute.

Harding, L.E. 1976. In: Den-site characteristics of arctic coastal grizzly bears (*Ursus arctos* L.) on Richards Island, Northwest Territories, Canada. Canadian Journal of Zoology. 54(8): 1357-1363.

Harding, L.E. and J.A. Nagy. 1977 (in press). Responses of grizzly bears to hydrocarbon exploration on Richards Island, Northwest Territories, Canada. In: Fourth Internat. Conference on Bear Research and Management. Kalispell, Montana.

Harris, S. 1977. Distribution, habitat utilization and age structure of a suburban fox (*Vulpes vulpes*) population. Mammal Review 7:25-39.

Hatter, D.F. 1967. Some aspects of the ecology of the black bear (*Ursus americanus*) in Interior Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 111 p.

Heimer, W.E. 1973. Dall sheep movements and mineral lick use. Final Rep., Fed. Aid in Wildl. Restor. Projs. W-17-2 through W-17-5, Job 6.1R. ADFG, Juneau.

Heimer, W.E. 1975. Study area selection in the Tok management area. Final Rep., Fed. Aid Wildl. Restor., Proj. W-17-7, Job 6.8R. ADFG, Juneau.

Heimer, W.E. 1976. Interior sheep studies. Vol. II. Annual Proj. Prog. Rep. Fed. Aid in Wildl. Restor., ADFG, Juneau.

Heimer, W.E. 1980. Personal communication. ADFG, Fairbanks.

Hemming, J.E. 1971. The distribution and movement patterns of caribou in Alaska. ADFG Wildl. Tech Bull. No. 1. 60 p.

Hemming, J.E. Undated. Wild reindeer and pipelines in north central Siberia. Unpubl. rep. of an exchange visit under terms of USA/USSR Env. Protect. Agreement. Proj. V-2. Ecosystems of N. Regions.

Hemming, J.E. and K.A. Morehouse (eds.). 1976. Wildlife Atlas: Trans-Alaska Oil Pipeline, Valdez to Prudhoe Bay. JFWAT, Spec. Rep. No. 3. 30 p.

Herrero, S. 1970. Human injury inflicted by grizzly bears. Science 170:593-598.

Herrero, S. 1976. Conflicts between man and grizzly bears in the national parks of North America. In: Third Internat. Conference on Bear Research and Management. Binghamton, New York. p. 121-147.

Hicks, L.L. and J.M. Elder. 1979. Human disturbance of Sierra Nevada Bighorn Sheep. Journal of Wildlife Management 43:909-915.

Hoffman, W.H. 1975. The barren-ground caribou (*Rangifer tarandus granti*) of the Porcupine herd wintering in the Richardson Mountains. Final rep. prepared for Environ.-Social Committee, Northern Pipelines. 99 p.

Holter, J.B., W.E. Urban, Jr., H.H. Hayes, and H. Silver. 1976. Predicting metabolic rate from telemetered heart rate in white-tailed deer. Journal of Wildlife Management 40:626-629.

James, D. 1980. Personal communication. Univ. Alaska, Fairbanks.

Jensen, B. and D.M. Sequeira. 1978. The diet of the red fox (*Vulpes vulpes* L.) in Denmark. Danish Review of Game Biology Vol. 10. 16 p.

Johnson, D. 1980. Personal communication. ADFG, Fairbanks.

Johnson, D.R. and M.C. Todd. 1977. Summer use of a highway crossing by mountain caribou. Canadian Field Naturalist 91:312-314.

Johnson, S.F. and J.A. Gessaman. 1973. An evaluation of heart rate as an indirect monitor of free-living energy metabolism. In: J.A. Gessaman (ed.), Ecological Energetics of Homeotherms. Utah State Univ. Press, Logan, Utah. p. 44-54.

Joint State/Federal Fish and Wildlife Advisory Team. Files. Anchorage, Alaska.

Jones, F.F., R.F. Batchelor, H.R. Merriam, and L.A. Viereck. 1963. Sheep and goat investigations. Vol. III. Ann. Proj. Segment Rep. Fed. Aid in Wildl. Restor. Act. Proj. W-6-R-3, work plan E. ADFG, Juneau.

Jonkel, C.J. and I. McT. Cowan. 1971. The black bear in the spruce-fir forest. Wildlife Monographs No. 27. 57 p.

Jordan, P.A., P.C. Shelton, and D.L. Allen. 1967. Numbers, turnover, and social structure of the Isle Royale wolf population. American Zoologist 7:233-252.

Kautz, M.V. 1978. Energy expenditure and heart rate of active mule deer fawns. M.S. thesis, Colorado State Univ., Fort Collins. 76 p.

Kellyhouse, D. 1980. Personal communication. ADFG, Tok.

Klein, D.R. 1971. The reaction of reindeer to obstructions and disturbances. Science 173:393-398.

Klein, D.R. 1972. Problems in conservation of mammals in the north. Biological Conservation 4:97-101.

Klein, D.R. 1973a. The reaction of some northern mammals to aircraft disturbance. In: XI Internat. Cong. Game Biologists. Stockholm, Sweden. p. 377-383.

Klein, D.R. 1973b. The impact of oil development in the northern environment. Proc. 3rd Interpetrol Congress, Rome, Italy. Petrolio e ambiente. p. 109-121.

Klein, D.R. 1979a. The Alaska Oil Pipeline in retrospect. Transactions of the North American Wildlife and Natural Resources Conference. 44:235-246.

Klein, D.R. 1979b. Reaction of caribou and reindeer to obstructions - a reassessment. Paper presented at 2nd Internat. Reindeer/Caribou Symposium, Roros, Norway, 17-21 Sept. 1979.

Krebs, C.J. and J.H. Meyers. 1974. Population cycles in small mammals. Advances in Ecological Research. Vol. 8. Academic Press, London.

Larson, R.W. 1974. Bison survey-inventory progress rep. ADFG, Juneau.

Larson, R.W. 1980. Personal communication. ADFG, Delta Junction.

Leiby, P.D. and W.G. Dyer. 1971. Cyclophyllidean tapeworms of wild carnivora. In: Parasitic Diseases of Wild Mammals (J.W. Davis and R.C. Anderson, Eds.). The Iowa State University Press, Ames, Iowa.

Lenarz, M. 1974. The reaction of Dall sheep to an FH-1100 helicopter. Chapter III, In: R.D. Jakimchuk (ed.), The Reaction of Some Mammals to Aircraft and Compressor Station Noise Disturbance. Arctic Gas Biol. Rep. Ser. Vol. 23.

Lent, P.C. 1964. Calving and related social behavior in the barren-ground caribou. Ph.D. thesis, Univ. Alberta, Edmonton. 220 p.

Lent, P.C. and R. Summerfield. 1973. Population dynamics and seasonal movement patterns of Dall sheep in the Atigun River Canyon. Alaska Coop. Wildl. Res. Unit monthly report, August 1973. Univ. Alaska, Fairbanks.

LeResche, R.E. 1966. Behavior and calf survival in Alaskan moose. M.S. thesis, Univ. Alaska, Fairbanks. 85 p.

LeResche, R.E. 1974. Moose migrations in North America. Naturaliste Canadien 101:393-415.

LeResche, R.E. 1975. The international herds: present knowledge of the Fortymile and Porcupine caribou herds. In: Proc. First Internat. Reindeer/Caribou Symp. Biol. Pap. Univ. Alaska, Spec. Rep. No. 1:127-139.

LeResche, R.E., R.H. Bishop, and J.W. Coady. 1974. Distribution and habitats of moose in Alaska. Naturaliste Canadien 101:143-178.

Linderman, S. 1972. A report on the sheep study at the Dietrich River headwaters. Appendix III. In: L. Nichols and W. Heimer (eds.), Sheep Report, Vol. XIII. ADFG, Juneau.

Linderman, S. 1974. Ground tracking of arctic grizzly bears. Final Rep., Fed. Aid in Wildl. Restor. Proj. W-17-6, Job 4.12R. ADFG, Juneau. 24 p.

MacArthur, R.A., R.H. Johnston, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57:2010-2021.

MacLean, S.F. Jr., B.M. Fitzgerald, and F.A. Pitelka. 1974. Population cycle in arctic lemmings: winter reproduction and predation by weasels. Arctic and Alpine Research 6:1-12.

MacLennan, R.R. 1975. Use of forest cuts by big game in the Porcupine Forest. North American Moose Conference and Workshop 11:27-35.

Macpherson, A.H. 1965. The barren-ground grizzly bear and its survival in northern Canada. Canadian Audubon 27(1):2-8.

Macpherson, A.H. 1969. The dynamics of Canadian arctic fox populations. Can. Wildl. Serv. Rep. Ser. No. 8, Ottawa. 52 p.

Maher, W.J. 1967. Predation by weasels on a population of lemmings in winter at Banks Island, Northwest Territories. Canadian Field Naturalist 81:248-250.

McCaffrey, E.R., G.B. Will and A.S. Bergstrom. 1976. Preliminary Management Implications for Black Bears, *Ursus americanus* in the Catskill Region of New York State as the Result of an Ecological Study. In: Third International Conference on Bear Research and Management. Binghamton, New York. p. 235-245.

McArthur, K.L. 1969. The behavior of grizzly bears in relation to people in Glacier National Park: a literature review. Unpubl. National Park Service Progress Rep. Glacier National Park, Montana. 70 p.

McCourt, K.H., J.D. Feist, D. Doll, and J.J. Russell. 1974. Disturbance studies of caribou and other mammals in the Yukon and Alaska, 1972. Arctic Gas Biol. Rep. Ser., Vol. 5. 246 p.

McCourt, K.H. and L.P. Horstman. 1974. The reaction of barren-ground caribou to aircraft. Chapter 1, In: R.D. Jakimchuk (ed.), The Reaction of Some Mammals to Aircraft and Compressor Station Noise Disturbance. Arctic Gas. Biol. Rep. Ser., Vol. 23.

McIlroy, C. 1972. Bison survey-inventory progress report. ADFG, Juneau.

McMillan, J.F. 1954. Some observations of moose in Yellowstone Park. American Midland Naturalist 52:392-399.

Meagher, M. 1980. Personal communication. Yellowstone National Park, Wyoming.

Meagher, M. and J.R. Phillips. 1980 (in press). Restoration of natural populations of grizzly and black bears in Yellowstone National Park. In: Fifth Internat. Conference on Bear Research and Management. Madison, Wisconsin.

Mech, L.D. 1966. The wolves of Isle Royale. U.S. National Park Service, Fauna Series No. 7. 210 p.

Mech, L.D. 1970. The wolf: the ecology and behavior of an endangered species. Natural History Press, New York. 384 p.

Milke, G.C. 1969. Some moose-willow relationships in the interior of Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 60 p.

Milke, G.C. 1977. Animal feeding: problems and solutions. JFWAT, Spec. Rep. No. 14. 11 p.

Miller, F.L. and E. Broughton. 1973. Behaviour associated with mortality and stress in maternal-filial pairs of barren-ground caribou. Canadian Field Naturalist 87:21-25.

Miller, F.L. and A. Gunn. 1979. Responses of Peary caribou and muskoxen to helicopter harassment. Can. Wildl. Serv. Occas. Paper. No. 40. 90 p.

Miller, F.L., C.J. Jonkel, and G.D. Tessier. 1972. Group cohesion and leadership response by barren-ground caribou to man-made barriers. Arctic 25:193-202.

Morris-Elye, L.T.S. 1951. The black bear as a predator of man. Journal of Mammalogy 32:222-223.

Mould, E.D. 1977. Movement patterns of moose in the Colville River area, Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 82 p.

Mueggler, W.F. 1967. Voles damage sagebrush in south-western Montana. Journal of Range Management 20:88-91.

Mundy, K.R. and D.R. Flook. 1973. Background for managing grizzly bears in the national parks of Canada. Can. Wildl. Serv. Rep. Series, No. 22. 35 p.

Murie, A. 1940. Ecology of the coyote in the Yellowstone. U.S. National Park Service, Fauna Series No. 4. 206 p.

Murie, A. 1944. The wolves of Mount McKinley. U.S. National Park Service, Fauna Series No. 5. 238 p.

Murphy, E.C. 1974. An age structure and a re-evaluation of the population dynamics of Dall sheep (*Ovis dalli dalli*). M.S. thesis, Univ. Alaska, Fairbanks. 113 p.

Nagy, J.A. and R.H. Russell. 1978. Ecological status of the boreal grizzly bear (*Ursus arctos* L.), annual report for 1977. Canadian Wildl. Service. Edmonton, Alberta. 72 p.

Nichols, L. 1972. Productivity in unhunted and heavily exploited Dall sheep populations. In: L. Nichols and W. Heimer (eds), Sheep Report Vol. XIII. Proj. Prog. Rep., Fed. Aid in Wildl. Restor. Projs. W-17-3 and W-17-4. ADFG, Juneau.

Nichols, L. 1978. Dall sheep reproduction. Journal of Wildlife Management 42:570-580.

Nichols, L. 1978. Dall's Sheep. In: J.L. Schmidt and D.L. Gilbert (eds.), Big Game of North America. Stackpole Books. Harrisburg, Pa. p. 173-189.

Ozoga, J.J. Jr. 1963. An ecological study of the coyote on Beaver Island, Lake Michigan. M.S. thesis, Michigan State Univ., East Lansing. 122 p.

Pamplin, W.L., Jr. 1979. Construction-related impacts of the Trans-Alaska Pipeline System on terrestrial wildlife habitats. JFWAT, Spec. Rep. No. 24. p. 132.

Pearson, A.M. 1975. The northern interior grizzly bear (*Ursus arctos* L.). Can. Wildl. Serv. Rep. Ser. No. 34. Information Canada, Ottawa. 86 p.

Pearson, A.M. 1976. Population characteristics of the arctic mountain grizzly bear. In: Third International Conference on Bear Research and Management. Binghamton, New York. p. 247-260.

Peek, J.M., R.E. LeResche, and D.R. Stevens. 1974. Dynamics of moose aggregations in Alaska, Minnesota, and Montana. Journal of Mammalogy 55:126-137.

Peterson, R.O. 1974. Wolf ecology and prey populations on Isle Royale. Ph.D. diss., Univ. Michigan, Ann Arbor. 228 p.

Peterson, R.O. 1975. The wolves of Isle Royale - new developments. In: E. Klinghammer (ed.), The Behavior and Ecology of Wolves. Garland STPM Press, New York. p. 3-18.

Phillips, R.L., R.D. Andrews, G.L. Storm, and R.A. Bishop. 1972. Dispersal and mortality of red foxes. Journal of Wildlife Management 36:237-248.

Pitelka, F.A., P.Q. Temich, and G.W. Treichel. 1955. Breeding behavior of jaegers and owls near Barrow, Alaska. Condor 57:3-18.

Price, R. 1972. Effect of human disturbance on Dall sheep. Final report. Alaska Coop. Wildl. Res. Unit Quarterly Rep. 23(3):23-38.

Quimby, Roland. 1974. Grizzly bear. Chapter II. In: R.D. Jakimchuk (ed.), Mammal Studies in Northeastern Alaska with Emphasis within the Canning River Drainage. Arctic Gas Bio. Rep. Ser., Vol. 24.

Quimby, R. and D.J. Snarski. 1974. A study of furbearing mammals associated with gas pipeline routes in Alaska. Chapter 2, In: R.D. Jakimchuk (ed.), Distribution of Moose, Sheep, Muskox, and Furbearing Mammals in Northern Alaska. Arctic Gas Biol. Rep. Ser., Vol. 6.

Rausch, R.A. 1962. Population characteristics, distribution and movements, Big Delta and Nabesna (upper river) bison herds. Fed. Aid in Wildl. Restor. Proj. No. W-6-R-3, Job No. 2. ADFG, Juneau.

Rausch, R.A. 1967. Some aspects of the population ecology of wolves, Alaska. Am. Zoologist 7(2):253-265.

Rausch, R.A. and A.M. Pearson. 1972. Notes on the wolverine in Alaska and the Yukon. Journal of Wildlife Management 36:249-268.

Rausch, R.L. 1950. Observations on a cyclic decline of lemmings (*Lemmus*) on the arctic coast of Alaska during the spring 1949. Arctic 3:166-177.

Rausch, R.L. 1952. Hydatid disease in boreal regions. Arctic 5:157-174.

Rausch, R.L. 1958. Some observations on rabies in Alaska with special reference to wild Canidae. Journal of Wildlife Management 22:246-260.

Rausch, R.L. 1972. Observations on some natural-focal zoonoses in Alaska. Archives of Environmental Health 25:246-252.

Rausch, R.L. and F.S.L. Williamson. 1959. Studies on the helminth fauna of Alaska. XXXIV. The parasites of wolves (*Canis lupus* L.). Journal of Parasitology 45:395-403.

Reynolds, H. 1980. Personal communication. ADFG, Fairbanks.

Reynolds, H.V., J.A. Curatolo, and R. Quimby. 1976. Denning ecology of grizzly bears in northeastern Alaska. In: Third Internat. Con ference on Bear Research and Management. Binghamton, New York. p. 403-411.

Reynolds, P.C. 1974. The effects of simulated compressor station sounds on Dall sheep using mineral licks on the Brooks Range, Alaska. Chapter II, In: R.D. Jakimchuk (ed.), The Reaction of Some Mammals to Aircraft and Compressor Station Noise Disturbance. CAGSL Biol. Rept. Ser., Vol. 23.

Richards, S.H. and R.L. Hine. 1953. Wisconsin fox populations. Final rep. Pittman-Robertson Research Project 12-R. Wisconsin Conservation Dept., Tech. Wildl. Bul. No. 6. 78 p.

Riegelhuth, R. 1966. Grizzly bears and human visitation. M.S. thesis, Colorado State Univ., Fort Collins. 80 p.

Robinson, W.B. and E.F. Grand. 1958. Comparative movements of bobcats and coyotes as disclosed by tagging. Journal of Wildlife Management 22:117-122.

Roby, D.D. 1978. Behavioral patterns of barren-ground caribou of the Central Arctic Herd adjacent to the Trans-Alaska Pipeline. M.S. thesis, Univ. Alaska, Fairbanks. 200 p.

Rogers, L.L. 1977. Social relationships, movements, and population dynamics of black bears in northeastern Minnesota. Ph.D. thesis, Univ. Minnesota, St. Paul. 194 p.

Rogers, L.L. and S.M. Rogers. 1976. Parasites of bears: a review. In: Third Internat. Conference on Bear Research and Management Binghamton, New York. p. 411-430.

Rogers, L.L., D.W. Kuehn, A.W. Erickson, E.M. Harger, L.J. Verme and J.J. Ozoga. 1976. Characteristics and management of black bears the feed in garbage dumps, campground or residential areas. In: Third International Conference on Bear Research and Management. Binghamton, New York. P. 169-175.

Roseneau, D.G. and J.A. Curatolo. 1975. The distribution and movements of the Porcupine caribou herd in northeastern Alaska and the Yukon territory, 1975. Chapter 1, In: R.D. Jakimchuk (ed.), Studies of Mammals Along the Proposed MacKenzie Valley Gas Pipeline Route, 1975. Arctic Gas Biol. Rep. Ser., Vol. 36.

Roseneau, D.G., P. Stern, and C. Warbelow. 1974. Distribution and movements of the Porcupine caribou herd in northeastern Alaska. Chapter 4 In: K.H. McCourt and L.P. Horstman (eds.), Studies of Large Mammal Populations in Northern Alaska, Yukon, and Northwest Territories, 1973. Arctic Gas Biol. Rep. Ser., Vol. 22.

Russell, J. 1977. Some overt responses of muskox and caribou to seismic activities, northeastern Banks Island, March and April 1977. Unpubl. rep. for Northwest Territories Fish and Wildl. Serv., Yellowknife. 85 p.

Ruttan, R.A. 1974a. Arctic fox on North Slope of the Yukon Territory, 1972. Chapter 1, In: R.A. Ruttan and D.R. Wooley (eds.), Studies of Furbearers Associated with Proposed Pipeline Routes in the Yukon and Northwest Territories. Arctic Gas Biol. Rep. Ser., Vol. 9.

Ruttan, R.A. 1974b. Muskrat studies on Old Crow Flat, Yukon Territories, 1972. Chapter 4, In: R.A. Ruttan and D.R. Wooley (eds.), Studies of Furbearers Associated with Proposed Pipeline Routes in the Yukon and Northwest Territories. Arctic Gas Biol. Rep. Ser., Vol. 9.

Ruttan, R.A. 1974c. Observations of grizzly bear in the northern Yukon Territory and Mackenzie River Valley, 1972. Chapter VII. In: R.A. Ruttan and D.R. Wooley (eds.), Studies of Furbearers Associated with Proposed Pipeline Routes in the Yukon and Northwest Territories. Arctic Gas Bio. Rep. Ser., Vol. 9.

Ruttan, R.A. and D.R. Wooley. 1974. A study of furbearers associated with proposed pipeline routes in the Yukon Territory and MacKenzie River Valley, 1971. Arctic Gas Biol. Rep. Ser., Vol. 8. 118 p.

Schallenberger, A. 1977 (in press). Review of oil and gas exploration impacts on grizzly bears. In: Fourth Internat. Conference on Bear Research and Management. Kalispell, Montana.

Schweinsburg, R.E. 1974. An ornithological study of proposed gas pipeline routes in Alaska, Yukon Territory and Northwest Territories, 1971. Arctic Gas Bio. Rep. Ser., Vol. 10.

Schofield, E. 1975. Some considerations of the possible effects of local and global sources of air pollution on lichens grazed by reindeer and caribou. In: Proc. First Internat. Reindeer/Caribou

Searing, G.F. 1979. Distribution, abundance, and habitat associations of beaver, muskrats, mink, and river otters in the AOSERP study area, northeastern Alberta. Unpubl. Rep. to Alberta Oil Sands Environ. Research Program. LGL Ltd., Edmonton, Alberta. 115 p.

Shaffer, S.C. 1971. Some ecological relationships of grizzly bears and black bears of the Apgar Mountains in Glacier National Park, Montana. M.S. thesis, Univ. Montana, Missoula. 133 p.

Sigman, M. 1979. Response of wintering moose to mechanical habitat rehabilitation in Alaska. Canadian Field Naturalist 93:191-193.

Singer, F.J. 1976. Seasonal concentrations of grizzly bears and notes on other predators in the North Fork of the Flathead River. Research Noe No. 2, Glacier National Park. West Glacier, Montana. p. 19.

Skóog, R.O. 1956. Range, movements, population, and food habits of the Steese-Fortymile caribou herd. M.S. thesis, Univ. Alaska, Fairbanks. 145 p.

Skoog, R.O. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Ph.D. thesis, Univ. California, Berkeley. 699 p.

Smith, D.R. 1954. The bighorn sheep in Idaho--its status, life history, and management. Idaho Dept. Fish and Game, Wildl. Bull. No. 1. Boise, Idaho. 154 p.

Soutiere, E.C. 1979. Effects of timber harvesting on marten in Maine. Journal of Wildlife Management 43:850-860.

Speller, S.W. 1972. Food ecology and hunting behavior of denning arctic foxes at Aberdeen Lake, Northwest Territories. Ph.D. thesis, Univ. Saskatchewan, Saskatoon. 145 p.

Stephenson, R.O. 1974. Characteristics of wolf den sites. Fed. Aid in Wildl. Restor. Projs. W-17-2 through W-17-6, Job 14.6R. ADFG, Juneau. 27 p.

Stephenson, R.O. and V. Van Ballenberghe. 1976. Wolf progress report (research) Fed. Aid in Wild. Restoration Proj. W-17-8, Jobs No. 14.9, 14.10. ADFG, Juneau. p. 75.

Summerfield, B.L. 1974. Population dynamics and seasonal movement patterns of Dall sheep in the Atigun Canyon area Brooks Range, Alaska. M.S. thesis, Univ. Alaska, Fairbanks. 109 p.

Summerhayes, V.S. 1941. The effect of voles (*Microtus agrestis*) on vegetation. Journal of Ecology 29:1-48.

Surrendi, D.C. and E.A. DeBock. 1976. Seasonal distribution, population status and behaviour of the Porcupine caribou herd. Prep. for Environ.-Soc. Program, North. Pipeline Task Force on North Oil Dev. by Can. Wildl. Serv., Edmonton, Alberta. 144 p.

Swartz, L.G., W. Walter II, D.G. Roseneau, and A.M. Springer. 1975. Populations of gyrfalcons on the Seward Peninsula, Alaska. 1968-1972. In: J.R. Murphy, C.M. White, and B.E. Hooval (eds.), Population Status of Raptors. Raptor Research Foundation, Inc. Rep. No. 3, Vermillion, South Dakota.

Syuzyumova, L.M. 1968. Epizootiology of rabies among arctic foxes on the Yamai Peninsula. Problems of the North 11:113-121.

Tempany, I.R., J.G. Stelfox, and G.C. Lyster. 1976. Reactions of bison to aircraft herding and surveys. In: J.G. Stelfox (compiler), Wood Buffalo National Park Bison Research, 1972-1976. 1976 Annual Rep. Parks Canada and Can. Wildl. Serv., Edmonton, Alberta.

Thompson, D.Q. 1955. The role of food and cover in population fluctuations of the brown lemming at Point Barrow, Alaska. Transactions North American Wildlife Conference 20:166-176.

Thomson, B.R. 1972. Reindeer disturbance. Deer: Journal of the British Deer Society 2:882.

Tracy, D.M. 1977. Reactions of wildlife to human activity along Mount McKinley National Park road. M.S. thesis, Univ. Alaska, Fairbanks. 260 p.

Underwood, L.S. 1975. Notes on the arctic fox (*Alopex lagopus*) in the Prudhoe Bay area of Alaska. In: J. Brown (ed.), Ecological Investigations of the Tundra Biome in the Prudhoe Bay Region, Alaska. Biol. Pap. Univ. Alaska, Spec. Rep. No. 2.

Underwood, L.S. and J.E. Baldrige. 1978. Ecological values along the North Slope portion of the haul road. Unpubl. rep. to the North Slope Borough by Alaska Environ. Info. and Data Center, Anchorage, Alaska. 40 p.

Urquhart, D.R. 1973. Oil exploration and Banks Island wildlife: a guide for the preservation of caribou, muskox, and arctic fox populations on Banks Island, Northwest Territories. Game Management Div. Rep., Gov. of the Northwest Territories. 105 p.

Van Ballenberghe, V. 1977. Migratory behavior of moose in southcentral Alaska. Transactions Internat. Congress Game Biologists 13:103-109.

Van Ballenberghe, V. 1978. Final report on the effects of the Trans-Alaska Pipeline on moose movements. JFWAT, Spec. Rep. No. 23. 41 p.

Van Ballenberghe, V., A.W. Erickson, and D. Byman. 1975. Ecology of the timber wolf in northeastern Minnesota. Wildlife Monographs No. 43. 43 p.

Van Ballenberghe, V. and J.M. Peek. 1971. Radio-telemetry studies of moose in northeastern Minnesota. Journal of Wildlife Management 35:63-71.

Villmo, L. 1975. Potential impact of accelerated northern development on caribou and reindeer populations and ecology: the Scandanavian viewpoint. In: Proceedings First Internat. Reindeer/Caribou Symp. Biol. Pap. Univ. Alaska, Spec. Rep. No. 1:4-9.

Walters, C.J., M. Stocker, and G.C. Haber. 1978. Simulation and optimization models for a wolf-ungulate system. Paper presented at the Internat. Ungulate Symp. Salt Lake City, Utah.

Webster, A.J.F. 1967. Continuous measurement of heart rate as an indicator of the energy expenditure of sheep. British Journal of Nutrition 21:769-785.

Weeden, R.B. and D.R. Klein. 1971. Wildlife and oil: a survey of critical issues in Alaska. The Polar Record 15:479-494.

White, R.G., B.R. Thomson, T. Skogland, S.J. Person, D.E. Russell, D.F. Holleman, and J.R. Luick. 1975. Ecology of caribou at Prudhoe Bay, Alaska. In: J. Brown (ed.), Ecological Investigations of the Tundra Biome in the Prudhoe Bay Region, Alaska. Biol. Pap. Univ. Alaska, Spec. Rep. No. 2:151-201.

Whitlock, S.E. 1950. The black bear as a predator of man. Journal of Mammalogy 31:135-138.

Whitten, K.R. 1980. Personal communication. ADFG, Fairbanks.

Wilson, K.A. 1954. The role of mink and otter as muskrat predators in northeastern North Carolina. Journal of Wildlife Management 18:199-207.

Wooley, D.R. 1974a. Beaver (*Castor canadensis*) studies in the MacKenzie Valley, 1972. Chapter 2, In: R.A. Ruttan and D.R. Wooley (eds.), Studies of Furbearers Associated with Proposed Pipeline Routes in the Yukon and Northwest Territories. Arctic Gas Biol. Rep. Ser., Vol. 9.

Wooley, D.R. 1974b. Population surveys of terrestrial furbearers. Chapter 2, In: R.D. Jakimchuk (ed.), Surveys of Mammals Along the Proposed Gas Pipeline in Alberta. Arctic Gas Biol. Rep. Ser., Vol. 25.

Wooley, D.R. 1974c. A study of marten (*Martes americana*) in the MacKenzie District, N.W.T. Chapter 3, In: R.A. Ruttan and D.R. Wooley (eds.), Studies of Furbearers Associated with Proposed Pipeline Routes in the Yukon and N.W.T. Arctic Gas Biol. Rep. Ser., Vol. 9.

Wooley, D.R. 1976. Terrestrial mammal studies along the Cross Delta Pipeline Route, 1975. Chapter 3, In: R.D. Jakimchuk (ed.), Studies of Mammals Along the Proposed MacKenzie Valley Gas Pipeline Route, 1975. Arctic Gas Biol. Rep. Ser., Vol. 36.

Worley, D.E., K.R. Greer, and D. Palmisciano. 1980 (in press). Possible relationships between trichinellosis and abnormal behavior in bears. In: Fifth Internat. Conference on Bear Research and Management. Madison, Wisconsin.

Young, S.P. and H.H.T. Jackson. 1951. The clever coyote. The Stackpole Co., Harrisburg, Pa. 411 p.

Appendix 1.

CONTACT MATRIX

Species Dall Sheep Herd or Region I (Prudhoe Bay to Atigun Pass)

		Right-of-Way	Haul Road	Air Fields	Atigun	Galbraith	Compressor Station # 3	Compressor Sation # 4
Winter Range	Present	1,2 20,24 31	1,2 20,24 31	2	2	2	2	2,20 24,31
	peripheral	20,24 31	20,24 31	2	2	2	2	2,20 24,31
	major	2,20 24,31	2,20 24,31	2	2	?	2	2,20 24,31
	Historic	?	?	?	?	?	?	?
Migration Routes	Present	20,24 25,31	20,24 25,31	?	2	?	2	20,24 31
	minor	?	?	?	?	?	?	?
	major	20,24 25,31	20,24 25,31	?	?	?	?	20,24 31
	Historic	?	?	?	?	?	?	?
Calving Areas	Present	2,20 24,31	2,20 24,31	2,24	2	2,20 24,31	2	2,20 24,31
	Historic	?	?	?	?	?	?	?
Summer Range	Present	20,24 31	20,24 31	?	?	20,24 31	?	20,24 31
	Historic	?	?	?	?	?	?	?
Mineral Licks		2	2	2,20 24,31	2	2,20 24,31	2	2,20 24,31

1,2 documented contact within 5 miles

1,2 documented contact

1,2 unclear or conflicting documentation

? no data available

1,2 documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd) CONTACT MATRIX

Species Dall Sheep Herd or Region II (Atigun Pass to Yukon River)

		Right-of-Way	Haul Road	Air Fields	Chandalar	Dietrich	Compressor Station # 5	Compressor Station # 6	Coldfoot								
Winter Range	Present	2	2	2	2	2,21	2	2	2								
	peripheral	2	2	2	?	2,21	2,21	2	2								
	major	2	2	2	2	2,21	2,21	?	?								
	Historic	?	?	?	?	?	?	?	?								
Migration Routes	Present	2,21 25	2,21 25	2	2	2,21	2,21	?	?								
	minor	?	?	?	?	?	?	?	?								
	major	2,21 25	2,21 25	?	?	?	?	?	?								
	Historic	?	?	?	?	?	?	?	?								
Calving Areas	Present	2,21	2,21	2	2	2,21	2,21	2	2								
	Historic	?	?	?	?	?	?	?	?								
Summer Range	Present	21	21	2	?	?	?	?	?								
	Historic	?	?	?	?	?	?	?	?								
Mineral Licks		1,2 21	1,2 21	1,2	2	2,21	2,21	2	2								

1,2	documented contact within 5 miles	1,2	documented contact	1,2	unclear or conflicting documentation	?	no data available	1,2	documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Dall Sheep Herd or Region IV (Delta Junction to Alaska/Yukon Border)

		Right-of-Way	Alaska Highway	Air Fields	Sears Creek	Compressor Station # 14
Winter Range	Present	1,30	1,30	1	1,30	1,30
	peripheral	30	30	?	1,30	1,30
	major	30	30	?	1,30	30
	Historic	?	?	?	?	?
Migration Routes	Present	?	?	?	1,30	?
	minor	?	?	?	1,30	?
	major	?	?	?	1,30	?
	Historic	?	?	?	?	?
Calving Areas	Present	30	30	30	1,30	30
	Historic	?	?	?	?	?
Summer Range	Present	1,30	1,30	1,30	1,30	1,30
	Historic	?	?	?	?	?
Mineral Licks		19,30	19,30	30	1,30	30

1,2 documented contact within 5 miles; 1,2 documented contact; 1,2 unclear or conflicting documentation; ? no data available; 1,2 documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Bison

Herd or Region III (Yukon River to Delta Junction)

		Right-of Way	Richardson Highway	Air Fields	Delta	Compressor Station # 11
Winter Range	Present	1,2 23,63	1,2 23,63	2,3 23,63	23,63	1,2
	peripheral	1,2 23	1,2 23	2,3 23	23,63	1,2
	major	1,2 23	1,2 23	2,3 23	23,63	1,2
	Historic	?	?	?	23	23
Migration Routes	Present	2,3 23	2,3 23	23	23	1,2
	minor	?	?	?	23	1,2
	major	2,3 23	2,3 23	?	23	1,2
	Historic	?	?	?	23	23
Calving Areas	Present	2,3	2,3	2,3	2,3	1,2
	Historic	?	?	?	?	23
Summer Range	Present	3,23 63	3,23 63	2,3 23	2,3 23	1,2
	Historic	?	?	?	23	23
Mineral Licks		?	?	?	?	?

1,2 documented contact within 5 miles

1,2 documented contact

1,2 unclear or conflicting documentation

? no data available

1,2 documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Bison

Herd or Region IV (Delta Junction to Alaska/Yukon Border)

		Right-of-Way	Alaska Highway	Air Fields	Sears Creek	Compressor Station # 12
Winter Range	Present	1,23 63	1,23	1,23	1,23	1
	peripheral	1,23	?	1,23	1,23	1
	major	1,23 63	1,23 63	1,23	1,23	1
	Historic	?	?	?	?	?
Migration Routes	Present	3,23 63	3,23 63	1,23	1,23	1
	minor	?	?	1,23	1,23	?
	major	3,23 32,63	3,23 32,63	1,23	1,23	?
	Historic	32	32	?	?	?
Calving Areas	Present	23	1,23	1,23	1,23	1,23
	Historic	1,23	1,23	?	?	?
Summer Range	Present	23,32 63	23,32 63	1,23 63	1,23 63	1,23 63
	Historic	?	?	?	?	?
Mineral Licks		?	?	?	?	?

1,2 documented contact within 5 miles

1,2 documented contact

1,2 unclear or conflicting documentation

? no data available

1,2 documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd) CONTACT MATRIX

Species Moose Herd or Region I (Prudhoe Bay to Atigun Pass)

		Right-of-Way	Haul Road	Air Fields	Franklin Bluffs	Happy Valley	Toolik	Galbraith	Atigun	Compressor Station # 1	Compressor Station # 2	Compressor Station # 3	Compressor Station # 4				
Winter Range	Present	1,2 33	1,2 33	1,2	1,2 33	1,2	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33				
	peripheral	1,2	1,2	1,2 33	1,2 33	1,2	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33				
	major	1,2 33	1,2 33	1,2 33	1,2 33	1,2	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33	1,2 33				
	Historic	?	?	?	?	?	?	?	?	?	?	?	?				
Migration Routes	Present	?	?	?	?	?	?	?	?	?	?	?	?				
	minor	?	?	?	?	?	?	?	?	?	?	?	?				
	major	?	?	?	?	?	?	?	?	?	?	?	?				
	Historic	?	?	?	?	?	?	?	?	?	?	?	?				
Calving Areas	Present	?	?	?	?	?	?	?	?	?	?	?	?				
	Historic	?	?	?	?	?	?	?	?	?	?	?	?				
Summer Range	Present	1	1	1	1	1	1	1	1	1	1	1	1				
	Historic	?	?	?	?	?	?	?	?	?	?	?	?				
Mineral Licks		?	?	?	?	?	?	?	?	?	?	?	?				

1,2 documented contact within 5 miles — 1,2 documented contact — 1,2 unclear or conflicting documentation — ? no data available — 1,2 documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Moose

Herd or Region II (Atigun Pass to Yukon River)

		Right-of-Way	Haul Road	Air Fields	Chandalar	Dietrich	Coldfoot	Prospect	Old Man	Five Mile	Compressor Station # 5	Compressor Station # 6	Compressor Station # 7	Compressor Station # 8
Winter Range	Present	2	2	1,2	1,2	1,2	1,2	2	1,2	1,2	1,2	1,2	2	1,2
	peripheral	2	2	1,2	1,2	1,2	1,2	2	1,2	1,2	1,2	1,2	2	1,2
	major	2	2	1,2	1,2	1,2	1,2	2	1,2	1,2	1,2	1,2	2	1,2
	Historic	?	?	?	?	?	?	?	?	?	?	?	?	?
Migration Routes	Present	?	?	?	?	?	?	?	?	?	?	?	?	?
	minor	?	?	?	?	?	?	?	?	?	?	?	?	?
	major	?	?	?	?	?	?	?	?	?	?	?	?	?
	Historic	?	?	?	?	?	?	?	?	?	?	?	?	?
Calving Areas	Present	21	21	21	1,2	21	?	?	?	?	1,2			?
	Historic	?	?	?	?	?	?	?	?	?	?	?	?	?
Summer Range	Present	1,21	1,21	1,21	1	1,21	1	1	1	1	1,2	1	1	1
	Historic	?	?	?	?	?	?	?	?	?	?	?	?	?
Mineral Licks		?	?	?	1	?	?	?	?	?	1,2	?	?	?

1,2	documented contact within 5 miles
1,2	documented contact
1,2	unclear or conflicting documentation
?	no data available
1,2	documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Moose   Herd or Region III (Yukon River to Delta Junction)

		Right-of-Way	Haul Road, Elliott, Richardson,[1]	Air Fields	Livengood	Fairbanks, (Fort Wainright)	Delta	Compressor Station # 9	Compressor Station # 10	Compressor Station # 11	Compressor Station # 12	[1]Highways					
Winter Range	Present	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	2	2						
	peripheral	1,2	1,2	1,2	1	1,2	1	1,2	1	2	1,2						
	major	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	2	2						
	Historic	?	?	?	?	?	?	?	?	?	?						
Migration Routes	Present	2	2	2	?	2	?	?	?	?	?						
	minor	?	?	?	?	2	?	?	?	?	?						
	major	?	?	?	?	2	?	?	?	?	?						
	Historic	?	?	?	?	?	?	?	?	?	?						
Calving Areas	Present	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1	1,2						
	Historic	?	?	?	?	?	?	?	?	?	?						
Summer Range	Present	1	1	1,2	1,2	1,2	1,2	1	1	1	1						
	Historic	?	?	?	?	?	?	?	?	?	?						
Mineral Licks		?	?	?	?	?	?	?	?	?	?						

1,2	documented contact within 5 miles
1,2	documented contact
1,2	unclear or conflicting documentation
?	no data available
1,2	documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species: Moose

Herd or Region: IV (Delta Junction to Alaska/Yukon Border)

		Right-of-Way	Alaska Highway	Sears Creek	Tok	Northway	Compressor Station # 13	Compressor Station # 14	Compressor Station # 15	Compressor Station # 16
Winter Range	Present	1	1	1	1	1	1	1	1	1
	peripheral	1	1	1	1	1	1	1	1	1
	major	1	1	1	1	1	1	1	1	1
	Historic	?	?	?	?	?	?	?	?	?
Migration Routes	Present	?	?	?	?	?	?	?	?	?
	minor	?	?	?	?	?	?	?	?	?
	major	?	?	?	?	?	?	?	?	?
	Historic	?	?	?	?	?	?	?	?	?
Calving Areas	Present	1	1	1	1	1	1	1	1	1
	Historic	?	?	?	?	?	?	?	?	?
Summer Range	Present	1	1	1	1	1	1	1	1	1
	Historic	?	?	?	?	?	?	?	?	?
Mineral Licks		?	?	?	?	?	?	?	?	?

1,2 documented contact within 5 miles	1,2 documented contact	1,2 unclear or conflicting documentation	? no data available	1,2 documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Caribou Herd or Region Western Arctic Herd

		Right-of-Way	Haul Road	Air Fields	Franklin Bluffs, Happy Valley	Toolik, Galbraith, Atigun,[1]	Prospect, Old Man	Compressor Stations # 1,2	Compressor Station # 3	Compressor Stations # 4,5	Compressor Stations # 6,7	Compressor Station # 8		[1]Chandalar, Dietrich, Coldfoot			
Winter Range	Present	1,4 5,62	1,4 5,62	1,4 5,62	4,5	5	1,4 5	4,5	4,5	5	5	5					
	peripheral	1,4 5,62	1,4 5,62	1,4 5,62	4,5	5	1,4 5	4,5	4,5	5	5	5					
	major	1,4 5	1,4 5	1,4 5	4,5	5	1,4 5	4,5	4,5	5	5	5					
	Historic	4	4	4	4	4	4	4	4	4	4	4					
Migration Routes	Present	1,2 5	1,2 5	1,2 5	5	1,2 5	5	5	5	1,2 5	1,2 5	1,2 5					
	minor	1,2 5	1,2 5	1,2 5	5	1,2 5	5	5	5	1,2 5	1,2 5	1,2 5					
	major	1,2 5	1,2 5	1,2 5	5	1,2 5	5	5	5	1,2 5	1,2 5	1,2 5					
	Historic	12	12	12	?	?	?	?	?	?	?	?					
Calving Areas	Present	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5					
	Historic	4	4	4	4	4	4	4	4	4	4	4					
Summer Range	Present	4,5	4,5	4,5	4,5	5	5	4,5	5	5	5	5					
	Historic	4	4	4	?	?	?	?	?	?	?	?					
Mineral Licks		?	?	?	?	?	?	?	?	?	?	?					

1,2	documented contact within 5 miles
1,2	documented contact
1,2	unclear or conflicting documentation
?	no data available
1,2	documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Caribou Herd or Region Central Arctic Herd

		Right-of-Way	Haul Road	Air Fields	Franklin Bluffs	Happy Valley	Toolik, Galbraith	Compressor Station # 1	Compressor Station # 2	Compressor Stations # 3,4							
Winter Range	Present	12,15	12,15	12,15	12,15	15	15	12,15	15	15							
	peripheral	12,15	12,15	12,15	12,15	12,15	12,15	?	?	?							
	major	12,15	12,15	12,15	12,15	12,15	12,15	?	?	?							
	Historic	12	12	12	?	?	?	?	?	?							
Migration Routes	Present	2,14	2,14	2,14	?	?	?	?	?	?							
	minor	2,14	2,14	2,14	?	?	?	?	?	?							
	major	2,14	2,14	2,14	?	?	?	?	?	?							
	Historic	12	12	12	?	?	?	?	?	?							
Calving Areas	Present	12,13	12,13	12,13	2,12	2,12 13	2,12 13	2,12	2,12 13	2,12 13							
	Historic	12	12	12	12	?	?	?	?	?							
Summer Range	Present	1	1	1	15	15	15	15	15	15							
	Historic	4,12	4,12	4,12	?	?	?	?	?	?							
Mineral Licks		?	?	?	?	?	?	?	?	?							

1,2	documented contact within 5 miles
1,2	documented contact
1,2	unclear or conflicting documentation
?	no data available
1,2	documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Caribou   Herd or Region Porcupine Herd

		Right-of-Way	Haul Road	Air Fields	Franklin Bluffs, Happy Valley	Toolik	Galbraith, Atigun Chandalar	Dietrich	Coldfoot	Prospect, Old Man	Compressor Stations # 1,2	Compressor Station # 3	Compressor Stations # 4,5	Compressor Station # 6	Compressor Stations # 7,8		
Winter Range	Present	1,5 9	1,5 9	1,5	1,5	1,5	5	1,5	1,5	1,5	1,5	1,5	5	1,5	1,5		
	peripheral	1,5 9	1,5 9	1,5	1,5	1,5	5	1,5	1,5	1,5	1,5	1,5	5	1,5	1,5		
	major	1,5	1,5	1,5	1,5	1,5	5	1,5	1,5	1,5	1,5	1,5	5	1,5	1,5		
	Historic	4	4	4	4	?	?	4	4	4	4	4	?	4	4		
Migration Routes	Present	1,4 5,8 59	1,4 5,8 59	1,4 5,8 59	12	1	1,4 5,8 59	1	2,5	1,5	12	1,5	1,4 5,8 59	2	1,5		
	minor	1,5 8,59	1,5 8,59	1,5 8,59	12	1	1,5 8,59	1	2,5	1,5	12	1,5	1,5 8,59	2	1,5		
	major	1,5 8,59	1,5 8,59	1,5 8,59	12	1	1,5 8,59	1	2,5	1,5	12	1,5	1,5 8,59	2	1,5		
	Historic	4,5 12	4,5 12	4,5 12	4,12	?	5	5	4	4	4,12	?	5	5	4		
Calving Areas	Present	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5	1,4 5		
	Historic	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
Summer Range	Present	1,5	1,5	1,5	1,5	5	5	5	5	5	1,5	1,5	5	5	5		
	Historic	4	4	4	5	?	?	4	4	4	5,12	?	?	4	4		
Mineral Licks		?	?	?	?	?	?	?	?	?	?	?	?	?	?		

1,2	documented contact within 5 miles	1,2	documented contact	1,2	unclear or conflicting documentation	?	no data available	1,2	documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

CONTACT MATRIX

Species Caribou Herd or Region Forty-Mile Herd

		Right-of-Way	Elliott, Richardson, Alaska[1]	Air Fields	Livengood	Fairbanks, Delta, Sears Creek	Tok, Northway										
Winter Range	Present	1,10	1,10	1,10	1,7	1,2 7	1,10										
	peripheral	1,10	1,10	1,10	1,7	1,2 7	1,10										
	major	1,10	1,10	1,10	1,7	1,2 7	1,10										
	Historic	4,6	4,6	4,6	4,6	4,6	6										
Migration Routes	Present	1,7	1,7	1,7	1,7	1,2 7	1										
	minor	1,7	1,7	1,7	1,7	1,2 7	1										
	major	1,7	1,7	1,7	1,7	1,2 7	1										
	Historic	4,6	4,6	4,6	4,6	4,6	4,6										
Calving Areas	Present	7	7	7	7	7	7										
	Historic	6	6	6	6	6	6										
Summer Range	Present	7	7	7	7	7	7										
	Historic	6	6	6	6	6	6										
Mineral Licks		?	?	?	?	?	?										

[1] Highways

1,2	documented contact within 5 miles
1,2	documented contact
1,2	unclear or conflicting documentation
?	no data available
1,2	documented no contact

(numbers in boxes refer to Matrix References)

Appendix 1. (cont'd)

Contact Matrix for Furbearers Found Along the Proposed NWA Corridor

	Prudhoe Bay-Brooks Range	Brooks Range-Yukon River	Yukon River-Delta Junction	Delta Junction-Alaska/Yukon Border
Lynx	174*,175,173	174,175,173	174,175,4	174,175,173
Wolverine	174,173,74,1	174,173,74,1	174,173,175,1	174,74,173,175,1
Marten	174,175	174,74,175	174,175	174,175
Mink	174,74,173,175	174,74,173,175	174,74,173,175	174,74,173,175
Ermine	174,74,173,175	174,74,173,175	174,74,173,175	174,74,173,175
Least Weasel	174,74,173,175	174,74,173,175	174,74,173,175	174,74,173,175
River Otter	174,74,175	174,74,175	174,173,175	174,74,175
Muskrat		174,175	174,175	174,175
Beaver		175	175	175

* See list of Matrix Citations

Appendix 2.

IMPACT MATRIX

Species Dall Sheep Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Runway Berm Construction
Barriers to movement or migration	?	?	60	?	?	?	?	?
Mechanical	?	?	?	?	?	?	?	?
Sensory	?	?	60	?	?	?	?	?
Other disturbances	?	?	60	20,21 26	28	28	20,60	?
Mechanical	?	?	?	?	?	?	?	?
Sensory	?	?	60	20,21 26	28	28	20,60	?
Direct mortality	?	?	?	?	?	?	?	?
Habitat modification	*	*	22,36	*	*	*	*	*
Remove forage	?	?	*	*	?	?	*	?
Remove cover	?	?	*	*	?	?	*	?
Add forage	*	*	?	*	*	*	*	*
Add cover	*	*	*	*	*	?	*	?

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Dall Sheep　　　Period Construction

	Clearing	Slash Disposal	Ditching	Blasting	Bed Preparation	Assembling Pipe	Laying Pipe	Back Filling	Preparation of Berm	Revegetation	Gravel Pit Use	Construction of Compressors	Ground Traffic	Air Traffic	Fuel Spillage	Garbage Dump	Thermal Erosion
Barriers to movement or migration	?	?	61	?	?	?	?	?	?	?	?	?	60	?	?	?	?
Mechanical	?	?	61	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Sensory	?	?	?	?	?	?	?	?	?	?	?	?	60	?	?	?	?
Other disturbances	?	?	?	28	?	?	?	?	?	?	?	?	60	20,21 26	?	?	?
Mechanical	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Sensory	?	?	?	28	?	?	?	?	?	?	?	?	60	20,21 26	?	?	?
Direct mortality	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Habitat modification	*	*	*	*	*	*	*	*	*	*	*	*	22,36	*	*	*	?
Remove forage	?	?	*	*	*	*	*	*	*	*	?	*	*	*	?	?	?
Remove cover	?	*	*	*	*	*	*	*	*	*	?	*	*	*	?	?	?
Add forage	*	?	*	*	*	*	*	*	*	30,58	?	*	?	*	*	?	?
Add cover	*	?	*	*	*	*	*	*	*	*	?	*	*	*	*	?	?

1,2 Adequate quantitative data available　　* Impact is obvious　　1,2 Available data inadequate or anecdotal　　? Impact unknown　　* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd) IMPACT MATRIX

Species Dall Sheep Period Construction

	Alteration of Drainage	Human Disturbance	Presence of Runway Berm
Barriers to movement or migration	?	?	?
Mechanical	?	?	?
Sensory	?	?	?
Other disturbances	?	20,60	?
Mechanical	?	?	?
Sensory	?	20,60	?
Direct mortality	?	?	?
Habitat modification	36	*	*
Remove forage	?	*	?
Remove cover	?	*	?
Add forage	?	*	*
Add cover	?	*	?

1,2 — Adequate quantitative data available

* — Impact is obvious

1,2 — Available data inadequate or anecdotal

? — Impact unknown

* — No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Dall Sheep | Period Operation

	Presence of Compressor	Compressor Noise	Compressor Exhaust	Presence of Berm	Revegetation	Maintenance	Ground Traffic	Air Traffic	Garbage Dump	Human Disturbance	Presence of Runway Berm						
Barriers to movement or migration	?	27	?	?	?	?	60	?	?	?	?						
Mechanical	?	?	?	?	?	?	?	?	?	?	?						
Sensory	?	27	?	?	?	?	60	?	?	?	?						
Other disturbances	?	27,57	?	?	?	?	60	20,21 26	?	20,60	?						
Mechanical	?	?	?	?	?	?	?	?	?	?	?						
Sensory	27	27,57	?	?	?	?	60	20,21 26	?	20,60	?						
Direct mortality	?	?	?	?	?	?	?	?	?	?	?						
Habitat modification	*	*	?	*	*	?	22,36	*	*	*	*						
Remove forage	?	*	?	*	*	?	*	*	?	*	?						
Remove cover	?	*	?	*	*	?	*	*	?	*	?						
Add forage	?	*	?	*	58	?	?	*	?	*	*						
Add cover	?	*	?	*	*	?	*	*	?	*	?						

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Dall Sheep Period Abandonment

	Presence of Right-of-Way	Presence of Berm	Vegetation Succession	Presence of Compressor	Presence of Support Facilities	Ground Traffic	Air Traffic	Presence of Runway Berm
Barriers to movement or migration	?	?	?	?	?	60	?	?
Mechanical	?	?	?	?	?	?	?	?
Sensory	?	?	?	?	?	60	?	?
Other disturbances	?	?	?	?	?	60	20,21 26	?
Mechanical	?	?	?	?	?	?	?	?
Sensory	?	?	?	?	?	60	20,21 26	?
Direct mortality	?	?	?	?	?	?	?	?
Habitat modification	*	*	*	*	*	22,36	*	*
Remove forage	?	?	?	?	?	*	*	?
Remove cover	?	?	?	?	?	*	*	?
Add forage	?	?	?	?	?	22	*	*
Add cover	?	?	?	?	?	*	*	?

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species BISON

Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance									
Barriers to movement or migration	?	?	?	?	?	?	?									
Mechanical	?	?	?	?	?	?	?									
Sensory	?	?	?	?	?	?	?									
Other disturbances	?	?	?	77	?	?	?									
Mechanical	?	?	?	?	?	?	?									
Sensory	?	?	?	77	?	?	?									
Direct mortality	?	?	23,34	?	?	?	?									
Habitat modification	*	*	*	*	*	*	*									
Remove forage	*	*	*	*	*	*	*									
Remove cover	?	?	*	*	?	?	*									
Add forage	*	*	*	*	*	*	*									
Add cover	*	*	*	*	*	?	*									

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Bison   Period Construction

	Clearing	Slash Disposal	Ditching	Blasting	Bed Preparation	Assembling Pipe	Laying Pipe	Back Filling	Preparation of Berm	Revegetation	Gravel Pit Use	Construction of Compressors	Ground Traffic	Air Traffic	Fuel Spillage	Garbage Dump	Thermal Erosion
Barriers to movement or migration	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Mechanical	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Sensory	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Other disturbances	?	?	?	?	?	?	?	?	?	?	?	?	?	77	?	?	?
Mechanical	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Sensory	?	?	?	?	?	?	?	?	?	?	?	?	?	77	?	?	?
Direct mortality	?	?	?	?	?	?	?	?	?	?	?	?	23,34	?	?	?	?
Habitat modification	*	*	*	*	*	*	*	*	*	*	*	*	*	*	22	*	*
Remove forage	*	?	*	*	*	*	*	*	*	*	?	*	*	*	?	?	?
Remove cover	*	?	*	*	*	*	*	*	*	*	?	*	*	*	?	?	?
Add forage	*	*	*	*	*	*	*	*	*	23	?	*	*	*	?	*	?
Add cover	*	?	*	*	*	*	*	*	*	?	?	*	*	*	?	*	?

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Bison

Period Construction

	Alteration of Drainage	Human Disturbance	Presence of Runway Berm												
Barriers to movement or migration	?	?	?												
Mechanical	?	?	?												
Sensory	?	?	?												
Other disturbances	?	?	?												
Mechanical	?	?	?												
Sensory	?	?	?												
Direct mortality	?	?	?												
Habitat modification	?	?	*												
Remove forage	?	?	*												
Remove cover	?	?	*												
Add forage	?	?	*												
Add cover	?	?	*												

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Bison

Period Operation

	Presence of Compressor	Compressor Noise	Compressor Exhaust	Presence of Berm	Revegetation	Maintenance	Ground Traffic	Air Traffic	Garbage Dump	Human Disturbance							
Barriers to movement or migration	?	?	?	?	?	?	?	?	?	?							
Mechanical	?	?	?	?	?	?	?	?	?	?							
Sensory	?	?	?	?	?	?	?	?	?	?							
Other disturbances	?	?	?	?	?	?	?	77	?	?							
Mechanical	?	?	?	?	?	?	?	?	?	?							
Sensory	?	?	?	?	?	?	?	77	?	?							
Direct mortality	?	?	?	?	?	?	23,34	?	?	?							
Habitat modification	*	*	?	*	*	?	*	*	*	*							
Remove forage	?	*	?	*	*	?	*	*	?	*							
Remove cover	?	*	?	*	*	?	*	*	?	*							
Add forage	?	*	?	*	23	?	*	*	?	*							
Add cover	?	*	?	*	?	?	*	*	?	*							

1,2 — Adequate quantitative data available

* — Impact is obvious

1,2 — Available data inadequate or anecdotal

? — Impact unknown

* — No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Bison   Period Abandonment

	Presence of Right-of-Way	Presence of Berm	Vegetation Succession	Presence of Compressor	Presence of Support Facilities	Ground Traffic	Air Traffic									
Barriers to movement or migration	?	?	?	?	?	?	?									
Mechanical	?	?	?	?	?	?	?									
Sensory	?	?	?	?	?	?	?									
Other disturbances	?	?	?	?	?	?	77									
Mechanical	?	?	?	?	?	?	?									
Sensory	?	?	?	?	?	?	77									
Direct mortality	?	?	?	?	?	23,34	?									
Habitat modification	*	*	*	*	*	*	*									
Remove forage	?	?	?	?	?	*	*									
Remove cover	?	?	?	?	?	*	*									
Add forage	?	?	?	?	?	*	*									
Add cover	?	?	*	?	?	*	*									

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Moose

Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Runway Berm Construction
Barriers to movement or migration	?	?	?	?	66	?	?	66
Mechanical	?	?	?	?	?	?	?	?
Sensory	?	?	?	?	66	?	?	?
Other disturbances	56	56	60,64 65	27,45 52,53 54	66	?	52,53 56,60 65,66 37	66
Mechanical	?	?	64	?	?	?	?	?
Sensory	56	56	60,65	27,45 52,53 54	66	?	52,53 56,60 65,66 37	66
Direct mortality	?	?	47	?	?	?	?	?
Habitat modification	*	*	22,36	*	*	*	*	*
Remove forage	*	?	?	*	*	*	*	?
Remove cover	*	?	?	*	*	*	*	?
Add forage	?	*	?	*	*	*	*	*
Add cover	*	*	*	*	*	?	*	*

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Moose   Period Construction

	Clearing	Slash Disposal	Ditching	Blasting	Bed Preparation	Assembling Pipe	Laying Pipe	Back Filling	Preparation of Berm	Revegetation	Gravel Pit Use	Construction of Compressors	Ground Traffic	Air Traffic	Fuel Spillage	Garbage Dump	Thermal Erosion
Barriers to movement or migration	?	?	55,61	?	66	55	55	?	?	?	55,61 66	66	?	?	?	?	?
Mechanical	?	?	55	?	?	55	55	?	?	?	55	?	?	?	?	?	?
Sensory	?	?	61	?	66	?	?	?	?	?	61,66	66	?	?	?	?	?
Other disturbances	56,65 66	?	66	?	66	?	66	66	66	60,61	66	66	60,64 65	27,45 52,53 54	?	?	?
Mechanical	?	?	?	?	?	?	?	?	?	?	?	?	64	?	?	?	?
Sensory	56,65 66	?	66	?	66	?	66	66	66	60,61	66	66	60,65	27,45 52,53 54	?	?	?
Direct mortality	?	?	?	?	?	?	?	?	?	?	?	?	47	?	?	?	?
Habitat modification	*	*	*	?	*	*	*	*	*	*	*	*	22,36	*	*	*	?
Remove forage	*	?	?	?	*	*	*	*	*	*	*	*	?	*	?	?	?
Remove cover	*	?	?	?	*	*	*	*	*	*	*	*	?	*	?	?	?
Add forage	?	?	*	*	*	*	*	*	*	*	*	*	?	*	*	?	?
Add cover	*	?	*	*	*	*	*	*	*	*	*	*	*	*	*	?	?

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Moose Period Construction

	Alteration of Drainage	Human Disturbance	Presence of Runway Berm
Barriers to movement or migration	?	?	?
Mechanical	?	?	?
Sensory	?	?	?
Other disturbances	?	52,53 56,60 65,66 37	?
Mechanical	?	?	?
Sensory	?	52,53 56,60 65,66 37	?
Direct mortality	?	?	?
Habitat modification	36	*	*
Remove forage	?	*	?
Remove cover	?	*	?
Add forage	?	*	?
Add cover	?	*	?

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Moose Period Operation

	Presence of Compressor	Compressor Noise	Compressor Exhaust	Presence of Berm	Revegetation	Maintenance	Ground Traffic	Air Traffic	Garbage Dump	Human Disturbance	Presence of Runway Berm						
Barriers to movement or migration	?	?	?	50,51 64	?	?	?	?	?	?	?						
Mechanical	?	?	?	64	?	?	?	?	?	?	?						
Sensory	?	?	?	50,51	?	?	?	?	?	?	?						
Other disturbances	?	?	?	50,51	60,61	?	60,64 65	27,45 52,53 54	?	52,53 56,60 65,66 37	?						
Mechanical	?	?	?	?	?	?	64	?	?	?	?						
Sensory	?	?	?	50,51	60,61	?	60,65	27,45 52,53 54	?	52,53 56,60 65,66 37	?						
Direct mortality	?	?	?	?	?	?	47	?	?	?	?						
Habitat modification	*	*	?	*	*	?	22,36	*	*	*	*						
Remove forage	?	*	?	?	*	?	?	*	?	*	?						
Remove cover	?	*	?	?	*	?	?	*	?	*	?						
Add forage	*	*	?	?	*	?	?	*	?	*	?						
Add cover	?	*	?	?	*	?	?	*	*	*	?						

1,2 Adequate quantitative data available	* Impact is obvious	1,2 Available data inadequate or anecdotal	? Impact unknown	* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species MOOSE

Period Abandonment

	Presence of Right-of-Way	Presence of Berm	Vegetation Succession	Presence of Compressor	Presence of Support Facilities	Ground Traffic	Air Traffic	Presence of Runway Berm
Barriers to movement or migration	50,51 64	50,51 64	35	?	?	?	?	?
Mechanical	64	64	35	?	?	?	?	?
Sensory	50,51	50,51	35	?	?	?	?	?
Other disturbances	?	50,51	29,47	?	?	60,64 65	27,45 52,53 54	?
Mechanical	?	?	?	?	?	64	?	?
Sensory	?	50,51	29,47	?	?	60,65	27,45 52,53 54	?
Direct mortality	?	?	?	?	?	47	?	?
Habitat modification	*	*	*	*	*	20,36	*	*
Remove forage	?	?	?	?	?	?	*	?
Remove cover	?	?	?	?	?	?	*	?
Add forage	?	?	?	?	?	?	*	?
Add cover	?	?	?	?	?	?	*	?

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Caribou Period Pre-construction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Runway Berm Construction
Barriers to movement or migration	27,40 36	38	15,22 39,40 41,60 68,76	38	?	?	?	?
Mechanical	40	?	?	?	?	?	?	?
Sensory	27,76	?	15,22 39,40 41,60 68,76	38	?	?	?	?
Other disturbances	27,40 76	?	22,60 68	27,41 43,44 45,46 62,69 70	?	?	22,38 40,60 70,76	?
Mechanical	40	?	?	?	?	?	?	?
Sensory	27,76	?	22,60 68	27,41 43,44 45,46 62,69 70	?	?	22,38 40,60 70,76	?
Direct mortality	?	?	39 40,68	?	?	?	?	?
Habitat modification	*	*	22,36	*	*	*	*	*
Remove forage	?	?	?	*	*	*	*	?
Remove cover	?	?	?	*	*	*	*	?
Add forage	?	*	22	*	*	*	*	*
Add cover	*	*	*	*	*	?	*	*

1,2 Adequate quantitative data available; * Impact is obvious; 1,2 Available data inadequate or anecdotal; ? Impact unknown; * No impact, obvious

(numbers in boxes refer to Matrix References)

IMPACT MATRIX

Appendix 2. (cont'd)

Species Caribou Period Construction

	Clearing	Slash Disposal	Ditching	Blasting	Bed Preparation	Assembling Pipe	Laying Pipe	Back Filling	Preparation of Berm	Revegetation	Gravel Pit Use	Construction of Compressors	Ground Traffic	Air Traffic	Fuel Spillage	Garbage Dump	Thermal Erosion
Barriers to movement or migration	27,40 41	?	*	67	?	11,12 13,22 27,49 72,73 78	?	?	?	?	?	?	15,22 39,40 41,60 68,76	38	?	?	?
Mechanical	40	?	*	?	?	49,78	?	?	?	?	?	?	?	?	?	?	?
Sensory	27,41	?	?	67	?	11,12 72	?	?	?	?	?	?	15,22 39,40 41,60 68,76	38	?	?	?
Other disturbances	27	?	?	67	?	?	?	?	?	22	?	?	22,60 68	27,41 43,44 45,46 62,69 70	?	22	?
Mechanical	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Sensory	27	?	?	67	?	?	?	?	?	22	?	?	22,60 68	27,41 43,44 45,46 62,69 70	?	22	?
Direct mortality	?	?	?	?	?	?	?	?	?	?	?	?	39,40 68	?	?	?	?
Habitat modification	*	*	*	?	*	*	*	*	*	*	*	*	22,36	*	*	*	*
Remove forage	*	?	?	?	*	*	*	*	*	*	*	*	?	*	?	?	?
Remove cover	?	?	?	?	*	*	*	*	*	*	?	*	?	*	?	?	?
Add forage	*	?	*	*	*	*	*	*	*	*	*	*	22	*	*	?	?
Add cover	*	?	*	*	*	*	*	*	*	?	?	?	*	*	?	?	?

1,2 Adequate quantitative data available; * Impact is obvious; 1,2 Available data inadequate or anecdotal; ? Impact unknown; * No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Caribou Period Construction

	Alteration of Drainage	Human Disturbance	Presence of Runway Berm
Barriers to movement or migration	?	?	22,41
Mechanical	?	?	41
Sensory	?	?	22,41
Other disturbances	22	22,38 40,60 70,76	?
Mechanical	?	?	?
Sensory	22	22,38 40,60 70,76	?
Direct mortality	?	?	?
Habitat modification	22,36	*	*
Remove forage	?	*	?
Remove cover	?	*	?
Add forage	?	*	?
Add cover	?	*	?

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Caribou　　　Period Operation

	Presence of Compressor	Compressor Noise	Compressor Exhaust	Presence of Berm	Revegetation	Maintenance	Ground Traffic	Air Traffic	Garbage Dump	Human Disturbance	Presence of Runway Berm						
Barriers to movement or migration	27,42	27	?	22,41	?	?	15,22 39,40 41,60 68,76	38	?	?	22,41						
Mechanical	?	?	?	41	?	?	?	?	?	?	41						
Sensory	?	27	?	22,41	?	?	15,22 39,40 41,60 68,76	38	?	?	22,41						
Other disturbances	22,79	27	112	22,40 79	22	?	22,60 68	27,41 43,44 45,46 62,69 70	22	22,38 40,60 70,76	?						
Mechanical	22,79	?	?	?	?	?	?	?	?	?	?						
Sensory	?	27	?	22,40	22	?	22,60 68	27,41 43,44 45,46 62,69 70	?	22,38 40,60 70,76	?						
Direct mortality	?	?	?	?	?	?	39,40 68	?	?	?	?						
Habitat modification	*	*	?	*	*	?	22,36	*	22	*	*						
Remove forage	?	*	112	?	?	?	?	*	?	*	?						
Remove cover	?	*	?	?	?	?	?	*	?	*	?						
Add forage	*	*	?	?	22	?	22	*	?	*	?						
Add cover	?	*	?	?	?	?	*	*	?	*	?						

Legend:
- [1,2] Adequate quantitative data available
- [*] Impact is obvious
- [1,2] Available data inadequate or anecdotal
- [?] Impact unknown
- [*] No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Caribou

Period Abandonment

	Presence of Right-of-Way	Presence of Berm	Vegetation Succession	Presence of Compressor	Presence of Support Facilities	Ground Traffic	Air Traffic	Presence of Runway Berm
Barriers to movement or migration	27,40 41	22,41	?	27,42	27,42	15,22 39,40 41,60 68,76	38	22,41
Mechanical	40	41	?	?	?	?	?	41
Sensory	27,41	22,41	?	?	?	15,22 39,40 41,60 68,76	38	22,41
Other disturbances	27	22,40 79	?	22,79	22,79	22,60 68	27,41 43,44 45,46 62,69 70	?
Mechanical	?	?	?	22,79	22,79	?	?	?
Sensory	27	22,40	?	?	?	22,60 68	27,41 43,44 45,46 62,69 70	?
Direct mortality	?	?	?	?	?	39,40 68	?	?
Habitat modification	*	*	*	*	*	22,36	*	*
Remove forage	?	?	?	?	?	?	*	?
Remove cover	?	?	?	?	?	?	*	?
Add forage	?	?	?	*	*	22	*	?
Add cover	?	?	?	?	?	*	*	?

Legend: 1,2 Adequate quantitative data available; * Impact is obvious; 1,2 Available data inadequate or anecdotal; ? Impact unknown; * No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd) IMPACT MATRIX

Species Grizzly and Black Bear Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Stroage	Fuel Spillage	Material Storage	Animal Control			
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*			
Other disturbances	*	?	60 145	45 138 139 154	?	?	60 146 150	*	*	*	*	?	*	*			
Mechanical	*	*	*	*	?	*	?	*	*	*	*	*	*	*			
Sensory	*	?	60 145	45 138 139 154	?	?	60 146 150	*	*	*	*	?	*	*			
Direct mortality	*	*	147 150 151	*	*	*	150 178	*	*	*	*	*	*	61 88 179			
Habitat modification	*	*	151	161	141	88 143	146 154 180	*	*	*	*	?	141 142	?			
Remove forage	*	*	?	?	?	?	146 154	*	*	*	*	?	?	?			
Remove cover	*	*	?	161	*	?	154 180	*	*	*	*	?	*	*			
Add forage	*	*	151	*	*	?	*	*	*	*	*	*	?	*			
Add cover	*	*	*	*	141	88 143	*	*	*	*	*	*	141 142	*			
Artificial food sources	*	*	*	*	*	*	*	83 140 155	*	60 149 151 152 155	*	*	*	*			
Habituation	*	*	60	27	?	*	142 155	88 140 155	*	60 149 151 152 155	*	*	*	*			

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Grizzly and Black Bear Period Construction

	Clearing	Slash Disposal	Ditching	Bed Preparation	Stringing Pipe	Welding Pipe	Laying Pipe	Backfilling	Berm Preparation	Revegetation	Material Site	Ground Traffic	Air Traffic	Compressor Site Construction	Dust Production	Fuel Spillage	Blasting
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	*	*	*	*	*	?	60 45	27 45 138 139 154	?	?	?	*
Mechanical	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*	*
Sensory	?	*	*	*	*	*	*	*	*	*	?	60 45	27 45 138 139 154	?	?	?	*
Direct mortality	*	*	*	*	*	*	*	*	*	*	*	147 150 151	*	*	*	*	160
Habitat modification	*	*	*	*	*	*	*	*	*	60 102 143 148	154	151	161	88 143	*	?	*
Remove forage	*	?	*	*	*	*	*	*	*	*	*	?	?	*	?	?	*
Remove cover	*	?	*	*	*	*	*	*	*	*	154	?	161	*	*	?	*
Add forage	*	?	*	*	*	*	*	*	*	60 102 143 148	*	151	*	*	*	*	*
Add cover	*	*	*	*	*	*	*	*	*	?	*	*	*	88 143	*	*	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Habituation	*	*	*	*	*	*	*	*	*	*	*	60 142	27	*	*	*	*

1,2 — Adequate quantitative data available

* — Impact is obvious

1,2 — Available data inadequate or anecdotal

? — Impact unknown

* — No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Grizzly and Black Bear   Period Construction

	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Road Construction	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*
Other disturbances	60 146 150	*	*	*	*	?	*	*
Mechanical	?	*	*	*	*	?	*	*
Sensory	60 146 150	*	*	*	*	?	*	*
Direct mortality	150 178	*	*	*	*	*	*	88 61 179
Habitat modification	146 154 180	*	*	*	*	141	141	?
Remove forage	146 154	*	*	*	*	?	?	?
Remove cover	154 180	*	*	*	*	*	*	*
Add forage	*	*	*	*	*	*	*	*
Add cover	*	*	*	*	*	141	141	*
Artificial food sources	*	88 155 140	*	60 152 149 155 151	*	*	*	*
Habituation	142 155	140 88 155	*	60 152 149 155 151	*	?	*	*

1,2 — Adequate quantitative data available

* — Impact is obvious

1,2 — Available data inadequate or anecdotal

? — Impact unknown

* — No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Grizzly and Black Bear Period Operation

	Compressor Noise	Compressor Presence	Compressor Exhaust	Compressor Blowdown	Presence of Right-of-way	Berm	Revegetation	Ground Traffic	Air Traffic	Human Disturbance	Garbage Disposal	Littering	Feeding	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	144	?	*	?	*	*	*	60 145	45 138 139 154	60 146 150	*	*	*	*	?	*	*
Mechanical	*	*	*	*	*	*	*	*	*	?	*	*	*	*	*	*	*
Sensory	144	?	*	?	*	*	*	60 145	45 138 139 154	60 146 150	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	147 150 151	*	150 178	*	*	*	*	*	*	61 88 179
Habitat modification	?	88 142 143	*	?	141	141	102 143 148	151	161	146 154 180	*	*	*	*	?	141 142	?
Remove forage	?	*	*	?	*	*	*	?	?	146 154	*	*	*	*	?	?	?
Remove cover	*	*	*	*	*	*	*	?	161	154 180	*	*	*	*	?	*	*
Add forage	*	*	*	*	?	?	102 143 148	151	*	*	*	*	*	*	*	?	*
Add cover	*	88 142 143	*	*	141	141	?	*	*	*	*	*	*	*	*	141 142	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	60 149 151 152	*	88 140 155	*	*	*	*
Habituation	?	*	*	*	60	*	*	60 142	27	142 155	60 149 151 152	*	88 140 155	*	*	*	*

1,2 — Adequate quantitative data available

* — Impact is obvious

1,2 — Available data inadequate or anecdotal

? — Impact unknown

* — No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Wolf   Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	*	?	111	120 107 133 108	?	?	60 136 108	*	*	*	*	?	*	*
Mechanical	*	*	*	*	?	*	?	*	*	*	*	*	*	*
Sensory	*	?	111	120 107 108 133	?	?	60 136 108	*	*	*	*	?	*	*
Direct mortality	*	*	104 111 176	*	*	*	108 134 176	*	*	*	*	*	*	137
Habitat modification	*	*	60, 111 22, 108 104 112	108	*	88	132 108 111	*	*	*	*	?	*	?
Remove forage	*	*	111	?	?	?	108	*	*	*	*	?	?	?
Remove cover	*	*	108 111	108	*	?	108 111 132	*	*	*	*	?	*	*
Add forage	*	*	104 22 60 111 112	*	*	*	*	*	*	*	*	*	?	*
Add cover	*	*	*	*	?	88	*	*	*	*	*	*	*	*
Artificial food sources	*	*	*	*	*	*	*	77 88	*	103 104 112	*	*	*	*
Habituation	*	*	22 60	45 120	?	*	88 108 177	77 88	*	103 104 112	*	*	*	*

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Wolf Period Construction

	Clearing	Slash Disposal	Ditching	Bed Preparation	Stringing Pipe	Welding Pipe	Laying Pipe	Backfilling	Berm Preparation	Revegetation	Material Site	Ground Traffic	Air Traffic	Compressor Site Construction	Dust Production	Fuel Spillage	Blasting
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	*	*	*	*	*	?	111	107 108 120 133	?	?	?	*
Mechanical	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*	*
Sensory	?	*	*	*	*	*	*	*	*	*	?	111	107 108 120 133	?	?	?	*
Direct mortality	*	*	*	*	*	*	*	*	*	*	*	104 111 176	*	*	*	*	*
Habitat modification	*	*	*	*	*	*	*	*	*	102	*	22,111 60,104 108 112	108	88	*	?	*
Remove forage	*	?	*	*	*	*	*	*	*	*	*	111	?	*	?	?	*
Remove cover	*	?	*	*	*	*	*	*	*	*	*	108 111	108	*	*	?	*
Add forage	*	?	*	*	*	*	*	*	*	102	*	22,111 60 104 112	*	*	*	*	*
Add cover	*	*	*	*	*	*	*	*	*	?	*	*	*	88	*	*	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Habituation	*	*	*	*	*	*	*	*	*	*	*	22 60	45 108 120	*	*	*	*

1,2	Adequate quantitative data available	*	Impact is obvious	1,2	Available data inadequate or anecdotal	?	Impact unknown	*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Wolf   Period Construction

	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Road Construction	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*
Other disturbances	60 108 136	*	*	*	*	?	*	*
Mechanical	?	*	*	*	*	?	*	*
Sensory	60 108 136	*	*	*	*	?	*	*
Direct mortality	108 134 176	*	*	*	*	*	*	137
Habitat modification	108 111 132	*	*	*	*	*	*	?
Remove forage	108	*	*	*	*	?	?	?
Remove cover	108 111 132	*	*	*	*	*	*	*
Add forage	*	*	*	*	*	*	?	*
Add cover	*	*	*	*	*	?	*	*
Artificial food sources	*	77 88	*	103 104 112	*	*	*	*
Habituation	88 108 177	77 88	*	103 104 112	*	?	*	*

1,2 Adequate quantitative data available; * Impact is obvious; 1,2 Available data inadequate or anecdotal; ? Impact unknown; * No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Wolf Period Operation

	Compressor Noise	Compressor Presence	Compressor Exhaust	Compressor Blowdown	Presence of Right-of-way	Berm	Revegetation	Ground Traffic	Air Traffic	Human Disturbance	Garbage Disposal	Littering	Feeding	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	?	*	?	*	*	*	111	107 108 120 133	60 108 136	*	*	*	*	?	*	*
Mechanical	*	*	*	*	*	*	*	*	*	?	*	*	*	*	*	*	*
Sensory	?	?	*	?	*	*	*	111	107 108 120 133	60 108 136	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	104 111 176	*	108 134 176	*	*	*	*	*	*	137
Habitat modification	?	88	*	?	?	22	102	22,111 60,108 104 112	108	108 111 132	*	*	*	*	?	*	?
Remove forage	?	?	*	?	*	*	*	111	?	108	*	*	*	*	?	?	?
Remove cover	*	*	*	*	*	*	*	108 111	108	108 111 132	*	*	*	*	?	*	*
Add forage	*	*	*	*	?	?	102	22,60 104 111 112	*	*	*	*	*	*	*	?	*
Add cover	*	88	*	*	*	22	?	*	*	*	*	*	*	*	*	*	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	103 104 112	*	77 88	*	*	*	*
Habituation	?	88	*	*	*	*	*	22 60	45 120	88 108 177	103 104 112	*	77 88	*	*	*	*

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Coyote   Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	*	?	?	?	?	?	?	*	*	*	*	?	*	*
Mechanical	*	*	*	*	?	*	?	*	*	*	*	*	*	*
Sensory	*	?	?	?	?	?	?	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	*	*	*	*	*	*	127
Habitat modification	*	*	*	?	*	*	?	*	*	*	*	?	?	?
Remove forage	*	*	?	*	?	?	?	*	*	*	*	?	?	?
Remove cover	*	*	?	?	*	*	?	*	*	*	*	?	*	*
Add forage	*	*	*	*	*	*	*	*	*	*	*	*	?	*
Add cover	*	*	*	*	?	?	*	*	*	*	*	*	?	*
Artificial food sources	*	*	*	*	*	*	*	127 129	127 130 131	127 130 131	*	*	*	*
Habituation	*	*	?	?	?	?	128 129 131	127 129	127 130 131	127 130 131	*	*	*	*

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Coyote　　Period Construction

	Clearing	Slash Disposal	Ditching	Bed Preparation	Stringing Pipe	Welding Pipe	Laying Pipe	Backfilling	Berm Preparation	Revegetation	Material Site	Ground Traffic	Air Traffic	Compressor Site Construction	Dust Production	Fuel Spillage	Blasting
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	*	*	*	*	*	?	?	?	?	?	?	*
Mechanical	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*	*
Sensory	?	*	*	*	*	*	*	*	*	*	?	?	?	?	?	?	*
Direct mortality	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Habitat modification	*	*	*	*	*	*	*	*	*	*	*	*	?	*	*	?	*
Remove forage	*	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*
Remove cover	*	?	*	*	*	*	*	*	*	*	*	?	?	*	*	?	*
Add forage	*	?	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Add cover	*	*	*	*	*	*	*	*	*	?	*	*	*	?	*	*	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Habituation	*	*	*	*	*	*	*	*	*	*	*	?	?	?	*	*	*

Legend:

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Coyote Period Construction

	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Road Construction	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	?	*	*
Mechanical	?	*	*	*	*	?	*	*
Sensory	?	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	127
Habitat modification	?	*	*	*	*	*	?	?
Remove forage	?	*	*	*	*	*	?	?
Remove cover	?	*	*	*	*	*	*	*
Add forage	*	*	*	*	*	*	?	*
Add cover	*	*	*	*	*	*	?	*
Artificial food sources	*	127 129	127 130 131	127 130 131	*	*	*	*
Habituation	128 129 131	127 129	127 130	127 130	*	*	?	*

1,2 — Adequate quantitative data available

* — Impact is obvious

1,2 — Available data inadequate or anecdotal

? — Impact unknown

* — No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Coyote   Period Operation

	Compressor Noise	Compressor Presence	Compressor Exhaust	Compressor Blowdown	Presence of Right-of-way	Berm	Revegetation	Ground Traffic	Air Traffic	Human Disturbance	Garbage Disposal	Littering	Feeding	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	?	*	?	*	*	*	?	?	?	*	*	*	*	?	*	*
Mechanical	*	*	*	*	*	*	*	*	*	?	*	*	*	*	*	*	*
Sensory	?	?	*	?	*	*	*	?	?	?	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	127
Habitat modification	?	?	*	?	?	?	*	*	?	?	*	*	*	*	?	?	?
Remove forage	?	?	*	?	*	*	*	?	*	?	*	*	*	*	?	?	?
Remove cover	*	*	*	*	*	*	*	?	?	?	*	*	*	*	?	*	*
Add forage	*	*	*	*	?	?	*	*	*	*	*	*	*	*	*	?	*
Add cover	*	?	*	*	*	?	?	*	*	*	*	*	*	*	*	?	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	127 130	127 130 131	127 129 131	*	*	*	*
Habituation	?	?	*	*	*	*	*	?	?	128 129 131	127 130 131	127 130 131	127 129	*	*	?	*

Legend: [1,2] Adequate quantitative data available; [*] Impact is obvious; [1,2] Available data inadequate or anecdotal; [?] Impact unknown; [*] No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Red Fox

Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	*	?	?	?	?	?	?	*	*	*	*	?	*	*
Mechanical	*	*	*	*	?	*	?	*	*	*	*	*	*	*
Sensory	*	?	?	?	?	?	?	*	*	*	*	?	*	*
Direct mortality	*	*	123	*	*	*	*	*	*	*	*	*	*	121 124
Habitat modification	*	*	60 85 119	?	*	85 122	85 118 125	112	*	*	*	?	85 122	?
Remove forage	*	*	?	*	?	?	?	*	*	*	*	?	?	?
Remove cover	*	*	85	?	*	*	85 118 125	*	*	*	*	?	*	*
Add forage	*	*	60 119	*	*	*	*	112	*	*	*	*	?	*
Add cover	*	*	*	*	?	85 122	*	*	*	*	*	*	85 122	*
Artificial food sources	*	*	*	*	*	*	*	85 112	85 119	85 119	*	*	*	*
Habituation	*	*	?	?	?	85 122	118	85 112	85 119	85 119	*	*	85 122	*

1,2	Adequate quantitative data available	*	Impact is obvious	1,2	Available data inadequate or anecdotal	?	Impact unknown	*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Red Fox

Period Construction

	Clearing	Slash Disposal	Ditching	Bed Preparation	Stringing Pipe	Welding Pipe	Laying Pipe	Backfilling	Berm Preparation	Revegetation	Material Site	Ground Traffic	Air Traffic	Compressor Site Construction	Dust Production	Fuel Spillage	Blasting
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	*	*	*	*	*	?	?	?	?	?	?	*
Mechanical	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*	*
Sensory	?	*	*	*	*	*	*	*	*	*	?	?	?	?	?	?	*
Direct mortality	*	*	*	*	*	*	*	*	*	*	*	123	*	*	*	*	*
Habitat modification	*	*	*	*	*	*	*	*	*	102	*	60 85 119	?	85 122	*	?	*
Remove forage	*	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*
Remove cover	*	?	*	*	*	*	*	*	*	*	*	85	?	*	*	?	*
Add forage	*	?	*	*	*	*	*	*	*	102	*	60 119	*	*	*	*	*
Add cover	*	*	*	*	*	*	*	*	*	?	*	*	*	85 122	*	*	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Habituation	*	*	*	*	*	*	*	*	*	*	*	?	?	85 122	*	*	*

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Red Fox Period Construction

	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Road Construction	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	?	*	*
Mechanical	?	*	*	*	*	?	*	*
Sensory	?	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	121 124
Habitat modification	85 118 125	112	*	*	*	*	85 122	?
Remove forage	?	*	*	*	*	*	?	?
Remove cover	85 118 125	*	*	*	*	*	*	*
Add forage	*	112	*	*	*	*	?	*
Add cover	*	*	*	*	*	*	85 122	*
Artificial food sources	*	85 112	85 119	85 119	*	*	*	*
Habituation	118	85 112	85 119	85 119	*	*	85 122	*

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Red Fox Period Operation

	Compressor Noise	Compressor Presence	Compressor Exhaust	Compressor Blowdown	Presence of Right-of-way	Berm	Revegetation	Ground Traffic	Air Traffic	Human Disturbance	Garbage Disposal	Littering	Feeding	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	57	?	*	?	*	*	*	?	?	?	*	*	*	*	?	*	*
Mechanical	*	*	*	*	*	*	*	*	*	?	*	*	*	*	*	*	*
Sensory	57	?	*	?	*	*	*	?	?	?	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	123	*	*	*	*	*	*	*	*	121 124
Habitat modification	?	85 122	*	?	?	*	102	60 85 119	?	85 118 125	*	*	112	*	?	85 122	?
Remove forage	?	?	*	?	*	*	*	?	*	?	*	*	*	*	?	?	?
Remove cover	*	*	*	*	*	*	*	85	?	85 118 125	*	*	*	*	?	*	*
Add forage	*	*	*	*	?	?	102	60 119	*	*	*	*	112	*	*	?	*
Add cover	*	85 122	*	*	*	*	?	*	*	*	*	*	*	*	*	85 122	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	85 119	85 119	85 112	*	*	*	*
Habituation	57	85 122	*	*	*	*	*	?	?	118	85	85 119	85 112 119	*	*	85 122	*

1,2 (heavy box)	Adequate quantitative data available
* (heavy box)	Impact is obvious
1,2 (heavy top and bottom lines)	Available data inadequate or anecdotal
? (heavy top and bottom lines)	Impact unknown
* (light box)	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Arctic Fox Period Preconstruction

	Surveying Activities	Test Drilling Activities	Ground Traffic	Air Traffic	Road Construction	Development of Support Facilities	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	*	?	?	86	?	?	?	*	*	*	*	?	*	*
Mechanical	*	*	*	*	?	*	?	*	*	*	*	*	*	*
Sensory	*	?	?	86	?	?	?	*	*	*	*	?	*	*
Direct mortality	*	*	85 93 100	*	*	*	*	*	*	*	*	*	*	82 98
Habitat modification	*	*	*	?	*	85 93 95	85 99	*	*	*	*	?	85 93 95	?
Remove forage	*	*	?	*	?	?	?	*	*	*	*	?	?	?
Remove cover	*	*	?	?	*	*	85 99	*	*	*	*	?	*	*
Add forage	*	*	*	*	*	*	*	*	*	*	*	*	?	*
Add cover	*	*	*	*	?	85 93 95	*	*	*	*	*	*	35 93 95	*
Artificial food sources	*	*	*	*	*	*	*	82 85 93 95	82 85 93 95	82 35 93 95	*	*	*	*
Habituation	*	*	?	?	?	85 93 95	?	82 85 93 95	82 85 93 95	82 85 93 95	*	*	85 93 95	*

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Arctic Fox   Period Construction

	Clearing	Slash Disposal	Ditching	Bed Preparation	Stringing Pipe	Welding Pipe	Laying Pipe	Backfilling	Berm Preparation	Revegetation	Material Site	Ground Traffic	Air Traffic	Compressor Site Construction	Dust Production	Fuel Spillage	Blasting
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	*	*	*	*	*	?	?	86	?	?	?	*
Mechanical	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*	*
Sensory	?	*	*	*	*	*	*	*	*	*	?	?	86	?	?	?	*
Direct mortality	*	*	*	*	*	*	*	*	*	*	*	85 93 100	*	*	*	*	*
Habitat modification	*	*	*	*	*	*	*	*	*	102	*	*	?	85 93 95	*	?	*
Remove forage	*	?	*	*	*	*	*	*	*	*	*	?	*	*	?	?	*
Remove cover	*	?	*	*	*	*	*	*	*	*	*	?	?	*	*	?	*
Add forage	*	?	*	*	*	*	*	*	*	102	*	*	*	*	*	*	*
Add cover	*	*	*	*	*	*	*	*	*	?	*	*	*	85 93 95	*	*	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Habituation	*	*	*	*	*	*	*	*	*	*	*	?	?	85 93 95	*	*	*

1,2 Adequate quantitative data available

* Impact is obvious

1,2 Available data inadequate or anecdotal

? Impact unknown

* No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Arctic Fox Period Construction

	Human Disturbance	Feeding	Litter	Garbage Disposal	Food Storage	Road Construction	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	*	*	?	*	*
Mechanical	?	*	*	*	*	?	*	*
Sensory	?	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	98 82
Habitat modification	85 99	*	*	*	*	*	85 93 95	*
Remove forage	?	*	*	*	*	*	*	*
Remove cover	85 99	*	*	*	*	*	*	*
Add forage	*	*	*	*	*	*	?	*
Add cover	*	*	*	*	*	*	85 93 95	*
Artificial food sources	*	32 85 93 95	32 85 93 95	32 85 93 95	*	*	*	*
Habituation	?	32 85 93 95	32 85 93 95	32 85 93 95	*	*	85 93 95	*

1,2	Adequate quantitative data available
*	Impact is obvious
1,2	Available data inadequate or anecdotal
?	Impact unknown
*	No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX

Species Arctic Fox   Period Operation

	Compressor Noise	Compressor Presence	Compressor Exhaust	Compressor Blowdown	Presence of Right-of-way	Berm	Revegetation	Ground Traffic	Air Traffic	Human Disturbance	Garbage Disposal	Littering	Feeding	Food Storage	Fuel Spillage	Material Storage	Animal Control
Barriers to movement or migration	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Mechanical	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sensory	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Other disturbances	?	*	*	?	*	*	*	?	86	?	*	*	*	*	?	*	*
Mechanical	*	*	*	*	*	*	*	*	*	?	*	*	*	*	*	*	*
Sensory	?	*	*	?	*	*	*	?	86	?	*	*	*	*	?	*	*
Direct mortality	*	*	*	*	*	*	*	85 93 100	*	*	*	*	*	*	*	*	82 98
Habitat modification	?	85 93 95	*	?	?	*	*	*	?	85 99	*	*	*	*	?	85 93 95	?
Remove forage	?	?	*	?	*	*	*	?	*	?	*	*	*	*	?	?	?
Remove cover	*	*	*	*	*	*	*	?	?	85 99	*	*	*	*	?	*	*
Add forage	*	*	*	*	?	?	*	*	*	*	*	*	*	*	*	?	*
Add cover	*	85 93 95	*	*	*	*	?	*	*	*	*	*	*	*	*	85 93 95	*
Artificial food sources	*	*	*	*	*	*	*	*	*	*	82 85 93 95	82 85 93 95	82 85 93 95	*	*	*	*
Habituation	?	85 93 95	*	*	*	*	*	?	?	?	82 85 93 95	82 85 93 95	82 85 93 95	*	*	85 93 95	*

1,2 Adequate quantitative data available · * Impact is obvious · 1,2 Available data inadequate or anecdotal · ? Impact unknown · * No impact, obvious

(numbers in boxes refer to Matrix References)

Appendix 2. (cont'd)

IMPACT MATRIX - IMPACTS OF CANIDS/URSIDS ON HUMAN ACTIVITY

	Grizzly Bear	Black Bear	Wolf	Coyote	Red Fox	Arctic Fox
Zoonotic Disease Transmission	162 175	162 175	87 101 106 114 115 116	96 115	85 88 101 114 115 117	82,82 84,85 88,92 97 100 101
Bites and Scratches	88 152 155	88 140 142 153	88 61 106 137	127	61 85 88	61 85 88 92 99
Fatal Attacks	150 152 155 170	106 110	*	*	*	*
Property Damage	88 135 154	88 135 142 153	135	*	135	92 98 135
Work Stoppage (feeding, etc.)	170	61	*	*	*	85 95

*	impact is obvious
1,2	adequate quantitative data available
*	no impact, obvious

MATRIX REFERENCES

1. Alaska Department of Fish and Game, 1974.
2. Hemming and Morehouse, 1976.
3. Fedeler, 1977.
4. Skoog, 1968.
5. Hemming, 1971.
6. Skoog, 1956.
7. Davis *et al.*, 1978.
8. Roseneau *et al.*, 1974.
9. Foothills Pipe Lines (Yukon) Ltd., 1978.
10. Alaska Department of Fish and Game,files, Tok.
11. Child and Lent, 1973.
12. Child, 1973.
13. Cameron and Whitten, 1978.
14. Cameron and Whitten, 1979a.
15. Cameron and Whitten, 1979b.
16. Cameron *et al.*, 1979.
17. Ericson, 1972.
18. Roseneau and Curatolo, 1975.
19. Heimer, 1975.
20. Price, 1972.
21. Linderman, 1972.
22. Roby, 1978.
23. Larson, 1980, personal communication.
24. Summerfield, 1974.
25. Price, 1973.
26. Lenarz, 1974.
27. McCourt *et al.*, 1974.
28. Lent and Summerfield, 1973.
29. Sigman, 1979.
30. Heimer, 1980, personal communication.
31. Andersen, 1971.
32. McIlroy, 1972.
33. Alaska Department of Fish and Game, files, Fairbanks.
34. Griffin, 1968.
35. Milke, 1969.
36. Brink, 1978.
37. Altmann, 1958.
38. Hoffman, 1975.
39. Johnson and Todd, 1977.
40. Klein, 1971.
41. Surrendi and DeBock, 1976.
42. Calef and Lortie, 1973.
43. Miller and Gunn, 1979.
44. Calef *et al.*, 1976.
45. Klein, 1974.
46. McCourt and Horstman, 1974.

47. LeResche *et al.*, 1974.
48. Miller and Broughton, 1973.
49. Hemming, undated.
50. Hamilton and Drysdale, 1975.
51. MacLennan, 1975.
52. Mould, 1977.
53. LeResche, 1966.
54. Evans *et al.*, 1966.
55. Van Ballenberghe, 1978.
56. Geist, 1963.
57. Reynolds, 1974.
58. Whitten, 1980, personal communication.
59. LeResche, 1975.
60. Tracy, 1977.
61. JFWAT, files, Anchorage.
62. Davis and Valkenburg, 1979.
63. Burbank and Sigman, 1979.
64. Van Ballenberghe and Peek, 1971.
65. McMillan, 1954.
66. Denniston, 1956.
67. Russell, 1977.
68. Villmo, 1975.
69. Geist, 1971c.
70. Thomson, 1972.
71. Espmark, 1972.
72. Miller *et al.*, 1972.
73. Klein, 1979b.
74. Bee and Hall, 1956.
75. Dufresne, 1942.
76. Bergerud, 1974.
77. Geist, 1975.
78. Cameron and Whitten, 1977.
79. White *et al.*, 1975.
80. Chesemore, 1975.
81. Macpherson, 1969.
82. Hanson and Eberhardt, 1978.
83. Speller, 1972.
84. Chesemore, 1967.
85. Eberhardt, 1977.
86. Ruttan, 1974.
87. Rausch and Williamson, 1959.
88. Milke, 1977.
89. Eberhardt and Hanson, 1978.
90. Brooks *et al.*, 1971.
91. Wooley, 1976.
92. Uruquhart, 1973.
93. Hanson and Eberhardt, 1979.
94. Burgess, in prep.
95. Garrott, in prep.

96. Gier *et al.*, 1978.
97. Syuzyumova, 1967.
98. Weeden and Klein, 1971.
99. Underwood, 1975.
100. Hanson and Eberhardt, 1977.
101. Rausch, 1958.
102. Bliss and Peterson, 1973.
103. Grace, 1976.
104. Van Ballenberghe *et al.*, 1975.
105. Tempany and Stelfox, 1976.
106. Whitlock, 1950.
107. Peterson, 1974.
108. Chapman, 1977.
109. Clark, 1971.
110. Morrie-Elye, 1951.
111. Carbyn, 1974.
112. Murie, 1944.
113. Mech, 1970.
114. Rausch, 1972.
115. Rausch, 1952.
116. Chapman, 1978.
117. Cowan, 1949.
118. Allison, 1971.
119. Englund, 1970.
120. Mech, 1966.
121. Scott, 1955.
122. Harris, 1977.
123. Phillips *et al.*, 1972.
124. Jensen and Sequeira, 1978.
125. Richards and Hine, 1953.
126. Mundy and Flook, 1972.
127. Murie, 1940.
128. Robinson and Grand, 1958.
129. Cornell and Cornely, 1979.
130. Young and Jackson, 1951.
131. Ozoga, 1963.
132. Stephenson, 1974.
133. Jordan *et al.*, 1967.
134. Klein, 1979.
135. Klein, 1973b.
136. Peterson, 1975.
137. Bellringer, 1974.
138. Linderman, 1974.
139. Pearson, 1975.
140. Eager and Pelton, 1980.
141. Barnes and Bray, 1966.
142. Barnes and Bray, 1967.
143. Jonkel and Cowan, 1971.
144. Hanson, 1972.

145. Schallenberger, 1977.
146. Elgmork, 1978.
147. Nagy and Russell, 1978.
148. Shaffer, 1971.
149. Rogers, 1977.
150. Riegelhuth, 1966.
151. Hamer *et al.*, 1979.
152. Herrero, 1970.
153. Hatler, 1967.
154. Harding and Nagy, 1977.
155. Craighead and Craighead, 1972c.
156. Meagher and Phillips, 1980.
157. Elgmork, 1976.
158. Beecham *et al.*, 1980.
159. Herrero, 1976.
160. Campbell, 1975.
161. Reynolds *et al.*, 1976.
162. Rogers and Rogers, 1976.
163. James, 1980, personal communication.
164. Craighead *et al.*, 1974.
165. Cole, 1971.
166. Kaal, 1976.
167. Meagher, 1980, personal communication.
168. Glaspell, 1980, personal communication.
169. Johnson, 1980, personal communication.
170. Reynolds, 1980, personal communication.
171. Kellyhouse, 1980, personal communication.
172. Cameron, 1980, personal communication.
173. Underwood and Baldridge, 1978.
174. Quimby and Snarski, 1974.
175. Alaska Department of Fish and Game, 1978.
176. Stephenson and Van Ballenberghe, 1976.
177. Rausch (R.A.), 1967.
178. Harding, 1976.
179. McCaffrey *et al.*, 1976.
180. Craighead and Craighead, 1972a.