RECOMMENDED CARNIVORE CONTROL PROGRAM FOR THE NORTHWEST ALASKAN PIPELINE PROJECT INCLUDING A REVIEW OF HUMAN-CARNIVORE ENCOUNTER PROBLEMS AND ANIMAL DETERRENT METHODOLOGY

Final Report

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BACKGROUND

The Northwest Alaskan Pipeline (NWA) project will traverse areas inhabited by the grizzly bear (Ursus arctos), black bear (U. americanus), wolf (Canis lupus), coyote (C. latrans), red fox (Vulpes vulpes) and arctic fox (Alopex lagopus). To a greater or lesser degree, each of these species can rapidly habituate to artificial food sources, such as dumps, and to accepting hand-outs from people. The extent of this habituation and the problems it can cause for both the animals and people became evident during construction of the trans-Alaska pipeline system (TAPS).

Constructing a large project through expanses of relatively undisturbed areas requires a great deal of manpower and logistical support. This entails import of large quantities of food and generation of large quantities of garbage and other refuse, items which can attract carnivores to work sites and facilities. Proper handling, storage and disposal of food and garbage can do much to reduce the attractiveness of a project to carnivores, but even the best maintained facility will attract animals because of odors produced. Therefore, NWA should develop and enforce a philosophy and program to not only conduct a "clean" operation but to implement animal deterrent methods that will reduce contact between carnivores and pipeline workers. This program will minimize disturbances to animals, will minimize health and safety hazards to pipeline workers, will minimize project delays and thus ultimately contribute to a well-managed and cost-effective construction project.

The first phase in the development of this program is manifested in this report which reviews the state-of-the-art of approaches to animal deterrence and methods of dealing with problem animals. The recommendations that evolve from this review should form the basis of the NWA program to avoid and minimize encounters between carnivores and pipeline workers.

OBJECTIVES

This project had the following objectives:

1. to review human-carnivore encounter problems on a broad scale and as they occurred on the TAPS project,
2. to review existing and proposed laws and regulations regarding those problems,
3. to review methods to avoid and minimize human-carnivore encounter problems on the NWA project,
4. to recommend methods and approaches to avoid and minimize adverse encounters between workers and carnivores along the pipeline corridor.

APPROACH

Information for this report was obtained from published literature and from interviews of people experienced with animal problems and deterrent methods. Computer searches utilizing Biological Abstracts, Index Veterinarius, Predator Data Base, Bibliography of Agriculture, and Fish and Wildlife Reference Service were conducted. In addition, the Bear Bibliography (Tracy et al. 1979) and the Bibliography on the Control and Management of the Coyote and Related Canids with Selected References on Animal Physiology, Behavior, and Control Methods and Reproduction (Dolnick et al. 1976) were reviewed. Of the 18,500 titles reviewed several hundred were considered potentially relevant. Individuals contacted for information are identified in Table 1.

Three fenced areas were visited to observe the design and construction aspects of the fences. The fence around Alyeska Pipeline Service Company's Pump Station 8 south of Fairbanks was designed and constructed principally for human deterrence. The fence around the dump at Banff National Park (Canada) was designed for animal deterrence, specifically bears. The fence built by NWA at Seven-Mile Camp was designed for animal deterrence according to specifications provided by the Office of the Federal Inspector.

Table 1. Individuals contacted for information on human-carnivore problems and deterrent and animal control methodology.

Name	Affiliation
Sam Aikens	Alyeska Pipeline Service Company
Jim Baker	Baker Engineering Enterprises, Ltd., Canada
Gary Boswell	Baker Engineering Enterprises, Ltd., Canada
Bob Brown	Alaska Dept. of Fish and Game
Gary Brown	Mt. McKinley National Park, AK
Mel Buchholtz	Alaska Dept. of Fish and Game
Tom Buhite	Alyeska Pipeline Service Company
John Dalle-Molle	Mt. McKinley National Park, AK
Philip Gipson	Alaska Cooperative Wildlife Research Unit
Jim Glaspell	Alaska Dept. of Fish and Game
Ken Greer	Montana Dept. of Fish and Game
John Gunson	Alberta Recreation, Parks and Wildlife
Ole Hermanrude	Kootenay National Park, Canada
Stephen Herrero	University of Calgary, Canada
Ben Hilliker	Alyeska Pipeline Service Company
Robert Hinman	Alaska Department of Fish and Game
Dan Hoover	U.S. Steel Supply, San Francisco, CA
Hal Hume	Alaska Dept. of Transportation and Public Facilities
Perry Jacobsen	Banff National Park, Canada
Bob Larsen	Alaska Dept. of Fish and Game
Jack Luick	University of Alaska
Dwayne Martin	Jasper National Park, Canada
Cliff Martinka	Glacier National Park, MT
Leonard McKinney	Bureau of Land Management
Mary Meagher	Yellowstone National Park, WY
Gary Milke	Alaska Dept. of Fish and Game
Gary Miller	University of Montana
Lee Miller	Alaska Dept. of Fish and Game

Table 1. Continued.

Name	Affiliation
Joe Nava	University of Alaska
Al Ott	Alaska State Pipeline Coordinator's Office
Bruce Paige	Glacier Bay National Park, AK
Lew Pamplin	Office of the Federal Inspector
Jerry Phillips	Yellowstone National Park, WY
Arvind Phukan	University of Alaska
George Selby	Naval Arctic Research Lab., AK
Dick Shideler	Alaska Dept. of Fish and Game
Terry Skjonsberg	Banff National Park, Canada
Bob Stephenson	Alaska Dept. of Fish and Game
Al Townsend	Alaska Dept. of Fish and Game
Ken Whitman	West Yellowstone, MT
Max Winkler	Waterton National Park, Canada
John Woods	Revelstoke National Park, Canada

PERTINENT GOVERNMENTAL REGULATIONS

FEDERAL STIPULATIONS DEVELOPED FOR THE NWA PROJECT

The stipulations reviewed below represent those submitted by the United States government for use on the NWA project. The State of Alaska will have a set of stipulations that apply to state lands traversed by the pipeline project. The content of the state stipulations is not expected to be substantially different from the federal stipulations (A. Ott 1980 pers. comm.).

The seven stipulations identified relate specifically to problems associated with encounters between people and carnivores. The NWA project is required to comply with these stipulations during the design, construction, operation, maintenance and termination of the pipeline system.

Stipulation 1.6 - DESIGN CRITERIA, PLANS AND PROGRAMS. "The COMPANY shall submit DESIGN CRITERIA to the FEDERAL INSPECTOR. It shall also submit comprehensive plans and/or programs (including schedules where appropriate) which shall include but not be limited to the following: ...(3) camps, ...(7) environmental briefings, ...(10) liquid waste management, ...(16) quality assurance/quality control, ...(19) solid waste management, ...(21) surveillance and maintenance..."

The plans and programs submitted by NWA to comply with this stipulation should include the designs, procedures and surveillance schemes intended to avoid, minimize and control encounters with bears and canids along the pipeline corridor. Those of particular concern are fence designs, solid waste management procedures, incinerator specifications and procedures, and environmental briefing contents. This stipulation was expanded in the Department of Interior Draft Right-of-Way Grant to include Human-Animal Interactions as one of the plans and/or programs to be submitted (Pamplin 1980 pers. comm.).

Stipulation 1.8 - QUALITY ASSURANCE AND CONTROL. "The COMPANY shall provide for continuous inspection of pipeline construction to ensure compliance with the approved design specifications and these Stipulations..." 1.8.2 - "At a minimum, the following shall be included in the quality assurance program: (1) Procedures for the detection and prompt abatement of any actual or potential procedure, activity, event or condition, of a serious nature, that: ...

(c) that at any time may cause or threaten to cause: (1) a hazard to the safety of workers or to public health or safety...

(8) A plan for conducting surveys and field inspections of all facilities, processes and procedures of the COMPANY, its contractors, subcontractors, vendors and suppliers critical to the achievement of quality."

This stipulation requires that the NWA be able to identify and remedy any problems regarding bears and canids that may arise, for example, a bear mauling or exposure of a worker to a potentially rabid animal. These procedures should be included in the quality assurance program to ensure safe working conditions and the health of workers.

Stipulation 1.10 - SURVEILLANCE AND MAINTENANCE. "During the construction, operation, maintenance and termination phases of the PIPELINE SYSTEM, the COMPANY shall conduct a surveillance and maintenance program applicable to the subarctic and arctic environment. At minimum, this program shall...be designed to: (1) provide for public health and safety..."

The surveillance program required by this stipulation should include protection of pipeline workers from bears and canids along the corridor. This would entail identification of problem areas or animals, and the taking of remedial actions as appropriate.

Stipulation 1.11 - HEALTH AND SAFETY. "The COMPANY shall take measures necessary to protect the health and safety of all persons directly affected by activities performed by the COMPANY...and shall immediately abate any health or safety hazards."

This stipulation is quite similar to previously identified stipulations in that it requires the NWA to protect pipeline workers from potential hazards, including bears and canids, along the corridor. If potential hazards with animals occur NWA should be prepared to deal with them with appropriate control actions.

Stipulation 2.1 - ENVIRONMENTAL BRIEFINGS. "The COMPANY shall develop and provide environmental briefings for supervisory and field personnel...in accordance with the approved briefings plan required by Stipulation 1.6.1."

This stipulation requires the NWA to develop a program to brief pipeline workers on environmental conditions along the pipeline corridor. This program should include warnings regarding the potential dangers from bears and canids and the need to avoid feeding animals and attracting them to work areas and camps. A list of suggested topics relevant to carnivores is included in a subsequent section of this report.

Stipulation 2.2.4 - SANITATION AND WASTE DISPOSAL. "All HAZARDOUS SUBSTANCES and WASTE generated in construction, operation, maintenance and termination of the PIPELINE SYSTEM shall be removed or otherwise disposed of in a manner acceptable to the FEDERAL INSPECTOR."

Any wastes generated at camps and work areas, such as kitchen wastes and discarded sack lunches, must be disposed of in a manner to avoid attracting carnivores and other scavengers. NWA should design facilities and develop procedures to avoid or greatly minimize this potentially serious problem. A quality control surveillance program should include this aspect.

Stipulation 2.16 - HUNTING, FISHING AND TRAPPING. "The COMPANY shall inform its employees, agents, contractors, subcontractors and their employees of applicable laws and regulations relating to hunting, fishing, and trapping."

Transfer of this information should be in the Environmental Briefing required by Stipulation 2.1.

STATE REGULATIONS

Alaska Administrative Code 5 (5 AAC) is concerned with the protection of game in the State of Alaska. The sections of this code which are relevant to carnivores along the pipeline corridor and must be adhered to by the NWA, are identified below.

Central to understanding the applicability of the following sections to the NWA project is the definition of the word TAKE. The Alaska Department of Fish and Game (1979) defines TAKE to include any manner of disturbing an animal. Therefore, any disturbances that are specifically included in the following sections of 5 AAC, must be avoided by the NWA and workers under its auspices.

5 AAC 81.090. FUR ANIMALS. "Fur animals may be taken while hunting, by any methods or means except those prohibited by Sec. 120 of this chapter and the following methods and means:... (2) by disturbing or destroying dens..."

All of the canids that occur along the pipeline corridor utilize dens during some portion of their annual life history. The NWA project must make efforts to avoid disturbing these dens. Bears use dens from mid-fall to late spring but, by definition (ADF&G 1979), are not included in this restriction. However, their dens should be protected immediately before bears enter and while they are inside.

5 AAC 81.120. GENERAL PROVISIONS. "The following methods and means of taking game are prohibited:...(5) by use of an airplane... or

other motorized vehicle for the purpose of driving, herding, or molesting game..."

This regulation prevents workers on the NWA project from harassing carnivores with motorized vehicles and airplanes.

5 AAC 81.218. FEEDING OF GAME. "Within the State of Alaska it is unlawful to deliberately feed bears, wolves, foxes or wolverine or to deliberately leave human food or garbage in such a manner that it attracts such animals."

The intent of this regulation is quite clear. It is essential that the NWA brief project workers on the illegality of feeding these carnivores directly or indirectly by intentionally leaving food and/or garbage to attract animals. Adequate designs and procedures must be developed to properly store food and dispose of garbage.

5 AAC 81.375. TAKING GAME IN DEFENSE OF LIFE OR PROPERTY. "(a) Nothing in this chapter prohibits a person from taking game in defense of life or property provided that:... (2) the necessity for taking is not brought about by the improper disposal of garbage or a similar attractive nuisance..."

This regulation allows harassing or killing animals in defense of life or property. However, if inadequate food storage or garbage disposal or the feeding of animals is the cause for the action, the NWA and its contractors and subcontractors could be held liable for harassment or killing. Therefore, it is imperative that adequate safeguards be developed for the NWA project so that animal attraction to construction areas and camps is avoided or greatly minimized.

FEDERAL REGULATIONS

One federal regulation applies to the bears and canids along the pipeline corridor and other areas affected by the NWA project. It falls under Title IV - Fish and Wildlife Conservation.

16 U.S.C. 742 j-1. Airborne Hunting. "Any person who...(2) uses an aircraft to harass any bird, fish, or other animal; or (3) knowingly participates in using an aircraft for any purpose referred to in paragraph...(2); shall be fined... All... aircraft... shall be subject to forfeiture to the United States."

This regulation clearly prohibits NWA project workers from harassing any animal while working from aircraft. This regulation should be included as a topic in the Environmental Briefing.

CONCLUSIONS

The stipulations that were developed for the NWA project and other state and federal regulations require the NWA to avoid or minimize contacts with carnivores along the pipeline corridor. Human-carnivore encounters during construction of the TAPS have shown that the life and safety of pipeline workers and the animals can be threatened in these cases. In addition, the economic losses to a project resulting from property damage and from delays and distraction of staff can be significant. The NWA should develop the project design, construction planning, and surveillance activities to meet the intent of these comprehensive and wide-ranging stipulations and regulations. To do so early in the planning will reduce problems during construction and operation and will result in a more safe, efficient and cost-effective project that substantially reduces effects on bears and canids residing along the pipeline corridor.

REVIEW OF HUMAN-CARNIVORE ENCOUNTER PROBLEMS

The coexistence of man and wild animals affects both in a number of ways. Although many are positive there are also many potentially detrimental aspects to coexistence. The effect of man on animals entails loss of habitat, changes in numbers and distribution, behavioral modifications or elimination. For man the effect can be annoyance, economic loss or injury, disease and death. The degree of effect is related to the nature and extent of the human activity and the species of animals in the area. Where agricultural crops are planted most of the damage occurs from herbivores, such as deer (Odocoileus sp.), and omnivores such as raccoons (Procyon lotor) and bears which can consume or destroy large quantities and acreages of crops. Livestock production can suffer when in areas inhabited by carnivores and omnivores such as bears, wolves, coyotes and foxes. The diverse diets of these animals also facilitates their attraction to processed human foods and garbage, attractants common to all areas of human habitation and activity.

The impacts of man's activities on carnivores is the focus of an earlier report (Douglass et al. 1980). The problems encountered between carnivores and man, emphasizing the effects on man, are reviewed in this section. First, problems are discussed in a broad spectrum reviewing North American experiences. This review is somewhat brief since most of the information does not deal with species or problems of specific interest or with application to Alaska. However, it does attempt to provide an overview of the significance of the problems. One aspect of human-carnivore encounters not considered in this review is the economic loss of wildlife to predation. This subject has little or no direct relevance to the pipeline project from standpoints of providing either a historical perspective or a base for planning an animal control program. The second section deals specifically with carnivore problems that occurred during the construction of the TAPS. The problems are quantified by location and category. This section is the more significant and relevant because it reflects the types and degree of animal problems that may be experienced during construction of the NWA gas pipeline project.

CARNIVORE PROBLEMS - AN OVERVIEW

The carnivores of concern in this section are the canids (wolf, coyote, red fox and arctic fox), and the ursids (grizzly and black bear). These groups are treated separately because the types of problems encountered can be somewhat different.

Canids

The greatest impact from canids in general is predation on livestock. Foxes prey on smaller livestock such as chickens and rabbits especially in areas where protection for domestic animals is lacking or inadequate. In the west, red foxes kill lambs in unprotected pastures (Henne 1975; Munoz 1977), although the red fox is usually not considered a major problem in sheep country.

The larger coyote is a significant predator on sheep in the western states. Numerous articles have been written on the problem over a period of many years. Other livestock that are preyed upon by coyotes include goats, pigs, calves, house cats, turkeys and other poultry (Gipson 1978). Major efforts have been made to eliminate coyotes over wide areas using poison, traps, snares, and a variety of hunting techniques (Beasom 1974; Brawley 1977; Henderson 1930; Henne 1975; Leopold 1971; Munoz 1977; Robinson 1962; Rush 1939; Sterner and Shumake 1978; Wade 1976, 1978), however, these efforts have proved somewhat fruitless over the long term (Bekoff 1979). Predator control has been reduced in recent years and Terrill (1975) reports that since 1960 sheep losses to coyotes have increased, in fact, 63 percent from 1971 to 1973 in 22 western states. Much emphasis is currently being placed on deterrents to coyote predation and protection for livestock. These include fences, sound, aversive agents and odor repellents (Cringan 1972; McColloch 1972; Sander 1972; Shelton 1972). These deterrents are reviewed in subsequent sections of this report.

The wolf in North America is no longer considered a significant predator of livestock principally because it has been eliminated in most areas of livestock production. However, the wolf is a significant predator on reindeer herds during certain seasons in the Buckland and Deering areas of western Alaska (Luick 1980 pers. comm.). Wolves in Minnesota also take some livestock (VanBallenberghe et al. 1975).

Non-livestock related economic losses from canids have not been well documented. Brooks et al. (1971), Urquhart (1973) and Weeden and Klein (1971) identify some problems with arctic foxes in northern areas, including damage to wires and cables. Probably other canids can cause similar problems.

In most areas wild canids are not particularly feared as direct threats to man. However, some of the canids are particularly susceptible to diseases which are transmissable to man, primarily rabies (Chapman 1978; Kaplan 1977; Rausch 1972; Speller 1972; West 1973). Transmission of these diseases to man is usually through unprotected family pets and rarely from domestic livestock that come in contact with infected animals. Sometimes canids are attracted to artificial food sources such as dumps, or campgrounds where they are fed (Chapman 1977; Cornell and Cornely 1979; Grace 1976; Murie 1940, 1944; Ozoga 1963; VanBallenberghe et al. 1975). These situations increase the probability of direct transmission of zoonotic diseases to man. For the most part, however, wild canids if not habituated to artificial foods are shy and avoid direct contact with man, thus greatly reducing the possibility of direct attacks on man.

Bears

A significant literature has been written on bear problems throughout North America. To facilitate review black and grizzly bears are discussed separately in this section.

Black Bear. Predation by black bears on crops and livestock is not widespread but can be significant in localized areas. They are particularly fond of honey and cause extensive damage to apiaries (Ernst 1974; Gunson 1977; Harlow 1961; McDaniel 1974). Many attempts have been made to deter black bears from apiaries using fences and aversive agents, aspects that are reviewed in subsequent sections of this report. Other agricultural impacts by black bears include feeding on crops such as corn (Landers et al. 1979), destruction of trees by stripping bark (Poelker and Hartwell 1973) and livestock predation (Bailey 1953; Bersing 1956; Cahalane 1948; Lorenzen 1923), particularly when natural foods are in low abundance (Cahalane 1948). These problems are usually less severe and more localized than damage done to apiaries.

Property damage from black bears usually results from their attempts to get at human food, garbage or other food (Barnes and Bray 1967; Erickson 1965a; Singer and Bratton no date). In addition, Barnes and Bray (1966) report the use of road culverts and Rowan (1945) the undersides of buildings as winter dens. These activities can cause indirect damage by blocking drainage and by affecting utility systems.

Black bears because of their size and strength pose hazards to man. They have been reported to attack man without being provoked (Norris-Elye 1951; Townsend 1976; Whitlock 1950) but these instances are rare, except in Alaska where attacks are more common. During 1963 Interior Alaska experienced a rash of problems, and five unprovoked attacks on people were recorded (Erickson 1965a; Hatler 1967). Black bears become dangerous when they are surprised, are guarding a food cache or when a sow is protecting young. But most instances of attack involve bears that are being fed or are using a dump as a food source. Numerous instances of bears being fed or using dumps are reported (Barnes and Bray 1967; Bersing 1956; Bray et al. no date; Chase 1971; Eager and Pelton 1980; Erickson 1965a; Ernst 1974; Hatler 1967; Herrero 1976; Meagher and Phillips in press; Merrill 1978; Mundy and Flook 1973; Rogers et al. 1976; Rowan 1945). Bears can become rapidly habituated to these feeding conditions and lose their fear of man. When this occurs animals can become quite bold in their approach and sometimes attack people in their efforts to obtain food. Singer and Bratton (no date) report that 107 injuries from black bears between 1964 and 1976 occurred in Great Smoky Mountains National Park. Many of these instances occurred as a result of bears being attracted by handouts and garbage. Burghardt et al. (1972) report that most bear injury reports in Great Smoky Mountains National Park result from people feeding bears. Buskirk (1976) reports on three black bears that caused problems at Mt. McKinley National Park, all undoubtedly related to food. Black bears were a significant problem at Yosemite National Park, more so than at any other U.S. national park (Riegelhuth 1980 pers. comm.).

Grizzly Bear. Little information is available on the impact of grizzly bears on livestock. The limited distribution of grizzlies undoubtedly accounts for this. The grizzly bear is more of a wilderness dweller but where grazing allotments occur in grizzly habitat a conflict exists. Undoubtedly, grizzlies occasionally prey upon cattle or sheep in western states. Erickson (1965b) reports that brown bears on Kodiak Island sometimes take cattle. Grizzly bears occasionally take reindeer on the Seward Peninsula (Luick 1980 pers. comm.).

Property damage from grizzly bears also occurs to homesteads, field camps and other wilderness facilities. Bee and Hall (1956), Buskirk (1976) and Macpherson (1965) report on damage that has been caused by grizzlies. They are generally considered to be more aggressive than black bears and thus more dangerous.

As with black bears, grizzlies that become habituated to handouts and garbage are prone to lose their fear of man and become more dangerous. Feeding of grizzlies on unnatural food sources is widely reported (Buskirk 1976; Cole 1971, 1974; Craighead and Craighead 1971; Dean 1968; Greer 1974, 1976; Herrero 1970a, 1976; Martinka 1974; Stokes 1970). Herrero (1976) reports that as many as 70 grizzly bears have been seen at one time eating at one of the Yellowstone National Park dumps. Injuries resulting from encounters near developments, from active feeding, and as a result of provoking or startling grizzlies are reviewed in several papers (Cahalane 1948; Cole 1974; Erickson 1965b; Herrero 1970a, b; Martinka 1974). Erickson (1965b) speculates that there is less than one unprovoked attack by grizzlies in Alaska per year. Herrero (1976) reports that injury rates are the highest in North

Problems occurred throughout all six construction sections of the right-of-way, although north of the Yukon River they were most severe. The data used for this review were obtained principally from the files of the Joint State/Federal Fish and Wildlife Advisory Team (JFWAT). Their function was to monitor pipeline construction to ensure compliance with environmental stipulations and other state and federal regulations pertaining to the protection of fish and game, and to provide recommendations and advice to the Alaska Pipeline Office (federal authority) and the Pipeline Coordinator's Office (state authority). An additional data source was the Office of Special Projects of the Bureau of Land Management's Alaska State Office.

The information on carnivore problems that were encountered is scattered throughout the JFWAT files and, for the most part, is included in Narrative Surveillance Reports prepared by each of the monitors following a field tour. Milke (1977) summarized the general problem of animal feeding during TAPS construction but did not provide quantitative information on the problem. The information on animal problems in the Narrative Surveillance Reports shows the scope of the problem but does not convey its magnitude. The reason for this is that active animal feeding and utilization of garbage by bears and canids was commonplace in certain areas. Unless an observer related feeding incidents to a monitor it was not reported. Additionally, after enforcement of animal feeding violations began, many of these activities only took place when monitors were not present. Thus, the numbers of incidents reported here, although large, are conservative.

Regional Analysis

Carnivore related problems were encountered throughout the TAPS right-of-way during construction. The problems were more severe in some regions than others. The area north of the Yukon River, particularly south of Atigun Pass, had the most consistent and significant problems. The terminal site at Valdez also experienced a large number of problems with black bears.

The carnivore problems encountered were tabulated by right-of-way segments to illustrate regional differences (Table 2). This tabulation was developed only for the area between Prudhoe Bay and Delta Junction. The area south of Delta Junction is not traversed by the NWA gas pipeline and, therefore, the data would not be useful to NWA for predicting anticipated problems. In general, the problems were not as significant south of Delta Junction, except at the Valdez terminal site.

It is obvious from Table 2 that the most significant problems occurred between the Yukon River and Atigun Pass. Bears accounted for 122 of the reported incidents. The majority of black bear problems occurred at Five-Mile Camp and grizzly bear problems at Chandalar Camp The wolf problem was also significant throughout this area but the Middle Fork Koyukuk and Dietrich River valleys experienced more problems.

The North Slope had fewer carnivore problems than the area south of Atigun Pass (Table 2). The wolf problem was about the same and most of these incidents extended north to the area of Happy Valley Camp. Arctic fox problems occurred principally north of Happy Valley Camp, and red foxes to the south. Significantly fewer bear problems were encountered in this region, and the majority of these were south of Happy Valley Camp in the Brooks Range.

Between Fairbanks and the Yukon River only a total of 19 carnivore problems were documented of which 17 entailed black bears (Table 2). The area between Fairbanks and Delta Junction had the least number of reported problems, totalling 5. These involved black bears and wolves.

Red fox problems occurred throughout the TAPS right-of-way but the number of incidents reported (Table 2) does not reflect the actual significance of the problem. The probable reason for this is that bear problems overshadowed fox problems and attracted much more attention because of the greater potential threat to human safety. In addition, red foxes are more secretive in their habits and are considerably more difficult to observe than wolves and bears. Red foxes can be encountered regularly throughout the region between Delta Junction and Franklin Bluffs Camp and are attracted by unnatural food sources and feeding.

Table 2. Number of reported animal related problems (bites, charges, feeding, damage, etc.) by region during TAPS preconstruction through operation (1971-1979).[1] See text for explanation.

Species	Region: Delta Jct. to Fairbanks	Fairbanks to Yukon R.	Yukon R. to Atigun Pass	North Slope
Grizzly Bear	0	1	53	15
Black Bear	3	17	69	--[2]
Wolf	2	0	31	32
Red Fox	0	1	6	4
Arctic Fox	--[2]	--[2]	--[2]	11
Total	5	19	159	62

[1]Source of information was JFWAT files

[2]Not applicable

The generalization on the TAPS red fox problem underestimation also applies to the arctic fox. However, because this fox is usually found only on the North Slope, principally north of Happy Valley Camp, problems are more localized.

Although carnivore surveys were not conducted along the TAPS corridor prior to camp placement, it can be assumed that these species were not uniformly distributed throughout the corridor and that densities varied with habitat quality. In some cases, TAPS facilities were located in excellent habitat, for example, Five-Mile Camp in an area apparently highly suitable for black bears. Placement of facilities in such locations undoubtedly contributed to the magnitude of the animal problems at these sites.

The TAPS camp construction schedule also contributed to the regional differences in the magnitude of animal problems. Many of the camps north of the Yukon River were built several years before Haul Road and pipeline construction began. These camps were staffed by maintenance crews who provided food for the resident carnivores. Therefore, at these locations, habituated animals were already present when the major construction activities started in 1974.

There are two additional factors which must be acknowledged when comparing carnivore problems regionally along the pipeline corridor. These are the presence of camp perimeter fences and hunting. When TAPS construction camps were built, all camps south of the Yukon River were fenced whereas those north were not. The fences were installed to prevent human trespass and for security against theft. This was not a problem north of the Yukon River because of limited human habitation and restricted access to the Haul Road.

The fences constructed at TAPS camps consisted of chainlink mesh installed on grade to a height of 7 ft. Three strands of barbed wire were angled outward at the top, adding about one additional foot to the total fence height. Even though these fences were not built specifically to deter animals, they undoubtedly added significantly to minimization of animal problems at camps. A fence of this design could be easily penetrated by a determined bear by either going over, through or under the fence. Similarly a determined canid could rapidly dig under these fences. No such incidents were reported during TAPS construction, except for black bears at the terminal site at Valdez. A fence of this type has its greatest effect by preventing the casual wandering animal from entering camps. The first experiences of bears and canids north of the Yukon River probably entailed wandering into camps out of curiosity. Once they found food there or were actively fed they became habituated to the camps. The animals were not provided this opportunity south of the Yukon River and thus habituation to camps was avoided or greatly minimized. The TAPS experience with regard to fences in part illustrates the importance of preventing animals from becoming habituated to artificial food sources.

The factor of hunting must be considered in the evaluation of animal problems north and south of the Yukon River. North of the Yukon River hunting was not permitted within 5 miles either side of the pipeline corridor. Lack of hunting pressure eliminated animal mortality other than from natural causes, road and control kills and some trapping. Thus some of the problems which occurred involved some of the same animals year after year. Since animals were unmarked the incidents reported in Table 2 could not be refined to illustrate the actual numbers of individual animals that caused problems.

Hunting and more extensive trapping occurred south of the Yukon River and many of the problem animals probably were taken during the harvest seasons along with non-problem animals. This fact would significantly reduce the number of recurrent problems with habituated animals. In fact, habituated animals probably are more vulnerable to hunting and trapping because, for the most part, they have lost much of their fear of people. An additional consideration is that animals killed during the season would not be available during subsequent periods to introduce their offspring to unnatural food sources and to people. The net result of these factors is that in the area south of the Yukon River many of the problem animals would have to become acquainted with and habituate to artificial foods each year whereas north of the Yukon River the animals' habituation would carry over from year to year especially when reinforced by inadequate garbage disposal and active feeding by pipeline workers.

It is apparent from this evaluation that several factors contributed to the lower incidents of problems south of the Yukon River. These same factors would apply during construction of the NWA gas pipeline.

The attitude of individuals in understanding and minimizing carnivore problems must also be considered. Some camp and section managers were quite sincere in their efforts to minimize animal attractants in their areas whereas others were negligent, especially early in the construction phase. Thus, some areas probably experienced fewer problems because fewer attractants were present to lure animals. Camp fences and the occurrence of hunting must be considered in this analysis because they would tend to reduce the problems at any one location. For example, it would be unfair to compare the effectiveness of a manager making a concerted effort at a camp north of the Yukon River with one equally concerned at a camp to the south.

Analysis by Problem Category

The following review presents the various carnivore related problems by category. The six categories are not all mutually exclusive because some of them are related. For example, an animal reported as being in a camp might have been eating garbage. Therefore, that incident would be recorded in two categories.

The six problem categories and numbers of incidents by species are included in Table 3. The numbers represent the total occurrences that took place throughout the TAPS right-of-way between Prudhoe Bay and Valdez. Again, because these data were obtained from JFWAT files and, therefore, include only instances observed by or brought to the attention of the monitors, the data represent the minimum number of occurrences. The total number of incidents is large but many more undoubtedly were unreported. This probably would not apply to animal bites because they would require medical attention and, therefore, be reported.

Table 3. Incidents of animal related problems during TAPS preconstruction through operation (1971-1979); Prudhoe Bay to Valdez.[1] See text for explanations.

Problem Category	Grizzly Bear	Black Bear	Wolf	Red Fox	Arctic Fox	Total
Bites/Charges	4	5	10	1	1	21
Abnormal Behavior	0	0	2	1	1	4
Under/In Buildings	1	12	3	2	6	24
In Camps/Dumps	56	68	26	12	4	166
Property Damage/ Economic Loss	13	7	1	0	0	21
Feeding on Garbage/Handouts	11	15	35	9	2	72
Total	85	107	77	25	14	308

[1]Source of information was JFWAT files

Bites and Charges. A total of 21 instances of animal bites and charges were reported (Table 3). The bites were from wolves and foxes and usually were associated with animal feeding. Cases were reported where foxes were enticed to jump up for food held in the hand (Milke 1977). Bites are not always serious as witnessed in one occasion when a worker's forearm was grabbed by a wolf but the skin was not broken. The wolf could easily have broken the bones of the forearm in this situation.

Animal bites such as this can occur even when animals are not being fed by the victim. When canids and bears become accustomed to receiving handouts from people they can become beggers and will often approach people. In these cases, a person may be grabbed or bitten by the animal seeking food or when the animal responds to a kick or other behavior intended to scare it away. Thus innocent people can be victims of animals fed by less concerned workers.

Animals are usually destroyed if they bite people. Because foxes and wolves can transmit rabies and other diseases to man the purpose of destruction is to have portions of the carcass analyzed. If rabid, the bite victims must obtain a series of shots that are both uncomfortable and will require work loss. Happy Valley Camp experienced a rabid fox problem in spring, 1974.

Animal charges as tabulated here (Table 3) involve bears. These can occur in a variety of situations. Where cubs are involved a female bear is extremely dangerous, and any real or imagined threat to the cubs usually will elicit a reaction from the adult. Where habituated animals are seeking a handout their approach could be interpreted as a charge in some circumstances or, if taunted, they might charge in anger. Similarly any attempts to scare a bear from a food source, whether garbage or natural food, can elicit a reaction.

The nine charges reported on the TAPS project are remarkably few when considering the numbers of animals and people involved. The low number of charges which occurred may suggest the extent to which the bears along the pipeline corridor had become habituated to the presence of people and the availability of garbage and handouts. This "cooperative" association could very well reduce the need for threat behaviors by the animals. This would probably be more a factor with black bears which are more complacent than grizzly bears.

Abnormal Behavior. This situation entails only foxes and wolves and consists of unusual movements or other behaviors. Only four instances of this were reported (Table 3).

This type of behavior can reflect the health status of an animal. Rabies, for example, is a neurological disorder which affects behavior in its later stages. An animal that runs in circles, stumbles, attacks inanimate objects, etc., could be suffering from rabies or another disease. These animals must be avoided and destroyed before they cause injury and, perhaps, transmit the disease. At least one animal collected during the TAPS construction was rabid.

Although the cases of abnormal behavior on TAPS involved foxes and wolves, bears are also susceptible to some of these diseases. Therefore, they should be treated in a similar manner. Evaluations of abnormal behavior should be made by a qualified individual to ensure that animals are not unnecessarily destroyed.

Under and in Buildings. A total of 14 reports of animals in buildings and frequenting the areas under camp facilities was reported (Table 4). These included bears, wolves and foxes. This was a problem north of the Yukon River particularly early in the construction phase before buildings were skirted to prevent access to these areas.

Both black and grizzly bears sometimes entered mess halls, kitchens or dormitories in search of food. Sometimes doors to these facilities were left open thus allowing easy access for animals. No reports of foxes or wolves in buildings were found, although the various shops around the periphery of camps could have been entered and reports not submitted.

Animals that went beneath buildings probably were seeking shelter. In early fall bears seek out dens in which to overwinter. Black bears denned beneath camp buildings at Five-Mile, for example. Maintenance workers who have to crawl beneath buildings for repairs could be endangered by a bear in these close quarters.

Similarly, wolves and particularly foxes would use areas beneath buildings for shelter. This was especially the case in winter when the availability of these protected areas near the ever present garbage and handouts provided an ideal situation.

Skirting of buildings prevented many of these animal entries and alleviated some of the problems of animals frequenting camps for purposes other than food. Maintaining skirts in place and keeping doors closed are the obvious solutions to keeping animals from beneath and out of buildings.

In Camps and Dumps. The most numerous animal problem reported was the frequenting of camps and dumps by animals (Table 3). The number reported is undoubtedly less than what actually occurred because not all incidents were reported.

The primary reason animals frequented these sites was to obtain food. Garbage storage and disposal in camps was not always adequate. Garbage stored in plastic bags and left in accessible areas were opened by animals. Dumpsters used to store garbage could be entered easily by bears. Incineration of garbage could not always keep up with the accumulation. Also, incompletely burned garbage often attracted animals to disposal sites.

Bears at certain camps had become accustomed to breaking into trucks and buses in which garbage was left following work shifts. The active feeding of animals from vehicles compounded this problem. Food was left out at kitchen entrances for animals who made regular rounds. Also, workers would provide food for begging animals and to entice others to come closer.

These various unauthorized activities made camps extremely attractive for bears, foxes and wolves. At several sites some animals including bears were known to reside in camp which strongly suggests that they were obtaining sufficient food from garbage and handouts to maintain themselves without foraging on natural foods. Considering the quantity of food required daily by a bear, the supplies of unnatural foods made available must have been quite large, especially where several bears in one camp were thought to rely solely on these sources.

The numbers of animals eating garbage and handouts along the right-of-way at construction sites is unknown. This problem was significant and perhaps as troublesome as the conditions in the camps. Numerous reports were made of food and garbage left on the right-of-way after meal breaks. Litter and animal feeding problems at worksites were as serious as in camps but were not easily monitored. In camps it was easier to report animal feeding because of the presence of monitors or Alyeska representatives whereas at construction sites, often only the work crews were present.

Property Damage and Economic Loss. Most of the damage caused by animals was due to grizzly bears (Table 3) in Chandalar, Galbraith and Coldfoot Camps. Bears can cause extensive damage searching for food in buildings and vehicles. During summer 1975, 10 black bears living under the buildings at Five-Mile Camp caused extensive damage to electrical and plumbing installations. These kinds of animal problems can be significantly reduced by maintaining skirts around all buildings and by keeping doors closed. However, doors will not deter a determined grizzly or black bear. Buildings at both Galbraith Lake and Chandalar Camps were damaged by grizzlies after the camps were closed and abandoned.

No reports were submitted on damage caused by foxes or wolves (Table 3). Arctic foxes have been reported to chew through various wires and cables (Urquhart 1973; Weeden and Klein 1971). Perhaps instances of chewing damage occurred from canids during TAPS but remained unreported.

Economic loss caused by animals can occur when a carnivore, particularly a bear, enters a construction site. When these animals are aggressive or show little hesitation about approaching people, the crew scatters and work essentially stops until the animal is scared off or leaves by its own accord. Similarly picture taking by workers when an animal is near reduces work productivity. When animals have become habituated to eating garbage and handouts these problems are recurring. In summer 1975, grizzly bear cubs and yearlings were visiting work sites regularly, causing work delays in an area south of Glennallen. A female grizzly with three young caused a work stoppage at Atigun Pass during TAPS repair work in 1979.

Feeding on Garbage and Handouts. The 72 reported sightings of animals feeding on garbage and handouts (Table 3) does not reflect the magnitude of the problem. The problem was constant and the habituated animals that resided in camps or frequently visited camps, dumps and construction sites were eating at every opportunity. Many of the 166 sightings of animals in camps and dumps (Table 3) probably involved animals in search of food or actually eating, but those behaviors were either not observed or reported. The problem occurred throughout the TAPS right-of-way but, as discussed under a previous section (Regional Analysis), there were some places that had more severe problems than others. These were usually north of the Yukon River, although the Valdez terminal site had significant black bear problems.

The Alaska Pipeline Office (APO) maintained records on stipulation compliance during construction of the TAPS project. This Office's responsibility was broader than that of JFWAT who dealt only with fish and wildlife considerations. APO was responsible for monitoring the litter problem, however, it entailed all litter not just food sources that could attract animals. During construction of the TAPS, 853 Spot Check Reports involving litter were prepared (McKinney 1980 pers. comm.). Of these, 454 were non-compliance reports which required remedial action by Alyeska. The number of these incidents that involved a potential food source for carnivores is unknown, but the magnitude of the total litter problem is apparent from these data.

The problem of active animal feeding occurred throughout the construction phase of the TAPS project. Although workers were advised at environmental briefings prior to entering the field that animal feeding was prohibited, many, or at least some, ignored the restriction. The initial violations undoubtedly set the stage for the significant and regular problems that occurred throughout the construction phase of TAPS and that are still ongoing in certain areas north of the Yukon River.

These animals learned early in the project that people were sources of easily obtained food, and they rapidly became habituated to this situation. Panhandling was rampant, and hazardous working and living conditions in certain areas and camps were created.

The problem of animal feeding became so serious that, in July 1976, the Alaska Department of Fish and Game (ADF&G) issued an emergency regulation prohibiting the active feeding of bears, wolves, foxes and wolverines and leaving garbage exposed within the pipeline corridor. This was about 1-1/2 years after Haul Road construction began, and animals were already well habituated to feeding on artificial food sources. According to Milke (1977) passage of this regulation did not significantly alleviate the problem during the remainder of the summer. State of Alaska 5 AAC 81.218 was passed in early 1977 which prohibited animal feeding statewide, but it was too late to be of much use during TAPS construction. The occurrence of panhandling bears on the Haul Road during 1980 (Hechtel pers. comm.; Wrightsman, pers. comm.), 3 years after TAPS construction, suggests that this behavior is still being encouraged by truckers and others using the road.

Remedial Actions Taken

Depending on the species and circumstances involved actions taken by pipeline workers and ADF&G personnel ranged from ignoring problems to hazing, translocations and shooting. The data on these various activities are incomplete and difficult to interpret. Both Alyeska and ADF&G personnel were involved with these activities, and JFWAT monitors did not always have access to the details of translocation or control kill operations. Therefore, the information in surveillance reports is sometimes incomplete or lacking. The ADF&G Fairbanks office compiled a list of bear incidents and remedial actions taken for the area north of the Yukon River. This information was used in conjunction with JFWAT data to compile records of control actions taken.

During construction several hazing operations were conducted at problem areas. Cracker shells (explosive devices fired from 12-gauge shotguns), M-80 fire crackers, vehicles and helicopters were used to harass problem animals (Milke 1977). Repeated use of cracker shells and M-80's, however, was sometimes ineffective. Kennedy (pers. comm., in Bellringer 1974) using cracker shells was able to scare red foxes away from a camp for up to three days, but he felt that they would soon ignore the shells.

An emetic, lithium chloride, was used by JFWAT personnel in association with R. A. Dieterich of the University of Alaska's Institute of Arctic Biology, but this program was sporadic and not consistently applied. Grizzly bears, black bears, wolves and a red fox were dosed, but the results were inconclusive (Table 4) due to lack of controlled application and inability to keep track of treated animals not otherwise marked. Additional information on this program is included in a following section on emetics.

Final control actions included translocation and shooting. The numbers of these events are included in Table 5. These data should be fairly complete because usually either agency or pipeline supervisory personnel were involved. These numbers do not include road kills or poached animals. The killed column includes animals that were injured during a control action and presumably died later. The translocation data clearly reflect the policy of killing problem black bears and translocating other than incorrigible grizzly bears.

One grizzly bear was trapped in the vicinity of Chandalar Camp and translocated away from the corridor. The same bear caused problems later at Happy Valley Camp (Reynolds 1980 pers. comm.). The bear was again translocated to an area far to the east of the pipeline corridor on Red Sheep Creek. From there it moved about 70 miles north where it caused problems at a camp at Peters Lake. It was later shot at a guide's camp after it became belligerent. This example illustrates that translocation may only be a temporary solution for bears which have been shown to have quite effective homing capabilities (see the section on Translocation and Dispatch in this report). It also illustrates that translocation of bears is not a panacea because once a bear is habituated

Table 4. Emetic (lithium chloride) application during TAPS construction for animal control.[1] See text for explanation. Number in parenthesis represents number of individuals.

Species	Immediate Result	Long-Term Result
Wolf (4)	Not Seen Again	Not Seen Again
Wolf (2)	Not Seen Again	Seen 3 Mos. Later
Wolf	Did Not Leave	Did Not Leave
Red Fox	Not Seen Again	Not Seen Again
Black Bear	Would Not take Bait	Stayed Around
Black Bear	Got Sick	No Data
Grizzly Bear (11)	No Effect	Stayed Around
Grizzly Bear	Apparently Got Sick	Came Back
Grizzly Bear	Got Sick	No Data

[1]Source of information was JFWAT files

Table 5. Final control actions taken on animals along the TAPS right-of-way during preconstruction through operation (1971-1979).[1] See text for explanation.

Species	Translocated	Killed
Grizzly Bear	12	13
Black Bear	1	25
Wolf	0	1
Fox[2]	0	1

[1]Source of information was JFWAT files and ADF&G data

[2]Species unidentified

to human presence and food it may continue to behave in this manner at its new location and be killed. Translocation can solve the immediate problem but the bear's life is still jeopardized because its lifestyle was negatively altered by the pipeline project.

REVIEW OF ANIMAL DETERRENT METHODS

Conflicts between wild animals and people have probably occurred ever since man's social structure evolved from a nomadic lifestyle to one where aggregations of people developed fixed sites in the form of homesteads and villages. Problems arose when wild animals were attracted to these areas because of new and consistent food sources in the form of cultivated crops and livestock that would be associated with agrarian societies. In order to sustain our present lifestyle and economy, further encroachment of man into previously undisturbed areas in the search for natural resources must occur. These intrusions also can attract animals to areas of human activity principally by import of potential attractants in the form of foodstuffs and the resultant garbage and trash. Avoidance of human-animal conflicts by either minimizing the attractiveness of these essential materials or by exclusion of unwanted animals is as much a necessity today as it was when these conflicts first arose. Similarly, some of the approaches to reduce conflicts are the same as used long ago, however, the level of sophistication has increased for some, if not the effectiveness.

This section reviews approaches that have been used to deter animals in a variety of situations. Although information is available on other species, particularly birds, this discussion is restricted to mammals. The limited data available on bears and canids necessitates reference to work conducted on other mammals, but this is minimized as much as practicable. This section is subdivided into three parts: animal deterrents, aversive conditioning and translocation and dispatch.

ANIMAL DETERRENTS

In this discussion, deterrent includes any physical, chemical or other device or approach whose purpose is to discourage the presence of an animal in a specific area. For convenience of discussion, deterrents are subdivided as follows: fences, sound (noise), noxious chemicals, and electromagnetic radiation.

Fences

Fences have been used quite widely and for many years to control movements of both domestic and wild animals. Fences act as physical barriers to animal movements as do trenches and combinations of trenches and fences (Fitzwater 1972; Brown 1968, in Fitzwater; Woodley 1965). Each, individually or in combination, can be quite effective in controlling movements of animals depending on the quality of the barrier and species of concern. Fitzwater (1972) provides a useful summary of the use of fencing in wildlife management. Burris (1965) described the use and effectiveness of big game fences in Alaska for control of moose depredation. One of the most spectacular uses of animal control fences is in Australia where thousands of miles of barrier fences have been constructed to deter passage of the dingo, a form of feral dog (Bauer 1964; McKnight 1969). Although not completely effective, these fences have been successfully employed to reduce the predation of dingos on sheep.

The NWA pipeline project will face encounters with black and grizzly bears, wolves, coyotes, red foxes, arctic foxes and dogs. The types of barrier fences utilized to deter these various species will differ to some degree based principally on the physical and behavioral characteristics of these animals. Therefore, the following discussion of barrier fences is subdivided according to species of animals that are similar in their ability to confront and pass a barrier fence.

Red and Arctic fox. Little published data is available on the use of fences to control movements of foxes. However, fences have long been used to protect poultry yards from raiding foxes. The mesh size of these fences is an important consideration since a 6-inch mesh was found to be ineffective in deterring red foxes in Illinois (Follmann unpublished data). A 4-inch or smaller mesh size would seem necessary to deter any adult red or arctic fox, but 4-inch might permit pups to penetrate the barrier.

At the Naval Arctic Research Laboratory (NARL) in Barrow, Alaska, standard 2-inch-mesh chain link fence was used to pen arctic foxes.

This fence eliminated any possibility for fence penetration but in itself would have been insufficient in preventing escape of foxes. Foxes, as well as other canids, dig well, and a fence built on grade will not necessarily deter them for long. At the NARL it was necessary to bury the bottom of the 8-ft chain link fence to deter digging. The fence was buried 2 to 3 ft vertically in the gravel pad, and chain link mesh was laid horizontally in the pad at the same depth. Where the pen adjoined the side of a building standard chicken wire was laid horizontally in the gravel pad to a 1-ft maximum depth. This proved unsatisfactory because where the edge of the mesh was exposed the foxes learned to dig beyond it and then tunnel under the mesh. Several animals escaped by that route.

Arctic foxes are quite capable of climbing chain link fences. Based on experience with red foxes in enclosed cages they too could probably climb chain link. To deter foxes from climbing over the fence at the NARL, a 2-ft band of thin-gauge sheet metal was nailed to the inside of the wooden fence posts above the 6-ft chain link material, thus yielding an 8-ft fence above ground. The animals were unable to get a purchase on this material and thus could not climb over the fence. Once the fence was properly buried and the sheet metal in place the pen was quite secure in preventing escapes. A new fox pen designed for the NARL consisted of 10 ft of 2-inch chain link fence with 6 ft vertically above grade and the lower 4 ft sloped horizontally to a depth of 2-3 ft into the gravel pad. It was topped by a 2-ft band of sheet metal. It was felt that this enclosure would have been successful in holding both arctic and red foxes.

Limited information is available on the use of electrical fences for the control of foxes. However, the three papers reporting on this type of fence (Forster 1975; Patterson 1977; Sargeant et al. 1974) suggested its usefulness in deterring wild red foxes. The fence described by Forster (1975) consisted of three strands of wire at 5.9 inch intervals with a total height of 17.7 inches. The fence was energized by two standard charger units (specifications not provided). Use of this fence resulted in a 5-fold increase in the number of pairs of nesting sandwich terns (Sterna sandvicensis) over the previous year when the nesting colony was not protected from red fox predation. Patterson (1977) used a fence similar to that described above but it included an "earth wire" which was laid on the surface of the ground and connected to the fence posts. The purpose of this wire was not explained but it could have functioned to insure a shock when a fox attempted to crawl between it and the "hot" wire 5.9 inches above. Also, it could have deterred digging under the fence as barbed wire has been used to deter coyotes (Gipson 1978; Thompson 1979). The fence was energized by a Koltek Big Tom charger powered by 10-volt batteries. This fence was effective in reducing fox visits to the protected area by over two-thirds.

Sargeant et al. (1974) described a fence that is supplemented with electrical wires for use in protecting the nests of ground nesting birds from mammalian predators. The fence consists of a 24-inch high fence of 2-inch mesh chicken wire. Two strands of electrical wire are mounted at an outward angle above the mesh at about 3.9 and 9.8 inches. A portable charger is used to energize the wires. The same fence but without the electrical wires was used in another study area. Both fences reduced predation by mammals, including red foxes, thus leaving unknown the amount of added security provided by the supplementary electrification.

It is apparent from available information that fences can be effective in deterring both red and arctic foxes. The degree of protection afforded with non-electrified fences depends greatly on measures taken to prevent digging under and climbing over the fence. These added features plus the need for small mesh wire increase costs accordingly. A less costly fence can be erected if electrification is included. The reduced cost reflects both less expensive materials and reduced labor in erecting the fence. However, maintenance requirements of an electrical fence are greater to ensure that wires do not short out, to eliminate vegetation, snow, etc. from making contact with charged wires, to charge and replace batteries for DC units, and in maintaining a taut fence.

Coyotes. A great deal of effort and money has been spent to control the movements of coyotes. The vast majority of this effort was expended in protecting sheep and other livestock from coyote predation in the western states. The problem of deterring coyotes with fences is similar to that of controlling foxes, the chief difference being the coyote's larger size. Their ability to dig, climb and pass through narrow openings requires a fence design to minimize penetration by all of these routes. Thompson (1978) described fence-crossing methods of coyotes and categorized them into four groups: climbing over, jumping over, passing through and passing under. It could be assumed that these categories would describe the behavior of other canids also.

A variety of fence designs have been deployed to deter coyotes. Their effectiveness varied considerably, principally dependent on the fences capacity to deter the various fence crossing mehtods used by coyotes. Shelton (1973, in Gipson 1978) provided a general review of coyote resistant fences. More recent literature unquestionably favors the use of electrified fences for the control of coyote predation (Anonymous 1977a, 1977b; Gates 1978; Linhart et al. 1979; Shelton 1977) based on experimental and field evaluations. Thompson (1979) conducted an excellent experiment evaluating 34 different fence configurations including both electrified and non-electrified fences. From the abstract he states "Fence height and mesh size were important factors in controlling jumping over and crawling through, respectively. Overhangs and aprons were necessary to preclude climbing over and crawling under fences." It is interesting that the electric fence configurations that he used were ineffective in deterring coyotes under the conditions of his experiment. However, he did not test the design that has been found effective by other investigators (Gates 1978).

The fence specifications recommended by Thompson (1979) for coyote control are: height of at least 66 inches, mesh size smaller than 6 x 4 inches, an overhang and an on-grade apron of at least 15-inch-width mesh material with openings less than 6 inches, and corners protected by shields to minimize climbing at these locations. DeCalesta and Cropsey (1978) tested this type of fence under field conditions using a fence height of 71 inches, a 16-inch overhang and a 24-inch apron. This fence effectively deterred coyotes from entering the protected pastures whereas sheep in surrounding pastures suffered high mortality.

The electrical fence described by Gates (1978) consists of 12 strands of alternating charged (+) and ground (-) wires varying from 4-inch separation at the bottom to 6-inch at the top. The total height is 5 ft. An additional charged trip wire is located 8 inches from the outside of the fence and 6 inches above the ground. A high voltage fencer is needed to ensure a good shock and to minimize the effects of vegetation coming in contact with the charged wire, thereby reducing voltage. This fence design overcomes the most serious shortcoming of conventional electrical fences, that of inadequate grounding under certain conditions. An animal in contact with a charged wire while at the same time insulated from a ground by dry snow or dry soil, will not be shocked. This problem was recognized long ago by McAtee (1939), and use of metal matting, such as chicken wire, was recommended under these conditions to ensure grounding. Alternating charged and ground wires is a simpler and less costly solution. The proximity of the wires virtually eliminates the possibility of climbing over or through the fence without touching two wires. The charged trip wire on the outside is effective in minimizing digging under fences, but under poor ground conditions it is possible that an animal would not be shocked when in contact with only that wire.

It is apparent from the above review that fences can be built to deter coyotes and, presumably, other canids of similar size. The same fences probably would be useful in the control of wolves and dogs. The height probably would have to be increased for wolves because of their jumping capability. Both electric and non-electric fences are effective in controlling coyotes but, as with the previous discussion on foxes, the non-electrified fence requires more materials and manpower to construct, and they are more complex. Therefore, they are more costly.

The materials for the non-electrified fence are about 50 percent higher than for the electrified fence (DeCalesta and Cropsey 1978), but the latter may be more costly because of long-term maintenance requirements.

Wolves. No published data were found on fences for control of wolves, however, some zoos obviously employ fencing and other barriers to contain captive animals. The NARL constructed a pen for wolves that was completely effective in maintaining captive animals. The fence consisted of standard 2-inch mesh chain link on grade to a height of 11 ft. Buried vertically beneath the fence was 2 to 3 ft of perforated steel plate (Marston matting) which was also laid horizontally at this depth out into the pen for a distance of 5 to 6 ft (Selby 1980 pers. comm.). The matting deterred any attempts to dig out of the pen. No escapes occurred even though up to 26 different wolves were maintained in the pen for varying lengths of time.

Although information was not found regarding the use of electric fences for controlling wolves, it is felt that the fence described for coyote control (Gates 1978) would be effective for wolves. The height would have to be increased, perhaps, to deter jumping over the fence. The non-electric fence described as effective for coyotes by Thompson (1979) and DeCalesta and Cropsey (1978), perhaps, would also be effective with height modifications. The differential cost and maintenance factors for electric and non-electric fences would apply as previously described.

Grizzly and Black Bear. Fences have been successfully used to deter both grizzly and black bears in certain instances. The black bear is probably easier to control because of its smaller size and milder temperament although both species are more difficult to deal with than any of the canids.

The majority of literature on the use of fences to deter black bears is associated with prevention of bear depredation in beeyards or apiaries (Alt 1980; Anonymous 1970; Caron 1978; Dacy 1939; Doughty 1947; Harlow 1962; Robinson 1961, 1963; Storer et al. 1938). The range of dates for the above references clearly indicates that the problem of black bear deterrence is not an easy one to solve and may require different approaches depending on circumstances. It is interesting to note that over this 40-year period, only electrical fences or conventional fences supplemented with electrical wires were developed. Non-electrified fences obviously would not be effective, therefore, unless a very costly physical barrier is erected. The non-electrified fence recommended by Thompson (1978) for deterring coyotes was not effective in deterring a black bear at one of the study sites. The overhang section was merely bent backward when the bear climbed over. Open-space-concept zoos often use moats to contain black bears but the Alaskaland Zoo in Fairbanks uses chain link fence supplemented with electrical wires.

Probably the principal reason for the relatively large number of reports on electrical fences, each illustrating an improvement over earlier designs, is the increased sophistication of electrical fence equipment and the experience gained in different parts of the country. Only the most current fence designs and specifications are reviewed here.

Boddicker (1978) reviews two types of fences for control of black bears that have been found to be effective. The principal difference is that one is totally electrical whereas the other consists of two electrical wires supplementing a mesh wire fence (Fig. 1). These designs are based on experiences and specifications developed elsewhere. Totally electric fences consisting of 4 or more strands of wire have been developed as portable exclosures for black bears (Wynnyk and Gunson 1977).

Although smooth wire is easier to handle and install than barbed wire there is an advantage to using the latter. Because of the heavy fur on bears it is possible for the hair to insulate the bear from the current thereby preventing a shock. Using barbed wire the points will penetrate farther into the hair thereby increasing the probability for a shock (Alt 1980; Caron 1978; Doughty 1947; Harlow 1962; Robinson 1963).

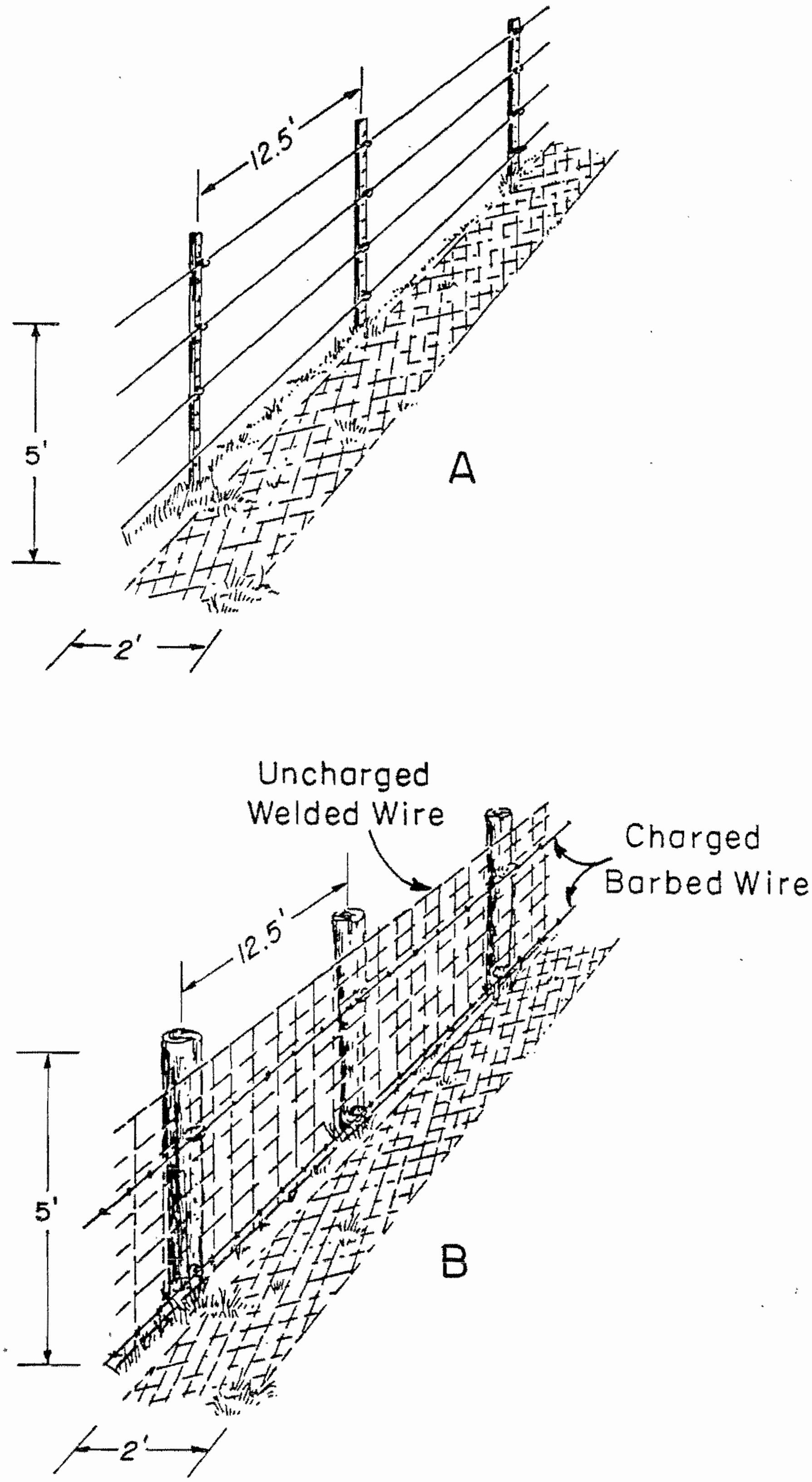

Figure 1. Two types of deterrent fence found to be effective for black bears (from Boddicker 1978). Not to scale.

An additional advantage might be the deterrent value of the points, however, this would not deter a determined animal.

The problem of ensuring a good ground is important if an electrical fence is to be effective. Because dry snow and soil can insulate an animal thus preventing a shock, two approaches have been used to overcome this problem. A wire mesh laid on the ground on the outside of the exclosure fence that is connected to the negative terminal of the charger will ensure a shock when an animal is standing on it and is simultaneously in contact with the charged fence wires. This approach is illustrated in Boddicker's (1978) review of useful fence designs (Fig. 1). Others have described this approach also (Anonymous 1970; Dacy 1939; Harlow 1962; Robinson 1963; Storer et al. 1938; Gunson 1980 pers. comm.). The other approach is to alternate charged (+) and uncharged (-) wires in the fence such that an animal attempting to climb over or through the fence must simultaneously touch two wires thus eliciting a shock (Robinson 1961; Gunson 1980 pers. comm.; Boswell 1980 pers. comm.; Baker 1980 pers. comm.). Both methods will increase the likelihood for a shock but the fence using the ground mesh would be more costly and difficult to install. In addition, it would increase the likelihood of shocking people who approach the fence.

Electrical fences for deterring black bears require a high voltage. Wynnyk and Gunson (1977) used about 10,000 volts; Boswell (1980 pers. comm.) indicated that a minimum of 4,000 volts is required; and Robinson (1961) used 10,000 volts. In the latter study when a 12-volt battery was replaced with a 6-volt battery, thus halving the line voltage to 5,000, the bears crawled through the wires because the charge was insufficient to deter them. The current used in combination with these voltages is quite low, usually in the milliamp range, for safety. However, Baker Engineering Enterprises, Ltd. (Edmonton, Alberta) makes fencers using 1 amp with voltages in excess of 4,000 that can safely energize fences without causing injury due to their very short pulse width (75 to 250 microsecond duration). Therefore, if accidental contact is made no injury will result because the duration of the charge on the body is extremely short. According to Boswell (1980 pers. comm.) Underwriters Laboratory indicates a maximum duration of 300 microseconds for these charge levels, thus suggesting the safety of their equipment. However, this combination of voltage and amperage is quite effective in deterring bears and other animals.

Several investigators (Alt 1980; Dacy 1939; Storer et al. 1938) recommend that the charged wires be baited after installation and the charge is applied. The purpose is to draw the bears to the charged wires where they will be shocked on the nose or mouth. Once this occurs the bears will be conditioned to avoid areas protected by fences.

Less published information is available on the effectiveness of fences in the control of grizzly/brown bears than for black bears. Electric fences consisting of one and two strands of wire were shown to reduce predation by brown bears on red salmon on Kodiak Island (Clark 1957, 1959; Gard 1971). Haga (1974) reported that effective electrical fences have not been developed to deter the Yezo-brown bear (Ursus arctos yesoensis) in Japan.

Greer (1974) reported that a 10-ft chain link fence with 3 ft buried surrounded by a 3-strand electric fence was penetrated by grizzly bears at the West Yellowstone dump in Montana. The bears were getting access to the dump by going over the fence. The top was inadequately reinforced so that the weight of the bears collapsed the fence inward. During the 1973 season 11 attempts to dig under the fence were made by grizzlies but Greer (1974) does not identify whether any were successful. Grizzlies entered and exited this fenced dump at least 28 times during the 1973 summer season. During mid-summer the electric fence was relocated and a electrified wire attached 18 inches out from the chain link fence. This did not deter the bears either. Greer (1974) does not provide details of the electric fence but it is presumed that a standard livestock charger was used.

Whitman (1980 pers. comm.) indicated that the grizzly bear problem at the West Yellowstone dump prior to 1974 was serious. The fence now used is a 10-ft chain link with 4 ft buried; it was first buried at 2 ft but bears dug under it. Strands of electric wire were attached to the outside of the fence using 110 volts AC. The charge was kept on for 30 days during 1974 and has not been turned on since. They have not had bear problems at this dump in the last 5 years.

Meagher (1980 pers. comm.) indicated that a 9-ft chain link fence with 3 ft buried was used in conjunction with electrification (Hepburn 1974) at Yellowstone National Park, and was effective. At one place where the electricity had been turned off grizzly bears had dug under the fence. As a temporary measure a 6-ft width of chain link fence was laid on the ground and weighted with logs. This proved effective in deterring further digging. Brown (1980 pers. comm.) used this same fence design at the landfill in Mt. McKinley National Park and they have not had any bear problems. He felt that addition of the electric fence to the chain link was the main factor in solving the bear problems at Yellowstone Park.

At Jasper National Park an unburied 8-ft chain link has not been particularly effective in deterring grizzly bears from the dump. Bears can go through the fence and dig under during one night (Martin 1980 pers. comm.). A similar fence is used at Banff National Park and bears dig under it and have even gone over it (Jacobsen 1980 pers. comm.). They have not used electric fences to supplement the chain link at these locations but they are considering it at Jasper Park. These fences have concrete pads at the base of the chain link that are continuous between posts but these are not deep enough to deter bears from digging.

It is apparent from this review that grizzly bears are more difficult to deter effectively than are black bears. It would appear that the shorter height fences used for black bears even with electrification could be penetrated by grizzlies. This would be particularly true where the electrical specifications of the fence are below maximum levels. A voltage of 12,000 at 0.022 amps has been used to deter grizzly bears at Yellowstone Park (Hepburn 1974) and at Mt. McKinley Park. Although the high voltage with 1 amp described by Boswell (1980 pers. comm.) has not been tried on grizzlies, it should be effective because of the high power. Also, mesh fence laid on the ground outside of the vertical fence was effective in deterring digging by grizzly bears (Meagher 1980 pers. comm.) as it was for black bears at Glacier Bay National Park (Paige 1980 pers. comm.) and at an apiary (Robinson 1963). In neither case was the mesh grounded to the charger but this added assurance would appear to greatly enhance the deterrent quality of the fence.

An aspect of electrical fences that was stressed by virtually all information sources was the need to adequately maintain the fence. This is essential to maintain the high powers necessary to deter bears. It was reported by several that even though bears usually stay away from fences once they have been shocked, they regularly test the fences when there is an attractant of some kind within the exclosure. If the wires are shorted or have reduced power when tested by the bears, they will penetrate the fence by either going over, through or under the fence. In any case, it does not appear that anything less than a very secure and costly physical barrier in itself will be able to deter a bear if an attractant is located on the opposite side. Only electrification has been shown effective. Electrical specifications for various fences used to control bears are summarized in Table 6.

General. A problem common to all animal deterrent fences is accomodating human passage through the fence without reducing the deterrent qualities of the fence. Most of the areas or facilities that were protected in the studies reviewed above required only periodic and irregular access; there was no constant traffic. In these cases, the problem is not as difficult to solve.

For non-electric coyote deterrent fences Gates (1978) recommends a gate of at least 5 ft height with an outwardly angled overhang. A 6-inch square concrete sill is placed the length of the gap between gate posts. The gate for the mesh wire and electrical strand fence for black bears (Boddicker 1978) uses 5 strands of barbed wire only, 3 of which are charged. The totally electric fence continues the 4 strands of charged wire across the gate openning (Boddicker 1978). Both designs

Table 6. Electrical specifications for and effectiveness of black and grizzly bear deterrent fences as reported by various sources.

Source	Volts	Amps	Pulse rate per minute	Effectiveness
Black bear				
Storer et al. (1938)	---	0.015	30-50	Yes
Dacy (1939)	---	0.015	30-50	Yes
Robinson (1961)	10,000	---	---	Yes
"	5,000	---	---	No
Wynnyk & Gunson (1977)	10,000	0.1	60	Yes
Boswell (1980 pers. comm.)	4,000	1.0	---	Yes*
Grizzly bear				
Hepburn (1974)	12,000	0.022	---	Yes

* These specifications are for fencers designed by Baker Engineering Enterprises Ltd., Alberta. The short pulse duration (75 to 250 microseconds) permits use of higher amperage without danger.

use plastic gate handles to open and close the gate. A similar procedure is recommended for black bear control in Manitoba (Anonymous 1970). Robinson (1961) used wood-frame swinging gates with what appears to be electrical wires across them. The pictures are not clear and the text does not provide gate specifications.

Most of the dumps or landfills protected by fences use single or double swinging gates. The double gate at Glacier Bay National Park has a concrete sill between the gate posts to deter digging under the chain link gate (Paige 1980 pers. comm.). The addition of electrical wires across the outside of the gate would greatly reduce efforts to go over or through the gate.

Australia has had trouble with dingo barrier fences particularly with the increased cross-country travel in recent years (McKnight 1969). Swing gates have always been used, but many people fail to close them after passing. To alleviate this problem they designed "motor-car passes" which resemble the guards used to deter ungulates. These passes consist of metal pipes or bars laid horizontally a few inches apart and perpendicular to the road axis. Vehicles travel over these without problem, but they have been found to be somewhat effective in deterring dingos. If they work for dingos they should work for other canids, however, no data are available. It is doubtful that these guards would be effective to control bears because of their large feet and resourcefulness.

Sound

Considerable literature has been written on the biological effects of sound. However, many of these involve health related studies and the effects of man-induced noises on domestic and wild animals. Studies of the effects of noise on wildlife became important when environmental impact statements were required to treat this potential mode of disturbance. In this regard Memphis State University (1971) was contracted to review available literature on the effects of noise on wildlife for the U.S. Environmental Protection Agency. Subsequently, a symposium was held to review this subject (Fletcher and Busnel 1978). None of the information contained in either volume pertains directly to the use of noise/sound as a deterrent. However, many useful generalizations are identified that have application, principally with regard to audible sensitivities, the nature and propagation of sound waves, the biological significance of sound and the acute and chronic effects of sound.

From the biological standpoint, several generalizations can be made with regard to the effects of sound on animals. There are definite species differences in the ability to hear at different frequencies (Brown and Pye 1975; Ewer 1973; Peterson et al. 1969), although little information is available on threshold perception levels (Harrison 1978). This factor must be appreciated if sound is to be used as a deterrent. Additionally, the behavior, social environment and biological condition (for example, reproductive status) of an animal can affect its sensitivity to sound (Busnel 1978). Animals can habituate to sound particularly if it is constant or of regular occurrence in their environment (Ames 1978; Busnel 1978; Campbell and Bloom 1965; Sprock et al. 1967). Similarly, it has been noted that animals can even habituate to sonic booms (Cottereau 1978), although when first subjected to either actual or simulated booms, they show some response (Bell 1972; Cottereau 1978).

The physical aspects of sound that affect its propagation and thereby its potential effect on animals include frequency (Hz) and sound pressure level (or acoustic level or intensity) (dB). Environmental aspects include atmospheric conditions, terrain, ground impedance, and the presence of foliage or other potential barriers (Harrison 1978). All of these factors should be considered in determining the effects of sound on animals and in determining its utility as a deterrent.

Two approaches to the use of sound as a deterrent have been utilized, and both are currently considered viable. The first utilizes a sound that animals find discomforting or painful which causes them to leave or avoid an area. These sounds usually are of high intensity (above 85 dB) and are either in the ultrasonic (above 15 kHz) or audible (below 15 kHz) range (Frings 1964; Greaves and Rowe 1969; Sprock et al. 1967). The second approach for the use of sound as a deterrent is biosonics (or biologically significant sound) (Frings 1964; Haga 1974; Sprock et al. 1967). This entails the playback of recordings of actual or simulated distress or alarm calls of animals. Both approaches have been shown to be effective for certain species and under certain conditions.

The majority of work on sound as a deterrent has been on ridding areas of avian pests. Both sound (noise) and biosonics have been useful under certain conditions and for certain species (Frings 1964; Frings and Frings 1963).

A few studies have been conducted on mammals showing that both sound (noise) and biosonics are somewhat effective in deterring these animals or modifying their behavior. Sprock et al. (1967), working with rats and mice, reported that both ultrasonic noise and recorded rat distress calls reduced nesting and time spent near the sound source. They suggested that ultrasonic sounds may never be very effective as rat and mouse deterrents because they are more directional and attenuate more rapidly in air than lower frequency sounds and because they do not penetrate obstacles nor reflect around corners. An important point made was that the distress-call technique seemed to have greater promise in controlling rats than other sound techniques. Greaves and Rowe (1969) felt that ultrasounds could be used to expel rodents from an area and to maintain an area free of rodents by applying ultrasonic fields across all entry points. The latter seemed to be most feasible.

Crummett (1970, in Memphis State University 1971) reported that rabbits and deer were repelled by an acoustic jamming signal device produced by a noise unit called Av-alarm. Hill (1970) rid an atomic reactor building of bats by connecting 12 high frequency (4 to 18 kHz) dog whistles to compressed oxygen cylinders and operating them continuously for 48 hours.

Only one report (Sander 1972) describing the effects of sound as a deterrent for coyotes was found. This report provided only an overview of a project that was initiating research on the effects of sound on coyotes. The purpose was to identify sounds that annoy, distress or deny predation information to coyotes and which then could be generated in pastures to deter raiding coyotes. Continuous tones, random noise, and continuous and interrupted combinations of these were to be employed. Results of this work have not been obtained. Information on the effects of sound as a deterrent for foxes, wolves and dogs has not been found in the published literature. However, Kennedy (1980 pers. comm., in Bellringer 1974) reported that shotgun cracker shells were used to chase red foxes from Dietrich Camp during TAPS construction. The foxes stayed away for 3 days, but Kennedy felt that they would soon ignore the cracker shells.

A few papers are available on the effects of noise on bears. In Florida, Whisenhunt (1957) indicated that a "set-gun" consisting of a shotgun pointed upward was effective in deterring black bears from an apiary. Based on further study, however, he concluded that the "set-gun" was effective in stopping bears from making an initial entry but not for those who had already tasted the honey during previous raids. An added disadvantage was that they required regular inspection and resetting of trip wires.

A similar approach using "weed burners" which shoot out a flash and make a cracking sound, has been tested on bears in Yellowstone National Park, but no results were provided (Jonkel 1977). Scaring devices (unidentified) using sound were ineffective for polar bears (<u>Thalarctos maritimus</u>) (Jonkel 1977), and one bear was wounded by a teleshot which is a explosive scaring device (Schweinsburg 1977). Woods (1980 pers. comm.) reported that wardens use cracker shells to harass problem bears at Revelstoke National Park (Canada). Alt et al. (1977) reported that cracker shells were ineffective in deterring a female and four yearling black bears.

Wooldridge and Belton (1977) synthesized nine versions of sounds to simulate the aggressive sounds of male polar bears. One or more of these sounds produced a behavioral effect in five captive polar bears, 18 wild polar bears, two captive brown bears and 13 wild black bears. Four of these sounds (unidentified) produced a greater effect than the others. Miller (in press) reported that only extremely loud and sharp sounds were effective as repellents for captive grizzly and polar bears. Thunderflash, boat horn and Cap-chur gun sounds were effective but bells and whistles were not.

Amplified (up to 120 dB) aggressive polar bear sounds were effective in deterring captive polar bears, except females with cubs (Jonkel 1977; Schweinsburg 1977). At great distances the sounds attracted bears, presumably because of curiosity. These sounds were found to be painful to man at 140 to 150 dB but the pain level for bears was unknown. Where captive animals were not able to escape the sounds, it was found that they could become habituated to it. Wooldridge (in Schweinsburg 1977) stated that high frequency dog scaring devices were ineffective on bears but that automobile engine noise was effective.

The bear workshop attendants (Jonkel 1977; Schweinsburg 1977) agreed that as bear deterrents coyote getters, teleshots and hand explosive devices had limited value. On the other hand, high frequency sounds, amplified sounds, and biosonics (for example, grizzly growls and dog barks) were considered to have potential. Biosonics would probably have a significant effect on bears if they could be used in conjunction with other sensory stimuli such as scent, sight or touch (Schweinsburg 1977).

Haga (1974) studied the effects of unpleasant and bear-frightening sounds on the Yezo-Brown bear in Japan. The five sounds used were: barking of many dogs; pile-hammer; gun-firing; synthesized sounds, the principal one being a jet plane; and various high frequency sounds (2 to 4 kHz). The sounds were tested on captive bears held in grazing fields. No significant reaction was observed from the pile-hammer, gun-shot or synthesized jet plane sound. The high-frequency sounds did not always elicit an immediate reaction but bears would show avoidance behavior over a period of time when these sounds were produced for extended periods. They tentatively concluded that the high frequency sounds caused psychological stress in the bears after a period of time. The recordings of barking dogs had the greatest effect on bears. The frightening sound approach was concluded to be an effective deterrent for these bears. A notable point made was that, in general, the reactions of bears to various sounds was most striking in younger age groups and was gradually less in increasingly older aged bears. However, all age groups responded about equally to the sound of barking dogs. Using their equipment under similar environmental conditions it was also determined that the volume of the barking dog sound was less attenuated than pure sounds. The greater distance achieved and the greater relative effectiveness over other sounds, suggested the value of barking dog sounds as a bear deterrent in Japan.

It is apparent from these various investigations that the use of sound can be effective in deterring mammals. Both pure sounds or noise and biosonics have potential depending on the species involved and the circumstances surrounding the situation or area where deterrence is desired.

Several generalizations can be gleaned from this information and applied to the potential for deterring carnivores with sound. It is important that the hearing frequencies of the mammals of concern be known so that the use of non-biosonic sound can be synthesized in the range of greatest effect. Peterson et al. (1969) provided information on coyotes, red foxes, and dogs showing that the upper frequency limits of audibility are 80 kHz, 65 kHz, and 60 kHz, respectively. The only data available on bears is on the Asiatic black bear (Selenarctos thibetanus) showing that its upper hearing limit is 80 kHz (Peterson et al. 1969). Ranges of maximum sensitivity and other data for these species are also provided in this paper. Since the sensitivity of hearing varies with frequency (Ewer 1973), assumptions that species have similar hearing abilities because they use the same frequency range, must be made with caution. For example, because the coyote and the Asiatic black bear hear within the same frequency range, does not mean that they are equally sensitive to sound. The sensitivity of each within the frequency range may vary and differ between the two species.

Animals have an ability to habituate to sound especially when it is continuous. Therefore, it appears that deterrent sounds should be discontinuous, irregular and even include frequency variations to minimize the potential for habituation (Frings 1964; Frings and Frings 1963; Haga 1974; Sprock et al. 1967).

Frings (1964; Frings and Frings 1963) feels that high intensity sounds (high dB level) probably are not necessary to produce an effective deterrent. Unless in the ultrasonic range (above 15 kHz) these levels could be harmful to people as has been shown in several investigations on people and other animals (Alexander 1968; Allen et al. 1948; Kryter et al. 1966).

Biosonics seem to have great promise as animal deterrents because they can be effective, they do not always require high amplification, and they are meaningful to the animal. Frings (1964) points out several problems in their application but which can be overcome with the accumulation of more information. Whether alarm or distress calls are more effective is probably species specific or perhaps varies depending on the circumstances. The fidelity of sound reproduction appears to be important for some species but not for others. The timing and spacing of sound application is important and can only be determined effectively by being familiar with the behavior of the species of concern.

Noxious Substances

A noxious substance, as used in this report, pertains to any chemical compound that animals find distasteful or discomforting when inhaled or contacted and that, therefore, has potential as a deterrent. Emetics, whose action requires ingestion, are not included in this category but are treated in a following section. The literature on deterrent substances for carnivores is very limited; considerably more is written on deterring herbivores, such as deer and insects, from agricultural crops. A few papers are available on the use of noxious substances to deter dogs and coyotes but nothing was found for foxes and wolves. The information on bears consists mostly of anecdotal discussions at workshops.

The interest in developing noxious chemical deterrents for coyotes is in response to the problem of predation on sheep. Potential deterrent substances that could be applied to sheep to prevent coyote attacks are being evaluated. Cringan (1972) briefly reviews the nature of the program at Colorado State University to identify substances and evaluate their effectiveness as odor repellents for coyotes. Indications that a substance in the skin of toads accounts for the low predation on these animals, particularly by coyotes, has stimulated a line of research to determine whether this substance could be applied to sheep to deter predation (Anonymous 1973). At the University of Wyoming about 500 different chemicals have been tested on sheep and the most promising is the synthetic compound undecovanillylamide which tastes like Tabasco sauce (Anonymous 1977c). It is a stable compound lasting up to 6 months. After biting treated sheep coyotes were reported to back away and, if enough contact was made, to either rub their muzzle or seek water.

Linhart et al. (1977) identify a series of potential coyote repellents that were tested by various investigators but conclude that the reason most of the work is not published is that the results were either inconclusive or negative. The compounds identified are: cyclohexylmercaptan, n-amyl mercaptan, cinnamic aldehyde, Bitrex, capsaicin, and mustard oil. Linhart et al. (1977) tested six different compounds that had potential as coyote repellents. These were: denatonium benzoate (Bitrex), N-acetyl-4-cyclohexylmethylcyclohexylamine (DRC-5593), N-amyl mercaptan, chloropicrin, benzaldehyde, and cinnamic aldehyde. Chloropicrin is very volatile and, therefore, may have limited application even though it produced the greatest response in coyotes. Liquid cinnamic aldehyde reduced prey killing the most in the experiment but there was evidence that coyotes could habituate to its repellent effects.

Huebner and Morton (1964) evaluated the effectiveness of five commercially available dog repellents (product names not included) in a controlled experiment using 60 dogs. The active ingredients of these repellents were as follows:

Product A: oil of lemongrass and synthetic oil of mustard. (aerosol)

Product B: tobacco dust, lemongrass oil, eucalyptol, citrol, amyl acetate, geranium oil, methyl salicylate, and oil lavender. (dust)

Product C: allyl isothiocyanate, bone oil, imitation oil of sassafras, and paradichlorobenzene. (aerosol)

Product D: liquid animal bone oil. (dust)

Product E: New formula (unidentified). (pellets)

The results of this study indicated that Product B was 79 percent effective, C was 65 percent effective, and D was 42 percent effective. Products A and E were considered comparatively ineffective. No active chemical ingredient was common to the three effective repellents; however, Products C and D both contained bone oil. It is possible that some of these repellents or ingredients therein would be effective on wild canids. However, some or all of these may already have been included in the tests of 500 chemicals at the University of Wyoming (Anonymous 1977c).

Whether natural secretions from canids could be used as deterrents has not been studied. However, Donovan (1967) suggests that secretions from the anal glands of dogs may serve as a deterrent to other dogs.

A workshop on man/bear conflicts was held in Canada (Jonkel 1977; Schweinsburg 1977). It is quite apparent that little information is available on the use and effectiveness of chemical deterrents on bears. Formaldehyde and a mixture of mustard oil and kerosene were ineffective in deterring bears in Banff and Jasper National Parks. However, where formaldehyde was applied to garbage cans, some success was achieved. It was agreed that noxious chemicals and natural repellants, such as mercaptan, had merit as deterrents but more work is necessary to determine their effectiveness (Jonkel 1977) and the best ways for application (Schweinsburg 1977). Haga (1974) reported that chemical repellents were ineffective against the Yezo-Brown bear in Japan.

A variety of deterrents are marketed for personal protection against bear and dog attacks. These contain substances such as tear gas, cayenne pepper and eucalyptus oil as the active ingredient. Brown (1980 pers. comm.) of the Alaska Division of Fish and Wildlife Protection is skeptical about their effectiveness principally because thorough studies on these substances have not been conducted. Nava (1980 pers. comm.) found that Halt (a commercial dog repellent) caused three captive black bears to slowly back away when this substance was sprayed in their faces. Miller (in press) found that Halt, when sprayed in the faces of two captive grizzly bears, elicited a strong avoidance response. Ammonia (Windex) and a mixture of dry mustard and water elicited a similar strong response. Although these various substances are either packaged for personal protection or are household items, it is possible that if found to be effective after more study, they could be prepared for wider application and to deter animals from specific places or areas.

The lacrimating agents such as tear gas have been studied to some extent, principally to determine their harmfulness to people during crowd control. There are two basic types used: chloroacetophenone (CN) and o-chlorobenzylidenemalononitrile (CS) (Gaskins et al. 1972). These substances can cause damage to the eyes, skin and respiratory tract depending on the dose, duration of exposure and manner of application (Andrews 1964; Cucinell et al. 1971; Gaskins et al. 1972; Kalman 1971; Leopold and Lieberman 1971; MacLeod 1969). Under controlled experimental conditions Andrews (1964), testing several mammal species, found no abnormalities in a gray fox (Urocyon cinereoargenteus) 24 hours after exposure. Cucinell et al. (1971) found that CS caused heart rate increase, rise in blood pressure, altered breathing pattern, reduced blood oxygen level, decreased blood pH level, and increased CO_2 pressure in the blood of a dog exposed to a high dose. If the dose level used in this experiment could be achieved under field conditions, these reactions would suggest that use of tear gasses could injure animals or cause pain. In either case the animal may become enraged and either attack or cause unintentional injury or damage during its reaction to the substance. These could produce more problems than if the animal was left alone.

It is obvious from the above review that certain noxious substances show promise as deterrents for canids and bears. However, more work will be necessary to test these and other substances before broad application can be attempted.

Electromagnetic Radiation

Microwave irradiation has been used as an animal deterrent. Ark and Parry (1940) long ago reviewed the effects of high frequency electromagnetic waves on various species of animals. It was determined then that high frequency waves heated the irradiated subject. Electromagnetic irradiation produces both heating and chemical effects depending on the wave length (Baker et al. 1955). Chemical effects involve changes in cellular metabolism (Tanner et al. 1967). Wave lengths longer than 2880A produce heating whereas shorter wave lengths produce chemical effects (Baker et al. 1955).

Tanner et al. (1967) irradiated chickens with microwaves (9,000 MHz) and elicited behavioral responses which presumably occurred because neural tissue was directly affected by the microwaves. In an earlier paper Tanner (1966, in Tanner et al. 1967) elicited avoidance or escape reaction when chickens were exposed to microwaves that produced a thermal effect. Both studies showed that chickens, and presumably other birds, do respond to microwaves and, therefore, this approach could be used as a possible deterrent. This method was being studied because it perhaps could be applied as a deterrent for birds near airport runways.

There appears to be more work on the use of microwaves for the control of birds but this literature was not reviewed because of its questionable application to mammals.

King et al. (1971) tested rats and found that they were sensitive to microwave irradiation and that it could be used as a cue for impending electroshock in behavioral experiments. Whether animals detect microwave irradiation by thermal or some other sensory change is not known. Microwaves used were 2450 ± 50 MHz at doses up to 6.4 mw/g, a value well below the safety limit of 10 mw/cm^2 observed in the United States (King et al. 1971). It would appear that microwaves to be used as deterrents would have to be more powerful than used in this experiment since these levels were essentially near the threshold of sensitivity. These higher levels could be injurious to man.

No information has been found on the use or effectiveness of microwave irradiation on larger mammals, including the carnivores. Therefore, the potential utility of this method cannot be speculated upon in this report.

AVERSIVE CONDITIONING

Aversive conditioning involves a process of training an animal to avoid or reject an object, food or behavior that is normally desirable. This is accomplished by applying an unpleasant or painful stimulus during the undesirable activity. For example, if an animal enters an area which it is being trained to avoid, it can be shocked so that it associates pain with the area. Aversive conditioning is accomplished with negative reinforcers such as electrical shock and emetics.

Aversive conditioning involves modifying the behavior of an animal by pairing the target undesirable behavior with a painful stimulus. This is in contrast to noxious chemical deterrents which repel animals by their odor or taste, or on contact with the mouth or skin. These do not by necessity require behavioral modification. To illustrate the difference, if a hot dog is treated with a chemical repellent a fox will avoid it because of the repellent. On the other hand, if the hot dog is treated with an emetic the fox will eat the hot dog and later become sick. Subsequently, the fox will avoid hot dogs because they are associated with sickness. Thus the fox's natural behavior to eat hot dogs is altered.

Aversive conditioning has been used widely in behavioral experiments under laboratory conditions. Most of this work involved rodents. The use of aversive conditioning in larger animals has been less studied.

Aversive conditioning is one of the techniques that has been tested to control predation of coyotes on livestock, especially sheep. It has also been used to aversively condition black bears from raiding apiaries for honey. The conditioners used in these experiments were a series of drugs called emetics which cause nausea when ingested. The following section discusses the use and effectiveness of emetics.

Other aversive conditioning studies in the laboratory involved the use of electrical shock as the conditioning stimulus. A brief section follows speculating on its use for nuisance animals.

Emetics

The use of emetics (nausea producing agents) as aversive conditioning agents has been the subject of interest to livestock owners for the past several years. Several different research projects have provided valuable information on the effectiveness of these agents in preventing or controlling predation of livestock. The majority of information gathered relates to laboratory animals and non-Alaskan wildlife in ranching situations of the contiguous 48 United States.

Limited experimental and field data were collected in 1976 by R. A. Dieterich and JFWAT personnel during the construction of the TAPS. During that study, dogs and captive wolves were fed different types of food which contained lithium chloride in free form, in capsules and in delayed release wraps. Dogs were easily conditioned to avoid specific types of food and this aversion lasted for several weeks. Wolves were more selective in what they ate and appeared more willing to retest baited food to determine if it still contained an emetic. Wolves were fed lithium chloride in sandwiches along the oil pipeline during its construction phase. It was a common practice for workers to throw sandwiches to wildlife along the haul road. This led to several problems. Not only were the health and safety of the workers jeopardized but also many carnivores were injured or killed while frequenting roadsides in search of handouts. The continual feeding of the animals led to their dependence on human-supplied food sources. The baiting of sandwiches appeared to have some aversive effects on these carnivores, but a very limited testing period and lack of marked animals did not allow any conclusions to be made.

A study by Gustavson et al. (1976) indicated a 30 to 60 percent reduction in sheep killed by coyotes following application of taste aversion conditioning agents in comparison to past loss records maintained by individual ranchers. In this study, captive coyotes were fed rabbit flesh treated with lithium chloride, and captive wolves were fed similarly treated sheep flesh. One or two treatments inhibited predatory attack upon the living prey, but left the appetite for alternative prey unaffected.

The success of these first studies led investigators to try several different agents to control wildlife interactions with man, domestic animals or man's environment (Ellins et al. 1977; Cornell and Cornely 1979; Dorrance and Gilbert 1977; Brett et al. 1976; Rusiniak et al. 1976). The more common products used as emetic aversion control agents include lithium chloride, sodium salicylate, syrup of Ipecac, apomorphine, peruvoside and ouabain (Harrison et al. 1972; Wittlin and Brookshire 1965; Yeary 1972). A review of numerous articles on emetics indicates that lithium chloride shows the most promise at this time. Baseline information is available on its use in a number of species. Apomorphine is another effective product, but its narcotic status limits its availability and would probably curtail widespread distribution of loaded baits in uncontrolled areas.

Several nausea-inducing chemicals have been tested in bears to determine their potential as aversive conditioning agents. Black bear kills in British Columbia's interior showed a significant difference in the rate of consumption of the carcass between chemically treated and untreated carcasses (Wooldridge 1977). Also, lithium chloride in combination with electric fences effected a 94 percent reduction in damage of beeyards by black bears as compared to unprotected beeyards.

The action of nausea producing drugs depends on their effect on the emetic apparatus located in the brain (Smith et al. 1974). This apparatus is functional at three days of age in dogs; thus most emetics are effective in all age groups. Emetics as aversive conditioning agents function by having the animal which received the baited food containing an emetic, associate the food with an unpleasant experience. Experiments with caged dogs and wolves in Alaska indicated this aversion is relatively long standing (several weeks), but a limitation is that it is food specific. A wolf fed a meat sandwich baited with lithium chloride will avoid that type of sandwich but may well eat a fish sandwich. Reinforcement with another baited sandwich may be necessary at future times to assure success. A random baiting of food sources which draw carnivores to pipeline construction areas may prove effective as an inexpensive and effective control measure in areas unsuitable for fencing. It has been shown that location is not an ecologically important cue in bait shyness so that animals baited in one area would probably avoid similar food sources in another area (Slotnick et al. 1977).

Several problem areas have been identified which need further study before widespread use of emetics as aversive conditioning agents can be started. Animals can soon learn the taste of emetics and avoid only baited foods. This has been overcome in some cases by the use of capsules that contain the emetic until it reaches the stomach. The rate that these capsules dissolve is critical because if the animals vomit immediately after ingesting the emetic the aversive conditioning will be lessened. Dieterich and co-workers overcame some of these problems by wrapping the capsule containing the emetic in a plastic film which dissolved slowly after being eaten.

The primary problems in using emetics as aversive conditioning agents revolve around the duration of aversion possible in different species, the specificity of aversion and the changing behavioral patterns of the carnivores in adapting to the presence of aversive agents in food.

Electroshock

Electroshock has been used as a conditioning agent in many behavioral experiments on rodents. This usually involves an electrified cage floor or other device to induce a shock when an animal performs an activity that is not desired.

Collars are commercially available for dogs that are energized and can induce a shock by remote control. These collars are used to train dogs for hunting and for controlling other behaviors.

It is possible that nuisance animals could be controlled with this device if it was a situation where the animal was unsuitable for translocation or dispatch. For example, there is evidence that female black bears are territorial (Ruff and Kemp 1980). In this situation, one alternative available to dealing with a problem bear would be to aversively condition it. To translocate or dispatch the bear would provide a vacancy for another to move in and become a problem. Use of this technique would require live capture of the animal, fitting with the collar, and release. Any time the animal performed an objectionable behavior it could be shocked by remote control. If successful, the animal would be aversively conditioned to the unwanted behavior. Major disadvantages of this technique are that it is relatively expensive and time-consuming. The animal has to be captured and handled twice (to fit it with and afterward remove the collar), and someone has to observe the animal during this period to administer the shocks at the appropriate times. These would appear to seriously reduce the utility of this technique under field conditions with wild animals.

TRANSLOCATION AND DISPATCH

Problem animals are often dealt with in manners more direct and final than developing deterrents to elicit avoidance of areas or food items. The previous sections reviewed various types of deterrents and aversive conditioning, and their effectiveness. This section briefly reviews approaches for dealing with problem or incorrigible animals. Problem animals are ones that either have failed to be deterred by other methods or that pose problems as first-time offenders.

Canids

Canids, because of their predatory lifestyle, have long caused problems in areas of livestock production and where competition with man for game animals is considered important. Most of the literature on control, therefore, is related to these problems and not where dumps or other artificial food sources have attracted these animals. Foxes and coyotes usually are shot or trapped and killed where they cause problems. Although wolves can be dealt with in similar ways, little published information is available because the distribution of this species is limited in areas of human habitation, and densities are low. Exceptions are Alaska and the northern regions of Canada. Control philosophies and methods developed for coyotes to a large degree should be applicable to other North American canids.

Typically, troublesome canids are eliminated by either shooting or trapping. A series of papers has been published on this subject, mostly on coyotes (Casto and Presnall 1944; Cowan 1949; Fitzwater 1970; Gipson 1975; Henderson 1972; Spencer 1938; Thompson 1976). Brawley (1977) tested several control methods for coyotes that were preying on domestic sheep. Jackson and Davies (1973) reported on live trapping of dogs in remote situations, however, these animals were later destroyed. Generally, foxes and coyotes in these situations are considered vermin, and efforts are not made to live trap and move them because they might cause problems elsewhere or perhaps even return to the original problem area. Homing behavior in North American canids is virtually unknown mostly because trapped animals are usually killed. Even where animals are live-trapped for study they are released at the point of capture. Homing has been reported in an adult red fox which moved 35 miles in 12 days to the area of capture (Phillips and Mech 1970). Henshaw and Stephenson (1974) reported homing in gray wolves. One wolf raised at the NARL and translocated near Umiat 175 miles southeast of Barrow returned and was again caged 4 months after release. Two others were killed midway between Umiat and Barrow 2 months and 7 months, respectively, after release. Both were on a degree bearing between Umiat and Barrow suggesting that their movements were not random. Wolves in northwestern Alaska annually move between summer grounds on the North Slope to areas south of the Brooks Range in winter (Stephenson 1980 pers. comm.). If a wolf from these packs was trapped and relocated in this general area it could be assumed that it would be able to return to the capture area.

The costs associated with a trapping and relocation program can be high and perhaps prohibitive in most situations. Occasionally problem animals are live-trapped and transported to zoos or nature parks in need of representative animals. These situations are infrequent, however, and most nuisance animals of fox and coyote size are destroyed. Where diseases such as rabies may cause human health problems, animals are definitely destroyed (National Academy of Sciences 1970) for analysis of tissue.

Bears

Bears pose a different problem because of their size, their protected or big-game status and their ability to arouse public interest. However, where these animals become a nuisance they are either destroyed or translocated. On the TAPS project problem bears were handled in this way. Grizzly bears were either translocated or shot and black bears usually shot (JFWAT files).

The circumstances surrounding the animal nuisance problem often dictate the solution. In northern Alberta where apiaries are an important part of the local economy black bears cause considerable problems.

From 1972 through 1978, 2,122 problem black bears were shot with the highest annual kill of 506 occurring in 1976 (Gunson 1979). Mortalities of this magnitude caused some public outcry; therefore, deterrents such as fences and aversive conditioning were tested for effectiveness. Even where deterrents are somewhat effective the usual procedure is to destroy an incorrigible animal.

Grizzly bears can also cause damage in agricultural regions although population densities in these areas are usually low. Where populations are higher, such as in western Canada and Alaska, man's presence is not as significant and, therefore, problems are not common. Problem grizzly bears that are repeat offenders or threaten human life are usually destroyed but are sometimes translocated (Craighead and Craighead 1971). In Yellowstone National Park 140 grizzlies were killed between 1931 and 1970 with 22 of those killed in 1970 (Craighead and Craighead 1971). Destruction is usually a last resort because of the low population densities in problem areas and to avoid public outcry.

A considerable amount of literature is available on capture and translocation of bears, particularly black bears. Most bears are live-trapped, drugged and released at sites distant from the problem area. Others are captured with projectile drug syringes prior to relocation. Both black and grizzly bears have demonstrated homing behavior, a factor that must be considered when considering the utility of relocating bears away from the problem area.

Black Bears. Most information on homing behavior concerns black bears. Gunson (1979) reported that 914 bears were translocated from 1972 through 1978. Of 15 bears on which data is available seven returned to the vicinity of capture. The distance from the capture point beyond which some bears did not return was 29 miles. One bear returned from a distance of 53 miles. No time intervals for return were provided in this report. In British Columbia 37 of 54 black bears were recaptured at the original site (Rutherglen and Herbison 1977). Ten of these bears returned within one month whereas others occurred within one year. Over a period of one year a female with cubs homed three times after translocations of up to 59 miles. In Newfoundland three black bears were translocated to offshore islands (Payne 1975). Within four weeks all had returned to the capture site which required a minimum 0.6 mile swim through salt water and a minimum overland movement of 12 miles. In the same study a female with cubs homed 43 miles overland in 18 days.

In New York 4 of 13 black bears demonstrated homing behavior with one male returning to the trap site a distance of 32 miles in 8 days; another male returned 43 miles after one year (Black 1958). Twenty of 51 black bears translocated in Pennsylvania homed (Alt et al. 1977). Releases greater than 38 miles from the capture site reduced homing in this study. Six of these bears were radio-tagged and it is significant that solitary males and females, a female with cubs, and a female with yearlings all exhibited homing behavior. Beeman and Pelton (1976) reported homing behavior in black bears translocated in Great Smoky Mountains National Park. The greatest distance moved to the capture site by a male was 38 miles and by a female 11 miles. The farther away the release point the less likely was the chance for homing. In the upper peninsula of Michigan, 115 black bears were translocated in a study of homing behavior (Harger 1970, 1974). Twenty-seven bears homed and 11 others moved long distances in the direction of the capture site. The greatest distance moved was 142.5 miles. Both males and females had similar homing ability. Rogers et al. (1976) reported that young male black bears in the same area were less likely to home than older males and females.

The various reports cited above in some cases contain more detailed information on homing behavior in black bears than reported here. Because most of the reports involved bears without radio-tags, it is difficult to interpret what proportion of bears will usually home. Bears that did not home perhaps died or were translocated from a different problem area. However, several generalizations can be made that are supported by most of these reports. Both male and female bears have homing ability including both solitary females and ones with cubs or yearlings. Cub and yearling black bears, when translocated without an adult female, are less likely to home than older aged bears. The greater the distance translocated from the capture site the less likely will homing occur, although black bears have been shown to home over considerable distances in a relatively short time. Bears that are translocated tend to move a great deal more than animals released in the vicinity of the capture site. This may be associated with search behavior for familiar territory but could increase the probability of homing because these search movements often are oriented in the direction of the capture site. The additional movement in unfamiliar territory may also increase the probability of being killed.

Grizzly Bears. Less information is available on homing in grizzly bears. Craighead and Craighead (1971) reported that 145 grizzlies were translocated in Yellowstone National Park between 1959 and 1969. Sixty-eight percent of these bears returned to the same or another campground; the actual number returning to the capture site was not identified. Greer (1974) reported that of 30 grizzlies translocated from the vicinity of West Yellowstone between 1971 and 1973, four returned within the year of capture and four during the following year. One of the males traveled a distance of 45 miles to return to the vicinity of capture the following year. Craighead (1976) reports that grizzlies translocated less than 48 miles can return quickly to the point of capture. Eleven translocated grizzlies in Yellowstone National Park in 1968 and 1969 returned 32 times to the capture area. The greatest distance returned was 28 miles. Most of these bears were adults but yearlings returned to the capture site four times. In the Yukon Territory, Pearson (1972) reports that one translocated female grizzly traveled 70 miles back to its home site in three days. Pearson (in Cowan 1972) suggests that adult female grizzlies should be translocated at least 50 miles and males at least 100 miles if the operation is to be successful.

Dalle-Molle (1980 pers. comm.) provided information on grizzly bears translocated between 1974 and 1980 at Mt. McKinley National Park. A subadult male and an adult male released 24 and 60 miles, respectively, from the capture site, did not return. A subadult female returned 30 miles in five days; an adult female returned 60 miles in two weeks; a subadult female moved about 45 miles in five weeks to an area approximately 10 miles beyond the capture site; and a subadult female which was moved about 45 miles from the capture site returned about 30 miles in approximately four weeks. Four other bears translocated an average distance of 87 miles were not seen again.

Although less information is available on grizzly bear homing than for black bears, some generalizations can be made. Grizzlies are able to home great distances in a short period of time. Both adult males and females are capable of these movements, as are yearlings. Apparently, the farther an animal is transported from its home range the less likely it will return.

Summary

It is obvious from the above review that both canids and bears can home after translocation. Although only minimal data are available for canids it appears that translocation can be successful only if animals are moved great distances from the problem area. Several authors felt that other management techniques were needed to deal with problem bears mostly because of their homing ability (Craighead and Craighead 1971; Lindzey et al. 1976). Another reason for considering alternative plans for dealing with problem bears is the great cost and time needed for these operations (Alt et al. 1977; Beeman and Pelton 1976; Cowan 1972; Greer 1974) although none of these reports specifically used this reason. It has been suggested that black bears be moved soon after entering a potential problem area because the chance for homing is less (Beeman and Pelton 1976). This, however, may not be supported by other workers in different circumstances.

Destruction of problem animals is the rule for all canids and for bears that have taken or threatened human life or are repeat offenders. This obviously is the least costly and time consuming method but can induce public outcry especially when dealing with animals such as grizzly bears and even wolves. Recent treatises on predator management, which in this context is a problem similar to that faced with animals concentrating at artificial food sources, suggest that if control is necessary the offending animals should be dealt with and not necessarily all members of the species that happen to be in the area (Berryman 1972; McCabe and Kozicky 1972). In addition, conditions contributing to the problem should be reviewed prior to taking control actions and, if control is necessary, alternatives should be evaluated (McCabe and Kozicky 1972). Thus, animal control should not be the first subject addressed, but should be considered only after conditions contributing to or causing the problem are remedied, if this is possible.

RECOMMENDATIONS TO AVOID AND MINIMIZE CARNIVORE PROBLEMS

The NWA project will be faced with the same problems that TAPS encountered because the proposed gas pipeline will traverse areas inhabited by both black and grizzly bears, wolves, and red and arctic foxes. In the area between Prudhoe Bay and Delta Junction, where the gas pipeline will parallel the TAPS, the problems encountered during the initial stages of construction may be compounded due to the presence of animals, particularly bears, that were habituated to handouts and garbage by TAPS activity. Some bears are known to have caused problems after TAPS construction camps were closed, at abandoned camps, Alaska Department of Transportation and Public Facilities camps and at TAPS pump stations. Some of these animals were destroyed, but others are still active along the Haul Road. The influx of people into the corridor during preparation of camps and the initiation of construction will be accompanied by the arrival of problem animals. This will occur whether pipeline workers are exposed to a good environmental briefing or not. It is imperative that the initial approaches of these animals are not rewarded with food derived from garbage and active feeding. These animals must be discouraged at their first arrival and chased away.

The problem described above will occur most frequently between the Yukon River and Galbraith Lake Camp, less frequently north of Galbraith Lake Camp, and least south of the Yukon River. The segment of the corridor between Delta Junction and the Canadian border should contain only "naive" animals because the TAPS project did not follow this route and the Haines Pipeline and Alaska Highway were built too long ago to expect any animals from that period to be alive yet. It is essential to maintain a clean operation in all areas to ensure that carnivores in contact with the construction project do not become accustomed to unnatural food sources.

Some of the recommendations that follow reflect the regional differences in animal problems that can be expected along the NWA route. The most difficult area will be between the Yukon River and Galbraith Lake Camp. Tailoring deterrent programs to the anticipated severity of animal problems is valid and justified. It emphasizes more effective controls where they are needed and, in areas where fewer problems are anticipated, permits a program involving less effort and less capital expenditure. There is one aspect of an animal deterrent program that cannot be regionalized and must apply throughout the route between Prudhoe Bay and the Canadian border: <u>ANIMAL FEEDING AND IMPROPER FOOD STORAGE AND GARBAGE DISPOSAL MUST BE STRICTLY FORBIDDEN</u>.

The following sections provide animal deterrent recommendations for the NWA project. These recommendations are developed specifically to reduce problems with bears, wolves and foxes. However, if followed these programs should reduce problems with other potential mammalian scavengers such as wolverine (*Gulo gulo*), mink (*Mustela vison*), marten (*Martes pennanti*) and ground squirrel (*Spermophilus undulatus*) and scavenging birds such as ravens (*Corvus corax*) and gulls.

GENERAL ANIMAL DETERRENT RECOMMENDATIONS

It is very important that NWA establish an animal control program before construction begins. Initially this requires a commitment to avoid establishing conditions that are attractive to scavenging animals. A program of consistent and adequate garbage collection and proper and adequate food storage is necessary to ensure that camps and construction areas are kept free of exposed attractants. In addition, animal feeding must be strictly prohibited. Immediate disciplinary action should be taken against anyone feeding wild animals. Warnings against this activity should be included in the Environmental Briefing that each worker must attend before entering the field. The warning should include reference to the state law which prohibits active feeding and leaving food and garbage with the intent of feeding animals (5 AAC 81.218).

It should be clearly stated that in addition to state punishment for this violation, NWA also prohibits this activity, actively enforces the prohibition and disciplines any and all violations. NWA's disciplinary action, whether loss of pay, job or other punishment, should be clearly described so that workers entering the field know exactly what disciplinary measures will be levied if they violate the prohibition.

Following this notification of intent to enforce the regulation, violators should be promptly disciplined the first time. This policy is for two reasons. Firstly, it establishes a precedent and announces to other workers that NWA intends to stand by its commitment to minimize animal problems and thereby protect the environment and the health and safety of workers. Secondly, it is dangerous to reward animals with food when they first approach NWA facilities and construction areas because they will become habituated. Habituation is dangerous in the long term because the animals lose their fear of man a little more each time and eventually are quite bold in their scavenging and panhandling. At this point NWA will have to deal with a serious problem that could have been avoided. If the program is not firmly enforced from the very beginning, NWA can expect animal problems to develop and recur throughout the project.

A commitment to avoid or minimize the presence of animal attractants on the NWA project must form the philosophical basis for NWA's animal deterrent program. Taking firm disciplinary action against violators of the animal feeding prohibition, constitutes one of the procedural components of the program. Other procedural components include food handling, garbage storage, collection and incineration, and inorganic disposal. These aspects of an animal deterrent program can be supplemented with physical deterrents that will contribute significantly to an effective program. The following sections review recommended deterrents for use on the NWA project.

RECOMMENDED ANIMAL DETERRENT FENCES

Designs, specifications and descriptions of fences recommended for use at construction camps and compressor stations on the NWA gas pipeline project are presented. Three fence designs, each representing different animal deterrent capabilities, are proposed. Different designs recommended for different sites reflect the degree of carnivore, principally bear, problems anticipated at each. These designs and recommended locations are based partially on the densities of animals along the right-of-way but are more closely tied to the locations where TAPS experienced problems.

The designs and recommended locations presented here are for the 16 major construction camps and the seven compressor stations planned for the initial phase of pipeline operation. They should not be haphazardly recommended for other areas or facilities without a prior review of the potential for animal problems. The intent of recommending three designs specific to areas is to provide a cost effective fencing program, one which neither overkills and, therefore, is more expensive than necessary, nor is inadequate, and thus will require a considerable amount of additional animal control at camps.

The designs, specifications and other recommendations contained herein are essentially the same as those previously submitted (Follmann 1980). However, they have been further refined and contain more complete information and, therefore, supercede the previous report.

Site Recommendations for Fences

It should be reemphasized here that the fences are recommended for specific camps assuming the camps will be maintained such that animal attractants are eliminated or greatly minimized by proper food storage, by an effective and consistent garbage storage, collection and incineration program and by prohibition of animal feeding activities. If these functions are not included in the NWA comprehensive animal control program the fences recommended here may not be adequate in all cases and the next highest design may be required. It would be a serious mistake to assume that fences are a panacea and by themselves will eliminate all problems.

The TAPS construction experience strongly suggests that temporary and permanent facilities located in certain areas north of the Yukon River have a high potential for encountering animal problems, particularly with bears. An additional consideration is the Bureau of Land Management (1980) plan to develop facility nodes near Five-Mile, Prospect, Coldfoot and Chandalar Camps and just south of TAPS Pump Station 3. These could add to the overall attractiveness of these areas for scavenging animals. The NWA sites planned in these areas should be enclosed with above-standard-grade animal repellent fences.

Construction camps recommended for the highest grade animal repellent fence are Five-Mile and Chandalar. These two areas had severe black bear and grizzly bear problems, respectively, during TAPS construction.

Old Man, Prospect, Coldfoot, Dietrich, Atigun and Galbraith Lake Camps are recommended for the intermediate grade repellent fence. The proximity of Compressor Station 7 to Prospect Camp and Compressor Station 4 to Galbraith Lake Camp requires similar protection for these sites. The intermediate grade fence at Compressor Stations 4 and 7 could be restricted to the area around the temporary construction camps proper, rather than around the entire site. Since neither of these compressor stations is planned as an Operation and Maintenance Site during pipeline operation, they probably will be adequately protected with the standard grade fence once the large construction work force is reduced to the operation staff. Again, this assumes good maintenance within the site boundaries to avoid attracting animals to the site.

Compressor Stations 5, 6 and 8 fall within this problem area but are not planned for the initial construction phase. Therefore, fence designs for these sites should be determined later based on the effectiveness of animal control procedures utilized during the first phase of construction.

Specific animal problems have not been identified between Delta Junction and the Canadian border but the proposed Sears Creek Camp is located close to an area indicative of good grizzly bear habitat. It is therefore possible that the intermediate grade fence may be needed at this camp, although at this time the standard grade fence is recommended.

All other construction camps and compressor station facilities should be adequately protected by the standard grade animal repellent fence. However, should animal problems arise at these sites, they can be relatively easily upgraded to the intermediate grade fence to increase the fence's effectiveness.

The camp used at Delta during the construction of TAPS will be reopened for the NWA project. The camp is already fenced with the on-grade 8-ft chain link and barbed wire barrier used by TAPS. No specific animal problems were noted at this camp (JFWAT files), and there is no reason to believe that the situation will be different during gas pipeline construction. Therefore, it is recommended that the existing fence not be upgraded to the specifications proposed in this report.

Facilities and recommended fence designs are summarized in Table 7.

Recommended Fence Specifications

Fence specifications for the standard, intermediate and high grade fences are presented separately. Oblique and end views of these designs are illustrated in Figures 2 and 3.

Standard Grade Fence. Following are recommended specifications for the standard grade animal deterrent fence suggested for use at the camps and compressor stations identified in Table 7.

- 10-ft 2-inch-mesh chain link fence with 3 ft buried vertically; place on outside side of posts.
- 9-gauge chain link material.
- 3-inch fence posts spaced at 10-ft maximum intervals. Corner posts should be of 4-inch diameter and gate posts of at least 7-inch diameter. Posts can be set in concrete or in other ways that ensure strength and stability.

Table 7. Fence grade recommendations for NWA construction camps and compressor station sites.[1]

High Grade	Intermediate Grade	Standard Grade
Five-Mile	Old Man	Happy Valley
Chandalar	Prospect	Franklin Bluffs
	Coldfoot	Prudhoe Bay
	Dietrich	Livengood
	Atigun	Sears Creek
	Galbraith Lake	Tok
	Comp. St. 4	Northway
	Comp. St. 7	Comp. St. 2
		Comp. St. 9
		Comp. St. 11
		Comp. St. 13
		Comp. St. 15

[1] Fence grades for Phase 2 compressor stations can be determined when they are being planned for construction; use Phase I results to determine grades.

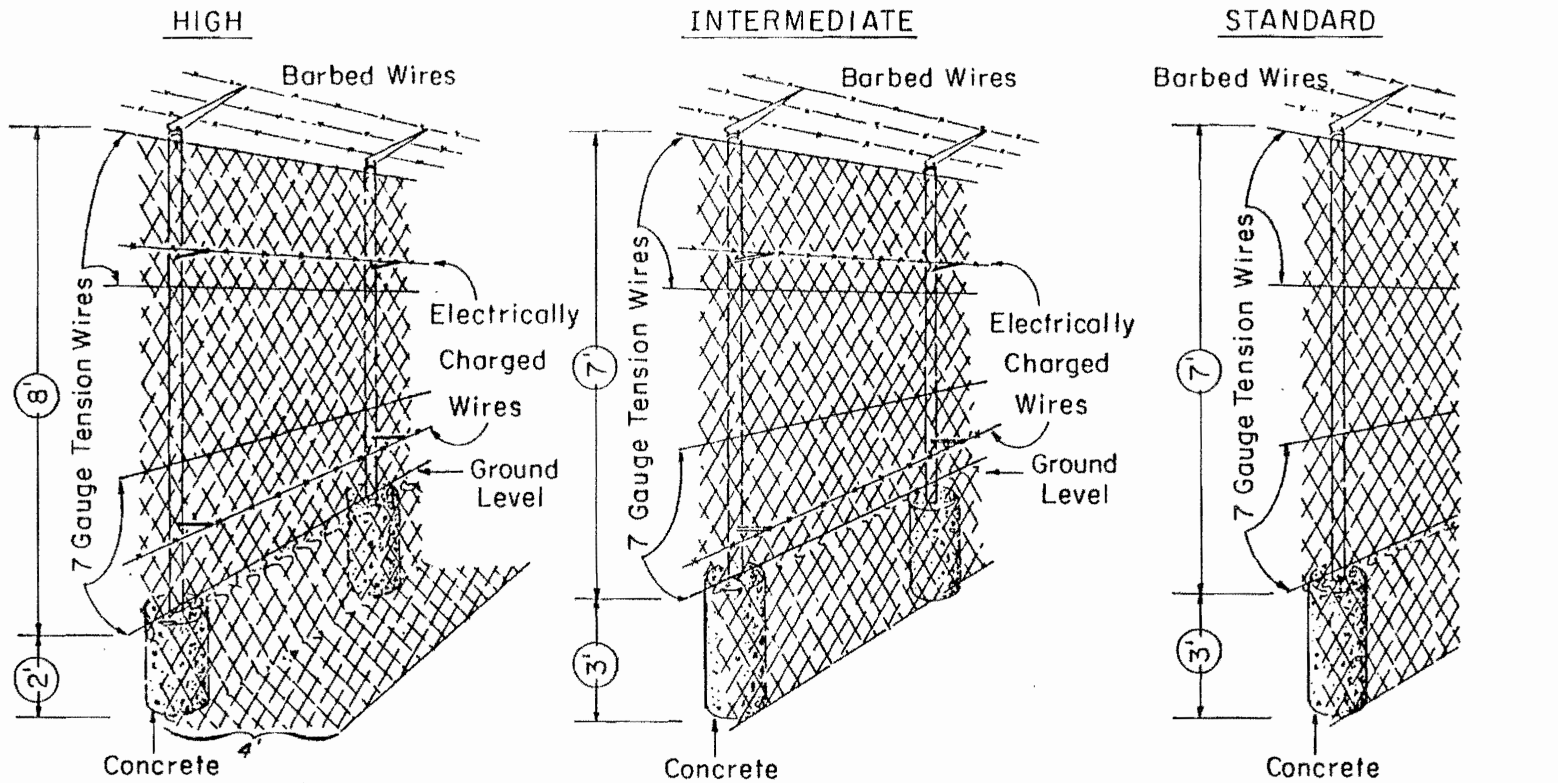

Figure 2. Oblique view of recommended high, intermediate and standard grade animal deterrent fences. Not to scale.

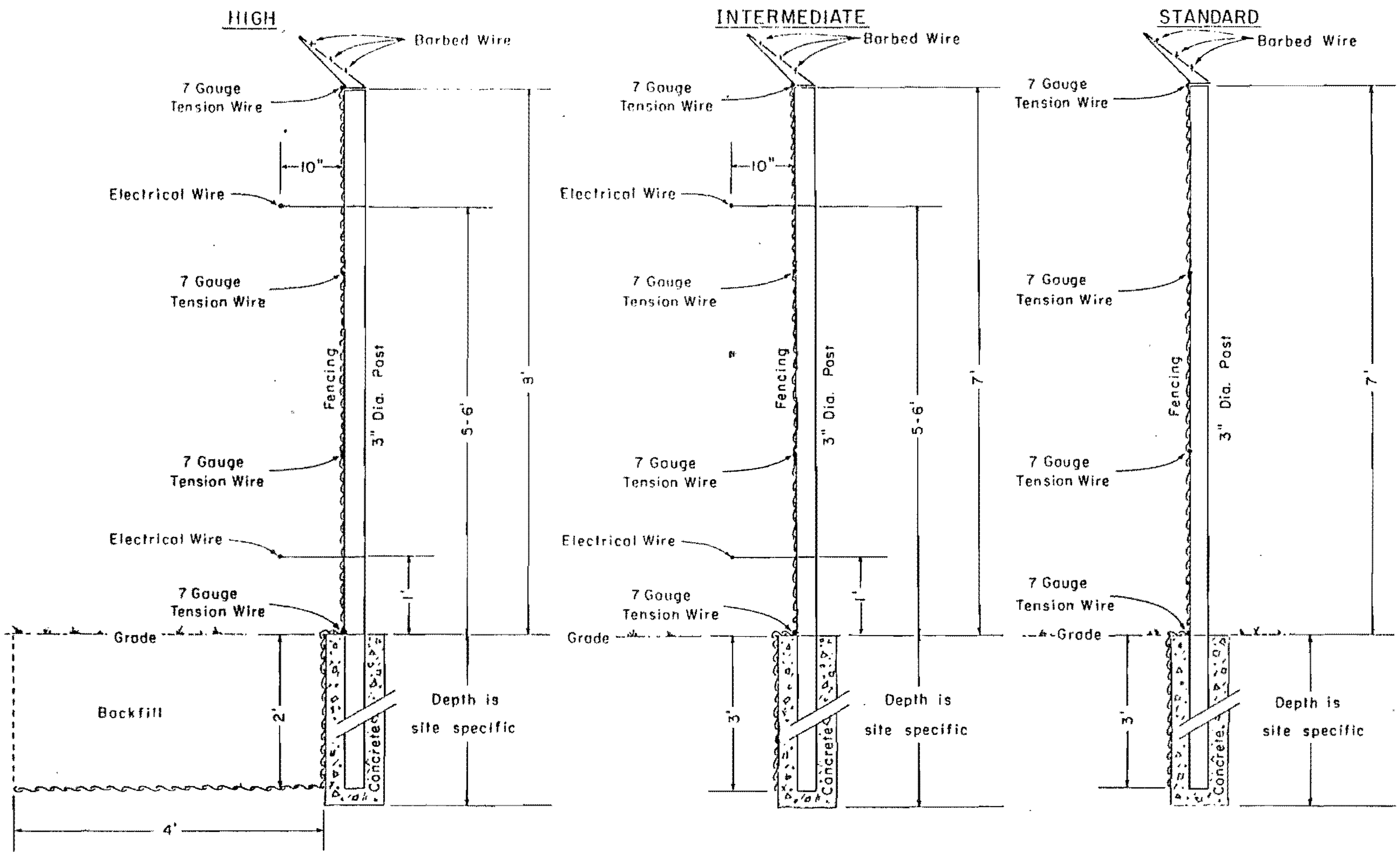

Figure 3. End view of recommended high, intermediate and standard grade animal deterrent fences. Not to scale.

- 3 strands of barbed wire (double strand 12-1/2 gauge; 4-point barbs on 5-inch centers) at top of fence angled outward.
- 7-gauge top, bottom and two intermediate tension wires.
- 3/8-inch truss rods.
- all tension bars, fasteners, etc. should be of steel, not aluminum.

Intermediate Grade Fence. Following are recommended specifications for the intermediate grade animal deterrent fence suggested for use at the camps and compressor stations identified in Table 7.

- 10-ft 2-inch-mesh chain link fence with 3 ft buried vertically; place on outside side of posts.
- 9-gauge chain link material.
- 3-inch fence posts spaced at 10-ft maximum intervals. Corner posts should be of 4-inch diameter and gate posts at least 7-inch diameter. Posts can be set in concrete or in other ways that ensure strength and stability.
- 3 strands of barbed wire (double strand 12-1/2 gauge; 4-point barbs on 5-inch centers) at top of fence angled outward.
- 7-gauge top, bottom and two intermediate tension wires.
- 3/8-inch truss rods.
- all tension bars, fasteners, etc. should be of steel, not aluminum.
- at 1 ft and 5-6 ft above ground level, one strand of electrically charged wire should be bracketed to the outside of the fence about 10 inches away from the chain link fence.
- the two electrical wires should be charged independently with chargers yielding high voltage and low amperage (see recommended specifications below).
- electrical wires should be charged (+) and the chain link grounded (-).

High Grade Fence. Following are recommended specifications for the high grade animal deterrent fence that is suggested for use at Five-Mile and Chandalar Camps.

- 10-ft 2-inch-mesh chain link fence with 2 ft buried vertically; place on outside side of posts.
- 4-ft width of the same grade chain link fence laid horizontally on the outside of the fence at a depth of 2-ft and hog-ringed to the bottom of the vertical fence; backfilled with pad material.
- 9-gauge chain link material.
- 3-inch fence posts spaced at 10-ft maximum intervals. Corner posts should be of 4-inch diameter and gate posts at least 7-inch diameter. Posts can be set in concrete or in other ways that ensure strength and stability.
- 3 strands of barbed wire (double strand 12-1/2 gauge; 4-point barbs on 5-inch centers) at top of fence angled outward.
- 7-gauge top, bottom and two intermediate tension wires.
- 6-gauge hog-rings (not aluminum) spaced at 1-ft intervals to connect horizontal and vertical fence materials.
- 3/8-inch truss rods.
- all tension bars, fasteners, etc. should be of steel, not aluminum.
- at 1 ft and at 5-6 ft above ground level, one strand of electrically charged wire should be bracketed to the outside of the fence about 10 inches away from the chain link fence.
- the two electrical wires should be charged independently by chargers yielding high voltage and low amperage (see recommended specifications below).
- electrical wires should be charged (+) and the chain link grounded (-).

General. Recommendations for construction of chain link fence presented here assume that the standard techniques of using braces, truss rods, etc. at corners and pull posts, and hanging and stretching fence on posts will be used. The specifications provided here are only intended to make the fence more secure against animal intrusion and do not include standard fence construction procedures and techniques.

If sites recommended for the standard grade animal deterrent fence encounter animal problems that stress the fence, remedial action can be taken by upgrading the fence to the intermediate grade. This requires only the addition of electrification.

Where a fence must pass over a culvert or other drainage structure, it is extremely important that these structures be equipped to prevent passage of carnivores. Culvert entrances can be covered with chain link mesh, rebar or similar material to prevent animal entry. This procedure was used to protect a culvert at Seven-Mile Camp after a female black bear with two cubs got into the camp by crawling through a culvert. Protected culvert entrances will require regular maintenance to remove any accumulated debris.

Electric Fence

The electric fence is recommended to supplement the chain link fence in areas where significant to moderate bear problems are expected to occur based on the experience during TAPS construction and operation (see preceding section in this report). The review of fences as deterrents (see preceding section in this report) clearly indicated that either electric fences or electric fences that supplement physical barrier fences are necessary to provide protection against bear intrusions. Purely physical barriers would not be adequate unless designed to extreme specifications. These would be unnecessarily difficult and expensive to build for NWA construction camps and compressor stations.

Wire. The wire used for the electric fence should be barbed. It has been suggested by various authors, as reviewed in a preceding section of this report, that the barbs will penetrate into the heavy fur of the animals and thereby increase the probability of effectively shocking an intruding animal. Unless the animal is shocked and deterred, it will continue to test the fence and perhaps damage the electrical installation and/or the chain link.

Barbed wire is more difficult to string than smooth wire. In addition, it appears that it requires more tension to maintain its tautness than smooth wire. These disadvantages are outweighed by the value of the barbs. The level, unvegetated gravel pad over which the electric wires are suspended greatly reduces the probability of the wires grounding on vegetation or the soil. Thus, the wire can be strung at a lower tension than what would be recommended for a standard pasture application, for example. The electrified barbed wires at Seven-Mile Camp were not strung at high tension, yet were found to be effective in deterring a black bear on two occasions. Similar results were obtained when a grizzly bear encountered the electric wire at Chandalar Camp.

Electric Wire Deployment. Two approaches have been shown effective in overcoming the problem of an animal not being adequately grounded when in contact with a charged wire: alternating charged (+) and ground (-) wires and placing wire mesh attached to the charger ground terminal so that an animal is standing on it when in contact with the charged wire. Neither approach is desirable for NWA camps. A series of (+) and (-) wires sufficiently close to insure simultaneous contact to a height of 5 to 6 ft would be costly and require considerable maintenance. A horizontal mesh on-grade would be covered by snow much of the year and thus be insulated from an animal, particularly the canids which are active throughout the year. In addition, it would increase the probability of shock to workers.

A workable solution is to suspend only charged (+) wires on the outer side of the chain link fence and to attach the chain link fence to the ground (-) terminal of the charger. To be effective the brackets on which the charged (+) wires are suspended must be of non-conductive material. Any animal that attempts to penetrate the fence by climbing over or going through, by design, will have to be in contact with a charged (+) wire and the chain link thus ensuring a good shock. This design also reduces the probability of a person being shocked.

The two electrical wires should be independently charged with two fence chargers. Therefore, if one wire is grounded or broken the other will still be charged. The lower wire should deter canids and bears that investigate or attempt to dig under the fence. The upper wire should be placed at 5 ft above ground if black bears are present or 6 ft if the larger grizzly is present. The upper wire should deter bears standing upright or animals attempting to climb the fence.

Chargers. NWA should use only commercially available chargers to energize electric fences. These have been developed over a period of years, are effective and are safe to use. Gunson (1980 pers. comm.), who has considerable experience with black bears and who designed a portable electric fence for black bears (Wynnyk and Gunson 1977), recommends chargers manufactured by Baker Engineering Enterprises Ltd. (Edmonton, Alberta, Canada) and by Gallagher Electronics Ltd. (Hamilton, New Zealand). These high power chargers would be effective against bears.

The Baker charger operates at 5,000+ volts and 1 amp with a pulse width between 75 and 250 microseconds (Boswell 1980 pers. comm.). This short pulse width permits safe operation at these high voltage and amperage levels. Boswell (1980 pers. comm.) indicated that Underwriters Laboratories requires a pulse width of 300 microseconds or less for safety using these voltage and amperage levels. The chargers, therefore, are safe to use, and the high power developed during the pulse is quite effective as a deterrent.

Specifications have not been obtained on the Gallagher charger. Other chargers described in studies of electric fence effectiveness have used voltages ranging from 5,000 to 12,000 volts and 0.015 to 0.1 amp (Table 6). With high voltages it is essential to maintain low amperage, unless the pulse width can be shortened as with the Baker charger. The higher power developed by the Baker charger should provide a better bear deterrent than the power developed by a standard livestock charger.

Most studies have shown that a pulse rate of about 60 per minute is suitable. Slower pulse rates leave too much time between shocks and a faster rate uses more energy than necessary for deterrence.

Both AC and DC chargers are available. At camps 110 volts AC could be used to energize the fence, but a DC charger using 12-volt batteries (not 6-volt) would be more flexible. In this case the batteries could be charged with AC line voltage. The AC charger is probably the best choice since it would reduce the amount of maintenance necessary. An extended power outage that coincides with a period of nuisance animal activity could pose a problem. With proper safeguards, however, this should not be significant. Animals that have already experienced a shock, will be less prone to test the fence during a short outage. Bears have been reported to test fences periodically, however, and outage durations should be kept to a minimum.

Safety. An electric fence will shock a person as readily as a wild animal. The commercially available chargers are safe. They are used throughout the country on farms, ranches and other areas, even where children are present. The shock is unpleasant but harmless. The more powerful chargers described above will provide a stronger shock, but the specifications of the chargers are within established criteria for safety.

Although many workers will live in camps most of the activity occurs within the perimeter fence and not outside of it. The chain link fence will not shock a person who comes in contact with it even though it is connected to the ground (-) terminal of the charger. The charged (+) wires are suspended 10 inches out from the outside of the chain link, beyond the reach of anyone on the inside.

A person suitably grounded will be shocked when in contact with the electric wires. This is unavoidable. It is essential that signs identifying the fence as being electrified be hung on the outside of the chain link at regular intervals. A suggested interval might be every other 10-ft section. This is considerably more frequent than normal but may be justified in this application. These signs are commercially available and should be installed before the electrical wires are energized.

Any time work is conducted on the camp pad beyond the fence perimeter, such as for maintenance, the electric fence can be turned off. This is not difficult and will prevent accidental shocks. The current should be switched on immediately afterward, however, for a bear could easily damage the wires if it is not shocked.

Fence Operation. The charger units should be housed in the gate shack so that the attendants are in control of the fence. The attendants should know how to use the on/off switch and ensure that the charger is connected to 110 volts AC camp power. If DC units are used, they should check the batteries, replace expended batteries and charge used batteries. The attendant should check the voltage in the wire with commercial units made specifically for this task. It would be good procedure to check fence voltages at shift changes or at least once each day.

During the period when bears are out of dens (determined site specifically in spring and fall by the occurrence of bears or their sign), both electric wires should be charged at all times. During late fall, winter, and early spring the top wire can be turned off because the overhanging barbed wire will probably be adequate to deter any canids from climbing over the fence. The lower wire should be charged until snow covers it, thus grounding it. At this point the presence of snow cover, frozen pad material and the buried fence will deter digging.

When the fence is first charged each year, the charged (+) wires SHOULD NOT be baited as suggested by several authors (see review in preceding section). It would be a mistake to attract any bear in the vicinity to the fence because some might not approach without bait. However, once a bear begins to frequent the area it would be appropriate to suspend a bait on a post to attract the animal and ensure a good shock. Once shocked the animal will probably leave, and the bait can be removed. The bait should be placed so the bear in its attempt to obtain it will simultaneously contact the charged (+) wire and the chain link or posts (-), in case the gravel pad is insulating the bear from a ground.

When work is required on the outside of the fence the charger should be turned off to prevent accidental shocks. This will only entail notification of the gate attendant. When the work is completed the attendant should be notified and the fence turned on. This procedure is quite simple and entails only communication between the work crew, camp manager and gate attendant.

Gates

Gates represent an unavoidable weak point in an animal deterrent fence. This is particularly the case where the gates experience a great deal of traffic as in a pipeline construction camp. The solution appears to be more procedural than physical.

Two types of gates are feasible for use at construction camps and compressor stations. They are: a standard 2-leaf swinging gate and a single unit sliding gate. The latter type is used at TAPS pump stations, and is remotely operated by a gate attendant. A major disadvantage of these gates, at least as used on TAPS, is that there is about a 1-1/2 ft space between the ground and the bottom of the gate to allow for snow accumulation in winter. Even when closed this gate will not deter a fox or wolf and perhaps would allow black bears and small grizzly bears to penetrate. A comment made by the gate attendant (unidentified) at TAPS Pump Station 8, who worked at TAPS construction camps, was that the remote control mechanism would not be sufficiently durable to handle the opening and closing required for the traffic volume at a construction camp. He felt that a manually operated gate would be more reliable and trouble-free.

As suggested above, the solution to the gate problem is procedural. Either a sliding or 2-inch-mesh double-leaf chain link swing gate should be used and be manually operated, unless a durable remote control mechanism is commercially available. The gate should not have a clearance exceeding 4 inches. This will require regular maintenance of the gate area to ensure clearance during snow conditions.

The gate should have a full-time attendant who will be responsible for maintaining proper function of the gate. During peak use hours the gate can be left open to accommodate traffic. During non-peak hours the gate should be kept closed and only opened to permit passage of individual vehicles. Any time an animal is in the vicinity (within 100 yards) of the gate and demonstrating interest in entering the camp, the attendant should be prepared to close the gate and implement a contingency plan to drive off the animal.

A minimum 12-inch square timber should be buried at ground level between the gate posts to deter digging beneath the gate. If desired, a concrete sill can be used instead of a timber, but it may be more subject to cracking from traffic loads. At least a 4-ft width of chain link mesh should be buried on the outside of the gate sill. It should be attached to the lower edge of the sill and extend outward so that the outer edge is buried to a depth of 2 ft. The mesh should extend laterally at least 3 ft beyond the gate posts. Animals attempting to dig under the gate will be deterred by the combination of sill and buried mesh.

At camps using supplementary electrical fences it will not be necessary to place electrical wires across the main gate(s). However, at auxiliary gates located in other areas of the camp, electrical wires should be strung across them using plastic gate openers. These gates should be kept closed at all times except when emergencies or maintenance require their use. Auxiliary gates should be protected with a 12-inch square timber sill and buried mesh between the gate posts. The clearance between the timber and bottom of the gate should not exceed 4 inches.

CONTROL OF PROBLEM ANIMALS

Conscientious solid waste disposal, fencing of camps and compressor stations, and strict enforcement of no-feeding regulations should do much to minimize or prevent many carnivore problems. Habituated animals already inhabit areas to be traversed by the NWA project, however, and preventive measures will not ever be completely effective. Therefore, the question of providing for the control of problem animals must be addressed.

It is important that NWA employ an experienced biologist capable of, and responsible for, handling animal problems. This will help ensure consistency in administering a standard animal control policy while providing the flexibility necessary to handle situations on a case by case basis. This individual should keep records on control actions and act as a liaison with agency personnel. He should also ensure that prompt action be taken whenever problems occur in order to avoid a gradual buildup of more serious situations. He should also be sure that a lack of incidents does not result in a slackening of preventive efforts.

The NWA project should obtain two portable culvert traps. One of these should be kept north of and one south of the Yukon River. These traps are typically 3 x 8 or 4 x 8 ft sections of culvert with 1/2 x 1/2 inch steel mesh over one end and either a guillotine-type or swinging door attached to a trigger mechanism on the opposite end (Rutherglen 1976; California Dept. of Fish and Game 1965). The ADF&G and Alyeska Pipeline Service Company have had culvert traps made in Fairbanks (Buhite 1980 pers. comm.). These traps should be used to capture and transport problem bears from areas of human activity.

Suggested Guidelines

Although it is possible to suggest some general guidelines, there are no hard and fast rules for handling all carnivore/human problems. In emergency situations where carnivores threaten life or property no prior authorization is needed to kill the problem animal. However, if the incident is precipitated by feeding or improper garbage disposal the person is liable for killing the animal. Game taken in defense of life or property is the property of the state. For non-emergency situations, decisions must be made on a case by case basis at the discretion of the control officer within the framework of applicable state and federal regulations. The following sections contain points to consider with regard to animal control.

Canids. Problems with foxes, coyotes and wolves can, in most cases, be handled in a similar manner. When a problem involving canids arises the nature of the problem must first be determined. In the case of an animal exhibiting abnormal behavior, sickness, or aggression resulting in bites or attempted bites, the animal should be destroyed and the head salvaged and sent to the Virology-Rabies Unit in Fairbanks to test for rabies. If the animals are non-aggressive and merely present, the source of attraction (inadequate garbage disposal or handouts) should be eliminated to disperse the animals. If it is not possible to remove the attractant or if the canids continue to frequent the area, other methods are justified. Relocation of canids is not recommended, however. ADF&G must be contacted to get permission to use deterrents or harrassment techniques. If canids do not pose actual health and safety problems they should not be dispatched.

Bears. When a bear problem is reported it is necessary to evaluate whether the presence of the bear alone has precipitated the complaint or whether a real hazard to life or property exists. If artificial food sources have caused or aggravated the problem they must be eliminated immediately. The longer bears are permitted to utilize artificial food sources the more habituated and incorrigible they become. Before proceeding with any action (other than emergency defense of life or property) permission must be obtained from ADF&G.

The most appropriate action when bears continue to loiter in the vicinity of human activity would be to use a deterrent to elicit avoidance of an area or a food source. Lacking this, with clearance from ADF&G and the U.S. Fish and Wildlife Service, the next best choice would be to attempt harassing bears with a helicopter, chasing them away from the problem area in hope that the stress would cause them to avoid the vicinity in the future.

Translocating problem bears is a generally unsatisfactory approach due to the expense involved and the ability of bears to return even over long distances to the vicinity of their capture. There are, however, certain circumstances when translocation should be considered as an option if deterrents and helicopter harassment fail. Translocation must be evaluated on a case by case basis taking into consideration the sex and past history of the bears involved.

Considering the expense (to be borne by NWA) and the probability of success, it is evident that translocation must be a selective tool. It is probably most appropriate to move female grizzlies with cubs of the year and young-age grizzly bears. In the case of female grizzlies with cubs the entire family group should be moved. However, it would also be worthwhile to consider breaking up the family group of an aggressive female with older offspring by translocating her 2-year- or 3-year-old young. This could reduce the threat from the adult (who would probably be less aggressive without young) without removing a breeding female from the area. In addition, young age bears may be less likely to return to the place of capture. The main objective of a bear control program should be, whenever possible, to protect female grizzlies because they are the productive segment of the population. Generally, the ADF&G policy is to not translocate black bears although in the case of a troublesome female with cubs it might be considered.

If bears can be captured in culvert traps and transported without drugging, it is preferable. It would be useful to mark them even if only with peroxide or paint in order to detect any returns. Bears should be moved at least 100-150 miles to increase the probability of a successful translocation.

Destroying bears should be a last resort not only because of adverse ecological impacts but because of potentially negative public response. There are a number of situations, however, where killing a problem bear is appropriate. These include cases of very aggressive bears that, though unprovoked, threaten or attack people (this does not include females defending young or bears defending a carcass, for example), bears that cause extensive property damage, visibly unhealthy or senile individuals, incorrigible black bears and male grizzlies, and nuisance female grizzlies after two or three unsuccessful attempts to translocate them. In any of these situations careful judgment of the control officer is needed. The most important bears to avoid killing are productive female grizzlies. These and young-age grizzlies should be considered for relocation as mentioned previously.

It is important to act promptly and to address problems as they occur. If a dangerous situation develops it is neither in the best interests of the bears nor the project to avoid taking necessary action. Once again, this does not apply to the case where a bear is merely present. When truly hazardous conditions exist, however, a well-meaning but misguided attitude of looking the other way to protect an individual bear may in the long run do more harm than good.

RECOMMENDED ENVIRONMENTAL BRIEFING TOPICS

An Environmental Briefing for all NWA pipeline workers is required by Stipulation 2.1 (see previous section in this report). This stipulation requires that all workers be informed of environmental concerns along the pipeline corridor and of the ways that NWA intends to minimize problems. This should be a broad-spectrum briefing entailing subjects from permafrost and spawning beds to garbage disposal. The following topic outline includes those subjects relevant to carnivores along the NWA pipeline corridor that should be included in the environmental briefing developed by NWA:

- Introduce workers to grizzly bears, black bears, wolves, red foxes, and arctic foxes (both summer and winter pelage) with color slides.
- Provide general information on distributions of these animals along the pipeline corridor. Also, sensitive periods such as denning, breeding and rearing of young, and critical areas such as floodplains for grizzly bears in the spring, should be identified.

- A general review of bear behavior should be included to identify types of animals that are most dangerous (for example, females with cubs and bears guarding kills), situations that could lead to attack, and the nature of charges. Stress avoiding these situations and how to minimize the probability of an attack.
- Stress the physical danger from bears and wolves and the disease and parasite danger from wolves and foxes. Augment with color slides of property damage and maulings caused by bears. Identify the need for inoculations when bitten and stress that even contacting a suspected rabid animal may necessitate treatment. Also explain that rabies is usually fatal.
- Feeding these animals is prohibited by the Alaska Department of Fish and Game (5AAC 81.218 Feeding of Game). This includes leaving food or garbage on the ground with intent to attract animals. Identify that NWA policy entails termination of anyone actively feeding animals or leaving food or garbage with the intent of attracting animals.
- Garbage and other solid and liquid wastes must be disposed of promptly and in approved containers.
- Harassing animals with motorized vehicles and airplanes is prohibited by state (5AAC 81.120 General Provisions) and federal [16 U.S.C. 742 (a) - 754. Fish and Wildlife Service. 742 j-1 Airborne Hunting] regulations. In addition, disturbing dens is prohibited (5AAC 81.090. Fur Animals); this is significant because all carnivores use dens in some phase of their annual life history.
- Harassing or killing animals is permitted in defense of life and property (5AAC 81.375. Taking Game in Defense of Life and Property). However, this does not apply if the nuisance is caused by improper garbage disposal or by some other attractant.

- The workers should be informed as to the state and federal regulations regarding hunting, fishing and trapping in the areas traversed by the pipeline corridor.
- NWA intends to build and operate the gas pipeline with as little damage to the environment as possible. Commitments to this effect have been made to the government and to the public. These commitments can only be met with everyone's cooperation. It is each individual's responsibility and mandate to adhere to these regulations and to company policies. Violation of these rules will result in job termination.

RECOMMENDATIONS FOR ADDITIONAL STUDY OF ANIMAL DETERRENTS

The commitment of NWA to storing food properly, to disposing of garbage in an acceptable manner, to prohibiting animal feeding and to fencing camps, can significantly reduce the number of contacts between carnivores and project workers. However, because of the size and linear extent of the project it will be difficult to ensure full implementation of these methods. If not fully implemented, problems will occur.

The animal feeding problem is one of worker attitude. A good environmental briefing can review the dangers of this practice and its prohibition on the NWA project but, as with any educational effort, a certain percentage of the workers will either not grasp the significance of the problem or will ignore the prohibition. These individuals will be the primary source of potential animal problems.

Animal feeding problems occur at work sites throughout the north even though workers are informed that the practice is dangerous and unlawful. Workers at the Prudhoe Bay field feed arctic foxes (Eberhardt et al. manuscript) as do workers at the Barrow gas field. These people are told not to feed animals, however, a certain percentage continue to do so. The same can be expected to occur on the NWA project. Many of the workers on the NWA project will have worked on the TAPS project where, at least initially, the significance and extent of the animal problems were not anticipated. The bad habits of some of these workers will carry over to the NWA project, and will not be altered even by the most sophisticated environmental briefing techniques.

As reviewed in previous sections, it is important that animals not be positively reinforced when they first approach. Because of the circumstances reviewed above some curious animals drawn to the work sites by odors, etc., will be rewarded with food. Even if the worker who violated the prohibition is immediately terminated, a problem animal will have been created who must be dealt with before it becomes totally habituated or significantly interferes with work. In the previous section translocation and dispatch of problem animals are recommended according to certain criteria and guidelines. However, these are terminal actions, and NWA should have at least one additional animal control technique that can be applied site specifically in areas not protected with fences, and to augment fences. It is in this context that this section recommends additional studies of animal deterrents.

The state-of-the-art of animal deterrents other than fences is not adequate for us to recommend that any or all should become a part of NWA's animal control problem. However, some have potential merit should additional information be obtained. Inclusion of one or more of these techniques in NWA's animal control program could enhance the program's effectiveness throughout the 741 mile route, not just at the points represented by camps and compressor stations. The purpose of this section is to identify additional studies on the more promising approaches that have been reviewed in preceding sections of this report. Recommended studies are as follows:

1. Tests of the effectiveness of commercially available and other noxious chemical deterrents should be conducted under controlled conditions on bears and representative canids. Captive arctic foxes, red foxes and wolves are available in the Fairbanks area for these experiments. Bear facilities are available at the University. The controlled tests should be conducted in both summer and winter to determine the temperature lability of test compounds. Favorable results should then be applied to limited field tests.

   The application of these materials to garbage bags, garbage containers and other food and garbage storage facilities could be important as part of the animal control program. An effective garbage removal and storage program prior to incineration will entail use of bags and other containers. Bears and canids will be attracted to and perhaps destroy these containers scattering the contents thus, in part, hindering NWA's concerned effort to maintain a clean project. These deterrent compounds could eliminate this possibility and thereby greatly enhance NWA's garbage removal and clean-up program. Treatment of containers and storage facilities would be a significant supplement to the garbage handling and food storage program.

2. A logical systematic approach should be taken to develop emetics as aversive conditioning agents in carnivores along the NWA corridor. Carnivore species likely to be involved in man-carnivore interactions should be fed emetics under controlled conditions in the laboratory. Several species (arctic fox, red fox and wolves) are available for this type of study in the Fairbanks area, and the University has bear facilities.

   After proper dosage and dissolving rates are established for each species, the study would be expanded to controlled field situations. Food similar to that which would be available to carnivores during NWA pipeline construction would be used and by monitoring marked animals (preferably radio-collared) the degree of aversion could be determined. Animals may return to natural food hunting patterns or may learn other methods to avoid baited foods in which case baiting procedures should be modified.

   The use of emetics on the NWA project would be in field applications along the right-of-way. If animals are attracted to work sites by garbage, litter and handouts, they should be deterred from continued approach to the right-of-way. Application of emetics to baits consisting of scraps of garbage or food could condition the animals to avoid these foods. Emetics could provide a relatively inexpensive and useful technique to handle problems and could reduce the need to kill nuisance animals.

3. Noise deterrents should be tested in the field to determine their effectiveness on the species of concern. These experiments could be conducted on an opportunistic basis where problem animals occur, but probably would be more conclusive where animals already concentrate such as at existing dumps.

   Noise deterrents could supplement NWA's animal control program when other techniques are unsuitable or ineffective. For example, a noise deterrent could be used at camp gates to deter approaching animals. This technique would be controlled by the gate attendent. The amount of time that the gates need to be kept closed could be reduced and the need to close the gates during peak traffic at the approach of a potentially troublesome animal could be eliminated. Noise deterrents might also apply to work sites along the right-of-way, reducing work stoppages due to nuisance animals. Portable noise generators would add flexibility to a control program and be useful where animals occasionally pose problems at remote locations along the route.

Two criteria regarding field studies are important to consider. Field studies north of the Yukon River should be conducted on opportunistic bases where problem animals can be used. Baits should not be used in this area because of the presence of "experienced" animals. Allowing these and "naive" animals to become habituated to artificial food sources for purposes of experimentation could cause problems later. Secondly, field tests of emetics should be conducted where animals are already using artificial food sources or, if animals must be baited, these experiments should be conducted away from the pipeline corridor. This will help avoid habituating animals to artificial food sources in the vicinity of future construction activities.

We strongly recommend that any or all of these studies be considered by NWA. Favorable results could significantly increase the effectiveness of both the food storage/garbage disposal and animal control programs. No matter how concerned and effective the NWA policy is in maintaining a clean project and preventing animal feeding, some problems will still occur. Bears and canids are curious opportunists readily attracted to food and garbage odors and to new sources of food. Potential nuisance animals are always present and ready to take advantage of any lapses in preventative programs. Non-lethal means of discouraging such behavior could strengthen NWA's animal control program.

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